Available online at www.sciencedirect.com
SCIENCE DIRECT®

Journal of Ethnopharmacology 96 (2005) 303–323

Journal of ETHNO-PHARMACOLOGY

www.elsevier.com/locate/jethpharm

Snakebite ethnopharmacopoeia of eastern Nicaragua

Felix G. Coe[a,*], Gregory J. Anderson[b]

[a] *University of Connecticut, 85 Lawler Road, West Hartford, CT 06117-2697, USA*
[b] *Department of Ecology and Evolutionary Biology, University of Connecticut, Box U-43, Storrs, CT 06269-3043, USA*

Received 18 June 2004; received in revised form 16 September 2004; accepted 16 September 2004
Available online 5 November 2004

We dedicate this paper to Aldric Cayasso[1] and Florentine Joseph[1] two shamans that dedicated their lives to providing healthcare to the people of eastern Nicaragua.

Abstract

Results of an ethnopharmacognostic study of snakebite treatments in eastern Nicaragua are presented. Data and specimens were collected during several years of field studies. Field work consisted of plant collecting trips and interviews of snakedoctors. The annual mortality from snakebites in eastern Nicaragua is about 25% and most bites are caused by the fer-de-lance (*Bothrops asper*). The vascular flora of the region is estimated at 2500 species of which 435 have medicinal application including 81 that are used in snakebite treatment. The majority of species used in snakebite cures are flowering plants, 76% dicots and 20% monocots, and 80% are obtained from the second-growth forest. About half the species are herbs. Leaves are the most frequently utilized plant part. Most herbal remedies are prepared as decoctions and are administered orally. Remedies are mostly prepared with native wild species, but some are introduced domesticates, derived from either the American or Old World Tropics. All the species used contain at least one bioactive compound, and most of these bioactives have been shown in other studies to have pharmacological effects. The use of species in snakebite treatments does not necessarily imply efficacy, but it does give a limited list of species that can be studied pharmacologically for possible bioactive effects. Studies like this one are also important because they document traditional practices and species utilized for the people of the region studied as well.

Keywords: Snakes; Snakebites; Ethnopharmacopoeia; Eastern Nicaragua

1. Introduction

Traditional healers use a wide range of plants to treat many ailments including snakebites. A review of the literature indicates that about 600 species of higher plants from some 100 families are used as snakebite antidotes (Coe and Anderson, 1996a, 1997, 1999; Duke, 1985; Houghton and Osibogun, 1993; Leung and Foster, 1996; Mors et al., 1989; Morton, 1981). This is impressive given that only 7% (200 of 2700 species) of snakes are poisonous (Arena and Drew, 1986; Greene, 1997). However, this relatively small number of species of snakes has a broad geographical distribution, and even if all snakebites are not venomous, the consequences of those that are, are so great that traditional treatments are abundant. The broad geographic distribution of poisonous snakes in general also presumably accounts for at least some of the high diversity of plants used as antidotes. Nearly three-quarters (145 species) of poisonous snakes are native to Latin America (Campbell and Lamar, 1989). Mexico has the largest number of poisonous snakes of any country in the world with 59 species (Campbell and Lamar, 1989). Central America has 34 species of poisonous snakes; Guatemala has the most (19 species) and El Salvador the least (7 species) (Table 1) (Campbell and Lamar, 1989). In Nicaragua there are 14 species of poisonous snakes; 50% of these occur in the area we studied, the eastern lowlands, a region that consists primarily of lowland tropical forest (Fig. 1) (Tables 1 and 2).

Nicaragua's poisonous snakes are found in most habitats, vegetation types, and ecoregions (Table 2). However, they

* Corresponding author. Tel.: +1 860 570 9254; fax: +1 860 570 9210.
E-mail address: fcoe@uconn.edu (F.G. Coe).
[1] Deceased.

0378-8741/$ – see front matter © 2004 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.jep.2004.09.026

Table 1
Species distribution of poisonous snakes in Latin America[a]

Region	Number of species	% Latin America	% Central America
Latin America	145	100	–
Mexico	59	41	–
Central America	34	23	100
Guatemala	19	13	56
Belize	9	6	26
El Salvador	7	5	21
Honduras	14	10	41
Nicaragua	14	10	41
Costa Rica	17	12	50
Panama	21	14	62

[a] Based on Campbell and Lamar (1989).

are not the great threat to humans that their wide distribution would imply. The majority of poisonous snakes are not aggressive and bites are nearly always the result of accidental or careless contact, with the snake striking in response to pain or fear (Campbell and Lamar, 1989). However, as with people everywhere, poisonous snakes—because they have the potential to cause death—are viewed negatively by rainforest dwellers. Unfortunately, all snakes are perceived by eastern Nicaraguans as poisonous, so most snakes are killed when encountered. The most feared poisonous snake in eastern Nicaragua is the fer-de-lance (8 *Bothrops asper*, the number is a guide to finding the species in Table 2) found in the northwestern highlands, the central highlands, and more commonly in the eastern lowlands (Table 2). The human mortality caused by the fer-de-lance (8) makes it the most important poisonous snake in Mesoamerica (Bolaños, 1982, 1984; Campbell and Lamar, 1989; Greene, 1997). Because of its ubiquity and poisonous nature, the fer-de-lance (8) is known to all the ethnic groups in eastern Nicaragua, a notoriety reflected by the variety of common names assigned to it (Table 2). The most widely used common names for this species are: (a) barba amarilla, tamagás, and terciopelo by the Mestizos (people of Spanish and Amerindian ancestry), (b) tamigar and tommygoff by the Creoles (people of English and African or English and Amerindian ancestry), (c) damágasi by the Garífuna, (d) pyuta ainghwa and pyuta lal pauni by the Miskitu, (e) aalbut by the Rama, and (f) bil palka, bil tunak pauka, and dîmuih tunak pauka by the Sumu/Ulwa.

Fig. 1. Map of Nicaragua: autonomous regions and major settlements in eastern Nicaragua.

Table 2
Poisonous snakes of Nicaragua: abundance and distribution by habitat and vegetation type[a,b]

Scientific name[a,b]	Standard English name[a]	Common name[c]	Abundance[d]	Habitat[e]	Vegetation type[f]
Squamata-serpentes					
Elapidae					
1. *Pelamis platurus*[g]	Pelagic sea snake	Serpiente de Mar Listada (h)	C	A	–
Micruridae					
2. *Micrurus alleni*[h]	Allen's coral snake	Coral, Coralillo (h)	C	T	A, D, G
3. *Micrurus multifasciatus*[h]	Many-banded coral snake	Coral, Coralillo, Gargantilla (h)	C	T	A, G, J
4. *Micrurus nigrocinctus*[h,i]	Central American coral snake	Coral, Coralillo, Gargantilla (h); Babaspul (m)	A	T	A, D, F, J, L
Viperidae					
5. *Agkistrodon bilineatus*	Cantil	Castellana de Jáquima (h)	C	T	C, D, F
6. *Bothriechis marchi*	March's palm-pitviper	Chocoya, Lora, Víbora de las Palmas (h)	R	B	A, G, J
7. *Bothriechis schlegelii*[h]	Eyelash palm-pitviper	Green Tamigar, Green Tommygoff, Sleeping Cough (c); Bocacá, Culebra de Cachitos, Oropel, Terciopelo de Pestaña (h)	C	B	A, G, K
8. *Bothrops asper*[h]	Fer-de-lance	Tamigar, Tommygoff (c); Barba Amarilla, Tamagás, Terciopelo (h); Pyuta Ainghwa, Pyuta Lal Pauni (m); Damágasi (g); Bil Palka, Bil Tunak Pauka, and Dîmuih Tunak Pauka (s/u); Aalbut (r)	A	T	A, B, C, D, F, G
9. *Crotalus durissus*	Neotropical rattlesnake	Cascabel (h)	A	T	C, D, E, F, G
10. *Lachesis muta*[h,j]	Bushmaster	Bushmasta (c); Cascabel Muda, Mapaná, Matabuey, Mazacuata, Toboa Real, Verrugosa (h)	U	T	A, B, D, J
11. *Porthidium godmani*	Godman's montane-pitviper	Toboa Oscura, Toboíta (h)	R	T	G, J, L, M
12. *Porthidium nasutum*[h]	Rainforest hognosed pitviper	Aspid (c); Chatilla, Tamagás (h)	C	T	A, J
13. *Porthidium nummifer*[h]	Jumping pitviper	Cabeza de Sapo, Patoca, Timbo (h)	C	T	A, G
14. *Porthidium ophryomegas*	Slender hognosed pitviper	Corníz, Tamagás (h)	C	T	D, E, H, I

[a] Campbell and Lamar (1989).
[b] Greene (1997).
[c] Common name: c, Creole; g, Garífuna; h, Spanish; m, Miskitu; r, Rama; s/u, Sumu/Ulwa.
[d] Abundance: A, abundant; C, common; U, uncommon; R, rare.
[e] Habitat: A, aquatic; B, arboreal; T, terrestrial.
[f] Vegetation type: A, lowland tropical rainforest (tropical wet forest, tropical moist forest); B, tropical evergreen forest; C, savannah; D, tropical deciduous forest (tropical dry forest, lowland dry forest); E, tropical arid forest; F, tropical scrub forest (thorn forest); G, subtropical wet forest (cloud forest); H, subtropical moist forests; I, subtropical dry forest; J, lower montane wet forest; K, montane wet forest; L, lower montane dry forest; M, high montane forest and meadow.
[g] Pacific marine habitat.
[h] Species present in eastern Nicaragua.
[i] Also found on Big Corn Island.
[j] World's largest viper exceeding 3.6 m (Campbell and Lamar, 1989).

However, fer-de-lance is the name most widely used in Standard English language literature (Table 2).

According to estimates by the World Health Organization (WHO), poisonous snakes are responsible for at least 40–50,000 human fatalities annually (Arena and Drew, 1986; Dreisbach, 1980; Greene, 1997; Habermehl, 1981). However, documentation of snakebite morbidity (frequency of bites), includes bites without venom injection (empty bites) and bites with venom injection (venomous bites) and mortality (frequency of deaths caused by bites (empty and venomous)) rates vary greatly from country to country and from region to region within countries. For example, Costa Rica has a long history of research on poisonous snakes that dates back to the 1930's (Greene, 1997), therefore record keeping of snakebite morbidity and mortality rates is much better than in the other Central American countries. The reported annual snakebite mortality rate of 3.3 per 100,000 inhabitants in Costa Rica is probably the most accurate in Central America (Greene, 1997). In Nicaragua, documentation of snakebites is sporadic at best; data are mostly available on a regional level from hospital and church records and from interviews of traditional healers and the general populace. Therefore, snakebite morbidity and mortality rates in most instances are estimates, in particular rates of morbidity because most snake bites are treated locally with traditional medicine (Dennis, 1988; Barrett, 1994; Coe, 1994; Coe and Anderson, 1996a, 1997, 1999; Loveland, 1975), and thus, may go unreported. One would expect higher morbidity and mortality rates in eastern Nicaragua compared to the rest of the country because: (a) the abundance of fer-de-lance in the region, (b) over 60% of the inhabitants of this region live in rural areas, (c) there is higher exposure or contact with poisonous snakes because of human activities (e.g., agriculture, foraging, gathering, and timber extraction) in this region coupled with lack of protective shoes/clothing, and (d) there is less access to Western medicine.

People living in rural areas of eastern Nicaragua rely mostly on traditional medicine for the treatment of snake bites. However, the documentation of traditional medicine treatment for snake bites has never been done in a systematic manner. Until recently most ethnomedicinal studies were limited to reports of a select group of medicinal plants (e.g., Barrett, 1994; Dennis, 1988; Fey and Sindel, 1993; Loveland, 1975; MINSA, 1988, 1989). The only exhaustive ethnobotanical studies that focused on the overall use of plants by the indigenous groups of eastern Nicaragua are by Coe (1994) and Coe and Anderson (1996a, 1996b, 1997, 1999). With the exception of cursory reports by Loveland (1975) and Dennis (1988), the snakebite ethnopharmacopoeia of eastern Nicaragua has remained undocumented. Consequently, the objective of this study was to document the snakebite lore of four ethnic groups: the Garífuna, Miskitu, Rama, and Sumu. Our goals were to: (a) document the species of plants used in eastern Nicaragua to treat snakebites, (b) synthesize published data on the chemical constituents of species used in snakebite remedies, and (c) highlight the potential pharmacological activity and toxicity of the chemical constituents of snakebite species.

2. The study area

The study area consists of eastern Nicaragua in what was formerly the Department of Zelaya, constituting about one-third (41,000 km^2) of the national territory, located between 11°22′ and 15°00′N latitude and 83°15′ and 85°30′W longitude. Today this area is divided into two autonomous regions: the Región Autónoma Atlántico Norte (RAAN) and the Región Autónoma Atlántico Sur (RAAS) (Fig. 1). Elevations range from sea level to over 600 m, with isolated peaks reaching over 1600 m. The climate is tropical, with a rainy season of 6–8 months and no well-defined dry season. The average annual rainfall is 2500–6000 mm (it increases from north to south and west to east) and the average annual temperature is 25–30 °C (Incer, 1975; Stevens et al., 2001). The predominant ecosystem in the area is broadleaf evergreen forest (both primary and secondary) that consists of the terra firma rain forest, moist tropical forest, swamp forest and mangrove forest (Incer, 1975; Stevens et al., 2001). This study was conducted primarily in the moist tropical forest, swamp forest, and mangrove forest.

3. Methods

The methodology employed is similar to those used by Coe and Anderson (1996, 1997, 1999). Identification and classification of vascular plants were made with the following guides: (a) ferns and ferns allies (Davidse et al., 1995), (b) gymnosperms (Stevens et al., 2001), (c) angiosperms (Cronquist, 1981; Stevens et al., 2001), (d) species names (Stevens et al., 2001), (e) author name abbreviations (Brummitt and Powell, 1992), (f) book abbreviations (Stafleu and Cowan, 1976–1988; Stafleu and Mennega, 1992–2000), and (g) journal abbreviations (Bridson, 1991). One of the authors (FGC) is a native of Bluefields, Nicaragua, and has been in contact with the ethnic groups since 1960; he carried out the field studies. Interviews were conducted mostly in "Creole" and interpreters were used as needed for indigenous languages. Interviews were tape-recorded with the consent of the interviewee. Participants were paid for their time with cash, food supplies, household utensils or clothing.

Vouchers were collected during field trips with participants. Specimens were identified by the authors and by specialists from several institutions listed in the acknowledgments. Four voucher specimens were collected for each species and were deposited at HACN, MO, and CONN.

4. The people

The eastern Nicaraguan people are of diverse ethnic backgrounds (Hale and Gordon, 1987; Vilas, 1989; Coe and Anderson, 1996, 1997, 1999). The largest ethnic groups are the Mestizos and Creoles. The indigenous population (Garífuna, Miskitu, Rama, and Sumu) constitutes only 30% of the estimated 285,150 inhabitants of the region (CIDCA, 1982; Hale and Gordon, 1987; Vilas, 1989; Herlihy, 1997; Williamson et al., 1993). The indigenous groups of eastern Nicaragua are more closely related culturally to groups in the lowlands of South America than to cultures of Mexican and Mayan affinity. This association is based on a number of cultural features reminiscent of South American groups. These traits include a hunting and fishing economy with little emphasis on agriculture; cassava (30 *Manihot esculenta* [the number is a guide to finding the species in Table 3]) rather than maize (*Zea mays*) is the principal cultigen; emphasis is on canoe travel; excessive intoxication occurs during rituals; use of hammocks; and the manufacture of bark cloth (Adams, 1956; Conzemius, 1932; Kidder, 1940; Mason, 1962; Stone, 1962, 1966). The languages spoken by the Miskitu, Rama, and Sumu, belong to the Macro-Chibcha linguistic group of Colombia and northern Ecuador (Kidder, 1940; Mason, 1962; Stone, 1966). The Garífuna language is a blend of African and Amerindian languages and French, acquired during bondage on Caribbean sugar plantations (Conzemius, 1928; Holm, 1978). Most of the indigenous people are Christians, highly acculturated, and speak some form of Creole English or Spanish.

Table 3
Species used to treat snakebites in eastern Nicaragua

Scientific name[a]	Common names[b]	Use[c]	Plant material[d]	Prep.[e]	Adm.[f]	Habit[g]	Plant source[h]	Regional use[i]	Bioactive compound[j]	Voucher[k,l]
Pteridophyta										
Filicopsida										
Pteridaceae										
1. *Acrostichium aureum* L.[m,n]	Taiga bush (c), helecho de manglar (h), gaigusi arabu (**g**), limsi dusa (**m**) nawah damaska (**u**), krúuba kuula (**r**)	A, B	L, R	B, D	B, O	H	S	–	4, 7, 9, 10, 18	3536
Schizaeaceae										
2. *Lygodium heterodoxum* Kuntze[m]	Witts (c), bejuco de alambre (h), púntugu (**g**), unta kyuca (**m**)	A	L	D	O, T	V	S	–	4	2770
3. *L. venustum* Sw.[m]	Withes (c), bejuco de alambre (h), withes (c/**g**), wa tawa (**m**)	A	L, P	D, P	O, T	V	S	–	4	4337
Magnoliophyta										
Magnoliopsida (Dicots)										
Acanthaceae										
4. *Blechum pyramidata* (Lam.) Urb.[n]	Ghost bush (c), cascabelito (h), inma paskaia (**m**), kunsil (**s**)	B	L, P	D	O	H	S	MCA (11)	15, 36	3706
Anacardiaceae										
5. *Anacardium occidentale* L.[n,o]	Cashew (c), marañon (h), úri (**g**), kasuh, kasau (**m**), kasauh (**u**), kasuu (**r**)	A, B	B	D	O, T	T	S	SEA (6)	9, 10, 12, 21	2725
Apiaceae										
6. *Eryngium foetidium* L.[n]	Culantro (c), culantro (h), gúlantro (**g**), bilta, kiasaura (**m**), kasauri (**u**), prouk (**r**)	B	L	D, I	O	H	S	MCA (11), SEA (2), WI (4)	12, 13,15,31,45	12967
Apocynaceae										
7. *Echites umbellata* Jacq.[n]	Bean witts (c), bean witts (c/**g**), bins unta kyuka (**m**)	B	R	D	O	V	S	–	15, 36	3490
8. *Odontadenia puncticulosa* (Rich.) Pull.[n]	ámali (**g**), latawira (**m**), sakaluk (**s**)	B	L	D	O	V	S	–	15	2142
Aristolochiaceae										
9. *Aristolochia trilobata* L.[m,n]	Snakeroot (c), contribo (h), cuntríbo (**g**), kuntribu (**m**), kuntribu (m/**u**)	A, B	L, P, R	D, I, P	O, T	V	S	MCA (11), WI (4, 12)	9, 10, 12, 15, 18, 20, 35, 44	12968

Table 3 (*Continued*)

Scientific name[a]	Common names[b]	Use[c]	Plant material[d]	Prep.[e]	Adm.[f]	Habit[g]	Plant source[h]	Regional use[i]	Bioactive compound[j]	Voucher[k,l]
Asclepiadaceae										
10. *Asclepias curassavica* L.[m]	Yellow head (c), señorita, vibórana (h), lamúruhéwe (**g**), piuta saika (**m**), wahbara (**u**), yella hed (c/**r**)	A, B	B, F, L, P, R, S	D, P	O, T	H	S	MCA (11)	9, 10, 12, 15, 27, 31, 35, 36, 46, 47	12969
11. *Blepharodon mucronatum* (Schltdl.) Decne.[n]	Witts (c/**r**) bejuco de pescado (h)	A	L, P	D, P	O, T	V	S	MCA (11)	15, 36	2196
Asteraceae										
12. *Mikania cordifolia* (L.f.) willd[m,n]	Guacu (c/**r**), guaco de serpiente (h), guagú (**g**), guahku (**m**), kunsisil (**u**)	A, B	L, M, P	D, P	O, T	V	S	MCA (11), P (5),WI (11)	7, 9, 10, 15, 47	3254
13. *M. guaco* Bonpl.[m,n]	Guacu (c/**r**), guaco de serpiente (h)	A, B	L, M, P	D, P	O, T	V	S	MCA (11), SA (7), SEA (9)	15, 31	3793
14. *Neurolaena lobata* (L.) R. Br[m,n]	Jackass bittas (c/**r**), gavilán, tres puntas (h), gúye árani (**g**), yâkal satka (**m**), kunata palska (**u**)	B	L	D	O, T	H	S	SA (7)	5, 13, 15, 24, 30, 31	2515
15. *Sphagneticola trilobata* (L.) Pruski[n]	Beach marigold (c), romero de playa (h), kaisinpata (m/**g**), kaisinpata (**m**), mululuh (**u**), kaismitin (c/**r**)	A, B	F, L, M, P	D	O	H	S	–	13, 15	4208
Bixaceae										
16. *Bixa orellana* L.[n]	Natta (c), achiote (h), gusébwe (**g**), aulala, tmariñ (**m**), awal (**u**), aliup, natam (**r**)	B	S	D	O	S	C	P (14), SEA (6)	6, 12, 13, 15, 31	3316
Boraginaceae										
17. *Heliotropium indicum* L.[m,n]	Scarpion tail (c), cola de alacrán (h), tiliágura (**g**), misri wâika (**m**), wâkurus umah (**u**), scarpion tail (c/**r**)	A, B	L, P	D	O	H	S	SEA (6), WI (4)	12, 13, 15, 31, 35, 37, 46, 47	4042
Burseraceae										
18. *Bursera simaruba* (L.) Sarg.[m,n]	Burch, naked indian (c), indio desnudo, jiñocuabo (h), surúsu wügüri (**g**), limsi, daktar (**m**), limsi (m/**u**), naykid indian (c/**r**)	B	B, P	D	O	T	O	CA (11), SA (7)	6, 12, 13, 15	2804

Campanulaceae										
19. *Hippobroma longiflora* (L.) G. Don.[m,o]	Star flower (c/**r**), mata Ganado (h)	B	L, P, R	D, P	O, T	H	S	CA, WI (11)	15, 31, 36	12141
Cecropiaceae										
20. *Cecropia obtusifolia* Bertol.[n]	Trompet (c), guarumo (h), trompit (c/**r**)	B	L	D	O	T	S	–	15, 31, 35	N
21. *C. peltata* L.[n]	Trompet (c), guarumo (h), trumpet (c/**g**), plan, plang (**m**), palang (**u**), trompet (c/**r**)	B	L	D	O	T	S	CA (11), WI (4)	6, 14, 15, 19, 35	4007
Convolvulaceae										
22. *Ipomoea mauritiana* Jacq.[n]	Taiga paw (c), latawira (**m**), salalani (**u**), taiga paw (c/**r**)	B	L	D, P	O, T	V	S	–	15	4061
23. I. pes-caprae (L.) R. Br.[n]	Beach morning glory (c/**g**), camote de playa (h), kâbu unplâplapra (**m**), pulu kuma kungka (**u**)	B	E, L	D	O	V	S	–	7, 9, 10, 12, 15, 31, 46	2003
24. *I. setifera* Poir [n,o]	Tutuk, ulupuy (**u**)	A	L	D, P	O, T	V	S	–	15	3371
25. *Operculina pteripes* (G. Don) O'Donell[n]	Bitta tataku (m/**g**), bitta tataku, latawira, tataku (**m**), bitta tataku (m/**u**)	A, B	L	P	T	V	S	–	15	4102
Cucurbitaceae										
26. *Fevillea cordifolia* L.[m,n]	Antidote bush (c), cabalonga, chichimora (h), antidote bush (c/**g**), mukula (**m**), mula (**u**)	A, B	E	I, P	O, T	V	S	TA (11)	1, 2, 9, 10, 15, 22, 31	4432
27. *Momordica charantia* L.[m,n,o]	Sorosi (c), cundeamor (h), sorosí (**g**), tasplira, twasplira (**m**), panaminik, makalalaska, miniklasni (**u**), sorosi (c/**r**)	A, B	L, M	D	O, T	V	S	SEA (6), USA (15), WA (3)	7, 9, 10, 12, 25, 27, 31, 46, 47	3634
Euphorbiaceae										
28. *Acalypha arvensis* Poepp. & Endl.[m,n]	Worm bush (c), hierba de cancer (h), worm bush (c/**g**), blâ síka (**m**), kiskita (**u**), worm bush (c/**r**)	B	L, P	D	O, T	H	S	CA (11)	12, 18, 21, 35, 36	3640
29. *Euphorbia thymifolia* (L.) Millsp.[n]	Milky–milky (c), míliqi-míliqi (**g**), mahkira, talalaya (**m**), baska, bisini (**u**), siksik (r)	B	L, P, S	D	O	H	S	P (14), SEA (6, 13)	9, 10, 12, 35, 46	2474
30. *Manihot esculenta* Crantz[n,o,p]	Cassava, yuca (c), yucca (h), añaha (**g**), yauhra (**m**), malai, maley (**u**), iik (**r**)	B	L, R	D	O	S	C	–	7, 15	3269

Table 3 (*Continued*)

Scientific name[a]	Common names[b]	Use[c]	Plant material[d]	Prep.[e]	Adm.[f]	Habit[g]	Plant source[h]	Regional use[i]	Bioactive compound[j]	Voucher[k,l]
Fabaceae										
31. *Bauhinia guianensis* Aubl.[m,n]	Monkey ladder (c), escalera de mico (h), kaléra mégu (**g**), urus mina-mangka (**m**), monkey ladder (c/**r**)	A, B	B, M	D	O, T	V	O	MCA (11)	12, 15	12164
32. *Caesalpinia bundoc* (L.) Roxb.[n,o]	Stuco weed (c/**r**)	B	E	D	O	V	S	MCA (11), SEA (6), WI (11)	7, 12, 15, 23, 25, 31	NV
33. *Desmodium adscendens* (Sw.) DC.[n]	Burbur, strang-back (c), mozote, pega-pega (h), strang-back (c/**g**), dusa karnira (**m**), danka dangpanak (**u**), strang-back (c/**r**)	B	L, P, R	D, I	O	H	S	–	9, 10, 12, 15, 34, 42	4115
34. *Indigofera suffruticosa* Mill.[n]	Blue (c), añil (h), blû (**m**)	B	P, S	D	O, T	H	P	SA (11)	15, 46	2773
35. *Mucuna urens* DC.[n]	Cowitch, quaqua (c/**g**), ojo de venado (h), kuakua, kwakwa (**m**), wabala (**u**)	B	S	D, P	T	V	S	SA (11)	15, 31, 47	2870
36. *Pentaclethra macroloba* (Willd.) Kuntz[n]	Pigeon bush (c/**g**), gavilán (h), krikaika (**m**), tikbus damaska (**u**), kiskis (**r**)	B	B	D	O, T	T	S	–	15, 31, 47	2441
37. *Senna alata* (L.) Roxb.[m,n,o]	Christmas blossom (c/**g**,**r**), soroncontil (h), kislin, krismis tangni, sus saika (**m**), daka, papaih, tata, tatah (**u**)	B	F, L, P	B, D, J, P	B, O, T	S	S	P (1, 6, 10, 11, 12)	9, 10, 12, 13, 15, 31, 36, 39, 43, 47	3618
38. *S. occidentalis* (L.) Link[m,n]	Piss-a-bed (c/**r**), frijolillo, pico de pajáro (h), ginībisi (**g**), singsingya (**m**), singsingya (**u**)	B	L, P, R	D, J	O, T	H	S	SEA (2, 6), WA (3)	7, 9, 10, 13, 15, 25, 31, 46	3523
39. *S. reticulata* (Willd.) H.S. Irwin & Barneby[n]	Sorocontil (c/**g**,**r**), soroncontil (h), sus saika (**m**), tislin (**u**)	A, B	L, R	D	O	H	S	MCA (11)	9, 10, 15, 36	2799
Lamiaceae										
40. *Ocimum campechianum* Mill.[n]	Barsley (c/**g**,**r**), albahaca montera (h), sîka kaira (**m**), kuma sirpi (**u**)	B	L, P	D, I	O, T	H	S	–	12, 14, 26, 29, 31	2231
Loranthaceae										
41. *Struthanthus cassythoides* Millsp. ex Standl.[n]	Scani growd (c/**g**), matapalo (h), tati sau (**m**), dâwan damaska (**u**)	A, B	L, P	D, P	O, T	V	S	–	9, 10, 15	3850

Malpighiaceae										
42. *Banisteriopsis cornifolia* (Kunth) C.B. Rob.[n]	Witts (c/**g**), sîka wani (**m**)	A, B	B, L, M	D	T	V	S	–	15, 31	3311
43. *Byrsonima crassifolia* (L.) Kunth[m,n]	Crabu (c), nance, nancite (h), mureí (**g**), krabu (**m**), krabu (m/**r**,**u**)	A, B	B	D	O	T	S	MCA (8, 11), SA (7, 11)	6, 9, 10, 14, 15, 31	12182
44. *Stigmaphyllon puberum* (Rich.) A. Juss.[n]	Snakeroot (c/**g**,**r**), pyuata wâkia (**m**), bil siwanak (**u**)	B	L, M	D	O, T	V	S	–	15	3788
Malvaceae										
45. *Sida rhombifolia* L.[n]	Broom weed (c/**r**), escoba (h), sagádi abuídagülei (**g**), brum sirpi, dinar (**m**), muluh, muluh alnimuk (**u**)	B	L	D	O, T	H	S	SEA (6)	7, 13, 15, 35, 46, 47	4343
Menispermaceae										
46. *Cissampelos pareira* L.[m,n]	Alcotán, curarina (h,**g**)	A, B	L, P, R	D	O, T	V	S	P (3, 6, 8, 11, 13, 14)	13, 14, 31, 34, 35, 46, 47	4341
Moraceae										
47. *Dorstenia contrajerva* L.[m]	Contrayerba (h,**r**)	A, B	L, P	D	OT	H	O	–	8, 40, 46	NV
Ochnaceae										
48. *Sauvagesia erecta* L.[n]	Sticky bush (c), lilia sara (**m**)	B	P	D, P	O, T	H	S	–	15	4201
Phytolaccaceae										
49. *Petiveria alliacea* L.[m,n]	Fitsy bush, zorrillo (h) (c,**g**), kiski, sbatkira, surua (**m**), kiski, sbatkira, surua (m/**u**), guinny hen, obeah bush (c/**r**)	B	L, P, R	D, P	O, T	H	S	TA (11)	6, 18, 31, 45	3566
Piperaceae										
50. *Peperomia pellucida* (L.) Kunth[n]	Shiney bush (c/**g**), hierba de sapo (h), sumu mairen (**m**), sumu yal (**u**), clearweed (c/**r**)	B	P	D	O	H	S	–	7, 15, 31	3750
51. *Piper amalago* L.[n]	Black joint (c/**r**), alcotán, cordoncillo (h)	B	L, R	D	O	H	S	–	11, 12, 15, 35, 36	15198
52. *P. auritum* Kunth[n]	Cowfoot (c), santa maría (h), ugúdi bágasu (**g**), kauput, síka tara (**m**), kalamata (**u**), biip kaat (**r**)	B	L, P	I, J	O, T	H	S	–	3, 9, 10, 12, 15, 17, 31, 32, 35, 46	12970
53. *P. peltatum* L.[n]	Bullfoot (c), santa maría (h), ugúdi bágasu (**g**), bulput, síka tara, upla kalula (**m**), kalamata (**u**), biip kaat (**r**)	B	P	S	O	H	S	–	9, 10, 15	3525

Table 3 (*Continued*)

Scientific name[a]	Common names[b]	Use[c]	Plant material[d]	Prep.[e]	Adm.[f]	Habit[g]	Plant source[h]	Regional use[i]	Bioactive compound[j]	Voucher[k,l]
Rhizophoraceae										
54. *Rhizophora mangle* L.[m,n]	Red mangro (c), mangle colorado (h), gurúra (**g**), mankru (**m**), mankru (m/**s**), laulau (**r**)	A, B	B	D	O, T	T	O	–	7, 13, 15, 16, 31	2099
Rubiaceae										
55. *Borreria assurgens* (Ruiz & Pav.) Griseb.[n]	Button bush (c/**r**), botoncillo (h), kalila, li dukya saika, twisa (**m**), titiska mâ baka (**u**)	B	L, R	D, J, P	O, T	H	S	–	9, 10, 14	3899
56. *Chiococca alba* (L.) Hitchc.[n]	Snakeroot (c), suelda-con-suelda (h), sriri (**m**)	B	L, R	D, P	O	H	S	TA (11)	15, 36	4176
57. *Hamelia axillaris* Sw.[n]	Silbyara (**m**), silbyara (m/**r**)	B	L, P	D, P	O, T	H	S	–	9, 10, 15	2503
58. *H. barbata* Standl.[n]	Silbyara (**m**)	B	L, P	D, P	O, T	H	S	–	9, 10, 15	2588
59. *H. patens* Jacq.[m,n]	Red scholars (c), coralillo, pinta machete (h), yamni sîka (**m**), pauka damaska (**u**)	B	L, P	D, P	O, T	H	S	MCA (11)	9, 10, 13, 28, 36, 38, 47	2768
60. *H. rovirosae* Wernham[n]	Silbyara (**m**)	B	F, L, M	D	O, T	H	S	–	9, 10, 15	4236
61. *Psychotria elata* (Sw.) Hammel[n]	Red scholars (c/**g**,**r**), coloradito (h), inma pauni (**m**), pauka kungmak (**u**)	B	F, L, M, P, R	D, P	O, T	H	S	–	9, 10, 15, 47	2472
62. *P. poeppigiana* Müll.[n]	Sore mouth bush (c/**g**,**r**), tangni pauni (**m**)	B	P	D, P	O, T	H	S	–	9, 10, 15, 47	2010
Scrophulariaceae										
63. *Scoparia dulcis* L.[m,n]	Wild rice (c/**r**), escoba dulce (h), ri haráchan (**g**), haraspata (**m**), ubitna, salalaini, ubitna bikisni (**u**)	A, B	L, P, R	D	O	H	S	MCA (10), SEA (2)	9, 10, 15, 31, 36, 47	3358
Simaroubaceae										
64. *Quassia amara* L.[m,n]	Bittawood (c/**r**), hombre grande (h), wéwe gífi (**g**), wanabaka (**m**), batakka dî basta (**u**)	A, B	M	D	O	T	S	MCA (11)	9, 10, 12, 15, 33, 47	2790
Solanaceae										
65. *Nicotiana tabacum* L.[n]	Tubaco (c), tabaco (h), iúri (**g**), twâko, twâku (**m**), aka (**u**), tuu (**r**)	B	L	N	O, T	H	P	–	7, 31, 47	NV
66. *Solanum torvum* Sw.[n]	Turtle egg (c), lava plato (h), mirá-mira-furúda (**g**), dusmâ kyayá (**m**)	B	L, R	D, P	T	H	S	–	6, 7, 46, 47	2892

Liliopsida (Monocots)										
Aloeaceae										
67. *Aloe vera* (L.) Burm. f.[n]	Aloes (c/**r**), sábila (h), sábila (**g**), kyurtakaia sut (**m**), singwanaka luih (**u**)	B	L	J	O, T	H	C	–	13, 15	2743
Araceae										
68. *Philodendron hederaceum* (Jacq.) Schott[n]	Snake vine (c/**g**), kura siaka (**m**)	B	L, M	D, P	O, T	V	S	–	15	3416
Bromeliaceae										
69. *Ananas comosus* (L.) Merr.[n,o]	Pine (c), piña (h), yeíawa (**g**), pihtu (**m**), masa, mâsahti (**u**), suurak (**r**)	B	F, L	D	O	H	C	–	15, 36, 46	2727
70. *Bromelia pinguin* L.[n]	Wild pine (c), piñuelo (h), tíbidu yeíawa (**g**), ahsi (**m**), ahsi, wakari (**u**)	B	L	D, P	O, T	H	S	–	15	2737
Haemodoraceae										
71. *Xiphidium caeruleum* Aubl.[n]	Brujita (h), swilawan (**m**), swilawan, umah tikbus (**u**)	A, B	L	D	O, T	H	S	–	9, 10, 15, 36	4439
Liliaceae										
72. *Hymenocallis littoralis* (Jacq.) Salisb.[m,n]	Spaida lily (c), ngaungauk katuruk (**r**)	A, B	L, R	D, J, N	O, T	H	S	–	15, 35, 47	2713
Menyanthaceae										
73. *Nymphoides indica* (L.) Kuntze[m,n]	White lily (c/**r**)	B	L, R	D	O	H	S	–	36	NV
Musaceae										
74. *Musa* sp.[n,o,p]	Cosco (c), guineo cuadrado (h), gasíbu (**g**), plâs (**m**), yâmanh (u), sumuu (**r**)	B	F, S	N, P	O, T	H	C	–	15, 46, 47	NV
75. Musa paradisiaca L.[n,o,p]	Plantain (c), platano (h), burúru (**g**), plâtu (m), waka, waki (**u**), pranti, tirbi (**r**)	B	F, S	N, P	O, T	H	C	–	7, 15, 46, 47	NV
76. *M. paradisiaca* var. *sapientum* L.[n,o,p]	Banana (c), banano (h), bímena (**g**), siksa (**m**), inkini, ingkinih, pasa, wakisa (**u**), sumuu (**r**)	B	F, S	N, P	O, T	H	C	–	15, 46, 47	NV
Poaceae										
77. *Gynerium sagittatum* (Aubl.) P. Beauv.[m,n]	Wild cane (c), caña brava (h), gániesi haráchan (**g**), yauhrus (**m**), dapa (**u**), kartuk (**r**)	A, B	L, R	D	O	H	S	TA (11)	15	3871

Table 3 (*Continued*)

Scientific name[a]	Common names[b]	Use[c]	Plant material[d]	Prep.[e]	Adm.[f]	Habit[g]	Plant source[h]	Regional use[i]	Bioactive compound[j]	Voucher[k,l]
Smilacaceae										
78. *Smilax regelii* Killip & C. V. Morton[m,n]	Chainey root (c/**r**), cuculmeca, zarzaparilla (h)	A, B	R	D	O	V	S	SA (7)	12, 14, 15, 27, 31	3043
79. *S. spinosa* Mill.[m,n]	Chainey root (c/**r**), cuculmeca, zarzaparilla (h), ílagülei gürígüri (**g**), chiny, tâ wâkia (**m**), samalai wasalanaka (**u**)	A, B	R	D	O	V	S	–	6, 14, 15, 27, 43	4358
Zingiberaceae										
80. *Hedychium coronarium* (J.) König[m,n,o]	High lily (c/**r**)	A, B	P	B	B	H	S	–	15, 41	NV
81. *Zingiber officinale* Roscoe[n,o]	Ginja (c/**r**), jengibre (h), chichámbara (**g**), marid tangni, sinsa (**m**), sinsa, marid puluni (**u**)	B	R	D	O	H	P	SEA (6)	7, 12, 15, 31, 36, 43	2826

[a] Scientific name of the families follow Davidse et al. (1995) for the fern and fern allies; Cronquist (1981) and Stevens et al. (2001) for the angiosperms; the order within families, genera, and species is alphabetical.

[b] Common names: c, Creole English; g, Garífuna; h, Spanish; m, Miskitu; r, Rama; u, Sumu/Ulwa; letters in bold indicates use of species by the group; (/): (language of common name/group using the species); spelling follows CIDCA (1985, 1986, 1987, 1989) and Smutko (1985).

[c] Use: A, antidote; B, treat side effects caused by snakebite.

[d] Plant material used: B, bark; E, seed; F, fruit; L, leaf; M, stem; P, whole plant; R, root (bulb included); S, sap; W, wood.

[e] Preparation: B, bath; D, decoction; I, infusion; J, juice; N, none; P, poultice.

[f] Administration: B, bath; O, oral; T, topical.

[g] Habit: H, herb; V, vine; S, shrub; T, tree.

[h] Plant source: C, cultivated; O, old-growth forest; P, purchased; S, second-growth forest.

[i] Regional use: regions—MCA, Mexico and Central America; P, Pacific; PT, Pantropical; SA, South America; SEA, Southeast Asia; TA, tropical America; WI,West Indies. Literature source—1, Abbiw (1990); 2, Anderson (1993); 3, Ayensu (1978); 4, Ayensu (1981); 5, Cambie and Ash (1994); 6, Chopra (1958); 7, García-Barriga (1992); 8, Grijalva (1992); 9, Gunawardena (1975); 10, Lewis and Elvin-Lewis (1977); 11, Morton (1981); 12, Nuñez (1992); 13, Perry and Metzger (1980); 14, Quissumbing (1951); 15, Ross (1999); 16, Von Reis (1973).

[j] Bioactive compound: literature source—1, Achenbach et al. (1993); 2, Achenbach et al. (1995); 3, Ampofo et al. (1987); 4, Berti and Bottari (1968); 5, Bohlmann (1979); 6, Cáceres and Samayoa (1989); 7, Cambie and Ash (1994); 8, Casagrande et al. (1974); 9, Coe and Anderson (1996a); 10, Coe and Anderson (1996b); 11, Dominguez and Alcorn (1985); 12, Duke (1985); 13, Duke (1994); 14, García-Barriga (1992); 15, Gibbs (1974); 16, Griffiths (1959); 17, Hansel et al. (1975); 18, Hegnauer 1962–2001; 19, Hocking (1997); 20, Houghton and Osibogun (1993); 21, House et al. (1995); 22, Johnson et al. (1989); 23, Kapoor (1990); 24, Kerr et al. (1981); 25, Lampe and McCann (1985); 26, Leung and Foster (1996); 27, Lewis and Elvin-Lewis (1977); 28, Li (2002); 29, Maia et al. (1988); 30, Manchand and Blount (1978); 31, Morton (1981); 32, Nair et al. (1989); 33, Newall et al. (1996); 34, Quissumbing (1951); 35, Raffauf (1970); 36, Raffauf (1996); 37, Rizk (1991); 38, Robineau et al. (1998); 39, Ross (1999); 40, Saavedra et al. (1987); 41, Schultes and Raffauf (1990); 42, Terreaux et al. (1994); 43, Tyler et al. (1988); 44, Wagner and Proksch (1985); 45, Weniger and Robineau (1988); 46, Willaman and Li (1970); 47, Willaman and Schubert (1961).

[k] Voucher number: N, common native, only one voucher collected for all groups; NV, no voucher.

[l] F.G. Coe accession numbers.

[m] Antidote species.

[n] Ancillary species.

[o] Exotic species to eastern Nicaragua.

[p] Food plants used in the diet of snakebite victims during treatment.

4.1. Mestizos

Mestizos are people of mixed Amerindian and European descent. Mestizos presently are the largest ethnic group in eastern Nicaragua (172,000 inhabitants or 60% of the population) (CIDCA, 1982; Hale and Gordon, 1987; Vilas, 1989; Herlihy, 1997; Williamson et al., 1993). The mestizos are relatively newcomers to eastern Nicaragua arriving in the 1860's during the economic boom caused by American investment in the timber industry and banana plantations (Vilas, 1989). The first mestizo settlement in eastern Nicaragua was the town of Rama on the river of the same name; founded by a group of mestizos from the Nicaraguan city of Granada. In a few years, Rama became the center of commerce between the Atlantic and Pacific regions. Another wave of mestizo immigrants arrived during World War II when the gold mines and rubber industry were at their peak. Today, immigration to eastern Nicaragua is the highest it has ever been because of shortage of agricultural land in the Pacific region. In addition, people have moved east to escape from natural disasters such as volcanic eruptions and earthquakes.

4.2. Creoles

"Creole" is the name applied to the descendants of Africans mixed with other ethnic groups. African immigration dates back to the arrival of the buccaneers in the 16th century to eastern Nicaragua (Vilas, 1989). More recently, in the 19th century, several U.S. lumber and banana companies started operations in the region creating a demand for labor that caused the immigration of blacks from the Antilles and the southern United States (Vilas, 1989). Today the majority of Creoles live in Bluefields with smaller populations in Corn Island, Pearl Lagoon, and Puerto Cabezas (Fig. 1). The Creole population is about 26,000 (CIDCA, 1982; Hale and Gordon, 1987; Vilas, 1989; Herlihy, 1997; Williamson et al., 1993).

4.3. Garífuna

The Garífuna are descendants of Red Carib Islanders and African slaves (Davidson, 1979, 1980; Crawford, 1984). Originally from the island of St. Vincent, they came to eastern Nicaragua from Honduras ca.1890 to work in timber extraction and banana plantations (Hale and Gordon, 1987). However, we include the Garífuna among the indigenous groups of eastern Nicaragua because their language and cultural beliefs most closely match those of these groups. Garífuna settlements in eastern Nicaragua are located on the northern and western shores of the Pearl Lagoon (Fig. 1). Presently the Garífuna population is estimated at 1500 inhabitants of which over 40% live in the village of Orinoco (Fig. 1) (Davidson, 1980; CIDCA, 1982; Hale and Gordon, 1987; Vilas, 1989; Herlihy, 1997; Williamson et al., 1993). The Garífuna practice slash-and-burn agriculture on parcels of 1–2 ha in size. Most of their income is derived from agriculture and logging, with seasonal fishing and hunting. They participate in the local market economy, selling some of their goods in regional markets (Coe and Anderson, 1996).

4.4. Miskitu

The Miskitu are the largest indigenous group in eastern Nicaragua with a population currently estimated at 80,000 (CIDCA, 1982; Hale and Gordon, 1987; Vilas, 1989; Herlihy, 1997; Williamson et al., 1993). They live mostly in small villages of 200–300 inhabitants, usually located along rivers and the coast. The largest Miskitu settlement in southeastern Nicaragua is Tasbapauni (Fig. 1) with about 1000 persons (Hale and Gordon, 1987; Nietschmann, 1969, 1972, 1973, 1979).

The Miskitu are fishing and hunting people, but they supplement their subsistence with slash-and-burn agriculture and the gathering of wild resources. Today, many work for wages in the extraction of timber, exploitation of ores, and in the fishing industries owned by outsiders. They participate in the regional market economy; speak "Creole" (English spoken in eastern Nicaragua), Miskitu, and Spanish (Coe and Anderson, 1997).

4.5. Rama

The Rama are descendants of the Chibcha-speaking peoples of northern South America (Colombia and northern Ecuador) that migrated to southeastern Nicaragua (Fig. 1) (CIDCA, 1987). Today, the Rama population consists of 650 individuals with over 80% of the population living on the island of Rama Cay and the remainder in small settlements up rivers and along the coast south of Bluefields (Fig. 1) (CIDCA, 1982; Hale and Gordon, 1987; Vilas, 1989; Herlihy, 1997; Williamson et al., 1993). The Rama are a small group of foraging agriculturists. They practice slash-and-burn agriculture, fish, hunt, and collect food and medicinal plants from the mainland rainforest.

4.6. Sumu

The Sumu population in eastern Nicaragua is dispersed through a region that extends from the Rio Coco in the north to the Rio Grande de Matagalpa and the Prinzapolka River in the south (Fig. 1) (Conzemius, 1932; Hale and Gordon, 1987; Vilas, 1989). Linguistically the Sumu consist of three subgroups: Panamahka, Twahka, and Ulwa (Vilas, 1989). The Panamahka and the Twahka live in RAAN and the Ulwa live in RAAS (Fig. 1). The Sumu population in eastern Nicaragua is estimated at 5000 inhabitants: 73% are Panamahka, 16% are Twahka, and only 11% are Ulwa (CIDCA, 1982; Hale and Gordon, 1987; Vilas, 1989; Herlihy, 1997; Williamson et al., 1993). Like the Rama, the Sumu practice slash-and-burn agriculture, they fish, hunt, and collect food and medicinal plants from the rainforest. The Ulwa are the most highly acculturated of the three Sumu sub-groups because of a long tradition of continuous contact with outsiders—primarily missionaries and traders (Conzemius, 1932; Dozier, 1985; Coe and Anderson, 1999).

5. Results

5.1. The snakes

Though only 7% of snakes worldwide are poisonous, annual morbidity and mortality rates are relatively high (Arena and Drew, 1986; Dreisbach, 1980; Greene, 1997; Habermehl, 1981) with most fatalities occurring in parts of the world where access to antivenins used in Western medicine is not readily available and where poisonous snakes are numerous (Greene, 1997). Such is the case in eastern Nicaragua where 8 of the 14 species of poisonous snakes of Nicaragua occur (Tables 1 and 2). In eastern Nicaragua the most abundant and widely distributed poisonous snakes are the eyelash palm-pitviper (7 *Bothriechis schlegelii* (an arboreal species, that bites mostly on the upper extremities)), the rainforest hog-nosed pitviper (12 *Porthidium nasutum*), the Central American coral snake (4 *Micrurus nigrocinctus*), and the fer-de-lance (8 [the latter three are primarily terrestrial species, that bite on the lower extremities]) (Table 2). The fer-de-lance is by far the most abundant, and thus feared, species of eastern Nicaragua (Campbell and Lamar, 1989). The abundance of fer-de-lance (8) in eastern Nicaragua is promoted by the clearing of the old-growth forest, which creates areas of secondary growth that provide good habitat for this species. The annual mortality from snakebites in eastern Nicaragua is about 25% (i.e., deaths/reported bites) based on data obtained from Moravian Church records in Bluefields and Rama Cay, hospital records and interviews of healers and others.

5.2. Curing practices

The ethnopharmacopoeia of the indigenous groups in eastern Nicaragua is a blend of Amerindian and African ethnomedicinal lore and beliefs (see Coe, 1994; Coe and Anderson, 1996a, 1996b, 1997, 1999). Besides the overall similarity of their ethnopharmacopoeia (e.g., species used, materials used, modes of preparation and administration of remedies), healers share a series of beliefs, practices, and taboos, particularly those associated with snakebites (Coe, 1994; Coe and Anderson, 1996a, 1996b, 1997, 1999; Dennis, 1988; Loveland, 1975). The following are the primary beliefs/practices associated with snakebites. Snakedoctors believe that when a snake bites someone: (a) it must be killed otherwise the victim will die, even if the head of the snake is not used to prepare the remedy; (b) if a person is alone, it is his/her responsibility to kill the snake immediately; (c) the snake must not be killed with a gun, otherwise the victim will die; (d) if the snakebite victim is with someone else, the other person must kill the snake; (e) if the victim were to kill the snake in someone else's presence, the companion will die; (f) snakedoctors are forbidden to kill snakes, such an act meaning they will lose their healing powers (therefore, when a snakedoctor is bitten, another person is summoned to kill the snake and then immediately seeks treatment from another snakedoctor); (g) once treatment begins, the snakedoctor remains with the patient and all other activities (e.g., tending fields, fishing) are suspended for both the snakedoctor and the victim's immediate family; and (h) a snakebite victim should not have contact with a pregnant or menstruating women, otherwise both the victim will die and the fetus will abort or suffer a birth defect.

Other cultural practices that are implemented during snakebite treatment are social isolation and dietary restriction. For example, once the victim is under the care of the snakedoctor, contact with outsiders is not permitted. The snakedoctor, his (they are always men) assistants, and the victim's relatives serve as intermediaries between the patient and outsiders. Practitioners believe that the venom causes heat to accumulate in the victim's body inducing the blood of the victim to boil. Therefore, the cure is aimed at getting rid of the venom and cooling-down the blood. However, during treatment care must be taken not to cool the blood too fast because it could kill the patient, so cold beverages and foods are avoided. In an effort to cool the blood, the victim is not allowed to eat foods considered to be hot such as meat, particularly game (e.g., armadillo, deer, turtle, wild boar) and seafood (e.g., cockles, oysters, certain species of fishes). Also prohibited are salt, sugar, and spicy foods. The patient's diet consisting of foods that are considered cool is usually quite a bland diet. The victim's bland diet consists of roasted foods such as cassava (30), cosco (74 *Musa* spp.), banana (76 *Musa paradisiaca* var. *sapientum*), plantain (75 *Musa paradisiaca*), and catfish (e.g., *Arius* spp. and *Cathorops* spp.). Treatment practices among groups vary slightly based on availability of materials, but are generally quite similar because of the cross-cultural training of healers and the use of basically the same botanical resources (see Coe and Anderson, 1996a, 1997).

Apprenticeship in snakedoctoring is based on several factors. First is the issue of the candidate's kinship and status in the community. In most instances snakedoctoring practices/lore are highly guarded secrets, this secrecy serving to protect or elevate the status of the practitioners. Healers were willing to share their knowledge with one of us (FGC) because he made the intentions of the study clear (science and recording practices for community posterity), and because he did not live in their community and thus did not present a threat to their status. Apprentices and snakedoctors are often snakebite survivors. Apprenticeship usually involves a period of sexual abstinence and multiple forays into the forest to learn how to identify, collect and use medicinal species. The amount of time required for an apprentice to become a snakedoctor is not clear. In general when both live in the same community, the apprentice takes over when his teacher dies or either one moves to another locality. However, ascending to this post must follow many years of training and usually

Table 4
Taxonomic distribution of species used as an antidote or treatment of side effects of snakebite

Taxonomic rank	Number of families	Number of genera	Number of species
Total taxa	42	65	81
Antidotes species			
Pteridophyta	2	2	3
Filicopsida	2	2	3
Magnoliophyta	22	25	28
Magnoliopsida (Dicots)	17	20	22
Liliopsida (Monocots)	5	5	6
Total	24	27	31
Ancillary species			
Pteridophyta	1	1	1
Filicopsida	1	1	1
Magnoliophyta	40	63	75
Magnoliopsida (Dicots)	30	51	60
Liliopsida (Monocots)	10	12	15
Total	41	64	76

also requires the successful treatment of the snake bite of a family member.

5.3. Snakebite remedies

Snakebite remedies in eastern Nicaragua consist of a mixture of both plant and animal materials. Antidotes consist of a mixture of a select group of plants (see Tables 3 and 4) and the pulverized head of a snake. The head of the snake that bit the victim is preferred; however, the head of another snake of the same species can also be used. The snake head and the plant materials are prepared by drying over an open fire, after which they are pulverized and mixed. Once prepared, the remedy is either administered or stored for later use. It could not be determined with certainty how long various dried components can be stored. However, in most instances snakebite remedies are administered upon preparation. Some snakedoctors store small amounts of prepared snakebite remedies. Antidotes are mostly prepared from leaves (54%) in the form of decoctions (69%) and are administered orally (69%) and/or topically (46%). Leaves (versus other plant parts) are preferred probably due to the level of bioactive compounds sequestered therein or because they are readily available.

5.4. Plant types used and their source

Worldwide, snakedoctors use a large number and diverse group of plants in the preparation of snakebite remedies (Coe and Anderson, 1996a, 1997, 1999; Duke, 1985; Houghton and Osibogun, 1993; Mors et al., 1989; Morton, 1981). Similarly, in eastern Nicaragua, snakebite species belong to a broad taxonomic group that includes the ferns and a range of flowering plants (Tables 3 and 4). A total of 81 species of vascular plants from 42 families are used by snakedoctors to treat snake bites (Tables 3 and 4). Most (96%) snakebite species are flowering plants of which 78% are dicots and 18% are monocots (Table 3). Species used in the preparation of snakebite remedies are mostly native (83%) and are gathered from the forest, disturbed sites, agricultural plots, dooryard gardens, or are purchased (Tables 3 and 5). However, most snakebite species are obtained from the second-growth forest (83%) and the majority are herbs (54%) (Tables 3 and 5). Important snakebite species obtained from the second-growth forest include antidote bush (26 *Fevillea cordifolia*), bittawood (64 *Quassia amara*), contrayerba (47 *Dorstenia contrajerva*), curarina (46 *Cissampelos pareira*), guacu (12 *Mikania cordifolia*), and snakeroot (9 *Aristolochia trilobata*) (Table 3). The importance of the second-growth forest of eastern Nicaragua as a source of medicinals for the indigenous people is similar to those of other indigenous groups of the Atlantic lowlands of Central America (Arvigo and Balick, 1993; Chazdon and Coe, 1999; Coe and Anderson, 1996a, 1997, 1999; Gupta et al., 1993; House et al., 1995; Joly et al., 1987). An example of a key species from the lowland swamp forest is spider lily (72 *Hymenocallis littoralis*). Another monocot, high lily (80 *Hedychium coronarium*) is also an important species; this species is an escape from cultivation often found in disturbed sites. Seeds and cuttings of other species such as barsley (40 *Ocimum campechianum*), sorosi (27 *Momordica charantia*), and wild rice (63 *Scoparia dulcis*) are gathered from the wild and transplanted into dooryard gardens for quick access (Coe and Anderson, 1996a, 1997, 1999).

5.5. Snakebite treatment

As in Western medicine, early treatment is critical for the survival and recovery of snakebite victims. Traditional first

Table 5
Snakebite species distribution by habit and source of plant materials[a]

Habit	Source of plant materials					
	Old-growth	Second-growth	Cultivated	Purchased	Total species	Percentage
Herb	1	35	5	3	44	54
Vine	1	23	–	–	24	30
Shrub	–	3	2	–	5	6
Tree	2	6	–	–	8	10
Total	4	67	7	3	81	
Percentage	5	83	8	4		

[a] Included are species used to treat side effects and as food during snakebite treatment.

aid measures for snake bites include ligature, incision, excision, and suction as adjunct therapy to herbal remedies. A common practice is to probe the wound to remove the teeth left by the snake and bleeding is encouraged, sometimes by sucking (with the mouth) provided that there is no wound in the mouth. Plant remedies are administered subsequently either orally or by external application to the wound or both. For example, a common first aid treatment consist of having the victim chew the root of spider lily (72) or high lily (80) or drink a decoction made from snakeroot (9) or guacu (12). These species contain bioactive compounds that are effective antivenims, immunostimulators, antiinflamatories, and sedatives (Table 3).

The symptoms of a snakebite victim are vomiting, bleeding (in the case of snakes with anticlotting venom e.g., *Bothrops* spp.), fever, pain, and inflammation around the wound. The primary objectives of treatment are to: (a) stop the patient from losing blood (sources of bleeding are: gum (gingival), vomit or feces (gastrointestinal), nose (respiratory), urine (urinary tract) and the bite itself), (b) lower the fever, and (c) get rid of the venom. To accomplish these objectives, decoctions are administered to counteract the venom, and poultices are applied to the wound to control infections (over 50% of snakebite deaths are attributed to gangrene (necrosis)). As the treatment starts to take effect, vomiting subsides and body temperature return to normal.

Most snakebites occur on arms or legs with occasional upper body bites, depending on the species of snake. Victims are mostly adult males bitten while performing tasks in the forest or in agricultural plots. In most instances the time needed to cure a snakebite victim is 3–14 days, most commonly 7 days. The recovery rate of snakebite victims over the past 100 years is about 75% based on interviews of snakedoctors, snakebite victims, and their relatives. This suggests that snakebite remedies used by snakedoctors in eastern Nicaragua might well have some efficacy. However, the data are anecdotal, many snakebites are empty bites, and no definitive scientific tests have been performed. Nonetheless, the traditional remedies have a long history, and could be effective in various ways. Thus, we discuss the chemical constituents and potential therapeutic properties of the species used in preparing these remedies. It is up to others to take the next steps to evaluate the efficacy of the compounds or their combinations.

In an effort to increase the odds of surviving snakebites, a common prophylactic practice among the indigenous groups is to often drink a decoction made with a mixture of powdered head of snakes (mostly fer-de-lance [8]) and selected plant materials. According to local beliefs, these decoctions will provide “protection” against the venom if they are taken 7–14 days before engaging in any high-risk activity (e.g., clearing the forest, cutting timber). Species used in the prophylactic drinks are antidote bush (26), bittawood (64), contrayerba (47), curarina (46), guacu (12), and snakeroot (9) (Table 3). It is possible that these potions do provide some protection because they contain bioactive compounds that may act as antivenims and immunostimulators (Table 3). Another practice is to ingest and/or rub certain species of plants with strong odors over the body to repel snakes. Species used as snake repellents include antidote bush (26), culantro (6 *Eryngium foetidium*), garlic (*Allium sativum*), and guinea hen (49 *Petiveria alliacea*). According to local beliefs, snakes do not like strong noxious odors.

6. Bioactivity of snakebite plants

The herbal pharmacopoeia of eastern Nicaragua consists of 435 species of vascular plants (Barrett, 1994; Coe and Anderson, 1996a, 1996b, 1997, 1999; Dennis, 1988; Fey and Sindel, 1993; Loveland, 1975; and MINSA, 1988, 1989) of which some 81 are used in snakebite treatment (Tables 3–5). Snakedoctors use about 31 of the 81 snakebite species in the preparation of antidotes and 76 species for ancillary treatment (e.g., side effects of bites, diet) (see Tables 3 and 4). Most of the species (96%) containing bioactive compounds are angiosperms; 78% of these are dicots (Table 3). Herbs and vines had the largest number of species containing bioactive compounds (Table 3). The bioactivity of these 81 species is largely due to the presence of compounds such as alkaloids, glycosides, phenols, saponins, steroids, tannins, and volatile oils (Table 3). The three most abundant types of bioactive compounds were alkaloids, phenols, and glycosides. Many of the bioactive compounds contained in the 81 snakebite species may not neutralize the venom itself, but serve as analgesics, antiemetic, anti-inflammatory, immunostimulants, local anesthetics, and sedatives (Table 3), making them useful to alleviate some of the ancillary symptoms or responses (Table 4). Nine of the 31 species used in eastern Nicaragua as snakebite antidotes contain steroids such as the sterols, sitosterol and stigmasterol, one species contains the alkaloid aristolochine (aristolochic acid), and another fevillin (Table 3). All of these compounds are potentially effective antidotes because of their constituents (e.g., the venom of the neotropical rattlesnake (9 *Crotalus durissus*) is inhibited by wedelo-lactone, a coumarono-coumarin, from *Eclipta prostrata* (L.) L. (Mors et al., 1989). Some 76 species are used to help alleviate the symptoms of the snakebites (Tables 3 and 4). For example, to reduce pain and fever, snakebite victims are given a decoction made from wild rice (63), curarina (46) guacu (12) (13 *Mikania guaco*), jackass bittas (14 *Neurolaena lobata*), yellow head (10 *Asclepias curassavica*), black joint (51 *Piper amalago*), or cowfoot (52 *Piper auritum*). These species have reputed analgesic and antipyretic properties because they contain bebeerine, berberine, dicentrine, eugenol, methyl salicylate, and salicylic acid (Table 3). As discussed above, one of the main objectives of snakebite treatment is to stop the victim from vomiting (emesis) to allow the remedy to take effect. To control vomiting, the victim is given a decoction made with plants containing bioactive compounds that inhibit muscular contractions (anticholinergic) in the gastrointestinal tract. Species of reputed anticholinergic effects contain tropane alkaloids such as atropine, hyoscyanine, and scopolamine are often found in members of the Solanaceae (Lewis and Elvin-Lewis, 1977; Tyler et al., 1988). In eastern Nicaragua, however, species more commonly used contain luteolin, pyridine, piperidine, quercitin, and quercitrin, compounds with similar effects on the vomiting center. Species that are the sources of antiemetics are barsley (40), bullfoot (52), cordoncillo (51), guacu (12), jack-ass-bittas (14), monkey ladder (31 *Bauhinia guianensis*), and sorosi (27) (Table 3). Other snakebite species used have anti-inflammatory properties because they contain bioactive compounds such as bebeerine, berberine, coumarins, cryptolepine, kaempferol, kaempferol methyl ether, luteolin, phenols, quercitin, saponins, salicylic acid, and tannins (Cambie and Ash, 1994; Duke, 1985; Leung and Foster, 1996; Lewis and Elvin-Lewis, 1977; Tyler et al., 1988). Phenols are well known as anti-inflammatory agents and for their ability to bind with proteins. The complex polyphenols known collectively as tannins are especially well known for their anti-inflammatory and detoxification properties (Foye et al., 1995; Okonogi et al., 1970, 1979; Tyler et al., 1988). Tannin-rich species used in snakebite treatment include red mangrove (54 *Rhizophora mangle*), cashew (5 *Anacardium occidentale*), chaney root (78 *Smilax regelii*, 79 *S. spinosa*), krabu (43 *Byrsonima crassifolia*), and monkey ladder (23) (Table 3). Other species used but with lesser anti-inflammatory effects, because of their known lower tannin content, are broom weed (45 *Sida rhombifolia*), guacu (12), limsi (18 *Bursera simaruba*), curarina (46), trumpet (21 *Cecropia peltata*), and contrayerba (47) (Table 3).

Another important element of snakebite treatment is the stimulation of the immune system, which helps to relieve some of the effects of the bite and promote a more rapid removal of the venom (Houghton and Osibogun, 1993). Snakedoctors in eastern Nicaragua use several species that act as immunostimulators: these contain bioactive compounds such as aristolochic acid in snakeroot (9), β-sitosterol in bitta-wood (64), bebeerine and berberine in curarina (46), sesquiterpene in bullfoot (52), sesquiterpene dilactones in guacu (12), sesquiterpene lactones in jack-ass-bittas (14), and kaismitin (15 *Sphagneticola trilobata*). These species are highly regarded by snakedoctors in eastern Nicaragua as snakebite remedies (Table 3). Aristolochic acid is probably the most effective of the compounds in inhibiting the action of enzymes in snake venom (Viswanatha et al., 1987a, 1987b; Viswanatha and Gowda, 1987). Thus, not surprisingly, species of the genus *Aristolochia* are highly regarded as efficacious in the treatment of snakebites (Table 3). It is important to note that many *Aristolochia* species contain compounds related to aristolochic acid but do not contain aristolochic acid itself; these are called aristolactams (Houghton and Osibogun, 1993). Recent pharmacologic studies on the long-term use of aristolochic acid, showed it to be carcinogenic and mutagenic, causing tumors and kidney and liver damage in laboratory animals and in humans (Chen and Zhu, 1987; Greensfelder, 2000; WHO, 1998). Consequently, it is important to investigate analogs that are chemically related to aristolochic acid some of which may present similar or greater antivenin properties than aristolochic acid with fewer side effects.

The use of local anesthetics is an important component of snakebite treatment in eastern Nicaragua. To provide relief from the pain of the snakebite and any first aid measures given to the victim, snakedoctors apply raw plant extracts or mashed plant parts directly to the wound. These plant materials contain bioactive compounds such as bebeerine, berberine, and eugenol that are reputed anesthetics (Table 3). Remedies used as local anesthetics are prepared from species such as curarina (46), barsley (40), bullfoot (52), and cordoncillo (51) (Table 3). The most widely used local anesthetic is bullfoot (35) (see Coe and Anderson, 1996a, 1996b, 1997, 1999).

Sedatives are also important therapeutic agents in snakebite treatment. They are used to keep snakebite victims calm, reduce fear, and avoid panic. Sedation is important because it helps to immobilize the victim, thus decreasing the systemic absorption of venom especially if the bite occurs on the extremities (hands or feet). Herbal remedies used as sedatives by snakedoctors contain bioactive compounds such as bebeerine, berberine, dicentrine, ergoline, indole alkaloids, methyl tryptamine, phenylethylamine, piperidine, safrole, and tazettine (Table 3). Remedies used as sedatives are prepared from species such as beach morning glory (23 *Ipomoea pes-caprae*), broom weed (45), cowfoot (52), strong back (33 *Desmodium adscendens*), curarina (46), high lily (80), and spider lily (72) (Table 3).

As discussed above, many eastern Nicaraguan snakebite plants reputed to be effective antidotes contain numerous bioactive compounds (Table 3). In addition, many of these species are widely used throughout eastern Nicaragua and other geographical regions for the same purpose (Arvigo and Balick, 1993; Barrett, 1994; Chazdon and Coe, 1999; CNMPT, 1992; Coe, 1994; Coe and Anderson, 1996a, 1996b, 1997, 1999; Dennis, 1988; Fey and Sindel, 1993; Grijalva, 1992; Gupta et al., 1993; Hoogerheide and Saavedra, 1989; House et al., 1995; Joly et al., 1987; MINSA, 1986, 1988, 1989, 1990a, 1990b, 1991; Morales and Uriarte, 1999; Morton, 1981; Ramírez-Goyena, 1909; Salas, 1981) (Table 3). For example, 44% of the 81 species used in eastern Nicaragua are reputed snakebite remedies among a great diversity of people over a broad geographical area (Table 3). The widespread use of these species is another indication of their possible efficacy as snake bite antidotes.

7. Discussion and conclusions

The flora of Nicaragua consists of about 5300 species of spermatophytes or seed plants (Stevens et al., 2001). Based on our studies, and those of others, we estimate that 12% (over 600 species) of seed plants are used medicinally in Nicaragua (Barrett, 1994; Bolaños, 1974; CNMPT, 1992; Coe and Anderson, 1996a, 1997, 1999; Conzemius, 1932; Dennis, 1988; Fey and Sindel, 1993; Grijalva, 1992; MINSA, 1986, 1988, 1989, 1990a, 1990b, 1991; Morales and Uriarte, 1999; Morton, 1981; Ramírez-Goyena, 1909; Salas, 1981). Of the 5300 species of seed plants in Nicaragua, about 54% (2890 species) occur in eastern Nicaragua (Stevens et al., 2001). About 15% (over 435 species) are used medicinally (Barrett, 1994; Coe and Anderson, 1996a, 1997, 1999; Conzemius, 1932; Dennis, 1988; Fey and Sindel, 1993; Loveland, 1975; MINSA, 1986, 1988, 1989, 1991). Similarly, it is estimated that 10–15% of the flora in Mexico and Central America is used for medicinal purposes (Bye, 1993; Bye et al., 1995; Coe and Anderson, 1996a, 1997, 1999; House et al., 1995). Based on data from our studies, the number of medicinals used by each indigenous group is as follows: the Rama use 43% (189 medicinal species) compared to 71% (310 species) by the Miskitu, 52% (229 species) by the Garífuna, and 43% (187 species) by the Sumu/Ulwa (Table 3) (Coe and Anderson, 1996a, 1997, 1999).

As discussed earlier, snakebite species used in eastern Nicaragua contain a wide variety of bioactive compounds such as alkaloids, glycosides, phenols, steroids, tannins, and volatile oils (see Table 3). These compounds have a broad range of therapeutic properties and are widely distributed in plants, particularly among the angiosperms (Table 3). The bioactivity of the angiosperms is well known compared to other plant groups (as documented by Gibbs, 1974; Hegnauer (1962–2001), Raffauf (1996), Willaman and Li (1970); and Willaman and Schubert (1961)). Among the angiosperms, the largest number of species bearing bioactive compounds are dicots (Gibbs, 1974; Hegnauer, 1962–2001; Raffauf, 1996; Willaman and Li, 1970; Willaman and Schubert, 1961). Therefore, it is not surprising that 78% of snakebite species used in eastern Nicaragua that contain bioactive compounds are dicots and only 18% are monocots (Table 3).

The most important medicinal species used in snakebite remedies in eastern Nicaragua and elsewhere consist primarily of a select group of angiosperms (Table 3) (Coe and Anderson, 1996a, 1996b, 1997, 1999; Houghton and Osibogun, 1993). These generally used angiosperm species belong to families and genera with a wide geographical distribution and are known to contain bioactive compounds. As shown in Table 3, some plant families and genera include species with the same reputation in different regions of the world. Although not definitive, as indicated above, this gives some indication of the efficacy of the species in question and increases the likelihood that there are bioactive compounds common to the genus and family. A good example is from the genus *Aristolochia* where the alkaloid aristolochic acid may both inhibit the action of the venom and stimulate the immune system, this combination may provide an explanation of the very wide use of these species as snakebite antidotes.

Recent efforts have been made to elucidate the efficacy of herbal remedies that are used to treat snakebites (Houghton and Osibogun, 1993). A species that is highly regarded as a snakebite antidote throughout its distribution from the southern United States to South America is *Eclipta prostrata* (Asteraceae). In a study by Mors et al. (1989), extracts of *Eclipta prostrata* were effective in neutralizing the venom of neotropical rattlesnake (9). In another study by Melo et al. (1990), extracts of *Eclipta prostata* successfully neutralized the venom of *Bothrops* spp. by eliminating hemorrhage at the site of the bite (venom of *Bothrops* spp. causes hemorrhages by inhibiting clotting). The efficacy of *Eclipta prostrata* extracts as an antivenim is primarily due to the presence of wedelo-lactone and to a lesser extent sitosterol and stigmasterol (Mors et al., 1989). The latter two compounds are also present in many eastern Nicaraguan snakebite species (see Table 3)—perhaps providing some explanation for their efficacy. Unfortunately, this widely distributed (pantropical and subtropical) and reputed snakebite antidote, is not used by snakedoctors in eastern Nicaragua. It is common in western Nicaragua, but it is only sporadically distributed in eastern Nicaragua.

In another study, extracts of *Mandevilla velutina* (Apocynaceae) were effective in decreasing the effects of *Bothrops jararaca* venom (Calixto et al., 1985). The extracts of *Mandevilla velutina* were effective perhaps because they contained sitosterol and stigmasterol, compounds that block the bradykinin receptors, thereby reducing pain (Calixto et al., 1985). Again, though *Mandevilla velutina* is not found in eastern Nicaragua, sitosterol and stigmasterol are present in many eastern Nicaraguan species (see Table 3).

In view of the morbidity and mortality rates of snakebites among people living in areas where poisonous snakes are abundant and access to Western medicine is limited, studies of the efficacy of traditional snakebite remedies are needed. This research could lead to the development of standardized plant extracts that are cheap and accessible, thus suitable for emergency treatment of snakebites. As shown in this study, many eastern Nicaraguan snakebite species contain bioactive compounds that are effective antivenins. However, many of the bioactives may also have other side effects. For example the pantropical genus *Aristolochia* has many species containing aristolochic acid, a reputed antivenin and immunostimulant. Aristolochic acid, though highly regarded as an antivenin, is also very toxic (as discussed above). In view of the toxicity of aristolochic acid, the use of species of *Aristolochia* in herbal remedies is highly questionable. Therefore, pharmacological screening of plant extracts is important because it provides insights to both their therapeutical and toxic properties. This research will contribute to a safer and more effective pharmacopoeia.

In summary, this study clearly indicates that medicinal plants are still an important natural resource to the people of eastern Nicaragua for the treatment of snakebite. The use of particular species does not certify efficacy, but it does provide a highly selected group of species that can be the subject of phytochemical and pharmacological investigations. However, probably even more importantly, it documents the snakebite lore of the indigenous people of eastern Nicaragua for the indigenous people, knowledge that is fast disappearing because of acculturation.

Acknowledgments

This study was partially supported by grants from the National Science Foundation, The University of Connecticut Research Foundation and the Department of Ecology and Evolutionary Biology. We are most grateful to the people of eastern Nicaragua for welcoming one of us (Coe) into their homes and sharing their ethnobotanical knowledge. The field assistance of Basilio Benjamin, Harry Simmons, Jr., and Rodney Martin is appreciated. We thank the staffs of CIDCA (Centro de Investigación y Documentación de la Costa Atlántica) and FADCANIC (Fundación Para la Autonomía y Desarrollo de la Costa Atlántica de Nicaragua). Many specialists provided assistance in the identification of vouchers: William D'Arcy[1] (MO), Daniel Austin (FAU), Rupert Barneby[1] (NY), Gerrit Davidse (MO), James Grimes (NY), Helen Kennedy (UBC), Ronald Leisner (MO), Michael Nee (NY), Amy Pool (MO), Velva Rudd[1] (SFV), George Schatz (MO), Warren D. Stevens (MO), and Charlotte M. Taylor (MO). We thank Virge Kask for help with illustrations.

References

Abbiw, D., 1990. Useful plants of Ghana. Intermidiate Technology, London.

Achenbach, H., Waibel, R., Hefter-Bübl, U., Constenla, M.A., 1993. Constituents of *Fevillea cordifolia*: new norcucurbitacin and cucurbitacin glycosides. Journal of Natural Products Lloydia 56, 1506–1519.

Achenbach, H., Horn, K., Waibel, R., 1995. Constituents of tropical medicinal plants, LXVII: 21-acetylaminofevicordin D-glucoside, an artificial constituents of *Fevillea cordifolia*? On the reactivity of the fevicordines. Archiv der Pharmazie Weinheim 328, 481–485.

Adams, R.N., 1956. Cultural components of Central America. American Anthropologist 58, 881–907.

Ampofo, S.A., Roussis, V., Weimer, D.F., 1987. New prenylated phenolics from *Piper auritum*. Phytochemistry 26, 2367–2370.

Anderson, E.F., 1993. Plants and people of the golden triangle:ethnobotany of the hill tribes of northern Thailand. Dioscorides Press, Portland, Oregon.

Arena, J.M., Drew, R.H., 1986. Poisoning: poisonous plants, reptiles, arthropods, insects, and fish, fifth ed. Charles C. Thomas Publisher, Springfield, Ill.

Arvigo, R., Balick, M., 1993. Rainforest Remedies: one Hundred Healing Herbs of Belize. Lotus Press.

Ayensu, E.S., 1978. Medicinal Plants of the West Africa. Reference Publications, Algonac, MI.

Ayensu, E.S., 1981. Medicinal Plants of the West Indies. Reference Publications, Algonac, MI.

Barrett, B., 1994. Medicinal plants of Nicaragua's Atlantic Coast. Economic Botany 48, 8–20.

Berti, G., Bottari, F., 1968. Constituents of ferns. In: Reinhold, L., Liwschitz, Y. (Eds.), Progress in Phytochemiatry, vol. I. John Wiley and Sons, New York, NY.

Bohlmann, F., 1979. Thymol derivate aus *Neurolaena* Arten. Phytochemistry 18, 489–490.

Bolaños, D., 1974. La Medicina Indígena Pre-Colombina de Nicaragua. Editorial "La Imprenta," Estelí, Nicaragua.

Bolaños, R., 1982. Las serpientes venenosas de Centro América y el problema del ofidismo. Primera Parte. Aspectos zoológicos, epidemiológicos y biomédicos. Revista Costarricense Ciencia Médica 3, 165–184.

Bolaños, R., 1984 Serpientes Venenosas y Ofidismo en Centroamérica. San José, Editorial Universidad de Costa Rica.

Bridson, G.D.R., 1991. Botanico-Periodicum-Huntianum/Suplementum. Allen Press Inc, Lawrence, Kansas.

Authors of Plant Names. Whitstable Litho Ltd, Whitstable, Hent, Great Britain.

Bye, R., 1993. The role of humans in the diversification of plants in Mexico. In: Ramamoorthy, T.P., Bye, R., Lot, A., Fa, J. (Eds.), Biological Diversity of Mexico: Origins and Distribution. Oxford University Press, Inc, New York, NY, pp. 707–731.

Bye, R., Linares, E., Estrada, E., 1995. Biological diversity of medicinal plants in Mexico. In: Arnason, J.A., Mata, R., Romeo, J.T. (Eds.), Phytochemistry of Medicinal Plants. Plenum Press, New York, NY, pp. 65–82.

Cáceres, A., Samayoa, B., 1989. Tamizaje de la Actividad Antibacteriana de las Plantas Usadas en Guatemala para el Tratamiento de Affecciones Gastrointestinales. In: Dirección General de Investigaciones. Universidad San Carlos (DIGI_USAC), Guatemala, 138 pp.

Calixto, J.B., Nicolau, M., Yunes, R.A., 1985. The selective antagonism of bradkyinin action on rat isolated uterus by crude *Mandevilla velutina* extract. British Journal of Pharmacology 85, 729–731.

Cambie, R.C., Ash, J., 1994. Fijian Medicinal Plants. CSIRO (Commonwealth Scientific and Industrial Research Organisation), Australia.

Campbell, J.A., Lamar, W.W., 1989. The Poisonous Reptiles of Latin America. Cornell University Press, Ithaca, NY.

Casagrande, C., Ronchetti, F., Russo, G., 1974. The structure of syringenin. Tetrahedron Letters 30, 3587–3589.

Chazdon, R.L., Coe, F.G., 1999. Ethnobotany of woody species in second-growth, old-growth, and selectively logged forests of northeastern Costa Rica. Conservation Biology 13, 1312–1322.

Chen, Z.L., Zhu, D.Y., 1987. Aristolochia alkaloids. In: Brossi, A., Cordell, G.A. (Eds.), The Alkaloids, vol. 31. Academic Press, New York, pp. 30, 54–62.

Chopra, R.N., 1958. Chopra's Indigenous Drugs of India, second ed. Dhur and Sons, Calcutta, India.

CIDCA (Centro de Investigación y Documentación de la Costa Atlántica), 1982. Demografía Costeña. CIDCA, Managua, Nicaragua.

CIDCA (Centro de Investigación y Documentación de la Costa Atlántica), 1985. Gramática Miskita. Editado e impreso en MIDINRA, Managua, Nicaragua.

CIDCA (Centro de Investigación y Documentación de la Costa Atlántica), 1986. Diccionario Elemental: Miskito-Español/Español-Miskito. Editado e impreso en MIDINRA, Managua, Nicaragua.

CIDCA (Centro de Investigación y Documentación de la Costa Atlántica), 1987. Diccionario Elemental Rama. University of Oregon, Eugene, OR.

CIDCA (Centro de Investigación y Documentación de la Costa Atlántica), 1989. Diccionario Elemental del Ulwa: Sumu Meridional. Centro de Ciencia Cognitiva, MIT, Cambridge, MA.

CNMPT (Centro Nacional de Medicina Popular Tradicional), 1992. ISNAYA: Manual de Plantas Medicinals para el Promotor de Medicina Preventiva y Salud Comunitaria. Impresiones ISNAYA, Centro Nacional de la Medicina Popular Tradicional, Estelí, Nicaragua.

Coe, F.G., 1994. Ethnobotany of the Garífuna of Eastern Nicaragua. Ph.D. dissertation. University of Connecticut, Storrs, CT.

Coe, F.G., Anderson, G.J., 1996a. Ethnobotany of the Garífuna of eastern Nicaragua. Economic Botany 50, 71–107.

Coe, F.G., Anderson, G.J., 1996b. Screening of medicinal plants used by the Garífuna of eastern Nicaragua for bioactive compounds. Journal of Ethnopharmacology 53, 29–50.

Coe, F.G., Anderson, G.J., 1997. Ethnobotany of the Miskitu of eastern Nicaragua. Journal of Ethnobiology 17, 171–214.

Coe, F.G., Anderson, G.J., 1999. Ethnobotany of the Sumu (Ulwa) of southeastern Nicaragua and comparisons with Miskitu plant lore. Economic Botany 53, 363–386.

Conzemius, E., 1928. Ethnographical notes on the Black Carib (Garif). American Anthropologist 30, 183–205.

Conzemius, E., 1932. Ethnographical survey of the Miskito and Sumu Indians of Honduras and Nicaragua. In: Bureau of American Ethnology Bulletin No. 106. U.S. Government Printing Office, Washington, D.C.

Crawford, M., 1984. Current Development in Anthropological Genetics: Black Caribs: A Case Study in Biocultural Adaptation. Plenum Press, New York, NY.

Cronquist, A., 1981. An Integrated System of Classification of Flowering Plants. Columbia University Press, New York, NY.

Davidse, G., Sousa, M., Chater, A.O. (Eds.), 1995. Flora Mesoamericana, vol. 1: Psilotaceae a Salviniaceae. Universidad Nacional Autónoma de México, Cuidad Universitaria, México, DF.

Davidson, W.V., 1979. Dispersal of the Garífuna in the Western Caribbean. Actes du XLII Congrès International des Américanistes, vol. VI:467–474. Société des Américanistes, Musée de l'Homme, Paris, France.

Davidson, W.V., 1980. The Garífuna of Pearl Lagoon: ethnohistory of an Afro-American enclave in Nicaragua. Ethnohistory 27, 31–47.

Dennis, P.A., 1988. Herbal medicine among the Miskito of eastern Nicaragua. Economic Botany 42, 16–28.

Dominguez, X.A., Alcorn, J., 1985. Screening of medicinal plants used by Huastec Mayans of northeastern Mexico. Journal of Ethnopharmacology 13, 139–156.

Dozier, C.L., 1985. Nicaragua's Moskito Shore: The Years of British and American Presence. The University of Alabama Press, Tuscaloosa.

Dreisbach, R.H., 1980. Handbook of Poisoning. Lange Medical, Los Altos, CA.

Duke, J.A., 1985. Handbook of Medicinal Herbs. CRC Press, Inc, Boca Raton, Florida.

Duke, J.A., 1994. Chemical Composition of Belizean Plants Discussed in Rainforest Remedies: One Hundred Healing Herbs of Belize. New York Botanical Garden, Bronx, NY.

Fey, U., Sindel, M., 1993. Plantas Medicinales de los Sumus. Imprenta Universidad Centroamericana, Managua, Nicaragua.

Foye, W.O., Lemke, T.L., Williams, D.A., 1995. Medicinal Chemistry. Williams and Wilkins, Media, PA.

García-Barriga, H., 1992. Flora Medicinal de Colombia. Imprenta Nacional, Bogota, Colombia.

Gibbs, R.D., 1974. Chemotaxonomy of Flowering Plants. McGill-Queen's University Press, Montreal, Canada.

Greene, H.W., 1997. Snakes. University of California Press, Berkeley, CA.

Greensfelder, L., 1946. Herbal product linked to cancer. Science 288.

Griffiths, L.A., 1959. On the distribution of gentisic acid in green plants. Journal of Experimental Botany 10, 437–442.

Grijalva, A., 1992. Plantas Útiles de la Cordillera Los Maribios. Imprenta UCA, Universidad Centroamericana, Managua, Nicaragua.

Gunawardena, D.C., 1975. Medicinal and economic plants of the Museum Zeylanicum of Paul Hermann. Journal of the Sri Lankan Branch of the Royal Asiatic Society 19, 33–48.

Gupta, M.P., Correa, M.D., Solis, P.N., Jones, A., Galdames, C., Guionneau-Sinclair, F., 1993. Medicinal plant inventory of Kuna Indians: part 1. Journal of Ethnopharmacology 40, 77–109.

Habermehl, G.G., 1981. Poisonous Animals and their Toxins. Springer, Berlin.

Hale, C., Gordon, E.T., 1987. Costeño Demography: Historical and Contemporary Demography of Nicaragua's Atlantic Coast. In: Ethnic Groups and the Nation State: the Case of the Atlantic Coast in Nicaragua. CIDCA/University of Stockholm, Stockholm, Sweden.

Hansel, R., Leuschke, A., Gómez-Pompa, A., 1975. Aporphine-type alkaloids from *Piper auritum*. Lloydia 38, 529–530.

Hegnauer, R., Hegnauer, M., 1962–2001. Chemotaxonomie der Pflanzen. Birkhäeuser Verlag, Basel.

Herlihy, P.H., 1997. Central American Indian peoples and lands today. In: Coates, A.G. (Ed.), Central America: a Natural and Cultural History. Yale University Press, New Haven, CT, pp. 215–240.

Hocking, G.M., 1997. Dictionary of Natural Products. Plexus Publishing, Inc, Medford, NJ.

Holm, J.A., 1978. The Creole English of Nicaragua's Atlantic Coast: Its Sociolinguistic History and a Comparative Study of its Lexicon and Syntax. Ph.D. dissertation. University of London, London, Great Britain.

Hoogerheide, J.M., Saavedra, M.A., 1989. Plantas Medicinals mas Frecuentemente Utilizadas en la Region IV. CEDEMETRA, Juigalpa, Nicaragua.

Houghton, P.J., Osibogun, I.M., 1993. Flowering plants used against snakebite. Journal of Ethnopharmacology 39, 1–29.

House, P., Lagos-Witte, S., Ochoa, L., Torres, C., Mejia, T., Rivas, M., 1995. Plantas Medicinals Communes de Honduras. Litografia Lopez, S. de R.L, Tegucigalpa, Honduras.

Incer, J., 1975. Geografía Iilustrada de Nicaragua. Editora y Distribuidora, Nicaragüense, S.A., Managua, Nicaragua.

Johnson, L.B., Reese, P.B., Roberts, E.V., Lam, L.K.P., Vederas, J.C., 1989. Structure elucidation of cordifolin A, a novel cucurbitacin from *Fevillea cordifolia*, using one and two dimensional NMR techniques. Journal of The Chemical Society Perkin Transactions 1, 2111–2116.

Joly, L.G., Guerra, S., Septimo, R., Solis, P.N., Correa, M., Gupta, M., Levy, S., Sandberg, F., 1987. Ethnobotanical inventory of medicinal plants used by the Guaymi Indians in western Panama. Part 1. Journal of Ethnopharmacology 20, 145–171.

Kapoor, L.D., 1990. Handbook of Ayurvedic Medicinal Plants. CRC Press, Inc, Boca Raton, FL.

Kidder, A.V., et al., 1940. South American penetrations in Middle America. In: Hay, C.L. (Ed.), The Maya and Their Neighbors. Appleton-Century Publisher, New York, NY, pp. 441–459.

Kerr, K.M., Mabry, T.J., Yoser, S., 1981. 6-Hyrdoxy and 6-methoxy flavonoids from *Neurolaena lobata* and *N. macrocephala*. Phytochemistry 20, 791–794.

Lampe, K.F., McCann, M.A., 1985. AMA Handbook of Poisonous and Injurious Plants. American Medical Association, Chicago, Illinois.

Leung, A.Y., Foster, S., 1996. Encyclopedia of Common Natural Ingredients. John Wiley & Sons, Inc, NY.

Lewis, W.H., Elvin-Lewis, M.P.F., 1977. Medical Botany: Plants Affecting Man's Health. John Wiley and Sons, New York, NY.

Li, T.S.C., 2002. Chinese and related North America Herbs: Phytopharmacology and Therapeutic Values. CRC Press, Boca Raton, FL.

Loveland, D., 1975. Snakebite cure among the Rama Indians of Nicaragua. In: Haley, H., Grollig, F. (Eds.), Medical Anthropology. Mouton Publishers, The Hague, pp. 81–102.

Maia, J.G.S., Ramos, L.S., Luz, A.I.R., Da Silva, M.L., Zoghbi, M.G.B., 1988. Uncommon Brazilian essential oils of the Labiatae and Compositae. Developments in Food Sciences 18, 177–188.

Manchand, P.S., Blount, J.F., 1978. Stereo structures of neurolenins A and B-novel germacrolides sesquiterpenes from *Neurolaena lobata*. Journal of Organic Chemistry 43, 4352–4354.

Mason, J.A., 1962. The native languages of Middle America. In: Hay, C.L., Linton, R.L., Lothrop, S.K., Shapiro, H.L., Vaillant, G.C. (Eds.), The Maya and their Neighbors. Appleton-Century Company, Inc, New York, NY, pp. 52–87.

Melo, P.A., Mors, W.B., do Nasciamento, M.C., Suarez-Kurtz, G., 1990. Antagonism of the myotoxin and hemorrhagic effects of Crotalidae venoms by *Eclipta prostrata*. European Journal of Pharmacology 183, 572.

MINSA (Ministerio de Salud de Nicaragua), 1986. Primer Informe Sobre 72 Plantas Medicinals en la Region I. Las Segovias. Rescate de la medicina popular. Ministerio de Salud, Nicaragua.

MINSA (Ministerio de Salud de Nicaragua), 1988. La Medicina Popular Tradicional en el Atlántico Sur de Nicaragua. Una Contribucion a la Medicina y Farmacopea Popular en el Caribe. Primer Informe. Ministerio de Salud, Managua, Nicaragua.

MINSA (Ministerio de Salud de Nicaragua), 1989. Plantas Medicinals mas Frecuentemente Utilizadas en la Region V. Imprenta Ruben Dario-Los Pipitos, Managua, Nicaragua.

MINSA (Ministerio de Salud de Nicaragua), 1990a. Plantas Médicas. Centro Nacional de la Medicina Popular Tradicional, Estelí, Nicaragua.

MINSA (Ministerio de Salud de Nicaragua), 1990b. Plantas Tóxicas. Centro Nacional de la Medicina Popular Tradicional, Estelí, Nicaragua.

MINSA (Ministerio de Salud de Nicaragua), 1991. Nuestras Plantas, Nuestra Farmacia. Centro Nacional de la Medicina Popular Tradicional, Estelí, Nicaragua.

Morales, M.E., Uriarte, A.M., 1999. Medicinas del Campo: Plantas Medicinals Usadas en la IV Región de Nicaragua. Imprimatur Artes Gráficas, Managua, Nicaragua, Tomo I.

Mors, W.B., do Nasciamento, M.C., Parente, J.P., da Silva, M.H., Melo, P.A., Suarez-Kurtz, G., 1989. Neutralization lethal and myotic activities of South American rattlesnake venoms by extracts and constituents of the plant *Eclipta prostrata* (Asteraceae). Toxicon 27, 1003–1009.

Morton, J.F., 1981. Atlas of Medicinal Plants of Middle America. Charles C. Thomas Publisher, Springfield, IL.

Nair, M.G., Sommerville, J., Burke, B.A., 1989. Phenyl propenoids from roots of *Piper auritum*. Phytochemistry 28, 654–655.

Newall, C.A., Anderson, L.A., Phillipson, J.D., 1996. Herbal Medicines: A Guide for Health-Care Profesionals. The Pharmaceutical Press, London.

Nietschmann, B.Q., 1969. The distribution of Miskito, Sumu, and Rama Indians, eastern Nicaragua. Bulletin of the International Committee on Urgent Anthropological and Ethnological Research 11, 91–102.

Nietschmann, B.Q., 1972. Hunting and fishing focus among the Miskito Indians, Eastern Nicaragua. Journal of Human Ecology 1, 41–67.

Nietschmann, B.Q., 1973. Between Land and Water: the Subsistence Ecology of the Miskito Indians, Eastern Nicaragua. Seminar Press, New York, NY.

Nietschmann, B.Q., 1979. Caribbean Edge: The Coming of Modern Times to Isolated People and Wildlife. Bobbs-Merrill, New York, NY.

Nuñez, E., 1992. Plantas medicinales de Puerto Rico. Editorial de la Universidad de Puerto Rico, Rio Piedras, Puerto Rico.

Okonogi, T., Hattori, Z., Amagai, E., 1970. Emergency treatment of poisonous snakebite with tannic acid solution. Snake 2, 106–110.

Okonogi, T., Hattori, Z., Ogiso, A., Mitsui, S., 1979. Detoxification by persimmon tannin of snake venoms and bacterial toxins. Toxicon 17, 524–527.

Perry, L.M., Metzger, J., 1980. Medicnal Plants of East and Southeast Asia. MIT Press, Cambridge, MA.

Quissumbing, E., 1951. Medicinal plants of the Phillipines. Manila: Technical Bulletin, vol. 16, Department of Agriculture and Natural Resources, Bureau of Printing.

Raffauf, R.F., 1970. A Handbook of Alkaloids and Alkaloid-Containing Plants. John Wiley and Sons, New York, NY.

Raffauf, R.E., 1996. Plant Alkaloids: A Guide to their Discovery and Distribution. Food Products Press, an imprint of The Haworth Press Inc, Binghamton, NY.

Ramírez-Goyena, M., 1909. Flora de Nicaragua, Conteniendo la Botánica Elemental y Plantas Medicinals. Compañia Tipográfica Internacional, Managua, Nicaragua.

Rizk, A.F.M., 1991. Natural Occurring Pyrrolizidine Alkaloids. CRC Press Inc, Boca Raton, Florida.

Robineau, L.G., Weniger, B., Caraballo, A., Lagos-Witte, S., 1998. Farmacopea Vegetal Caribeña. Editorial Universidad, UNAN, León, Nicaragua.

Ross, I.A., 1999. Medicinal plants of the World: chemical constituents, traditional and modern uses. Humana Press, Totowa, NJ.

Saavedra, D., et al., 1987. Estudio de las plantas medicinals en Nicaragua: Dorstenia drakena L. (contrayerba), un ejemplo. I Seminario Mesoamericano de Etnofarmacologia y III seminario nacional de medicina tradicional. CONAPLAMED. Guatemala.

Salas ,J.B., 1981. Investigacion Sobre Plantas Medicinals en el Departamento de Managua. Instituto Nicaraguense de Recursos Naturales y del Ambiente (IRENA), Managua, Nicaragua.

Schultes, R.E., Raffauf, R.E., 1990. The Healing Forest. Dioscorides Press, Portland, Oregon.

Smutko, G., 1985. La Mosquitia: Historia y Cultura de la Costa Atlántica. Editorial La Ocarina, Managua, Nicaragua.

Stafleu, F.A., Cowan, R.S., 1976–1988. Taxonomic Literature, second ed. W. Junk.

Stafleu, F.A., Mennega, E.A., 1992–2000. Taxonomic Literature, second ed. Koeltz Scientific Books, Supplement I-VII.

Stevens, W.D., Ulloa, C., Pool, A., Montiel, O.M. (Eds.), 2001. Flora de Nicaragua. Missouri Botanical Garden Press, St. Louis, MO, Tomo I–III.

Stone, D., 1962. The Talamanca Tribes of Costa Rica. Peabody Museum Papers, vol. XLIII (2). Cambridge, MA.

Stone, D., 1966. El estado actual de la etnología en la América Central. Actas del XXXVI Congreso International de Ameriscanistas vol. 3, Barcelona, Spain.

Terreaux, C., Maillard, M., Stoeckli-Evans, H., Gupta, M.P., Dowbum, K.R., Quirke, J.M.E., Hostettmann, K., 1994. Structure revision of a furanocoumarin from *Dorstenia contrajerva*. Phytochemistry 39, 645–647.

Tyler, V.E., Brady, L.R., Robbers, J.E., 1988. Pharmacognosy. Lea and Febiger, Philadelphia, PA.

Vilas, C.M., 1989. State, Class, and Ethnicity in Nicaragua: Capitalist Modernization and Revolutionary Change on the Atlantic Coast. Lynne Rienner Publishers, Inc, Boulder, CO.

Viswanatha, B.S., Gowda, T.V., 1987. Interaction of aristolochic acid with *Vipera russelli* phospholipase A_2: its effect on enzymatic and pathological activities. Toxicon 25, 929–937.

Viswanatha, B.S., Kini, R.M., Gowda, T.V., 1987a. Characterization of three edema-inducing phospholipase A_2 enzymes from Habu (*Trimeresurus flavoviridis*) venom and their interaction with the alkaloid aristolochic acid. Toxicon 25, 501–515.

Viswanatha, B.S., Rao, A.G.A., Gowda, T.V., 1987b. Interaction of phospholipase A_2 from *Vipera russelli* venom with aristolochic acid: a circular dichroism study. Toxicon 25, 939–946.

Von Reis, S., 1973. Drugs and Foods From Little-Known Plants. Harvard University Press, Cambridge, MA.

Wagner, H., Proksch, A., 1985. In: Wagner, H., Hikino, H., Farnsworth, N. (Eds.), Economic and medicinal plant research, vol. I. Academic Press, London.

Weniger, B., Robineau, L., 1988. Seminario TRAMIL 3. Elementos para una Farmacopea Caribena. ENDA-Caribe y Ministerio de Salud Pública, Habana, Cuba, p. 318.

WHO (World Health Organization), 1998. Medicinal Plants in the Republic of Korea. WHO Regional Publications Western Pacific Series No. 21, Manila, Philippines.

Willaman, J.J., Schubert, B.G., 1961. Alkaloid-bearing plants and their contained alkaloids. In: Technical Bulletin No. 1234. U.S. Department of Agriculture, Washington, DC.

Willaman, J.J., Li, H.L., 1970. Alkaloid-bearing plants and their contained alkaloids. Lloydia 33, 1–286.

Williamson, D., Avilés, J., McLean, M., 1993. Aspectos generales de las comunidades Sumus de la RAAN. Wani 14, 18–27.