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Review Paper

SOUTH AMERICAN *STRYCHNOS* SPECIES. ETHNOBOTANY (EXCEPT CURARE) AND ALKALOID SCREENING

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Summary

The ethnobotanical uses of South American species of *Strychnos* L. (Loganiaceae) are reviewed, with the exception of their major rôle in the preparation of curare, which will be dealt with in detail elsewhere. Medicinal uses are less common than is the case with the African and Asian species of the genus.

About 140 samples, mostly of leaves, belonging to 53 species, have been screened for alkaloids. As with species from other parts of the world, the stem bark and root bark tend to be a richer source than leaves. Nor-harman is present in extracts from *S. barnhartiana* leaves. Pyridino-indolo-quinolizidinone (angustine-type) bases are also found in several species. The occurrence and pharmacology of the (non-curarizing) alkaloids known to be present in South American *Strychnos* species is reviewed.

1. Introduction

In previous publications the ethnobotany and alkaloid screening of African (Bisset, 1970; Bisset and Phillipson, 1971) and Asian (Bisset, 1974; Bisset and Phillipson, 1976) species of *Strychnos* L. (Loganiaceae) have been explored in some detail. Some years ago, the late Boris Krukoff made available to the senior author about 120 samples of leaf fragments of American species of the genus; and since then further samples have been acquired from a number of other sources.

In 1935 Krukoff "was given a commission from the Merck Research Labo-

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ratories to investigate and obtain authentic materials of plants entering into the curare of the Tecuna Indians of Brazil" (Krukoff, 1965). This led to several botanical expeditions to Brazil in which he concentrated on collecting species of *Strychnos* and other genera utilized in preparing the dart poison. Extensive collections were also made by Adolpho Ducke and Rafael Fróes of the Instituto Agronômico do Norte in Belém.

These various activities culminated in the preparation of a monograph on the taxonomy of the American species of *Strychnos* (Krukoff and Monachino, 1942), which was followed by 21 supplements (Krukoff, 1982). Prominent in all Krukoff's papers on the genus throughout this long period of time, and there were also many that dealt with more limited aspects, was an abiding interest in the utilization of its species as ingredients of curare. The remaining ethnobotany of the Central and South American species of *Strychnos* is quite limited, as will be appreciated from the summary below of the information that has come to the authors' attention.

Previous experience in the screening of *Strychnos* species for alkaloids has shown that by and large the leaves are a rather poor source of alkaloids, and this has also proved to be the case with the American members of the genus. Table 1 gives details of the samples investigated; but only those that yielded alkaloid tests with responses + or better are dealt with in greater detail in the text. The species are listed in alphabetical order and, where appropriate, the principal alkaloids known to be present are mentioned briefly. The pharmacology of the alkaloids is also considered in order to determine whether their presence may lie at the basis of the reported medicinal uses.

2. Ethnobotany

This section deals with the ethnobotany of Central and South American *Strychnos* species, with the exception of their reported use as dart- and arrow-poison ingredients, which will be considered in detail elsewhere. The species are arranged in alphabetical order. Brief botanical details of those species whose chemistry has been studied but for which no uses have been encountered are also included.

S. acuta Progel (58)[a] Breviflorae/Breviflorae[b]

An erect shrub occurring in the south-eastern part of Brazil (Krukoff, 1972, 1979).

[a]The numbers after the species names are those assigned in the arrangement of species adopted by Krukoff in his later publications (1969, 1972, etc.); their inclusion is intended to facilitate reference to his work.

[b]Krukoff and Barneby (1969) grouped the American species of the section Breviflorae into two subsections whose members differ primarily in the nature of the seed testa: crustaceous in subsection Breviflorae and soft fibrous in subsection Eriospermae.

TABLE 1

SAMPLE DATA AND RESULTS OF THE ALKALOID SCREENING PROCEDURE FOR CENTRAL AND SOUTH AMERICAN *STRYCHNOS* SPECIES.

Species and collectors' numbers	Locality	Date: month/ year	Plant part[a]	% Extract	Alkaloid test	Remarks
S. amazonica (27)[b]						
N.T. Silva 3429	Brazil: Pará	5/68	l	0.62	Tr	
Krukoff 6825a	Brazil: Amazonas	9–10/34	l	0.78	+	
Krukoff 7987	Brazil: Amazonas	8–9/36	l	0.72	Tr	
Krukoff 9061	Brazil: Amazonas	10–12/36	l	0.28	Tr	
Ducke 2007	Brazil: Amazonas	10/46	l	0.6	Tr	
Ducke 2096	Brazil: Amazonas	9/47	l	1.07	Tr	
Murça Pires 31	Brazil: Amazonas		l	0.78	Tr	
S. bahiensis (15)						
Romeu P. Belem s.n.	Brazil: Bahia	6/65	l	0.31	Tr	
S. barnhartiana (8)						
Krukoff 9074	Brazil: Amazonas	10–12/36	l	1.28	+ +	Norharman present
Krukoff 9103	Brazil: Amazonas	10–12/36	l	2.75	+ + +	Norharman present
Krukoff 9103 (ex U)	Brazil: Amazonas	10–12/36	l	0.5	+ +	Norharman present
S. bicolor (42)						
Mendes Magalhães 9777	Brazil: Minas Gerais		l	3.14	Tr	
Maguire et al. 57122	Brazil: Federal District		l	1.12	Tr	
S. brachiata (10)						
Krukoff 10864	Bolivia: La Paz	9/39	l	3.2	–	

TABLE 1 (*Continued*)

Species and collectors' numbers	Locality	Date: month/ year	Plant part[a]	% Extract	Alkaloid test	Remarks
S. brachistantha (63)						
W.A. Schipp 285	Belize		l	1.04	Tr	
S. brasiliensis (59)						
Hatschbach 8332	Brazil: São Paulo	10/61	l	5.9	+	
Hatschbach 16086	Brazil: São Paulo		l	0.97	+	
S. bredemeyeri (35)						
A.C. Smith 2278	Guyana: Essequibo	10/37	l	1.22	Tr +	Angustine-type bases
Yakki (Ex H. King) no. 2302[c]	Guyana		b	0.82	+ + + +	Angustine-type bases
S. castelnaeana (50)						
Krukoff 7537	Brazil: Amazonas	11/35	l	0.57	Tr	
Krukoff 8679	Brazil: Amazonas	10—12/36	l	0.14	Tr	
S. chlorantha (1)						
Humberto Barquero M. 102	Costa Rica: Alajuela	—/69	l	1.03	Tr	
S. cogens (47)						
Ducke 1986	Brazil: Amazonas	9/46	l	0.72	Tr	
Fróes 23190	Brazil: Roraima		l	1.15	Tr	
A.C. Smith 2272	Guyana: Essequibo	5/37	l	0.48	Tr	
A.C. Smith 3598	Guyana: Essequibo	3—4/38	l	1.73	Tr	
S. croatii (32a)						
Correa and Dressler 1660	Panama: Panamá	—/69	l	1.27	Tr	

S. darienensis (38)						
Foster 1465	Panama: Canal Zone	12/69	l	1.25	+	
Fróes 20956	Brazil: Amazonas	5/45	l	0.78	Tr	
Fróes 20956 (ex U)	Brazil: Amazonas	5/45	l	1.17	Tr	
S. diaboli (21)						
T.G. Tutin 458	Guyana: Essequibo	8/33	l	0.31	Tr	Angustine-type bases
S. divaricans (14)						
Boswezen (Stahel) s.n.	Surinam	2/42	l	2.57	Tr	
Ducke 2309	Brazil: Pernambuco	10/49 – 1/53	l	0.47	Tr	
S. erichsonii (32)						
F. Cardona 1228	Venezuela: Bolívar		l	0.49	+ + +	Angustine-like bases
Boswezen 358	Surinam	7/15	l	1.5	+ + +	Angustine-like bases
Boswezen 5568	Surinam	11/26	l	0.52	+ + +	
Krukoff 9092	Brazil: Amazonas	10 – 12/36	l	0.38	+ + + +	Harman-type base?
						Angustine-type bases
Romeu P. Belem 3460	Brazil: Bahia	5/68	osb	0.16	+ +	Angustine-type bases
			isb	0.27	+ +	Angustine-type bases
			orb	14.4	+ + + +	Angustine-type bases
			irb	3.07	+ + + +	Angustine-type bases
S. eugeniifolia (16)						
Fróes 26730	Brazil: Amapá		l	0.78	+	
S. fendleri (53)						
Ll. Williams 13254	Venezuela: Bolívar		l	1.2	Tr	
S. froesii (29)						
Fróes 32154	Brazil: Pará	10/55	l	0.85	Tr	Angustine-type bases
Fróes 32169	Brazil: Pará		l	0.81	+	Angustine-type bases
Ducke 2320	Brazil: Amazonas	– /53	l	1.09	Tr	Angustine-type bases

TABLE 1 (*Continued*)

Species and collectors' numbers	Locality	Date: month/ year	Plant part[a]	% Extract	Alkaloid test	Remarks
S. fulvotomentosa (57)						
L.E. de Mello Filho 1047	Brazil: Rio de Janeiro		l	0.64	Tr	
L.E. de Mello Filho 1154	Brazil: Rio de Janeiro		l	0.47	Tr	
Ducke 2283	Brazil: Rio de Janeiro	2/51	l	0.84	+	
S. gardneri (33)						
Prance and Silva 58252	Brazil: Goias		l	0.52	Tr	
S. glabra (40)						
Forest Dept. 2467	Guyana		b	1.51	+ + + +	Angustine-type bases
Forest Dept. 2620	Guyana		b	0.41	+ + + +	
Krukoff 9062	Brazil: Amazonas	10–12/36	l	1.2	Tr	
Krukoff 9098	Brazil: Amazonas	10–12/36	l	0.36	–	
Fróes 21528	Brazil: Amazonas	–/45	l	0.77	Tr	
S. grayi (60)						
Leon 662	Cuba: Santa Clara		l	3.2	+ + + +	Angustine-type bases
S. quianensis (39)						
C.A. Cid 8482	Brazil: Amazonas	11/86	l	0.23	+	
C.A. Cid 7462	Brazil: Amazonas	9/86	l	0.02	–	
			sb	0.93	Tr	
Geijskes 1032	Surinam: Coppename	11/43	l	3.34	Tr	
N.T. Silva 3156	Brazil: Amazonas	–/70	l	0.91	Tr	
Fróes 20628	Brazil: Amazonas		l	0.53	–	
Fróes 20904	Brazil: Amazonas	5/45	l	0.91	–	
Prance et al. 3164	Brazil: Amazonas	11/66	l	0.77	–	

S. hirsuta (46)						
L.E. de Mello Filho 567	Brazil: Amazonas		l	1.4	–	
Krukoff 6060	Brazil: Amazonas	9/34	l	1.3	Tr	
S. javariensis (22)						
Krukoff 7656	Brazil: Amazonas	11–12/35	l	1.52	Tr	Angustine-type bases
S. jobertiana (24)						
Krukoff 9063	Brazil: Amazonas	10–12/36	l	1.51	Tr	Angustine-type bases
Prance et al. 12690	Brazil: Acre	–/71	st	0.44	Tr	Angustine-type bases
S. macrophylla (7)						
Ducke 1975	Brazil: Amazonas	9/47	l	0.38	Tr	
C.A. Cid 8138	Brazil: Amazonas	9/86	l	0.1	+	
S. mattogrossensis (65)						
Fróes 23942	Brazil: Amazonas	1/49	l	2.95	+ + + +	
D. Coelho s.n.	Brazil: Amazonas	6/87	l	0.19	Tr +	
S. medeola (18)						
Van Donselaar 1080	Surinam: Kabelstation	3/64	l	1.23	Tr	
S. melinoniana (48)						
Sandwith 377	Guyana: Essequibo	10/29	l	0.75	Tr	
Forest Dept. 2279	Guyana: Essequibo		b	0.55	+ + +	Angustine-type bases
Forest Dept. 2286	Guyana: Essequibo		b	1.5	+ +	Angustine-type bases
Forest Dept. 2303	Guyana: Essequibo		b	0.58	+ + +	Angustine-type bases
Boswezen 718	Surinam: Brownsberg	9/15	l	0.29	Tr	
Geijskes 1040	Surinam: Coppename	11/43	l	0.34	Tr +	
S. mitscherlichii var. *mitscherlichii* (36a)						
Steyermark et al. 93032	Venezuela: Bolívar		l	0.24	Tr	
Forest Dept. 2621	Guyana: Berbice		b	0.30	+ + + +	

TABLE 1 (*Continued*)

Species and collectors' numbers	Locality	Date: month/ year	Plant part[a]	% Extract	Alkaloid test	Remarks
Van Donselaar 2353	Surinam: Brownsweg	4/65	l	0.27	–	
Tutin 109 var. *pubescentior* (36b)	Guyana: Essequibo	5/33	l	0.93	–	
Krukoff 8749	Brazil: Amazonas	10–12/36	l	0.52	Tr	
S. nigricans (64)						
L.E. de Mello Filho 2682	Brazil: Rio de Janeiro	2/69	l	1.13	Tr	Angustine-type bases
S. oiapocensis (52)						
Irwin et al. 54542	Surinam	8/63	l	0.3	Tr	Angustine-type bases
S. panamensis (12)						
J. Dwyer 1640	Panama: Veraguas	8/61	l	3.7	Tr	
Gentry 5750	Panama: Panamá	8/72	fr	2.1	+	
			l	0.89	Tr +	
			st	0.27	Tr +	
A. Guillen 201	Guatemala: Suchitepéquez		l	1.3	Tr +	
			sb	0.53	Tr	
N. Bristan 1029	Panama: Darien		l	0.14	Tr	
S. panurensis (43)						
Correa and Dressler 725	Panama: Panamá	–/68	s	2.26	+	
			l	1.03	Tr	
Foster and Kennedy 1824	Panama	9/70	l	1.27	Tr	
Prance et al. 13131	Brazil: Acre	–/71	r	0.52	+ +	
Krukoff 5756	Brazil: Acre	9/33	l	0.19	Tr	
S. parviflora (49)						
Krukoff 7798	Brazil: Amazonas	–/36	l	0.57	Tr	Angustine-type bases
Krukoff 9079	Brazil: Amazonas	10–12/36	l	0.91	Tr	Angustine-type bases

S. parvifolia (56)						
Krukoff 1825	Brazil: Maranhão	8/32	l	1.25	+ +	Angustine, etc. (angustine, co-TLC)
L.E. de Mello Filho OVB-42	Brazil: Espírito Santo		l	0.77	+ +	
S. peckii (31)						
Fróes 21185	Brazil: Amazonas		l	0.41	Tr +	Angustine, etc.
Fróes 21256	Brazil: Amazonas		l	0.4	Tr	Angustine (co-TLC)
Fróes 22270	Brazil: Amazonas	4/47	l	0.41	Tr	
S. poeppigii (69)						
Krukoff 8593	Brazil: Amazonas	9—10/36	l	2.05	—	
Fróes 20806	Brazil: Amazonas	4/45	l	0.93	Tr	
S. pseudo-quina (25)						
(Guibourt)	Brazil: Rio de Janeiro	19th Cent.	b	1.73	+ + + +	
Irwin and Soderstrom 5451	Brazil: Minas Gerais	8/64	l	0.7	Tr	
S. ramentifera (2)						
Ducke 1658	Brazil: Pará		l	0.5	Tr	
Kramer and Hekking 2696	Surinam	1/61	l	0.18	Tr	
S. rondeletioides (6)						
Fróes 22247	Brazil: Amazonas	4/47	l	0.73	Tr	
S. sandwithiana (23)						
Fróes 20799	Brazil: Amazonas	4/45	l	1.03	Tr	
S. schultesiana (67)						
Breteler 4940	Venezuela: Mérida	3/66	l	1.3	Tr	
S. solerederi (37)						
Krukoff 7800	Brazil: Amazonas		l	0.61	—	
Krukoff 9067	Brazil: Amazonas	10—12/36	l	1.58	—	
Krukoff 9068	Brazil: Amazonas	10—12/36	l	1.09	—	

TABLE 1 (*Continued*)

Species and collectors' numbers	Locality	Date: month/ year	Plant part[a]	% Extract	Alkaloid test	Remarks
S. solimoesana (28)						
Krukoff 9066 (type colln)	Brazil: Amazonas	10—12/36	l	0.8	+ + + +	Angustine-type bases
Strychnos sp.						
Correa et al. 4586	Panama: Panamá	12/84	l	1.4	Tr +	
			tw	0.8	Tr	
			st	3.1	Tr	
S. subcordata (41)						
Prance et al. 11578	Brazil: Amazonas	—/71	st/r	0.27	Tr +	
Fróes 20798	Brazil: Amazonas		l	0.64	Tr	
Krukoff 7957	Brazil: Amazonas	8—9/36	l	1.8	Tr	
S. tabascana (13)						
Humberto Banquero M. 105	Costa Rica: Alajuela	—/69	l	0.69	Tr	
S. tarapotensis (70)						
Krukoff 5671	Brazil: Acre	8/33	l	0.27	Tr	
S. tomentosa (20)						
Krukoff 9117	Brazil: Amazonas		l	0.21	Tr	
Lindeman s.n.	Surinam: nr. Republiek	—/53	l	1.24	Tr +	
S. toxifera (19)						
Foster 2153	Panama: Canal Zone	—/71	l	0.97	Tr +	
Rich. Schomburgk s.n.	Guyana: Essequibo	1844	s	0.6	+	
Forest Dept. 5958	Guyana: Essequibo	12/48	l	0.93	+ +	
Krukoff 5081	Brazil: Amazonas	7/33	l	0.83	Tr	

9.B.3. (ex Pharm. Soc. Mus.)	Guyana		b	1.13	+ + +
37.F.6 (ex Pharm. Soc. Mus.)	Guyana	< 1878	b	0.57	+ +
S. trinervis (11)					
Nadeaud s.n.	Brazil: Rio de Janeiro or Santa Catarina	1862	l	0.59	Tr +
Regnell III 182[x]	Brazil: Minas Gerais	1866/7	l	0.95	Tr

[a]Abbreviations: b = bark; fr = fruit; irb = inner root bark; isb = inner stem bark; l = leaves; orb = outer root bark; osb = outer stem bark; r = root; s = seed; sb = stem bark; st = stem; tw = twigs.

[b]The number of the species used in Krukoff's later publications.

[c]A Rich. Schomburgk collection of 1842 from the Sururu River, Essequibo, Guyana, with the vernacular name *yakki*, has been identified as *S. bredemeyeri* (Krukoff and Monachino, 1942: 291, under the synonym *S. pedunculata*).

Os frutos carnosos, moles, contêm polpa doce e comestível . . . (Ducke, 1951).
In São Paulo (and other southern states) the somewhat bitter infusion of the leaves, *cha paulista*, is used in folk medicine as a tonic (Ducke, 1955; Pimenta, 1959).

S. alvimiana Krukoff et Barneby (66a) Breviflorae/Eriospermae
A liane known only from a few collections made in the coastal region of the Brazilian State of Bahia (Krukoff, 1979).

S. amazonica Krukoff (27) Strychnos
A climber up to about 30 m long found especially in Amazonian Brazil, as well as in Peru and Colombia (Krukoff, 1972, 1979).

S. atlantica Krukoff et Barneby (54) Breviflorae/Breviflorae
A small shrub or tree up to 4 m in height and 5 cm in diameter known from the coastal forests of the Brazilian States of Bahia and Espírito Santo (Krukoff, 1972, 1979).

S. bahiensis Krukoff et Barneby (15) Strychnos
Bush rope so far known only from the coastal forests of the Brazilian State of Bahia (Krukoff, 1972, 1979).

S. barnhartiana Krukoff (8) Strychnos
A large bush rope occurring throughout the lower and upper parts of the Amazon basin (Krukoff, 1972, 1979).

S. bicolor Progel (42) Rouhamon
A modest-sized bush rope found in the sub-tropical highlands of Central Brazil (Krukoff, 1972, 1979).

**S. brachiata* Ruiz et Pavón (10)[a] Strychnos
A bush rope whose distribution ranges from sub-Andean Peru to the Brazilian States of Amapá and Pará; it is also in Bolivia, Colombia, and Venezuela (Krukoff, 1972, 1979).

The pulp of the fruit is reported to be edible and to have a pleasant odour and taste (Brazil: *G.A. Black 48—2948*)[b] (Krukoff and Barneby, 1969; Krukoff, 1972).
Deer are said to like eating the plant (Peru: Flückiger, 1892).

S. brachistantha Standley (63) Breviflorae/Eriospermae
An erect shrub that becomes scandent above. It is found in the forests of Central America and in Mexico (Krukoff, 1972, 1979).

The yellowish fruit pulp has a pleasant odour and taste (Krukoff and Barneby, 1969; Krukoff, 1972).

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[a]Species with an asterisk in front of their name are reported to have been used as an ingredient in curare. This aspect of the ethnobotany of South American *Strychnos* species will be discussed in detail elsewhere.
[b]The collector(s) and collection number are cited (in italics) for annotations that have been taken from herbarium sheets, including those for which no literature references are available.

S. brasiliensis (Sprengel) C. Martius (59) Breviflorae/Breviflorae
S. macroacanthos Prog.

A spiny shrub occurring in south-eastern Brazil, Paraguay, northern Argentina, and Bolivia in sub-tropical and highland regions (Krukoff, 1972, 1979).

Salta-martinho (Pio Corrêa, 1978b).
Quássia-mineira. Under the incorrect name *S. monacanthos* Prog. Pio Corrêa (1978a) indicates that in Minas Gerais and São Paulo the root is used as a bitter and stomachic.
A petite dose, employé comme amer, tonique et fébrifuge (Baillon, 1884).

**S. bredemeyeri* (Schultes) Sprague et Sandw. (35) Strychnos

A modest-sized liane found on Trinidad and in Venezuela, Guyana, and Brazil (Roraima) (Krukoff, 1972, 1979).

**S. castelnaeana* Wedd. (50) Breviflorea/Breviflorae

A bush rope up to about 13 m long, usually found in high forest in the western part of the Amazon basin in the region where Peru and Brazil (and Colombia) meet (Krukoff, 1972, 1979).

Very bitter bark (Brazil: *Fróes 23771*).[a]

S. chlorantha Progel (1) Strychnos

An enormous liane, up to 35 m in length and with a diameter of 12 cm, found in the highlands of Central America (Krukoff, 1972, 1979).

**S. cogens* Benth. (47) Rouhamon

A widely distributed large bush rope known from Venezuela, the Guianas, throughout a large part of Amazonian Brazil, and Bolivia (Krukoff, 1972, 1979, 1980).

. . . fruto es amarillo en su madurez . . . y es combile; la corteza es delgada . . . y tiene un sabor amarga (Venezuela: *Llewelwyn Williams 13378*).
Orange sweet pulpy fruit (Brazil: *Fróes 23190*).

S. croatii Krukoff et Barneby (32a) Strychnos

A recently described species known from Panama and north-eastern Colombia (Krukoff, 1979).

**S. darienensis* Seemann (38) Strychnos

A moderately large liane with a wide distribution in Central and South America (Krukoff, 1972, 1979, 1980).

Frutos alarañjados, suculentes (Brazil: *Fróes 29437*).
Frutos amarelos, suculentes (Brazil: *Fróes 29462*).

S. diaboli Sandw. (21) Strychnos

A huge liane, up to 15 cm in diameter, known from Guyana and nearby Venezuela and Brazil (Krukoff, 1972, 1979).

S. divaricans Ducke (14) Strychnos

A moderately large liane occurring in French Guiana and nearby parts of Brazil (Krukoff, 1972, 1979).

S. duckei Krukoff et Monach. (45) Rouhamon

A huge liane occurring in the forests of the Brazilian State of Amazonas near Tabatinga on the frontier with Colombia (Krukoff, 1972, 1979).

. . . floribus albis Jasminum fortiter redolentibus (*Ducke 1771* (Krukoff and Monachino, 1942)).

**S. erichsonii* Rich. Schomb. (32) Strychnos

A very large liane growing in the Amazon forests of Venezuela, the Guianas, Brazil, Colombia, and Peru (Krukoff, 1972, 1979, cf. 1982).

Flowers white, very fragrant. Fruit yellow, edible (Colombia: *Schultes and Cabrera 16883*).
Bark bitter (Guyana: *Altson 457*).
Koni-koni-bita or *doberdoewa:* Gebruikt voor buikziekte en ook volgens bewering: liaan in spiritus getrokken, dan ervan nu en dan een bitters voor een oude heer dewelke nog wil vrijen maar niet kan!! (Suriname: *BW s.n. 4/11/14*).
Resembles *urali*, used as fish poison (Surinam: *A.M.W. Mennega 467*).
Geschikt voor opwekking der geslachtsdrift — Indiaansche vrouwen gebruiken een decoctie met succes tegen bloeding na menstruatie en abortus (Surinam: *BW 5568*).
Buikziekte, venerische ziekte, aphrodisiacum (Surinam: *BW 358*).
Cette liane de forêt est un aphrodisiaque réputé chez les Saramaka du Surinam. Les guérisseurs distinguent plusieurs variétés: dobouldoi rouge, dobouldoi blanc, correspondant peut-être à des variétés de cette espèce de *Strychnos*. La plus réputée est *le Dobouldoi route*. L'écorce de cette liane est mise à macérer dans le rhum (tafia). Cette drogue est considérée comme plus efficace que le "bois bandé" (*Ptychopetalum olacoides*, Olacacées), les deux drogues intervenant souvent dans la même préparation (French Guiana: Grenand et al., 1987).

S. eugeniifolia Monach. (16) Strychnos

A large liane known from only a few collections made in Surinam, French Guiana, and nearby Brazil (Territory of Amapá) (Krukoff, 1972, 1979).

S. fendleri Sprague et Sandw. (53) Breviflorae/Breviflorae

A small tree with spines found in the drier tropics of Venuezela (Krukoff, 1972, 1979).

Cuspa gris. Bark bitter (Venezuela: *F.D. Smith 115*).
Cruceto. La corteza hervida se usa contra el paludismo (Venezuela: *L. Aristeguieta 5821*) (Von Reis and Lipp, 1982).
Quina. Used as a source of quinine in this area supposedly and is type known to conocedores (Venezuela: *Steyermark 55559*) (Von Reis and Lipp, 1982).
Cruceta real. Used for treating malaria — said to be stimulating when having malaria and cures it according to natives (Venezuela: *Steyermark 57680*) (Von Reis and Lipp, 1982).

S. froesii Ducke (29) Strychnos

A huge climber known from a small number of collections made in Amazonian Brazil (Krukoff, 1972, 1979).

S. fulvotomentosa Gilg (57) Breviflorae/Breviflorae

A climber found in the forests of south-eastern Brazil (Krukoff, 1972, 1979).

S. gardneri A.DC. (33) Strychnos

A moderate-sized liane occurring in the dry virgin and secondary forests of central and eastern Brazil (Krukoff, 1972, 1979).

Quina-de-cipó. Used in small doses as a febrifuge, but dangerous because it is toxic (Pio Corrêa, 1978a).
"Cipó do jacú". Cipó com frutos; êstes quando maduros são procurados pelos jacús [= guans] (Brazil: *T.N. Guedes 626*).

**S. glabra* Sagot ex Progel (40) Rouhamon

A huge liane distributed from Venezuela to the Brazilian Territory of Amapá and in the northern half of Amazonian Brazil (Krukoff, 1972, 1979).

Frutos . . . com polpe brancacenta dôce (Brazil: *Ducke 1925*).

S. grayi Griseb. (60) Breviflorae/Breviflorae

A very spiny shrub with slender branches known from Cuba and the Dominican Republic (Hispaniola) (Krukoff, 1972, 1979).

**S. gubleri* G. Planchon

There are indications, to be detailed elsewhere, suggesting that the material so named (Gubler, 1879; Planchon 1880) and that collected and called *S. gubleri* by Gaillard de Tiremois (in: Labesse, 1905) may in fact belong to *S. panurensis*. However, in the absence of definitive evidence, the following note on the edibility of its fruits is placed here under the name originally used.

. . . fruits ressemblant à de petites oranges. . . l'intérieur est rempli d'une pulpe blanche se teintant légèrement en rose, sous l'action de l'air... Cette pulpe est très agréable... sa saveur douce, sucrée, légèrement parfumée, rappelant celle de l'Anona squamosa [sweet sop; sugar or custard apple] (Venezuela: Gaillard de Tiremois, in: Labesse, 1905).

**S. guianensis* (Aublet) C. Martius (39) Rouhamon

Together with *S. brasiliensis*, the most frequently collected American species of the genus. It is a moderate-sized liane that occurs widely throughout the middle and upper Rio Orinoco basin and the entire Amazon basin (Krukoff, 1972, 1979, 1980).

Curare de pescado . . . fruits orange. Said to be eaten by fish but seeds considered to be very poisonous (Colombia: *Zarucchi 2474*).
. . . fruto maduro com pericarpo amarelo, sementes envolvidas por uma mucilagem adocicada, comestível (Brazil: *P. Cavalcante 2529*).
Wũrarimõ. Tiriyó Indians apply the plant in anaemia and general debility; the young shoots are grated and an infusion of them is taken by mouth and used externally in baths (Cavalcante and Frikel, 1973).

The bark of this species, collected by one of us (L.A.) at the Rio Taruma (Manaus in April 1988, was found to be very bitter.

S. hirsuta Spruce ex Benth. (46) Rouhamon

An erect shrub without spines that becomes scandent above; it occurs in Amazonian Brazil (Krukoff, 1972, 1979).

**S. javariensis* Krukoff (22) Strychnos

Yet another large bush rope; it is found in high forest in the western part of the Amazon basin (Krukoff, 1972, 1979).

Tikuna Indians chew bark to relieve toothache (Colombia: *Schultes and Black 8401*) (Schultes, 1983).

**S. jobertiana* Baillon (24) Strychnos

A liane often up to 40 m long and 8 cm in diameter; it occurs chiefly in high forest in the Amazon basin (Venezuela, Colombia, Ecuador, Peru, French Guiana, and Brazil) (Krukoff, 1972, 1979).

Fruit eaten by monkeys (Brazil: *Bassett Maguire et al. 47100*).
Leaves mashed, placed in rum, and made into a perfume, with intent of attracting opposite sex (Venezuela: *Steyermark 57910*) (Von Reis and Lipp, 1982).

S. macrophylla Barb. Rodr. (7) Strychnos

A moderate-sized liane occurring in the Brazilian State of Amazonas round Manaus and to the north-east (Krukoff, 1972, 1979).

. . . flores amarelas . . . aromaticas (Brazil: *Cid et al. 1986*).

S. malacosperma Ducke et Fróes (68) Breviflorae/Eriospermae

A small vine with both spines and tendrils known only from a few collections in one locality in the Brazilian State of Pará (Krukoff, 1972, 1979).

The pulp of the mature fruits is edible with a pleasant odour and taste (Brazil: *Fróes 30600* (Krukoff and Barneby, 1969; Krukoff, 1972)).

S. mattogrossensis S. Moore (65) Breviflorae/Eriospermae

A species with both tendrils and spines, occurring in a variety of habitats in Colombia, Venezuela, Peru, and Brazil. It may become a huge liane when old (Krukoff, 1972, 1979).

S. medeola Sagot ex Progel (18) Strychnos

A small liane found in Surinam, French Guiana, and Brazil in the lower reaches of the Amazon basin (Amapá, Pará, and the eastern tip of Amazonas) (Krukoff, 1972, 1979).

**S. melinoniana* Baillon (48) Rouhamon

A huge liane found in the three Guianas and the Brazilian States of Amapá and Pará (Krukoff, 1972, 1979).

Dobroedoewa. De bast van de wortels staat bij de bosbewoners bekend als een krachtig aphrodisiacum (Ostendorf, 1962).
Doberdoea: aphrodisiacum! (Suriname: *BW (Stahel) s.n.*).

**S. mitscherlichii* Rich. Schomb. var. *mitscherlichii* (36a) Strychnos

A very large liane, often more than 30 m long and 10 cm in diameter. It is found in a wide variety of habitats, but mostly in high forest in Venezuela, Colombia, Ecuador, Guyana, Surinam, Brazil, Peru, and Bolivia; its distribution covers a large part of the Amazon basin (Krukoff, 1972, 1979).

. . . fruit orangish-yellow; orange pulp around seeds edible, sweet; seeds said to be poisonous; . . . (Colombia: *Zarucchi 1231*).
Veneno caimán (Colombia: *Idrobo 2628*).
A reputed aphrodisiac (Guyana: *Altson 441*).

**S. mitscherlichii* var. *pubescentior* Sandw. (36b) Strychnos

A much smaller liane than var. *mitscherlichii*, occurring in Amazonian Brazil and Colombia mainly along creeks, small rivers, and lakes (Krukoff, 1972, 1979).

S. mitscherlichii var. *amapensis* Krukoff et Barneby (36c) Strychnos

A moderate-sized liane occurring chiefly along the shores of creeks and small rivers in the eastern part of Amazonian Brazil (Krukoff, 1972, 1979).

S. nigricans Progel (64) Breviflorae/Eriospermae

A scandent shrub bearing spines and tendrils found in different habitats in south-eastern Brazil (Krukoff, 1972, 1979).

The flowers are distinguished from those of all other Brazilian *Strychnos* species by their foetid smell (Ducke, 1955).

S. oiapocensis Fróes (52) Breviflorae/Breviflorae

An erect shrub devoid of spines and tendrils but becoming scandent above. It occurs in high and secondary forest in Surinam, French Guiana, and Brazil (Amapá) (Krukoff, 1972, 1979).

Les Palikur préparent l'écorce des racines en décoction qu'ils boivent comme aphrodisiaque (French Guiana: Grenand et al., 1987).

S. pachycarpa Ducke (61) Breviflorae/Eriospermae

A huge bush rope found in high forest in the vicinity of Manaus in the Brazilian State of Amazonas (Krukoff, 1972, 1979); more recently, reported from Colombia (Krukoff, 1980). It is known from fewer than 10 collections.

It is doubtful whether jungle animals eat the sweet, white pulp; but apparently they take the shattered fruits after they have fallen (Brazil: Ducke, 1945).
In the fruit there is an almost white, juicy sweet pulp (Brazil: Ducke, 1955).
The fruit pulp is edible with a pleasant odour and taste (Krukoff, 1972).

S. panamensis Seemann (12) Strychnos

A liane found in a variety of habitats from the Pacific coast of tropical Mexico through Central America to Colombia and Venezuela (Krukoff, 1972, 1979).

"Maximino Martinez (Plantas utiles de la Flora Mexicana, p. 509. 1959) gives the following interesting information on the plant: '. . . *S. panamensis*, de Sinaloa y Nayarit a Guerrero y Oaxaca, que se usa como *S. tabascana*, para matar perros y coyotes, molendo la semilla y mezclándola con carne.' The pulp of fruits is sweet, with pleasant odor and it is often consumed by men and animals." (Krukoff, 1965).

". . . pulp edible with pleasant odor and taste (Several annotated specimens at The New York Botanical Garden and some several hundred fruits collected recently from several bush-ropes growing on the shore of a small river, a few kilometers from railroad station Nahualate (alt 500 ft), Suchitepequez, Guatemala . . . " (Krukoff and Barneby, 1969)).

Guaco; remedy for pains (Honduras: *P.C. Standley 52619*) (Von Reis Altschul, 1973).

Fruta de murcielago (Panama: *Standley 28086*).

Naranjuelo. Seeds eaten by monkeys (Venezuela: *J. de Bruijn 1424*) (Von Reis and Lipp, 1982).

**S. panurensis* Sprague et Sandw. (43) Rouhamon

A modest-sized bush rope that begins life as a scandent shrub; it is known from Panama, Colombia, Venezuela, French Guiana, Peru, and Brazil (Amapá, Amazonas, Acre) (Krukoff, 1972, 1979).

Cf. *S. gubleri.*

S. parviflora Spruce ex Benth. (49) Breviflorae/Breviflorae

A large liane found in Amazonian Brazil and in Peru (Krukoff, 1972, 1979).

Children call the sweet pulp of the fruits *pitomba*, because of a slight resemblance to the ordinary *pitomba* which is derived from *Talisia esculenta* Radlk. (Sapindaceae) (Ducke, 1945).

Fructi maturi flavi, pulpa dulci eduli, cortex ramorum redolet caryophyllum . . . (Brazil: *Ducke s.n.* (Krukoff and Monachino, 1942; cf. Ducke, 1950, 1955)).

The bark (even of branchlets after many years in the herbarium) has a strong odor of cinnamon (Keukoff, 1972).

S. parvifolia A.DC. (56) Breviflorae/Breviflorae

A highly variable species with a very extensive distribution in Brazil south of the Amazon (Pará to Paraíba to São Paulo), Paraguay, and Bolivia. It grows both as an erect shrub that becomes scandent above and as a small liane (Krukoff, 1972, 1979).

In the sterile state the species is distinguished by the smell of cloves from its branches which persists for many years when dry in the herbarium (Ducke, 1955).

Fruto maduro, côr de laranja, polpa branca, doce, comestível (Brazil: *Ducke 2117*).

**S. peckii* Robinson (31) Strychnos

A gigantic liane that in high forest may be as much as 60 m long with a diameter of 20 cm; along creek and small rivers it is usually much smaller. It is widely distributed in Central America (on the Atlantic coast) and in South America as far as Brazil (Rondônia and Mato Grosso) (Krukoff, 1972, 1979, 1980).

Cacheta vieja. Fruit brown, said to be edible (Venezuela: *Bassett Maguire et al. [41941] 25—26/10/37*).

The fruit is reported to be eaten by Carib and Maya Indians in Belize (British Honduras: *W.A. Schipp 121*) (Krukoff and Monachino, 1942; Von Reis Altschul, 1973).

S. poeppigii Progel (69) Breviflorae/Eriospermae

This is a scandent shrub provided with both spines and tendrils known from Peru (basins of the Ríos Marañón, Ucayali, Huallaga, and Nanay) and Brazil (basin of the Amazon) (Krukoff, 1972, 1979).

**S. progeliana* Krukoff et Barneby (51) Breviflorae/Breviflorae

Probably a shrub armed with spines and becoming scandent above. It is known only from the type collection made by C.F.P. von Martius in the early 19th century in the basin of the Rio Japurá, Amazonian Brazil (Krukoff, 1972, 1979).

S. pseudo-quina A.St.Hil. (25) Strychnos

A fairly common tree about 5 m tall occurring particularly in Central Brazil (Minas and Goiás) and adjacent Paraguay (Krukoff, 1972, 1979).

. . . per magnam imperii regionem (in prov. Minarum, S. Pauli, Goyazana) ob corticis virtutem antipyreticam decantatur. . . . Baccae hujus arbores absque noxa comedi possunt. Cortex aut in pulverem redactus aut infuso aut extracto aquoso propinatur; egregiae amaritudinis itemque mitis, ita ut ejus usus tam in febribus intermittentibus, quam in hepatis, lienis et glandularum mesaraicarum infarctu digestionis debilitate rel. indicetur (Brazil) (Martius, 1868).

The bark known as *quina do campo* has been confused with *copalchi bark*, possibly derived from a *Coutarea* species (Rubiaceae) (Guibourt, 1869; cf. Rosenthal, 1862).

Quina do cerrado or *quina do campo* has been successfully used in the treatment of fevers (Hoehne, 1939).

Falsa quina, quina branca, quina cruzeiro, quina dachapada, quina de mandá, quina de mato grosso, quina de periquito, quina do cerrado, quina do campo. During the first quarter of the 19th century, the bark was one of the most commonly used remedies in Brazil, since at that time it had the reputation of being a valuable tonic and febrifuge and useful against diseases of the liver, spleen, and stomach. Medicinal preparations were called *agua da Inglaterra* or *agua inglêsa.* The fruit is edible and quite harmless (Pio Corrêa, 1952).

Frutos muito procurados pelas caças [game (birds?)] (Brazil: *J.M. Pires and G.A. Black 2475, 2523/4/5*).

. . . casca grossa suberosa e caraquenta, tida como infalivel na cura de malaria — raspa-se a parte suberosa morta e aproveita-se a parte viva como chá, muito amarga. Frutos muito procurados pelas caças (Brazil: *J.M. Pires and G.A. Black 2475*).

Arvores . . . venenosas, perfunadas, recebem abelhas. Frutos alimentos para pássaro (Brazil: *E.P. Heringer 12858*).

Pulp of fruit sweet (Krukoff, 1972).

The thick outer bark is not favoured as a source of cork (Rizzini and Mors, 1976).

"Tônico e febrifugo, É considerada um grande remédio para combater, as febres palustres, sendo também um bom reconstituinte." Also known as *quino de velozo* (Cruz, 1982).

S. ramentifera Ducke (2) Strychnos

A very large bush rope in the high forest of Amazonian Brazil and also found in savanna country in Surinam (Krukoff, 1972, 1979).

S. recognita Krukoff et Barneby (57a) Breviflorae/Breviflorae

A moderate-sized liane or small tree with spines and tendrils, probably endemic in the coastal region of the Brazilian States of Bahia and Espírito Santo (Krukoff, 1979).

S. romeu-belenii Krukoff et Barneby (5) Strychnos

A liane up to 30 m long probably endemic in the coastal forests of the Brazilian State of Bahia and possibly also Espírito Santo (Krukoff, 1972, 1979).

**S. rondeletioides* Spruce ex Benth. (6) Strychnos

A huge liane up to about 50 m long and 13 cm in diameter, but much smaller near the shores of creeks, widely distributed in the Amazon basin (Venezuela, Colombia, Brazil, Peru, and Bolivia) and in the Orinoco basin (Venezuela) (Krukoff, 1972, 1979).

Fruits yellow, with sweet pulp. Often eaten by the local Indians (Colombia: *P. Allen 3341*).
Uiarirana. Unlike other *Strychnos* species, this one is said not to be poisonous (Pio Corrêa, 1978b).
Bark & mashed leaves mixed with water and strewn in water by Paumarís Indians as a fish poison (Brazil: *Prance et al. P21206/7, P3403* (Krukoff: 1977; Von Reis and Lipp, 1982)).

S. rubiginosa A.DC. (55) Breviflorae/Breviflorae

An erect shrub provided with spines and tendrils and becoming scandent above; it is known from eastern Brazil (Krukoff, 1972, 1979).

In Pernambuco concoctions called *capitão* are made and used for a very wide variety of complaints (Ducke, 1951; Pimenta, 1959).

**S. sandwithiana* Krukoff et Barneby (23) Strychnos

A very large bush rope occurring in high primary and secondary forest in Amazonian Colombia, Brazil, and Peru (Krukoff, 1972, 1979).

S. schultesiana Krukoff (67) Breviflorae/Eriospermae

A small liane with both spines and tendrils, up to 10 m long, found in Amazonian Brazil and Venezuela (Krukoff, 1972, 1979).

"The pulp of the fruits is edible; a paper (C. Seelkopf (1964): Ensayos sobre una fruta hasta ahora desconocida, *Rev. Fac. Farm. (Univ. de Los Andes, Venezuela)* 5, 41—45) was recently published on their chemical composition and conservation. At Universidad de Los Andes the plant is being cultivated experimentally to determine its possible value and economic feasibility as a commercial crop." (Krukoff and Barneby, 1969; Krukoff, 1972).
Extracts from the twigs (but not the leaves) have some antimicrobial activity against *Staphylococcus aureus* but not against *Bacillus subtilis* and *Pseudomonas aeruginosa* (Verpoorte et al., 1983).

Strychnos species

In addition to being sources of poison, the plants also provide construction materials for the Makiritare and Kariña Indians of Venezuela (de Civrieux, 1973).

S. solerederi Gilg (37) Strychnos

A huge liane occurring in high forest throughout the Amazon basin (Colombia, French Guiana, and especially Brazil) (Krukoff, 1972, 1979).

S. solimoesana Krukoff (28) Strychnos

A large liane of the high forest in parts of Amazonian Colombia, Brazil, and Peru (Krukoff, 1972, 1979, 1982).

S. subcordata Spruce ex Benth. (41) Rouhamon
S. ericetina Barb. Rodr.

A small woody climber usually found in old clearings and high forest in Colombia, Amazonian Brazil, and also Peru (Krukoff, 1972, 1979).

Anzol de lontra, uirary tarerem, yuakáka-pindá. The root bark of *S. ericetina* is bitter and contains a reddish dyeing substance (Pio Corrêa, 1926).

S. tabascana Sprague et Sandw. (13) Strychnos

A liane of tropical lowland forests in Central America (Mexico to Costa Rica) (Krukoff, 1972, 1979).

Cabalonga de Tabasco, mata-perros, or *veneno del Diablo:* "Esta planta que se viene usando en Tabasco hace algún tiempo para matar perros . . . , se usa también para destruir otra clase de animales que perjudican los intereses de los hacendados. Para verificar la intoxicación, machacan las semillas y mezclan después el polvo grueso obtenido con un pedazo de carne, que se hace en seguido comer á los animales que se trata de envenenar: al cabo de media hora, cuando mucho, comienza á obrar el principio activo de la Cabalonga de Tabasco, y pocos momentos después mueren los susodichos animales en medio de terribles convulsiones tetánicas . . ." (Mexico: Tabasco (Graham y Ponz, 1894; cited from: Krukoff, 1965)). Cf. *S. panamensis.*

Extracts of the leaves have no antimicrobial activity against *Bacillus subtilis, Staphylococcus aureus,* or *Pseudomonas aeruginosa* (Verpoorte et al., 1983).

S. tarapotensis Sprague et Sandw. (70) Breviflorae/Eriospermae

A small spiny shrub occurring in high forests of the Orinoco (Venezuela) and Amazon (Peru, Brazil) (Krukoff, 1972, 1979, 1980).

Mature fruit brown, edible (Peru: *Ynes Mexia 6180*).

Tsacik. Comestible su fruta (Peru: *E. Ancuash 718*) (Von Reis and Lipp, 1982).

S. tomentosa Benth. (20) Strychnos

A huge bush rope up to 12 cm in diameter ranging from the three Guianas to Amazonian Brazil (Amapá, Amazonas, Maranhão) (Krukoff, 1972, 1979, 1980).

Alcoholic extracts are prepared from the bark (*murapé branco*) (Brazil: Pernambuco) (Pimenta, 1959).

"Os frutos maduros permanecem no pedúnculo, sendo aí mesmo furados por animais que comem a polpa." (Ducke, 1950; Krukoff and Barneby, 1969).

Volgens Indianen worden tegen rheumatiek dampbaden met aftreksel van den stengel genomen (Suriname: *BW 3659*).

*S. *toxifera* Rob. Schomb. ex Lindley (19) Strychnos

A liane of modest size ranging from Panama through Colombia, Venezuela, and the three Guianas to Ecuador and parts of Amazonian Brazil (Krukoff, 1972, 1979).

The bark applied externally is considered to be a good remedy for foul ulcers (festering sores) and, if it "could be safely managed", when taken internally "it would no doubt become a valuable remedial agent in the treatment of convulsive and spasmodic disorders" (Hancock: in Lindley, 1838).
Rather scarce here because leaf-cutter ants partial to plant and kill off the young ones (Ecuador: *C.C. Fuller 64*).
Apparently used by Indian medicine men (Brazil, Maranhão: Krukoff and Monachino, 1947).

S. trinervis (Vell.) C. Martius (11) Strychnos
S. triplinervia C. Martius

A large bush rope confined to the eastern states of Brazil and ranging from Paraíba to Santa Catarina; it also occurs in eastern Bolivia (Krukoff, 1972, 1979).

Febrifuga (Brazil: *Barb. Rodrigues 12*).
Cruzeiro, quina cruzeiro, cipó cruzeiro. Employed as a bitter, tonic, stomachic and febrifuge, especially in folk medicine (de Mello Filho, 1954).
Quina-cruzeiro, quina-de-remíjio, quina-brasileira, and in Paraíba *quina-do-campo.* Bark used as a substitute for *quina* as a tonic and bitter but not as a febrifuge (Brazil: Pio Corrêa, 1978a).

3. The alkaloids

The available samples were screened for the presence of alkaloids by the method outlined below. The species and collectors' numbers, a brief indication of the localities and approximate dates of collection (as far as known), and the plant part are listed in Table 1, together with the results of the screening.

3.1. Screening

3.1.1. Extraction. A standard weight of 300 mg of powdered (ground) sample was macerated with 0.75 ml conc. ammonium hydroxide solution and 5 ml ethyl acetate for a period of 3 days. After filtration, the marc was washed with a few more milliliters of ethyl acetate. The ethyl acetate extract was extracted with 2 × 5 ml 2% sulphuric acid, which, after basification with conc. ammonium hydroxide solution, was shaken out with 2 × 5 ml chloroform. Filtration of the combined chloroform extracts over anhydrous sodium sulphate and subsequent removal of the chloroform yielded a residue that was taken up in 0.5 ml chloroform.

The chloroform solution (10 μl) applied to a filter paper to give a spot 8 mm in diameter and 5, 10, 20 and 30-μl spots of a reference solution of strychnine containing 0.3 mg/ml applied in the same way were compared after visualization with Dragendorff reagent.

The intensity of the spots visualized with the reagent was graded as follows:

–	No reaction
tr	Very weak reaction
tr +	Definitely positive, but less intense than the 5 μl reference spot
+	Intensity of colour corresponding to that of the 5-μl reference spot, and equivalent to the presence of about 0.025% alkaloid in the original plant material
+ +	Intensity of colour about equal to that of the 10-μl reference spot, and equivalent to the presence of about 0.05% alkaloid in the original plant material
+ + +	Intensity of colour about equal to that of the 20-μl reference spot, and equivalent to the presence of about 0.1% alkaloid in the original plant material
+ + + +	Intensity of colour at least equal to that of the 30-μl reference spot, and equivalent to the presence of at least 0.15% alkaloid in the original plant material

3.1.2. Thin-layer chromatography. The chloroform extract (40 μl) was then chromatographed after being applied to the plate as a band 1 cm in length. In some cases, when only traces of alkaloids were present, the entire residue from the chloroform extract was dissolved in a single drop of solvent and chromatographed.

The marc from the ethyl acetate maceration was allowed to stand in 5 ml ethanol for 3 days, after which the solvent was filtered, taken to dryness, and redissolved in 0.5 ml ethanol. Usually, a volume of between 20 and 30 μl could be applied to the TLC plate, again as a band 1 cm in length, but not more if much pigment was present.

The following four systems were used:

(a) Ethyl acetate/propan-2-ol/conc. ammonium hydroxide solution (90:8:2), with as reference substances:

	R_f
Akagerine*	0.43
Strychnine	0.05
Strychnopentamine	0.55
Alcuronium	0.00
Diaboline	0.03
Harman	0.68
Harmaline	0.15
Harmine	0.59
Harmol	0.47

(b) Ethyl acetate/propan-2-ol/4.25% ammonium hydroxide solution (60:25:15), with as reference substances:

	R_f
Akagerine	0.90
Strychnopentamine	0.99
Strychnine*	0.40
Diaboline	0.26
Alcuronium	0.0
Toxiferine	0.0

(c) Methanol/0.2 M ammonium nitrate solution (3:2), with as reference substances:

	R_f
Alcuronium	0.41
Strychnine*	0.34
Toxiferine	0.37

(d) Methanol/1 M ammonium nitrate solution/2 M ammonium hydroxide solution (7:2:1), with as reference substances:

	R_f
Strychnine*	0.23
Alcuronium	0.39
Toxiferine	0.27

The chromatograms were assessed by examination under both long- and short-wave UV light, followed by spraying with Dragendorff reagent.

3.2. Occurrence

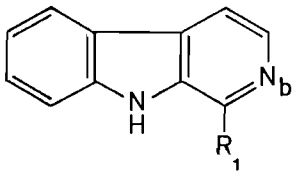
S. alvimiana Krukoff et Barneby — Breviflorae/Eriospermae

Among the tertiary alkaloids isolated from the bark of this species are tabascanine (**15a**) and its acetyl derivative, as well as the related compounds strychnobrasiline (**17b**) and alvimine (**15c**), and strychnosiline (**15b**) (Marini-Bettolo et al., 1982).

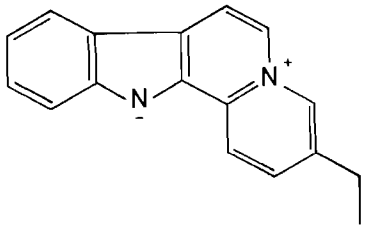
S. amazonica Krukoff — Strychnos

Of the seven leaf samples screened for alkaloids, only one (*Krukoff 6825a*)

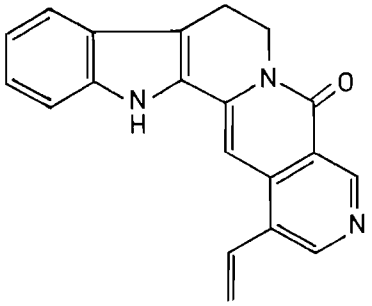
*The substance on which the R_f calculations were based.



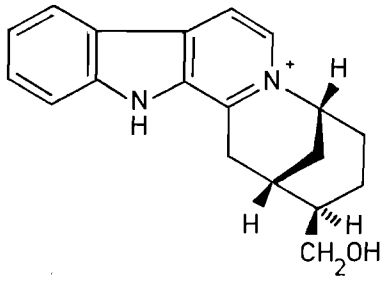
1a Nor-harman R_1 = H
1b Harman R_1 = Me
1c Melinonine F R_1 = Me, N_b^+–Me



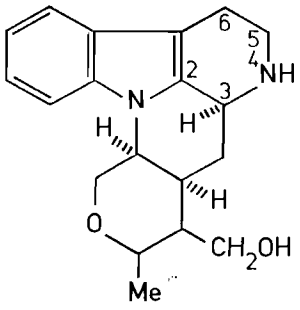
2 Melinonine G (Flavopereirine)



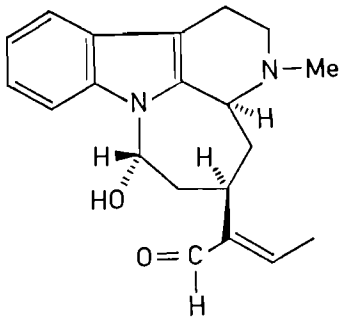
3 Angustine



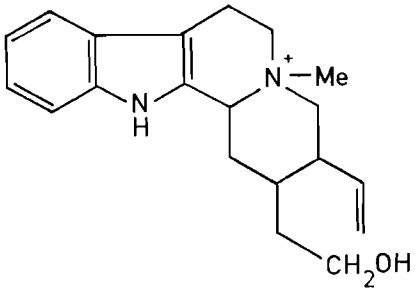
4 Melinonine E



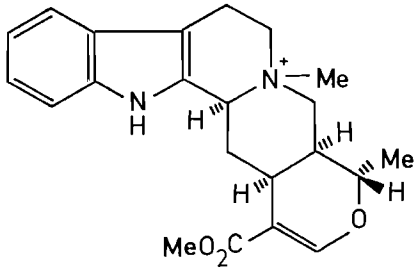
5a Tetradehydrostrychnohirsutine $\Delta^{3,5}$
5b Strychnohirsutine



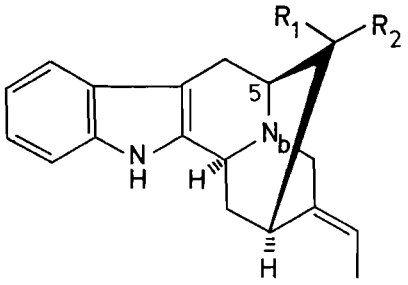
6 Akagerine



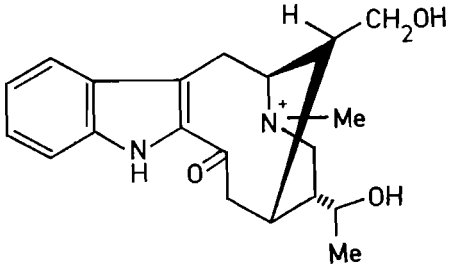
7 Melinonine B



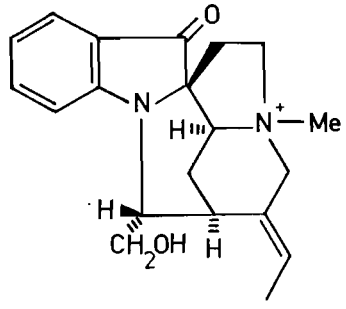
8 Melinonine A



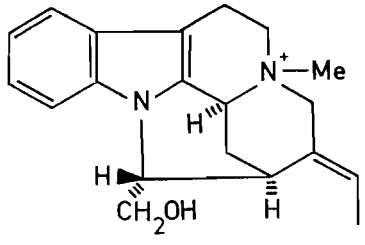
9a Mascusine A $R_1 = CH_2OH$, $R_2 = CO_2Me$, N_b^+-Me
9b Nor-macusine B $R_1 = H$, $R_2 = CH_2OH$
9c Macusine B $R_1 = H$, $R_2 = CH_2OH$, N_b^+-Me



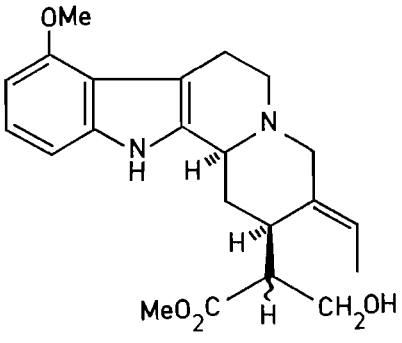
10 Erichsonine



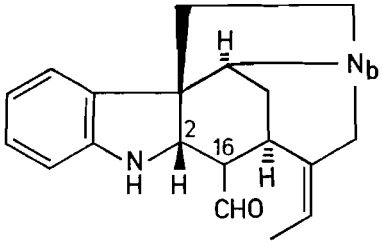
11 Fluorocurine



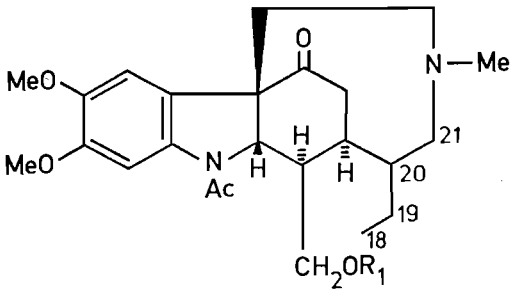
12 Mavacurine



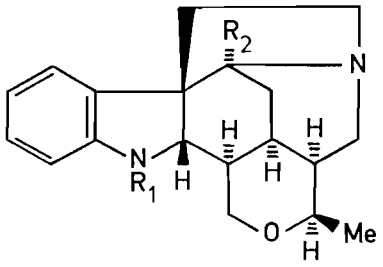
13 Strychnorubigine



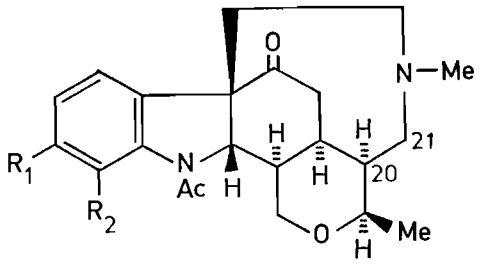
14a Nor-dihydrofluorocurarine
(18-Dehydroxy-Wieland-Gumlich aldehyde)
14b Fluorocurarine N_b^+-Me, $\Delta^{2(16)}$



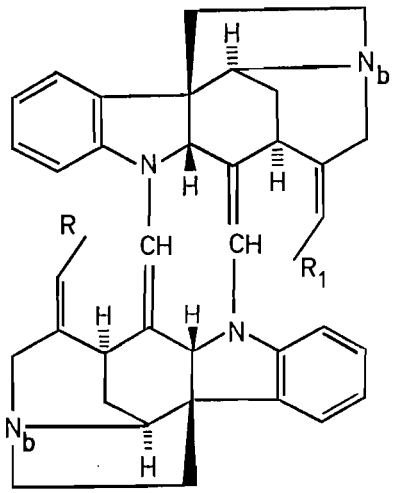
15a Tabascanine R_1 = H, Δ^{19}
15b Strychnosiline R_1 = Ac, $\Delta^{18,20}$
15c Alvimine R_1 = Ac, 19-OH, Δ^{20}



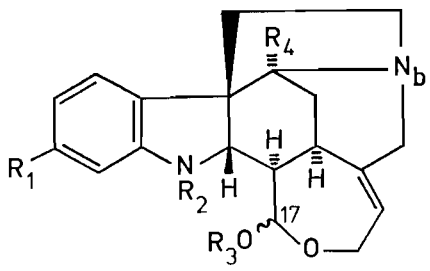
16a Spermostrychnine R_1 = Ac, R_2 = H
16b Strychnosplendine R_1 = H, R_2 = OH
16c N_a-Acetyl-*O*-methylstrychnosplendine
R_1 = Ac, R_2 = OMe



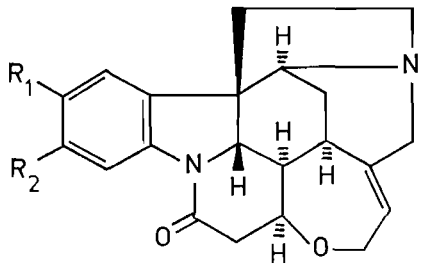
17a Strychnofendlerine R_1 = R_2 = H
17b Strychnobrasiline R_1 = R_2 = H, $\Delta^{20(21)}$
17c 11-Methoxystrychnobrasiline
R_1 = OMe, R_2 = H, $\Delta^{20(21)}$
17d 12-Hydroxy-11-methoxystrychnobrasiline
R_1 = OMe, R_2 = OH, $\Delta^{20(21)}$



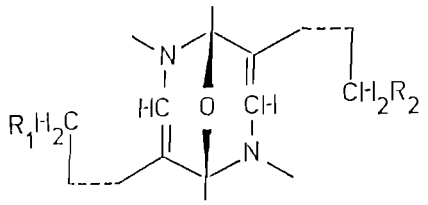
18 Bis-tertiary bases
Bis-quaternary bases 2 × N_b^+—Me
See also Scheme 1



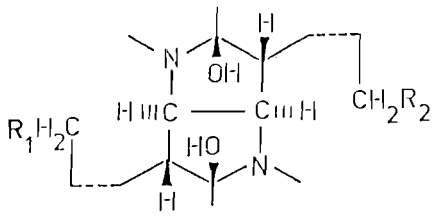
19a Wieland-Gumlich aldehyde (= N_a-Deacetyldiaboline = Caracurine VII)
R_1 = R_2 = R_3 = R_4 = H, 17-OH β
19b Diaboline R_1 = R_3 = R_4 = H, R_2 = Ac, 17-OH β
19c Jobertine (N_a-Acetyldiaboline A) R_1 = R_4 = H, R_2 = R_3 = Ac, 17-OAc α
19d Henningsamine (N_a-Acetyldiaboline B) R_1 = R_4 = H, R_2 = R_3 = Ac, 17-OAc β
19e 3-Hydroxydiaboline R_1 = R_3 = H, R_2 = Ac, R_4 = OH



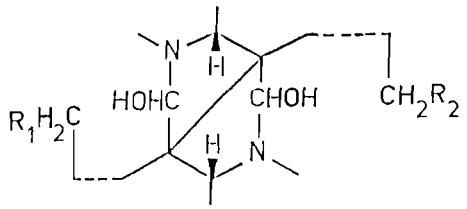
20a Strychnine $R_1 = R_2 = H$
20b Brucine $R_1 = R_2 = OMe$



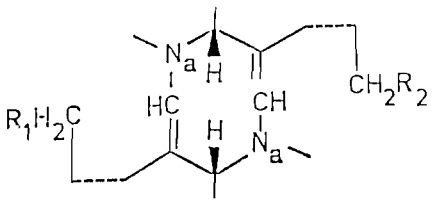
curarine: $R_1 = H, R_2 = H$
C-alkaloid G: $R_1 = H, R_2 = OH$
C-alkaloid E: $R_1 = OH, R_2 = OH$



calebassine: $R_1 = H, R_2 = H$
C-alkaloid F: $R_1 = H, R_2 = OH$
C-alkaloid A: $R_1 = OH, R_2 = OH$



C-alkaloid D: $R_1 = H, R_2 = H$



dihydrotoxiferine: $R_1 = H, R_2 = H$
C-alkaloid-H: $R_1 = H, R_2 = OH$
toxiferine: $R_1 = OH, R_2 = OH$

Scheme 1.

gave indications for the presence of more than traces of alkaloid; while the TLC of the ethyl acetate extracts yielded no further information, the concentrated extracts gave evidence for the presence of a number of alkaloid components. The chromatograms of *Krukoff 9061* and *Pires 31* were almost identical, but those of the other samples examined were different and were also different from each other.

The stem bark contains macusine B (**9c**) and 11-methoxydiaboline (**19f**), and

also the quaternary base mavacurine (**12**) (Galeffi et al., 1973; Bovet et al., 1955; Gasinovi, 1957). The root bark also has macusine B and 11-methoxydiaboline and in addition nor-dihydrotoxiferine (cf. **18**) and 18-deoxy-Wieland-Gumlich aldehyde (**14a**) (Galeffi et al., 1973; Marini-Bettòlo and Delle Monache, 1973). Nothing is known about the leaf alkaloids.

S. atlantica Krukoff et Barneby — Breviflorae/Breviflorae

Only tertiary alkaloids have been found in the root bark (Marini-Bettòlo, in: Krukoff, 1972).

S. bahiensis Krukoff et Barneby — Strychnos

The single leaf sample screened afforded no more than traces of alkaloid. However, chromatograms of the concentrated ethyl acetate and ethanolic extracts showed the presence of a single alkaloidal component.

S. barnhartiana Krukoff — Strychnos

The three leaf samples examined afforded + + to + + + alkaloid tests and chromatograms of the ethyl acetate extracts indicated the presence of the same principal alkaloidal constituent fluorescing blue in UV light and giving a reddish colour with Dragendorff reagent (typical of harman and related compounds). Initial TLC in system (a) suggested possible identity with harman. However, after isolation from the extract of *Krukoff 9103* by silica-gel preparative TLC, this major base on positive-ion FAB mass spectrometry yielded a molecular-ion $[M + 1]^+$ peak at 169; and co-chromatography with harman and norharman in the system chloroform/methanol (9:1), which separates these two compounds, showed that the alkaloid in question was in fact norharman (**1a**). This base is likewise present in the other two *S. barnhartiana* leaf extracts.

S. bicolor Progel — Rouhamon

Both leaf samples examined afforded trace amounts of Dragendorff-positive material.

S. brachiata Ruiz et Pavón — Strychnos

The ethyl acetate extract from the one leaf sample examined did not contain any alkaloidal material. TLC in system (b) of the ethanolic extract gave a single brownish spot with Dragendorff reagent — the substance responsible may be an artefact.

Wieland-Gumlich aldehyde (**19a**) and 11-methoxydiaboline (**19f**) have been found in the stem bark of Peruvian material of this species (Galeffi et al., 1973).

S. brachistantha Standley — Breviflorae/Eriospermae

A single leaf sample from Belize was studied. Only the TLC of the concentrated ethyl acetate extract showed that Dragendorff-positive material was present.

S. brasiliensis (Sprengel) C. Martius — Breviflorae/Breviflorae

The two leaf samples both gave ethyl acetate extracts producing a clearly positive reaction with Dragendorff reagent; however, the TLC were rather different.

Stem bark from the Argentine/Brazil frontier was shown to contain a variety of indoline alkaloids, the main one being 12-hydroxy-11-methoxystrychnobrasiline (**17b**); interestingly, a small amount of spermostrychnine (**16a**), first isolated from Australian material of *S. axillaris* Colebr. (*S. psilosperma* F. Muell.), was also present (Iwataki and Comin, 1971).

S. bredemeyeri (Schultes) Sprague et Sandw. — Strychnos

The ethyl acetate extract of the leaves contains a small amount of alkaloid, the principal component of which fluoresces turquoise in UV light, colours yellow with Dragendorff reagent, and has R_f 0.32 in system (a). It is evidently an angustine-type base; and other bases of the same type are also present.

The sample of *yakki*, which may have come from the bark of this species (see Table 1), proved to be rich in alkaloidal material.

S. castelnaeana Wedd. — Breviflorae/Breviflorae

The two leaf samples examined contained little or no material giving a positive reaction with Dragendorff reagent.

Diaboline (**19b**), 3-hydroxydiaboline (**19e**) and jobertine (an acetyldiaboline, **19c**) are among the tertiary bases present in the stem bark. Diaboline also occurs in the root bark (Delle Monache et al., 1970; Galeffi et al., 1982).

S. chlorantha Progel — Strychnos

The leaf sample investigated, from Costa Rica, contained not more than traces of Dragendorff-positive substances.

Among the alkaloids present in the stem bark from Costa Rica are diaboline (**19b**) and an acetyldiaboline (possibly henningsamine, **19d**) (Müller et al., 1965).

S. cogens Benth. — Rouhamon

Examination of the available leaf samples has shown that they do not have more than traces of Dragendorff-positive substances.

S. croatii Krukoff et Barneby — Strychnos

The quite small amount of alkaloid in the leaves comprises at least three components, including base-line material, according to TLC run in system (a). The ethanolic extract did not appear to contain any alkaloids.

S. darienensis Seemann Strychnos

The leaves of two of the samples investigated evidently contained little alkaloidal material. The ethyl acetate extract of the third sample gave a + response in the alkaloid test. For all three samples, only base-line material was observed on TLC in systems (a) and (b); the ethanolic extract appeared not to contain any alkaloid.

The stem bark contains an appreciable amount of alkaloid (Imbiriba da Rocha, personal communication).

S. diaboli Sandw. Strychnos

The leaves of the Guyanan sample examined had not more than traces of alkaloids, among which was an angustine-type base.

It is from this species that the alkaloid diaboline (**19b**) was first isolated (King, 1949a; Bader et al., 1953).

S. divaricans Ducke Strychnos

The two leaf samples examined were found to contain no more than traces of alkaloidal material.

Among the alkaloids detected in its bark by 2D-PC were calebassine (cf. 18), curarine (cf. 18), mavacurine (12) and fluorocurarine (**14b**) (Adank et al., 1954; Marini-Bettòlo et al., 1955).

S. erichsonii Rich. Schomb. Strychnos

The leaves of all four samples investigated gave extracts which afforded + + + to + + + + responses with Dragendorff reagent. TLC of the ethyl acetate extracts showed a series of alkaloid spots. Sample *Krukoff 9092* from the Brazilian State of Amazonas produced a different pattern of spots and included a blue-fluorescing one which at first sight appeared to be harman; however, after preparative TLC to isolate this component, an attempt to observe the molecular ion on FAB mass spectrometry failed and TLC indicated that it was not identical with any of the available reference alkaloids (harmine, harmol, harmaline, harmalol, harman, and nor-harman). Angustine-type alkaloids (cf. 3) were noted as being present in all leaf samples except *Boswezen 358*. The bark samples examined proved to be a richer source of alkaloidal material; again, angustine-type bases were present.

Diaboline (**19b**) has been isolated from the root bark (Marini-Bettòlo et al., 1978). Quite recently, in addition to deacetyldiaboline (**19a**), diaboline (**19b**), henningsamine (**19d**), condensamine, 17-*O*-ethyldiaboline (artefact?), and 17-*O*-ethyl-11-*O*-methyldiaboline (artefact?), a vobasine-type base called erichsonine (**10**) has been obtained as the main alkaloid of the stem bark. Saponins appear to be present in the leaves and stem bark (Forgacs et al., 1986; Grenand et al., 1987).

S. eugeniifolia Monach. Strychnos

Extracts from the leaf sample examined contained a very small amount of base-line alkaloid (system (a)).

S. fendleri Sprague et Sandw. Breviflorae/Breviflorae

The extracts from the leaf sample investigated contained not more than traces of alkaloid.

The stem bark is known to contain a range of tertiary bases that includes strychnofendlerine (**17a**) and derivatives of strychnosplendine (**16b**) and diaboline (**19b**); spermostrychnine (**16a**) is also present (Marini-Bettòlo et al., 1978; Galeffi et al., 1976; Galeffi and Marini-Bettòlo, 1980).

S. froesii Ducke Strychnos

Two of the leaf samples gave extracts containing only traces of alkaloids. TLC of the ethyl acetate extract of all three samples revealed the presence of at least two components of the angustine type; the less polar one (probably angustine) appeared to be present in all three extracts, but was not visualized with the reagent except in the case of *Fróes 32109*.

As shown by 2D-PC, the bark has a complex mixture of quaternary alkaloids, among them toxiferine and curarine (cf. **18**) and mavacurine (**12**) (Bovet et al., 1954; Adank et al., 1954). In the root bark the tertiary bases Wieland-Gumlich aldehyde (**19a**), diaboline (**19b**) and nor-dihydrofluorocurarine (**14a**) are present (Marini-Bettòlo and Delle Monache, 1973).

S. fulvotomentosa Gilg Breviflorae/Breviflorae

Only one sample of the leaves seemed to contain little more than traces of very polar alkaloidal material.

S. gardneri A.DC. Strychnos

The leaf sample examined yielded traces of base-line Dragendorff-positive material in system (a).

2D-PC shows that the root bark contains a number of quaternary bases, including alkaloid H and curarine (cf. **18**). The tertiary bases akagerine (**6**) and 11-methoxydiaboline (**19f**) are also present (Delle Monache et al., 1967a; Marini-Bettòlo et al., 1980b).

S. glabra Sagot ex Progel Rouhamon

Little or no alkaloid was found to be present in the leaves, but one spot with R_f 0.04 was visible after concentration of the extract of sample *Krukoff 9062*. TLC of the extracts from this sample and *Fróes 21528* run in system (a) showed base-line material. In marked contrast, two samples of bark from Guyana, examined originally by King, produced + + + + ethanol extracts which according to TLC in system (b) contained 5—6 distinct alkaloid spots; the *F.D. 2467* extract contained angustine-type alkaloids (cf. **3**).

S. grayi Griseb. Breviflorae/Breviflorae

The rather small leaf sample yielded 3.2% ethyl acetate extract which gave a + + + + response in the alkaloid test. TLC in system (a) indicated the presence of three major components and a number of minor ones, among

them angustine-type bases (cf. 3). The ethanolic extract showed only a single Dragendorff-positive spot on TLC in system (b).

S. guianensis (Aublet) C. Martius — Rouhamon

Only one of the seven leaf samples examined afforded evidence for the presence of alkaloidal material.

According to the screening results of Grenand et al. (1987), the leaves and stems contain little or no alkaloid. Saponins may be present in both leaves and stems and flavonoids in the leaves.

2D-PC of the stem-bark and root-bark alkaloids reveals that they are complex mixtures of quaternary bases mostly of unknown structure; curarine (cf. 18) has been detected in the root bark (Adank et al., 1954; Bovet et al., 1954; Giesbrecht et al., 1954).

S hirsuta Spruce ex Benth. — Rouhamon

Again, the leaf extracts worked up contained not more than traces of Dragendorff-positive material; this is in agreement with previous findings (Galeffi and Marini-Bettòlo, 1981).

The stem bark and root bark contain strychnohirsutine and its tetrahydro derivative (**5a,b**) (Marini-Bettòlo et al., 1978; Galeffi and Marini-Bettòlo, 1981).

S. javariensis Krukoff — Strychnos

Only TLC of the concentrated ethyl acetate extract in system (a) indicated the presence of several Dragendorff-positive components, including angustine-type alkaloids (cf. 3).

S. jobertiana Baillon — Strychnos

The ethyl acetate extract from the leaves appeared to contain only traces of angustine-like bases; one such component was detected in the ethanolic extract.

Akagerine (**6**) is the main tertiary alkaloid occurring in the root bark and it is found along with a small amount of diaboline (**19b**) and its acetyl derivative jobertine (**19c**) (Delle Monache et al., 1967; Marini-Bettòlo et al., 1980b).

S. macrophylla Barb. Rodr. — Strychnos

Traces only of alkaloidal material are present in the leaves and on TLC of the concentrated ethyl acetate extract in system (a) the only Dragendorff-positive material was on the base line.

Among the quaternary bases revealed by 2D-PC of the alkaloids present in the bark are fluorocurine (**11**) and mavacurine (**12**) (Bovet et al., 1954; Iorio et al., 1957).

S. mattogrossensis S. Moore — Breviflorae/Eriospermae

The ethyl acetate extract of the leaf specimen *Fróes 23942* afforded a + + + + alkaloid response, while that from the other specimen gave only a

tr + response. TLC in system (a) indicated at least four components with a major one at about R_f 0.24. TLC of the *Fróes 23942* ethanolic extract showed two components in system (b). The differences between the two extracts are unexplained, but could be due to seasonal differences, for example.

The principal alkaloid of the stem bark is strychnobrasiline (Belém-Pinheiro, personal communication).

S. medeola Sagot ex Progel — Strychnos

The ethyl acetate extract of *Van Donselaar 1080* contained traces of alkaloidal material and TLC in system (a) revealed a single component at R_f 0.17; the concentrated extract showed nothing further, but that of the other sample examined had Dragendorff-positive base-line material.

Nor-macusine B (**9b**) has been found in the stem bark and 11-methoxydiaboline (**19f**) in the root bark (Marini-Bettòlo et al., 1973).

S. melinoniana Baillon — Rouhamon

The leaves contain mere traces of alkaloids and only two of the concentrated ethyl acetate extracts showed base-line material on TLC in system (a). On the other hand, the bark samples gave + + to + + + alkaloid tests. TLC of the ethyl acetate extracts in system (a) revealed mainly base-line material, but in system (b) up to six components were observed with the main one at about R_f 0.95. Angustine (**3**) and related alkaloids were present. The ethanolic extracts also contained a number of Dragendorff-positive components.

The bark is known to contain the melinonines A—M, a series of alkaloids belonging to different structural groups (**1c**, **2**, **4**, **7**, **8**), and the quaternary bases fluorocurine (**11**), mavacurine (**12**) and melinonine E (**4**) (Schlittler and Hohl, 1952; Bächli et al., 1957; Borris et al., 1984).

S. mitscherlichii Rich. Schomb. var. *mitscherlichii* — Strychnos

The leaves contain negligible amounts of alkaloidal material. The bark sample examined gave a + + + + response with Dragendorff reagent. TLC of the ethyl acetate extract in systems (a) and (b) indicated the presence of a very complex mixture of alkaloids with two fairly polar main components.

The source, and hence the identity, of the bark studied by Kebrle et al. (1953), in which they found a number of quaternary bases, including fluorocurarine (**14b**) and calebassine and other dimers (cf. **18**), is indicated by Krukoff and Barneby (1969) to be uncertain.

S. mitscherlichii var. *pubescentior* Sandw. — Strychnos

Negligible amounts of the alkaloidal substances are present in the leaves.

S. mitscherlichii var. *amapensis* Krukoff et Barneby — Strychnos

2D-PC of the bark quaternary alkaloids indicates the presence, among others, of fluorocurine (**11**), mavacurine (**12**), and curarine, alkaloid D, and

calebassine (cf. 18) (Marini-Bettòlo et al., 1955; Marini-Bettòlo and Bisset, in: Krukoff, 1972).

S. nigricans Progel — Breviflorae/Eriospermae

The leaves contain traces of Dragendorff-positive material; TLC in system (a) of the ethyl acetate extract shows components at about R_f 0.0 and 0.87 and in system (b) the ethanolic extract has one at about R_f 0.95, corresponding to angustine-type bases (cf. 3).

S. oiapocensis Fróes — Breviflorae/Breviflorae

TLC in system (a) of the concentrated ethyl acetate extract from the leaves revealed the presence of a major Dragendorff-positive component at R_f 0.87, together with several minor ones, corresponding to angustine-type bases (cf. 3).

Tests on the leaves and stems for alkaloids, quinones, steroids/triterpenoids, tannins, and flavonoids were negative and for saponins doubtfully positive (Grenand et al., 1987).

S. panamensis Seemann — Strychnos

Little more than trace amounts of alkaloids are present in the leaves. TLC of the concentrated ethyl acetate extracts in system (a) show only base-line material.

Again, TLC of the ethyl acetate extract from the stem and stem bark samples examined showed only base-line material. In contrast, TLC of the ethanolic extract from the stem bark in system (b) revealed several alkaloidal components, probably either quaternary or very polar tertiary bases; the main one had R_f approximately 0.11.

Approximately 0.1% each of strychnine (**20a**) and brucine (**20b**) has been isolated from the mature, and only the mature, seeds of this species; no other New World *Strychnos* material is known to contain these two alkaloids (Marini-Bettòlo et al., 1972). The upper stem bark has the tertiary base diaboline (**19b**) and the quaternary bases fluorocurine (**11**) and alkaloids F, G, and K (cf. **18**) (Pellicciari et al., 1966). According to H.P. Castañeda and L.R. Castañeda (1964; cited from Garcia Barriga, 1975), the root bark also contains strychnine; the observation requires verification.

S. panurensis Sprague et Sandw. — Rouhamon

The concentrated ethyl acetate extract from the leaves has little more than traces of alkaloidal substances and only base-line material appears on TLC run in system (a). The ethyl acetate extract from the root gave a + + response in the alkaloid test. While TLC in system (a) indicated only base-line material, in system (b) there was a major component at about R_f 0.26. The ethanolic extract produced a more complicated chromatogram in system (b), with the principal constituent at about R_f 0.33.

The seeds contained at least two alkaloids with R_f 0.0 and 0.47 in system (a).

S. parviflora Spruce ex Benth. Breviflorae/Breviflorae

TLC in system (a) of the traces of Dragendorff-positive material present in the concentrated ethyl acetate extracts of the leaves showed mainly base-line constituents, but the occurrence of angustine-type bases (cf. **3**) was also noted.

S. parvifolia A.DC. Breviflorae/Breviflorae

The ethyl acetate extracts from both leaf samples afforded + + alkaloid tests and TLC in system (a) revealed the presence of several components: one at R_f 0.32 fluorescing turquoise in UV light and spraying yellow with Dragendorff reagent; another one at R_f 0.47 becoming yellow with Dragendorff reagent; and the main component at R_f 0.72 again fluorescing turquoise in UV light but spraying yellow turning to red with Dragendorff reagent and identified by co-TLC as angustine (**3**).

In the bark, akagerine (**6**) is the principal tertiary base and, according to 2D-PC, calebassine (cf. **18**), mavacurine (**12**) and fluorocurarine (**14b**) are among the quaternary bases present (Marini-Bettòlo and Bovet, 1956; Marini-Bettòlo et al., 1980b; cf. Krukoff, 1980).

S. peckii Robinson Strychnos

Small amounts of alkaloids were present in the leaf extracts studied. In system (a), two of the ethyl acetate extracts showed the presence of the turquoise fluorescing and yellow staining component with R_f 0.32 also observed in one of the *S. parvifolia* extracts (angustine-type base); one of them, *Fróes 21256*, after concentration showed three other Dragendorff-positive components with the main one at R_f 0.87 identified by co-TLC as angustine (**3**). The third extract, *Fróes 22270*, even after concentration was shown to contain predominantly base-line material.

The stem bark contains a considerable amount of alkaloid (Imbiriba da Rocha, personal communication).

S. peoppigii Progel Breviflorae/Eriospermae

Alkaloid tests on the extracts from the two samples indicated the presence of only trace amounts.

S. pseudo-quina A. St. Hil. Strychnos

There is little alkaloid in the leaves. The ethyl acetate extract run in system (a) showed only base-line material. The bark, on the other hand, revealed quite a different picture. Not only did the extracts give a + + + + alkaloid test, but their composition proved to be very complex with at least three major components and more than 10 minor ones.

Small amounts of diaboline (**19b**) and its 11-methoxy derivative (**19f**) have been isolated from the leaves (Nicoletti et al., 1984) and about 6% nor-dihydrotoxiferine (cf. **18**) from the stem bark and root bark (Delle Monache et al., 1969). The leaves also contain iso-rhamnetin and a new biflavone named strychnobiflavone (Nicoletti et al., 1984).

S. ramentifera Ducke — Strychnos

The merest traces of alkaloids are present in the leaves and only one of the three concentrated ethyl acetate extracts examined revealed the presence of Dragendorff-positive base-line material.

S. recognita Krukoff et Barneby — Breviflorae/Breviflorae

A very small amount of tertiary bases has been found in the root bark (Marini-Bettòlo, in: Krukoff, 1980).

S. romeu-belenii Krukoff et Barneby — Strychnos

The stem bark of this species is known to contain 11-methoxydiaboline (**19f**) as the major alkaloid (Marini-Bettòlo et al., 1978).

S. rondeletioides Spruce ex Benth. — Strychnos

There is little alkaloid in the leaves of this species. Base-line material was detected in the concentrated ethyl acetate extract on TLC in system (a).

Diaboline (**19b**) and a trace of Wieland-Gumlich aldehyde (**19a**) have been found in the root bark (Delle Monache et al., 1967).

The stem bark contains an appreciable quantity of alkaloids (Imbiriba da Rocha, personal communication).

S. rubiginosa A.DC. — Breviflorae/Breviflorae

The stem bark and root bark contain nor-macusine B (**9b**) and 11-methoxydiaboline (**19f**); the root bark also has strychnorubigine (**13**) (Marini-Bettòlo et al., 1978; Marini-Bettòlo et al., 1980a).

S. sandwithiana Krukoff et Barneby — Strychnos

Only traces of alkaloid were present in the leaves of this species. Base-line material was noted on TLC of the concentrated ethyl acetate extract run in system (a).

Wieland-Gumlich aldehyde (deacetyldiaboline) (**19a**) and other bases have been found in the stem bark (Marini-Bettòlo, 1957; cf. Krukoff, 1972).

S. schultesiana Krukoff — Breviflorae/Eriospermae

Again, little alkaloid is present in the leaves; chromatograms indicate the presence of base-line material in the concentrated ethyl acetate extract.

S. solerederi Gilg — Strychnos

The ethyl acetate extracts from three leaf samples were not found to contain any Dragendorff-positive material.

The root bark is known to contain Wieland-Gumlich aldehyde (**19a**) and diaboline (**19b**) (Delle Monache et al., 1967; cf. Krukoff, 1972).

S. solimoesana Krukoff — Strychnos

The ethyl acetate extract from the leaf sample examined gave a + + + + alkaloid test; chromatograms run in system (a) showed base-line material and

a major component at R_f 0.04. A series of angustine-type and other bases, more readily separated in system (b), is also present.

The root bark contains the tertiary base diaboline (**19b**) and the quaternary bases calebassine (cf. **18**) and curarine (Marini-Bettòlo et al., 1978). 2D-PC indicates that the stem bark has a highly complex mixture of quaternary alkaloids that includes fluorocurine (**11**), fluorocurarine (**14b**), curarine, calebassine, alkaloids C—G (cf. **18**), and many others (Casinovi et al., 1957).

S. subcordata Spruce ex Benth. Rouhamon

Traces of base-line Dragendorff-positive material are present on TLC run in system (a) of the concentrated ethyl acetate extracts from the leaves. The same extracts from the stems and roots have more alkaloid, with at least two components in the ethanolic extract.

The stem bark is reported to contain Wieland-Gumlich aldehyde (deacetyldiaboline) (**19a**) and, according to 2D-PC, a complex mixture of quaternary bases, among them fluorocurine (**11**), mavacurine (**12**), fluorocurarine (**14b**) and caracurine III (Penna et al., 1957; Marini-Bettòlo, 1957).

S. tabascana Sprague et Sandw. Strychnos

The small amounts of alkaloid present in the leaves afforded chromatograms similar to those obtained with the *S. subcordata* extracts.

The major tertiary base of the root bark is strychnobrasiline (**17b**); it is accompanied by its 11-methoxy derivative (**17c**), tabascanine (**15a**), its acetyl derivative, and *N*-acetyl-*O*-methylstrychnosplendine (**16c**) are also present (Galeffi et al., 1971).

Graham y Ponz (1894; cited from : Krukoff, 1965) reported extracting from the seeds 1.83% of a slightly coloured crystalline mass which he recognized from its colour reactions as containing strychnine and brucine. The means of identifying the alkaloids is, of course, inadequate by to-day's standards, and the investigation needs to be repeated using modern methods. Nevertheless, the fact that these two alkaloids have been isolated from seeds of the closely related *S. panamensis* (q.v.) may well mean that the observation is correct.

S. tarapotensis Sprague et Sandw. Breviflorae/Eriospermae

Again, the chromatograms of the trace amounts of alkaloid present were similar to those obtained with the *S. subcordata* extracts.

S. tomentosa Benth. Strychnos

The small amounts of alkaloid present in the leaf extracts gave chromatograms similar to those of the *S. subcordata* extracts.

According to the screening results of Grenand et al. (1987), the leaves and stems contain at most small amounts of alkaloids; all other tests were negative (cf. *S. erichsonii*, above).

2D-PC of the quaternary alkaloids from the bark indicate the presence of a complex mixture, including fluorocurarine (**14b**) and the dimers curarine

and toxiferine (cf. 18) (Adank et al., 1954; Bovet et al., 1954; Pimenta et al., 1955; Marini-Bettòlo, 1957, 1970).

S. toxifera Rob. Schomb. ex Lindley Strychnos

The ethyl acetate extracts of the three leaf samples studied gave alkaloid tests of tr, tr + and + +, respectively; on TLC in system (a) the concentrated extracts were noted to contain only base-line material. Two bark samples were studied and their ethyl acetate extracts gave + + and + + + alkaloid tests and very simple chromatograms in system (a); the ethanolic extracts also contained much alkaloid and gave chromatograms in systems (b), (c) and (d) showing many more components, presumably quaternary alkaloids. Small amounts of alkaloid were also found to be present in the seeds and while the concentrated ethyl acetate extract revealed only base-line material on TLC in system (a) and three components in system (b), the ethanolic extract also contained at least three components according to TLC in system (b).

The alkaloids in the bark of this species have been investigated in some detail; most of the attention has been given to the quaternary bases, which include toxiferine, C-alkaloid A, and caracurine VII (cf. 18), macusines A, B, and C (**9a,c**), fluorocurine (**11**), mavacurine (**12**) and Wieland-Gumlich aldehyde (caracurine VII) (**19a**) and its N_b-metho derivative (hemitoxiferine I) (**19g**) (Battersby et al., 1960, 1964; Asmis et al., 1954, 1955; Kebrle et al., 1953; King, 1949b).

S. trinervis (Vell.) C. Martius Strychnos

The traces of alkaloid present in the concentrated ethyl acetate extracts remained on the base line of TLC run in system (a).

Nor-dihydrotoxiferine (cf. 18) has been isolated from the root bark (Melo et al., 1987).

3.3. Pharmacology

N_a-Acetyl-O-methylstrychnosplendine (**16c**). The alkaloid has strong muscle-relaxant activity in vivo and in vitro. In the screen grip test on mice the response to a 50 mg/kg i.v. dose was graded xx. The LD_{min} is 75 mg/kg i.v. At a concentration of 10.2 μg/ml (27.8 nmol/ml) the alkaloid caused a 50% reduction in the amplitude of contraction of the rat-diaphragm preparation after electrical stimulation of the phrenic nerve; this compares with 0.9 μg/ml (1.4 nmol/ml) for alcuronium (Weeratunga et al., 1984).

Akagerine (**6**). At 50 mg/kg the alkaloid brings about clonic and both the flexion and extension components of tonic convulsions (Verpoorte et al., 1975; Rolfsen et al., 1978, 1980). At concentrations of 1—10 μg/ml, the alkaloid shows some degree of cytotoxicity against cultured B16 mouse melanoma, Flow 2002 normal human embryonic lung, L1210 mouse ascites tumour and HeLa human carcinoma cells (Leclercq et al., 1986).

Brucine. See under *Strychnine.*

Caracurine V (cf. 18). This alkaloid also has antimicrobial activity. It exhibits weak muscle-relaxant activity in vivo; in the screen-grip test, 6 mg/kg

was without effect, 10 mg/kg was scored xx and 13 mg/kg xxxx (lethal). The effect is not antagonized by cholinesterase inhibitors (Verpoorte and Baerheim Svendsen, 1978).

Diaboline (**19b**). In mice this moderately toxic alkaloid (LD_{50} i.v. 29 mg/kg, i.p. 150 mg/kg, s.c. 486 mg/kg) brings about diffuse tremors, paralysis of the hind limbs, and death usually from respiratory paralysis. In the rabbit, at 40 mg/kg i.v. it brings about relaxation of the front and hind limbs and also of the neck muscles, this resulting in head drop. At 70 mg/kg, death results with distinct signs of respiratory paralysis. Smaller doses, 10—20 mg/kg, in the chloralosed dog lead to slight hypotension, but they also diminish the amplitude of respiratory movements as well as contractions of the gastrocnemius muscle; up to 40 mg/kg there is no curarizing effect on the mesenteric preparation nor is there any activity on isolated organs (rat diaphragm, rabbit intestine). The alkaloid is not antagonistic to acetylcholine (Casinovi et al., 1964).

In rats anaesthetized with urethan, the alkaloid has hypotensive effects at doses of 8—12 mg/kg; they are attributed to a central action (Singh and Kapoor, 1976). Diaboline is the principal alkaloid in the seeds of the Asian species *S. potatorum* L.f.; the depressant effect on the isolated heart is potentiated by the minor alkaloids which include acetyl derivatives of diaboline (Singh and Kapoor, 1980).

With doses up to 250 mg/kg s.c. in mice there are no convulsions (Sandberg and Kristianson, 1970).

The pharmacological activity of extracts of *S. erichsonii* is due primarily to the presence of diaboline derivatives. The leaf extract has analgesic properties, and the stem bark has spasmolytic properties and augments the activity of the central nervous system (Grenand et al., 1987).

Fluorocurarine (**14b**), *Fluorocurine* (**11**), *Mavacurine* (**12**). These three alkaloids all have very weak curarizing activity (Waser, 1972).

Harman (cf. **1**). Harman and certain of its derivatives act as competitive and selective inhibitors of type A monoamine oxidase (Udenfriend et al., 1958; Martin et al., 1983; Manabe et al., 1988).

The cytotoxic properties of the alkaloid have been established using in vitro cell cultures (Seegers et al., 1978). It inhibits the synthesis of DNA by direct interaction with chromatin, probably by intercalating itself between the base pairs of the DNA (Remsen et al., 1979; Husson, 1985).

On the other hand, recent studies have shown that harman and other β-carbolines attach reversibly to the benzodiazepine receptor and block the effects of these latter compounds by displacing them from the binding sites, which also blocks the effects of GABA. This is thought to explain the convulsant and anxiogenic effects of these molecules, effects that are antagonized by benzodiazepines (Rommelspacher et al., 1981; Dodd and Rossier, 1987.

Macusine B (**9c**). The base is an analeptic. It has hypotensive properties as a result of peripheral vasodilation. The heart rate is increased by stimulation

of β-adrenergic receptors; it blocks α-adrenergic receptors. The alkaloid at 50 mg/kg brings about clonic convulsant effects; it has no tranquillizing properties (Leonard, 1965a–c).

Mavacurine. See under *Fluorocurarine.*

Melinonine F (**1c**). Physico-chemical studies have shown that melinonine F and its nor-derivative bind to DNA; apparently, the aromatic chromophore is oriented parallel to the base pairs by partial insertion through the double helix groove (Caprasse and Houssier, 1983).

At the relatively high concentration of 50 μg/ml, melinonine F has weak in-vitro antimitotic activity against cultured human fibroblasts, probably through interaction with the chromatin of the nucleus (Caprasse, 1983), and against animal tumour cells (mouse B16 melanoma and Ehrlich tumour ELT) (Bassleer et al., 1982).

Nor-dihydrotoxiferine (cf. **18**). This dimeric tertiary alkaloid has antimicrobial activity against *Streptococcus* species, *Pseudomonas aeruginosa*, and *Escherichia coli* (Verpoorte et al., 1978). It has a marked depressant effect on the CNS and is therefore a sedative (Bernauer et al., 1963). It has muscle-relaxant activity (Verpoorte: in, Ohiri et al., 1983). The alkaloid has antidiarrhoeal activity on i.p. administration in rats; the effective dose is 4–10 mg/kg, depending on the model; the mechanism of action has also been investigated (Melo et al., 1987).

Nor-fluorocurarine (vincanine) (**14c**). The alkaloid is indicated to have properties similar to those of strychnine, i.e. stimulation of the CNS, causing tetanic convulsions, etc. The LD_{100} is 10–12 times more than that of strychine; the LD_{50} i.v. in mice is 7.5 mg/kg. Vincanine has been used in medical practice in the USSR as an analeptic (cf. Shemyakin, 1971; Hava, 1973).

Nor-macusine B (tombozine) (**9b**). In mice the LD_{50} i.v. is about 70 mg/kg; death is caused by respiratory paralysis after a few convulsions. In the chloralosed cat, at 10 mg/kg there is a slight hypotensive effect; at the same time, there are weak negative inotropic and chronotropic cardiac effects. Hypertension of central origin is reduced. The alkaloid also has local anaesthetic properties, a 1% solution being equivalent to a 2% procaine solution. The alkaloid has no tranquillizing activity and brings about contraction of the smooth muscle of the rat duodenum and of the arteries (Quevauviller and Takenaka, 1962).

The alkaloid acts as a sedative in mice at doses of 20–50 mg/kg. In cats and dogs it acts as a hypotensive in doses up to 5 mg/kg. Larger doses cause ganglionic block and cardiac depression (Hava, 1973).

Strychnine (**20a**), *Brucine* (**20b**). Strychnine is, of course, the archetypal convulsant poison. It acts on the medulla by blocking the chemical intermediate glycine; this results in paralysis of the cells of Renshaw which normally exercise an inhibitory function on the motor cells. In consequence, with toxic doses, about 50–60 mg for an adult, unco-ordinated movements are propagated to all parts of the spinal cord, all the muscles begin the act, especially the extensors, i.e. the action is "tetanizing". After two or three tonic crises,

contraction of the muscles of the thorax and diaphragm bring about death by asphyxia (Tits, 1982; cf. Ohiri et al., 1983).

Brucine is 50—100 times less active than strychnine (Sandberg and Kristiansson, 1970).

4. Discussion

4.1. Uses

Most American species of *Strychnos* occur in forested regions well away from the coastal areas that were first colonized after the discovery of the continent. It was only when botanical and anthropological exploration started in the 19th century that any knowledge of uses by the Amerindian tribes of Central and South America became available. On the other hand, the two species *S. brasiliensis* and *S. pseudo-quina*, which grow in central and south-eastern Brazil, came to be used as folk remedies in populated areas primarily as bitters, tonics and febrifuges. In particular, the bark of *S. pseudo-quina*, as the many vernacular names that include the word *quina* testify, in the early part of the 19th century had already gained a reputation as a valuable remedy against malaria, etc., and was widely used instead of *Cinchona* bark.

However, leaving aside the inclusion of *Strychnos* species as ingredients in South American dart- and arrow-poisons (which is their major use and interest), it is evident from the foregoing summary of the ethnobotany that, compared with the African and Asian species, their rôle as medicinal and useful plants is a very minor one. Because of the limited data available — summarized below — worthwhile comparisons are scarcely possible. It is nevertheless noteworthy that the fruits of some 20 species have a sweet pulp that is, or can be, eaten by human beings and animals; in this respect, at least, the similarity is with certain African, rather than Asian, species (Bisset, 1970, 1974).

The medicinal uses may be summarized as follows:

Stimulant and tonic: *S. acuta* (l), *S. brasiliensis*, *S. guianensis* (st), *S. pseudo-quina* (b), *S. rubiginosa*, *S. trinervis*

Stomach and abdominal complaints: *S. erichsonii*, *S. pseudo-quina*, *S. trinervis*

Antipyretic and antimalarial: *S. brasiliensis*, *S. fendleri* (b), *S. pseudo-quina* (b), *S. trinervis*

Analgesic and antirheumatic: *S. javariensis* (b), *S. panamensis*, *S. tomentosa* (st)

Spasmolytic: *S. toxifera* (b)

Menstruation, abortion, venereal disease: *S. erichsonii*

Aphrodisiac: *S. erichsonii*, *S. melinoniana* (rb), *S. mitscherlichii* var. *mitscherlichii*, *S. nigricans* (rb), *S. oiapocensis* (rb)

Anaemia: *S. guianensis* (st)

4.2. Phytochemistry

As regards the chemistry of South American *Strychnos*, emphasis in the past was on the investigation of the quaternary (mainly dimeric) alkaloids present in curare were obtained to enable their structures and an outline of that showed curarizing activity. Sufficient quantities of the major alkaloids present in curare were obtained to enable their structures and an outlien of their chemistry to be established (largely before the advent of NMR and mass spectrometry). However, in examining the plant materials for alkaloids with curarizing activity, often there was only sufficient extract for chromatographic study. In many cases, chromatograms of great complexity were obtained after spraying with such chromogenic reagents as ceric sulphate/sulphuric acid. Components thus detected were frequently given names, but they were obtained in amounts that, apart from their chromatographic properties, only enabled their UV spectra to be determined; and little or nothing more is known about them. The last two decades has been only minor improvements in our knowledge of the dimeric curarizing alkaloids occurring in South American *Strychnos* species. As will be seen from the summaries given in the section on alkaloid screening of the alkaloids known to be present in the various species, more success has attended the investigation of the tertiary alkaloids — it is unfortunate that they have less interest pharmacologically.

The present screening work has pin-pointed certain species, e.g. *S. barnhartiana* and *S. grayi*, not previously examined, where further study might well prove of interest. But it has also emphasized yet again the conclusion arising from previous alkaloid screening work that it is the stem bark or root bark, rather than the leaves, that is the part of the plant whose examination is most likely to be productive. Given the polarity of the TLC systems used in the present study, the frequent occurrence of base-line material on the chromatograms suggests the common presence possibly of highly polar (bis-)tertiary or (mono-)quaternary bases in the extracts.

4.3. Chemotaxonomy

It is difficult to derive any chemotaxonomic conclusions from the findings of the present alkaloid survey or from the data available in the literature. And indeed, it must be emphasized that many American species have been examined either rather superficially or not at all. The purpose of the chromatographic studies discussed above was in many cases to attempt to identify in the stem bark or root bark of various South American species alkaloids previously isolated from samples of curare from museums and other sources. Another point to bear in mind is that the alkaloid content depends not only on the species investigated but also on the part of the plant analysed, the time of collection, as well as the habitat and geographical location.

In spite of these caveats, there are a number of points worthy of discussion.

The genus *Strychnos* is divided into 12 sections (Leeuwenberg, 1969), only

three of which are represented in Central and South America, namely Strychnos, Rouhamon, and Breviflorae.

4.3.1. Section Strychnos. This section comprises 35 American species, including *S. toxifera*, *S. diaboli*, *S. panamensis*, *S. solimoesana*, etc., and 16 Asian species, among them *S. nux-vomica*, *S. ignatii*, *S. wallichiana*, etc.

The only species of this section in which angustine and related alkaloids have been found is the Asian *S. angustifolia* (Phillipson et al., 1974). In the present study, pyridino-indolo-quinolizidinone bases have been encountered in numerous American species belonging to this section.

S. panamensis is another species belonging to this section and it is the only American species from whose seeds strychnine and brucine have been isolated. These alkaloids are, of course, present in several well-known Asian species: *S. nux-vomica*, *S. ignatii*, *S. wallichiana* and *S. lucida* (Bisset and Phillipson, 1976). But, it should be noted that the seeds of *S. tabascana*, another American species closely related to *S panamensis*, may possibly also contain strychnine.

Many American *Strychnos* species contain dimeric alkaloids of the toxiferine type (*S. toxifera*, *S. divaricans*, *S. solimoesana*, etc.), while so far there is only one Asian species (*S. wallichiana*) known to have this type of dimeric base (Strömbom et al., 1982).

Species of this section, American as well as Asian, produce diaboline and/or derivatives (Bisset, 1980), but so far only American species are known to yield akagerine.

4.3.2. Section Rouhamon. This section comprises nine American species, including *S. guianensis*, *S. hirsuta*, *S. melinoniana*, etc., and 11 African species, among them *S. potatorum* (also in Asia), *S. usambarensis*, *S. dale*, *S. variabilis*, etc.

Again, angustine-type alkaloids are present in the leaves of species occurring in both continents. Another point in common between certain American and African species of Rouhamon is the presence of toxiferine-type dimers and the absence in those studied so far of strychnine or derivatives (cf. Ohiri et al., 1983). On the other hand, neither akagerine, which has been isolated often enough from African members of this section, nor dimers of the usambarine type, both of which are present especially in *S. usambarensis* (Angenot, 1976; Ohiri et al., 1983), have yet been found in any of the American species that have been examined.

It should be noted that little more than half of the American Rouhamon species have been analysed — some of them very superficially.

4.3.3. Section Breviflorae. This section has 20 American species, among them *S. brasiliensis*, *S. castelnaeana*, *S. fendleri*, *S. alvimiana*, *S. mattogrossensis*, etc., of which only six have been investigated, and 12 African species, of which *S. icaja*, *S. henningsii* and *S. angolensis* are worthy of note. The American species have been divided into two subsections according to the nature of the tegument of the seeds: Breviflorae and Eriospermae.

American and African species of Breviflorae have in common various groups of alkaloids, such as angustine-type bases, diaboline and derivatives,

normacusine B, retuline, and toxiferine-type dimers (cf. Ohiri et al., 1983).

It is worth noting that the alkaloid composition of *S. parvifolia*, which contains akagerine and curarizing dimers, approaches that of certain species in the section Strychnos.

Of the Eriospermae, only *S. alvimiana* has so far been studied in any detail; and chemotaxonomic discussion of this group of species is not possible.

In general, then, it can be said that American *Strychnos* species have the same types of alkaloids as those in other parts of the world. The occurrence of diaboline, which represents the (chemical) connection between the convulsant tertiary monomers of the strychnine type and the curarizing bis-quaternary dimers like toxiferine, in species from all three continents confirms the biochemical unity of the alkaloids that have been isolated from the genus *Strychnos*.

The presence of angustine, whether or not an artefact, deserves mention. This substance may arise through the action of ammonia on the lactams of vincoside or isovincoside. According to the currently held biogenetic theory (Saxton, 1983), these two compounds are believed to be precursors of the monoterpenoid indole alkaloids resulting from the condensation of tryptamine and secologanin. The detection of angustine-type bases thus proves the existence of these lactams and demonstrates their biogenetic importance, which is corroborated by the fact that they are found in species throughout the world.

4.4 Pharmacology

The pharmacology of the (non-curarizing) alkaloids occurring in South American species of *Strychnos*, summarized above, demonstrates very clearly the regrettable paucity of our knowledge concerning their actions. It is, therefore, mostly not possible to determine whether any of the reported folk-medicinal applications can be explained, even if only partially, by the presence of a particular alkaloid or mixture of alkaloids; the possibility of potentiation or synergism also has to be borne in mind. The fact that a number of species serve as tonics may simply be due to the very bitter taste of the alkaloids they contain. On the other hand, the indication that *S. toxifera* is used against convulsions and cramps is seemingly vindicated by the known presence in that plant of muscle-relaxant quaternary alkaloids; moreover, its use against festering sores may find a rationale in the known antibacterial properties of certain bis-tertiary indole bases. If future work on the alkaloids of *Strychnos* species is to have any meaning, it will be essential to associate it with a pharmacological rather than chemical screen.

The flowers, leaves and branches of several species are said to have a pleasant smell (jasmine, cloves, cinnamon), but the flowers of one species have a foetid odour which is one of the features enabling it to be distinguished from its close relatives.

Two species, *S. erichsonii* and *S. rondeletioides*, are reported to be

employed as fish poisons, but so far no highly toxic alkaloids have been detected in either plant. The possible concomitant occurrence of saponins, about which nothing is known, may reinforce any ichthyotoxic activity that the plants may have.

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