Plants Indicated by Brazilian Indians for Disturbances of the Central Nervous System: A Bibliographical Survey

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Abstract: Brazil possesses great biological and cultural diversity, above all, in view of the great number of indigenous ethnic groups – 218 in all - that inhabit the five main biomas in Brazil. The purpose of this review is to analyze the relationship between chemical constituents of species utilized by several groups of Brazilian Indians and the uses/indications made of the species by these same groups using ethnopharmacological surveys by different researchers, as from the seventies. The 34 publications selected, involving 26 indigenous ethnic groups, showed a total of 307 species utilized for 67 different diseases or effects possibly related to the Central Nervous System (CNS). These plants belong to 85 taxonomic families, mostly Fabaceae, Asteraceae, Rubiaceae, Poaceae, Apocynaceae, Bignoniaceae, Euphorbiaceae, and Solanaceae. The chemical constitution of these plants was researched as from the Pubmed and Web of Science and the information obtained was crossed with different indigenous uses, grouped in 12 categories according to similarities between their expected effects on the CNS: analgesics, to counteract fever, tonics and/or adaptogens, hallucinogens, anxiolytics, anticonvulsants, head illnesses, hypnotics, stimulants, weight control, memory enhancers, and others. Some phytochemical classes were observed to be more common among plants utilized for certain purposes: flavonoids (analgesia, fever, anxiety, hypnotic, weight control, and as a stimulant), alkaloids (hallucinogens, head illnesses, and as a stimulant), essential oils (fever and anxiety), lignans (hallucinogen), tannins (anxiety), triterpenes and saponins (hypnotic). These data suggest that these phytochemical classes possibly possess a greater number of chemical constituents that perform the effects described or that, in some way, assist in determining the use of the plant by the Indians.

Keywords: Ethnopharmacology, central nervous system, plants, phytochemistry, Indians, Brazil, flavonoids, alkaloids.

INTRODUCTION

Estimates show there are a total of some 350 million Indians in the world today belonging to at least 5 thousand indigenous groups. Of these, 218 indigenous groups inhabit Brazil – a total of some 370 thousand persons, approximately 0.2% of the total population of Brazil [1]. These ethnic groups occupy regions with a great variety of plant forms, mainly in the Amazon forest, the caatinga semi-arid lands, the cerrado brushlands, and the Atlantic rain forest. The indigenous population in Brazil, however, was once much greater. It is difficult to estimate how many Indians there were in Brazil before colonization by Portugal in 1500 – possibly 5 million. Three centuries subsequent to this contact with Europeans, this number was reduced to 1 million. The population was decimated by wars, epidemics, and, above all, by processes of enslaving that occurred in Brazil as from the sixteenth century [2].

At least three peculiarities should be an incentive to ethnopharmacological research among indigenous ethnic groups in Brazil: a) the considerable number of ethnic groups (218) with many that still hold to cultural tradition; b) the country includes the greatest number of angiosperms - some 55,000-60,000 species [3]; and c) the vast dimensions of the territory – 8,547,403.5 km^2 – which renders medical care by government services in locations farther from urban centers difficult, more severe in the case of indigenous areas. This factor, though, is propitious to holding to indigenous local medicine, the object of this ethnopharmacological study.

In spite of the numerous advantages cited above, few ethnopharmacological studies have been carried out among the Brazilian Indians up to the present time. Existing studies have in the majority, been by foreign researchers such as Richard Evans Schultes, Ghillean Prance, and Willian Balée, among others. From these studies, only two [4,5], specifically analyzed the plants with possible indication for neurological diseases or that had an effect on the Central Nervous System (CNS).

A knowledge of hallucinogenic plants that Indians of the Americas use in their rites, and of other properties of potions prepared from distinct plant species, have been common to man for thousands of years. Different chemical classes of natural products gave rise to drugs from distinct therapeutic categories. There are various examples of drugs utilized therapeutically whose application derives from indigenous knowledge: curare-type drugs, plaque blockers, among others [6]. Indigenous culture is also rich in hallucinogenic preparations and "poisons" [7]. Although in some cases, there is a high correlation between the active principle and indigenous use, such as in the case of the alkaloids and the hallucino-

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genic effect, or of cardioactive glicosides and their tonic effect on the cardiac muscles, this chemical constitutive effect is rarely observed in other uses.

The present review has endeavored to draw plant species with possible indications for the CNS from studies in ethnopharmacology carried out among the Indians in Brazil. These indications/uses were classified at a second stage in order to attempt to establish a correlation between these categories and the phytochemical classes of the species to which they belong based on phytochemical studies present in scientific literature.

METHODOLOGY

A Bibliographical Survey of Ethnopharmacological Publications

The following materials were consulted for studies in ethnopharmacology among Brazilian indigenous ethnic groups: the PubMed Data Base [8] on publications of scientific articles; Data Base of Theses and Dissertations from Brazilian universities through CAPES [9] and USP [10]; and also the NUPAUB-USP Database [11] publication data base (Nucleus for Support to Research on Human Populations in Brazilian Humid Areas - University of São Paulo) with books from the CEBRID library (Brazilian Center for Information on Psychotropic Drugs) and from a private collection.

Thirty-four publications were selected for this study: 20 scientific articles, 2 theses (doctorate), 3 dissertations (Master's degree), 3 books, 3 chapters from books, and 3 others.

Among publications selected, some refer to indigenous ethnic groups whose geographical distribution comprises other countries in South America. Examples of this include the Yanomami that occupy a region of Amazonia in both Brazilian and Venezuelan territory and the Tiriyó that inhabit the Brazilian Amazon region and part of Suriname. Forty (40), 18.5%, of the 218 indigenous peoples listed in this study, also inhabit other countries in South America [1]. All of the therapeutic plants from the ethnic groups whose geographical distribution exceeds Brazilian territory were included in this article, even those that do not occur in Brazil spontaneously. This criterion for inclusion was based on the fact that there is traffic of plant resources between these ethnic group settlements, as described by Chagon [12] concerning Yanomami peoples.

Plant species that the ethnic group under consideration had cited for diseases or for other uses reminiscent of possible action/effects on the CNS were drawn from these 34 publications.

The scientific names of some plant species cited in older publications (the seventies) had to be up-dated by consulting the Missouri Botanical Gardens data base [13], in cases in which they had fallen into disuse.

Uses cited for each plant were classified according to the similarity between possible effects/action, as for instance: plants for headache, earache, and other types of pain were grouped under the category "analgesic".

Research on the Chemical Constituents of the Plants Selected

A bibliographical survey was carried out initially on the PubMed data base [8] and Web of Science [14], utilizing the scientific names for each plant. Results of this search were subjected to screening (through titles and abstracts) to ascertain whether the articles contained chemical constituents of the species in question, and to discard false results. More complete papers were utilized when one specific species had been the object of studies showing these same chemical constituents. Finally, the information was classified into “phytochemical classes” present in each plant, and not chemical constituents, so that results might be more clearly visualized.

Pharmacological studies that confirmed the effects described by the Indians for the plant in question were also selected during the analysis of the results of the search.

Some limitations must be considered in spite of the careful survey. For instance, use of a scientific name as a key word will not bring results if the orthography of the scientific name published has been subject to alteration. It was not possible to check on all the botanic synonyms in the survey, given the large number of plants. Another limitation: some journals do not offer access to the full text - not even the abstract was available in some cases. It was not possible to check on the chemical constitution of these plants, except where the printed editions were available in the libraries consulted (University of São Paulo and Federal University of São Paulo). Finally, a number of studies with Brazilian plants have been presented at congresses and other regional events in Brazil: some of them were not consulted since the abstracts were of difficult access.

An attempt was made to establish a correlation between the said categories of use and specific chemical classes as from the data obtained in this bibliographical survey. The correlation between the presence of phytochemical classes and the therapeutic use made by the Indians was regarded as positive in cases where a reasonable part of the plants with that use possessed the phytochemical class in question.

RESULTS AND DISCUSSION

The importance of natural products in human therapeutics has been acknowledged since time immemorial. The chemical repertoire of plants is incredibly vast, probably somewhere well above 100,000 potentially active substances, of which only a minute proportion has been investigated by pharmaceutical laboratories [15]. Ethnopharmacological information on the use of medicinal plants, especially by Indians and traditional communities, are a valuable tool for a choice of plants to be studied. Unfortunately, these studies have as yet not focused as they should on fungi and animals indicated in these same ethnopharmacological studies.

The 34 publications analyzed in this revision referred to information from 26 ethnic groups, namely: Araraibo, Asurini, Baniwa, Deni, Fulni ô, Guajajara, Jamamadi, Kaapor, Krahô, Kubeo, Kuikuro, Maku, Makuna, Pankararu, Pareci, Pataxó, Paumari, Tembé, Terena, Ticuna, Tiriyó, Tukano, Xokleng, Xukuru, Yanomami, and Yawalapiti, as can be observed in Table **1**.

Table 1. Three Hundred and Seven (307) Plant Species Indicated by the Brazilian Indians During Ethnopharmacological Surveys, with Possible Effects on the Central Nervous System, and their Main Chemical Constituents Found in the Scientific Literature

Family (n° species) Species (vernacular name)	Use (as described in the literature)	Parts and form of use	Indigenous ethnic group using plant species	Chemical composition
Acanthaceae (3)				
Justicia pectoralis Jacq.	inebriating snuff		Waiká (Yanomami) [16,17]	coumarin, flavonoids, furofuranolignans, 3-phenilpropionic acid [47-50]
Justicia cf. *pectoralis* Jacq. (anador)	toothache, body ache, rheumatic pain	leaves	Pataxó [18]	
Justicia pectoralis Jacq. var. *stenophylla* Leonard (mashi-hiri)	additive (*Virola theiodora*)	leaves - snuff	Waiká (Yanomami) and others [16,19]	
Ruellia aff. *malacosperma* Greenm. (mo-ru-a-chi)	fever	a poultice of crushed leaves applied to the head	Ticuna [20]	no phytochemical data
Ruellia geminiflorsa Kunth (kana arokö)	epileptiform convulsions	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Amaranthaceae (2)				
Alternanthera dentata (Moench) Stuchlik ex R.E. Fr. (erva-de-penicilina)	fever, headache	leaves	Xokleng [22]	no phytochemical data
Cyathula prostrata (L.) Blume Blume (öpömötögö)	fever	leaves – decoction (bath)	Tiriyó [21]	steroids [51]
Amaryllidaceae (1)				
Curculigo scorzoneraefolia (Lam.) Baker (maripa-imö)	fever	roots – decoction (rubbing and massage)	Tiriyó [21]	no phytochemical data
Anacardiaceae (6)				
Anacardium giganteum W. Hancock ex Engl. (oroi)	to increase the breasts	liquid extract from roots – *in natura* (ingested or topical)	Tiriyó [21]	anacardic alcohols, tannins, flavonoids, terpenes, saponins, anagigantic acid [52,53]
Anacardium occidentale L. (cajueiro)	lower extremity pain	bark	Pataxó [18]	anacardic acid, phenolic acids, triterpenoids, flavonoids, essential oils, tannins, lactones, ketones, triterpenoids [54-62]
Mangifera indica L. (manga)	fever	leaves	Pataxó [18]	flavonoids, phenolic acids, terpenoids, anthocyanin, carotenoids, essential oils [63-72]
	pain in the backbone	leaves - decoction	Xukuru [23]	
Schinus terebinthifolius Raddi (aroeira)	fever, body ache	leaves	Pataxó [18]	flavonoids, terpenes, triterpenes, tannins [73-75]
Spondias lutea L. (mope)	to increase the breasts	liquid extract from roots – *in natura* (ingested and topical)	Tiriyó [21]	tannins, flavonoids, aldehydes, terpenoids, carotenoids [54,76,77]
Spondias mombin L.	pain	bark - decoction	Ticuna [20]	essential oils, phenolic acids, lactones, alcohols and esters, tannins [78-83]

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Spondias mombin L.	fever	leaves – infusion (for bathing head and body)	Yanomami [24]	essential oils, phenolic acids, lactones, alcohols and esters, tannins [78-83]
Annonaceae (3)				
Annona hypoglauca Mart. (arimina-imö)	muscle pain	leaves – decoction (bath and ablutions)	Tiriyó [21]	no phytochemical data
Duguetia duckei R.E. Fr. (pakira-txuwi)	fever	bark – decoction (bath)	Tiriyó [21]	no phytochemical data
Xylopia nitida Dunal (envira)	fever	bark	Asurini [25]	essential oils [84]
Apiaceae (1)				
Pimpinella anisum L. (erva-doce)	fever, chest pain	leaves	Pataxó [18]	flavonoids, essential oil, phenolic acids, coumarins [85-91]
Apocynaceae (9)				
Aspidosperma discolor A DC. (coronei, pau-quina)	fever	bark	Pataxó [18]	alkaloids [92,93]
Aspidosperma nitidum Benth. ex Müll. Arg.	toothache	bark - chewed	Waimiri-Atroari [26]	no phytochemical data
Himatanthus bracteatus (A. DC.) Woodson (a-nà-roó)	fever	leaves	Makuna [20]	no phytochemical data
Himatanthus lancifolius (Müll. Arg.) Woodson (janaúba)	fever, toothache	bark, resin	Pataxó [18]	alkaloids, iridoids [94-96]
Mandevilla illustris (Vell.) Woodson	headache	whole plant	Pareci [27]	steroids [97-98]
Mesechites trifidus (Jacq.) Müll. Arg. (epuku-imö)	headache, pain	stem – infusion (bath)	Tiriyó [21]	no phytochemical data
Parahancornia amapa (Huber) Ducke	general debility	latex of the bark	Indians living in Brazilian Amazon [28]	triterpenoids, steroids [99]
Tabernaemontana heterophylla Vahl	old people who are slow and forgetful	leaves – tea	Tukano and other Indians living in Brazilian Amazon [20, 28]	no phytochemical data
Tabernaemontana sananho Ruiz & Pav.	calmative, fever		Indians living in Brazilian Amazon [20]	no phytochemical data
	rheumatic pain	leaves and bark	Ticuna [20]	
Arecaceae (1)				
Mauritia minor Burret	to strengthening those who are weak and who no longer are interested in life because of age	fruit - beverage	Indians living in Brazilian Amazon [28]	no phytochemical data
Aristolochiaceae (1)				
Aristolochia medicinalis R.E. Schult. (loo-to-mê)	periodic attacks of an epileptic-like nature	root – infusion	Kubeo [20]	no phytochemical data
Asclepiadaceae (1)				
Asclepias curassavica L.	toothache	latex	Ticuna [20]	cardenolide glycosides, terpenoids, flavonoid glycosides, alkaloids [100-103]

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Aspleniaceae (1)				
Asplenium formosum Willd. (avenca-mirim)	toothache	whole plant – decoction	Xukuru [23]	no phytochemical data
Asteraceae (17)				
Acanthospermum hispidum DC. (pica-de-Minas)	chest pain	leaves	Pataxó [18]	sesquiterpene lactones, diterpene galactoside, alkaloids [104-106]
Achillea millefolium L. (novalgina)	fever	leaves – decoction	Indians living in the South of Brazil [29]	sesquiterpenoid, terpenoids, flavonoids aglycones, essential oil, carotenoids, alkaloids [107-113]
Achyrocline satureioides (Lam.) DC. (marcela-galego)	fever, body ache	whole plant	Pataxó [18]	flavonoids, essential oils, benzofuranes, kawa-pyrones [114-118]
Achyrocline satureioides (Lam.) DC. (poty ju)	tonic	flowers, leaves, roots – decoction	Indians living in the South of Brazil [29]	
Artemisia vulgaris L. (artemísia)	body ache	leaves	Pataxó [18]	coumarin; flavonoids; eudesmane acids, sesquiterpene lactones, cyanogenic glucoside, essential oils [119-124]
Baccharis cylindrica (Less.) DC. (carqueja)	lower extremity pain	bark	Pataxó [18]	no phytochemical data
Baccharis uncinella DC.(vassoura-do-campo)	calmative	leaves and flowers – decoction (ingested)	Xokleng [22]	essencial oils [125]
Chaptalia nutans (L.) Pol. (txawarokö)	fever	whole plant – decoction (bath)	Tiriyó [21]	coumarins [126,127]
Complaya trilobata (L.) Strother (malmequer)	fever, body ache, Rheumatic pain		Pataxó [18]	no phytochemical data
Conyza floribunda Kunth (mare-marepumpö)	fever	whole plant – decoction (bath)	Tiriyó [21]	flavonoids, tannins, sesquiterpene lactones and saponins [128,129]
Helianthus annuus L. (girassol)	fever	seed	Pataxó [18]	diterpenes, sesquiterpene lactones, flavonoids, lignans, essential oils, ketones [130-137]
Lactuca sativa L. (alface)	insomnia	leaves –tea	Terena [30]	phenolic acids, triterpenoids, saponins, flavonoids [138-141]
Mikania divaricata Poepp. (aimara ipifö)	fever	leaves – infusion (bath)	Tiriyó [21]	no phytochemical data
Neurolaena lobata (L.) R. Br. ex Cass.	fever, headache	leaves – warm water – crushed - headwash	Ticuna [20]	sesquiterpene lactones, pyrrolizidine alkaloids, flavonoids [142-146]
Piptocarpha rotundifolia (Less.) Baker (paratudo)	to stimulate appetite, tonic, rheumatic pain	tea	Terena [30]	no phytochemical data
Porophyllum ruderale (Jacq.) Cass. (arrudinho)	body ache	whole plant	Pataxó [18]	terpenoids, essential oils [147-149]
Porophyllum ruderale (Jacq.) Cass. (amescla)	toothache	leaves	Pataxó[18]	

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Tagetes erecta L.	fever	leaves	Ticuna [20]	fatty acids, essential oils, carotenoids [150-154]
Wulffia baccata (L.) Kuntze (werekeru arötöpiru)	fever	leaves – decoction (bath)	Tiriyó [21]	essential oils, triterpenes [155,156]
Bignoniaceae (9)				
Arrabidaea brachypoda (DC.) Bureau	paintful joints	whole plant–cataplasm	Pareci [27]	flavonoids [157]
Arrabidaea trailii Sprague (tapanapi)	fever	leaves – decoction (bath)	Tiriyó [21]	no phytochemical data
Callichlamys latifolia (Rich.) K. Schum.	fever	bark – infusion – imbibed	Waimiri-Atroari [26]	no phytochemical data
Jacaranda copaia (Aubl.) D. Don (marimari)	fever	leaves – decoction (bath)	Tiriyó [21]	triterpenes [158]
Mansoa standleyi (Steyerm.) A.H. Gentry	fever, headache	leaves – crushed	Ticuna [20]	no phytochemical data
Memora flavida (DC.) Bureau & K. Schum. (kuraiwêmö)	tonic	bark, roots and sap from stem – *in natura* (ingested)	Tiriyó [21]	no phytochemical data
Schlegelia macrophylla Ducke	when they refuse to eat and lose appetite	leaves – tea	Ticuna [20,28]	no phytochemical data
Schlegelia roseiflora Ducke	tonic	root	Ticuna [20]	no phytochemical data
Tanaecium nocturnum (Barb. Rodr.) Bureau & K. Schum. (koribo)	drowsiness and inability to concentrate	bark of the roots - Snuff	Paumari [4,16,17,31]	no phytochemical data
Boraginaceae (1)				
Cordia trichotoma (Vell.) Arrab. ex Steud. (louro-do-mato)	fever	leaves – decoction (ingested)	Xokleng [22]	essential oil, phenylpropanoid [159-160]
Burseraceae (3)				
Crepidospermum goudotianum (Tul.) Triana & Planch. (kuituku)	fever	leaves – decoction (bath)	Tiriyó [21]	no phytochemical data
Protium pallidum Cuatrec. (breu)	toothache	resin	Kaapor and Tembé [25]	no phytochemical data
Protium paraense Cuatrec. (breu)	headache	resin	Asurini [25]	no phytochemical data
Campanulaceae (1)				
Centropogon surinamensis (L.) C. Presl (tukuinetö)	otitis, ear ache	liquid extract from leaves – *in natura* (topical)	Tiriyó [21]	no phytochemical data
Cannaceae (1)				
Canna indica L. (pariri)	body ache	roots	Pataxó [18]	tannins [161]
Capparaceae (2)				
Crateva benthamii Eichler	tonic rheumatic pain	roots leaves (externally)	Indians living in Brazilian Amazon [20]	pentacyclic triterpenoid [162]

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Crateva tapia L.	tonic rheumatic pain	 sap (externally)	Indians living in Brazilian Amazon [20]	no phytochemical data
Caprifoliaceae (1)				
Sambucus australis Cham. & Schltdl. (sabugueiro)	fever, headache	leaves	Pataxó [18]	no phytochemical data
Cecropiaceae (1)				
Coussapoa intermedia Miq.	fever	fruit – infusion – imbibed over a period of three days	Ticuna [20]	no phytochemical data
Chloranthaceae (1)				
Hedyosmum brasiliense Miq.	rheumatic pain	flowers and leaves – tincture	Indians living in Brazilian Amazon [20]	sesquiterpene lactone [163]
Chrysobalanaceae (2)				
Licania heteromorpha Benth.	toothache	bark – decoction – chewed	Maku [20]	flavonoids, triterpenoids [164-166]
Licania humilis Cham. & Schltdl. (akukuti)	to see far (shamanism)	fruit – chewed and smeared over body and head	Yawalapiti [32]	no phytochemical data
Clusiaceae (3)				
Kielmeyera coriacea Mart. & Zucc. (pau-santo)	fever	bark (tea)	Terena [30]	benzoic acids, xanthones, flavonoids, coumarins, triterpenes [167-172]
Kielmeyera rugosa Choisy	tonic	bark (bath)	Pareci [27]	coumarins, xanthones, triterpenoids[173-175]
Vismia tomentosa Ruiz & Pav.	elderly who suffer difficulty in understanding instructions and physical degenaration	leaves – tea (chronic)	Makuna [28]	no phytochemical data
Cochlospermaceae (2)				
Cochlospermum orinocense (Kunth) Steud.	fever	bark – tea	Ticuna [20]	no phytochemical data
Cochlospermum regium (Mart.) Pilger	headache		Krahô [5]	no phytochemical data
Combretaceae (1)				
Terminalia catappa L. (amendoeiro)	fever	bark or leaves	Pataxó and other Indians living in Brazilian Amazon [18,20]	triterpenoids, flavonoids, tannins, terpenoids [176-181]
Commelinaceae (2)				
Connellia virginica L. (tokoro pömoi)	tonic	whole plant – decoction (bath and ablutions)	Tiriyó [21]	no phytochemical data

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Dichorisandra affinis Mart. (püreu-imö)	antidote against curare	leaves – infusion (ablutions)	Tiriyó [21]	no phytochemical data
Convolvulaceae (4)				
Ipomoea batatas (L.) Lam. (batata-doce)	toothache	leaves	Pataxó [18]	anthocyanins, phenolics compounds [182]
Ipomoea schomburgkii Choisy (kuriya xentü)	tonic	roots – decoction (baths)	Tiriyó [21]	no phytochemical data
Ipomoea wrighti A.Gray	body ache	whole plant – bath	Pareci [27]	no phytochemical data
Operculina alata (Ham.) Urb. (batata-de-purga)	toothache, tonic	exudate	Pataxó [18]	no phytochemical data
Curcubitaceae (2)				
Gurania pachypoda Harms	headache	leaves - crushed	Ticuna [20]	no phytochemical data
Luffa operculata (L.) Cogn. (makana)	fever	fruit	Paumari [33]	diterpenoids, saponins, cucurbitacin glucosides [183,184]
Cyperaceae (7)				
Bulbostylis junciformis (Kunth) C.B. Clarke (kumeu)	fever	leaves and colmo – decoction (bath and ablutions)	Tiriyó [21]	no phytochemical data
Bulbostylis lanata (Kunth) C.B. Clarke (kumu-imö)	fever, headache	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Cyperus articulatus L. (haro kiki)	fever	rhizoma – infusion (ingested and for bathing the head)	Yanomami [24]	flavonoids, saponins, terpenoids, ketones, tannins, essential oils [185-190]
Cyperus flavus J. Presl & C. Presl (kumeu)	fever	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Rhynchospora barbata (Vahl) Kunth (xaura-imö)	fever	leaves and stem – decoction and smoke (bath and smoke)	Tiriyó [21]	no phytochemical data
Rhynchospora nervosa (Vahl) Boeck. (tüpanapotüke)	fever	whole plant – infusion (bath and ablutions)	Tiriyó [21]	no phytochemical data
Scleria hirtella Sw. (kumeu, kumeumö)	epileptiform seizures in children	leaves and colmo – decoction (bath and ablutions)	Tiriyó [21]	essential oil [191]
Ebenaceae (1)				
Diospyros guianensis (Aubl.) Gürke (ömöriyatöimö)	tonic	leaves – infusion (baths and ablutions)	Tiriyó [21]	no phytochemical data
Elaeocarpaceae (1)				
Sloanea rufa Planch. ex Benth. (töfa-imö)	pain in the lower womb	fruit – decoction (bath)	Tiriyó [21]	no phytochemical data
Eriocaulaceae (1)				
Syngonanthus oblongus (Körn.) Ruhland	headache	whole plant (for bathing head)	Pareci [27]	no phytochemical data

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Erythroxylaceae (1)				
Erythroxylum coca L. var. *ipadu* (botô)	stimulant	leaves chewed	Maku and other Indians living in Brazilian Amazon [4,17]	tropane alkaloids, flavonoids, alkaloids [192-195]
Euphorbiaceae (9)				
Croton palanostigma Klotzsch	fever		Yanomami [24,46]	alkaloids, lignans, proanthocyanidins [196,197]
Jathropa gossypiifolia C (pinhão-roxo)	fever, headache	leaves	Pataxó [18]	diterpenoids, triterpenoids [198-200]
Jatropha curcas L.	fever	leaves - crushed	Ticuna [20]	triterpenes; phorbolesters, podocarpane diterpenoids; flavonoids, pyrrolidinones [201-207]
Manihot salicifolia Pohl	tonic	leaves and branches (ingested)	Pareci [27]	no phytochemical data
Maprounea guianensis Aubl. (paxiximö)	fever, headache	leaves – decoction (bath)	Tiriyó [21]	triterpenes, alkyl ferulates [208]
Omphalea diandra L. (warikü)	toothache	liquid extract from leaves or stem – *in natura* (topical)	Tiriyó [21]	alkaloid glycosides, aglycones [209-210]
Phyllanthus acuminatus Vahl (chihua-che)	headache	leaves – for bathing the head	Ticuna [20]	glycosides, lignans [211,212]
Phyllanthus dinizii Huber (arita-imö)	fever, body ache	leaves – infusion (bath)	Tiriyó [21]	no phytochemical data
Phyllanthus orbiculatus Rich. (ai-guapo i dapé)	body ache	whole plant	Bani [34]	no phytochemical data
Fabaceae – *sensu lato* (49)				
Alexa grandiflorsa Ducke (melancieira)	toothache	bark	Asurini [25]	pyrrolizidine-3-carboxylic acid [213]
Anadenanthera macrocarpa (Benth.) Brenan	hallucinogen		Indians living in Brazilian Amazon [35]	fisetinidol-3-O-beta-D-xylopyranoside (anadanthoside), flavonoids [214-215]
Anadenanthera peregrina (L.) Speg. (yopo)	hallucinogen	seeds, leaves and cortex – snuff	Yanomami and Indians living in Brazilian Amazon [4,12,17]	alkaloids [216]
Bauhinia acreana Harms (yapu-pacinem)	muscle pain	bark	Kaapor and Tembé [25]	no phytochemical data
Cajanus cajan (L.) Millsp. (andu)	headache	leaves	Pataxó [18]	triterpenoids, flavonoids [217,218]
Calliandra tenuiflora Benth (karauyarã)	tonic	stem – infusion (ingested)	Tiriyó [21]	no phytochemical data
Cassia latifolia G. Mey. (pokopoko inetü)	fever, headache	leaves – decoction (bath and ablutions)	Tiriyó [21]	no phytochemical data
Cassia quinquangulata Rich. (bakadoho'doho)	fever	paste from leaves	Paumari [33]	naphthopyrone derivative [219]

(Table 1) contd…

Family (n° species) Species (vernacular name)	Use (as described in the literature)	Parts and form of use	Indigenous ethnic group using plant species	Chemical composition
Clitoria guianensis (Aubl.) Benth. (yawi arokö)	antidote against curare	whole plant – decoction (topical, ablutions)	Tiriyó [21]	no phytochemical data
Clitoria javitensis (Kunth) Benth. (aiaiya)	headache	leaves, flowers, liquid extract from stem or bark – infusion (for baths and ablutions)	Tiriyó [21]	no phytochemical data
Copaifera langsdorffii Desf. (pau d´óleo)	body ache	fruit or leaves	Pataxó [18]	diterpenoids, essential oils [220-221]
Crotalaria maypurensis Kunth (xauxau)	fever	leaves and roots – decoction (bath)	Tiriyó [21]	no phytochemical data
Derris floribunda B (Benth.) Ducke (napiyarã)	headache	leaves – decoction (baths)	Tiriyó [21]	no phytochemical data
Desmodium axilare (Sw.) DC. (aware imopitökö)	fever	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Desmodium incanum DC. (mata-pasto)	fever	leaves	Pataxó [18]	no phytochemical data
Dialium guianense (Aubl.) Sandwith (jutaípororoca)	toothache	seeds	Asurini [25]	no phytochemical data
Dioclea elliptica R.H. Maxwell (aruma karau)	fever	leaves – decoction (bath)	Tiriyó [21]	no phytochemical data
Dioclea erecta Hoehne (mucunan)	to purify and fortify the body	roots washed with water that is then heated (ingested)	Kuikuro, Yawalapiti and other Indians from Alto Xingu [36,37,38]	no phytochemical data
Dioclea glabra Benth. (pömu inetü)	otitis (pain)	liquid extract of leaves – *in natura* (topical)	Tiriyó [21]	no phytochemical data
Dioclea latifolia Benth. (mucunan)	to purify and fortify the body	roots washed with water that is then warmed (ingested)	Kuikuro, Yawalapiti and other Indians from Alto Xingu [36,37,38]	no phytochemical data
Dioclea scabra (Rich.) R.H. Maxwell	fever	leaves – decoction (bath)	Tiriyó [21]	no phytochemical data
Dioclea ucayalina Harms	headache	leaves on the forehead	Ticuna [20]	no phytochemical data
Dipteryx odorata (Aubl.) Willd. (cumaru)	pain in the ribs, ear ache	seed oil	Kaapor and Tembé [25,39,40]	flavonoids, coumarins, lignans [222-224]
Discolobium leptophyllum Benth.	tonic	roots- decoction (ingested)	Yawalapiti [32]	no phytochemical data
Elizabetha princeps Schomburgk ex Benth.	adittive (*Anadenanthera peregrina*) additive (*Virola* spp.)	bark ashes bark ashes – snuff	Yanomami [12] Waiká (Yanomami) and others [19]	no phytochemical data
Eperua campestris (Ducke) Ducke	painful joints	bark (oil)	Indians living in Brazilian Amazon [20]	no phytochemical data
Erythrina glauca Willd.	rheumatic pain, narcotic	roots – tea	Indians living in Brazilian Amazon [20]	no phytochemical data

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Lonchocarpus floribundus Benth	tonic	roots grated, liquid extract smeared on leg previously scarred	Yawalapiti [32]	no phytochemical data
Hymenaea aurea Y.T. Lee & Langenh. (jatobá)	tonic	bark	Pataxó [18]	no phytochemical data
Hymenaea courbaril L. (kauru)	fever	bark – decoction (bath)	Tiriyó [21]	diterpenoids, terpenoids, enthalimane diterpenoids, clerodane diterpenoids, xyloglucan polysaccharide [225-229]
Macrolobium bifolium (Aubl.) Pers. (pare)	fever	leaves and stem – infusion (bath)	Tiriyó [21]	no phytochemical data
Macrolobium campestre Huber	tonic	bark-decoction	Pareci [27]	no phytochemical data
Mimosa hostilis (Mart.) Benth. (maconha-brava, wild marihuana, jurema, yurema)	hallucinogen	leaves and seeds - cigarettes are smoked (a substitute for marijuana) or roots – infusion - drink (jurema wine)	Pankararu, Fulni ô, Tukano and others Indians from the Brazilian coast [4,19,31,35]	indole alkaloids, labdane-type diterpenes [230,231]
Mimosa pudica L. (cipó-dorme-dorme)	insomnia	leaves and vines – decoction (ingested)	Xokleng [22]	tannins, steroids, triterpenes, flavonoids, phenolic ketone [232-237]
Mimosa tenuiflora (Willd.) Poir. (jurema-preta)	toothache	bark- grated in water (mouthwash)	Xukuru [23]	saponins, amines, 2-phenoxychromones [238-240]
Mucuna altisima (Jacq.) DC. (tamoko enu)	headache	leaves, fruit, liquid extract from stem– infusion (ingested and bath)	Tiriyó [21]	no phytochemical data
Periandra pujalu Emmerich & Senna	tonic	roots crushed in water and boiled (ingested)	Yawalapiti [32]	no phytochemical data
Phaseolus linearis Kunth (aware imopitokö)	fever, headache	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Pithecellobium dinizii Ducke	headache	caulis flowers crushed to rub on the forehead	Ticuna [20]	no phytochemical data
Pterocarpus michelii Britton (iru-luma-iriki)	antidote for *Dioclea* spp.		Indians from Alto Xingu [38]	no phytochemical data
Pterodon emarginatus Vogel	toothache	seed oil (topical)	Pareci [27]	diterpenoids [241,242]
Schizolobium amazonicum Huber ex Ducke	fever	leaves – tea	Ticuna [20]	polysaccharides [243]
Senna alata (L.) Roxb. (fedegosão)	fever, body ache	root	Pataxó [18]	flavonoids, volatile oils, steroids, anthraquinones glycoside, tannins [244,245]
Senna obtusifolia (L.) H.S. Irwin & Barneby (mata-pasto)	fever	leaves	Pataxó [18]	flavonoids, anthraquinones [246]
Swartzia recurva Poepp.	combat physical debilitation resulting from malaria, age or general infirmity	fruit- decoction	Indians living in Brazilian Amazon [28]	no phytochemical data

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Tachigalia paniculata Aubl. *Tachigalia paniculata* Aubl. (tachizeiro)	stimulant craziness fever	leaves – tea ants from petiole	Ticuna [20] Kaapor [41] Kaapor and Tembé [25]	alkaloids, flavonoids [247]
Tachigalia myrmecophila Ducke	Fever, to fatten dogs		Kaapor [41]	no phytochemical data
Tephrosia senna Kunth (senna)	fever, headache	leaves	Pataxó [18]	no phytochemical data
Zornia gemella Vogel (arrozinho)	fever	whole plant	Pataxó [18]	no phytochemical data
Flacourtiaceae (3)				
Banara guianensis Aubl. (lantama)	fever, headache	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Casearia silvestris Sw. (paxixi-imö)	fever	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Laetia procera (Poepp.) Eichler (pau-jacaré)	general debility	leaves	Kaapor and Tembé [25]	clerodane diterpenes [248-250]
Gentianaceae (2)				
Chelonanthus alatus (Aubl.) Pulle	substitute for *Nicatiana tabacum*	leaves	Indians living in Brazilian Amazon [20]	no phytochemical data
Coutoubea ramosa Aubl. (mokoko enu-imö)	toothache	liquid extract from leaves – in natura (topical, poultice)	Tiriyó [21]	no phytochemical data
Humiriaceae (1)				
Humiriastrum piraparanense Cuatrec.	toothache	bark – chewed	Makuna [20]	no phytochemical data
Lamiaceae (7)				
Hyptis hirsuta Kunth (maruipö)	pain in the sole of the foot	stem– decoction (baths and ablutions)	Tiriyó [21]	no phytochemical data
Leonotis nepetifolia (L.) R. Br. (bolo-de-frade)	fever	leaves	Pataxó [18]	no phytochemical data
Melissa officinalis L. (erva-cidreira)	calmative	tea	Terena [30]	flavonoids, essential oils, phenolic and benzoic acids, tannins [251-258]
Ocimum basilicum L. (mangericão)	fever ear ache	leaves leaves – decoction (ingested)	Pataxó [18] Xukuru [23]	phenolics acids; essential oils, tannins, anthocyanins[259-265]
Ocimum canum Sims (mangericão)	headache	leaves	Pataxó [18]	flavonoids, essential oil [266-269]
Ocimum micranthum Willd. (huo-ca)	fever	headwash with water in which leaves have been crushed	Ticuna [20]	essential oil [270,271]

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Plectranthus amboinicus (Lour.) Spreng (hortelã-da-leaves-grande)	ear ache	leaves – crushed (on the site)	Xukuru [23]	diterpenoids, essential oils [272-274]
Lauraceae (5)				
Aniba canelilla (Kunth) Mez	stimulant	bark	Indians living in Brazilian Amazon [20]	essential oils, alkaloids, flavonoids [275-279]
Nectandra amazonum Nees	fever	leaves	Pareci [27]	lignans [280]
Nectandra pisi Miq.	fever	bark – tea	Ticuna [20]	no phytochemical data
Ocotea aciphylla (Nees) Mez (airipana)	narcotic	leaves – cigarette	Yawalapiti [32]	lignans [281,282]
Persea americana Mill. (abacateiro)	rheumatic pain	fruit, leaves	Pataxó [18]	flavonoids, alkaloids, tannins, saponins, triterpene, essential oil, phenolic acid, trihydroxyheptadecane derivative, glucosylated abscisic acid [283-288]
Loganiaceae (2)				
Strychnos guianensis (Aubl.) Mart. (würarimö)	tonic	stem – infusion (ingested and external, baths)	Tiriyó [21]	lignans, alkaloids [289-291]
Strychnos javariensis Krukoff	toothache	bark – chewed	Ticuna [20]	no phytochemical data
Malpighiaceae (2)				
Banisteriopsis caapi (Spruce ex Griseb.) C.V. Morton (caapi, ayahuasca)	hallucinogen	bark – drink	Indians living in Brazilian Amazon [4,17,35]	beta-carboline alkaloids; triterpenoids, long chain alcohols [292-297]
Tetrapteris methystica (caapí-pinima)	hallucinogen	cortex – infusion (ingested) or prepared as a beverage in cold water	Maku [31]	no phytochemical data
Malvaceae (4)				
Gossypium barbadense L. (algodão)	chest pain	leaves	Pataxó [18]	gossypol [298, 299]
Malachra capitata (L.) L.	fever	leaves – decoction	Ticuna [20]	no phytochemical data
Pavonia rosa-campestris A.St.-Hil	headache	whole plant (bath)	Pareci [27]	no phytochemical data
Urena lobata L.	sedative		Indians living in Brazilian Amazon [43]	no phytochemical data
Marcgraviaceae (1)				
Marcgraviastrum elegans de Roon (no-tê-wê-tá)	elderly find difficult to sleep	leaves and flowers -tea	Kubeo [20]	no phytochemical data
Melastomataceae (5)				
Comolia microphylla Benth. (txãga-rapu)	fever	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Henriettea granulata O. Berg & Triana (pöra)	irritability and crying in small children	leaves – infusion (bath)	Tiriyó [21]	no phytochemical data

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Miconia holosericea (L.) DC (pöra-imö)	irritability and crying in small children	leaves – decoction (bath)	Tiriyó [21]	no phytochemical data
Miconia rubiginosa (Bonpl.) DC. (pöra-imö)	irritability and crying in small children	leaves – decoction (bath)	Tiriyó [21]	triterpenoids [300]
Tococa formicaria Mart.	calmative	ramifications (bath)	Pareci [27]	no phytochemical data
Meliaceae (3)				
Carapa guianensis Aubl. (andiroba)	fever	leaves	Indians living in Brazilian Amazon [20]	triterpenoids, essential oils, flavonoids, coumarin [301-303]
Trichilia macrophylla Benth. (tawariya)	tonic	bark and roots – decoction (ingested)	Tiriyó [21]	no phytochemical data
Trichilia tocacheana C. DC.	narcotic	ingested	Indians living in Brazilian Amazon [20]	no phytochemical data
Menispermaceae (6)				
Abuta concolor Poepp. & Endl.	tonic	root cataplasms	Indians living in Brazilian Amazon [20]	alkaloids [304]
Abuta imene (Mart.) Eichler	tonic for the elderly	leaves and root – decoction	Indians living in Brazilian Amazon [20,28]	alkaloids [305]
Chondrodendron platiphyllum (A. St.-Hil.) Miers (butí)	fever	leaves	Pataxó [18]	alkaloids [306]
Chondrodendron platiphyllum (A. St.-Hil.) Miers (abutua)	to stimulate appetite		Indians living in Brazilian Amazon [43]	
Chondrodendron tomentosum Ruiz & Pav.	craziness, fever, dropsy	root and stem – decoction (ingested)	Indians living in Brazilian Amazon [20,28]	curare alkaloids [307]
Odontocarya tripetala Diels	analgesic	leaves	Ticuna [20]	no phytochemical data
Sciadotenia pachnococca Krukoff & Barneby (tugbiden)	tootache	root bark	Maku [33]	no phytochemical data
Monimiaceae (1)				
Siparuna guianensis Aubl. (negramina)	rheumatic pain	leaves brewed into tea or juice from the root bark lining	Jamamadi and Pataxó [18,33]	essential oil, oxoaporphine alkaloids, flavonoids [308-310]
Siparuna guianensis Aubl. (irakö epü)	fever	leaves – decoction (banho)	Tiriyó [21]	
Moraceae (7)				
Brosimum acutifolium Huber (inharé)	stimulant, tonic	bark – bottled brew (ingested)	Guajajara [44]	flavonoids, steroids, lignans [311-315]
Dorstenia asaroides Hook. (munufö ampotü)	fever	rhizoma – decoction (bath)	Tiriyó [21]	furanocoumarins [316]
Ficus anthelmintica Mart.	aphrodisiac, improve memory	fruit	Indians living in Brazilian Amazon [20]	no phytochemical data
Ficus paraensis (Miq.) Miq.	toothache	latex	Makuna [20]	no phytochemical data
Ficus paraensis (Miq.) Miq. (madebwa)	rheumatic pain	latex	Paumari [33]	

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Helicostylis tomentosa (Poepp. & Endl.) Rusby (takini)	hallucinogen	sap (bark)	Karib Indians [4]	essential oils [317]
Maquira calophylla (Poepp. & Endl.) C.C. Berg	narcotic	fruit – snuff	Indians living in Brazilian Amazon [20]	cardiac glycoside, furanocoumarins [318, 319]
Maquira sclerophylla (Ducke) C.C. Berg (rapé-dos-índios)	hallucinogen	fruit – snuff aspirated	Indians living in Brazilian Amazon [16,20,31]	cardiac glycoside [320,321]
Musaceae (1)				
Musa paradisiaca L. (banana)	headache	latex from leaves	Xukuru [23]	steroids, triterpenes, tannins [322-325]
Myrsinaceae (2)				
Conomorpha cf. *obovata* (Ruiz Lopez & Pavon) Werdermann	toothache	root	Bará-Maku (Yanomami) [20]	no phytochemical data
Cybianthus subspicatus Benth. ex Miq. (amorimpö panaire)	dizziness, blurred/darkened vision (epileptic seizure)	leaves – decoction (baths and ablutions)	Tiriyó [21]	no phytochemical data
Myristicaceae (5)				
Virola calophylla (Spruce) Warb. (yakee, paricá, epená, nyakwana)	hallucinogen	reddish bark resin	Waiká and Surara (both Yanomami) and others [19,35]	lignans, alkaloids, flavonoids [326, 327]
Virola calophylloidea Markgr. (yakee, paricá, epená, nyakwana)	hallucinogen	reddish bark resin	Waiká (Yanomami), Tukano, Araraibo and others [19,35]	flavonoids, lignans [328,329]
Virola elongata (Benth.) Warb.	hallucinogen		Surara (Yanomami) [35]	lignans, arylalkanones, acylresorcinols [330-333]
Virola michelii Heckel	pain		Kaapor [41]	flavonoids, lignans [334]
Virola theiodora (Spruce ex Benth.) Warb. (yakee, paricá, epená, nyakwana)	hallucinogen	resin (bark) - snuff aspirated	Tukano, Waiká (Yanomami) and others [4,16,19,31,35,45]	no phytochemical data
Myrtaceae (5)				
Acca sellowiana (O. Berg) Burret (goiabeira)	body ache	leaves - decoction	Indians from the South of Brazil [29]	flavonoids [335]
Eugenia cauliflora O. Berg (jabuticaba)	body ache	bark, leaves	Pataxó [18]	no phytochemical data
Eugenia uniflora L. (pitanga)	fever, headache	leaves	Pataxó [18]	anthocyanin, essential oils, alkaloids, carotenoids [336-340]
Myrcia multiflora (Lam.) DC. (nono atü)	antidote against curare	ramifications, leaves, roots, bark – decoction (topical and ablutions)	Tiriyó [21]	flavonoids, triterpene [341,342]
Psidium quineense Sw. (araçá)	arthritis (pain)	whole plant	Pataxó [18]	no phytochemical data
Nyctaginaceae (1)				
Boerhavia coccinea Mill. (pega-pinto)	stimulant, tonic	leaves and roots – decoction (ingested)	Guajajara [44]	proanthocyanidins [343]

(Table 1) contd…

Family (n° species) Species (vernacular name)	Use (as described in the literature)	Parts and form of use	Indigenous ethnic group using plant species	Chemical composition
Ochnaceae (1)				
Ouratea castaneifolia (DC.) Engl. (waya-imö)	epileptiform convulsions	leaves and fruit – infusion (baths and ablutions)	Tiriyó [21]	no phytochemical data
Olacaceae (1)				
Ptychopetalum olacoides Benth.	tonic, neuromuscular problems, sexual debility, rheumatic pain	roots and stem – decoction –tea – internally	Indians living in Brazilian Amazon [20]	essential oils, flavonoids [344,345]
Onagraceae (1)				
Ludwigia nervosa (Poir.) H. Hara (papamã)	muscle pain	roots – decoction (ingested and bath)	Tiriyó [21]	no phytochemical data
Orchidaceae (3)				
Epidendrum nocturnum Jacq.	body ache	whole plant (bath)	Pareci [27]	no phytochemical data
Oncidium nanum Lindl.	headache	whole plant (bath)	Pareci [27]	no phytochemical data
Pleurothallis rubens Lindl. (barba-de-São-Sim)	headache, fever		Xukuru [23]	no phytochemical data
Papaveraceae (1)				
Argemone mexicana L. (cardo-santo)	chest pain	leaves, seeds	Pataxó [18]	benzylisoquinoline alkaloids, alkaloids, long chain alcohols, fatty acids [346-350]
Passifloraceae (4)				
Passiflora alata Curtis (maracujá-açú)	fever	leaves, fruit	Pataxó [18]	saponins, triterpenoids, flavonoids [351-356]
Passiflora costata Mast. (tawa)	headache	leaves – decoction (bath)	Tiriyó [21]	no phytochemical data
Passiflora edulis Sims (maracujá)	body ache calmative	leaves, fruit flowers and leaves – decoction (ingested)	Pataxó [18] Xokleng [22]	flavonoids, tannins, triterpenoids, saponins, cyanogenic glucosides, carotenoids [357-362]
Passiflora laurifolia L.	induce sleep	leaves – decoction	Kubeo [20]	no phytochemical data
Piperaceae (7)				
Peperomia macrostachya (Vahl) A Dietr. (kona hamaki)	fever	leaves – infusion (head and body bathed)	Yanomami [24]	no phytochemical data
Peperomia magnoliifolia (Jacq.) A. Dietr.	fever		Yanomami [46]	no phytochemical data
Peperomia obtusifolia (L.) A. Dietr.	rheumatic pain	leaves crushed	Kubeo [20]	phenolic compounds [363]
Piper arborea Aubl.	fever		Yanomami [46]	no phytochemical data
Piper arboreum Aubl. (katu mahi)	fever	leaves – infusion (head and body bathed)	Yanomami [24]	amides, pyridone alkaloids, essential oils [364-367]
Piper daguanum C. DC.	toothache	roots – chewed	Ticuna [20]	no phytochemical data

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Pothomorphe umbellata (L.) Miq. (capeba)	fever	leaves	Pataxó [18]	nerolidylcathecol, N-benzoyl-mescaline [368-370]
Phytolaccaceae (1)				
Petiveria alliacea L. (guiné)	body ache	liquid smeared on body, guiné roots and tobacco leaves	Terena [30]	flavonoids, coumarins, triterpenoids, essential oils [371-374]
Poaceae (11)				
Andropogon leucostachyus Kunth (ói)	fever	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Axonopus pulcher (Nees) Kuhlm. (ói)	fever	whole plant – decoction (bath e ablutions)	Tiriyó [21]	no phytochemical data
Cymbopogon citratus (DC.) Stapf (capim-santo)	fever, headache calmative	leaves – tea - crushed whole plant – decoction (ingested)	Ticuna [20] Xukuru [23]	flavonoids, essential oils, triterpenoids [375-380]
Elionurus adustus (Trin.) Ekman (xaura-imö)	fever	whole plant – decoction (bath e ablutions)	Tiriyó [21]	no phytochemical data
Eriochrysis cayennensis P. Beauv. (kumeau)	fever with pain	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Imperata brasiliensis Trin. (sapé) *Imperata brasiliensis* Trin. (capim-sapé)	toothache fever	root roots – decoction (ingested)	Pataxó [18] Xokleng [22]	no phytochemical data
Panicum cyanescens Nees ex Trin. (xaura-imö)	fever	leaves and roots – decoction (bath)	Tiriyó [21]	no phytochemical data
Panicum nervosum Lam. (xaura-imö)	fever, headache	whole plant –decoction (ingested and bath)	Tiriyó [21]	no phytochemical data
Paspalum serpentinum Hochst. ex Steud. (ói)	fever	whole plant – decoction (bath and ablutions)	Tiriyó [21]	no phytochemical data
Piresia leptophylla Soderstr. (acanfor-de-remédio)	to combat fatigue	leaves – decoction (ingested)	Xukuru [23]	no phytochemical data
Trachypogon plumosus (Humb. & Bonpl. ex Willd.) Nees (ói)	fever	whole plant – decoction (bath and ablutions)	Tiriyó [21]	no phytochemical data
Polygalaceae (1)				
Polygala asperuloides Kunth (txawiri)	headache	whole plant – decoction (baths)	Tiriyó [21]	no phytochemical data
Polypodiaceae (1)				
Polypodium polypodioides (L.) Watt (arekore ayomi)	fever	leaves – decoction (bath)	Tiriyó [21]	triterpenoids [381]
Proteaceae (3)				
*Panopsis rubescens (*Pohl) Rusby (txorana)	fever	bark- decoction (bath)	Tiriyó [21]	alkylresorcinols [382]

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Panopsis sessilifolia (Rich.) Sandwith (koiyarä)	fever (children)	leaves, bark and roots – decoction (bath)	Tiriyó [21]	no phytochemical data
Roupala obtusata Klotzsch (ariki arokö)	epileptiform convulsions	stem – decoction (baths)	Tiriyó [21]	no phytochemical data
Pteridaceae (1)				
Adiantum serratodentatum Humb. & Bonpl. ex Willd. (püyari epü)	headache	leaves – decoction (baths and ablutions)	Tiriyó [21]	no phytochemical data
Rosaceae (1)				
Rubus brasiliensis Mart. (amora-do-mato)	to lose weight	leaves – decoction (ingested)	Xokleng [22]	flavonoids [383,384]
Rubiaceae (14)				
Bertiera guianensis Aubl. (Tüpan-apopire)	dizziness and blurred/darkened vision (epileptic seizures)	leaves – decoction (baths)	Tiriyó [21]	no phytochemical data
Borreria verticillata (L.) G. Mey. (João-duru)	rheumatic pain	root	Pataxó [18]	iridoids, alkaloids [385-387]
Coccocypselum guianense (Aubl.) K. Schum. (mami enawetu)	fever	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Coutarea hexandra (Jacq.) K. Schum. (quina-quina)	fever	leaves – decoction (ingested)	Xukuru [23]	coumarins, flavonoids [388-391]
Declieuxia fruticosa (Willd. ex Roem. & Schult.) Kuntze	pain in legs	whole plant (bath)	Pareci [27]	no phytochemical data
Diodia ocimifolia (Willd. ex Roem. & Schult.) Bremek. (pöröru ella)	pain in anus	whole plant – carbonization (smoke)	Tiriyó [21]	no phytochemical data
Guettarda viburnoides Cham. & Schltdl.	tonic	roots grated, liquid extract smeared over arm previously scarred	Yawalapiti [36]	no phytochemical data
Palicourea coriacea (Cham.) K. Schum	pain, fever	leaves – tea	Pareci [27]	no phytochemical data
Perama hirsuta Aubl. (werekeru arötöpiru)	toothache	liquid extract from leaves – heated (topical)	Tiriyó [21]	no phytochemical data
Psychotria viridis Ruiz & Pav. (yajé)	hallucinogen	wine	Indians living in Brazilian Amazon [17]	alkaloids [392]
Randia armata (Sw.) DC. (pörepana)	epileptiform convulsions	leaves – decoction (bath)	Tiriyó [21]	no phytochemical data
Sipanea pratensis Aubl. (pöreru eya)	fever, headache	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Tocoyena formosa (Cham. & Schltdl.) K. Schum. (waxana-imö)	fever	leaves, bark and roots – decoction (bath)	Tiriyó [21]	triterpenoids, iridoids, flavonoids [393-395]
Uncaria guianensis (Aubl.) J.F. Gmel. (piyanaro)	otitis (pain)	liquid extract from stem of vine – *in natura* (topical)	Tiriyó [21]	alkaloids, quinovic acid glycosides [396-400]

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Rutaceae (7)				
Citrus aurantifolia (Christm.) Swingle	fever	fruit (juice)	Ticuna [20]	essential oils, flavonoids, coumarins, sesquiterpene hydrocarbons [401-405]
Galipea jasminiflora (A. St.-Hil.) Engl. (akucikarandu'wa)	fever	bark	Asurini [25]	no phytochemical data
Pilocarpus pennatifolius Lem. (ibirarta-iba)	sedative		Indians living in Brazilian Amazon [43]	no phytochemical data
Ruta graveolens L. (arruda-macho)	headache, ear ache	leaves – decoction - liquid extract from leaves dripped into ear	Xukuru [23]	alkaloids, ketones, essential oils, flavonoids [406-411]
Spiranthera odoratissima A. St.-Hil.	tonic	roots – decoction (steam bath)	Yawalapiti [36]	coumarins, indoloquinazoline alkaloids, limonoids, furoquinoline alkaloids [412-414]
Zanthoxylum pentandrum (Aubl.) R.A. Howard	toothache	bark grated and applied as a wad on lips	Yanomami [36]	no phytochemical data
Zanthoxylum rhoifolium Lam. (laranjeira-brava)	fever		Pataxó [18]	benzophenanthridine alkaloids, essential oils [415-417]
Sapindaceae (2)				
Paullinia cupana Kunth	stimulant	seeds	Indians living in Brazilian Amazon [20]	purine alkaloids, flavonoids, tannins [418-422]
Talisia cerasina (Benth.) Radlk. (wayanaturi)	fever (children)	leaves – decoction (bath)	Tiriyó[21]	no phytochemical data
Sapotaceae (2)				
Micropholis cyrtobotrya (Mart. ex Miq.) Baill. (aware parahta)	fever	liquid extract from leaves – infusion (oral and bath)	Tiriyó[21]	no phytochemical data
Micropholis guyanensis (A. DC.) Pierre	fever	liquid extract from leaves – infusion (oral and bath)	Tiriyó[21]	no phytochemical data
Schizaeaceae (1)				
Schizaea pennula Sw.	headache	whole plant (bath)	Pareci [27]	no phytochemical data
Smilacaceae (1)				
Smilax aequatorialis (Griseb.) A. DC.	re-establishing virility	root	Makuna [20]	no phytochemical data
Solanaceae (8)				
Brugmansia insignis (Barb. Rodr.) R.E. Schult.	sedative	leaves	Indians living in Brazilian Amazon [20]	no phytochemical data
Brugmansia insignis (Barb. Rodr.) R.E. Schult. and *Banisteriopsis caapi* (Spruce ex Griseb.) C.V. Morton (Malpighiaceae)	hallucinogen	leaves		

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Cestrum laevigatum Schltdl. (dama-da-noche)	psychoactive	leaves – cigarette – substitute for marijuana	Índias from the Brazilian coast [31]	no phytochemical data
Nicotiana tabacum L.	psychoactive	leaves	Indians living in Brazilian Amazon [16]	alkaloids, lactones, phenolic compounds [423-426]
Nicotiana tabacum L. (fumo) and *Petiveria alliacea* L. (guiné) (Phytolaccaceae)	body ache	liquid smeared on body, guiné roots and tobacco leaves	Terena [30]	
Nicotiana tabacum L. and *Theobroma subincanum* Martius in Buchner (Sterculiaceae) (shinã)	hallucinogen	tobacco leaves and bark ash of various species of cacao – snuff	Jamamadi and Deni [17]	
Physalis angulata L.	ear ache	sap	Indians living in Brazilian Amazon [20]	steroids, flavonoids, alkaloids, withanolide [427-430]
Physalis angulata L. (fé-de-terra)	fever	leaves	Pataxó [18]	
Schwenkia americana L. (txãga-rapu-imö)	fever	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Solanum americanum Mill. (erva-moura)	toothache	leaves + white rum – decoction (mouthwash)	Xokleng [22]	alkaloids[431]
Solanum asperum Rich (mokoko-enu)	toothache	liquid extract from leaves – *in natura* (topical)	Tiriyó [21]	alkaloids [432,433]
Solanum mauritianum Scop. (fumo-bravo)	fever, headache	leaves on forehead (poultice)	Xokleng [22]	alkaloids [434]
Sterculiaceae (2)				
Theobroma subincanum Martius in Buchner	additive (*Virola* spp.)	bark ashes - snuff	Indians living in Brazilian Amazon [19]	steroids, fatty acids [435,436]
Waltheria indica L. (malva-branca)	fever	whole plant	Pataxó [18]	flavonoids [437]
Theophrastaceae (1)				
Clavija membranacea Mez	rheumatic pain	root - decoction	Ticuna [20]	no phytochemical data
Thymelaeaceae (1)				
Schoenobiblus daphnoides Mart. (txawa arokö)	fever	liquid extract from bark – *in natura* (topical)	Tiriyó [21]	no phytochemical data
Turneraceae (2)				
Piriqueta cistoides (L.) Griseb. (wüyu-imö)	fever	whole plant – decoction (bath)	Tiriyó [21]	no phytochemical data
Turnera ulmifolia L. (piyuru ampotü)	headache	leaves – decoction (baths)	Tiriyó [21]	flavonoids, alkaloids, essential oils,[438-440]
Urticaceae (1)				
Urera baccifera (L.) Gaudich. ex Wedd.	pain, arthritis, tonic	whole plant (including fruit)	Yanomami [24]	flavonoids [441,442]
Verbenaceae (7)				

(Table 1) contd…

Family (n° species) Species (vernacular name)	**Use (as described in the literature)**	**Parts and form of use**	**Indigenous ethnic group using plant species**	**Chemical composition**
Amasonia angustifolia Mart. & Schauer (würüpö ixömã)	fever, headache	leaves – decoction (bath)	Tiriyó [21]	no phytochemical data
Amasonia campestris (Aubl.) Moldenke	tonic	whole plant (bath)	Pareci [27]	no phytochemical data
Lantana trifolia L. (maruipö)	fever, headache	whole plant – decoction (bath)	Tiriyó [21]	essential oil, flavonoids [443]
Lippia alba (Mill.) N.E. Br (cidreira)	to calm	leaves – decoction (ingested)	Xukuru [23]	aldehydes, saponins, sterols, flavonoids, essential oils, terpenoids, phenolic acids [446-456]
Lippia alba (Mill.) N.E. Br. (erva-cidreira)	fever	leaves	Pataxó [18]	
Stachytarpheta sprucei Moldenke	fever	leaves – tea	Pareci [27]	no phytochemical data
Stachytarpheta straminea Moldenke	fever	leaves crushed (for washing)	Ticuna [20]	no phytochemical data
Verbena erinoides Lam.	to stimulate appetite		Indians living in Brazilian Amazon [43]	no phytochemical data
Violaceae (2)				
Alsodeia guianensis (Aubl.) Eichler. (kana arokö)	epileptiform convulsions	leaves and bark – decoction (bath)	Tiriyó [21]	no phytochemical data
Hybanthus calceolaria (L.) Schulze-Menz (purga-do-campo)	fever	whole plant, root	Pataxó [18]	no phytochemical data
Vitaceae (1)				
Cissus sulcicaulis (Baker) Planch. (napökö-imö)	toothache	liquid extract from stem – *in natura* (topical and tampon)	Tiriyó [21]	no phytochemical data
Vochysiaceae (1)				
Salvertia convallariodora A. St.-Hil	body ache	bark (poultice and bath)	Pareci [27]	no phytochemical data
Zingiberaceae (3)				
Alpinia zerumbet (Pers.) B.L. Burtt & R.M. Sm. (colônia)	fever, headache	leaves	Pataxó [18]	essential oils, kava-pyrones, flavonoids, labdane diterpenes [457-462]
Renealmia alpinia (Rottb.) Maas	headache, general debility	branch (stem)	Yanomami [24]	labdane diterpenoids, essential oils [463,465]
Zingiber officinale Roscoe	toothache, rheumatic pain	rhizoma chewed or whole plant	Ticuna and Yanomami [20,24]	diarylheptanoids, phenolic compounds, ketones, phenolic acids, essential oils, diterpenoids, anthocyanin [466-481]

In addition, the said publications supply information concerning the Indians in a generic way – those that belong to the Karib language, those that inhabit the Brazilian Amazon, the south of Brazil, the Brazilian coast, and the Alto Xingu regions. Another three ethnic groups – Bará-Maku, Surara, and Waiká, although included in Table **1**, according to the nomenclature cited in their respective publications, are not included in the map in (Fig. **1**), for they belong to the Yanomami ethnic group.

Fig. (1). Map of South America showing the geographic location on Brazilian territory of each one of the 26 indigenous ethnic groups analyzed in this study (*apud* Brock University Map Library [482]). 1- Araraibo, 2- Asurini, 3- Baniwa, 4- Deni, 5- Fulni ô, 6- Guajajara, 7- Jamamadi, 8- Kaapor, 9- Krahô, 10- Kubeo, 11- Kuikuro, 12- Maku, 13- Makuna, 14- Pankararu, 15- Pataxó, 16- Pareci, 17- Paumari, 18- Tembé, 19- Terena, 20- Ticuna, 21- Tiriyó, 22- Tukano, 23- Xokleng, 24- Xukuru, 25- Yanomami, and 26- Yawalapiti.

The map shows that the 26 ethnic groups inhabit four of the Brazilian biomas: the Amazon forest, the caatinga semi-arid lands, the cerrado brushlands, and the Atlantic rain forest which, provides considerable biological diversity to the plants listed in this review.

Table **1** shows the 307 plants that are recorded in this study, as from the ethnopharmacological literature, from 26 Brazilian ethnic groups. Of the 307 species, only one is not an angiosperm: *Adiantum serratodentatum* Humb. & Bonpl. ex Willd. (püyari epü), namely a fern from the Pteridaceae family. The species belong to 85 taxonomic families, mostly Fabaceae (49 species recorded), Asteraceae (17), Rubiaceae (14), Poaceae (11), Apocynaceae (9), Bignoniaceae (9), Euphorbiaceae (9), Solanaceae (8), Cyperaceae (7), Lamiaceae (7), Piperaceae (7), Rutaceae (7), Verbenaceae (7), and Moraceae (7). The Fabaceae, Euphorbiaceae, Asteraceae, Bignoniaceae, and Rubiaceae families are also among the most cited in an ethnopharmacological survey carried out among the Krahô Indians that, like the present study, analyzed the plants with possible action on the CNS [5].

The 307 plants are used to treat 67 different complaints and/or ailments which is suggestive that they may, in some way, be active on the CNS: these uses were further grouped into 12 categories according to similarities between their expected effects on the CNS, as can be seen in Table **2**. They are: analgesics, to counteract fever, tonics/adaptogens, hallucinogens, anxiolytics, anticonvulsants, head illnesses, hypnotics/sedatives, stimulants, weight control, memory enhancers, and others (no defined effect). For example, category 1 - analgesics concerns 18 uses (arthritis; analgesic; body ache; chest pain; pain in the anus; muscle pain; pain in the backbone; pain in the sole of the foot; pain in the ribs; ear ache; pain in the lower womb; rheumatic pain; headache; toothache; pain; lower extremity pain, otitis, painful joints) and comprehended a total of 132 plants employed to alleviate these several kinds of pain.

On some occasions, the same species was cited for more than one use; for example, some plants indicated for fever are also utilized for headaches, since the use "fever with headache" was recurrent. Some pathologies, such as rheumatism and arthritis were included under the category analgesics, because they were indicated to counteract pain resulting from these diseases.

Fig. **2** shows the number of plants indicated for each one of the 12 categories, where six of these (marked by an asterisk), seem to exert possible psychoactive action/effects: hallucinogens, anxiolytics, head illnesses, stimulants, hypnotics, and memory enhancers.

A bibliographic survey with the plants from this survey showed that, of the 307 plants listed, 135 have been the subject of some type of scientific study (from the phytochemical point of view) available on the PubMed or Web of Science data base. The 172 others have not yet been studied from that point of view, or, these studies are to be found in theses and other articles of difficult access. The majority of plants whose chemical constitution has not yet been studied belong to the therapeutics of the Tiriyó, the Yawalapiti, and the Pareci Indians. These ethnic groups inhabit the Amazon forest and cerrado brushland biomas - Fig. **1**. The dearth of studies of the plants utilized by them may be indicative of greater isolation of their cultures, based on plants of the region, probably little explored. Several of the plants utilized by the Pareci were not included in this survey, for they were identified only as far as genus [27]. A lack of identification in some cases may have occurred through the non-availability of adequate material (fertile branches); moreover, some of these plants could possibly be new species.

Classifying of several uses/indications of the plants per category showed that **analgesics** and **to counteract fever** are in the lead in number of species, with 132 and 120 species respectively. The first category was, likewise, the second most cited (48 plants) in another ethnopharmacological survey among the Krahô Indians [5]. And, it may have ranked second because the leading category in that ethnic group was tonics, since the status of "champion runner" is extremely important culturally to these peoples.

In Table **2**, the main active principles found in the plants to which are attributed analgesic activity are, by decreasing order of number of citations in articles: flavonoids, alkaloids, triterpenoids, phenolic compounds, and coumarins. If we consider that the flavonoids, coumarins, and phenolic compounds possess phenolic groups in their structure, this group would, by far, be in greatest evidence among the plants utilized as analgesics in this survey. For instance, in the case of *Justicia pectoralis*, one of the species utilized by

Table 2. Frequency of Different Phytochemical Classes Among the Plants Indicated by the Brazilian Indians, with Possible Effects on the Central Nervous System (Grouped into 12 Categories of Use)

Categories of use (number of uses cited in the literature)	Number of species	Chemical constituents found in the scientific literature (number of plants that present the chemical constituent listed)
1- Analgesics (18) 1- arthritis (pain); 2- analgesic; 3- body ache; 4- chest pain; 5- pain in the anus; 6- muscle pain; 7- pain in the backbone; 8- pain in the sole of the foot; 9- pain in the ribs; 10- ear ache; 11- pain in the lower womb; 12- rheumatic pain; 13- headache; 14- toothache; 15- pain; 16- lower extremity pain; 17- otitis (pain); 18- painful joints.	132	flavonoids (28); alkaloids (18); essential oil (18); phenolic acids (9); triterpenoid (9); tannins (6); coumarin (5); terpenes (5); diterpenoids (4); steroids (3); glycosides (2); saponins (2); iridoids (2); sesquiterpene lactones (2); lactones (2); labdane diterpenes (2); diterpene galactoside (1); eudesmane acids (1); kava-pyrones (1); ketones (1); lignans (1); aliphatic compounds (1); polyacetylene compounds (1); sesquiterpene alcohols (1); lignan (1); aldehydes (1); anthocyanins (1); cardenolides (1); furanone (1).
2- Fever (3) 1- fever; 2- fever (children); 3- fever with pain.	120	flavonoids (26); essential oil (22); triterpenoid (17); tannins (13); alkaloids (12); saponins (6); coumarins (5); phenolic acids (7); iridoids (4); steroids (5); anthraquinones (2); terpenes (2); polysaccharides (2); sesquiterpene (2); lactones (2); lignans (2); diterpenoids neocucurbitacins (1); furanone (1); furanocoumarin (1); kava-pyrones (1); ketones (1); labdane diterpenes (1); naphthopyrone derivative (1); phenylpropanoid (1); phorbolesters (1); podocarpane diterpenoids (1); sesquiterpenic lactones (1); xanthones (1); diterpenoids (1); fatty acids (1); alkylresorcinols (1); amides (1); chromenes (1).
3- Tonics and/or adaptogens (15) 1- aphrodisiac; 2- combat physical debilitation resulting from malaria; 3- age or general infirmity; 4- to combat tiredness; 5- drowsiness and inability to concentrate; 6- elderly who suffer difficulty in understanding instructions and physical degeneration; 7- general debility; 8- old people who are slow; 9- tonic; 10- to purify and fortify the body 11- re-establishing virility; 12- to strengthening those who are weak and who no longer are interested in life because of age; 13- tonic for the elderly; 14- neuromuscular problems; 15- sexual debility.	40	alkaloids (4); coumarins (2); triterpenoids (2); flavonoids (1); lignans (1); essential oils (1); clerodane diterpenes (1); xanthones (1); terpenes (1); labdane diterpenoids (1).
4- Hallucinogens (9) 1- hallucinogen; 2- additive (*Virola* spp.); 3- additive (*Virola theiodora*); 4- adittive (*Anadenanthera peregrina*); 5- inebriating snuff; 6- narcotic; 7- psychoactive; 8- substitute for *Nicotiana tabacum;*9- to see far (shamanism).	25	alkaloids (10); lignans (5); coumarin (3); phenolic acids (3); flavonoids (2); cardiac glycoside (2); steroids (2); diterpenes (1); triterpenoids (1); tannins (1); O-methoxylated-C-glycosylflavones lactones (1); neolignans (1); furanocoumarins (1).
5- Anxiolytics (3) 1- calmative; 2- irritability and crying in small children; 3- to calm.	10	flavonoids (4); essential oils (4); tannins (2); alkaloids (2); triterpenoids (2); saponins (1); sterols (1); naphtoquinones (1); iridoids (1); glycosides (1).
6- Anticonvulsants (4) 1- seizures (children); 2- seizures; 3- periodic attacks of an epileptic-like nature; 4- dizziness and blurred/darkened vision (seizure).	9	essential oil (1).
7- Hypnotics (4) 1- induce sleep; 2- insomnia; 3- sedative; 4- elderly find difficult to sleep.	7	flavonoids (3); triterpenoids (2); saponins (2); phenolic acids (1); essential oils (1); tannins (1); steroids (1); alkaloids (1).
8- Stimulants(1) 1- stimulant.	6	flavonoids (3); alkaloids (2); steroids (1); lignans (1); proanthocyanidins (1); essential oils (1); purine alkaloids (1); indole alkylamines (1).
9- Weight control (4) 1- to fatten dogs; 2- to lose weight; 3- to stimulate appetite; 4- when they refuse to eat and lose appetite	6	flavonoids (2); alkaloids (1).

(Table 2) contd…

Categories of use (number of uses cited in the literature)	Number of species	Chemical constituents found in the scientific literature (number of plants that present the chemical constituent listed)
10- Others (3) 1- antidote against curare; 2- antidote against *Dioclea* spp.; 3- as stimulant for growth of breasts.	6	flavonoids (4); tannins (3), ginkgolides (1); alkyl and arylalkyl-1,3-diols (1); saponins (1); alcohols (1); aldehydes (1); terpenes (1); triterpene (1).
11- Head illnesses (1) 1- craziness.	2	curare alkaloids (1).
12- Memory enhancers (2) 1- improve memory; 2- old people who are forgetful.	2	

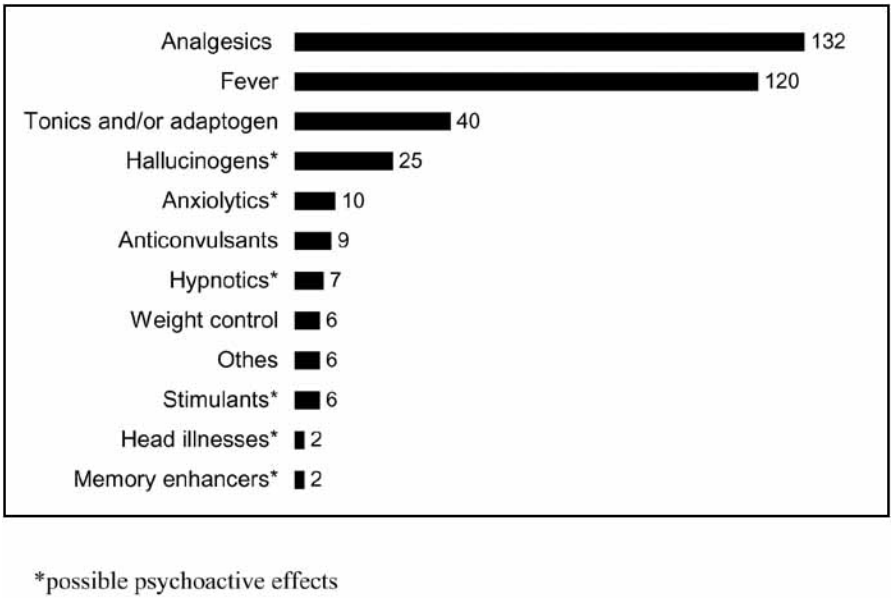

Fig. (2). Number of plants indicated for each one of the 12 categories of use that were indicated by the 26 Brazilian indigenous groups under study.

Yanomani, Pataxó, and other Indians in the Amazon forest, analgesic activity was attributed to the presence of coumarins [47]. Coumarin and umbelliferone presented antinociceptive and antiinflammatory activity in animal models [47,483]. Tannins, less frequent in plants of the analgesic categories, possess phenolic groups and have been the object of studies on their antinociceptive activity [484].

Research has shown that the analgesic activity of certain flavonoids depends on their structure. For instance, some authors have demonstrated that glycosylated flavonoids [485,486] are more active than the aglicone flavonoids [487]. Certain flavonoids, such as quercetin and flavones are known to inhibit the biosynthesis of prostaglandins by inhibiting the cyclooxigenase enzyme [488]. Various flavonoids, including rutin and quercetin produce significant antinociception in the acetic acid-, formalin- and capsaicin-induced nociceptive response [489].

Morphine (morphinan alkaloid) is the most famous example of an alkaloid with analgesic activity and one of the most powerful, showing that this phytochemical class is also rich in constituents with the said action, especially among the indolic alkaloids [489-492]. Alkaloids isolated from *Psychotria colorata* show marked naloxone-reversible antinociceptive activity in animals [493]. Some essential oils and terpenoids have also been described as possessing antiinflammatory and antinociceptive activity [494-496].

Among the 132 plants in the analgesic category, 19 have been the object of some kind of pharmacological study supporting indigenous use: *Justicia pectoralis, Anacardium occidentale, Neurolaena lobata, Hedyosmum brasiliense, Miconia rubiginosa, Cymbopogon citratus, Urera baccifera, Phyllanthus orbiculatus, Ocimum basilicum, Virola michelli, Petiveria alliacea, Uncaria guianensis, Physalis angulata, Lantana trifolia, Alpinia zerumbet, Zingiber officinalis, Mangifera indica,* and *Nicotiana tabacum* [47,59,143,163,300,378,442,497-508]. These spe-cies were studied in several animal models with results suggestive of antinociceptive action. On the other hand, patients with sickle cell anaemia related reduction of painful crises after taking an extract of *Cajanus cajan* [509], while patients taking *Zingiber officinalis* reported relief in rheumatic pain [510].

The second category most indicated, **to counteract fever**, may be justified in view of the high incidence of malaria in the Amazon region, one symptom being running a high temperature. Considering the greater part of the ethnic groups

in this review are to be found in the Amazon region, it can be inferred that the great number of species indicated for this category are explained by local therapeutic needs.

The main phytochemical classes of plants employed by the Indians to counteract fever are flavonoids, essential oils, triterpenoids, tannins, and alkaloids. Naphtoquinones, saponins, and coumarins were present in a lesser proportion of plants. Some flavonoids [511,512] and essential oils [513] are known to significantly reduce fever. Many antipyretic drugs also act as analgesics and antiinflammatory drugs. Acetylsalicylic acid, derived from salicylic acid isolated from *Salix* sp. is one example [489]. Many drugs with this threefold effect (analgesic-antipyretic-antiinflammatory), however, exert peripheral action [489]. It is therefore logical that the flavonoids have been the constituents most found among the plants utilized for analgesia such as those against fever, even because, in some cases, the plant was indicated to combat fever, in general, with pain (Table **1**). *Solanum mauritianum*, utilized against fever with headache by the Xokleng Indians, inhibited the synthesis of prostaglandins in a study carried out by Jager *et. al.* (1996) [514]. *Chaptalia nutans*, in turn, presented a hypothermic effect [441], indicative that it may, in fact, be useful against fever.

The hallucinogen category is also one of the most cited, with 25 plants indicated. Many of the plants in this category are utilized for shamanism practices by supposedly altering the perception of the shaman, to facilitate contact with the spiritual world and make for the ritual of cure and its therapeutic function. Tobacco (*Nicotiana tabacum* L.) was included under the category hallucinogen and indicated as psychoactive [16]. According to Prance [17], tobacco possesses a hallucinogenic effect when blended with the species *Theobroma subincanum* Martius in Buchner (Sterculiaceae). Schultes [16] explains that tobacco is definitely psychoactive in any method of use; the enigma remains as to how, under certain conditions and in various methods of use, *Nicotiana* can have strong psychoactive effects in aboriginal societies.

The alkaloids are the main active principles with hallucinogenic activity and were the most frequent constituents among the plants utilized for such a purpose by the Indians. Countless alkaloids present central properties, above all indolic derivates that occur in several plants utilized by the Indians of the Americas and by the African peoples as sacred beverages in pagan ceremonies. The structural similarity between the indolic alkaloids and serotonin explains the action of these substances at the level of central serotoninergics, because of their structural analogy to serotonin [515-517].

There are no pre-clinical models adequate to diagnose the hallucinogen effect. However, the hallucinogenic effect of one substance may be confirmed by a mere statement from an user, as described for the species *Tanaecium nocturnum*, *Anadenanthera peregrina*, *Banisteripsis caapi* and *Psychotria viridis* (Ayahuasca), those of the genus *Virola* in general, or the other plants of this category [218,518-520].

The tonics/adaptogens category includes 15 extremely broad uses, adaptogens being characterized because they are generally utilized for prophylactic purpose, or else, to attenuate the physical and psychological deficiencies as a result of aging or of stress [521,522]. In this category, there was no phytochemical class in common in the plants utilized by the Indians: of the 40 plants in the category, only four (10%) possess alkaloids, the constituent most commonly determined. Some of the plants best known as adaptogens are rich in saponins and do not possess alkaloids among their constituents, such as with *Panax ginseng* and *Eleutherococcus senticosus* [523]. The saponins found in the species *Panax* have proved to possess a great number of actions on the CNS [524]. However, although the pharmacological effects of the two species cited above are well described as to their saponins, other plants regarded as adaptogens (including *E. senticosus*) possess a very different chemical constitution [521]. Among the plants in the adaptogens category cited in this survey, the only species that has been the object of studies to support its action is *Ptychopetalum olacoides*: in addition to being beneficial to the memory, it is used as part of a preparation that induced increased sexual behavior in rats [525,526].

The main constituents employed by the Indians for purposes reminiscent of the anxiolytics are the flavonoids and essential oils. The anxiolytic activity of the flavonoids [527-529], alkaloids [516,530] and, essential oils [531] is known. The existence of a new family of ligands with a flavonoid structure was recently demonstrated in the search for safer benzodiazepine receptor ligands [532]. First isolated from plants used as tranquilizers in folk medicine, some natural flavonoids have proved to possess a selective and relatively mild affinity for benzodiazepine receptors and a pharmacological profile compatible with a partial agonistic action.

There are also studies showing a hypnotic effect for alkaloids, flavonoids, and essential oils [531,533-535]. In fact, the majority of anxiolytic agents become hypnotics when used in high doses. Valerian, Kava kava, and Passion flower are examples of phytomedicines available commercially that possess an anxiolytic and hypnotic effect [536]. Plants employed by the Brazilian Indians as sedative/anxiolytic, *Lipia alba*, *Passiflora edulis*, *Melissa officinalis* and *Cymbopogon citratus* have been the object of pharmacological studies that corroborate such indications [447,537-539]. On the other hand, remarkable is the fact that the species *Passiflora incarnata* and *Passiflora alata* (both native to South America and the object of studies that prove their anxiolytic action) have not been cited as tranquilizers / sedatives by the Indians in this review.

Some hypnotics and sedatives may also be used as anticonvulsants, as was observed for the flavonoids in *Goodyera schlechtendaliana* [540] and for *Equisetum arvense* [541]. Of the nine plants cited as anticonvulsants in this survey, the only phytochemical class identified is that of essential oils, and only in the *Scleria hirtella*. Anticonvulsant activity has been reported in literature for this phytochemical class [542].

In the stimulants category, the more frequent phytochemical classes were the flavonoids and the alkaloids, although few plants were cited for this category. The stimulant activity of the *Erythroxylum coca* due its cocaine content is well known [543]. The stimulating effect of caffeine, an alkaloid present in many plants, and of other xanthines has been well described in literature. Coffee, guarana, and mate tea are examples of plants used as stimulants with a high caffeine content [534]. Guarana seeds (*Paullinia cupana*) were already

in use for their tonic and stimulating properties by Brazilian Indians before the discovery of the country [544]. In fact, guarana is still in use by the Indians living in Amazonia, as verified in this review (Table **1**).

The category "weight control" includes both plants utilized for slimming and/or to reduce the appetite (anorectic drugs), and those to gain weight and/or stimulate the appetite. These are, therefore, "contrary" uses. Plants are used to gain weight, among the Indians, where the standards of beauty in these cultures differ from "western" values where a slim frame is viewed as an aesthetically ideal form. As to chemical constitution of the plants in the weight control category, the flavonoids are the only class identified in two of the 6 plants (33%), used to lose weight. Stimulating drugs commonly have an anorectic effect as with the amphetamines. Amphetaminic drugs possess different side effects and may induce dependence, for which reason, the search for alternative drugs for slimming and weight control continues, especially among medicinal plants. Guarana and Ma Huang (*Ephedra sinica*) are examples of stimulating plants used to augment the metabolism and burn energy [534]. Studies carried out with guarana have confirmed its property for burning energy and reducing weight [545-547].

The Brazilian Indians indicated only two plants to improve memory (*Ficus anthelmintica* and *Tabernaemontana heterophylla*), in contrast to the Schultes survey carried out among the Indians in the Columbian Amazon where several plants were cited for this purpose [28]. The two plants in evidence for this category in this review were not the object of phytochemical studies, which renders any correlation unfeasible. There are a reasonable number of studies, almost all of them with animals, indicating the potential of several Brazilian plants to improve cognitive processes [525,548-550]. The chemical constituents involved with the pharmacological activity are mostly cholinergic agonists or anticholinesterasics. However, in the case of *Ginkgo biloba*, one of the plants most used for the treatment of dementia and other cognitive problems, the active principles are flavonoids and diterpene lactones [536].

In addition, the antioxidant effect of many plants may contribute to an alleged therapeutic effect in some categories. Neurodegenerative diseases are known to present damage wrought by oxidative processes as a characteristic [551,552]. In the measure in which they may prevent or lessen damage as a result of the oxidative process, antioxidants could also contribute to the adaptogen property of some plants [553]. Flavonoids, tannins, and polyphenols are classes rich in antioxidating substances [554].

One strong limitation to analyze the data found in this review resides in the interpretation of the researcher concerning the uses indicated by the cultures involved in each one of the 34 ethnopharmacological surveys. To correlate one term in ethnomedicine with one in official medicine is not always an easy task: for some terms, researchers must resort to a type of "translation" compared to a type of "ethnopharmacological puzzle" – one of the greatest challenges to researchers who carry out ethnopharmacological surveys, above all in the absence of professionals in the medical area to follow up on field studies, who might contribute to establish this correlation [555]. One example of this is the use "to increase the breasts", found in one of the publications in this review for the species *Anacardium giganteum* and *Spondias lutea*, included in the category **others** for their possible action on the CNS. These two species might have been included under the category **illnesses of the head**, for they might well be of neuroleptic potential, since the dopaminergic blockers augment the levels of prolactin, leading to an augmented volume to the mamma.

This survey has endeavored to correlate the presence of several phytochemical classes with therapeutic use of these plants by Brazilian Indians. Although an attempt to establish this correlation has been much hampered by a lack of phytochemical studies with many of the species, it was possible, in some cases, to detect a predominance of certain phytochemical groups in some categories. It is impossible to generalize that these groups are, however, capable of such biological activity, even because the pharmacological effect was investigated only in very few plants in the survey. It is possible to suppose, however, that these phytochemical classes are richer in constituents capable of the respective pharmacological activity, probably with similar chemical groups. This positive correlation seems to have occurred with the flavonoids (analgesia, fever, anxiety, hypnosis, weight control, and as a stimulant), alkaloids (hallucinogen, head illness, and stimulating action), essential oils (fever and anxiety), lignans (hallucinogen), tannins (anxiety), triterpenes, and saponins (hypnotics).

It was not the objective of this review to indicate what the active principles for each plant or the chemical constituents involved in each pharmacological activity. Attempts were made only to establish a correlation with the **phytochemical classes**, since many studies identified only the classes present in the plant and not the constituents.

The presence of certain chemical groups in the plants utilized by the Indians may, in some ways contribute to choice of use for each species, even if by observation of plant organoleptic properties [556,557]. These choices could take place through "clues" such as color, odor, or other characteristics that are observable in plants (presence of latex, capacity for fermentation, sensitivity to the touch, etc.) in the same way as with the theory of signatures [558].

Among the 307 plants included in this survey, that are utilized by Brazilian Indians, with possible effects on the CNS, few have ever been proven pharmacologically. The analgesic category included the greater number of plants of proven effect. Antinociceptive activity is relatively easy to find in plants indicative of a certain non-specificity. It is important, however to view the results with caution, where experiments that are not well outlined may represent a false-positive result, through inexperience on the part of investigators in measuring and interpreting results [559].

It is difficult to determine which plants would be the "most promising" for each indication since the majority of the plants in this survey have never been the object of pharmacological studies. Some plants utilized for the same purpose by several indigenous groups, as in the case of *Dioclea erecta* and *Dioclea latifolia*, utilized by the Kuikuro, Yawalapiti, and other Indians in the Alto Xingu to purify and fortify the body, deserve to be studied pharmacologically. At

the other extreme, are plants utilized for three or more different purposes, such as in the case of *Achyrocline satureoides* (fever, body ache, and as tonic), *Cymbopogon citratus* (fever, headache, and tranquilizer), *Justicia pectoralis* (inebriating snuff, additive for *Virola theiodora*, and for three types of pain), *Piptocarpha rotundifolia* (to stimulate the appetite, as tonic and for rheumatic pain), *Tabernaemontana sananho* (tranquilizer, for rheumatic pain and fever) and *Tachigalia paniculata* (stimulant, fever, madness). Also worthy of special mention are the species the hallucinogenic use of which is common to Indians of several ethnic backgrounds: *Mimosa hostilis*, *Virola calophylla*, *V. calophylloidea* and *V. theiodora*.

The lack of integrated chemical-pharmacological studies is probably a strong obstacle to development of new drugs. There is no doubt that models of chemical structure versus biological activity are very useful to provide biochemical understanding of the biological activity of natural products [560,561]. The molecular structure is important, mainly, owing to the lipophilicity and steric hindrance factors, but it is in the interaction between chemical groups of the active principles and proteins / enzymes of the body that the key for a good effect most probably resides [562]. A search for a new drug by binding-receptor interaction often comes up against the incapacity of the compound to transpose the hemato-encephalic barrier when the therapeutic agent is to act on the CNS [563]. In addition, the chance of finding a biologically active substance by mere trial and error is lower when the molecules tested come from plants in popular use for any specific disease. Hence the importance of ethnopharmacological studies that will offer guidance for the study of these "more promising" plants. The discovery of new drugs must, therefore, be regarded as a complex and interdisciplinary search in biology, ethnopharmacology, ethnobotany, chemistry, pharmacology, and clinical sciences.

CONCLUSION

This study shows that the majority of plants utilized by Brazilian Indians for CNS disturbances have not as yet been the object of study from the chemical standpoint, nor from the pharmacological point of view. The study of these plants might well result in the development of new drugs, and point to chemical structures with important biological activities.

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