Psychoactive Plants Described in a Brazilian Literary Work and their Chemical Compounds

Rafaela Denise Otsuka[1], João Henrique Ghilardi Lago[2], Lucia Rossi[3], José Carlos Fernandes Galduróz[1] and Eliana Rodrigues[1,*]

[1]*Departamento de Psicobiologia-Universidade Federal de São Paulo, São Paulo, Brazil;* [2]*Departamento de Ciências Exatas e da Terra-Universidade Federal de São Paulo, Diadema-SP, Brazil;* [3]*Instituto de Botânica do Estado de São Paulo, São Paulo, Brazil*

Abstract: Ethnopharmacological research investigates the plants and other medicinal and toxic substances utilized by different traditional populations. One approach in this field is a literature search of the available publications on medicinal plants. The purpose of the current study was to select plants with psychoactive effects described in a Brazilian literary work written by Pio Correa in 1926. Those mentioned plants were classified in accordance with their indications for use as stimulants and depressors of the central nervous system. For the phytochemical study herein, we researched these species via a database search, and all the obtained information was compiled into a new database to analyze possible correlations between the chemical compounds and the psychoactive categories. Of the 813 plants searched in the literary work, 104 presented chemical data in the scientific periodicals consulted. Seventy-five of them belong to the stimulant category, while 31 are depressors and two of them belong to both categories. Phenols and flavonoids were the main compounds observed in plants of both categories, though at different frequencies. Monoterpenes (29.9%) and sesquiterpenes (28.6%) were also observed in plants from the stimulant category, while 25.8% of plants from the depressor category were comprised of carotenoids and 22.6% of steroids. The main specific compounds were identified as ferulic acid, α-pinene, limonene, α-humulene and kaempferol among the stimulant plants. Otherwise, in depressor plants were characterized caffeic acid, kaempferol, quercetin, β-carotene, physalins and withanolides as specific compounds. The association between ethnopharmacological and chemotaxonomic data, as presented in this study, could support plant selection in further investigations by research groups whose studies focus on psychoactive plants as potential therapeutics.

Keywords: Database, ethnopharmacology, medicinal plants, psychoactive plants, phytochemistry.

1. INTRODUCTION

Ethnopharmacology can be defined as the interdisciplinary scientific exploration of biologically active agents traditionally employed or observed by man [1]. Its objectives are to rescue and document an important cultural heritage as well as evaluate the agents employed [2]. One common approach in this field is a literature search using several published genetic resources. This approach aims to rescue the use of plants described in the literature that have not been investigated in pharmacological and phytochemical studies.

Therefore, bibliographical surveys may represent the first step of a scientific research process. According to Kate and Laird [3], bibliographic surveys are a useful source to guide pharmacological studies in the development of new drugs and are utilized by 80% of pharmaceutical laboratories.

The application of new bioinformatics database systems about herbal texts holds great promise for identifying novel bioactive compounds for pharmacotherapy [4]. Some International Databases, such as Natural Products Alert (http://w-ww.napralert.org/Default.aspx), provide information about pharmacological activities, ethnopharmacological data, che-mical compounds and data from tests on animals and hum-ans for thousand of species from all over the world.

Phytochemistry can contribute to the synthesis of new drugs with therapeutic properties [5]. Nature provides enormous potential for the discovery of new bioactive compounds; at least a million different compounds could be isolated [6].

The World Health Organization defines psychoactive substances as those that, when taken in or administered into one's system, affect mental processes [7]. Thus, psychoactive plants are those ingested in a simple form or as a complex preparation to affect the mind or alter the state of consciousness [8]. According to Chaloult [9], it is possible to classify psychoactive drugs as: depressors, which decrease the activity of the central nervous system, such as alcohol, hypnotics and anxiolytics; stimulants, which increase this activity, such as amphetamines and cocaine; and disturbants, which disrupt this activity, such as hallucinogens and anticholinergics.

Ethnopharmacological surveys of psychoactive substances, such as those developed by Schultes [10] and Rodrigues and Carlini [11,12], are important tools, as they may

*Address correspondence to this author at the Department of Psychobiology, Universidade Federal de São Paulo - Rua Napoleão de Barros, 925 Ed. Ciências Biomédicas (1º Andar), CEP 04024-002 São Paulo, Brazil; Tel: +55 11 21490155; Fax: +55 11 50842793; E-mail: 68.eliana@gmail.com

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indicate potential bioactive substances for researchers engaged in the development of medicines for psychiatry.

According to De Smet [13], scientific studies on psychoactive drugs may have an impact on medicine, provide new pharmacological tools for neurochemical research, and may result in the discovery of synthetic substances with potentially therapeutic properties. Adams *et al.* [14] add that several traditional remedies provide promising components with potential as therapeutics for neurodegenerative disorders, such as Alzheimer's disease.

Therefore, a database with information on the ethnopharmacological uses of psychoactive plants and their chemical compounds can support research groups that focus on these plants as potential therapeutics.

The purpose of the current study was to read the botanical compendia of Pio Correa ("Dicionário das Plantas Úteis do Brasil e das Exóticas Cultivadas") and: a) select plants with psychoactive effects; b) correlate their chemical groups found in current scientific literature with the ethnopharmacological use described in Pio Correa; and c) create and compile a database with that information.

2. METHODOLOGY

2.1. Botanical Compendia

Manuel Pio Correa (1874-1934), a Portuguese naturalist, came to Brazil, where he developed his literary work "Dicionário das Plantas Úteis do Brasil e das Exóticas Cultivadas". The work consists of six volumes containing approximately 10,000 species, wherein the author describes plants collected during his expeditions via the following characterizations: scientific and vernacular names, synonyms, botanical description, geographic distribution, medicinal use, and, in some cases, photos and illustrations.

After the publication of the first two volumes in 1926 and 1931, respectively, the author passed away, and the subsequent four volumes (published in 1952, 1969, 1974 and 1978) were written by Dr. Leonam de Azeredo Penna using data collected by Pio Correa. This work is a reference for Brazilian flora studies [15] and researchers in the medicinal plant field.

These six volumes were read and reviewed, and plants indicated as psychoactives were listed. Afterward, according to the use described for each plant component, they were categorized as stimulants (↑) or depressors (↓), based on the Chaloult [9].

2.2. Update of Scientific Names

It was necessary to update the plant scientific names because this literary work belongs to the 20th century. Thus, both specialized books and the following databases were consulted: Tropicos (Missouri Botanical Gardens - http://www.tropicos.org/), IPNI (International Plant Names Index - http://www.ipni.org/), Flora del Conosur (Instituto de Botánica Darwinion - http://www.darwin.edu.ar/Proyectos/ FloraArgentina/FA.asp), Kew (Royal Botanical Gardens - http://apps.kew.org/herbcat/gotoHomePage.do), Solanaceae Source (Natural History Museum - http://www.nhm.ac.uk/-research-curation/research/projects/solanaceaesource/) and Flora Brasiliensis (http://flora.cria.org.br/checklist).

2.3. Phytochemical Survey

To analyze possible correlations between the chemical compounds and the psychoactive plant categories indicated by Pio Correa, a survey was conducted in the Scifinder - Advanced Article Search - ACS Publications database (http://pubs.acs.org/wls/journals/query/subscriberSearch.html). We focused this search on any phytochemical studies developed for these plants. The survey was made using the updated scientific names of plants from January 2000 to January 2008.

Finally, all data were compiled into a database to perform the desired correlation.

3. RESULTS

3.1. Plants and their Psychoactive Categories

Of the 813 psychoactive plants searched in the literary work, there were chemical data in the scientific periodicals consulted for 104 of them. Of the 104 plants, 75 of them belong to stimulant category, while 31 are depressors and 2 of them belong to both categories. The exotic plants were highlighted with asterisk on Table **1**, the remaining are natives to Brazilian flora.

The uses most cited for the 31 depressor plants are as a narcotic, for calming effects and as a beverage compound. The 75 stimulant plants are used mainly as tonics, stimulants, excitants and aphrodisiacs.

The stimulant plants belong to 40 taxonomical families. The most cited were: Asteraceae (8 species), Lamiaceae (6) and Fabaceae s.l. (5). The depressors belong to 21 families, with Solanaceae being the most observed (6 species).

3.2. Chemical Groups x Psychoactive Categories

These analyses were based on the correlation between plant components cited in the periodicals and the ones cited in Pio Correa, as it is well known that the chemical composition of a plant may vary with its parts.

Phenols are found in both categories. Among the stimulants, we also observed monoterpenes (29.9%), sesquiterpenes (28.6%) and flavonoids (23.4%). Additionally, 35.5% of depressors are flavonoids, followed by carotenoids (25.8%) and steroids (22.6%) (Fig. (**1**)).

In stimulant plants, the specific main compounds were identified as ferulic acid, α-pinene, limonene, α-humulene and kaempferol. Among the depressor plants, phenols were observed mainly because the presence of caffeic acid, kaempferol and quercetin as well as β-carotene, physalins, and withanolides.

3.3. Chemical Groups x Families

Among the families most cited in the present study, 55.6% of the Asteraceae plants were comprised mainly of sesquiterpenes, followed by phenols (44.4%), monoterpenes and flavonoids (33.3% each). The Fabaceae s.l. plants were comprised of 66.7% flavonoids, while the remaining 33.3% were phenols, diterpenes and carotenoid derivatives. The

Table 1. 104 Species Cited as Psychoactive in the Pio Correa's Literary Work, and their Current Chemical Data (* Exotic Species, ↑ Stimulant, ↓ Depressor)

Specie	Plant Uses Cited in Pio Correa (Places or Populations)	Psychoactive Category	Plant's Part / Chemical Compounds Cited in Scientific Periodicals
Anacardiaceae			
Anacardium occidentale L.	Tonic-excitant	↑	Fruit / phenols, acids, alcohols, esters, phenylpropanoids, monoterpenes, ketones and aldehydes and steroids [16-19]
Cotinus coggygria Scop.*	Tonic	↑	bark / phenols and flavonoids [20]
Pistacia lentiscus L.*	Tonic, for excitant fumigation	↑	resin / monoterpenes, sesquiterpenes, alcohols and esters [21]
Annonaceae			
Asimina triloba (L.) Dunal*	for making liqueur, alkaloid which response is identical to the morphine, anesthetic with powerful sedative action	↓	fruit / acetogenines [22, 23]
Rollinia mucosa (Jacq.) Baill.*	narcotic	↓	leaf / acetogenines [24, 25]
Apiaceae			
Anethum graveolens L.*	hypnotic, for making liqueur	↓	in natura and seed / monoterpenes, sesquiterpenes, phenolic compounds and flavonoids [26-29]
Apium graveolens L.*	excitant	↑	carotenoid [30]
Coriandrum sativum L.*	stimulant	↑	fruit / aldehydes, monoterpenes, phenylpropanoids and sesquiterpenes [31-33]
	to counteract hysteria	↓	seed / carotenoids and steroids [34]
Daucus carota L.*	tonic nerves	↑	root and leaf / monoterpenes, sesquiterpenes, phenylpropanoids, aldehydes, ketones, carotenoids, alcohols and phenols [35-41]
			seed / acids, aldehydes, sesquiterpenes and phenylpropanoid [42]
			juice and fermented beverage / anthocyanins [43, 44]
			aerial parts / monoterpenes, sesquiterpenes and phenylpropanoids [45]
Foeniculum vulgare Mill.*	stimulant	↑	aerial parts / monoterpenes, phenylpropanoids, phenols and fatty acids [46-52]
	distilled provides excitant oil		seed / monoterpenes, phenylpropanoid, phenols and esters [53-55]
Apocynaceae			
Catharanthus roseus (L.) G. Don	stupefacient with action on certain brain and spinal cord cellular departments	↓	whole plant / alkaloids [56, 57]
Nerium oleander L.*	tonic poison	↑	whole plant / cardiac glycosides, triterpenes, steroids and sesquiterpenes [58-63]
Aquifoliaceae			
Ilex paraguariensis A. St.-Hil.	stimulant tonic, activates or excites the appetite, general stimulant of all functions, specially the intelligence and motility	↑	leaf / phenols, alkaloid, diterpene, steroids, flavonoids and fatty acids [64-69]

(Table 1) contd….

Specie	Plant Uses Cited in Pio Correa (Places or Populations)	Psychoactive Category	Plant's Part / Chemical Compounds Cited in Scientific Periodicals
Araliaceae			
Panax quinquefolius L.*	recover energy from fatigue and excessive love pleasure, increases the organic excitability, stimulant and tonic	↑	root / saponins [70-73]
Asclepiadaceae			
Asclepias curassavica L.	macerate induce convulsion	↑	stem / triterpenes and steroids [74]
Asteraceae			
Acanthospermum hispidum DC.	tonic	↑	flower and leaf / sesquiterpenes [75]
Artemisia dracunculus L.	stimulant	↑	leaf / aliphatics, monoterpenes, sesquiterpenes, diterpenes and phenylpropanoids and coumarins [76-78]
Artemisia vulgaris L.*	tonic and excitant	↑	root and leaf / monoterpenes, sesquiterpenes, esters and acids [79]
Baccharis dracunculifolia DC.	tonic	↑	stem and leaf / sesquiterpenes, phenols and flavonoids [80-83]
Cichorium intybus L.*	tonic	↑	aerial parts / phenols, flavonoids, phenylpropanoids and sesquiterpenes [84-86]
Lactuca sativa L.*	oil anaphrodisiac	↓	seed / phenols and carotenoids [87]
Tagetes erecta L.*	stimulant	↑	flower / carotenoids [88-90]
	to calm down	↓	resin / carotenoids [91]
Tanacetum vulgare L.*	tonic and stimulant	↑	leaves and flowers / monoterpenes [92, 93]
Taraxacum officinale F.H. Wigg.	tonic	↑	leaf / phenols, flavonoids and anthocyanins [94]
Bixaceae			
Bixa orellana L.	powder is aphrodisiac (aborigines)	↑	seed / alcohols, acids, aldehydes, hydrocarbons, sesquiterpenes, monoterpenes, ketones, carotenoids and anthocyanins [95-97]
Brassicaceae			
Eruca vesicaria subsp. *sativa* (Mill.) Thell*	excitant	↑	leaf / aliphatics, flavonoids and glucosinolates [98-100]
Nasturtium officinale R. Br.*	stimulant	↑	whole plant / glucosinolates and carotenoids [101-103]
Bromeliaceae			
Ananas comosus (L.) Merr.	fermented juice recovers energy (Chacriabas and Machacaris tribes)	↑	fruit / esters [104]
Buxaceae			
Buxus sempervirens L.*	alkaloid identical to strychnine, aphrodisiac (ancient Romans)	↑	leaf / sulfur compounds [105]
Cactaceae			
Opuntia ficus-indica (L.) Mill.*	fermented produces alcohol	↓	fruit / betalains, phenols, flavonoids and carotenoids [106-110]

(Table 1) contd….

Specie	Plant Uses Cited in Pio Correa (Places or Populations)	Psychoactive Category	Plant's Part / Chemical Compounds Cited in Scientific Periodicals
Canellaceae			
Cinnamodendron axillare Endl. ex Walp.	tonic and excitant	↑	bark / alkaloid [111]
Cannabaceae			
Humulus lupulus L.*	used in pillows to overcome insomnia (rural population from Europe)	↓	inflorescence / aldehydes, acids, esters, hydrocarbons, monoterpenes, sesquiterpenes, ketones, anthocyanidins, phenols, flavonoids, tannins, steroids, fatty acids and stilbenes [112-125]
Caprifoliaceae			
Sambucus nigra L.*	for making wine	↓	fruit / anthocyanins and anthocyanidins [126]
Caryophyllaceae			
Dianthus caryophyllus L.*	excitant, to prepare tonic syrup	↑	flower / anthocyanins [127]
Dianthus superbus L.*	stimulant	↑	petal / cyclic peptides [128]
Chenopodiaceae			
Chenopodium quinoa Willd.*	for making beer	↓	seed / saponins [129-134]
Clusiaceae			
Mammea americana L.	fermented produces wine and drunkenness	↓	fruit / carotenoids [135]
Cupressaceae			
Juniperus communis L.*	for making juniper liquor (England, Scotland and the Nordic countries)	↓	fruit / monoterpenes, sesquiterpenes and flavonoids [136, 137]
Cyperaceae			
Cyperus longus L.	tonic	↑	rhizome / monoterpenes, sesquiterpenes and alcohols [138]
Cyperus rotundus L.*	stimulant	↑	rhizome / alkaloids [139]
Ericaceae			
Vaccinium myrtillus L.*	for making alcohol beverage	↓	fruit / iridoids and anthocyanins [140-142]
Fabaceae			
Arachis hypogaea L.*	nervous system excitant (low action), possibly aphrodisiac	↑	seed / fatty acids, stilbenes and flavonoids [143-145]
Caesalpinia bonduc (L.) Roxb.	tonic	↑	seed / diterpenes [146]
Caesalpinia pulcherrima (L.) Sw.*	tonic	↑	root / diterpenes [147]
	excitant		leaf / diterpenes [148]
Ceratonia siliqua L.*	fermented produces strong drink and liqueur, for making alcohol	↓	fruit / phenols, tannins and flavonoids [149]
Glycine max (L.) Merr.*	to increase physical resistance	↑	seed / esters, aldehyde, anthocyanins, carotenoids and flavonoids [150-160]
Phaseolus vulgaris L.	conserved holds B vitamin which is nervous system tonic and appetite stimulant	↑	seed / tannins, flavonoids, anthocyanins, phenols and carotenoids [161-174]

(Table 1) contd….

Specie	Plant Uses Cited in Pio Correa (Places or Populations)	Psychoactive Category	Plant's Part / Chemical Compounds Cited in Scientific Periodicals
Gentianaceae			
Centaurium erythraea Rafn*	tonic	↑	aerial parts / xanthones and phenols [175, 176]
Lamiaceae			
Lavandula angustifolia Mill.*	tonic and stimulant	↑	flower / monoterpenes [177]
Origanum majorana L.	used in baths have excitant power	↑	whole plant / carotenoids, diterpenes and triterpenes [178, 179]
Rosmarinus officinalis L.*	stimulant oil	↑	seed / phenols [180]
	infusion useful against chlorosis		leaf / monoterpenes, diterpenes, phenols, flavonoids, triterpenes, phenylpropanoids, sesquiterpenes and hydrocarbons [181-187]
Salvia officinalis L.*	excitant, nervous system tonic and stimulant	↑	leaf, flower and stem / phenols, diterpenes, monoterpenes, sesquiterpenes, hydrocarbons and diterpene [188-191]
Satureja hortensis L.*	stimulant	↑	aerial parts / monoterpenes [192]
Thymus vulgaris L.*	stimulant	↑	leaf / phenols, flavonoids, monoterpenes, diterpenes and sesquiterpenes [54, 177, 189, 193]
Lauraceae			
Aniba canelilla (Kunth) Mez	overcomes nervous system weakness from any abuse	↑	bark / monoterpenes, aldehydes, phenylpropanoids and sesquiterpenes [194]
Laurus nobilis L.	tonic	↑	aerial parts / monoterpenes, phenylpropanoids, sesquiterpenes, carotenoids, phenols, flavonoids, ketones, aldehydes, esters, hydrocarbons, acids, alcohols and anthocyanins [53, 195-202]
Liliaceae			
Aloe vera (L.) Burm. f.*	plant juice is useful against hypochondria	↑	leaf / carotenoids [203]
Asparagus officinalis L.*	aphrodisiac	↑	fruit / carotenoids and phenols [204, 205]
Malvaceae			
Hibiscus sabdariffa L.*	tonic and aphrodisiac	↑	seed / phenols [206]
Meliaceae			
Melia azedarach L.*	for making whisky and wine	↓	fruit / limonoids [207, 208]
Trichilia catigua A. Juss.	tonic	↑	bark / flavonoids [209]
Moraceae			
Morus alba L.*	distilled produces alcohol and wine	↓	fruit / alkaloids [210]
Musaceae			
Musa paradisiaca L.*	fermented produces strong liquor (Amazonian aborigines)	↓	fruit / phenols [211]
Myristicaceae			
Myristica fragrans Houtt.*	aromatic stimulant	↑	seed / aliphatics and phenylpropanoid [212, 213]
Myrtaceae			
Eucalyptus globulus Labill.*	aphrodisiac	↑	leaf / monoterpenes and sesquiterpenes [214]

(Table 1) contd….

Specie	Plant Uses Cited in Pio Correa (Places or Populations)	Psychoactive Category	Plant's Part / Chemical Compounds Cited in Scientific Periodicals
Eugenia uniflora L.	excitant	↑	leaf / sesquiterpenes [215]
Pimenta dioica (L.) Merr.*	stimulant	↑	fruit / phenols [216]
Syzygium aromaticum (L.) Merr. & L.M. Perry*	excitant and aphrodisiac	↑	oil / phenylpropanoid [217, 218]
Oleaceae			
Jasminum sambac (L.) Aiton*	nervous system excitant	↑	flower / monoterpenes and esters [219]
Orchidaceae			
Vanilla planifolia Andrews	stimulant, to counteract chlorosis and any nervous affection	↑	phenols [220]
Papaveraceae			
Papaver somniferum L.*	analgesic substance, especially in insomnia due to pain; narcotic; induces pleasant drunkenness	↓	whole plant / alkaloids, alcohol and fatty acids [221, 222]
Passifloraceae			
Passiflora edulis Sims	to calm down and antihysteria	↓	leaf / triterpenes, saponins and flavonoids [223-225]
Phytolaccaceae			
Phytolacca americana L.*	holds a convulsant poison with action on the spine, which in higher doses is narcotic	↑	root / saponins [226]
Pinaceae			
Thuja occidentalis L.*	excitant	↑	leaf / diterpenes [227]
Poaceae			
Avena sativa L.	for making whisky and beer	↓	seed / carotenoids, phenols, fatty acids and flavolignans [228-230]
Hordeum vulgare L.*	fermented produces alcohol for beer production	↓	seed / carotenoids, flavonoids and phenols [231, 232]
Secale cereale L.*	fermented produces strong liquor (Prussia)	↓	seed / phenols [233, 234]
Polygonaceae			
Rumex crispus L.	tonic and against obesity	↑	leaf and seed / phenols [235]
Ranunculaceae			
Hydrastis canadensis L.*	holds a substance that produces excitability of nerves and sometimes, convulsions; tonic	↑	rhizome / alkaloids [236]
Rhamnaceae			
Discaria americana Gillies & Hook.	tonic	↑	root bark / cyclopeptides [237]
Rosaceae			
Rubus idaeus L.*	fermented produces wine	↓	fruit / flavonoids, phenols, monoterpenes and sesquiterpenes [238, 239]
Rubiaceae			
Coffea arabica L.*	nervous system excitant; opium and morphine antidote (counteracts the narcosis); alkaloid excites nervous and muscular systems, increases the contractile potency from muscles and makes the receptivity of the relationship muscles easier from nerve centers excitations; increases the functional activity from medullar and brain cells	↑	essential oil / alkaloids [240]

(Table 1) contd….

Specie	Plant Uses Cited in Pio Correa (Places or Populations)	Psychoactive Category	Plant's Part / Chemical Compounds Cited in Scientific Periodicals
Rutaceae			
Citrus aurantium L.*	tonic	↑	fruit / alkaloids [241, 242]
Citrus medica L.*	tonic	↑	peel fruit / aldehydes, monoterpenes, sesquiterpenes, esters and phenylpropanoids [243]
Ruta chalepensis L.*	excitant	↑	root / alkaloids and coumarins [244-246]
Santalaceae			
Santalum album L.*	stimulant	↑	wood / sesquiterpenes and monoterpenes [247, 248]
Saxifragaceae			
Ribes nigrum L.*	tonic	↑	fruit / phenols, anthocyanins, flavonoids, fatty acids and monoterpenes [249-253]
Scrophulariaceae			
Capraria biflora L.	infusion associated with other plants is stimulant	↑	leaf / sesquiterpenes [254]
Scoparia dulcis L.	tonic (British Guiana)	↑	aerial parts / diterpenes and flavonoids [255, 256]
Solanaceae			
Acnistus arborescens (L.) Schltdl.	narcotic	↓	leaf / steroids [257]
Cestrum nocturnum L.	used in bath and poultice to calm	↓	leaf / flavonoids, saponins and steroids [258, 259]
Cestrum parqui L'Hér.	sedative, to counteract epilepsy	↓	leaf / phenols and flavonoids [260]
Datura metel L.	narcotic	↓	flower / steroids [261]
Hyoscyamus niger L.*	narcotic	↓	seed / phenols, steroids and lignanamides [262]
Nicotiana tabacum L.*	chewed produces convulsion	↑	leaf / alkaloids [263]
Physalis angulata L.	to calm down	↓	sap / steroids [264, 265]
Solanum tuberosum L.	analeptic	↑	tuber / carotenoids, phenols, anthocyanins, alkaloids and fatty acids [266-271]
Sterculiaceae			
Cola acuminata (P. Beauv.) Schott & Endl.*	stimulant masticatory; recovers energy; decreases hunger; aphrodisiac (Western African indigenous)	↑	seed / flavonoids and alkaloid [272]
Turneraceae			
Turnera diffusa Willd. ex Schult.	tonic; stimulant; aphrodisiac; general tonic in neurasthenia and impotency	↑	leaf / phenols and flavonoids [273]
Verbenaceae			
Avicennia marina (Forssk.) Vierh.	aphrodisiac	↑	stem / quinones [274]
Lantana camara L.	tonic	↑	leaf / flavonoids and triterpenes [275]
Vitaceae			
Vitis vinifera L.*	for making wine	↓	fruit / stilbenes, monoterpenes, sesquiterpenes, phenols, alcohols, phenylpropanoids, esters, sulfur compounds, flavonoid, anthocyanidin, anthocyanins, carotenoids, stilbenes, acids, aldehydes, tannins, procyanidins, fatty acids and ketones [107, 276-315]

(Table 1) contd….

Specie	Plant Uses Cited in Pio Correa (Places or Populations)	Psychoactive Category	Plant's Part / Chemical Compounds Cited in Scientific Periodicals
Zingiberaceae			
Etlingera elatior (Jack) R.M. Sm.*	tonic	↑	rhizome / diterpenes, steroids and phenols [316]
Zingiber officinale Roscoe*	tonic and aphrodisiac (Northern Africa)	↑	rhizome / monoterpenes, phenols, fatty acids, sesquiterpenes and diarylheptanoids [317-321]

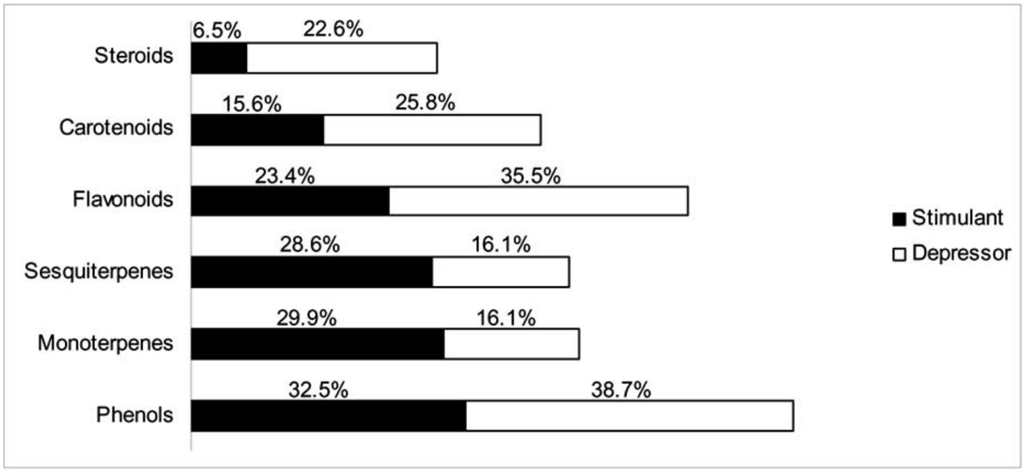

Fig. (1). Percentage of the predominant chemical compounds among depressor and stimulant plant categories.

Lamiaceae plants were comprised of 83.3% monoterpenes, followed by diterpenes (66.7%), sesquiterpenes and phenols (50% each) and flavonoids (33.3%). In Solanaceae, steroids (62.5%), phenols (37.5%) and flavonoids (25%) are the main compounds found (Fig. (**2**)).

4. DISCUSSION

Some uses for medicinal plants were recurrent in this study as well as in other studies that focused on psychoactive plants, such as tonics and anxiolytics, which were highly cited by Krahô Indians in Brazil [12,322]. Moreover, in a review about adaptogens, Mendes and Carlini [323] also described tonics and aphrodisiacs as the most popular uses reported in Brazilian contemporary books.

Some plants recorded in the present study had similar uses as those in other ethnopharmacological surveys focusing on psychoactive plants, such as: *Passiflora edulis* Sims. [322, 324], *Turnera diffusa* Willd. ex Schult. [323, 325], *Anacardium occidentale* L., *Arachis hypogaea* L., *Bixa orellana* L., and *Ilex paraguariensis* A. St.-Hil. [323].

Some of the families most cited in the present study were also the most frequent in other studies that analyze plants related to central nervous system, for example, Fabaceae s.l., Asteraceae, Lamiaceae and Solanaceae [11,12,14,323-327].

Furthermore, using a regression analysis of local ethnomedicinal flora from Mexico and southern Africa, Leonti *et al.* [328] and Douwes *et al.* [329], respectively, identified the Asteraceae, Fabaceae and Lamiaceae families as the most highly selected by traditional healers, and this does not occur randomly.

The present study observed that the Fabaceae s.l. family had the largest number of plants utilized as stimulants; the same was described by Rodrigues *et al*. [324] in an ethnopharmacological review about 26 native tribes of people. Plants from this family, as well as the Asteraceae and Solanaceae families, are widely distributed throughout the world and are represented by 18,000, 23,000 and 3,000 species, respectively, which explains why they are broadly used by traditional populations [330,331].

Rodrigues *et al.* [324] also observed that most of the plants used as stimulants had flavonoids in their composition. They were also the predominant chemical compounds among those species utilized as anxiolytics and hypnotics (depressors) in two ethnopharmacological reviews [324,327], corroborating data found in the present study. In fact, some studies verified the hypnotic and sedative effects of some flavonoids [332-334]. They are widely distributed in plants, mainly in angiosperms [335], which explains their presence in plants utilized for different biological activities.

The flavonoid kaempferol are associated with antioxidant activity; however it did not show central nervous system stimulant activity [336], maybe it is related with other substance. These antioxidant activity are related with a neuroprotective action [337].

According to Simões and Spitzer [338], the volatiles compounds are complex mixtures of volatile substances, are commonly odoriferous and liquid, and have important pharmacological activities as an appetite stimulant, central nervous system affector (stimulant, depressor, and convulsive), or local anesthetic, among others. Rätsch [8] adds that essen-

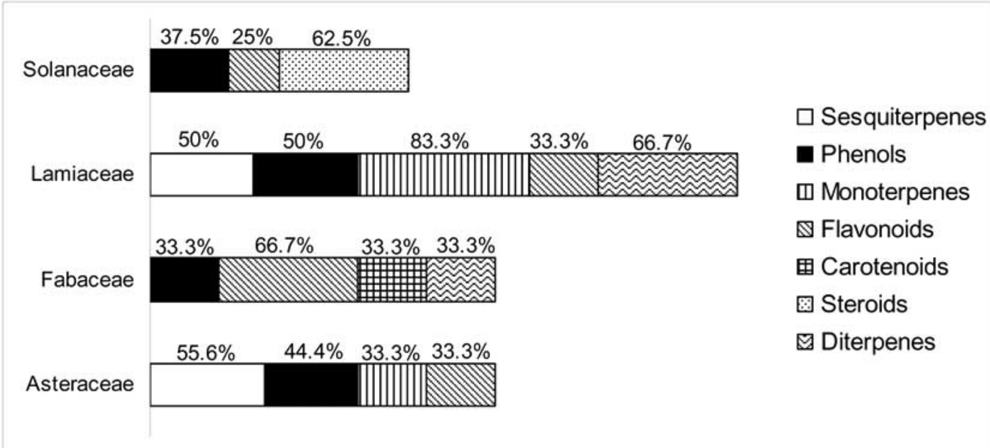

Fig. (2). Percentage of chemical compounds observed in the plants from the families most cited.

tial oils are common in psychoactive plants, and one of their activities is as an aphrodisiac. In fact, we also observed the presence of volatile compounds in both stimulants and depressors, although in higher percentage among the first.

The plant *Ptychopetalum olacoides* L. is employed by indigenous as the aphrodisiac qualities and one of its compounds is the monoterpene α-pinene and the sesquiterpene α-humulene [339]. A pharmacological study verified that *P. olacoides* has central nervous system effects interacting dopaminergic and/or noradrenergic systems [340]. On the other hand, studies correlating limonene and stimulant effect on central nervous system were not found, only one research relating limonene with gastrointestinal stimulant effect [341].

The high prevalence of phenols in the stimulant plants category could be related to antioxidant activity because some studies reported a relationship between the antioxidant effect and phenolic compounds from herbs used as tonics [342-344]. Studies correlating phenols with a depressor effect were not found in scientific literature, although this correlation was observed in the present study.

Some studies mention the beneficial effect of ferulic acid attributed not only to its antioxidant effect [345-347], but also to its stimulant effect on gastrointestinal tract [348]. The ferulic acid is not directly related to the stimulating effect; on the other hand caffeic acid produces antidepressant-like effects [349,350]. Although the caffeic acid is one of the main phenols found between depressor plants.

The carotenoids are associated with plant color [351], explaining their prevalence in depressor plants, mainly in wines, and referred to as such by traditional populations due to their purple coloration. Further, the carotenoids are also related to antioxidant effects [352-355].

As observed in this study, steroids are commonly found in Solanaceae plants [356], while plants in the Fabaceae s.l. family are characterized by impressive phytochemical diversity, with flavonoids being common in these plants [357]. According to Schultes and Raffauf [330], it is common to find sesqui- and diterpenes, carotenoids and flavonoids in Asteraceae plants. Volatiles are commonly found in the Asteraceae, Apiaceae and Lamiaceae families [336].

Studies relating depressant effects of the main specific steroids observed in this study were not found; however some researches mention that some withanolides in the diet may prevent or decrease the growth of tumors in human and other withanolides showed neurite extension in cortical neurons [358-360].

According to Douwes *et al*. [329], some plants are selected traditionally on the basis of bioactivity, according to their chemical diversity. Some plants show similar efficacy against certain diseases due to heritable similarities in secondary metabolites.

5. CONCLUSION

Comparing the main chemical groups detected in plants from each category, it was observed that phenols (ferulic and caffeic acid) and flavonoids (kaempferol and quercetin) were found in both stimulants and depressors, although in different frequencies. Monoterpenes (α-pinene and limonene) and sesquiterpenes (α-humulene) were also prevalent in plants from the stimulant category, while among depressors, carotenoids (β-carotene) and steroids (physalins and withanolides) were more common.

Despite the data found, it is not possible to affirm that the prevalence of compounds among plants of each category were responsible for their biological activities. Additionally, it cannot be excluded that the activity of some compounds can be promoted by their interaction with other compounds.

Therefore, as shown in this work, the association between chemotaxonomy and ethnopharmacology could support plant selection in future investigations.

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