"Ayahuasca," the South American Hallucinogenic Drink: an Ethnobotanical and Chemical Investigation[1]

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The Sharanahua and Culina, small Indian tribes located in the southwestern Amazon basin, use a hallucinogenic drink for medicinal and social purposes. This decoction, called "Ayahuasca" in Peru, is prepared from Banisteriopsis Caapi *stems and* Psychotria *sp. leaves. These plants have been botanically identified on the basis of voucher herbarium specimens and investigated for alkaloid content by means of a gas chromatography-mass spectrometry technique. A list of other occasional plant admixtures is given. Harmine, Harmaline, Tetrahydroharmine, Harmol and 6-Methoxytryptamine have been found in* Banisteriopsis Caapi. *Dimethyltryptamine, Monomethyltryptamine and 2-methyl-1,2,3,4-tetrahydro-β-carboline have been found in* Psychotria viridis *and* Psychotria carthaginensis. *Harmine, Harmaline, Tetrahydroharmine and Dimethyltryptamine have been found in the drink. Quantitative calculations show the amount of each alkaloid administered in the Ayahuasca drink.*

Introduction

> Some traveller who may follow my steps, with greater resources at his command, will, it is to be hoped, be able to bring away materials adequate for the complete analysis of this curious plant.
>
> —*Richard Spruce*

In the Peruvian Amazon, the Quechua expression "Ayahuasca" (literally "vine of the souls") is used to designate a hallucinogenic beverage prepared from the malpighiaceous vine *Banisteriopsis Caapi* (Spruce ex Griseb.) Morton. In Brazil, the drink is called "Caapi" and in Colombia "Yagé." Many ethnographical, botanical, chemical and pharmacological aspects concerning this decoction have recently been reviewed (18, 22, 41, 42, 53, 56). Several other plants may be mixed with the Ayahuasca during its preparation (47) and may change the hallucinogenic properties of the drink. However, even though the nature of the principal alkaloids of Ayahuasca is known, there is a lack of correlation in previous works between what can be observed in the field, the botanical identification and the chemical examination.

During a visit to the upper part of the River Purús in 1968, one of us (L.R.) obtained information concerning the local use of Ayahuasca and collected botanical material for analysis and voucher specimens. This work was carried out together with I. Rüf, a Swiss anthropologist. Identification of the botanical material was made by H. V. Pinkley (Botanical Museum of Harvard University).

This paper deals with the indigenous use of and the chemical analysis of the material.

The Upper River Purús: Social Context

The Purús is a tributary of the Amazon and rises in the humid tropical forest of southwestern Peru not far from the Peruvian-Brazilian border.

The settling of the Indians is recent. The people who worked on the borders of the river around 1860 disappeared after the crash of the rubber boom. The first groups who afterwards came to settle on the upper Purús about 25 years ago did not find any people there. They came

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from the north, hoping to find machetes and guns near more navigable rivers. Now Sharanahua, Cashinahua, Yaminahua, Marinahua, Mastenahua, Tshandinahua, Amahuaka, Masco, and Culina live there.

All the groups mentioned, with the exception of the Culina, speak the Pano language, and all of them understand each other. Only the Cashinahua are a little different because of their isolation (33). The Culina speak an Arawak language, which increases the social distance from other groups. The villages are separated from each other by at least half a day's canoe trip; visits are frequent.

The settlement of the villages changes often in order to avoid decrease of game. There is also a tendency to approach Esperanza, the mestizos village. The groups differ considerably but their material culture is very similar: they are cultivators, hunters and fishermen. They are strongly and rapidly influenced by contact with civilization. Transformation in living patterns can already be noticed — introduction of work, debt contracting, resulting changes due to the introduction of new technical devices, young people learning Spanish. On the whole, a movement from primitive collectivism towards individualism according to the Peruvian model is noticeable. In addition, these groups have also suffered from various epidemics and are often not sufficiently numerous to live in the traditional way. However, many of their cultural traditions are still alive, among them the use of Ayahuasca.

The Use of Ayahuasca

The following remarks are based on personal experience and observations made during a visit to the Culina Indians of the village of Zapote from March to November, 1968, and intervening visits to the Sharanahua of Marcos. Supplementary information about the Sharanahua has been taken from Siskind (61).

The inclusion of the ethnological observations was made possible through the collaboration of Miss I. Rüf.

All the Pano groups use Ayahuasca frequently. The Culina do not use it in the traditional manner.

Medical Use. This may be the traditional use, reserved for the witch doctor or shaman. He takes the drug when the illness of his patient cannot be treated by medicine and when the origin of the illness may be magical. Guided by the dreams related to him by the sick person, the shaman makes a "trip" under the influence of the drug. He interprets the visions in order to detect the cause of the illness and fights it symbolically. He tells about the fight, singing to the patient to liberate him from the evil. His song refers to the mythical content which he shares with the sick person.

Social Use. In addition to the above therapeutic use of the drug, there is also a profane one — Sharanahua and Culina men take the drink in order to have visions. They meet in the evenings in front of the house of the man who has prepared the drink. All men do not participate: some disapprove, others are afraid of the effects. There is no prestige connected with the drinking.

The women are not allowed to take the drug, since it is supposed to hurt them. However, the prohibition is not very strict nowadays. Children and adolescents do not use it. The drug can be taken up to 10 times a month and, frequently, even more often. Only difficulty in procuring the ingredients limits the meetings.

The Sharanahua can very well control the effects of the drug. If their health or work demand it, they can easily abstain from taking it.

It is possible that the frequency of the social use corresponds to the degree of anquish of the group or the individual. The situation of the Indian can be unsafe — he notices that his way of life is changing while the traditional obligations of society are still weighing upon him. It seems as if a well guided Ayahuasca

experience brings the participants close together. It permits certain common values to be confirmed because the mythological content of the visions is still prevailing deep in their souls. It may be that the Culina are looking for this type of experience in their present situation but do not succeed in finding it because of the lack of this common base.

Plants Used in Preparing the Drug

1. *Banisteriopsis Caapi* (Malpighiaceae) (Table II)

The mestizos use the name Ayahuasca for both the vine and the drink, as do the Purús inhabitants. The Sharanahua call it "Shuri," "Rambi" or "Undi"; the first word is the most common. The Culina use the word "Tsipu" but prefer "Rami," which is borrowed from the Pano language. The Indians distinguish between three kinds of Ayahuasca: the red, the black and the white. This distinction is based more on the difference in color of the drink than on the appearance of the plant. Some Indians, like the Peruvian mestizos, make no distinction between the red and the white drink.

Peruvian Name		
Black	=	Ayahuasca negro
Red	=	Ayahuasca blanco
White	=	Ayahuasca blanco
Sharanahua		
Black	=	Shuri fisopa
Red	=	Shuri oshinipa
White	=	Shuri oshopa
Culina		
Black	=	Tsipu tsueni
Red	=	Tsipu wetseni
White	=	Tsipu makuni

2. *Psychotria* sp. (Rubiaceae) (Table III)

In this whole region the stems of Ayahuasca are always blended with the leaves of *Psychotria* sp. According to informants, "one sees nothing" without this admixture.

The Sharanahua distinguish between at least two kinds of *Psychotria* without the general "Kawa" term:

(*1*) Batsikawa
(*2*) Pishikawa or Kawa kui

"Batsikawa" is said to be inferior to "Pishikawa": it gives an impression of coldness and produces fewer visions. The Culina know of two species too, but they do not distinguish between them by name: this one is "Rami appane" ("Appane" means "leaves"). One of the species is also weaker and gives an impression of coldness. Sharanahua and Culina translate "Kawa" and "Rami appane," respectively, by the Peruvian name of "Chacruna."

3. Admixtures

Banisteriopsis Caapi and *Psychotria* sp. are considered by Sharanahua and Culina to be the basic ingredients. Other plants, listed in Table I, are sometimes added to or taken together with the beverage.

Preparation of the Drug

The preparation of the drug varies little from one village to another. The person who has found the ingredients of the drink in the forest usually undertakes its preparation. This takes place in front of his house. Fifteen stems of *Banisteriopsis Caapi* (approx. 60 cm long and 1 to 4 cm in diam.) are crushed with a short thick pole and cut into pieces 10 cm long. In a 15 litres metal vessel reserved for this purpose, layers of vine are packed alternating with leaves of *Psychotria* sp., until the vessel is full. Ten litres of water are added, and the mixture is boiled for one hour. The vegetable sediments are eliminated by filtering through a strainer. As soon as it is cold, the decoction is ready for consumption.

The above procedure gives the Sharanahua sufficient drug for three days, but according to information, the Ayahuasca loses its strength rapidly and cannot be kept for a very long time.

TABLE I

PLANT ADMIXTURES TO *Banisteriopsis* AND *Psychotria* IN THE AYAHUASCA BEVERAGE

Botanical Name	Sharanahua	Culina	Uses
Lygodium venustum Sw. Schizaeceae No. 13 & 14	Tchai del monte	Rami	A handful of leaves is added to the decoction. Sharanahua think that it makes the drink stronger. The plant is not cultivated but grows in old gardens and in the forest.
Phrygilanthus eugenioides (HBK) Eichl. Loranthaceae No. 15	Miya	Kohobo	A quantity of leaves similar to that of Chacruna is boiled with Ayahuasca or the juice of this wild plant may be drunk at the same time as Ayahuasca.
Lomariopsis japurensis (Mart.) J. Sm. Plypoidaceae No. 17 & 18	Shoka	Dsuii-tetseperi	Only the Sharanahua add 3 to 4 branches. This plant is very abundant in the jungle.
Opuntia sp. Cactaceae (No voucher sp.)	Tchai		This cultivated cactus is considered by the Sharanahua to be hallucinogenic. It was brought to Marcos from the Amahuaca living on the Inuya River. The mixture of Ayahuasca and Tchai is very strong and is never used medically (cf. 36).
Epiphylium sp. Cactaceae No. 19	Pokere	Wamapanako	The Sharanahua add only one leaf to the drug or else drink the unboiled juice together with Ayahuasca.
Cyperus sp. Cyperaceae No. 12	Shakoshejeti	Anubedsetetseperi	This cultivated plant is called piri-piri in Peru. The Sharanahua put some of the powdered rhizome in the decoction. The Culina have received the plant from the Amahuaca and use it only when hunting peccary because of its special odour (cf. 22 page 85).

TABLE I (*Continued*)

Botanical Name	Sharanahua	Culina	Uses
Clusia sp. Guttiferae	Miya	Tara	The Sharanahua chew one or two leaves during the Ayahuasca session. This wild plant may also be boiled with the drink.
? Acanthaceae No. 16	Hwandarao	Uratetseperi	Only the Sharanahua add a handful of leaves to the Ayahuasca. The Culina use the leaves to darken their teeth as a sign of beauty.
? Bignoniaceae (?) No. 19	Potshesheti		A few leaves may be added to the drink or boiled apart. The Sharanahua put drops of this liquid in their eyes.
Datura sp. (Probably *D. suaveolens*) Solanaceae (No voucher sp.)	Wahashupa		The Sharanahua informed us that they put a few leaves of this plant (which they find up river) into Ayahuasca. The Peruvian name is "toe." The drink becomes then very toxic.
Nicotiana sp. Solanaceae (No voucher sp.)		Tsina	Customarily, the Indians smoke all night long, when taking Ayahuasca. Some shamans occasionally drink the juice of tobacco leaves from plants grown in their gardens.
Capsicum sp. Solanaceae (No voucher sp.)		Catsi	The Culina sometimes eat this fruit together with Ayahuasca. In Peru this cultivated plant is called "aji."
? (No voucher sp.)	Yamba		Powdered bark of this tree is added to the drink and boiled with it.
? (No voucher sp.)	Yambabusi		Idem

TABLE II

DISTRIBUTION OF ALKALOIDS IN AYAHUASCA PLANTS

Species	Part of the Plant	Alkaloids % Dry Weight	Alkaloids	%
Banisteriopsis Caapi (Spruce) Morton No. 1	Stem	0.11	Harmine	91
			Tetrahydroharmine	1
			232	1
Tsipi makuni Culina Indians Zapote, 22.7.68 Upper Purus River	Branches	0.14	Harmine	90
			Tetrahydroharmine	1
			Harmaline	1
			232	2
	Leaves	0.28	Harmine	94
	Branches Freeze-dried (Feb. 70)	0.19	Harmine	77
			Tetrahydroharmine	6
			Harmaline	Trace
			232	1
	Roots Freeze-dried (Feb. 70)	0.92	Harmine	40
			Tetrahydroharmine	44
			Harmaline	15
			232	Trace
Banisteriopsis Caapi, (Spruce) Morton No. 2	Stem	0.11	Harmine	96
			Tetrahydroharmine	2
			Harmaline	1
Tsipu wetseni Culina Indians Zapote, 22.8.68 Upper Purus River			232	Trace
	Branches + Leaves Freeze-dried (Feb. 70)	0.35	Harmine	69
			Tetrahydroharmine	11
			Harmaline	4
			Harmol	3
			232	4
	Roots Freeze-dried (Feb. 70)	1.95	Harmine	41
			Tetrahydroharmine	37
			Harmaline	17
			6-MeO-T	Trace
Banisteriopsis Caapi (Spruce) Morton No. 3	Stem	0.21	Harmine	68
			Tetrahydroharmine	22
			Harmaline	6
Shuri fisopa Sharanahua Indians Marcos, 8.8.68 Upper Purus River			232	3
	Root	0.64	Harmine	90
			Tetrahydroharmine	7
			Harmaline	3
	Leaves	0.45	Harmine	92

TABLE II (*Continued*)

Species	Part of the Plant	Alkaloids % Dry Weight	Alkaloids	%
			Tetrahydroharmine	1
(*Continued*)			Harmaline	Trace
			232	Trace
			Harmol	Trace
	Seeds	0.91	Harmine	58
			Harmol	8
Banisteriopsis Caapi (Spruce) Morton No. 4	Stem	0.20	Harmine	84
			Tetrahydroharmine	9
			Harmaline	1
Shuri oshinipa			232	3
Sharanahua Indians			Harmol	2
Marcos, 8.8.68				
Upper Purús River	Root	0.71	Harmine	78
			Tetrahydroharmine	15
			Harmaline	5
			232	1
	Leaves	0.70	Harmine	78
			Tetrahydroharmine	2
			Harmaline	Trace
			232	Trace
Banisteriopsis Caapi (Spruce) Morton B. Holmstedt and D. Martin	Stem	0.57	Harmine	64
			Tetrahydroharmine	29
			Harmaline	5
Piturijacu			6-MeO—T	Trace
Mestizos near Iquitos	Branches	0.37	Harmine	64
			Tetrahydroharmine	17
			Harmaline	4
			232	2
Banisteriopsis Caapi (Spruce) Morton Plowman and Martin No. 1805	Stem	0.83	Harmine	62
			Tetrahydroharmine	24
			Harmaline	7
			232	1
Cultivated Ayahuasca			Harmol	Trace
Tarapoto, Perú			6-MeO-T	1
August, 1967				
Banisteriopsis Caapi (Spruce) Morton Pinkley No. 445 Ecuador	Stem	0.35	Harmine	64
			Tetrahydroharmine	28
			Harmaline	7
			6-MeO-T	Trace
			232	1

TABLE II (*Continued*)

Species	Part of the Plant	Alkaloids % Dry Weight	Alkaloids	%
Banisteriopsis sp. (Probably)	Stem	0.31	Harmine	87
			Tetrahydroharmine	6
G. T. Prance No. 7498			Harmaline	3
Acre Territory			232	2
Brazil				
Banisteriopsis sp.	Stem	0.65	Harmine	42
G. Baer			Tetrahydroharmine	47
Kamalampi			Harmaline	9
Piro Indians			232	2
Perú, 1968				
Banisteriopsis sp.	Stem	0.65	Harmine	67
G. Baer			Tetrahydroharmine	21
Matsigenga Indians			Harmaline	8
Perú, 1968				
Banisteriopsis sp.	Stem	0.41	Harmine	88
(Probably)			Tetrahydroharmine	8
Shuri oshinipa			Harmaline	3
Sharanahua Indians			232	1
Marcos 7.10.68				
Upper Purús River				
Banisteriopsis sp.	Root	0.61	Harmine	74
(Probably)			Tetrahydroharmine	19
Shuri fisopa			Harmaline	6
Sharanahua Indians			232	1
Marcos, 7.10.68				
Upper Purús River				
Banisteriopsis sp.	Stem	0.20	Harmine	80
(Probably)			Tetrahydroharmine	16
Shuri oshopa			Harmaline	2
Sharanahua Indians			232	1
Marcos, 7.10.68			Harmol	Trace
Upper Purús River				
Banisteriopsis sp.		0.20	Harmine	95
(Probably)			Tetrahydroharmine	3
Tukondi			232	1
Marinahua Indians			Harmol	Trace
Conta, 13.10.68				
Upper Purús River				
Banisteriopsis sp.	Stem	0.05	Harmine	71
(Probably)			Tetrahydroharmine	Trace
			232	Trace

TABLE II (*Continued*)

Species	Part of the Plant	Alkaloids % Dry Weight	Alkaloids	%
(*Continued*)				
Ayahuasca Mestizos Jenaro Herrera, Ucayali River 10.11.68	Stem	0.39	Harmine	74
			Tetrahydroharmine	4
			232	3
			Harmol	16
	Leaves Freeze-dried (Feb. 70)	1.90	Harmine	85
			Tetrahydroharmine	5
			Harmaline	Trace
			Harmol	2
Banisteriopsis sp. (Probably)	Leaves	0.25	Harmine	98
			Harmol	Trace
Cielo-Ayahuasca or Ayahuasca blanco Mestizos Iquitos 5.11.68				

Taking the Drug

As soon as night falls, the men assemble and sit down around a fire. Before he drinks, each man blows over the drug and utters a short prayer that he will see well. They drink in turn a calabazo of liquid, approximately 200 ml, and continue to talk quietly. Later, other men join them. Gradually, those men who took the drink first feel the effect (20 to 30 min.). They spit, belch and vomit it. The vomiting is considered necessary to produce visions and is supposed to be purifying.

The singing begins as soon as hallucinations set in. The singers have the same rhythm, and the music is harmonic, although the words and melodies are different. The words describe the visions individually. The song serves to guide the vision and to give unity to the group. The individual songs turn at a counterpoint and return now and then. Those used to taking the drug see to it that the beginners do not get a bad experience. They try to comfort them by taking their heads in their hands and by blowing tobacco smoke on them. Sometimes they present to them a perfumed plant (*Ocimum micranthum* — Labiatae. *Rivier & Rüf 11*), if the anguish seems too great. A similar practice was observed in the Acre territory in Brazil (50, 51).

The effect of the drug lasts about two hours, and it can be prolonged until dawn by taking more drug (about 100 ml) every hour. The last members of the drug group retire usually around 2 A.M. They are accustomed to go to their work the following day.

The preparations by the Culina differ only slightly, and their drug is weaker than that of the Sharanahua. The Culina do not sing but sit in a row in the darkness while talking. They seem to be much less affected by the drug, and they are themselves rather troubled by their neighbors' customs and are curious to try the experience (60). For them, taking the drug is a

TABLE III
DISTRIBUTION OF ALKALOIDS IN PSYCHOTRIA PLANTS

Species	Part of the Plant	Alkaloids % Dry Weight	Alkaloids	%
Psychotria viridis R. and P. No. 9 Kawa Kui Sharanahua Indians Marcos, 7.10.68	Leaves	0.11	MMT MTHC	85 12
Psychotria viridis R. and P. No. 7 Rami appani Culina Indians Zapote, 22.7.68	Leaves	0.34	DMT MMT MTHC	99 Trace Trace
Psychotria carthaginensis Jacq. No. 8 Rami appani Culina Indians Zapote, 4.9.68	Leaves	0.66	DMT MMT MTHC	99 Trace Trace
Psychotria bacteriophylla Lausanne	Leaves	-	-	-
Psychotria emetica Borneo-Paris	Leaves	-	-	-
Psychotria undulata Borneo-Paris	Leaves	-	-	-
Psychotria sp. Culina Indians Zapote	Leaves Freeze-dried Feb. 70	-	-	-

marginal custom and badly accommodated to the life of the group.

The Effects of Ayahuasca

When used socially, the visions vary greatly. From the information that we obtained, however, some distinct points emerge. The drug lets one see unknown places; permits one to enter into contact with absent or dead people; shows terrifying animals, serpents, jaguars; shows aeroplanes, objects of high value; sometimes reveals the future.

The contents of the visions told to anthropologists are not nearly so rich as those coming forth in the songs. It may be that the most profound experiences cannot be communicated to another person. The visions correspond usually to traditional aspirations or new ones (such as aeroplanes). One of the characteristics of the drug is the creation of great suggestibility.

Personal Experiences

L.R. and I.R. had similar experiences; they took the drug at the same time and together with a group of natives. At Zapote on two occasions the effects were not very noticeable. (For composition of the drug taken, see Table IV: *Tsipu makuni*, Zapote 22.7.68, and *Tsipu tsueni*, Zapote 13.10.68).

At Marcos, the first time, sample collection was not possible. Physical sensations came at first: heaviness in the back of the neck, a feeling of movement in the stomach, a sensation of numbness and tingling in the extremities "as if there were ants in the body," heat, nausea which disappeared at the beginning of the first visions, yawning, salivation. At first a shining blue veil (the Sharanahua name is *Rami*) seemed to come between the subject and his surroundings; thereafter, objects in lively colors appeared. This rather geometrical vision was followed by pseudo-hallucinations: hands, faces, and fire lost their identity by being transformed into fantastic beasts, snakes, tigers. Other visions were far from reality — Dutch fishermen, trip over New York. These visions seemed like waves and corresponded to the intensity of the song. The visions were accompanied by a feeling of "harmony," desire to laugh and to communicate, by the visualization with great lucidity of "intellectual problems" and by a strong impression of verbal and nonverbal communications with the Indians. The visions faded during 4 hours after emptying the first calebass (two were taken, the second one hour after the first). The visions and sensations diminished but the "harmony" and the "spiritual lucidity" remained. They gradually subsided in the course of the next day. The contact with the companions of the night appeared to remain intimate and full of complicity even the day after the taking of the drug. A light pleasant fatigue followed and there were no side-effects.

Three months later, a second experience proved to be extremely violent, painful and quite negative compared to the first one. (For composition of the drug taken, see Table IV, *Shuri fisopa*, Marcos 7.10.68.) The physical sensations were considerably stronger — nausea, pain in the muscles, accompanied by compulsive and uncontrollable movements (swaying, hand moving), a feeling of coldness, fascination by the fire at the same time that its smoke was intolerable. These phenomena were connected with a feeling of anguish which was in absolute contrast to the pleasant feeling and the freedom during the first experience. Visions of the same type as experienced during the preceding experiment were, however, now terrifying, and the song accentuated the anguish. The Sharanahua tried to drive away disagreeable feelings by words and gestures which were meant to guide the visions, but the relief was of short duration. After the first dose, the experience lasted approximately 2 hours, but this period seemed interminable. Communications with other people were prevented. This experience left one with a feeling of fatigue and frustration and also a lasting fear that it might return.

It has not been possible to find out whether the Sharanahua have experienced this taking of the drug as painful.

Experimental

A. List of Abbreviations

DMT	= N,N-dimethyltryptamine
MMT	= N-monomethyltryptamine
6-MeO-T	= 6-methoxytryptamine
5-MeO-T	= 5-methoxytryptamine
Harmine	= 1-methyl-7-methoxy-β-carboline
Harmaline	= 1-methyl-7-methoxy-3,4-dihydro-β-carboline
Tetrahydroharmine	= 1-methyl-7-methoxy-1,2,3,4-tetrahydro-β-carboline
Harmol	= 1-methyl-7-hydroxy-β-carboline
MTHC	= 2-methyl-1,2,3,4-tetrahydro-β-carboline

TABLE IV
ALKALOIDAL CONTENT IN AYAHUASCA PREPARATIONS

Vernacular Name and Origin	Plants	Total Alkaloids (% w/v)	Alkaloids	%	mg./100 ml
Tsipu makuni (White Ayahuasca) Culina Indians Zapote, Perú, 22.7.68	*Banisteriopsis Caapi* *Psychotria viridis* (No. 7)	0,064	Harmine	26	17
			Tetrahydroharmine	11	7,2
			DMT	21	13
Tsipu tsueni "dsati" (Crude Black Ayahuasca) Culina Indians Zapote, Perú, 9.10.68	*Banisteriopsis* sp. *Psychotria* sp. *Lygodium venustum* (No. 13)	0,013	Harmine	62	Not drunk
			Tetrahydroharmine	18	
			Harmaline	4	
			232	6	
Tsipu tsueni "pekanani" (Boiled Black Ayahuasca) Culina Indians Zapote, Perú, 9.10.68	*Banisteriopsis* sp. *Psychotria* sp. *Lygodium venustum* (No. 13)	0,038	Harmine	47	18
			Tetrahydroharmine	6	2,3
			Harmaline	4	1,5
			DMT	31	12
			232	6	2,3
Tsipu tsueni "dsati" (Crude Black Ayahuasca) Culina Indians Zapote, Perú, 13.10.68	*Banisteriopsis* sp. *Psychotria* sp.	0,005	Harmine	56	Not drunk
			Tetrahydroharmine	11	
			Harmaline	Trace	
			232	10	
Tsipu tsueni "pekanani" (Boiled Black Ayahuasca) Culina Indians Zapote, Perú, 13.10.68	*Banisteriopsis* sp. *Psychotria* sp.	0,015	Harmine	43	6,6
			Tetrahydroharmine	10	1,5
			Harmaline	Trace	
			DMT	36	5,4
			232	6	0,9

TABLE IV *(Continued)*

Vernacular Name and Origin	Plants	Total Alkaloids (% x/v)	Alkaloids	%	mg./100 ml
Shuri fisopa (Tukondi) (Black Ayahuasca) Sharanahua Indians Marcos, Perú, 7.10.68	*Banisteriopsis Caapi* (No. 3) *Psychotria viridis* (No. 9) *Lygodium venustum*	0,049	Harmine Tetrahydroharmine Harmaline DMT 232	37 20 2 20 20	18 9,8 1,1 9,8 9,8
Shuri oshinipa (Red Ayahuasca) Sharanahua Indians Marcos, Perú, 11.10.68	*Banisteriopsis Caapi* (No. 4) *Psychotria viridis* (No. 5) *Lygodium venustum*	0,052	Harmine Tetrahydroharmine Harmaline DMT 232	37 14 3 30 16	19 7,2 1,6 16 8,2
Shuri (Ayahuasca) Sharanahua Indians Marcos, Perú, 1.8.68 Received from J. Siskind (61)		0,034	Harmine Tetrahydroharmine Harmaline DMT 232	22 9 1 41 16	7,1 2,9 0,3 14 5,2
Kamalampi (Ayahuasca) Piro Indians Rio Urubamba, Perú Received from G. Baer (5)	*Banisteriopsis* sp. Horowa leaves = Chacruna	0,058	Harmine Tetrahydroharmine Harmaline 232	21 40 4 6	

TABLE V
PREVIOUS CHEMICAL ANALYSES OF AYAHUASCA, CAAPI OR YAGÉ

Author	Year	Type of Analyses	Vernacular Name Identification Existence of Herbarium Specimen	Compounds Isolated	Ref.
Zerda Bayón	1905		Yagé (decoction) - -	Telepathine	(63)
Fischer Cardenas	1923	Micro-Chem. react.	Yagé *Aristolochia* sp. -	Telepathine	(21)
Seil and Putt	1924		Caapi *Banisteria Caapi* -	Three alkaloids (Impure)	(59)
Barriga Villalba	1925	Elementary anal. Micro-chem. react.	Yagé *Prestonia amazonica* -	Yageine and Yagenine	(6)
Albarracín	1925	Elementary anal. Micro-chem. react.	Yagé *Prestonia amazonica* -	Yageine and Yagenine	(3)
Michiels and Clinquart	1926	Micro-chem. react.	Yagé *Prestonia amazonica* -	Yageine and Yagenine	(39)
Clinquart	1926	Elementary anal. Micro-chem. react.	Yagé (decoction) - -	Yageine	(13)
Perrot and Raymond Hamet	1927	Micro-chem. anal.	Yagé *Banisteria Caapi* -	Telepathine (Yageine)	(46)

TABLE V (*Continued*)

Author	Year	Type of Analyses	Vernacular Name Identification Existence of Herbarium Specimen	Compounds Isolated	Ref.
Lewin	1928	Elementary anal. Micro-chem. anal.	Yaque, according to Merck *Banisteria Caapi* -	Banisterine	(35)
Wolfes and Rumpf	1928	Elementary anal. Degrad. to Harmol	Yaque, according to Merck Malpighiaceae -	Harmine = Yageine	(62)
Elger	1928	Elementary anal.	Yagé *Banisteria Caapi* -	Harmine + one alkaloid	(20)
Brückl and Mussgnug	1929	Elementary anal. Crystal caract.	- - -	Banisterine = Harmine	(9)
Dalmer	1929	U. V. spectra	- - -	Banisterine = Harmine	(15)
Keller and Gottauf	1929	Elementary anal. Micro-chem. react.	Ayahuasca *Banisteria* sp. -	Harmine-like alkaloid	(32)
Arispe	1938	Elementary anal. Micro-chem. react.	Ayahuasca *Banisteria Caapi* -	Yageine (and Yagenine)	(4)
Chen and Chen	1939	Elementary anal. Derivatives U. V. Spectra	Caapi *Banisteria Caapi* Yes	Harmine	(12)

TABLE V (*Continued*)

Author	Year	Type of Analyses	Vernacular Name Identification Existence of Herbarium Specimen	Compounds Isolated	Ref.
Mors and Zaltzman	1954	Paper chrom. Electrophoresis Micro-chem. react.	Ayahuasca *Banisteria Caapi* -	Yageine (Harmine)	(40)
Costa	1954	Micro-chem. react.	Yagé *Banisteria Caapi* -	Yageine	(14)
Hochstein and Paradies	1957	Paper chrom. U.V. or I.R. spectra	Ayahuasca *Banisteria Caapi* -	Harmine, Harmaline and d-tetrahydroharmine	(27)
Der Marderosian et al.	1968	Paper chrom. Thin layer chrom.	Yagé *Banisteriopsis Caapi* Yes	Harmine and Harmaline	(16)
Schultes et al.	1969	GC-MS GC	Caapi *Banisteriopsis Caapi* Yes	Harmine	(58)
Der Marderosian et al.	1970	Thin layer chrom.	-(Ayahuasca) *Banisteriopsis* sp. Yes	Harmine and Harmaline	(17)

B. Material (Tables I-IV)

The botanical material and drink preparations were collected during the summer of 1968. The plant material was dried in the air without exposure to the sun, which exposure is said by Indians to destroy the power of the drug. 4-Hydroxy-benzoic acid methylester (Nipagin M) was added to the beverage to prevent fermentation (approximately 1 g/100 ml).

Some samples of *Banisteriopsis Caapi* were collected around Jenaro Herrera, a mestizo Peruvian village along the Ucayali River. The *Cielo-Ayahuasca* plant was taken from the Botanical Garden of the Amazon Natural Drug Co. in Iquitos, Peru.

Piro and *Matsigenga* materials were collected by G. Baer, Museum für Völkerkunde, Basel, in 1968-1969, along the Urubamba River.

Other specimens of *Banisteriopsis* were obtained from G. T. Prance, New York Botanical Garden; R. T. Plowman and R. T. Martin, Harvard Botanical Museum; H. V. Pinkley, Harvard Botanical Museum; B. Holmstedt, Department of Toxicology, Karolinska Institutet, Stockholm; and R. T. Martin, Harvard Botanical Museum.

Freeze-dried *Psychotria bacterophylla* was obtained in the greenhouses of the City of Lausanne (Switzerland). The leaves of *Psychotria emetica* and *P. undulata* were obtained from "Jardin des Plantes," Paris, by Holmstedt in 1970. They were originally collected in Borneo.

Some living plants of *Banisteriopsis* and *Psychotria* were brought back from Peru to Switzerland and are now growing in the hot greenhouses of the city of Lausanne. Part of those plants were freeze-dried just before extraction.

Most of the plants of the collection of Rivier and Rüf were identified by H. V. Pinkley. Voucher herbarium specimens of this collection are deposited in the Botanical Museum of Harvard University. Some duplicates (*Nos. 1, 5, 8, 14, 15, 18,* and *21*) are in the Gray Herbarium of Harvard University. One sample of *No. 8* is in the New York Botanical Garden. Other samples of the specimen are deposited in the Conservatoire et Jardin Botanique de la ville de Genève, Switzerland (*1* to *9, 13, 15, 17, 18, 20* and *21*).

C. Isolation of Alkaloids

The powdered plant material (1-200 g) was stirred with methanol over night at room temperature. The solution was filtered and the residue was re-extracted with methanol for 4 hours. After filtration, the solution was evaporated under reduced pressure. The residue was shaken with 200 ml 2N H_2SO_4, centrifuged, and the solid extracted again with 100 ml 2N H_2SO_4. This was repeated once more. The acidic solutions were extracted with three 100 ml quantities of $CHCl_3$. The chloroform layer was rejected and the aqueous solution was made alkaline (pH = 10) by adding solid Na_2CO_3.

The basic compounds were then extracted from the aqueous solution with $CHCl_3$ three to five times, depending upon the quantity of starting material. The $CHCl_3$ solutions were combined and dried with anhydrous Na_2SO_4. The organic solution was evaporated under reduced pressure after filtration.

The liquid samples were acidified directly with H_2SO_4.

D. Gas Chromatography (GLC)

Gas chromatographic analyses were performed with an F & M Model 400 apparatus equipped with a hydrogen flame ionization detector system.

The column support, 100-120 mesh Gas Chrom CLP, was size-graded, acid-washed, and silanized, according to the method described by Horning et al. (30). The coating was applied by the filtration technique (29).

The stationary phase was 5% OV-17 in a 2,25 m × 3,2 mm glass tube. The column was operated at 210° for *Banisteriopsis* and drink, and at 190° for *Psychotria*. The injector block and the detector chamber were kept at 50° C above the oven temper-

ature. Carrier gas was nitrogen. Flow was 25 ml/min. Samples were injected in a 1/l methanol-chloroform solution with a 0-10 μl Hamilton syringe.

E. Gas Chromatography-Mass Spectrometry (GLC-MS)

The principles of the technique have been described earlier (28). The mass spectrometry work was carried out with LKB 9000 gas chromatograph-mass spectrometer. The ion source was 270°, the electron energy was 70 eV and the electron ionization current 60 μA, respectively.

The column consisted of a 2,5 m × 3,2 mm glass tube with the same stationary phase as the GC work, but the column support was Varaport-30.

Separation of the alkaloid mixture was made at 250° for *Banisteriopsis* and drink, and at 230° for *Psychotria*.

Injector block and "molecule separator" were maintained 30° above the column temperature. Helium was used as the carrier gas.

F. Quantitative Estimation

The amount of alkaloids in the dried plant material and in the drink and the percentage of each alkaloid in the alkaloid mixture were determined by planimetry using Harmine as a standard.

G. Reference Compounds

DMT = Schuchardt, Munich, Germany
6-MeO-T = Schuchardt, Munich, Germany
Harmine = Fluka, Bucks, Switzerland
Harmaline = Aldrich, Milwaukee, Wisconsin
Harmol = Aldrich, Milwaukee, Wisconsin

Dl-Tetrahydroharmine was obtained from Dr. Bernauer, Hofmann-La Roche, Basle, Switzerland.

MMT bioxalate was kindly placed at our disposal by Dr. A. Hofmann, Sandoz A. G., Basle.

2-Methyl-1,2,3,4-tetrahydro-β-carboline has been synthetized earlier (2).

Results

The results of the analysis of Ayahuasca (*Banisteriopsis* sp.) and Chacruna (*Psychotria* sp.) and of the drug are shown in Tables II-IV. In each case, the identity of the peaks of the gas chromatograms has been corroborated by mass spectra obtained with the combination instrument. This method assures complete identity with the reference compounds and gives direct evidence of identity. The complete botanical name is given only when the plant has been identified on the basis of the voucher herbarium specimen. In all cases we have indicated the vernacular name and the Peruvian name given by the Indians.

In some extracts, the mass spectra of peaks corresponding to the retention time of reference compounds was impossible to record because of the small amount available for injection of the sample and the relatively high background. In mass fragmentography (or Multiple Ion Detection), the mass spectrometer is used as a gas chromatographic detector which continuously monitors 1 to 3 selected mass numbers of compounds eluted from the gas chromatographic column. [For description and applications of this technique, see (24) and (25)]. Focussing upon mass number 198, mass fragmentograms of alkaloidal extracts of *Banisteriopsis* and the beverage were registered in view of controlling the presence of Harmol.

Concerning alkaloidal extracts of *Psychotria* sp. and beverage, the ions m/e 188, 174 and 186 were brought alternatively into focus to detect the occurrence of DMT, MMT and MTHC, respectively.

Discussion

Analysis of *Banisteriopsis* (Table II)

As shown in Table V, the most recent analytical work on an authentic specimen of *B. Caapi*, strangely enough, was made in 1968 on the material sent by R. Spruce from Brazil in 1852 and later kept in the Royal Botanical Garden at Kew. This ma-

TABLE VI
MASS SPECTROMETRIC DATA FOR REFERENCE COMPOUNDS

Compound	Mass spectrum, lit. ref. and major peaks at m/e
DMT	Ref. (28) 58 (base peak), 103, 115, 130, 143, 188 (M+)
MMT	Ref. (28) 44 (base peak), 103, 115, 130, 131, 145, 174 (M+)
MTHC	Ref. (2) 143 (base peak), 78, 102, 115, 186 (M+)
6-MeO-T	This paper 160 (base peak), 30, 117, 145, 146, 161, 190 (M+)
5-MeO-T	Ref. (2) 160 (base peak), 30, 117, 145, 146, 161, 190 (M+)
Harmine	Ref. (28) 212 (base peak and M+), 106, 169, 197
Harmaline	This paper 214 (base peak and M+), 169, 170, 186, 198, 199, 212, 213
Tetrahydroharmine	Ref. (28) 201 (base peak), 101, 172, 187, 216 (M+)
Harmol	This paper 198 (base peak and M+), 99, 115, 169, 170, 197

terial contained only Harmine (58). Earlier, Der Marderosian et al. (16) found Harmine and Harmaline in a voucher specimen identified by R. E. Schultes.

Only in 1939 did Chen & Chen publish a convincing analysis showing the presence of Harmine in the stem, leaves and roots of an authentic specimen of *B. Caapi* (12). This is, however, contested by Cuatrecasas, who believes that the samples represent *B. inebrians* (22). Schultes (in conversation) agrees with Cuatrecasas. According to Deulofeu (18), Elger analyzed a plant material identified as *B. Caapi* and found that it contained Harmine (20). It should be noted that the much-quoted investigation by Hochstein & Paradies (27) concerns a material the botanical identification of which later proved to be based solely on the vernacular name of the plant (57). These chemists isolated three β-carbolines: Harmine, Harmaline and d-Tetrahydroharmine.

In all the samples analyzed by us, we have found the β-carbolines: Harmine, Harmaline and Tetrahydroharmine, and, in addition, Harmol, and 6-MeO-T (Figs. 2 & 3). It should be noted that 6-MeO-T has a mass spectrum similar to that of 5-MeO-T but that the latter compound has a different retention time. In our own investigation, we have demonstrated, also, that the composition of stems from other parts of the Amazon differ quantitatively only slightly from those found in the southwestern parts (Table II).

Harmine, Harmaline and Tetrahydroharmine have been isolated from a number of other plants (54). Harmol has previously been isolated from *Passiflora incarnata* L. (37, 38) and from *Zygophyllum fabago* (8).

Other *Banisteriopsis* species that have been investigated contain DMT and

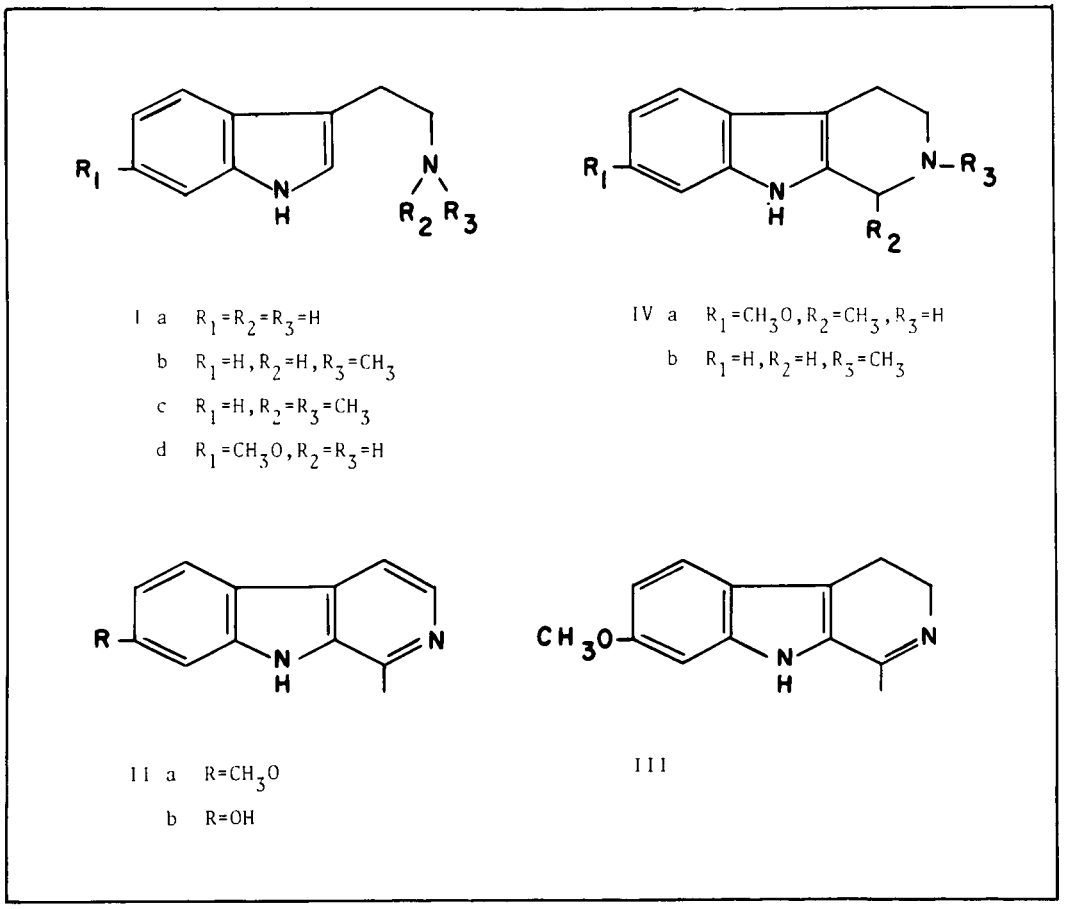

Fig. 1. Ia. Tryptamine; Ib. Monomethyltryptamine; Ic. Dimethyltryptamine; Id. 6-Methoxytryptamine. IIa. Harmine; IIb. Harmol; III. Harmaline; IVa. 1,2,3,4-Tetrahydroharmine; IVb. 2-Methyl-1,2,3,4-tetrahydro-β-carboline.

MTHC. They may be said to serve as admixtures of the basic Ayahuasca drink (47).

O'Connell & Lynn isolated and tentatively identified Harmine in *B. inebrians* in 1953. The botanical identification was made from material of the stem and leaves of the plant. No voucher specimens were, however, reported (44). Sixteen years later, O'Connell (43), searching for the possible occurrence of other alkaloids in the same plant, found caffein. This unique report on the presence of xanthine compound in Malpighiaceae may be questioned. At the time, Schultes gave O'Connell trunks of two plants to work with, *Banisteriopsis* and *Paullinia Yoco*. *P. Yoco* is used as a stimulant and is rich in caffeine. A confusion of the two collections may have occurred (Schultes, letter of July, 1971).

Psychotria (Rubiaceae) (Table III)

Der Marderosian et al. (17) have isolated DMT and two other non-indole alkaloids from leaves of *Psychotria viridis*. One of them was tentatively identified as dehydro-DMT by mass spectrometry: no spectrum of this compound was, however, published. In the same work, another *Psychotria* is reported to contain DMT only. A third specimen of *Psychotria*

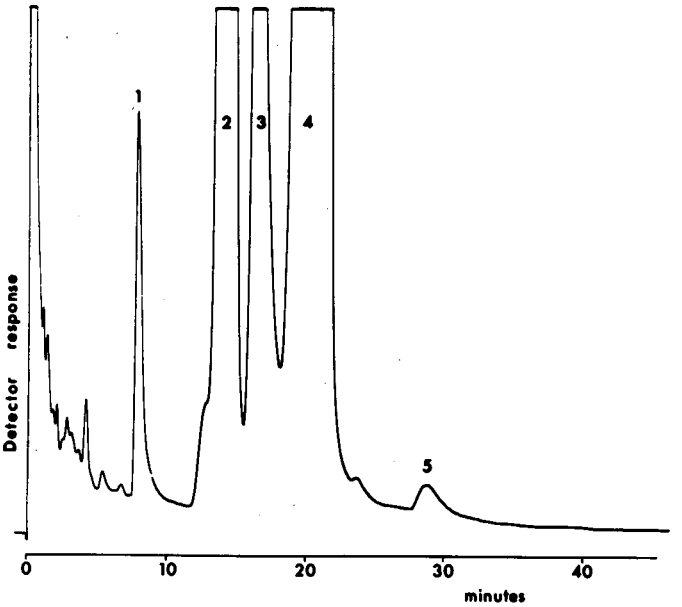

Fig. 2. Gas chromatogram of alkaloidal fraction from *Banisteriopsis Caapi* (Spruce) Morton, obtained from R. T. Plowman and R. T. Martin, Tarapoto, Perú. GLC conditions: 5% OV-17 on 100-120 mesh Gas Chrom CLP; temp. 210°.
1 = 6-MeO-T.; 2 = Tetrahydroharmine; 3 = Harmaline; 4 = Harmine; 5 = Harmol.

leaves was totally devoid of alkaloids. The Indians mix all three of these *Psychotria* species with Ayahuasca, according to Pinkley (47).

Our own analysis of the leaves of *Psychotria viridis* showed the presence of substantial amounts of DMT and traces of MMT and MTHC (Figs. 4 & 5). When DMT is not present, we find instead MMT and MTHC. The molecular weight of MTHC is 186 and its mass spectrum is presented in Fig. 5. Dehydro-DMT has the same molecular weight. The mass spectrum of "alkaloid 186" proves, however, that it is not an indole with an open side chain. The β-carboline structure was found to be correct by comparison with synthetic reference compound. The interpretation of the structure is in agreement with the interpretation of Agurell et al. (2) and Johns et al. (31).

Psychotria carthaginensis contains a larger quantity of alkaloids than *P. viridis*, practically all DMT (Table III). The other species of *Psychotria*, (*P. emetica*, *P. bacteriophylla* and *P. undulata*) contain neither indoles nor β-carbolines. Freeze-dried *Psychotria* sp., used with Ayahuasca by the Culina — which was grown in a greenhouse — contains none of the three alkaloids.

DMT has already been isolated from a number of plants (54). MMT or Dipterine has been identified in a few plant families (52). Analyses of hallucinogenic plants used by South American natives have shown the presence of MMT in the leaves of *Banisteriopsis Rusbyana* (1), in *Virola theiodora*, *V. rufula* (2), (10), in *Virola calophylla* (1), (28), in *Anadenanthera* (*Piptadenia*) *peregrina* (1), (28), (34). MTHC has been isolated, together with other simple indole compounds, from *B. Rusbyana* (1). MTHC is also to be found in *Arthrophytum leptocladum* and in *Gymnacranthera paniculata* (31).

The use of the expression "Chacruna" has spread all along the Ucayali between Pucallpa and Iquitos among the mestizos. Del Castillo (11) gives, on pages 73-74 of

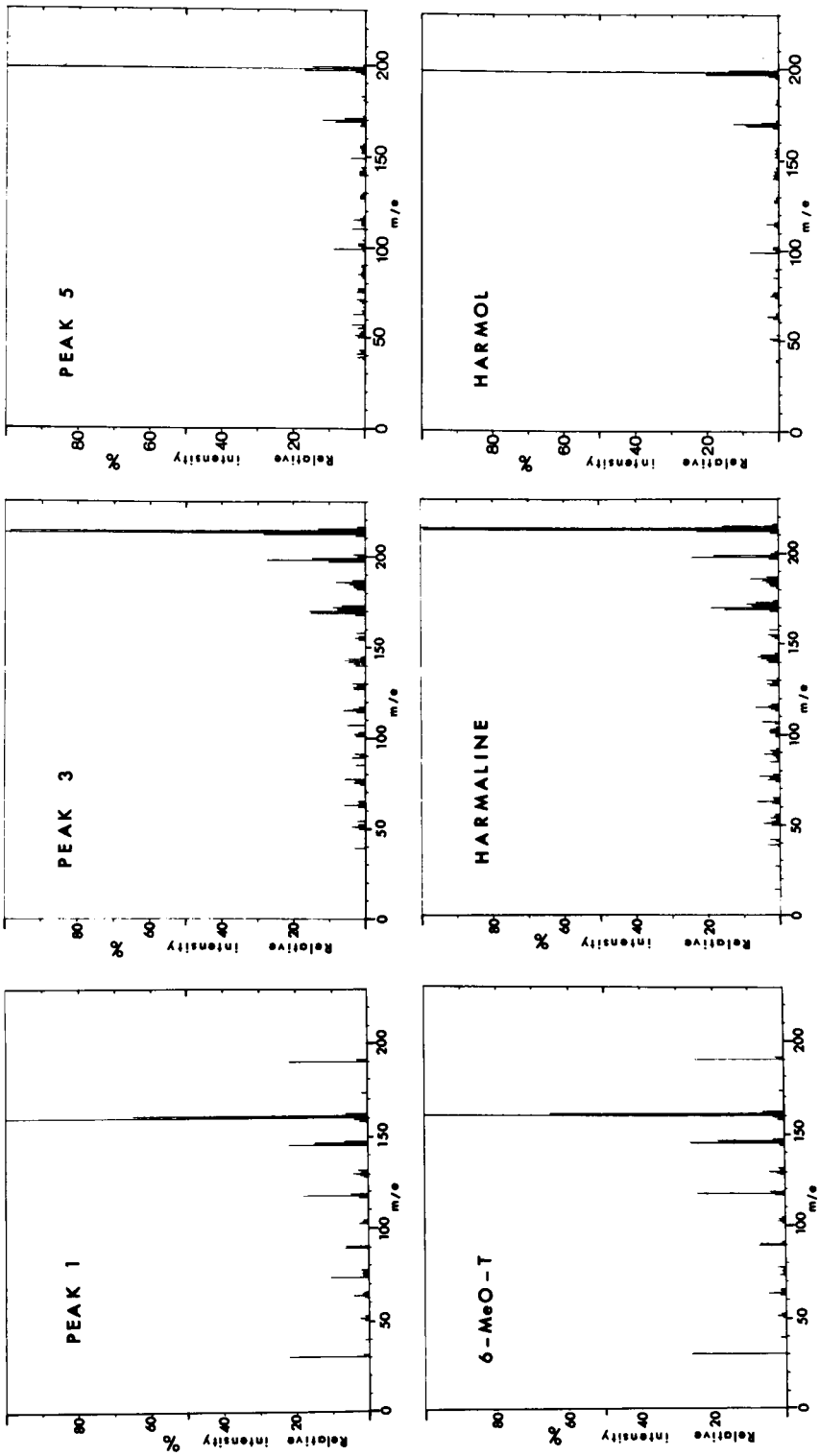

Fig. 3. Mass spectrometric recording of compound in peak effluents from alkaloid fraction (Fig. 2) and reference compounds.

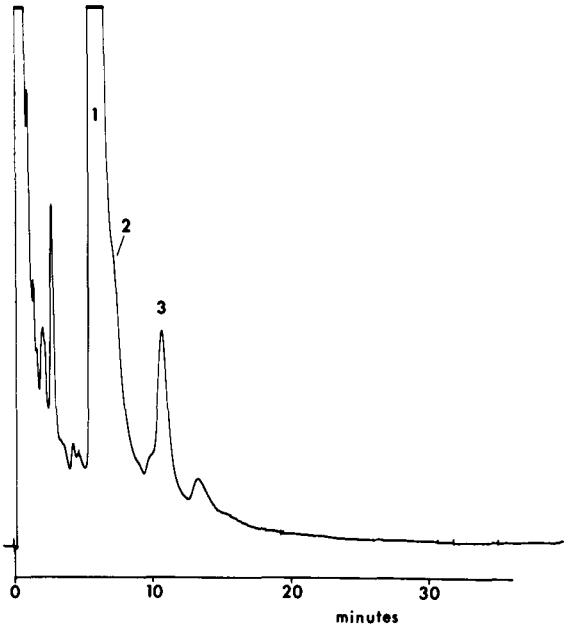

Fig. 4. Gas chromatogram of alkaloid fraction from *Psychotria viridis* R. et P., *Culina* Indians, Purús River, Perú. (No. 7). Conditions: same as Fig. 2 but temp. 190°.
1 = DMT; 2 = MMT; 3 = MTHC.

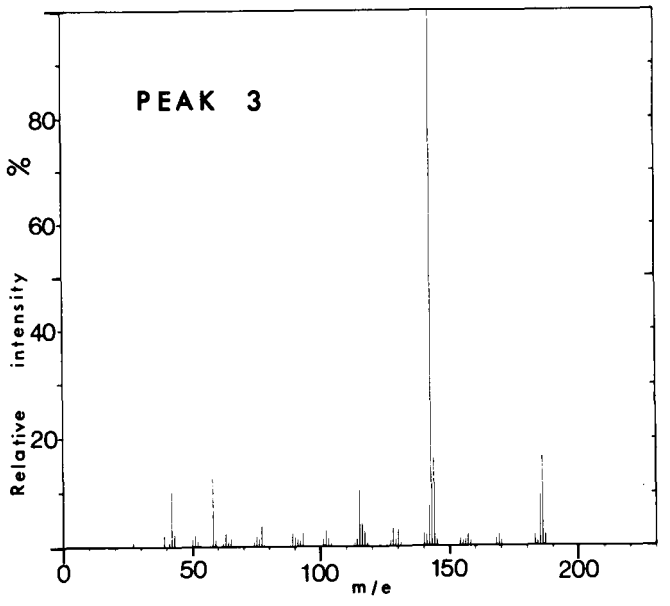

Fig. 5. Mass spectrometric recording of compound in peak effluent No. 3 from alkaloidal fraction (Fig. 4). Reference compound in (2).

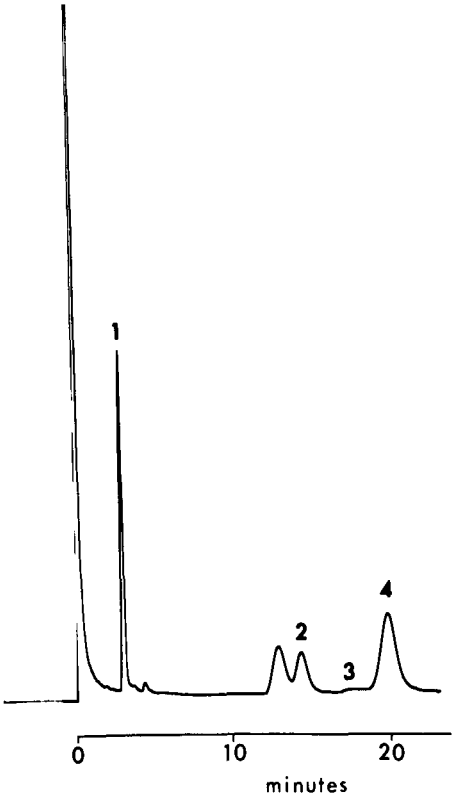

Fig. 6. Gas chromatogram of alkaloid fraction from *Ayahuasca* beverage (*Shuri oshinipa*), *Sharanahua* Indians, Purús River, Perú. Conditions: same as Fig. 2.
1 = DMT; 2 = Tetrahydroharmine; 3 = Harmaline; 4 = Harmine.

his thesis, a description of the Chacruna plant, which he saw 7 km from Iquitos:

La Chacruna es un arbusto de 3 a 4 metros de altura, de raíz napiforme, tallo leñoso, cilíndrico, de diez o más centímetros de diámetros. La corteza es de color verde, ligeramente obscuro, con manchas ligeramente blanquecinas y distribuidas como pequiñas aéreas de aspecto geográfico, do modo que en conjunto nos recuerda la piel de una serpiente. Las hojas son de forma lanceolada, alargadas, enteras, de pecíolo muy corto. Son hojas penninerviadas, con más de diez nervaduras secondarias. El haz es de color verde obscuro, lustroso; el envés es de un verde claro, opaco. Por su disposición en el tallo son opuestas y cruzadas, forman como manojos foliares en las ramas. Las hojas miden 13 a 15 cm de largo (incluyendo el pecíolo) por 4.5 cm en su parte más ancha. El pecíolo mide unos 0.5 cm de largo más o menos. La inflorescencia es compuesta, definida. El fruto es pequeño, de 4.5 por 5 mm, epicarpio de color rojo como el cerezo cuando está maduro; es una drupa, encierra dos semillas que nos recuerdan el café. Las semillas son pues dos, que se abren al igual que el café, convexas en su parte dorsal y aplanadas en su parte ventral, por la que se unen; unidas dan una forma ovoide, de 4 por 4.5 mm. Se parece al café. La testa (cubietra externa del epispermo) es de color blanco amarillento quando está fresca, ligeramente pardo cuando esta seca, y de aspecto rugoso en su parte dorsal.

Le llaman también yagé en Iquitos. Su habitat es el llano amazónico. Nosotros lo encontramos en las selvas de la circunscripción de San Juan, al este del caserió del mismo nombre, a uno siete u ocho kilómetros al S.O.

de la cuidad de Iquitos, en un terreno inculto, entre otros árboles y arbustos de la selva, con vegetación no muy tupida, en terrano arenoso obscuro, escasamente arcilloso y húmido, en "altura," como se dice en el argot regional. Nosotros lo encontramos con frutos por los meses de Febrero, Marzo y Abril.

Nos informan que hay otra variedad de chacruna que también asocian a la ayahuasca, pero, la que acabamos de describir es la que se usa en Iquitos y la que hemos empleado en nuestras experimencias.

No doubt it is a question of a rubiaceous plant, quite probably a *Psychotria*.

In 1929, two German chemists received from Bolivia Chacruna leaves, an admixture of Ayahuasca, but no chemical analyses were made (32). The leaves were, however, identified: it was a rubiaceous, probably *Mapouria formosa* (26).

The Piro of Rio Urubamba use also the Chacruna leaves (Horowa) to heighten the effect of a *Banisteriopsis* drink (Kamalampi). This plant was not botanically identified (5). Dobkin de Rios (19) quotes in a note that Chacruna (used by the mestizos of Iquitos) is *B. Rusbyana*. Schultes has a specimen of Chacruna from another collector near Iquitos and identified it as *B. Rusbyana* (Schultes, personal communication). Chacruna appellation can apply, probably, to both *Psychotria* and *Banisteriopsis*.

In view of the foregoing, it cannot be assumed that the decoction of the Yagé leaves, analyzed by Hochstein & Paradies (27) and found to contain DMT, was made from a *Psychotria* or *Banisteriopsis* plant. There is nothing to prove it, although these samples, which come from Rio Napo "near Iquitos," have the same vernacular name and have been shown indirectly to contain the same principal alkaloids.

Analysis of the Drink (Table IV)

Only a few chemical analyses of the beverage have previously been carried out (12, 13, 17, 27, 55). Hochstein & Paradies (27) declared that Harmine, Harmaline and Tetrahydroharmine were present in the aqueous extract "as used by the natives" and that the concentrations of Harmaline and Tetrahydroharmine were greater than in the plant. Der Marderosian et al. (17) have isolated DMT, "much Harmaline and a little Harmine" from "nixi pae" of Cashinahua. This Ayahuasca was prepared with the stem of *Banisteriopsis* sp. and the leaves of two species of *Psychotria* (not completely identified).

Of the sundry Ayahuasca drinks that have been analyzed in this study, only two have a botanical origin firmly established. As shown in Table IV, the several alkaloids identified in the plants are not present in the drink. Only DMT, Harmine, Harmaline and Tetrahydroharmine were detected in the decoction (Fig. 6).

On the gas chromatograms of the drink, as well as on those of the *Banisteriopsis* alkaloidal fractions, one component emerging just before Tetrahydroharmine still has to be identified (Fig. 2 & 6). This compound, probably a β-carboline, has a molecular weight of 232 (M+) and other peaks at 57 (base peak), 189, 176, and 174. Work on its identification is in progress.

Some clinicians have experimented with these substances in man by oral administration.

In 1929, Beringer & Wilmanns (7) used 0,02 g Harmine kreatinine capsules 4 to 6 times a day to treat Parkinson's disease.

Halpern (23) took up to 0,04 g per os in self-experiments. The effects came slowly after 10 to 15 minutes and optimal action was reached after two hours.

Pennes & Hoch in 1957 (45) reported no hallucinogenic effects from doses under 960 mg, although physical symptoms began with a 400 mg dose.

Naranjo (41) found Harmaline-HCl to be hallucinogenic at dosages above 4 mg/kg by mouth, which is about one half the threshold level of Harmine-HCl. The onset of the effects of those compounds was about one hour after ingestion by mouth.

Racemic Tetrahydroharmine-HCl, up

to the amount of 300 mg by mouth, was administered by Naranjo (41) to a volunteer who reported that, at this dosage level, there were subjective effects similar to those which he experienced with 100 mg of Harmaline.

Summing up from Table IV, we have calculated that an Indian, after drinking a portion of Ayahuasca (200 ml), has taken an average of 30 mg of Harmine, 10 mg of Tetrahydroharmine, and 25 mg of DMT.

In view of these results, new pharmacological experiments for a better understanding of the hallucinogenic action of Ayahuasca seem necessary.

Concluding Remarks

1. The South American drink called Ayahuasca studied here was collected among the Sharanahua and the Culina Indians of the upper Purús River in Amazonian Perú.

The present investigation established that this drink is prepared basically from the malpighiaceous *Banisteriopsis Caapi* and the rubiaceous *Psychotria viridis*. Sometimes Culina Indians used *P. carthaginensis* instead of *P. viridis*.

It is to be remembered that *Psychotria viridis* and *Banisteriopsis Rusbyana*, which contain closely related compounds, are used as additives to Ayahuasca by some native tribes (47).

Other ingredients are occasionally added to the decoction. They are not considered to be essential by the Indians. Some of those additives contain chemical constituents which could possibly add to or alter the hallucinogenic effects of the drink. They belong to the Solanaceae: *Nicotiana* sp., *Datura* sp. and *Capsicum* sp. *Nicotiana* and *Datura* have been already reported to be admixtures in other places (56). *Brunfelsia* is also frequently added in the Ecuadorian and Colombian Amazon along the eastern slopes of the Andes.

Other plants belonging to different families have not been reported before: *Lygodium venustum* (Schizaeaceae), *Phrygilanthus eugenioides* (Loranthaceae), *Lomariopsis japurensis* (Polypodiaceae), *Epiphyllum* sp. and *Opuntia* sp. (Cactaceae), *Cyperus* sp. (Cyperaceae) and *Clusia* sp. (Guttiferae). In other areas of the Amazon basin, *Prestonia amazonica*, *Malouetia Tamaquarina* (Apocynaceae) and *Alternanthera Lehmanii* (Amaranthaceae) are known to be added as admixtures together with *Banisteriopsis* (56). There are still numerous additives to the Ayahuasca drink unidentified or known only from native names.

2. By means of analytical tools giving direct evidence of identification of the alkaloids, we have definitively established that *Banisteriopsis Caapi* contains mainly Harmine, Harmaline, Tetrahydroharmine but also two minor compounds: Harmol and 6-Methoxytryptamine.

In the same way, both *Psychotria viridis* and *P. carthaginensis* have been shown to contain Dimethyltryptamine with traces of Monomethyltryptamine and 2-methyl-1,2,3,4-tetrahydro-β-carboline.

3. Even though many self-experiments with Ayahuasca preparation have been made with Indians, no composition of the beverage dosage of the alkaloids has previously been reported at the same time.

In this paper, qualitative and quantitative analyses of fully described Ayahuasca are presented: DMT, Harmine, Harmaline and Tetrahydroharmine were detected and identified. The relative concentrations of each compound present in the drugs are different from those present in the ingredients, *B. Caapi* and *P. viridis*.

An Indian, after drinking a portion of Ayahuasca of 200 ml, has taken an average of 30 mg of Harmine, 10 mg of Tetrahydroharmine, and 25 mg of Dimethyltryptamine.

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NOTE ADDED IN PROOF

After submission of the manuscript three papers with direct connection with this investigation have been published:

Ghosal, S., U. K. Mazumder & S. K. Bhattacharaya 1971. Chemical and Pharmacological Evaluation of *Banistereopsis argentea* Spring ex Juss. J. Pharm. Sci. **60**: 1209-1212.
Ribas, I., J. Saa & L. Casiedo 1972. Investigation del contenido en Alcaloides de la *Banisteriopsis inebrians* (Malphigiaceae). Anales di Quimica **68**: 299-302.
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