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A study of the chemical composition of *Erythroxylum coca* var. *coca* leaves collected in two ecological regions of Bolivia

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Abstract

Coca—*Erythroxylum coca* Lamarck var. *coca*—remains one of the most common plants of the folk medicine of Bolivia used as a general stimulant. Aymara and Quechua natives prefer to chew the sweeter coca leaves from the Yungas (tropical mountain forests of the eastern slopes of the Andes) rather than those from the Chapare lowlands. The contents in cocaine and minor constituents of leaf samples cultivated in these regions does not rationalize this choice. © 1997 Elsevier Science Ireland Ltd.

Keywords: *Erythroxylum coca* var. *coca*; Cocaine; Cinnamoylcocaine; Bolivia; Chapare; Yungas

1. Introduction

Erythroxylum coca Lamarck var. *coca* (Erythroxylaceae) is a shrub found in Bolivia and Peru and is one of the four varieties of coca largely cultivated in the Andes (Plowman, 1984). In Bolivia, one part of the production is traditionally consumed (10 000 metric tons per year) especially by means of chewing (Carter and Mamani, 1986). The two principal regions of coca cultivation are the moist tropical mountain forests along the eastern slopes of the Andes called Yungas, in the Department of La Paz (elevation: 1000–2000 m) and the wetter lowland of Chapare in the Department of Cochabamba (elevation: < 500 m). When the Bolivian peasants chew coca (or in Aymara

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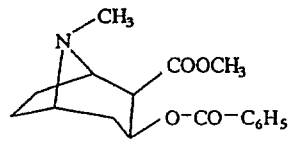

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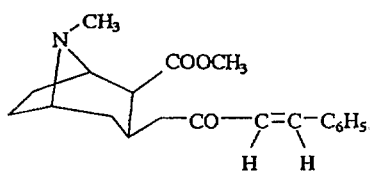

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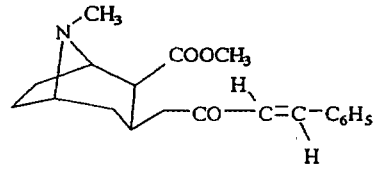

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Scheme 1.

language 'acullican'), they prefer the leaves from the Yungas region named 'coca paceña' because they are claimed to be sweeter and more aromatic than those from the Chapare region also called 'coca chapareña' (Carter and Mamani, 1986). In the traditional markets (La Paz, Cochabamba, Santa Cruz), coca leaves for chewing essentially come from the Yungas of La Paz. Previous chemical studies (Rivier, 1981; Plowman and Rivier, 1983) have established that: cocaine (1); *cis*-cinnamoyl cocaine (2); and *trans*-cinnamoyl cocaine (3) (Scheme 1) are the natural alkaloids of *E. coca* var. *coca* and that the relative amounts of these alkaloids depends on species and varieties. In order to understand the reasons for the Yungas coca choice, we performed botanical study and alkaloid analysis of samples, collected from every place in Bolivia where it is cultivated. Sampling included a historical research of the places where the old varieties were cultivated in the colonial period.

2. Method and materials

2.1. Plant material

The 110 samples of leaves were collected by two of us (ES and EG) during the wet (December) and dry seasons (June) in the Yungas mountains (Fig. 1) and the Chapare lowlands (Fig. 2) between the end of 1991 and the middle of 1992. They were identified at the University herbarium in Cochabamba and voucher specimens were deposited at the same herbarium under Saravia and Guttierez's names (Table 1). Three morphotypes, found in all of the localities of collection, were observed and described in Figs. 3–5. Study of the relocation of the coca production regions at the beginning of the Spanish conquest and during the first years of the Colony (16th century) was also undertaken through a careful consultation of historical archives. Two hundred grams of fresh coca leaves were collected in every field, from different shrubs and sun-dried.

2.2. Instruments

The liquid chromatograph was a Waters model 510 instrument, with a 20 μl injection loop. The column effluent was monitored with a Waters detector operating at 220 nm for cocaine and 280 nm for *cis* and *trans*-cinnamoylcocaine. Chromatograms were recorded and processed with a Waters baseline 810 computing integrator.

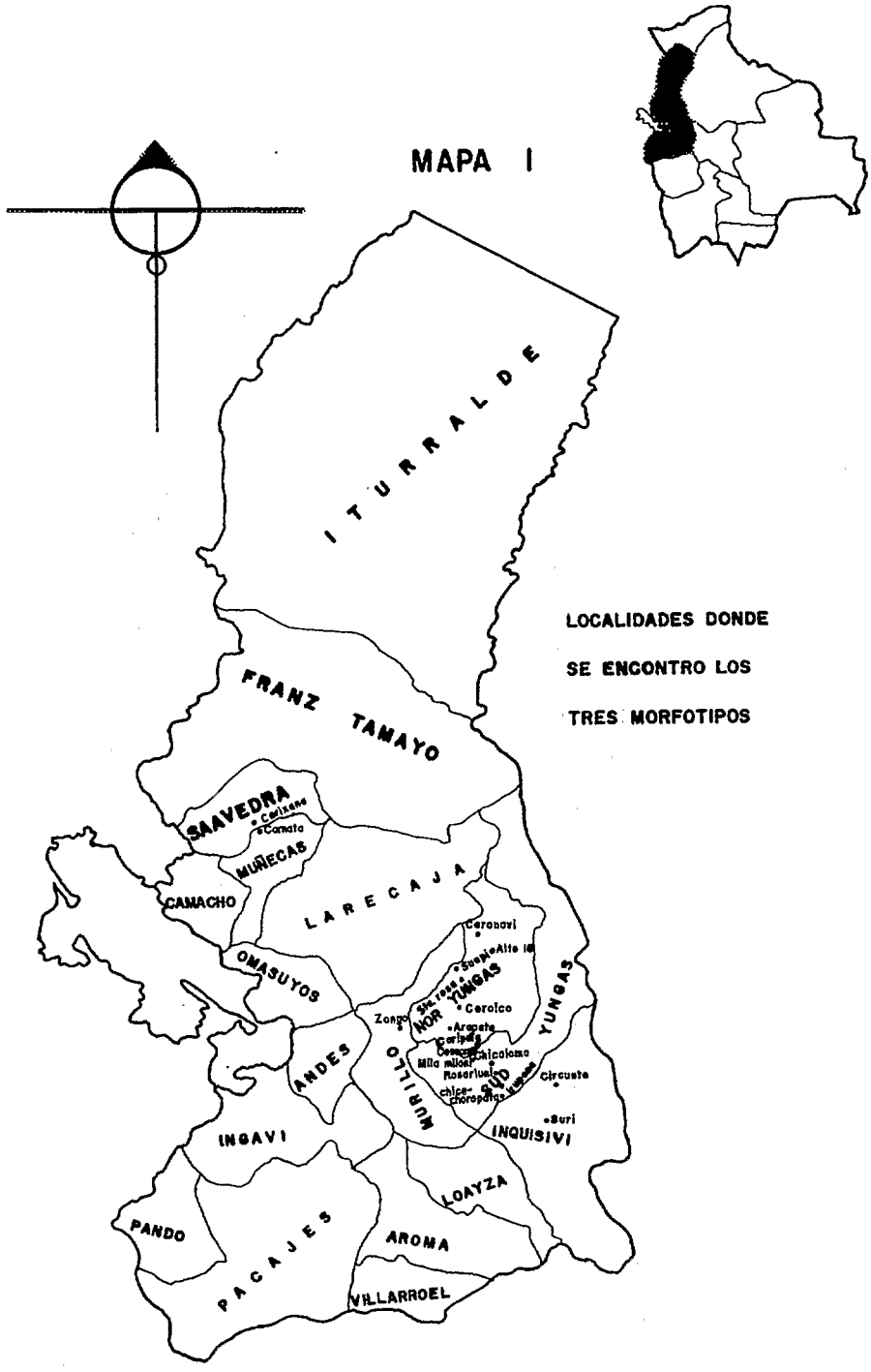

Fig. 1. Yungas' villages are situated in the Department of La Paz. The 18 villages with dots are field bases for ethnobotanical study.

Table 1
List of the voucher specimens: E.S., Edwin Saravia; E.G., Enrique Gutierrez; with the location (community—village—province—department), altitude and date of collection

Voucher specimens	Place of collection	Altitude	Date of collection
E.S. and E.G. 1	Alto 18—Caranavi—Nor Yungas—La Paz	1560	December 5, 1991
E.S. and E.G. 2	Alto 18—Caranavi—Nor Yungas— La Paz	1580	December 5, 1991
E.S. and E.G. 3	Cusilluni—Suapi—Nor Yungas—La Paz	1800	December 6, 1991
E.S. and E.G. 4	Coroico—Coroico—Nor Yungas—La Paz	1940	December 6, 1991
E.S. and E.G. 5	Arapata—Arapata—Nor Yungas— La Paz	1650	December 7, 1991
E.S. and E.G. 6	Coscoma—Coripata—Nor Yungas—La Paz	1800	December 7, 1991
E.S. and E.G. 7	Coripata—Coripata—Nor Yungas—La Paz	1780	December 7, 1991
E.S. and E.G. 8	Rosariuna—Chicaloma—Sud Yungas—La Paz	1640	December 7, 1991
E.S. and E.G. 9	Chicaloma—Chicaloma—Sud Yungas— La Paz	1800	December 8, 1991
E.S. and E.G. 10	Chica Choropata—Irupana—Sud Yungas—La Paz	1900	December 8, 1991
E.S. and E.G. 11	Suiqui Milamilani—Puente Villa—Sud Yungas—La Paz	1810	December 9, 1991
E.S. and E.G. 12	Cahua—Zongo—Murillo—La Paz	1650	December 13, 1991
E.S. and E.G. 13	Wailipaya—Zongo—Murillo— La Paz	1800	December 13, 1991
E.S. and E.G. 14	Puerto Aurora—Todos Santos—Carrasco— Cochabamba	330	December 19, 1991
E.S. and E.G. 15	Carmen Coni—Senda tres—Tiraque—Cochabamba	340	December 19, 1991
E.S. and E.G. 16	Santa Rosa—El Tacuaral—Tiraque—Cochabamba	380	December 19, 1991
E.S. and E.G. 17	San Carlos—Todos Santos—Chapare—Cochabamba	300	December 21, 1991
E.S. and E.G. 18	Alto San Franscico–San Franscico— Chapare—Cochabamba	280	December 21,1991
E.S. and E.G. 19	Chipiriri—Chipiriri—Chapare—Cochabamba	270	December 21, 1991
E.S. and E.G. 20	ND—Cristal Mayu—Chapare—Cochabamba	535	December 22, 1991
E.S. and E.G. 21	Avispas—Espiritu Santos— Chapare— Cochabamba	500	December 22, 1991
E.S. and E.G. 22	Itirapampa—Muyurina—Tiraque—Cochabamba	470	December 22, 1991
E.S. and E.G. 23	Muyurina—ND –Tiraque—Cochabamba	490	December 22, 1991
E.S. and E.G. 24	San Mateo bajo—San Mateo—Tiraque—Cochabamba	380	December 22, 1991
E.S. and E.G. 25	Carixana—Carixana—Bautista—La Paz	1680	February 14, 1992
E.S. and E.G. 26	Canquichoro—Camata—Muñecas—La Paz	1745	February 15, 1992
E.S. and E.G. 27	Bajo Tarawaya—Camata—Muñecas—La Paz	1550	February 15, 1992
E.S. and E.G. 28	Wailipaya—Zongo—Murillo—La Paz	1700	February 18, 1992
E.S. and E.G. 29	Cusilluni—Suapi—Nor Yungas—La Paz	1800	February 20, 1992
E.S. and E.G. 30	Alto 18—Caranavi—Nor Yungas—La Paz	1560	February 20, 1992
E.S. and E.G. 31	Santa Rosa—Arapata—Nor Yungas— La Paz	1940	February 21, 1992
E.S. and E.G. 32	Arapata—Arapata—Nor Yungas—La Paz	1650	February 22, 1992
E.S. and E.G. 33	Coscoma—Coripata—Nor Yungas—La Paz	1780	February 22, 1992
E.S. and E.G. 34	Coripata—Coripata—Nor Yungas—La Paz	1800	February 22, 1992
E.S. and E.G. 35	Suiqui Milamilani—Puente Villa—Sud Yungas— La Paz	1870	February 22, 1992
E.S. and E.G. 36	Suiqui Milamilani—Puente Villa—Sud Yungas—La Paz	1870	February 22, 1992
E.S. and E.G. 37	Chicaloma—Chicaloma—Sud Yungas— La Paz	1800	February 22, 1992
E.S. and E.G. 38	Huancara—Chicaloma—Sud Yungas—La Paz	1640	February 23, 1992
E.S. and E.G. 39	Chica Choropata—Irupana—Sud Yungas— La Paz	1900	February 23, 1992
E.S. and E.G. 40	Cirevata—Circuata—Inquisivi—La Paz	1840	February 24, 1992
E.S. and E.G. 41	Suri—Suri—Inquisivi—La Paz	2060	February 24, 1992
E.S. and E.G. 42	Suri—Suri—Inquisivi—La Paz	2060	February 24, 1992
E.S. and E.G. 43	Santa Rosa—El Tacuaral—Tiraque—Cochabamba	380	March 10, 1992
E.S. and E.G. 44	Cristal Mayu—Espiritu Santo—Chapare—Cochabamba	535	March 11, 1992
E.S. and E.G. 45	Avispas—Espiritu Santo—Chapare—Cochabamba	500	March 11, 1992
E.S. and E.G. 46	San Carlos—Toos Santos—Chapare—Cochabamba	300	March 12, 1992
E.S. and E.G. 47	Alto San Francisco San Francisco—Chapare—Cochabamba	280	March 12, 1992
E.S. and E.G. 48	Chipiriri—Chipiriri—Chapare—Cochabamba	270	March 12, 1992
E.S. and E.G. 49	Puerto Aurora—Todos Santos—Carrasco—Cochabamba	330	March 13, 1992
E.S. and E.G. 50	Puerto Aurora—Todos Santos—Carrasco—Cochabamba	330	March 13, 1992
E.S. and E.G. 51	Puerto Aurora—Todos Santos—Carrasco—Cochabamba	330	March 13, 1992
E.S. and E.G. 52	Puerto Aurora—Todos Santos—Carrasco—Cochabamba	330	March 13, 1992
E.S. and E.G. 53	Carmen Coni—Senda tres—Tiraque—Cochabamba	340	March 13, 1992

Table 1 (continued)

Voucher specimens	Place of collection	Altitude	Date of collection
E.S. and E.G. 54	Itiripampa—Muyurina—Tiraque—Cochabamba	470	March 14, 1992
E.S. and E.G. 55	Itiripampa—Muyurina—Tiraque—Cochabamba	470	March 14, 1992
E.S. and E.G. 56	Muyurina—Muyurina—Tiraque—Cochabamba	490	March 14, 1992
E.S. and E.G. 57	Muyurina—Muyurina—Tiraque—Cochabamba	490	March 14, 1992
E.S. and E.G. 58	San Mateo Bajo—San Mateo—Tiraque—Cochabamba	380	March 14, 1992
E.S. and E.G. 59	Cotacajes—Cocapata—Ayopaya—Cochabamba	1330	April 29, 1992
E.S. and E.G. 60	Cimarrón—Cocapata—Ayopaya—Cochabamba	1300	April 30, 1992
E.S. and E.G. 61	Cimarrón—Cocapata—Ayopaya—Cochabamba	1260	April 30, 1992
E.S. and E.G. 62	Cimarrón—Cocapata—Ayopaya—Cochabamba	1260	April 30, 1992
E.S. and E.G. 63	Atispaya—Cocapata—Ayopaya—Cochabamba	1300	May 2, 1992
E.S. and E.G. 64	Atispaya—Cocapata—Ayopaya—Cochabamba	1320	May 3, 1992
E.S. and E.G. 65	Maravillas—Cocapata—Ayopapa—Cochabamba	1485	May 3, 1992
E.S. and E.G. 66	Cotacajes—Cocapata—Ayopaya—Cochabamba	2340	May 4, 1992
E.S. and E.G. 67	Carixana—Carixana—Bautista Saavedra—La Paz	1680	May 16, 1992
E.S. and E.G. 68	Bajo Tarawaya—Camata—Muñecas—La Paz	1360	May 17, 1992
E.S. and E.G. 69	Alto Tarawaya—Camata—Muñecas—La Paz	1550	May 17, 1992
E.S. and E.G. 70	Wailipaya—Zongo—Murillo—La Paz	1700	May 21, 1992
E.S. and E.G. 71	Wailipaya—Zongo—Murillo—La Paz	1700	May 21, 1992
E.S. and E.G. 72	Cusilluni—Suapi—Nor Yungas—La Paz	1800	May 23, 1992
E.S. and E.G. 73	Cusilluni—Suapi—Nor Yungas—La Paz	1800	May 23, 1992
E.S. and E.G. 74	Alto 18—Caranavi—Nor Yungas—La Paz	1560	May 24, 1992
E.S. and E.G. 75	Santa Rosa—Arapata—Nor Yungas—La Paz	1940	May 25, 1992
E.S. and E.G. 76	Arapata—Arapata—Nor Yungas—La Paz	1650	May 25, 1992
E.S. and E.G. 77	Coscoma—Coripata—Nor Yungas—La Paz	1780	May 25, 1992
E.S. and E.G. 78	Coripata—Coripata—Nor Yungas—La Paz	1800	May 25, 1992
E.S. and E.G. 79	Suiqui Milamilani—Puente Villa—Sud Yungas—La Paz	1820	May 25, 1992
E.S. and E.G. 80	Yanka Kala—Puente Villa—Sud Yungas—La Paz	1870	May 25, 1992
E.S. and E.G. 81	Chicaloma—Chicaloma—Sud Yungas—La Paz	1800	May 26, 1992
E.S. and E.G. 82	Rosariuni Huancara—Chicaloma—Sud Yungas—La Paz	1640	May 26, 1992
E.S. and E.G. 83	Chica Choropata—Irupana—Sud Yungas—La Paz	1900	May 26, 1992
E.S. and E.G. 84	Cirevata—Circuata—Inquisivi—La Paz	1840	May 27, 1992
E.S. and E.G. 85	Suri—Suri—Inquisivi—La Paz	2060	May 28, 1992
E.S. and E.G. 86	Suri—Suri—Inquisivi—La Paz	2040	May 28, 1992
E.S. and E.G. 87	Carmen Coni—Senda tres—Tiraque—Cochabamba	340	June 6, 1992
E.S. and E.G. 88	Santa Rosa—El Tacarual—Tiraque—Cochabamba	425	June 6, 1992
E.S. and E.G. 89	San Carlos—Todos Santos—Chapare—Cochabamba	300	June 7, 1992
E.S. and E.G. 90	Alto San Francisco—San Francisco—Chapare—Cochabamba	280	June 7, 1992
E.S. and E.G. 91	Chipiriri—Chipiriri—Chapare—Cochabamba	270	June 7, 1992
E.S. and E.G. 92	Cristal Mayu—Espiritu Santo—Chapare—Cochabamba	535	June 8, 1992
E.S. and E.G. 93	Avispas—Esperito Santo—Chapare—Cochabamba	480	June 8,1992
E.S. and E.G. 94	Itirapampa—Muyurina—Tiraque—Cochabamba	470	June 9, 1992
E.S. and E.G. 95	Itirapampa—Muyurina—Tiraque—Cochabamba	470	June 9, 1992
E.S. and E.G. 96	Muyurina—Muyurina—Tiraque—Cochabamba	490	June 9, 1992
E.S. and E.G. 97	San Mateo Bajo—San Mateo—Tiraque—Cochabamba	380	June 9, 1992
E.S. and E.G. 98	Puerto Aurora—Todos Santos—Carrasco—Cochabamba	330	June 9, 1992
E.S. and E.G. 99	Puerto Aurora—Todos Santos—Carrasco—Cochabamba	330	June 10, 1992
E.S. and E.G. 100	Puerto Aurora—Todos Santos—Carrasco—Cochabamba	330	June 10, 1992
E.S. and E.G. 101	Arenales—Camino a Vandrola—Carrasco—Cochabamba	330	June 11, 1992
E.S. and E.G. 102	Arenales—Camino a Vandrola—Carrasco—Cochabamba	370	June 11, 1992
E.S. and E.G. 103	Arenales—Camino a Vandrola—Carrasco—Cochabamba	345	June 11, 1992
E.S. and E.G. 104	Ibarecito—Puerto Aurora—Carrasco—Cochabamba	250	June 11, 1992
E.S. and E.G. 105	Ibarecito—Puerto Aurora—Carrrasco—Cochabamba	250	June 12, 1992
E.S. and E.G. 106	Arepucho—Yungas de Totora—Carrasco—Cochabamba	1700	June 17, 1992
E.S. and E.G. 107	Antahuagana—Yungas de Totora—Carrasco—Cochabamba	750	June 18, 1992
E.S. and E.G. 108	Antahuagana—Yungas de Totora—Carrasco—Cochabamba	700	June 19, 1992
E.S. and E.G. 109	Icuna—Yungas de Totora—Carrasco—Cochabamba	850	June 19, 1992
E.S. and E.G. 110	San Pedro—Yungas de Totora—Carrasco—Cochabamba	1025	June 20, 1992

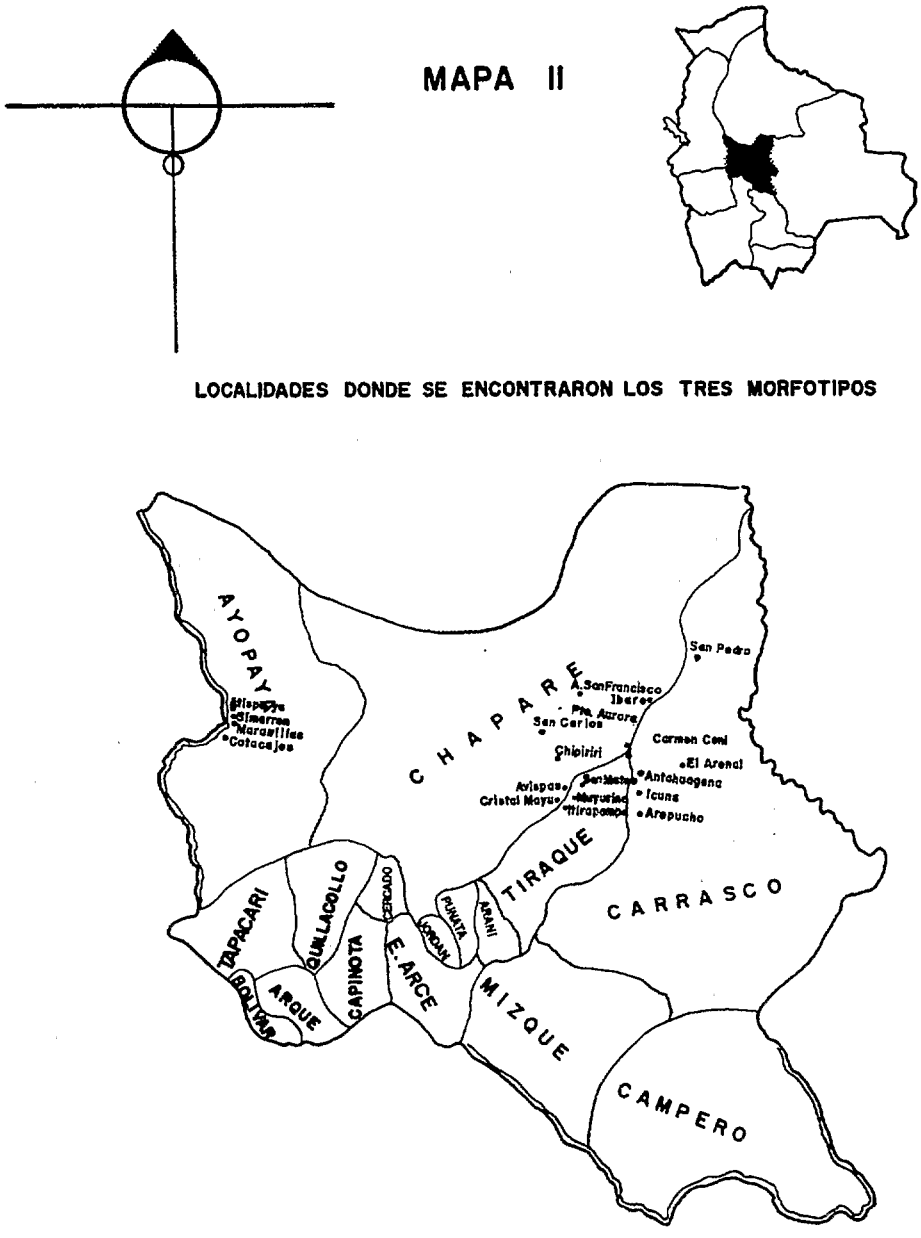

Fig. 2. Chapares' villages are situated in the Department of Cochabamba. The 20 villages with dots are field bases for ethnobotanical study.

A 15 cm × 3.9 mm Bondapak™ C-18 reversed-phase column (particle size, 5 μm) (Waters, Millipore) was operated at 35°C at a flow rate of 2 ml min^{-1} for cocaine measurements. The solvent, which was mixed by the chromatography system, consisted of 0.05 M phosphate buffer, pH 5, containing 25% (v/v) acetonitrile using the conditions described by Jatlow et al., 1978.

For the cinnamoylcocaines, a 25 cm × 4.6 mm Supelcosil™ LC-8 reversed-phase column (particle

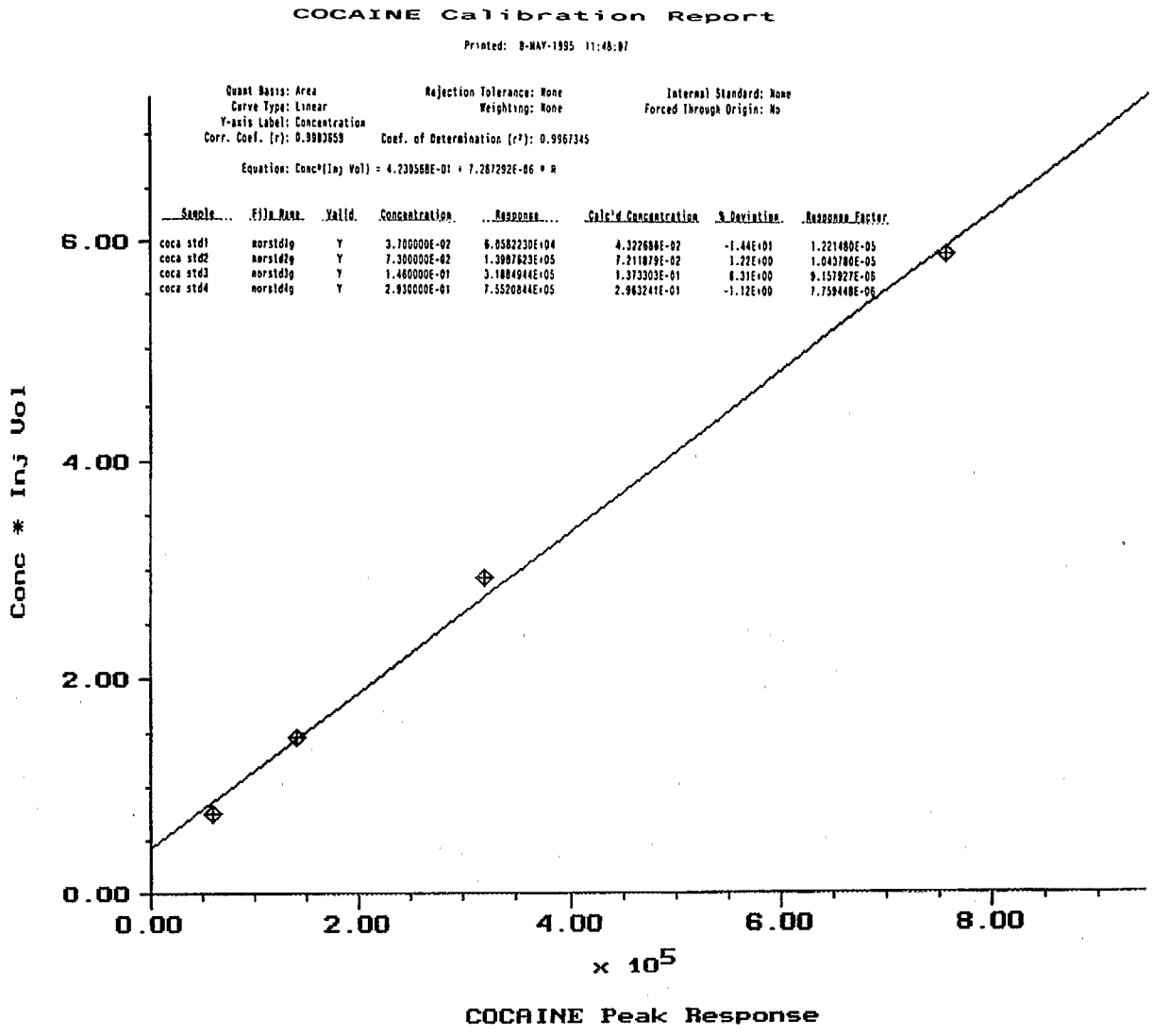

Fig. 3. Calibration curve for cocaine.

size, 5 μm) (Supelco, Bellefonte) was operated at 35°C at a flow rate of 1 ml min^{-1}. The solvent was a mixture of acetonitrile (40%), tetrahydrofuran (10%) and 0.1% v/v diethylamine in water (50%) as mentioned by Lebelle et al., 1988.

2.3. Chemicals

Reference standards: stock standards of cocaine hydrochloride, *cis*-cinnamoylcocaine and *trans*-cinnamoylcocaine bases were prepared and stored at −20°C in methanol at concentrations of 1 mg/ml. Cocaine was supplied by Merck and other standards were provided by the Drug Identification Division, Bureau of Drug Research, Health Protection Branch, Ottawa, Canada.

UV grade acetonitrile and tetrahydrofuran were used.

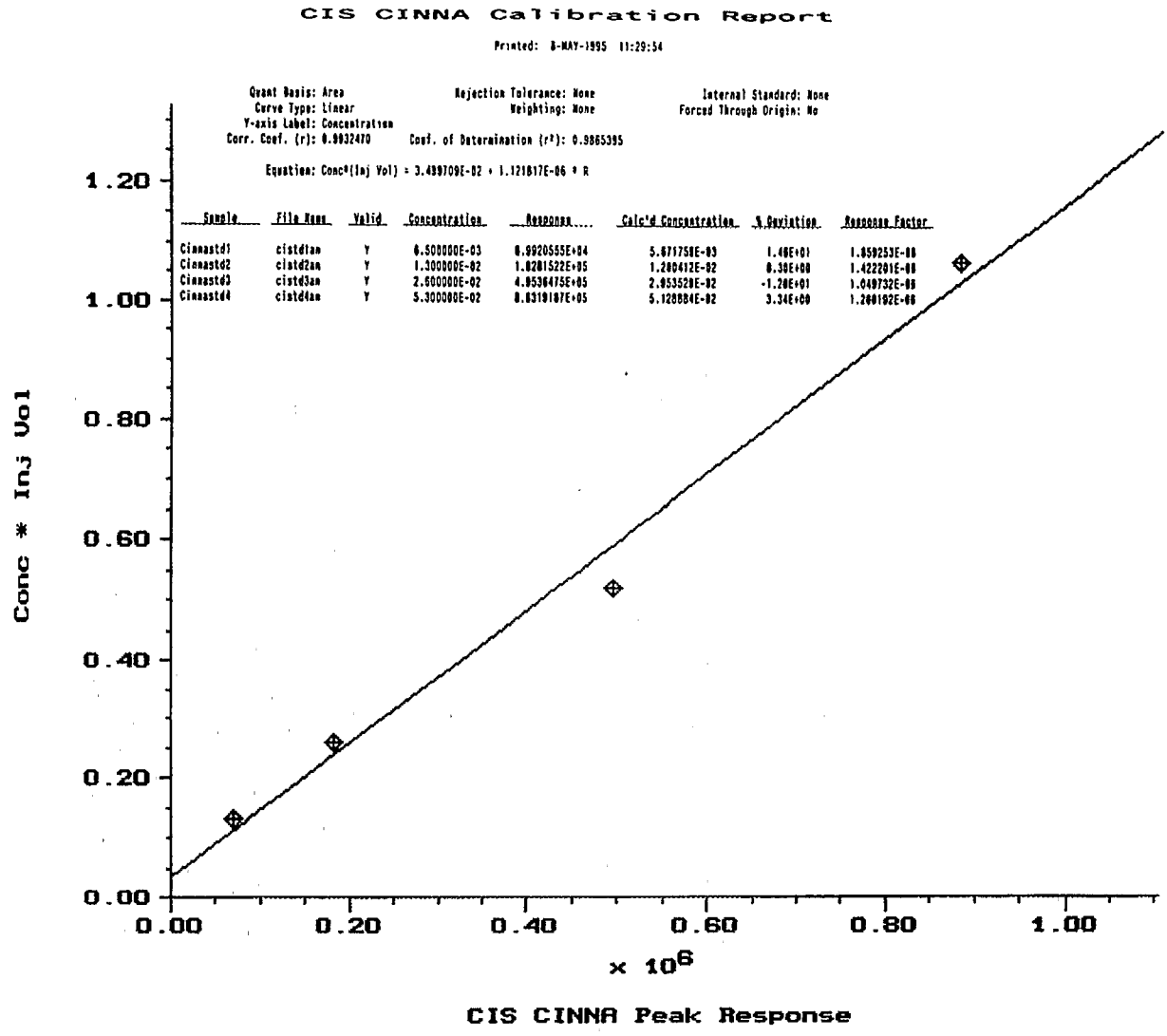

Fig. 4. Calibration curve for *cis*-cinnamoyl cocaine.

The concentration of phosphate buffer used was 0.05 M (pH 5). However, KH_2PO_4 (0.05 M) was adjusted to pH 5.00 with 0.1 M H_3PO_4.

2.4. Extraction procedure

Coca leaves were extracted using a modification of the method of Turner et al. (1981). One gram of the leaf powder was extracted with 95% ethanol (50 ml) at room temperature for 24 h before filtration. The operation was repeated until a negative Dragendorff reaction was reached. The filtrate was evaporated. The residue was then dissolved in 100 ml of chloroform and extracted three times with 50 ml of 1.5% citric acid (w/v). The aqueous layer was adjusted to pH 9 with Na_2CO_3 and extracted twice with $CHCl_3$ (100 ml). The organic phase was separated and evaporated

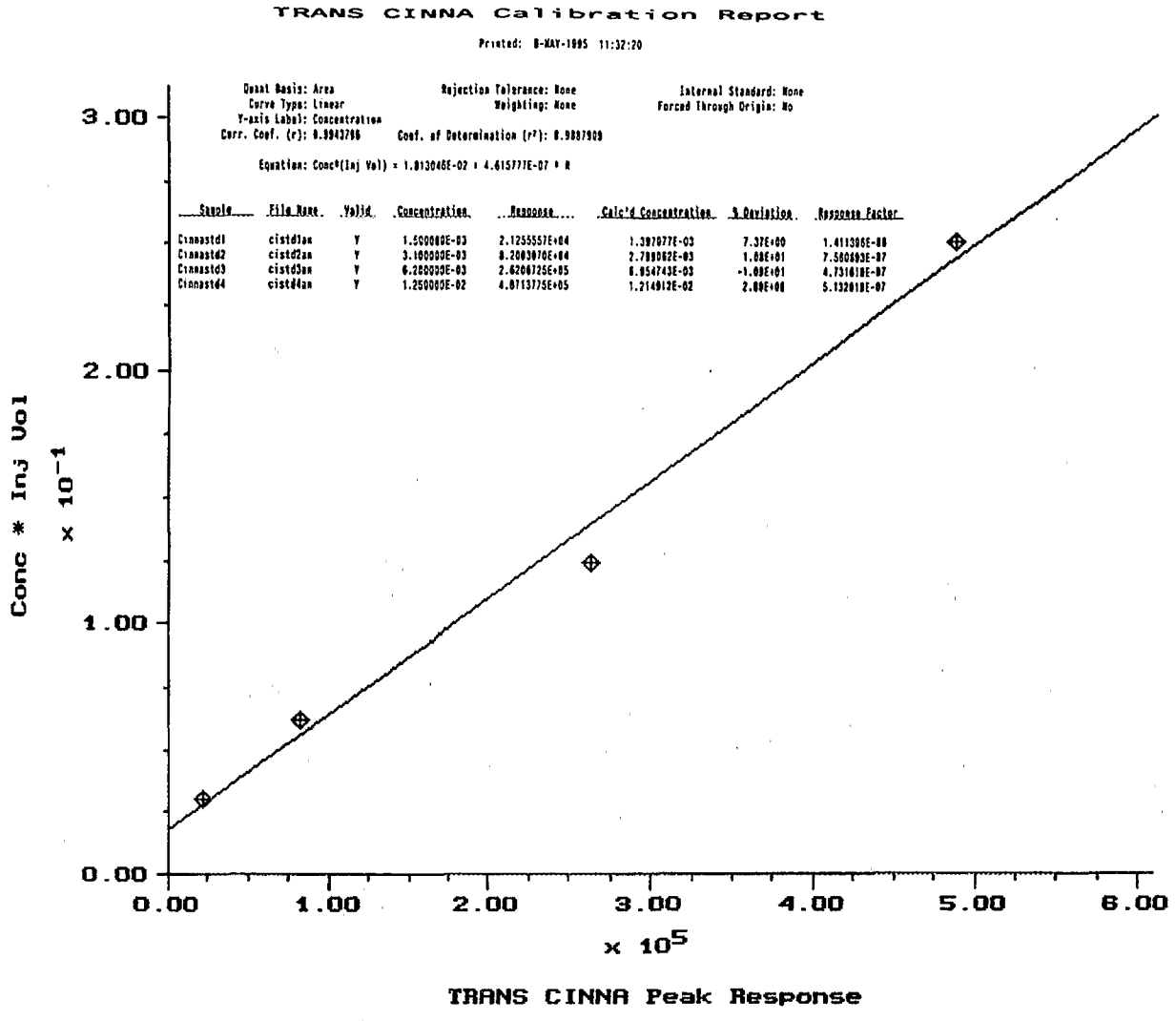

Fig. 5. Calibration curve for *trans*-cinnamoyl cocaine.

to dryness by roto-evaporation. The residue was dissolved in methanol (5 ml); 20 μl of this solution were used for titrations (in triplicate).

2.5. Quantification

Identification of the alkaloids was based upon comparison of retention times with those of external standards (Rosset et al., 1990). Calibration curves for the accurate determination of the endogenous substances, were obtained by calculation of the response factors of each individual component against itself according to Lebelle et al., 1991 (Figs. 7–9). Comparison of the average contents of alkaloids were submitted to statistical tests (Student's t-test) using the Statview® software.

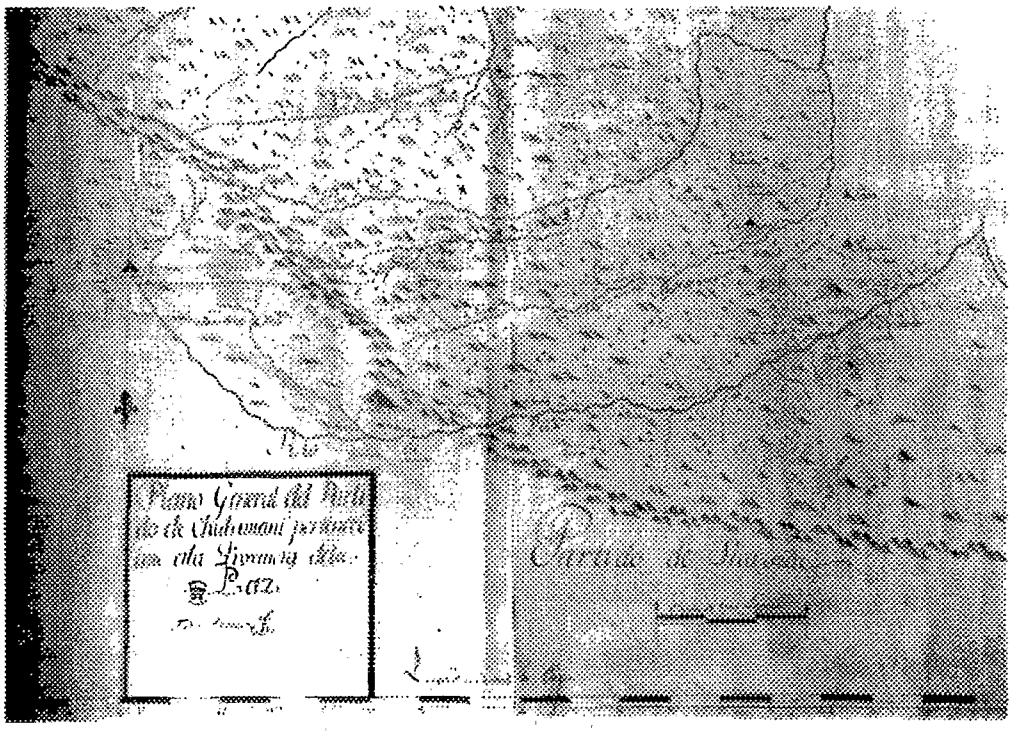

Fig. 6. Chulumani area from Yungas valleys, Department of La Paz. Drawing by Tadeo Peregrino Haenke, 1811.

3. Results

The historical places for coca location, some of them still producing coca leaves, occupy a long fringe on the eastern slope of the Andes. The Aymara kingdom—whose centers were located in the high lands—had access to the hot and wet valleys called Yungas where they cultivated coca leaves (Murra, 1991, Saignes, 1988). These valleys stretch North-West to South-East (Table 2). The main localities of coca cultivation during the colonial period are presented on the maps elaborated by Tadeo Haenke (Fig. 6).

Alkaloid mixtures of 109 leaf extracts were examined using our HPLC system. Three alkaloids were present in all the samples, cocaine (1), the main peak in the chromatogram and *cis*- (2) and *trans*-cinnamoylcocaine (3) (Scheme 1). None of the UV active alkaloids previously reported in the literature (e.g. benzoylecgonine or nicotine) could be detected in the material used. The average concentrations of cocaine from both types of ecological regions were identical for samples collected during the same season (Table 3). The concentration of cocaine however doubled between the wet and the dry seasons, in both regions, while the concentration of *cis*-cinnamoylcocaine diminished significantly in the Yungas during the same period of time. The average concentration for *cis*- and *trans*-cinnamoylcocaine were identical in the same season for the two ecological regions (Tables 4 and 5).

4. Discussion and conclusions

This study shows that the Bolivian peasant preference for coca from the Yungas is not related

to the cocaine concentration. The explanation may then be related to habits and to the presence and amount of other secondary metabolites.

Cultivation of coca in the Chapare lowlands is relatively recent and for centuries the principal region of cultivation in Bolivia were the Yungas (Soux, 1993). It is possible that the commercial routes to traditional markets as well as habits could not be modified in such a short lapse of time (20–40 years).

The presence of essential oils in *E. coca* was confirmed by Novak and Saleminck, 1987. The nature and amount of essential oils in the leaves of *E. coca* var. *coca* may be an important element for choice by the consumer. A definitive answer to problem addressed in this study will necessitate their analysis.

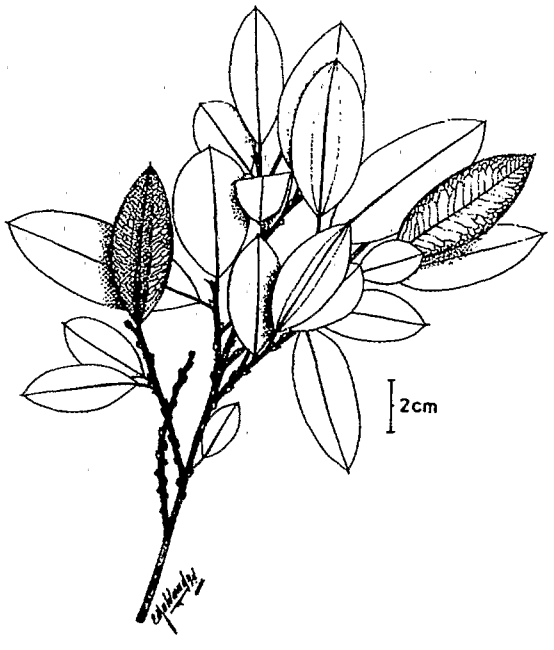

Fig. 7. Morphotype 1 of *Erythroxylum coca* var. *coca*: habit of plant. Drawing by Carlos Maldonado, 1994. Shrub 1–2 m, the bark wrinkled, branches suberect, with ash–grayish scales and lenticels, young branches with longitudinal cracks up to the apex; simple and membranous leaves oblong-lanceolate 8 × 5 cm, lateral venation and middle rib conspicuous, with two longitudinal and translucid areoles, from the base of the blade up to the apex, mucronate, with many stipules. Flowers white or yellowish; calyx gamosepalous with oval lobes, 3-teethed petals, 10 stamens, 4 styles. The fruit a red-orange drupe oblong to ovate.

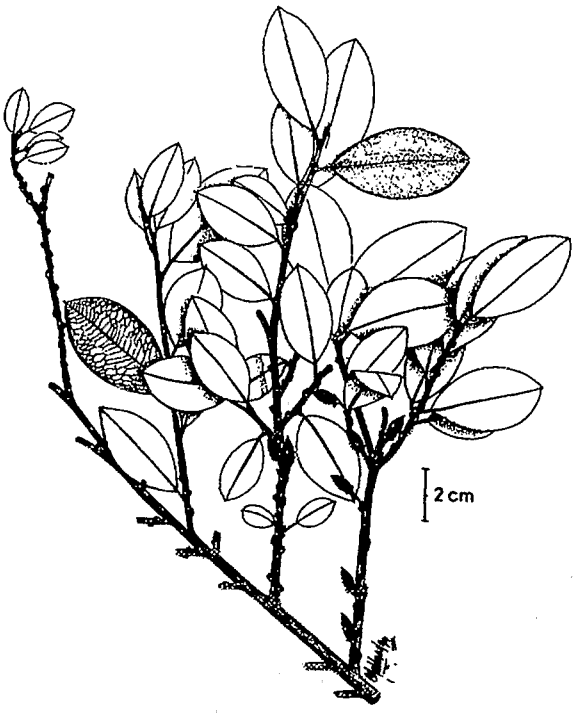

Fig. 8. Morphotype 2 of *Erythroxylum coca* var. *coca*: habit of plant. Drawing by Carlos Maldonado, 1994. Only the differences with the other two morphotypes are mentioned: the suberect branches are very scaly. Leaves simple, shorter and membranous, lateral venation, and middle rib prominent blade oblong, the apex more rounded 5.5 × 3 cm longitudinal areoles from the base of the blade up to the apex, blade darker than in morphotype 1.

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Table 2
Sites of coca production in the colony

Actual localisation	Place of coca's production in the Colony
Departamento of La Paz	
Provincia Muñecas	Camata—Carixana
Provincia Larecaja	Chacapa—Challana
Provincia Murillo	Songo
Provincia Nor Yungas	Yungas Peri (Coroico—Coripata)
Provincia Sur Yungas	Yungas Chapes (Chulumani – Yanacachi—Irupana)
Provincia Inquisivi	Suri
Departamento of Cochabamba	
Provincia Carrasco	Pocona (Arepucho—Chuquioma)

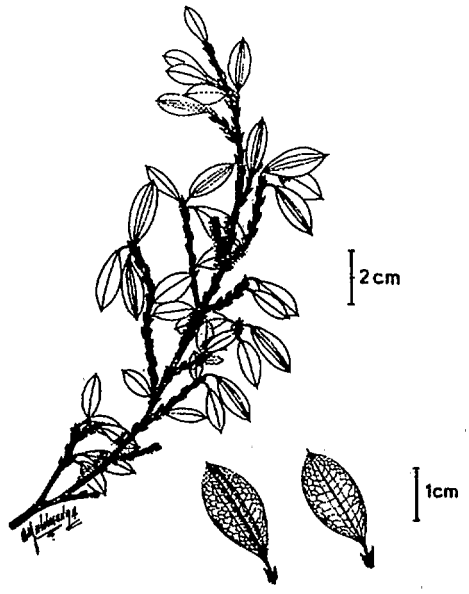

Fig. 9. Morphotype 3 of *Erythroxylum coca* var. *coca*: habit of plant. Drawing by Carlos Maldonado, 1994. Only the differences with the other two morphotypes are considered: suberect branches very scaly, the scales ash–grayish, lenticels present, young branches with longitudinal cracks up to the apex, leaves, simple smaller and thicker with a mucronate apex, this lanceolate, primary and secondary nerves inconspicous, the blade 3 × 1.3 cm with three pairs of translucid areoles at the base and parallel to the middle rib; stipules present at the base. Cultivators call this morphotype as 'ch'iñi coca' y 'ork'o coca' in the Yungas of La Paz and 'coca paceña' in the Chapare region. This uncommon morphotype is generally eliminated from cultures by cultivators. These plants are not harvested due to the harder and smaller leaves and are used only for personal consumption. Morphotype 3 seems to be an ill plant (virus or fungi diseases).

Table 3
Concentration of cocaine (in g for 100 g of dry leaves) in samples of coca leaves collected in Bolivia

Seasons	Alkaloid concentration Yungas	Alkaloid concentration Chapare	Significance
Wet season	0.33 ± 0.05	0.32 ± 0.04	NS
Dry season	0.60 ± 0.04	0.50 ± 0.04	NS
Significance	<0.05	<0.05	

Table 4
Concentration of *cis*-cinnamoylcocaine (in g for 100 g of dry leaves) in samples of coca leaves collected in Bolivia

Seasons	Alkaloid concentration Yungas	Alkaloid concentration Chapare	Significance
Wet season	0.0160 ± 0.003	0.0205 ± 0.0069	NS
Dry season	0.0079 ± 0.0010	0.0096 ± 0.0014	NS
Significance	<0.05	NS	

Table 5
Concentration of *trans*-cinnamoylcocaine (in g for 100 g of dry leaves) in sample of coca leaves collected in Bolivia

Seasons	Alkaloid concentration Yungas	Alkaloid concentration Chapare	Significance
Wet season	0.0030 ± 0.0008	0.0031 ± 0.0011	NS
Dry season	0.0031 ± 0.0005	0.0050 ± 0.0006	NS
Significance	NS	NS	

References

Carter, W.E. and Mamani, M. (1986) *Coca en Bolivia.* Juventud, La Paz, p. 530.

Jatlow, P.I., Van Dyke, C., Barash, P and Byck, R. (1978) Measurement of benzoylecgonine and cocaine in urine, separation of various cocaine metabolites using reversed-phase high-performance liquid chromatography. *Journal of Chromatography* 152, 115–121.

Lebelle, M.J., Callahan, S.A., Latham, D.J. and Lauriault, G. (1988) Identification and determination of norcocaine in illicit cocaine and coca leaves by gas chromatography—Mass spectrometry and high-performance liquid chromatography. *Analyst* 113, 1213–1215.

Lebelle, M.J., Callahan, S.A, Latham, D.J., Lauriault, G. and Savard, C. (1991) Comparison of illicit cocaine by determination of minor components. *Journal of Forensic Sciences* 36, 1102–1120.

Murra, J.V. (1991) *Visita de los valles de Sonqo en los Yunka de coca de La Paz (1568–1570).* Colección Economia Quinto Centenario, Madrid.

Novak, M. and Saleminck, C.A. (1987) The essential oil of *Erythroxylum coca. Planta Medica* 53, 113.

Plowman, T. (1984) The ethnobotany of coca (*Erythroxylum spp.*, Erythroxylaceae). *Advances in Economic Botany* 1, 62–111.

Plowman, T. and Rivier, L. (1983) Cocaine and cinnamoylcocaine content of *Erythroxylum* species. *Annals of Botany* 51, 641–659.

Rivier, L. (1981) Analysis of alkaloids in leaves of cultivated *Erythroxylum* and characterization of alkaline substances used during coca chewing. *Journal of Ethnopharmacology* 3, 313–335.

Rosset, R., Caude, M. and Jardy, A. (1990) *Manuel pratique de chromatographie en phase liquide.* Masson, Paris, 374 p.

Saignes, T. (1988) El consumo popular de estimulantes en el siglo XVII. *Revista de Indias*, Madrid, 48, 182–183.

Soux, M.-L. (1993) *La coca liberal, producción y circulación a principios del siglo XX.* CID-Cocayapu, La Paz, p. 212.

Turner, C.E., Ma, C.Y. and Elsohly, M.A. (1981) Constituents of *Erythroxylon coca.* II. Gas-chromatographic analysis of cocaine and other alkaloids in coca leaves. *Journal of Ethnopharmacology* 3, 293–298.