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A comparison of traditional healers' medicinal plant knowledge in the Bolivian Andes and Amazon

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Abstract

Medicinal plant knowledge of two groups of traditional healers was thoroughly studied during a 2-year ethnobotanical survey in the Bolivian Andes (Quechua farmers from Apillapampa) and Amazon rainforest (Yuracaré-Trinitario slash-and-burn cultivators from Isiboro-Sécure National Park), respectively. Both areas represent ecologically and culturally diverse zones, differing in floristic diversity, physical accessibility to health care and degree of modernization, the latter evidenced by presence or intensity in use of modern services such as electricity, water distribution, and materials for house construction. It is generally believed that indigenous people have an impressive knowledge of useful plant species and that this knowledge reflects the plant wealth of their living environment. However, the present study shows that healers' knowledge of collected medicinal plants (expressed as percentage of plants known by name and use by the majority of healers) is higher in the Andean area characterised by a long history of anthropogenic activity, than in the biodiversity-rich rainforest (protected since 1965). Therefore, medicinal plant knowledge does not seem to depend on the level of plant diversity, degree of modernization or absence of Western health care infrastructure. Indeed, although Andean healers live in a floristically poorer environment, have adopted more modern services and have easier access to primary health care facilities, they are more knowledgeable about medicinal plants than rainforest healers who live isolated in an environment with considerable floristic/ecological variation and lack of Western health care. It is hypothesised that social factors underlying traditional medical practices (background of extensive family in traditional medicine) play an important role in transmission—and hence survival of knowledge on medicinal plants.

Keywords: Medicinal plants; Bolivia; Biodiversity; Traditional healers; Andes; Amazon

Introduction

Plant diversity is asymmetrically distributed across Tropical America. Amazonia, one of the ten Neotropical phytogeographic regions defined by Gentry (1982), is the richest in species together with Central America (including Mexico). They contain each about a quarter of the Neotropical total. Intermediate levels of plant diversity (16–18% of the Neotropical flora) are found in the northern (Ecuador and Colombia) and southern (Bolivia, Peru, Argentina and Chile) Andes (Gentry, 1982). The Amazon Basin contains the largest area of

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tropical rainforest in the world (Bennett, 1992). Lowland moist forest is considered to be the most diverse neotropical vegetation type, structurally (in terms of plant habit), as well as taxonomically. It is generally accepted that precipitation is the determining factor for plant diversity richness. Also, plant diversity seems to decrease with increasing altitude (Gentry, 1988). However, taking into account all plant habits, i.e. also herbaceous plants, Andean regions can have a higher diversity than has been assumed (Henderson, Churchill, & Luteyn, 1991). Indeed, comparative studies on plant diversity between lowland forest and high altitude areas often compare the decline in tree species, while the dominant habit group of the southern Andes are herbs and shrubs (42%) and arid area trees (45%) (Gentry, 1982). On the other hand, one of the factors countering plant diversity richness is anthropogenic disturbance of high intensity such as widespread deforestation. Deforestation in the Andes is much higher as compared to the Amazon (90 versus 10%) (Henderson et al., 1991). Therefore, it can be expected that the negative influence of human pressure on levels of plant diversity will be more dramatic there.

Owing to its diversity, the tropical rainforest is a resource base for a plethora of indigenous communities who depend on knowledge of forest use for their livelihood. Various authors have emphasised the wealth (both in breadth and depth) of botanical knowledge of small-scale societies. In 2.5–3 ha of Amazon forest in the Northwest Amazon (Ecuador, Peru and Colombia), 84–90% of inventoried species are used by inhabiting indigenous communities (Macía, Romero-Saltos, & Valencia, 2001; Sánchez, Duque, Miraña, Miraña, & Miraña, 2001). Inventories of plant uses have repeatedly been found to be more extensive for rainforest populations than for populations living in other environments (Ellen, 1998). The high plant diversity of rainforests is considered to be responsible for this (Bennett, 1992).

Medicinal plant knowledge is, like all local knowledge, a "social product" that is part of the specific cultural system (Antweiler, 1998). Local knowledge is not always evenly distributed and not every member of the group necessarily knows the same knowledge. This is certainly true for medicinal plant knowledge, where usually a distinction can be drawn between specialists (traditional healers) who possess more in-depth knowledge, and laypersons. In Cameroon, knowledge of medicinal plants is considered secretive and healers claim to have learned from a host of relatives (Ryan, 1998). In Zambia, three ways were identified by which traditional healers acquire their healing practices: (1) after being taught by a family member (the majority); (2) through ancestral spirits; (3) having learnt from other healers. Healing tends to be a guarded family knowledge and is handed down through kinship (Ndubani & Höjer, 1999). In Malawi, many healers have assistants who are apprentices in training. The decision to train as a healer can come from a divine 'call' (dream or traumatic illness) (Courtright, 1995). In Tanzania, many healers reported receiving information on new, potentially medicinal plants during their sleep. They also communicate sometimes with other healers about the plants they use and how to administer them. This information exchange takes place in loosely organised healers' associations, or between close friends. In most cases, collaborating healers do not live in the same village (Gessler et al., 1995a). The following four ways (and sometimes a combination of them) of becoming a traditional healer were reported: (1) inheritance within the family; (2) initiation by (ancestor) spirits; (3) the experience of having an illness cured by traditional medicine (TM); (4) own decision, followed by a period of apprenticeship. The family seemed to be the most important source to acquire knowledge, followed by ancestor spirits and experienced traditional healers outside the family. Many traditional healers are initiated long before they start practising and it is the teacher who decides when the apprentice is ready to start practising (Gessler et al., 1995b). In Latin America, social transmission of medicinal plant knowledge and skills is similar to Africa. Yucatec Maya informants claimed to be taught by an experienced healer, or by elderly relatives. In addition, information was obtained through dreaming about useful medicinal plants (Ankli, Sticher, & Heinrich, 1999). In the Bolivian Andes, individuals who came in close contact with lightning are 'chosen' for initiation into healing by serving as assistants to qualified traditional healers (Alba, 1996). Aspiring herbalists seek the best teachers, but this is not always possible because the tradition can be inherited or passed along kinship lines, as is the case for the famous travelling Kallawaya healers. However, these kinship lines can be quite extensive, including also relatives of the respective parents and ritual godfathers (Bastien, 1987). Hence, medicinal plant knowledge can be transmitted either vertically through the family model, or horizontally by exchange of information between peers (Ladio & Lozada, 2001).

Given the highly diverse flora of tropical forests and the observation that forest peoples are exceptionally skilled ecologists, it might be expected that indigenous forest inhabiting groups also have extensive knowledge about medicinal plant names and their uses. Therefore, the present research aims at a quantitative intercultural comparison of the medicinal plant knowledge of a group of traditional healers from the Bolivian Andes and lowland Amazon rainforest. Since the Andean community is situated in an area with high anthropogenic activity, while the Amazon communities live relatively isolated in a natural reserve it was expected that medicinal plant knowledge would be considerably higher in the rainforest as compared to the Andes.

Research area

Apillapampa

Apillapampa, the Andean research area, is situated in the Cochabamba Department, Capinota province at 3250 m, 17°51′S (latitude) and 66°15′E (longitude). Mean annual temperature and precipitation are 18°C and 524 mm (data are from the village of Capinota at 2380 m). In Apillapampa, lower temperatures and a higher precipitation are expected due to the higher altitude. Medicinal plants are collected between 2800 and 3900 m. This range corresponds with two successive ecological units: the *prepuna* (from 2000–2300 to 3100–3300 m) and the *puna* (from 3100–3300 to 3900–4000 m). The *prepuna* is a transitional zone and considered to be the upper part of the dry interandean valleys *sensu lato*. The valleys *sensu strictu* are below 2000–2300 m (Navarro & Maldonado, 2002). Much variation exists between authors concerning the altitudinal limits of these units. One reason for this is regional differences in temperature and rainfall that influence vegetation. Also, many authors fail to distinguish between valleys and *prepuna* and just mention valleys up to 3000 m.

The vegetation of the research area has undergone significant human influence and is therefore mainly secondary in nature and characterised by shrubs of different height (*chaparrales* and *matorrales*) and grasses. Between 2600–2700 and 3100–3200 m, in the *prepuna* part, climax vegetation (free of anthropogenic disturbances) is formed by *Kageneckia lanceolata* and *Schinus molle*. In soils with a high degree of erosion this vegetation is substituted by *Dodonea viscosa* and *Baccharis dracunculifolia* (*matorrales* of 1–2 m). Among other associated species are: *Salvia haenkei*, *Lycianthes lycioides*, *Aloysia gratissima*, *Cheilanthes myriophylla*, *Kentrothamnus weddellianus* and *Buddleja tucumanensis*. Between 3200 and 3900 m, the *puna* part of the study area represents a climax vegetation of *Polylepis besseri* and *Berberis commutata*. *Schinus microphyllus* is among the associated species. This vegetation is replaced by grasslands containing, among other plants, *Astragalus* sp., *Peperomia peruviana*, *Hypseocharis pimpinellifolia*, *Satureja boliviana* and *Relbunium aff. ciliatum*. All the species discussed here (see Navarro & Maldonado, 2002 for more detailed floristic listings) are also part of our medicinal plant inventory.

National park Isiboro-Sécure (NPIS)

NPIS has a total area of 12,000 km^2 and is situated in the Amazon, Chapare province, Cochabamba Department, between 16°23′–16°40’S (latitude) and 65°41′–65°57′E (longitude). NPIS was declared a protected area in 1965 and the Indigenous Territory of Mojeño, Yuracaré and Chimane ethnic groups in 1992. The communities studied live at altitudes below 500 m. Commercial logging is prohibited in the park. Mean annual temperature is 27°C, with values fluctuating between 12°C (June) and 36°C (December–January). Average annual precipitation is 4000 mm (Cinep, 1998).

The floristic composition of Chapare Amazon plant ecosystems is still poorly known. In the study area, the following vegetation types can be distinguished (Navarro & Maldonado, 2002): (1) Chapare upland Amazonian rainforest, characterised in San Jose de la Angosta by four defined plant layers—the highest reaching 35 m—and by the following species: *Sterculia* sp., *Dipteryx odorata*, *Calycophyllum brasiliensis*, *Eschweilera coriacea*, *Ceiba pentandra*, *Iriartea deltoidea*, *Astrocaryum murumuru*, *Symphonia globulifera*, *Nectandra* sp., *Socratea exorrhiza*, *Clarisia racemosa*, *Cuararibea putumayensis*, *Geonoma deversa*, *Mouriri myrtilloides*, *Psychotria borucana*, *Psychotria capitata*, *Psychotria poeppigiana*, *Notopleura* sp., *Faramea occidentali*, *Piper* spp. (Alfaro, Aguayo, Balderrama, Vargas, & Cahill, unpubl. results); (2) seasonal upland Amazonian rainforest with a climax vegetation of *Swietenia macrophylla*, *Poulsenia armata* and *Terminalia oblonga*; (3) Chapare seasonally inundated (*várzea*) forests characterised a.o. by *Hura crepitans*, *Dipteryx odorata* and *Guadua chacoensis*; (4) pre- and subandean Chapare riverine successional shrub- and woodlands, including white water trees such as *Tessaria integrifolia* and *Salix humboldtiana*. Species from these ecological units were also collected during our ethnobotanical study.

Ethnographic data

Apillapampa

Apillapampa is a community of around 2500 Quechua speaking inhabitants (430 families) who live in village-like settlements (ex-haciendas) since the colonial period (Fepade, 1998). The population is agrarian and also dedicated to cattle-ranging (sheep, goats, cows). The majority practices agriculture without irrigation and with a vertical management of ecological units due to the altitudinal zone. Wheat, potato and maize are the principal crops. They are cultivated mainly for auto-consumption. One quarter of the production has a commercial destination. Cattle are considered a source of savings. Cattle excrement is used as fertiliser. Occasionally, meat is used as a source of protein in case of low crop yield (Fepade, 1998). Health care is provided by a primary health care service (PHC). It is operated on weekdays by a bilingual Spanish-Quechua speaking nurse and MD, originating from outside the community. In the weekend, one of the traditional healers from AMETRAC (*Asociación de Médicos Tradicionales*), who is also a health care worker, attends the PHC. The main health care contribution of the PHC is to provide first aid, vaccinations to children, oral rehydration therapy, mineral supplements to pregnant women and basic medication such as analgesics and antibiotics (Fepade, 1998). The PHC also trains health care workers originating from the community. As an alternative for Western health care, inhabitants can make use of the traditional healing practices of members of AMETRAC, a semi-formal organisation of eight traditional healers originating from the community.

NPIS

In NPIS, six settlements of Yuracarés-Trinitarios were studied: (1) Limo del Isiboro, (2) Santa Fe del Isiboro, (3) Villa San Juan del Isiboro, (4) San Jose de la Angosta, (5) San Antonio and (6) Carmen de la Nueva Esperanza. These communities are inhabited by 6–16 nuclear families and are dispersed throughout the Park along the banks of the rivers Isiboro, Moleto and Ichoa. The Yuracaré belong to a non-classified linguistic family. NPIS is one of their traditional habitats. Nowadays, they coexist with Trinitarios, also called Mojeños or Moxenos. The latter belong to the Arawak language family and have a long history of contacts with missionaries since the 17th century. The physical inaccessibility of NPIS helped to maintain this area free from outsiders until 1970, when a migration wave of highland Quechua farmers, called *colonos*, penetrated NPIS. Around the same time, the Trinitarios fled to NPIS from the neighbouring plains of Moxos, their traditional territory, as a reaction to increasing external pressures. Yuracarés and Trinitarios relate well to each other (historically they were neighbours), but both groups have conflicts with *colonos* (Paz, 1991). The main activity of contemporary Yuracarés and Trinitarios consists of low intensity agriculture, supplemented with fishing, hunting and, to a lesser extent, recollection of edible forest products. Main crops are banana, cassava and rice. Sporadically they sell salted game, fish, rice and canoes or provide wage labour for nearby Quechua farmers who live at the borders of the indigenous territory. PHCs in the Park are only present in some of these immigrant settlements (Cinep, 1998). Volunteers, such as the Park guards, provide free but very limited medical care (disinfection of wounds, provision of a few pharmaceutical tablets) without proper medical training or institutional back-up to some indigenous communities with easy physical access.

Material and methods

Acceptance of the research project by the indigenous leaders, individual healers and their communities was formalised by a written agreement between researchers and indigenous representatives. A copy of this agreement and all details of the project were sent to the Bolivian government, *Ministerio de Desarrollo Sostenible y Planificación* (*Dirección General de Biodiversidad*), in order to obtain the necessary research permits. The *Centro de Biodiversidad y Genética* from the *Universidad Mayor de San Simón*, Cochabamba, and the *Servicio Nacional de Areas Protegidas—Territorio Indígena Parque Nacional Isiboro-Sécure* also approved the project.

Comparison of communities in Apillapampa and NPIS in terms of physical accessibility and socio-economic indicators of modernisation

Observations in the field provided a good qualitative appreciation about physical accessibility of the communities, the presence of roads, shops, a public telephone, non-governmental organisations, road conditions and the possibility of radio communication with modern society. Quantitative data related to households (% monolingual native and bilingual native-Spanish speakers) and conditions of housing (use of electric energy, non-natural materials for house construction and a pipe network for water distribution) were obtained from the database of the *Instituto Nacional de Estadística* (INE, 2001) in Cochabamba. Only results for three communities, San Antonio (Yuracarés), San Jose de la Angosta and Carmen de la Nueva Esperanza (Trinitarios), were available. Quantitative data on distances between communities and several important socio-economic reference points (last stop of the public transport system, nearest village, nearest PHC) were defined in the field by GPS (Global Positioning System, Garmin 12XL) and are expressed as a straight line between two GPS-coordinates.

The qualitative and quantitative data presented here combine several variables of modernisation used in other studies. According to Benz, Cevallos, Santana, Rosales, and Graf (2000), modernisation is indicated by the loss of indigenous language and the incorporation of non-traditional community services such as literacy and quality of housing. In another study, integration into the market as an indicator of modernisation of Yuracaré–Trinitario households in Bolivia was measured by community-to-nearest-town-distance, use of a modern rice seeder, use of chemicals for farming, number of (non-)governmental institutions, teachers and health workers in the community (Godoy & Cárdenas, 2000).

Ethnobotany

During July 2000–June 2001 a standard ethnobotanical survey was performed in Apillapampa, and during July 2001–June 2002 in NPIS. Traditional healers who cooperated in the project were members of AMETRAC (eight persons) in the Andes. In the Amazon, seven healers were appointed by their indigenous leaders (five Trinitarios en two Yuracarés). Medicinal plants were collected during field trips with healers. Each collection, characterised by its own voucher number, was supplemented with GPS-coordinates, details about the location and plant photographs. Upon return from field trips, plants were pressed and dried. A few weeks later, they were presented to each healer during semi-structured interviews. In the rainforest, medicinal plants were mainly collected in the area around two communities (Limo del Isiboro and San Jose de la Angosta) and resident healers from other communities were visited at a later time for interviewing. Detailed information was asked about the healer's background (age, age at initiation in traditional healing, number of years practising TM) and about plant names, use(s), plant parts used, preparation, mode of administration, dosage, use restrictions, abundance and ecological unit(s) where plants grow. Voucher specimens were deposited in the herbaria of Cochabamba and La Paz where plants were identified by the authors and specialists.

Data analysis

Floristic diversity of both study areas was compared at the family level by calculating the proportion of plant species per family on the total species number. This proportion represents the abundance of each plant family in the sample. The *z*-test for comparison of proportions was used to test for differences between the Andes and Amazon in the summed abundances of plant families that contain only one species. The same comparison was made for the three most abundant plant families in both samples. These families contain the highest number of species in the inventories of the study areas. A *z*-test compares two groups when the total sample size (number of plant species collected) and the proportion of species with a characteristic of interest are known. One of the characteristics of interest was the percentage of plant species on the total species number that belongs to the three most frequently collected plant families. Shannon-wiener indices (H') and evenness (J') were calculated through the formula $H' = -\Sigma p_i \log(p_i)$ (base 10), where p_i is the proportion of the number of species belonging to the *i*th family. Evenness (J') is given by $H'/\log(s)$, with s being the total number of plant families. Shannon-wiener is based on information theory. It is a measure of order (or disorder) within a particular system. As the value of H' increases, it implies a higher level of diversity. Applied to the present research it is a measure of the likelihood that the next species will belong to the same family as the previous sample. Evenness represents equality in the abundance of species within plant families. A low evenness means a high dominance of certain plant families in the sample and hence a low diversity. A drawback of the Shannon-wiener index is that its value increases with sample size (in the present study with the number of plant species sampled). Hence, for a better comparison of two research areas with different samples sizes, the technique of rarefaction was used to calculate family richness for subsamples consisting of fewer species (Begossi, 1996).

Data from plant interviews were processed by classifying healers' responses about a given species as positive if the plant name, plant use, or both of them could be provided. Alternatively, healers' responses were considered negative when a plant was unknown by them. Responses were then summed for all plant species and all healers in order to compare the responses for NPIS and Apillapampa with Chi-square analysis. Healers' individual knowledge scores were calculated as the proportion of positive and negative responses on the total number of responses. These scores were compared between the Andes and Amazon by means of a Students' *t*-test. Pearson product moment correlation was used to analyse relationships between healers' personal and social background variables and knowledge scores.

Results

Comparison of communities in Apillapampa and NPIS in terms of physical accessibility and socio-economic indicators of modernisation

Qualitative and quantitative variables related to accessibility of communities are shown in Table 1A. From this table it is clear that Apillapampa is physically less isolated than communities in NPIS, both in terms of health care and transport of people and marketable goods. In NPIS, five communities can only be reached on foot crossing large rivers and three communities after 5–8 h walking from the last truck stop. Flooding of rivers in the rainy season makes it very difficult to reach the furthest communities. Four communities are also isolated from Western medical care as indicated by distances from a PHC with (assistant) nurse ranging from 6 to 18 km or from a PHC with MD ranging from 17 to 23 km. Apillapampa is easily accessed by private trucks departing from the nearest village of Capinota twice a week. The road continues as far as the community. A PHC is available in the community.

Percentages of interviewees who are monolingual native speakers or bilingual native—Spanish speakers are shown in Table 1B. Quantitative data for NPIS are only available for San Antonio, San Jose de la Angosta and Carmen de la Nueva Esperanza. Table 1B also depicts the degree of appropriated non-traditional domestic and community services. Comparison reveals that, although community members in NPIS are more fluent in Spanish than their Andean peers as

Table 1

(A) *Variables of physical accessibility (isolation) in Apillapampa (Andean community) and NPIS (six Amazon communities dispersed in the National Park Isiboro-Secure)*

	Apillapampa	NPIS
Accessibility of community	Good: road condition generally good and easy access from Capinota	Good to bad depending on distance from park entry, presence of road and situation of rivers (flooding)
Distance community—nearby village (km)	29	6–50
Road from nearby village to community	Present	Not present in five communities
Distance truck stop (public transport)—community (km)	0	<5 (three communities) >10 (three communities)
Physical distance community—primary health care service (km)	0	<5 (two communities) >5 (four communities)
(B) *Variables of modernisation (loss of native language and incorporation of modern community services) in Apillapampa (Andean community) and NPIS (6 Amazon communities dispersed in the National Park Isiboro-Secure)*		
Percentage of monolingual native speakers	74 ($n = 1318$)[a]	SA: 0 ($n = 58$)[a] SJA: 0 ($n = 60$)[a] Carmen: 54 ($n = 144$)[a]
Percentage of bilingual native—Spanish speakers	25 ($n = 1318$)[a]	SA: 70 ($n = 58$)[a] SJA: 77 ($n = 60$)[a] Carmen: 41 ($n = 144$)[a]
Presence of shops	Several, selling vegetables and consumption goods	None
Presence of institutions	2 ngo's	None
use of electric energy	since 2001: 19 ($n = 333$)[a]	No
Public telephone	Present (since 2001)	Not present
Use of artificial material (metal, cement) for house construction	40 ($n = 333$)[a]	No
Distribution of water by a network of pipes	67 ($n = 333$)[a]	No
Radio-communication	Yes	Only in two communities

(n = total number of interviewed persons); SA: San Antonio, SJA: San José de la Angosta, Carmen: Carmen de la Nueva Esperanza.
[a] Household variables are calculated from INE (2001) and represent the percentage of respondents.

demonstrated by a higher percentage of monolingual native speakers and a lower proportion of bilingual speakers, the former have clearly acquired less modern domestic and community services.

Medicinal floristic diversity of the samples

In total, 182 medicinal plant species were collected in Apillapampa, belonging to 143 genera and 56 families. For NPIS, the total number of collected species, genera and families was 124, 111 and 58, respectively. The difference in the number of species collected reflects the higher sampling results in the Andes due to better physical accessibility of the community and spatial homogeneity of the group of healers (residence in the same village). However, in spite of the larger sample size in the Andes, the family composition of the sample is more diverse in NPIS as compared to Apillapampa. The proportional abundances of plant families in the sampled study areas are shown in Fig. 1.

In Apillapampa, the three most abundant families with more than five species are Asteraceae, Fabaceae and Solanaceae. Together they constitute 37% of the inventory. This proportion is significantly higher as compared to NIPS where the best represented plant families (Asteraceae, Fabaceae and Rubiaceae) constitute 25% of the inventory ($z = 2.1$; $P < 0.05$). On the other hand, the percentage of all plant families that are represented by one species is significantly lower in Apillapampa (13 versus 30%; $z = 3.3$; $p = 0.001$). When considering only families that do not overlap between both study areas, a significantly lower percentage of

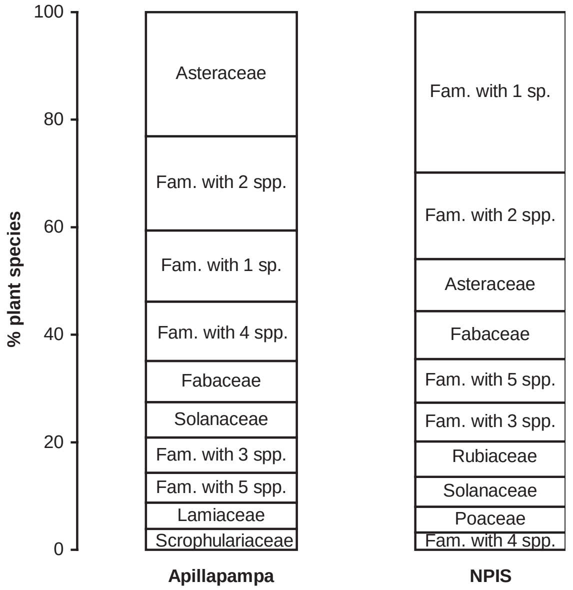

Fig. 1. Floristic composition of the medicinal flora in Apillapampa and NPIS according to the proportional abundances of plant families in the sample (number of medicinal plant species collected that belongs to a certain family divided by the total species number). Families that contain five species or less were grouped together. Bars represent decreasing percentages from top to bottem.

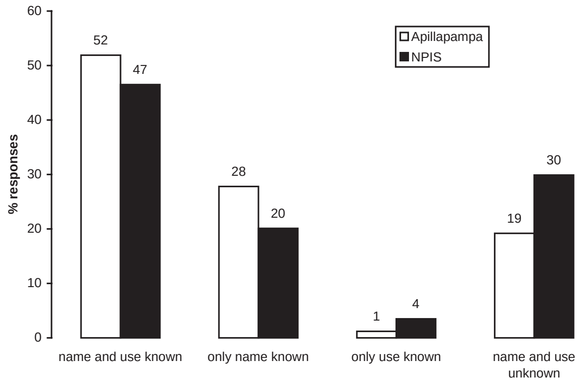

Fig. 2. Percentage of responses about plant knowledge on the total number of responses in the Andes (Apillapampa) and Amazon (NPIS).

plant families represented by one species is still observed in Apillapampa as compared to NPIS (8 versus 20%; $Z = 2.9$; $p<0.005$).

The Shannon-wiener indices (H') and evenness (J') (log based) were calculated as the number of plant species that belong to a specific family. H' is 1.46 and 1.59, while J' is 0.84 and 0.90 for Apillapampa and NPIS, respectively. Hence, in spite of the positive effect of the larger sampling size in Apillapampa on the H'-value, NPIS has a higher index. Furthermore, the abundances of the sampled species are also more equally distributed over the families in NPIS as expressed by the higher value of J'. Thus, in Apillapampa there exists a higher dominance of certain families in the sample and hence a lower diversity. Finally, rarefaction analysis revealed that a subsample of 124 plant species in Apillapampa would correspond with 46.6 ± 2.3 plant families. This is significantly less than the number observed in NPIS (58) for the same sample size. Taken together, these results point to a higher floristic diversity at the family level in NPIS as compared to Apillapampa.

Medicinal plant knowledge

Fig. 2 shows the percentage of healers' responses about medicinal plant knowledge in the Andes and Amazon.

In total 1423 responses were obtained in Apillapampa and 882 in NPIS, depending on the number of species collected and the number of healers in the sample. The number of negative (plant unknown) and positive (plant name, use or both known) responses in Apillapampa and NPIS is 273 and 264 (negative responses) and 1150 and 618 (positive responses), respectively. According to Fig. 2, the percentage of negative responses is higher in NPIS than in Apillapampa (30 versus 19%). Thus, healers in the first location know fewer plants. A χ^2 analysis of the summed positive and negative responses reveals a significant relationship between location and plant knowledge ($\chi^2 = 34.6$; $p<0.001$). The percentage of positive responses on plant name and use constitutes 52% of the healers' answers in Apillapampa against 47% in NPIS. For 28% of the responses in Apillapampa a plant name can be provided as compared to 20% in NPIS. The percentage of responses for which only a use but no plant name is known is negligible in both areas (Fig. 2).

Fig. 3 presents the percentage of plant species known (name and use) by, respectively, more than half and less than half of the group of healers. The plant species known by exactly 50% of the healers in Apillapampa (four out of eight healers) were omitted from the analysis because of the uneven number of healers (7) in NPIS.

From this figure it is clear that the percentage of plant species known by more than 50% of the informants (5–8 healers in Apillapampa; 4–7 healers in NPIS) is higher in the Andes than in the Amazon. In NPIS, the percentage of species known by only one informant nearly doubles the value of Apillapampa. The χ^2 test shows a significant relationship between location and the number of plant species known by the majority and minority of informants ($\chi^2 = 6.9$; $p = 0.032$).

Although less plants were known by name and use by healers from the Amazon as compared to the Andes, the

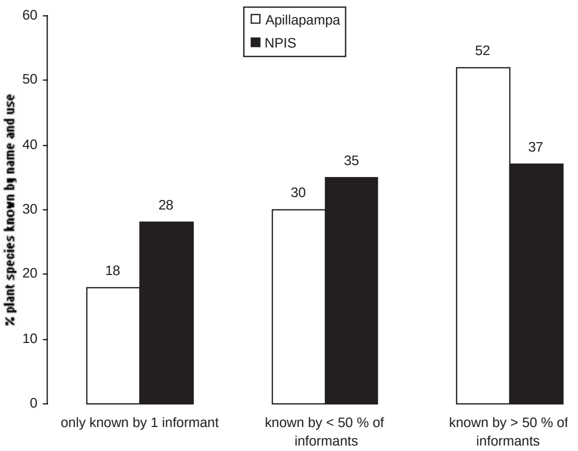

Fig. 3. Percentage of plant species from the inventory that are known by: (a) only one informant, (b) less than half of the group of informants, or (c) more than half of the group of informants in the Andes (Apillapampa) and Amazon (NPIS).

breadth of reported uses (i.e. total number of different uses listed) is comparable. In total, 70 versus 72 different ailments were mentioned in NPIS and Apillapampa, respectively. There exists a significant overlap (51%) in ailments mentioned in both areas. Ailments mentioned exclusively by informants from Apillapampa were Chagas' disease and digestive disorders (eructations of gastric juice, flatulence, gastric ulcers, gastritis and colic), while asthma, malaria, leishmaniasis and yellow fever were reported solely by informants in NPIS.

Healers' background variables

Table 2A and B summarise personal and social variables of healers. Family ties between some healers of the group exist in both areas. Pearson correlation reveals no significant differences between the Andes and Amazon with regard to healer's age, number of practising years or number of practising family members. However, healers from the Amazon are initiated in TM earlier as compared to Andean healers (14 ± 2 and 19 ± 1 years, respectively; $t = 2.5$; $P = 0.003$). Contrary to the Amazon, healers from the Andes do not always practise alone. Administration of medicinal plants can be carried out together with a member of the extensive family (blood or baptism-related relative) in a kind of apprenticeship relation, or with a member of the healers' organisation (AMETRAC) when cases are difficult (severe illness). Exchange of information in the Amazon group of healers is restricted to two members. In the Andes, all members of AMETRAC declare to exchange information among them. However, this exchange applies to joint preparation of a few processed medicinal plant products (syrup, ointment, eye drops) and does not include teaching about all known medicinal plants. The area covered by the healers for curing differs. In the Amazon, healing is restricted to the extensive family, the healer's own community and sometimes also neighbouring communities. In the Andes, healers practice within their family, others within the community or even expand their activities to the city of Cochabamba. In both the Amazon and Andes all healers have a positive attitude towards formal medicine.

Correlation between healers' background variables and plant knowledge

Fig. 4A and B represent individual knowledge scores of healers in the Amazon and Andes. These knowledge scores do not differ significantly between both areas. The highest score (95% of plant names and uses known) was obtained by a Trinitario healer from NPIS (Lucio S.). In NPIS, healers' knowledge about plant names and use is negatively correlated with the age of initiation in traditional healing ($r = -0.93$; $P = 0.003$). The number of years practising TM does not seem to influence knowledge scores. In Apillapampa, there is no relationship between age of initiation and amount of knowledge, nor between knowledge scores and the number of years of practising experience. However, in the Andes there exists a significant positive relationship between the percentage of plant names and uses known on the one hand and a combination of the number of practising years with the number of family members practising TM on the other hand ($r = 0.75$; $p = 0.03$).

Discussion

A flora of Bolivia does not yet exist. Comparative literature data on plot surveys of plant species in the study areas are not available. However, figures of mean annual rainfall in Apillapampa and NIPS already predict a higher plant diversity in the latter study area due to the positive correlation between plant diversity richness and precipitation (Gentry, 1988). Indeed, the vegetation of the Capinota valley in the vicinity of Apillapampa is characterised by xerophytic, deciduous and evergreen herbs, shrubs (*matorrales*), small trees (*chaparrales*) and open woodlands. The vegetation is mainly secondary in nature due to extensive agricultural activity with relicts of the original vegetation (Pedrotti, Venanzoni, & Suarez Tapia, 1988). On the contrary, the Amazonian vegetation of NPIS is actively protected by national legislation. Since in the present study the main objective was to study medicinal plant knowledge, no plot surveys were used. Instead, medicinal plants were collected during 'walks-in-the-woods' with traditional healers. This stimulates the healers to actively go out and seek the plants they know. Presuming that the plant

Table 2

(A). *Healers' background variables in Apillapampa*

	José C.	Teofilo S.	Agustin R.	Cristina R.	Francisco SL.	Francisco SV.	Joaquin J.	Sabino S.
Age (years)	26	34	45	27	33	27	64	47
Age at initiation	25	18	20	13	20	15	20	20
Teacher	Godfather Mother	Grandmother	Godfather Father	Uncle	Grandparents Parents	Grandparents Father	Grandparents Parents	Grandparents Father
Family ties with other members	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Number of years practising	1	2	10	2	7	5	32	14
Number Of Practising Family Members	0	1	5	8	5	7	2	10
Practising alone?	Not always	Preferably	Usually	Not always	Usually	Not always	Also with Ametrac	Usually
Exchange of information	Ametrac	Ametrac	Ametrac	Ametrac	Joaquin J., friend	Ametrac	Ametrac, Francisco SL	Many other persons
Range of healing activities	City	Family	Family	Community	Family	City	Community & City	Community
Attitude towards formal medicine	+	+	+	+	+	+	+	+

(B) *Healers' background variables in NPIS*

	Jorge V.	José C.	Esteban S.	Lucio S.	Margarita N.	Melania M.	Ignacio M.
Ethnic affiliation	Yuracaré	Yuracaré	Trinitario	Trinitario	Trinitario	Trinitario	Trinitario
Age (years)	38	38	42	44	38	22	44
Age at initiation	17	12	18	4	14	15	15
Teacher	Father, friends	Grandfather Father	Grandfather	Grandparents	Friends, Autodidact	Autodidact	Parents
Family ties with other members	Yes	Yes	No	No	No	Yes	Yes
Number of years practising	15	18	2	21	6	5	6
Number of practising family members	2	4	0	1	0	3	4
Practising alone?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exchange of information	Lucio S., José F.	Jorge V.	No	No	No	No	No
Range of healing activities	Family	Community	Community	Community	Family	Family	Community
Attitude towards formal medicine	+	+	+	+	+	+	+

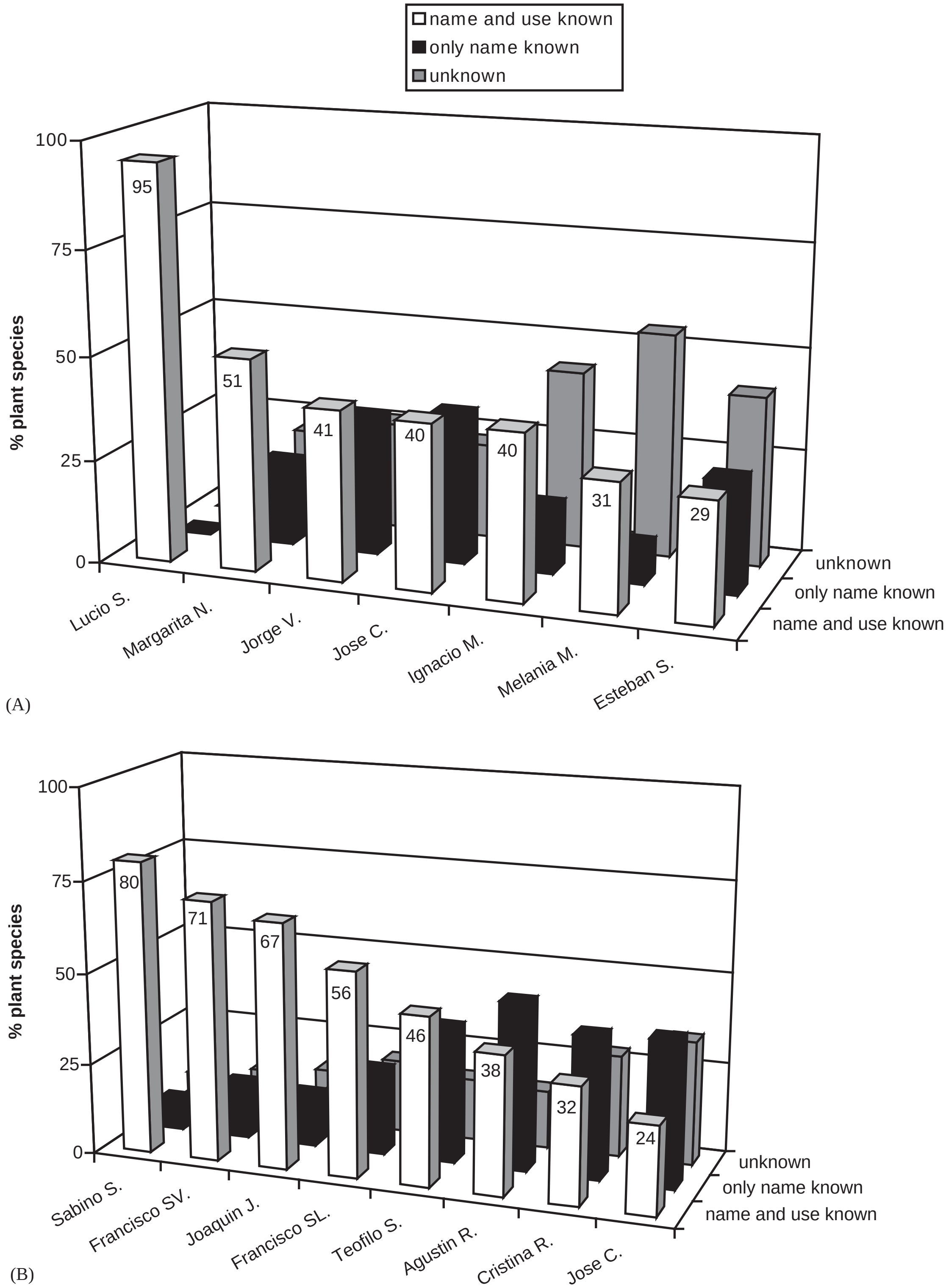

Fig. 4. Percentage of plant species from the inventory that are: (a) unknown, (b) only known by name, or (c) known by name and use by individual healers of NPIS (4A) or Apillapampa (4B).

diversity of a given study area is also to a certain extent apparent in its medicinal flora, the proportional abundances of plant families in the inventories can be compared between study areas as a prediction of their relative biodiversity. In the present study, the proportion of plant families represented by only one species in the inventory was higher in NPIS as compared to Apillapampa. This finding contributes to the assumption of a higher general plant diversity in the Amazon as compared to the Andes.

From the literature it is evident that the diversity of plant resources is reflected in most aspects of Amazonian ethnobotany (Bennett, 1992). It has been stated that this should also be reflected in the knowledge about and use of medicinal plants (Milliken & Albert, 1997). If this is true, then less medicinal plant knowledge will probably be obtained in less diverse environments. However, the present study shows that informants can have a higher knowledge of surrounding medicinal plant resources in a less as compared to a more diverse environment. This is all the more surprising because the Andean community has more general indicators of modernisation, including a PHC. By contrary, in the Amazon physical distance from PHCs is higher than 5 km for four of six communities and the rainy season makes travelling very difficult. It has been shown before that, in general, most people will not travel farther than 5 km for basic preventive and curative care (Stock, 1983). Another important barrier to seek medical assistance is the ability to pay for health care. While in the Andes the presence of various small shops indicates commercial activity, and hence a certain money flow, the more isolated communities of the Amazon have little means for marketing of products and hence for cash income. Thus, it can be assumed that there are little other alternatives for health care in the Amazon study area than TM based on medicinal plants. This in turn would imply a profound experimentation with natural resources and extensive knowledge of medicinal plants. However, the present results suggest that the indigenous people from the Amazon may not fully exploit the healing potential of their forest resources. The question that follows is what might be the cause? Voeks and Sercombe (2000) found that forest dwellers in Borneo have less knowledge about medicinal plants as compared to a group of neighbouring swidden rice cultivators. The range of illnesses treated by the first group with medicinal plants was likewise narrow. Davis and Yost (1983) made a similar observation for the Waorani of Amazonian Ecuador, at that time one of the least acculturated tribes in South America. While it was shown that the Waorani are skilled ecologists and have a superb knowledge of the forest, as is evident from their extensive use of wild foods, their pharmacopoeia proved to be relatively small, containing only 35 medicinal plants. The authors attribute this to the traditional lifestyle and hence the low degree of acculturation of these people and the subsequent low levels of illness associated with a low population density, combined with a nomadic hunting-gathering existence. Therefore, the need to develop an elaborate plant pharmacopoeia is consequently low. This scenario, however, does not seem to apply to the Amazon communities of the present study. For instance, already since the 17th century strong attempts were made by missionaries to make Trinitarios settle down (Paz, 1991). Thus, they have a long history of contact with outsiders as well as a semi-sedentary lifestyle. This is reflected in their ethnomedical system that mentions infectious illnesses such as malaria, influenza, rubella and measles; parasitic and viral diseases that are associated with sedentary societies and agricultural subsistence. Both the fact that these illnesses are known and that medicinal plants are used to treat them reveal familiarity and experience with Western concepts of health and disease. Thus, the Yuracaré–Trinitario people from the Bolivian Amazon do not conform to the 'healthy hunter-gatherer view' of Voeks and Sercombe (2000).

While Voeks and Sercombe (2000) hypothesise that rainforest dwellers do not need phytotherapy as a means for adaptation to their living conditions, the opposite is believed for Andeans (Bastien, 1982). According to the latter author, Andeans excel in the practice of TM because this has enabled them to adapt to a hostile environment with hypoxia, hypothermia, malnutrition and epidemics. Andean medical cosmology is full of images of human vulnerability to a hostile and unpredictable environment (Larme, 1998). If medicinal plants are indeed pivotal for the quality of life in harsh Andean environments it might explain the importance of a social component of TM as is evident from the present results. Indeed, family ties enable young healers to assimilate knowledge about medicinal plants rapidly from experienced relatives, while older healers with few practising family members but many years of experience with medicinal plants also have high knowledge scores. According to the present study, this social component of TM seems to be less pronounced in the Amazon. Therefore, knowledge scores are correlated with the age at initiation in TM but not with a combination of personal and social variables, as is the case in the Andes. In the Amazon, as compared to the Andes, healers become initiated in TM earlier in life. However, cumulative knowledge scores show a relative higher number of negative responses on plant knowledge in the former area. Thus age at initiation is not necessarily a common denominator for medicinal plant knowledge.

Milliken and Albert (1997) hypothesise that a high degree of human dispersion as a result of semi-nomadic migration is responsible for building up a vast plant pharmacopoeia. However, dispersion because of socio-political reasons, diminished availability of natural resources, increasing population size or religious motives can also interfere with the social structure of families, separating relatives from one another. In the case of Yuracarés and Trinitarios, the extensive patrilocal or matrilocal family was the traditional organisation form. However, with the influence of evangelisation a tendency has been observed to form nuclear neolocal families (Lema, 1998). The division/dispersion of the extensive family is more frequent now than in the past for two motives: (1) diminished access to forest resources results in a mobilisation of nuclear families without the extensive family; (2) currently the Yuracarés also consume manufactured products and nuclear families can decide independently from relatives to move closer to places where these products can be more easily obtained (Paz, 1991). This division and dispersion, in turn, can influence the social component of the transmission of medicinal plant knowledge.

In conclusion, the present results indicate that social variables, specifically the healing tradition of the extensive family, rather than the level of plant biodiversity of the study area, are important for medicinal plant knowledge of traditional healers. Finally, they show that a wealth of medicinal plant knowledge can also exist in a highly anthropogenic environment with moderate plant diversity.

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References

Alba, J. J. (1996). *Entre la pervivencia y la muerte: Los campo jampiris de campero*. Santa Cruz, Bolivia: Editora El Pías.

Alfaro, F., Aguayo, R., Balderrama, J., Vargas, A., & Cahill, J. Relevamiento de biodiversidad y análisis multitemporal en 6 zonas del corredor Amboro-Madidi. Tomo I. Cochabamba. Bolivia: Universidad mayor de San Simón (unpublished report).

Ankli, A., Sticher, O., & Heinrich, M. (1999). Yucatec Maya medicinal plants versus nonmedicinal plants: Indigenous characterization and selection. *Human Ecology*, *27*, 557–580.

Antweiler, C. (1998). Local knowledge and local knowing: An anthropological analysis of contested "cultural products" in the context of development. *Anthropos*, *93*, 469–494.

Bastien, J. W. (1982). Exchange between Andean and Western medicine. *Social Science and Medicine*, *16*, 795–803.

Bastien, J. W. (1987). *Healers of the Andes. Kallawaya herbalists and their medicinal plants salt.*. Lake City: University of Utah Press.

Begossi, A. (1996). Use of ecological methods in ethnobotany: Diversity indices. *Economic Botany*, *50*, 280–289.

Bennett, B. C. (1992). Plants and people of the Amazonian rainforests. The role of ethnobotany in sustainable development. *Bioscience*, *42*, 599–607.

Benz, B. F., Cevallos, J., Santana, F., Rosales, J., & Graf, S. (2000). Losing knowledge about plant use in the Sierra de Manantlan Biosphere reserve, Mexico. *Economic Botany*, *54*, 183–191.

Cinep (Centro de Investigación y Educación Popular). (1998). Plan de desarollo indígena, unidad de gestion territorial indígena TIPNIS. Cochabamba, Bolivia.

Courtright, P. (1995). Eye care knowledge and practices among Malawian traditional healers and the development of collaborative blindness prevention programmes. *Social Science and Medicine*, *41*, 1569–1575.

Davis, E. W., & Yost, J. A. (1983). The ethnomedicine of the Waorani of Amazonian Ecuador. *Journal of Ethnopharmacology*, *9*, 273–297.

Ellen, R. F. (1998). Indigenous knowledge of the rainforest. Perception, extraction and conservation. In B. K. Maloney (Ed.), *Human activities and the tropical rainforest* (pp. 87–99). The Netherlands: Kluwer Academic Publishers.

Fepade (Fundación Ecuménica Para el Desarrollo). (1998). Diagnostico del distrito Apillapampa. Cochabamba, Bolivia.

Gentry, A. H. (1982). Neotropical floristic diversity: Phytogeographical connections between central and South America, pleistocene climatic fluctuations, or an accident of the Andean orogeny? *Annals of the Missouri Botanical Garden*, *69*, 557–593.

Gentry, A. H. (1988). Changes in plant community diversity and floristic composition on environmental and geographic gradients. *Annals of the Missouri Botanical Garden*, *75*, 1–34.

Gessler, M. C., Msuya, D. E., Nkunya, M. H. H., Mwasumbi, L. B., Schär, A., Heinrich, M., & Tanner, M. (1995a). Traditional healers in Tanzania: The treatment of malaria with plant remedies. *Journal of Ethnopharmacoly*, *48*, 131–144.

Gessler, M. C., Msuya, D. E., Nkunya, M. H. H., Schär, A., Heinrich, M., & Tanner, M. (1995b). Traditional healers in Tanzania: Sociocultural profile and three short portraits. *Journal of Ethnopharmacology*, *48*, 145–160.

Godoy, R., & Cardenas, M. (2000). Markets and the health of indigenous people: A methodological contribution. *Human Organization*, *59*, 117–124.

Henderson, A., Churchill, S. P., & Luteyn, J. L. (1991). Neotropical plant diversity. *Nature*, *351*, 21–22.

INE (Instituto Nacional de Estadística). (2001). *Base de datos. Censo Nacional de Población y Vivienda 2001*. Departamento de Cochabamba. Cochabamba, Bolivia.

Ladio, A. H., & Lozada, M. (2001). Non-timber forest product use in two human populations from northwest Patagonia: A quantitative approach. *Human Ecology*, *29*, 367–380.

Larme, A. C. (1998). Environment, vulnerability and gender in Andean ethnomedicine. *Social Science and Medicine*, *47*, 1005–1015.

Lema, A. M. (1998). *Pueblos indígenas de la Amazonía boliviana*. La Paz, Bolivia: Editorial Plural.

Macía, M. J., Romero-Saltos, H., & Valencia, R. (2001). Patrones de uso en un bosque primario de la Amazonía ecuatoriana: Comparación entre dos comunidades huaorani. In J. F. Duivenvoorden, H. Balslev, J. Cavelier, C. Grandez, H. Tuomisto, & R. Valencia (Eds.), *Evaluación de recursos vegetales no maderables en la Amazonía noroccidental* (pp. 225–249). Universiteit van Amsterdam: IBED.

Milliken, W., & Albert, B. (1997). The use of medicinal plants by the Yanomami indians of Brazil, Part II. *Economic Botany*, *51*, 264–278.

Navarro, G., & Maldonado, M. (2002). *Geografía ecológica de Bolivia. Vegetación y ambientes acuáticos*. Cochabamba, Bolivia: Centro de Ecología Simón I. Patiño-Departamento de Difusión.

Ndubani, P., & Höjer, B. (1999). Traditional healers and the treatment of sexually transmitted illnesses in rural Zambia. *Journal of Ethnopharmacology*, *67*, 15–25.

Paz, S. (1991). Hombres de río, hombres de camino: relaciones interetnicas en las nacientes del río Mamore. Unpublished B.Sc.. Thesis, Universidad Mayor de San Simón, Cochabamba, Bolivia.

Pedrotti, F., Venanzoni, R., & Suarez Tapia, E. (1988). Comunidades vegetales del valle de Capinota Cochabamba, Bolivia. *Ecología en Bolivia*, *11*, 25–45.

Ryan, G. W. (1998). What do sequential behavioral patterns suggest about the decision-making process?: Modeling home case management of acute illnesses in a rural Cameroonian village. *Social Science and Medicine*, *46*, 209–225.

Sánchez, M., Duque, A., Miraña, P., Miraña, E., & Miraña, J. (2001). Valoración del uso no comercial del bosque—métodos en etnobotánica cuantitativa. In J. F. Duivenvoorden, H. Balslev, J. Cavelier, C. Grandez, H. Tuomisto, & R. Valencia (Eds.), *Evaluación de recursos vegetales no maderables en la Amazonía noroccidental* (pp. 179–224). Universiteit van Amsterdam: IBED.

Stock, R. (1983). Distance and the utilization of health facilities in rural Nigeria. *Social Science and Medicine*, *17*, 563–570.

Voeks, R. A., & Sercombe, P. (2000). The scope of hunther-gatherer ethnomedicine. *Social Science and Medicine*, *51*, 679–690.