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Relative Importance and Knowledge Distribution of Medicinal Plants in a Kichwa Community in the Ecuadorian Amazon

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Abstract Traditional knowledge, such as knowledge of the use of plants as medicine, influences how indigenous people manage forest resources. Gender and age-associated differences in traditional knowledge may impact forest resource management because of the traditional division of labor. We interviewed 18 men and 18 women between 9 and 74 years old in San José de Payamino, an indigenous community of the Kichwa ethnicity in the Ecuadorian Amazon, to determine if there are gender or age-associated differences in medicinal plant knowledge among the Payamino people and to identify the most important species from a sample of medicinal plants. Individuals were interviewed using a tablet that displayed images of 34 plants, which had been cited by traditional healers in the community. Quantitative analysis provided insight into the relative importance of plants in the sample as well as the distribution of medicinal plant knowledge among members of the community. The most important plants were *Tradescantia zanonii* and *Monolena primuliflora*. These plants should be considered candidates for further investigation. There was a positive correlation between age and knowledge of medicinal plants, but no significant difference between genders. Our results suggest that an interview method that relies on digital images can reveal differences in the importance of medicinal plants as well as provide insight into the distribution of traditional medical knowledge. While men and women are likely to manage forest resources similarly, younger members of the community may not have the same regard for forest resources as their elder counterparts.

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Introduction

San José de Payamino is a community of Quijos Kichwa-speaking people located in the Ecuadorian Amazon. The Payamino people are revered by neighboring communities for their adherence to a relatively traditional lifestyle, which includes the use of plants as medicine (Irvine 1987). The earliest account of Payamino ethnobotany included notes on plant use and a list of plants collected in the Payamino territory (Irvine 1987). Irvine delineated the role of Payamino shamans as individuals trained in the use of medicinal plants, and who have more knowledge of, and experience with, medicinal plants than other members of the community. According to Irvine, most members of the community have some basic medical knowledge, and she hypothesized that because of the traditional division of labor, gender

and age-associated differences in plant knowledge may have an impact on the management of forests. Research in the area of social ecology supports the idea that traditional knowledge, such as knowledge of the use of plants as medicine, impacts how indigenous people manage forest resources (Berkes et al. 2000; Colding and Folke 2001). The objective of our study was to determine if, in fact, there are any gender or age-associated differences in medicinal plant knowledge among the Payamino people. In addition, we aimed to determine the medicinal plants that are most important to the Payamino people to more fully characterize Payamino ethnomedicine and to identify species that might be candidates for further ethnobotanical, phytochemical, and pharmacological investigation.

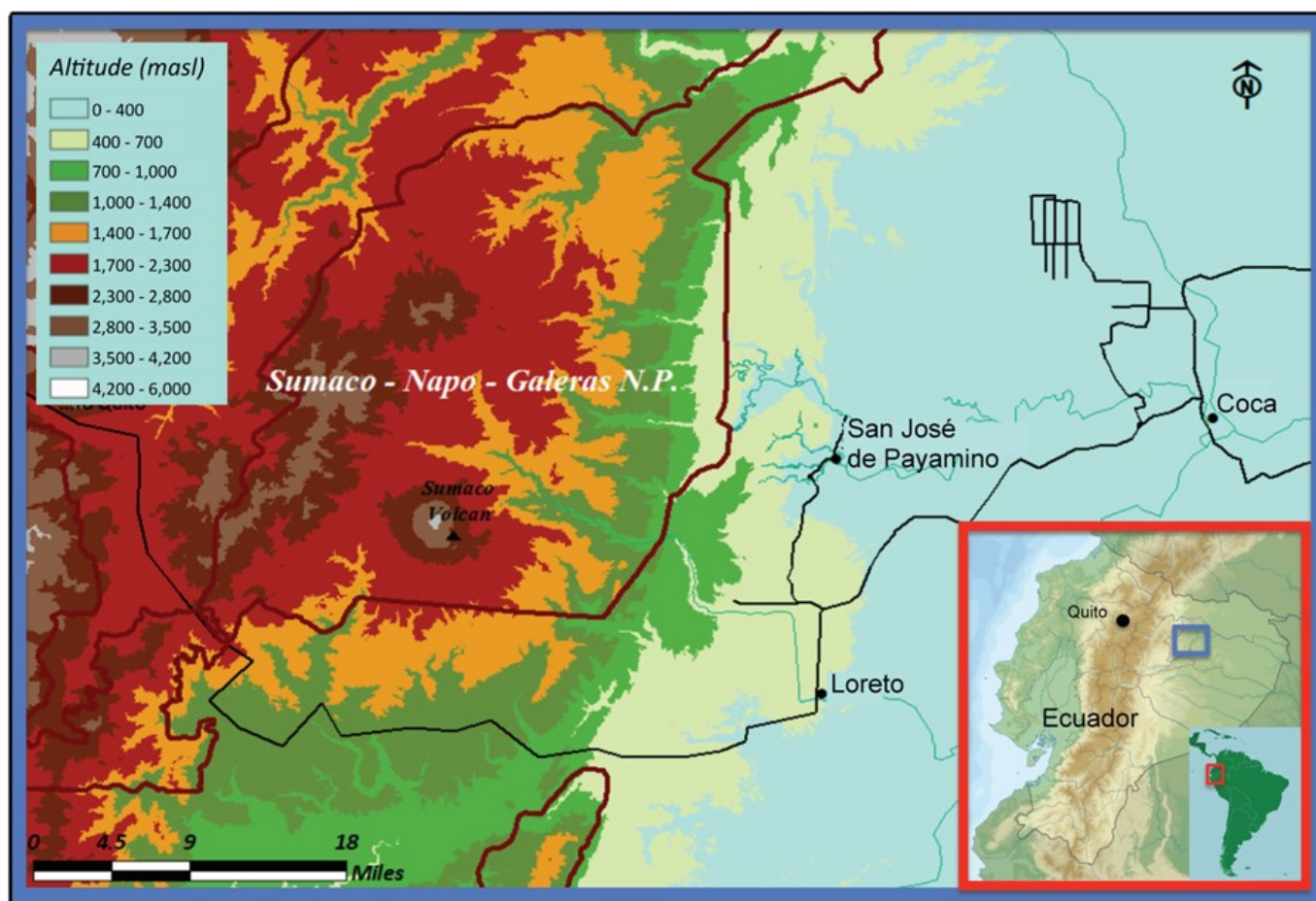


Figure 1 Location of San José de Payamino relative to the nearest towns of Coca and Loreto and the Sumaco - Napo - Galeras National Park (Timburi Cocha 2015).

Recently, the most knowledgeable members of the community, the traditional healers (shamans and *curanderos*), were interviewed using a forest walk, or walk-in-the-woods, method (Doyle et al. 2014). While an intensive forest walk interview may be appropriate for very knowledgeable participants, this approach is not practical for broader participation. Forest walks are typically very time consuming and labor intensive, particularly when conducted in challenging settings, such as in the Amazon. As an alternative approach, structured interviews that rely on plant images rather than fortuitously encountering plants in the forest allows for more efficient and consistent data collection (Thomas et al. 2007). Thomas et al. (2007) highlighted the advantages of using photographs of plants rather than voucher specimens or freshly collected plant material in ethnobotanical interviews. Participants recognized 92–96% of photographs of plants that they had indicated and named during prior

forest walk interviews but only 68–86% of voucher specimens. Therefore, using images of plants proved to be an effective interview method.

In the present study, we adapted the approach used by Whitecloud et al. (2014) where participants were presented digital photographs of plants on an electronic tablet. The presentation of digital images has several advantages over printed images or voucher specimens. For example, the tablet provides a similar visual experience under most conditions. Since most interviews are conducted in the homes of informants, which tend to be somewhat dark, the backlit screen, adjustable brightness, and zoom function of the tablet enable scrutiny of morphological characteristics under these conditions. Furthermore, tablets allow one to take photographs and record audio and video during the interview process, and in fact, images taken *in situ* are immediately available for use in *ex situ* interviews. Lastly, data can be entered directly into a spreadsheet

or text document on the tablet, which allows for organization, analysis and digital archival of field notes at the study site. Electronic tablets can be encased in a waterproof cover that does not interfere with the visibility or the interactivity of the screen. Only one informant, a male 79 years of age, was excluded due to difficulty seeing the images.

Methods

Description of the Study Area

San José de Payamino is located roughly 45 km west of Coca (Puerto Francisco de Orellana) in Loreto Canton, Orellana Province (Figure 1). The community claims ownership of a 16,800 ha territory and is comprised of between 270 and 300 individuals in approximately 60 households (Oldekop et al. 2012). The Payamino territory lies within the buffer zone of the Sumaco Napo-Galeras National Park, which was designated in 2000 as a World Biosphere Reserve by UNESCO. The study area is predominantly lowland tropical moist forest (elevation is 300–400 m AMSL (above mean sea level)) that is transitional between the Andes foothills and the lower elevation region inhabited by Kichwas along the Napo River to the east. The high biodiversity of the region is attributed to this transitional geography (Arias et al. 2012; Innerhofer and Bernhardt 2011). The Payamino people practice subsistence farming, hunting, and fishing as well as small-scale farming of cash crops such as corn, rice, and cacao. Anthropological and socioecological studies have been conducted in Payamino first by Irvine (1987), who conducted an extensive survey of the local flora, and more recently by Oldekop et al. (2012a, b, 2013).

Interview Method

Authorization to conduct our study was obtained from the Institutional Review Board of Alma College, and all necessary research permits and authorizations were obtained from the community of San José de Payamino and from the Ministry of Environment of Ecuador under the auspices of the National Museum of Natural Sciences of Ecuador. Interviews were conducted from May–June, 2014. Participants were sought with the assistance of a community liaison, and all participants gave their informed consent. A parent's signature was obtained for child participants. Interviews were conducted in Spanish, but in a few cases the community liaison translated between Spanish and Kichwa. The interviews were conducted individually whenever possible, although onlookers

and secondary participants were sometimes present. The average duration of the interviews was approximately one hour.

The interviews were semi-structured and based on the methodology described by Alexiades (1996) as a plant interview or checklist interview with the exception that digital images were used as visual aids rather than live, freshly-collected, or dried plant material. Vernacular names were not presented with the images because these names tend to correspond to the medicinal use of the plant (e.g. *kiru jambi yura* means tooth medicine stem). Each participant was shown a series of plant images on an iPad mini 2 with a 7.9 in. Retina display (Apple, Cupertino, CA). The name of the plant, the medicinal use, the preparation, and administration were recorded for each plant queried. The digital images, which were created by the authors in Payamino, represented 34 species that were cited by eight Payamino healers (men and women) during forest walk interviews from 2012–2014. Voucher specimens were collected at the time the photographs were taken and were identified by staff at the National Herbarium in Quito (QCNE) where the specimens are deposited. The Catalog of the Vascular Plants of Ecuador (Jorgensen and León-Yáñez 1999) was used to facilitate identification, and the currently accepted scientific name of each plant was determined by consulting The Plant List (2013). The 34 plants were selected from 60 species that had been identified as part of our ongoing ethnobotanical survey in Payamino (Doyle et al. 2014). They were cited by more than one of the traditional healers that had previously participated in forest walk interviews. Thus, plants that are more likely to be integral to the Payamino ethnomedical pharmacopoeia were chosen rather than plants that might be particular to an informant (Giovannini 2015; Vandebroek 2010).

Quantitative Analysis

Several indices were utilized to identify plants from among the 34 plants in our sample that are most important in the traditional medicine of the Payamino people. The first was the Relative Frequency of Citations (RFC), which is simply the fraction of informants that recognized a given plant as medicinal (Tardío and Pardo-de-Santayana 2008). RFC was calculated as follows:

$$RFC = N / N_i$$

where N is the number of informants who cited any medicinal use for the plant and N_i is the total number

of informants (36). An RFC of one would indicate that all informants recognized the plant as medicinal and cited at least one use, whereas, an RFC of zero would indicate that no informants cited a medicinal use for the plant.

The Use Value introduced by Philips and Gentry (1993a, b) and simplified by Rossato et al. (1999) was calculated as a measure of the diversity of medicinal uses cited for a given species. UV is expressed as:

$$UV = N_r / N_i$$

where N_r is the total number of medicinal use citations in all therapeutic categories for all informants, and N_i is the total number of informants (36). Use citations were divided into ten therapeutic categories, such that the theoretical maximum use value for a species is ten. This would require that all 36 informants cite a medicinal use in each of the ten therapeutic categories for a given species.

Fidelity Level (FL), as described by Friedman et al. (1986 cited in Andrade-Cetto and Heinrich 2011), is used to determine the level of agreement among informants on a plant's medicinal use. We calculated FL as follows:

$$FL = N_p / N$$

where N_p is the number of informants who reported a particular use for the species, and N is the number of informants who cited any medicinal use for the species. Our FL differs from that used by Friedman et al. (1986) in that we presented the informants with the plant images and asked them to cite uses rather than asking informants to cite plants that have a particular use. An FL of one would indicate that all informants that recognized the plant as medicinal cited the same medicinal use while an FL approaching zero would indicate that each informant that recognized the plant as medicinal cited a different use. Although an FL may be calculated for each use cited for a particular species, only the medicinal use for which the FL was highest is reported here.

The Index of Agreement on Remedies (IAR) is used to quantify the importance of plants for which there is consensus on more than one medicinal use (Mootoosamy and Mahomoodally 2014; Mutheeswaran et al. 2011; Vandebroek 2010). A variation on Trotter and Logan's (1986) Informant Agreement Ratio, the IAR considers all cited usage categories. Thus, a plant with a high number of citations in more than one use category may rank higher than plants

with more citations in any single category. IAR was calculated as follows:

$$IAR = (N_r - N_a) / (N_r - 1)$$

where N_r is the total number of use citations for a given species across all therapeutic categories and N_a is the number of cited therapeutic categories.

The last index is a sum of the IAR and RFC values and has a maximal value of two. It is intended to overcome the inherent limitations of each measure (Hoffman and Gallaher 2007; Kvist et al. 1995). For example, if few informants recognize a plant image, but all those who do recognize the plant agree on its medicinal use, IAR will be very high while the RFC will be low. Alternatively, many informants might recognize a plant as medicinal, which would result in a high RFC, but if each informant cites a different medicinal use, then IAR would be low. Neither index on its own gives a sense of the importance of the plant. We decided that combining these two values gave the best measure of relative importance for our study because it takes into account the percentage of informants who recognized a given plant as medicinal as well as the level of agreement among informants on the medicinal uses of the plant, realizing that the most important plants may have more than one agreed upon use.

Statistical Analysis

All statistical analyses were performed with IBM SPSS Statistics Version 20 software. A p-value of less than 0.05 was considered to be statistically significant. Spearman's rank-order correlation analysis was done to determine if there was a correlation between age and the number of plants recognized as medicinal. We conducted Fisher's Exact Test to identify differences in RFC and FL of plant species among age and gender groups.

Results

Thirty-six interviews were conducted with an equal number of male and female informants between 9 and 74 years old. Experts, such as individuals that would be considered shamans or *curanderos*, and non-experts were represented. The mean age of informants was 34 years, and the mean age of females (40 years) was 11 years \pm 6 (SE) older than the mean age of males. Use citations were grouped into ten categories as listed in Table 1 to facilitate quantitative analysis.

Table 1 Medicinal use citations were organized into ten use categories.

Use Category	Description
A—injuries	Bites, stings, cuts, burns, etc.
B—gastrointestinal	Stomach aches, diarrhea, etc.
C—respiratory	Fever, cold, cough, sore throat, etc.
D— <i>mal viento</i>	<i>Mal viento</i> or <i>mal aire</i> refers vaguely to a bad feeling or ill health. Some participants associated it with vomiting and/or having drank alcohol the night before.
E—skin infections	Includes rashes and <i>granos</i> , a word used to describe spots, marks, or lesions on the skin
F—aches/pains	Generalized pain, muscular pain, back/leg aches, headaches, toothaches, etc.
G— <i>tumores</i>	Swollen pustule in the abdomen or other part of the body.
H—women's health	Menstrual cramps, lactation-inducing, birth control, and other conditions specific to women
I—eye infections	Any condition described as making eyes itch, red, etc.
O—other	Insomnia, sleepiness, dizziness, laziness or misbehavior in children, fussiness in babies, and other conditions rarely mentioned during the interviews

The most often cited use category was aches and pains (120 citations) followed by injuries including bites and stings (107), respiratory ailments (74), gastrointestinal complaints (58), skin infections (42), *tumores* (40), *mal viento* (34), “other” (25), women's health (25), and eye infections (11). The most frequently used plant part was the leaves (19 plants) followed by stems (6), latex (4), bark (3) and flowers (2). Relative importance indices were calculated for each plant based on the responses of the participants (Table 2). Two of these indices, RFC and IAR, were summed resulting in a numerical value that was used to rank the plants in order of importance. By this measure the five most important plants in the sample are *Urera baccifera*, *Tradescantia zanoniana*, *Brunfelsia grandiflora*, *Croton lechleri*, and *Monolena primuliflora*.

We found that there was a positive relationship between age and medicinal plant knowledge as measured by the number of plants recognized as medicinal (Figure 2), though there was no significant difference in medicinal plant knowledge between male and female informants. Of the 34 plant species presented, both male and female informants recognized 14 plants on average. In order to identify any plants that might differ in importance depending on the age of the informant, informants were divided into three age groups (≤ 20 , 21–39, ≥ 40). Recognition of *Abuta imene* as a medicinally useful plant (RFC) was significantly higher in the oldest age group than the youngest age group ($p < 0.01$). Agreement on the medicinal use of *B. grandiflora* (FL) was higher in the

older age group than in the middle age group. Participants in the oldest age group mentioned *B. grandiflora* significantly more for treating colds than the other age groups ($p < 0.05$). In general, there was more agreement on use (FL or IAR) among informants in the older age groups than the younger age groups. No species emerged as significantly different in importance between gender groups.

Discussion

An interview method based on presentation of digital images on an electronic tablet enabled inclusion of a relatively large number of participants representing both genders and a wide range of ages. We determined that there was a positive correlation between age and knowledge of medicinal plants, but that there was no difference in knowledge between genders. In addition, the relative importance of species included in the study was determined through quantitative analysis of informant responses. Interestingly, a plant that is used for wound healing, and that has yet to be extensively investigated, emerged as one of the most important plants.

The plants that were most important to the Payamino people among the 34 in our sample were identified through calculation of RFC, FL, UV, and IAR indices. Because only a subset of medicinal plants used by the Payamino people are represented in our sample, it was not possible to calculate some relative importance indices such as informant consensus (Trotter and Logan 1986), which is a measure of



Table 2 The 34 plant species included in the study are listed in order of decreasing CV (FL + RFC). The most frequently cited therapeutic use category (see Table 1), method of preparation, and plant part used are also indicated. NA = not applicable because there was no predominant response. **Limpia* refers to the method of fanning or swatting the affected individual with leaves to achieve spiritual cleansing. ***Maito* refers to the method of cooking by wrapping the plant material in a *Heliconia* leaf and placing it in the ashes of the fireplace.

Scientific name	Kichwa name	Voucher #	Use category	Part used	Prep. /admin.	RFC	FL	UV	IAR	RFC + IAR
<i>Urera baccifera</i> (L.) Gaudich. ex Wedd. (Urticaceae)	Chini	233438	Mal viento	Leaves	<i>Limpia</i> *	1.0	0.7	1.2	0.9	1.87
<i>Tradescantia zanoniana</i> (L.) Sw. (Commelinaceae)	Kilon Kilon	233481	Injury	Latex	Topical	0.8	1.0	0.8	1.0	1.74
<i>Brunfelsia grandiflora</i> D. Don (Solanaceae)	Chiri Wayusa	233422	Respiratory	Leaves	Decoction	0.8	0.6	1.0	0.9	1.64
<i>Croton lechleri</i> Mull.Arg. (Euphorbiaceae)	Yawar Wiki	237567	Respiratory	Latex	Oral	0.8	0.5	1.0	0.8	1.57
<i>Monolena primuliflora</i> Hook. f. (Melastomataceae)	Kiru Jambi Yura	233434	Aches/pains	Stem	Masticant	0.6	0.9	0.6	0.9	1.52
<i>Abuta grandifolia</i> (Mart.) Sandwith (Menispermaceae)	Tara Tara	233411	GI	Stem	Decoction	0.6	0.8	0.7	0.9	1.45
<i>Monstera spruceana</i> (Schott) Engl. (Araceae)	Raya Panga	237557	Injury	Leaves	Vapor bath	0.6	0.9	0.6	0.9	1.45
<i>Petiveria alliacea</i> L. (Phytolaccaceae)	Condiso	233426	Respiratory	Leaves	Intranasal	0.5	0.7	0.5	0.8	1.33
<i>Philodendron campii</i> Croat (Araceae)	Abispa Chupu Panga	233435	Tumores	Leaves	<i>Maito</i> **/ Topical	0.5	0.5	0.5	0.8	1.33
<i>Witheringia solanacea</i> L'Her. (Solanaceae)	Atalpa Jaya Panga	233429	Mal viento	Leaves	Topical	0.6	0.7	0.6	0.8	1.31
<i>Mansoa standleyi</i> (Steyererm.) A.H.Gentry (Bignoniaceae)	Sacha Ajo	237560	Respiratory	Leaves	Decoction	0.5	0.8	0.6	0.8	1.27
<i>Begonia rossmanniae</i> A.DC. (Begoniaceae)	Kaka Tau Panga	233416	Eye infections	Leaves	Expression/Ocular	0.6	0.5	0.6	0.7	1.27

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Scientific name	Kichwa name	Voucher #	Use category	Part used	Prep. /admin.	RFC	FL	UV	IAR	RFC + IAR
<i>Passiflora vitifolia</i> Kunth (Passifloraceae)	Inda Panga	233412	Tumores	Leaves	Vapor bath	0.4	0.7	0.5	0.8	1.27
<i>Elaphoglossum raywaense</i> (Jenman) Alston (Dryopteridaceae)	Zingra Panga	233451	Aches/pains	Leaves	Vapor bath	0.4	0.7	0.5	0.8	1.26
<i>Piper</i> sp. (Piperaceae)	Armadillo Panga	237550	Aches/pains	Leaves	Vapor bath	0.5	0.7	0.5	0.8	1.24
<i>Xanthosoma hylaeae</i> Engl. & K.Krause (Araceae)	Mandi	237495	Injury	Stem	Topical	0.3	0.8	0.3	0.9	1.21
<i>Uncaria guianensis</i> (Aubl.) J.F.Gmel. (Rubiaceae)	Kasha Kara	233414	Aches/pains	Bark	Decoction	0.4	0.5	0.5	0.8	1.19
<i>Centropogon lorentensis</i> E. Wimm. (Campanulaceae)	Sulema	233415	Skin infections	Latex	Topical	0.4	0.8	0.4	0.8	1.16
<i>Heliconia</i> sp. (Heliconiaceae)	Pari Riwa	237514	Injury	NA	NA	0.1	1.0	0.1	1.0	1.08
<i>Syngonium podophyllum</i> Schott (Araceae)	Yuturi Panga	233445	Injury	Latex	Topical	0.3	0.8	0.3	0.8	1.08
<i>Dicranopygium grandifolium</i> Harl- ing (Cyclanthaceae)	Satun	233475	Injury	Stem	Topical	0.4	0.7	0.4	0.7	1.03
<i>Piper bellidifolium</i> Yunck. (Piperaceae)	Basu Panga	237610	Aches/pains	Leaves	NA	0.3	0.4	0.3	0.7	1.01
<i>Ouratea williamsii</i> J.F. Macbr. (Ochnaceae)	Amarun Caspi	237533	Injury	Inner bark	Decoction	0.2	0.4	0.3	0.7	0.94
<i>Piper macrotrichum</i> C. DC. (Piperaceae)	Uma Nanay Panga	237571	Aches/pains	Leaves	Vapor bath	0.1	0.8	0.1	0.8	0.89
<i>Drymonia coccinea</i> (Aubl.) Wieh- ler (Gesneriaceae)	Ayku Chuchu	233474	Women's health	Flower	Topical	0.2	0.5	0.2	0.7	0.86

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Scientific name	Kichwa name	Voucher #	Use category	Part used	Prep. /admin.	RFC	FL	UV	IAR	RFC + IAR
<i>Clavija weberbaueri</i> Mez (Theophrastaceae)	Paushi Mulyeja	233447	Aches/pains	Leaves	Decoction	0.2	0.4	0.3	0.6	0.85
<i>Solanum uleanum</i> Bitter (Solanaceae)	Churu Paju Panga	233486	GI	Leaves	NA	0.2	0.5	0.2	0.6	0.79
<i>Tabernaemontana sananho</i> Ruiz & Pav. (Apocynaceae)	Sikta Yura	233442	GI	Stem	Intranasal	0.1	0.8	0.1	0.7	0.78
<i>Costus amazonicus</i> (Loes.) J.F.Macbr. (Costaceae)	Sacha Wiru	233409	Respiratory	Stem	Masticant	0.3	0.7	0.3	0.5	0.75
<i>Thelypteris biformata</i> (Rosenst.) R.M. Tryon (Thelypteridaceae)	Istandi	233410	Injury	Bark	Topical	0.3	0.4	0.3	0.5	0.75
<i>Aniba</i> sp. (Lauraceae)	Paju Panga	237527	Aches/pains	Leaves	Vapor bath	0.3	0.2	0.3	0.4	0.69
<i>Piper poporense</i> Trel. & Yunck. (Piperaceae)	Basu Panga	237595	Mal viento	Leaves	Vapor bath	0.3	0.2	0.3	0.4	0.68
<i>Eucharis moorei</i> (Baker) Meerow (Liliaceae)	Sacha Cebolla	233424	GI	Flower	NA	0.2	0.4	0.2	0.4	0.65
<i>Abuta imene</i> (Mart.) Eichler (Menispermaceae)	Chalyua Paju Panga	233441	Aches/pains	Leaves	Decoction	0.1	0.3	0.1	0.5	0.58

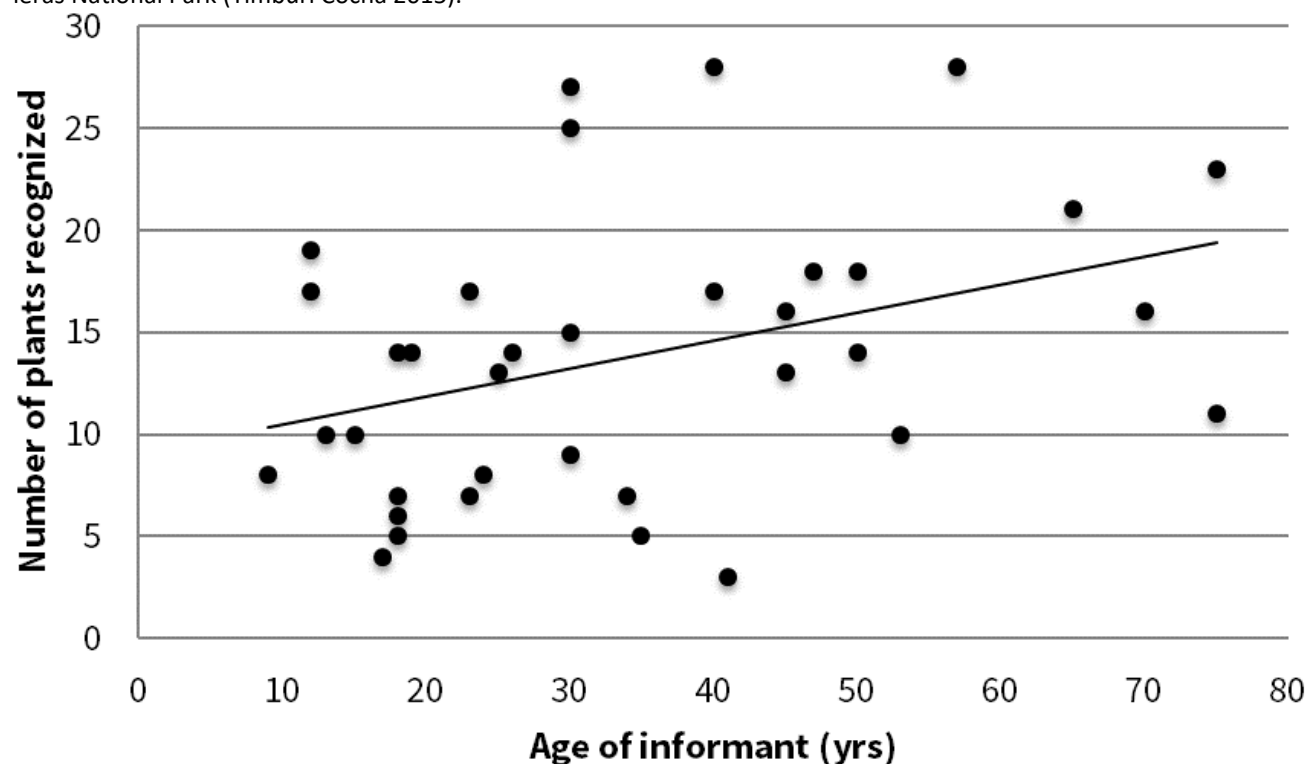
agreement on which plants are most important for a particular usage category. It is possible that the most important plant for a given category is not included among our 34 plants. In the future, however, the current study could be conducted with different plant species such that the data set covered a larger portion of the Payamino pharmacopoeia. Our approach could also be augmented by incorporating additional methods such as freelisting to gather data on plants not included in the sample.

There were no plants in our sample that were not recognized as medicinal by at least three informants, which suggests that the images were not seriously flawed in any way that would render the plants unrecognizable. Nonetheless, it is a concern that the RFC might be to some extent a measure of the quality of the image rather than the value or importance of the plant. Similarly, FL and IAR are imperfect measures of importance because they depend on the assignment of use citations to various therapeutic categories (Friedman et al. 1986). Although several use categories are commonly used, other use categories may be culture-specific, and categorization of each use citation may not always be obvious (Heinrich et

al. 1998). The number and inclusiveness of categories may also impact importance indices. When using FL as a measure of importance, an assumption is made that a plant with a single use is more important than a plant that is used for different purposes by different users, so the level of agreement on the most common use determines the plant's importance. In contrast, IAR takes into account the contribution of multiple different uses to a plant's relative importance. A species may have a higher IAR index than FL index if there is a high level of agreement on the plant's use in more than one category. The IAR would be lower than the FL if there is a high level of agreement in one category, but a low number of citations in multiple other categories. We reasoned that the sum of the IAR and RFC would best represent the importance of each medicinal plant since this would account for the percentage of informants who recognize the plant as medicinal (RFC) as well as the level of agreement among informants as to the use or uses of the plant (IAR).

The five plants with the highest IAR + RFC values were *U. baccifera*, *T. zanonina*, *B. grandiflora*, *C. lechleri*, and *M. primuliflora*. *Tradescantia zanonina* and *M.*

Figure 2 Location of San José de Payamino relative to the nearest towns of Coca and Loreto and the Sumaco - Napo - Galaras National Park (Timburi Cocha 2015).



primuliflora have not been widely reported in the ethnomedical literature, so their relative importance in Payamino ethnomedicine might not be expected. *Urera baccifera*, *B. grandiflora*, and *C. lechleri*, however, are well-known medicinal plants that are commonly used throughout the region. *Urera baccifera* is a stinging nettle that is used to treat aches and pains due to sore muscles, arthritis, stings and bites (Bennett et al. 2002; Davis and Yost 1983; Giovannini 2015; Schultes and Raffauf 1990). The affected region of the body is placed into contact with the plant's urticating hairs, usually by tapping with the stem and leaves followed by massaging the affected area. *Urera baccifera* is also used in ritual cleansing, and it is common to punish children with a swat of the stem. In the nearby town of Loreto, *U. baccifera* was the third most frequent response when participants were asked which plant they harvested most recently for medicinal use (Innerhofer and Bernhardt 2011).

The Payamino people use the viscous sap of *T. zanonía* as a liquid bandage to treat injuries ranging from small cuts to large open wounds. Although the plant does appear in the ethnomedical literature, its use as a cicatrizant is not widely reported. A hydroalcoholic extract of the sap of *T. zanonía* was demonstrated to be more effective at promoting wound healing in rats than the topical antibiotic and steroidal anti-inflammatory drug Lamoderm (Licuy-Mamallacta 2013). The latex of *T. zanonía* is applied topically by the Teribes of Bocas del Toro, Panama for hemorrhage, but not for wounds (Gupta et al. 2005). The Quechua people of the Chazuta Valley in Peru chew the aerial parts or boil them in water and drink the extract for cough suppression, referring to it as *pampa llullu* (Sanz-Biset et al. 2009). In the southern Ecuadorian provinces of Loja and Zamora, the fresh stem of *T. zanonía* is prepared as an infusion and drunk for fevers (Tene et al. 2007). Although *T. zanonía* has been the focus of cytological studies, primarily on the effects of radiation on chromosomal aberrations, few phytochemical studies have been conducted on this species (Anderson and Sax 1936; Chiriboga 1995; Savage and Pritchard 1969). A phytochemical screening of *T. zanonía* revealed the presence of alkaloids, sterols, and saponins, though the identities of these chemical constituents and their contribution to the cicatrizant activity of the plant are not known (Chiriboga 1995).

In Payamino the leaves of *B. grandiflora* are boiled in water and drunk or administered as a vapor bath

for fevers and body aches. The Kichwa word *chiri* in the name *chiri wayusa* means "cold" and refers to the chill felt upon ingestion of the plant. The use of stem and root bark is common in other parts of the Northwest Amazon where it is one of the most important remedies for rheumatism (Plowman 1977).

The red latex of *C. lechleri*, for which this tree is named dragon's blood or *sangre de drago*, is applied topically for cuts and wounds. In addition, a few drops of the latex are dissolved in water and taken for diarrhea. This traditional use as an anti-diarrheal has led to the development of the FDA-approved drug crofelemer, a crude botanical drug comprised of the latex of *C. lechleri*. Crofelemer is indicated specifically for diarrhea associated with antiretroviral drug use (Yeo et al. 2013).

Monolena primuliflora is referred to as *kiru jambi yura* by the Payamino people, a name which translates to tooth medicine stem. The stalk of the infructescence (scape) is chewed to relieve toothache. The sour-tasting juice is also considered to be a useful thirst quencher. Herbarium records indicate that in the highlands of northern Ecuador the plant is used as an emetic to expel parasites (Rios et al. 2007). *Monolena primuliflora* is also reported to be used for flu, stomachache, conjunctivitis, and for snakebite (Fierro et al. 2002). To our knowledge the phytochemistry and pharmacology of this species has yet to be explored.

The similarity in the average number of plants identified by males and females provides an interesting insight into the culture and importance of traditional medicine of the Payamino community. Because men and women have different roles in Payamino society, and their roles determine to some extent how they interact with plants, one would expect there to be differences in medicinal plant knowledge between genders (Irvine 1987). The results of our study suggest that Payamino men and women are equally knowledgeable about medicinal plants, a conclusion that is consistent with findings from other studies such as that conducted by Browner and Perdue in San Francisco, Mexico (1988). In contrast, Voeks and Leony (2004) found that women in Bahia, Brazil were much more knowledgeable about medicinal plants and traditional remedies than men. Our results do not support the claim that Payamino women know more about plants that are used in women's health, such as for menstruation or childbirth (Irvine 1987). Of the 25 citations for women's health, 12 were cited by female participants while 13 were cited by males.

Gender-dependent differences in knowledge of plants used in women's health should be investigated further, however, since we did not include all plants used for women's health in our study. Furthermore, a larger sample size may be necessary to achieve statistical significance.

Since we were unable to demonstrate a difference in medicinal plant knowledge between sexes, it is unclear as to how men and women might manage forest resources differently based on their respective knowledge of medicinal plants. Age, however, has been previously suggested as a predictor of medicinal plant knowledge (Alencar et al. 2014; Ayantunde et al. 2008; Mathez-Stiefel et al. 2012; Quinlan and Quinlan 2007), and younger individuals may not have the same regard for medicinal plants when managing forest resources. On one occasion during our fieldwork, we observed an example of the intergenerational difference in attitudes towards medicinal plants when an elder commented that, against his advice, his son cut down a medicinal plant when clearing forest to plant coffee. In Payamino, Irvine (1987) observed that people older than 40 years of age could identify more forest plants and knew more about their ecology and reproductive biology than did people who were 20 years old or younger. Although some of the youngest informants were surprisingly knowledgeable, our study confirms that older individuals tend to know more about medicinal plants than do younger individuals in Payamino, both in terms of their ability to recognize images of medicinal plants and agreement on their use. The community of San José de Payamino has only gained roadway access to nearby urban centers in the last ten years. While the road may offer more opportunity for education, employment, and sale of agricultural products, it may also have a negative cultural impact on the younger generation with regards to its willingness to learn about the traditional lifestyle of their parents and grandparents. The loss of traditional knowledge has implications for the health of the forest as well as for the health of community members. Plants that are considered to be of value to the community are likely to be preserved along with the habitat in which these plants grow (Berkes et al. 2000). Further work to document medicinal plants of high importance in indigenous communities as well as to determine the distribution of knowledge of these plants among community members might guide education efforts that will positively impact community health and forest ecology.

Conclusion

The use of digital plant images enabled efficient ethnobotanical data collection in a remote community in the Ecuadorian Amazon. Quantitative analysis revealed that two relatively unstudied plants, *T. zanonía* and *M. primuliflora*, along with *U. baccifera*, *C. lechleri* and *B. grandiflora*, are the most important medicinal plants of those included in the study. There is a positive correlation between knowledge of medicinal plants and age, though there is no difference in knowledge between genders. How distribution of medicinal plant knowledge in Payamino influences the management of forest resources is a topic that should be investigated further.

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Declarations

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