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# Different patterns in medicinal plant use along an elevational gradient in northern Peruvian Andes

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## ABSTRACT

*Ethnopharmacological relevance*: Through the study of mestizo people that share a common culture in a large geographic region and where traditional knowledge is still poorly documented, we compared medicinal plant use along +2000 m in the Andes of Peru.

*Aims of the study*: (1) To compare patterns of distribution of TK for a human group living between two ecoregions: high tropical montane forests vs. low tropical montane forests; (2) to understand the TK at the gender level; and (3) to analyse TK transmission over five generations.

*Material and methods*: The study was conducted in two ecoregions, four areas and 12 localities. We gathered information with 600 participants through semi-structured interviews. We worked with 3-7 expert informants per locality using the "walk in the woods" methodology for gathering ethnomedicinal information in the field. We annotated local vernacular names, medicinal indications, and collected the plants in their habitats. Then we interviewed the rest of the participants in their homes. To evaluate significant differences between highlands and lowlands, we use general mixed linear models test and its

corresponding *post hoc* LSD Fisher test of multiple comparisons ($p < 0.05$) at ecoregion, gender and generation level.

*Results*: A total of 416 species belonging to 107 plant families and 13,898 use-reports were found in both ecoregions. Overall, significant differences indicated that people in the highlands had higher TK than people in the lowlands for most of the medicinal categories. Women showed higher knowledge on medicinal plants in all medicinal categories and areas in both ecoregions. However, transmission of TK showed different patterns between ecoregions. In the highlands, the TK increased from the youngest to the senior group (51-60 years), with a slight decreasing for those over 60 years, whereas in the lowlands the findings were less clear and generations with highest TK were divergent across localities.

*Conclusion*: TK on medicinal plants is widely applied in the tropical montane forests of northern Peru. The localities with less prosperous socioeconomic development (highlands) were the areas with higher TK on medicinal plants. Women are mainly the depositories of the traditional medicine. The older generations maintain most of the TK in the highlands, whereas in the lowlands the TK is more widespread across generations. Future conservation programs on medicinal plants should understand who are the generations depositaries of the TK before dedicate any effort.

**Keywords:** altitudinal range; folk medicine; gender balance; mestizo phytotherapy; transmission of traditional knowledge

## 1. Introduction

The traditional medicine based on plants has been maintained through history, especially in remote rural areas and among ethnic minorities of modern society, as a necessity for people with few economic resources or inaccessible medical assistance (Macía et al., 2005; Heinrich et al., 2006; Leonti and Casu, 2013). Nowadays, there are clear evidences of the fading of traditional knowledge (TK in the following) indicating that the chain of oral transmission between generations is breaking (Reyes-García et al., 2013; Paniagua-Zambrana et al., 2016). In response, the World Health Organization has among its objectives for the 2014-2023 decade, the recovery of popular knowledge about medicinal plants as an alternative for primary health care, mainly in the poorest regions of developing countries (WHO, 2013). This is the case of Peru, with at least 3000 species of medicinal plants documented (Mostacero et al., 2011). In the last decade the number of studies on medicinal plants has significantly increased in the country, and specifically in the Andean region (e.g. De la Cruz et al., 2007; Bussmann and Glenn, 2010; Mathez-Stiefel et al., 2012; Gonzales et al., 2014), although the eastern flank of the northern Andes is still scarcely studied (Bussmann and Sharon, 2006; Schjellerup et al., 2009).

In the tropical montane forests of northern Peru are living mestizo communities under different environmental conditions and socio-economic factors, which determine their life habits and also the use of medicinal plants in their surroundings. Along more than 2000 m in elevation, people have a culture relatively common that shares common human ancestors integrated into the territory of the prehispanic culture (Monigatti et al., 2013).

Generally, gender and age are key factors which determine the distribution of TK (Lambaré et al., 2011; Sousa Júnior et al., 2013). Women are the main vehicle for transmitting this knowledge in rural societies because they usually assume the main responsibilities of child and elders care (McDade et al., 2007; Wayland and Walker, 2014) although men showed a

greater TK in some cases (e.g. Albuquerque et al., 2011; Paniagua-Zambrana et al., 2014). On the other hand, elder people are commonly the depositaries of ethnobotanical wisdoms and customs due to their accumulation of knowledge over time, as well as the alliance conformed between local flora, culture and faith in the plants as medicine (Upadhyay et al., 2010). However, this knowledge can be evenly distributed among several age groups, even showing higher records in younger age groups by vertical, horizontal or oblique TK transmission (Idolo et al., 2010; Almeida et al., 2015).

In this work we have three objectives: (i) to compare the use of medicinal plants for a human group with a similar culture and living between two ecoregions: high tropical montane forests vs. low tropical montane forests. We hypothesize that people with less economic resources and possibilities of resource exploitation will have greater traditional knowledge, which corresponds to the communities living in the highlands; (ii) to analyze the distribution of TK on medicinal plants and gender equality between the two ecoregions. We expect women have a greater TK than men, due to the division of labour, where women mainly dedicate to the family health care whereas men mainly carry out agricultural and livestock work, or work outside their localities (Pfeiffer and Butz, 2005; Sher et al., 2015); and (iii) to understand the TK transmission over generations: 18-30, 31-40, 41-50, 51-60, >60 years old between ecoregions. We expect elders have a greater TK than youngers due to their progressive accumulation of knowledge along their lives (Koster et al. 2016).

## 2. Methods

### *2.1. Study area*

The study was conducted in the tropical montane forests of the Amazonas Department, in the eastern slopes of the northern Andes in Peru (Fig. 1). We worked in two different ecoregions according to their elevation: high tropical montane forests located between 2500 and 3500 m

and low tropical montane forests, situated between 1500 and 2500 m. Both ecoregions have a seasonal climate, with a wet season from November to May and a dry season from June to October. In the highlands the annual average temperature is 14 °C and annual average rainfall is 780 mm, whereas in the lowlands is 19 °C and 900 mm respectively (SENAMHI, 2017). We studied two different areas per ecoregion and three localities per area (Fig. 1). In the highlands, the areas were: (1) Luya province, in the upper basin of the Utcubamba river and localities of Longuita, María and Yomblón; and (2) Chachapoyas province, in the upper basin of the Imaza river and localities of Granada, Olleros and Quinjalca. This ecoregion is mainly characterized by shrub vegetation and grassland extensions in a steep topography. The state of conservation is better than in the lowlands, but commonly altered by livestock pastures and agricultural activities of limited area (Young and León, 1988; Encarnación and Zárate, 2010). In the lowlands, the studied areas were: (1) Rodríguez de Mendoza province, in the middle basin of the Leiva river and localities of Totora, Santa Rosa and Huambo; and (2) Bongará province, in the middle basin of the Utcubamba river and localities of Valera, Cuispes and San Carlos. The conservation status of this ecoregion is discontinuous, with small patches of well-preserved forest but most areas are occupied by agriculture and livestock pastures (Schjellerup et al., 2009).

The population of both highlands and lowlands is conformed by spanish speaking mestizos. The principal source of income in the highlands is obtained from beef cattle work and complemented with small scale vegetable crops, such as corn, beans and potatoes. They have difficult access to suitable infrastructures and limited access to basic health services, like drinking water supply. The nearest hospital is located in the city of Chachapoyas, which takes 3-5 hours depending on the road conditions. The population of the lowlands is mainly dedicated to coffee, corn and sugar cane cultivations, which sometimes is complemented with a diverse livestock of cows, pigs and sheeps. They have the facility to fish in rivers and lakes

and commercialize their products. Overall, they have better infrastructure with nearby health services or hospitals, water treatments plants, and more prosperous economic conditions than population in the highlands. The population living in the six localities of the highlands is estimated at 3025 inhabitants, whereas in the six localities of the lowlands at 5865 inhabitants (INEI, 2015).

*2.2. Data collection*

To gather information about the uses of medicinal plants by local people, we carried out 50 semistructured interviews in each of the 12 localities of the Peruvian montane forests, totalling 600 interviews from July 2016 to May 2017. In the localities, we interviewed two types of informants: experts and generalists. The expert informants were those who have a greater knowledge of medicinal plants in their ecoregion and were chosen by the leaders of the respective localities. We interviewed 3-7 expert informants per locality, totalling 77. Experts were mostly women (62%) and older than 40 years (92%). With these informants, we used the "walk in the woods" methodology for gathering ethnomedicinal information in the field dedicating between 1-3 days with each person. We annotated local vernacular names, medicinal indications, and collected the plants in their habitats. For some species collected in sterile conditions and that could not be identified to species level, we carried out a second field trip to try to find them fertile.

Once the work with the expert informants was completed in a given locality, the rest of the interviews were carried out with the general informants. Doing so, we have a full picture of the plant diversity and medicinal uses of the different localities. General informants were selected seeking a balance in terms of gender and age within each locality. Informants were divided into five age groups: 18-30, 31-40, 41-50, 51-60 and >60 years old. In the locality of Granada we could only interviewed to one informant >60 years.

All collected specimens were deposited in the Herbarium Truxillense (HUT) with duplicates at the Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas (Peru). The scientific names followed *The Plant List* (The Plant List, 2018) and the family taxonomic classification followed the *Angiosperm Phylogeny Group* (Byng et al., 2016).

*2.3. Ethics statement*

Research was carried out according to the Convention of Biological Diversity taking into account the Bonn guidelines and the Nagoya Protocol (SCBD, 2002, 2011). A written permission was obtained from each locality leader. Informed consent was orally obtained from all participants and before conducting interviews. Interviewees could stop responding at any time and were informed that all data provided would be anonymized. The ethics committee of the Autonomous University of Madrid aproved this statement (CEI 73-1327 to M.J. Macía).

*2.4. Data analysis*

All the medicinal indications were classified into 18 categories following international standards (Cook, 1995) with additional modifications to adapt them to tropical regions and to include properly cultural diseases (Macía et al., 2011; Gruca et al., 2014) (Appendix A). To evaluate TK on medicinal plants across localities, we used four ethnomedicinal indicators: total number of useful plant species, medicinal uses, medicinal use-reports, and average number of uses per species. We define (1) a “medicinal use” as the use of a plant part of a species that is associated with a medicinal category for a particular disease or ailment (Paniagua-Zambrana et al., 2014); and (2) a "medicinal use-report” as the medicinal use defined previously and associated to an informant.

To evaluate possible significant differences between highlands and lowlands, we use the 15 medicinal categories with the highest number of use-reports (200 or more) using general mixed linear models and its corresponding *post hoc* LSD Fisher test of multiple comparisons ($p < 0.05$). Similarly, we run analyses to compare TK between women and men. Finally, to analyze TK transmission between age groups, we used the average percentages of use-reports per generation in mixed general linear models across localities. All analyses were performed in R 3.4.0. (R Development Core Team, 2017).

## 3. Results

### *3.1. Distribution of TK along the elevational gradient*

A total of 13,898 use-reports, 3720 medicinal uses and 416 species belonging to 107 families were found in 600 interviews conducted in four areas, and 12 localities of two different ecoregions in the montane forests of northern Peru (Table 1). Medicinal plants and uses are shown in the supplementary material. In general terms, people in the highlands had higher TK than in the lowlands, according to the four ethnomedicinal indicators used. Rodríguez de Mendoza (lowlands) was the area that showed the lowest numbers of TK. In Bongará (lowlands), we found a higher number of plant species than in Chachapoyas (highlands), but the other three ethnomedicinal indicators were lower. Within the highlands, Luya scored higher in three out of the four indicators, only surpassed by Chachapoyas in the number of use-reports.

In the highlands, 12 out of 18 medicinal categories showed higher number of use-reports than in the lowlands with *Digestive*, *General ailments, Nervous* and *Respiratory systems* cited more than double (Fig. 2A, 2E, 2F and 2H). The remaining six medicinal categories scored higher in the lowlands, but most of them were among the categories with the lowest number of use-reports. *Cultural diseases and disorders* (Fig. 2B) and *Ritual and magic uses* (data not

shown) showed slightly higher values in the lowlands. The two areas in the highlands showed similar values of use-reports: Chachapoyas scored higher in nine categories whereas Luya did so in the other nine categories. However, in the lowlands, Bongará showed higher values of use-reports in all categories compared to Rodríguez de Mendoza.

Significant statistically differences were found in seven out the 15 most cited categories along the elevational gradient: *Digestive system*, *General ailments*, *Muscular-skeletal system, Nervous system*, *Respiratory system*, *Sensory system* and *Skin and subcutaneous tissue* (Fig. 2A, 2D, 2E, 2F, 2H, 2K and 2L). All these categories scored higher in the highlands. Among the eight categories that did not have significant statistically differences between ecoregions, three of them showed higher percentages of use-reports in the lowlands (*Blood and cardio-vascular system, Cultural diseases and disorders*, and *Dental health*) (Fig. 2B, 2M and 2N), and five categories in the highlands (*Infections and infestations, Pregnancy, birth and puerperium*, *Reproductive system and reproductive health, Urinary system* and *Other uses*) (Fig. 2C, 2G, 2I, 2J and 2O).

*3.2. Gender distribution of TK*

Overall, women showed a higher percentages of use-reports in all medicinal categories and areas in both ecoregions with the exception of *Cultural diseases and disorders* in Luya province (Fig. 3B), and *Muscular-skeletal system* and *Urinary system* in Luya and Rodríguez de Mendoza (Fig. 3C). We found significant statistically differences in the distribution of TK between men and women in all medicinal categories except in *Cultural diseases and disorders*, *Dental health* and *Muscular-skeletal system* (Fig. 3B, 3N and 3K). Women cited more than double use-reports than men in the categories of *Blood and Cardio-vascular system*, *Pregnancy, childbirth and puerperium* and *Reproductive system*, with the exception of

Luya province (Fig. 3G, 3J and 3M). This was also the case in *Metabolic system* and *Ritual and magical uses* (data not shown).

### *3.3. TK transmission across age groups*

In the highlands, the TK of medicinal plants increased from the youngest (18-30 years) to the senior group (51-60 years), with a slight decreasing for those over 60 years in all localities (Fig. 4A–F) where statistically significant differences were found across groups. In the lowlands, the findings were less clear. In the Totora and Huambo localities, the pattern was similar to the highlands (Fig. 4K–L), but was not statistically significant. However in two other localities (Cuispes and San Carlos), the highest TK was recorded in the elders age group (Fig. 4G–H), whereas in Valera and Santa Rosa, the highest TK was reported in the middle age groups (Fig. 4I–J), although only in two of these cases were statistically significant (Fig. 4H–I). It is surprising the high percentage of use-reports found in Valera for the senior group (51-60 years), which represented more than double than the other four groups (Fig. 4I).

## 4. Discussion

### *4.1. Elevational gradient*

Traditional medicine is still widely practiced in the tropical montane forests of northern Peru. We found a higher number of medicinal species and medical indications than previuos studies in other Andean regions of the country (Hammond et al., 1998; De la Cruz et al., 2007; Huamantupa et al., 2011; Monigatti et al., 2013; Gonzales et al., 2014). Several factors can explain these results including the large area covered in our study, the stratified sampling across different age groups, the gender balance of the interviewers, the high number of informants, and the special focus posed on the expert informants.

The TK on medicinal plants was higher in the highlands than in the lowlands, which accept our first hypothesis. This can be explained by at least four variables. First, the socio-economic factors differentiate clearly the population in the ecoregions, being the lowlands more prosperous with permanent crops, land suitable for forestry production, fishing areas and greater economic income coming from tourism (Almeida et al., 2010). On the contrary, the economic resources in the highlands are more scarce, with predominance of subsistence crops or based on milk production of extensive beef cattle farming. So, areas with greater socio-economic development tend to be areas with lower TK on medicinal plants, such as the case of Rodríguez de Mendoza, that also have been reported in other studies (Kunwar and Bussmann, 2008; Lira et al., 2009; Vandebroek, 2010). Second, migration processes to urban areas. In the lowlands it took place mainly from the 90s, whereas in the highlands occurred only from the last decade (INEI, 2008, 2009). Migration use to cause rapid cultural and socio-economic changes that usually produce the loss of TK from one generation to the next (Takasasi et al., 2001; Reyes-García et al., 2013), which surely ocurred in the lowlands by a reduction in the use of medicinal plants. Third, the isolation of the localities in the highlands and the lack of health services and infrastructures resulted in a more prominent use of the traditional medicine as previously have been reported in other studies (Benz et al., 2000; Byg et al., 2007; Leonard et al., 2015). Fourth, the environmental conditions of the two ecoregions. In the highlands, the population is living in a harder climatic conditions than in the lowlands and probably have derived in the use of more plant resources to treat disorders of the *Respiratory system* (De la Cruz et al., 2007) and *General ailments*, such as fever and headache (D'Arcy, 2004). At the same time, remedies for disorders and diseases of the *Digestive* and the *Urinary systems* were mainly found in the highlands, which can be explained because they have not implemented water treatment systems for their consumption which tend to increase gastrointestinal and urinary problems (Collins et al., 2006; Pareek and

Kumar, 2013). Concerning *Cultural diseases and disorders*, TK was widely shared in both ecoregions with slightly higher values in the lowlands. In this case, diseases like *susto*, *gentil*, *tacsho*, *tijte, pulsario*, *shucaque*, *shadow* or *dispela*, came from traditional Andean medicine, so they are not treatable with the conventional medicine (Mathez-Stiefel et al., 2012; Gonzales et al., 2014).

In contrast with the results found in the provinces of Rodríguez de Mendoza and Chachapoyas, the localities of Bongará (lowlands) showed a similar TK than the localities of Luya (highlands). This can be explained by geographic, touristic and commercial factors. First, the road communication between the localities in Bongará and the localities in Luya (with the exception of Yomblón), has been recently paved and then has enabled the communication of people between both areas, generating a flow of information that also facilitates the exchange of TK. Second, both areas have the two most visited tourist attractions in the Department of Amazonas: Kuélap prehispanic archaeological complex and the Gocta waterfall (771 m). Third, one of the most important street markets in the ecoregion is weekly organized between the two areas, and regularly attracts merchants and buyers from the six locations, which again facilitate the transfer of knowledge and could have conformed a major similarity in TK between the areas (Gazzaneo et al., 2005).

### *4.2. Gender and TK*

Women are the keepers of the traditional medicinal knowledge in northern Peruvian Andes and therefore our hypothesis is accepted. This can be explain because women workplace is usually linked to their home, taking care of children and the elders, and to their homegardens and orchards (Coelho-Ferreira, 2009; Baliano et al., 2015). Often these homegardens are reservoirs of medicinal plants that women use as a family medicinal resource in most Andean societies (Finerman and Sackett, 2003). Many earlier studies conducted in the Andean regions

are in line with our hypothesis, indicating that women are the main connoisseurs and transmitters of this TK in these countries (e.g. Perry and Gessler, 2000; Arango, 2004; Gonzales et al., 2014; Zambrano et al., 2015). The role of women is almost exclusive in the application of medicinal plants in some domains, such as *Pregnancy, childbirth and puerperium* and *Reproductive system* (Vandebroek et al., 2010; Malan and Neuba, 2011; Barreto and Schultze-Kraft, 2014), and this knowledge is only limited to expert men informants in our study. However, there are other works in which men showed a greater TK on medicinal plants which resulted from the division of responsibilities (Paniagua-Zambrana et al., 2014) or due to their greater participation in agriculture or livestock activities (Vandebroek et al., 2004; Albuquerque et al., 2011). So future conservation programs should mainly focus on women to preserve the traditional medicine in this Andean ecoregions.

*4.3. Age and transmission of TK*

In the highlands and some localities of the lowlands, the TK on medicinal plants increased from the youngest population to the seniors and then decreasing progressively to the elders, so our hypothesis that elders have a greater TK than youngers is only partially accepted. However, this general pattern is also found in other studies throughout the world where older people are less affected by external influences, and therefore maintain their beliefs and TK acquired in the past (Byg and Balslev, 2004; Zabihullah et al., 2006; Srithi et al., 2009; Menendez-Baceta et al., 2014; Paniagua-Zambrana et al., 2016). Nevertheless, there is a lack of consensus on the relationship between age and TK (Almeida et al., 2015) and surely there are many reasons to explain the transmission of TK across societies. Some factors that explain this diacronic TK are related to the loss of interest from younger generations in traditional medicine (Eyssartier et al., 2008) and the more common use of medicaments that produce more rapid effects to alleviate diseases or ailments (Giday et al., 2003).

During the last 20 years, basic medical posts have been implemented in each of the localities studied in both ecoregions. The latter may be an explanation for the loss of knowledge among younger groups, because they had an easier access to the conventional medicine services which may entail to not use TK (Ayantunde et al., 2008; Ladio and Lozada, 2009; McMillen, 2012). It is easy to identify this dynamic in all the localities studied in the highlands. However, the same does not happen in the lowlands, where only some localities follow this pattern. The rest of localities in the lowlands without an identifiable pattern are suffering the visible abandonment of their traditional knowledge about medicinal plants. This can be derived from their perception that this form of knowledge is not up to their new socio-economic and cultural conditions (Reyes-García et al., 2013), which are far superior to the rest of the localities, mainly in the highlands.

Concerning the great difference of TK in Valera for people between 51 and 60 years old and the other age groups is simply because the majority of the experts interviewed in this locality fall in this generation. Finally, future national or international programs dedicated to the conservation of TK on medicinal plants should understand first, who are the depositaries generations that mostly retain the TK before dedicate any economic effort and support. And please, do not assume that elders are always the only depositaries of the TK across areas and regions.

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**Authors contributions**

FC and MJM designed the study; FC, OAGT and MJM conducted the fieldwork, FC, OAGT and MJM conducted the statistical analysis and wrote the manuscript; all authors read, corrected and approved the manuscript.

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**Figure legends**

**Fig. 1.** Map of the study area in northern Peruvian Andes showing the two ecoregions (high and low tropical montane forests), the four areas, and the 12 localities where medicinal plants uses were gathered in 600 interviews.

**Fig. 2.** Mean percentage of medicinal plants use-reports found comparatively in low tropical montane forests and high tropical montane forests based on 600 interviews in northern Peru. Letters (A, B) indicate significant differences based on general mixed lineal models and its corresponding *post hoc* LSD Fisher test ($p < 0.05$).

**Fig. 3.** Mean percentage of medicinal plants use-reports analyzed between women and men for four areas and the 12 localities in northern Peruvian Andes. Letters (A, B) indicate significant differences based on general mixed lineal models and its corresponding *post hoc* LSD Fisher test ($p < 0.05$).

**Fig. 4.** Mean percentage of medicinal plants use-reports broken down by five age cohorts in six localities in the highlands (A-F) and six localities in the lowlands (G-L) in the northern Andes of Peru. Letters (A, B, C) indicate significant differences based on general mixed lineal models and its corresponding *post hoc* LSD Fisher test ($p < 0.05$).

**Table 1.** Ethnomedicinal data gathered in two ecoregions, four areas, and 12 localities of the tropical montane forests of northern Peru.

| Ecoregion | Areas | Localities | No. plant species | No. medicinal uses | No. use-reports | Average (± SD) number of uses per species | No. men interviewed | No. women interviewed |
|---|---|---|---|---|---|---|---|---|
| High tropical montane forests (2500-3500 m) | All | All | 354 | 2636 | 8628 | 5.9 (±2.3) | 152 | 148 |
| | Chachapoyas | All | 254 | 1192 | 4806 | 4.0 (± 2.4) | 75 | 75 |
| | | Granada | 145 | 457 | 1459 | 2.9 (± 2.6) | 25 | 25 |
| | | Olleros | 190 | 598 | 1613 | 2.8 (± 2.6) | 27 | 23 |
| | | Quinjalca | 189 | 598 | 1734 | 2.7 (± 2.2) | 23 | 27 |
| | Luya | All | 301 | 1673 | 3822 | 4.7 (± 2.5) | 77 | 73 |
| | | María | 190 | 648 | 1244 | 3.0 (± 2.6) | 27 | 23 |
| | | Longuita | 221 | 707 | 1246 | 2.8 (± 2.4) | 24 | 26 |
| | | Yomblón | 210 | 729 | 1332 | 3.0 (± 2.9) | 26 | 24 |
| Low tropical montane forests (1500-2500 m) | All | All | 326 | 1638 | 5270 | 4.2 (± 2.2) | 149 | 151 |
| | Bongará | All | 273 | 1187 | 3306 | 3.7 (± 2.1) | 75 | 75 |
| | | Cuispes | 183 | 557 | 1258 | 2.6 (± 2.4) | 25 | 25 |
| | | San Carlos | 175 | 476 | 1307 | 2.4 (± 2.0) | 25 | 25 |
| | | Valera | 192 | 491 | 741 | 2.4 (± 2.2) | 25 | 25 |
| | Rodríguez de Mendoza | All | 223 | 689 | 1964 | 2.7 (± 1.5) | 74 | 76 |
| | | Santa Rosa | 145 | 282 | 613 | 1.7 (± 1.3) | 26 | 24 |
| | | Totora | 146 | 332 | 995 | 2.0 (± 1.6) | 23 | 27 |
| | | Huambo | 121 | 242 | 356 | 1.9 (± 1.3) | 25 | 25 |

Appendix A. Total number of use-reports (minimum, maximum) of the medicinal plants documented in two ecoregions, four areas, and 12 localities of the tropical montane forests in northern Peru. Medicinal uses are classified in 18 medicinal categories according to Cook (1995), Macía et al (2011) and Gruca et al (2014).

| | High Tropical Montane Forests | | | Low Tropical Montane Forests | | | |
|---|---|---|---|---|---|---|---|
| **Categories / Subcategories** | **Chachapoyas** | **Luya** | **All** | **Bongará** | **R. Mendoza** | **All** | **Total** |
| **Digestive system** | **888 (266-331)** | **404 (115-151)** | **1292** | **451 (78-189)** | **174 (34-72)** | **625** | **1917** |
| Diarrhoea | 170 (49-67) | 125 (33-50) | 295 | 114 (17-55) | 34 (6-17) | 148 | 443 |
| Stomach pain | 370 (74-155) | 4 (0-4) | 374 | 51 (8-24) | 7 (0-5) | 58 | 432 |
| Liver disorders | 132 (31-56) | 51 (11-24) | 183 | 23 (4-14) | 18 (2-10) | 41 | 224 |
| Stomach cramps | 26 (0-26) | 51 (10-21) | 77 | 68 (5-35) | 41 (4-23) | 109 | 186 |
| Laxative | 43 (11-17) | 56 (13-24) | 99 | 63 (14-28) | 8 (1-4) | 71 | 170 |
| Carminative | 65 (14-31) | 35 (1-18) | 100 | 23 (5-12) | 20 (4-9) | 43 | 143 |
| Stomach infection | 44 (11-17) | 4 (0-4) | 48 | 26 (1-18) | 7 (0-7) | 33 | 81 |
| Gastric ulcers | 9 (2-5) | 21 (5-9) | 30 | 33 (5-16) | 8 (0-8) | 41 | 71 |
| Digestive | 19 (0-1) | 16 (3-9) | 35 | 13 (3-6) | 4 (0-3) | 17 | 52 |
| Hepatitis | 2 (0-1) | 15 (2-8) | 17 | 23 (2-11) | 5 (0-4) | 28 | 45 |
| Constipation | 6 (0-5) | 20 (4-11) | 26 | - | 5 (0-4) | 5 | 31 |
| Indigestion | - | 4 (1-2) | 4 | 8 (0-8) | 11 (0-11) | 19 | 23 |
| Intestinal infection | 1 (0-1) | - | 1 | 5 (0-4) | - | 5 | 6 |
| Gallbladder | - | 2 (0-2) | 2 | - | 2 (0-2) | 2 | 4 |
| Stomach sickness | - | - | - | - | 4 (0-3) | 4 | 4 |
| Acidity | 1 (0-1) | - | 1 | - | - | - | 1 |
| Antiemetic | - | - | - | 1 (0-1) | - | 1 | 1 |
| **Cultural diseases and disorders** | **324 (87-139)** | **538 (158-216)** | **862** | **557 (113-224)** | **330 (37-148)** | **887** | **1749** |
| Susto, espanto | 65 (21-23) | 73 (15-35) | 138 | 101 (14-57) | 204 (16-99) | 305 | 443 |
| Antimonia, gentil, viejo, antiguo | 17 (1-11) | 180 (36-100) | 197 | 145 (37-68) | 33 (0-20) | 178 | 375 |
| Aire, malaire | 186 (55-74) | 71 (13-33) | 257 | 99 (14-44) | 5 (0-3) | 104 | 361 |
| Tacsho | 36 (9-16) | 123 (33-47) | 159 | 115 (31-42) | 42 (6-20) | 157 | 316 |
| Tijte | 7 (1-5) | 51 (10-25) | 58 | 53 (5-27) | 38 (0-20) | 91 | 149 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Pulsario | - | 30 (7-12) | 30 | 29 (3-17) | 7 (0-5) | 36 | 66 |
| Negative vibes | 1 (0-1) | 5 (0-5) | 6 | 9 (1-5) | 1 (0-1) | 10 | 16 |
| Shucaque | 5 (0-5) | 5 (0-5) | 10 | 3 (0-2) | - | 3 | 13 |
| Shadow | 5 (0-3) | - | 5 | 3 (0-3) | - | 3 | 8 |
| Dispela | 2 (0-2) | - | 2 | - | - | - | 2 |
| **Urinary system** | **633 (190-238)** | **290 (89-101)** | **923** | **285 (68-121)** | **277 (62-133)** | **562** | **1485** |
| Kidney disorders, emollient, diuretic | 564 (164-214) | 192 (59-67) | 756 | 184 (43-73) | 186 (49-84) | 370 | 1126 |
| Prostate disorders | 33 (9-15) | 83 (16-37) | 116 | 91 (23-45) | 85 (7-46) | 176 | 292 |
| Kidney stones | 36 (10-15) | 15 (4-6) | 51 | 10 (2-5) | 6 (1-3) | 16 | 67 |
| **Skin and subcutaneous tissue** | **460 (138-167)** | **276 (87-101)** | **736** | **284 (58-115)** | **155 (33-81)** | **439** | **1175** |
| Wounds, healing | 306 (96-105) | 74 (12-32) | 380 | 87 (18-35) | 21 (2-17) | 108 | 488 |
| Chirapa | 26 (2-13) | 97 (26-37) | 123 | 5 (0-5) | 45 (5-22) | 50 | 173 |
| Burns | 2 (0-1) | 67 (20-24) | 69 | 74 (12-31) | 17 (0-15) | 91 | 160 |
| Swelling | 118 (18-53) | 2 (0-2) | 120 | 23 (3-11) | 8 (0-5) | 31 | 151 |
| Itil | - | 12 (0-8) | 12 | 62 (14-25) | 49 (2-32) | 111 | 123 |
| Acne | 1 (0-1) | 15 (1-12) | 16 | 11 (1-5) | 11 (0-10) | 22 | 38 |
| Feet fungus | 1 (0-1) | 8 (0-6) | 9 | 20 (3-11) | 2 (0-1) | 22 | 31 |
| Liver spots | 6 (1-4) | 1 (0-1) | 7 | 1 (0-1) | 2 (0-2) | 3 | 10 |
| Wrinkles | - | - | - | 1 (0-1) | - | 1 | 1 |
| **Respiratory system** | **654 (196-260)** | **178 (48-71)** | **832** | **148 (40-63)** | **110 (25-49)** | **258** | **1090** |
| Cold | 262 (64-111) | 46 (10-20) | 308 | 28 (5-15) | 36 (6-17) | 64 | 372 |
| Flu | 93 (25-40) | 89 (23-40) | 182 | 86 (24-32) | 51 (8-25) | 137 | 319 |
| Cough | 196 (58-75 | 15 (2-7) | 211 | 15 (4-6) | 18 (1-11) | 33 | 244 |
| Tonsillitis | 50 (14-20) | 1 (0-1) | 51 | 8 (1-6) | 2 (0-2) | 10 | 61 |
| Bronchitis | 34 (4-16) | 5 (0-4) | 39 | 4 (0-4) | 2 (0-2) | 6 | 45 |
| Expectorant | 7 (1-4) | 10 (2-6) | 17 | 5 (1-2) | - | 5 | 22 |
| Sinusitis | 3 (0-2) | 10 (2-5) | 13 | - | - | - | 13 |
| Asthma | 9 (1-7) | - | 9 | 1 (0-1) | 1 (0-1) | 2 | 11 |
| Bad breath | - | 1 (0-1) | 1 | 1 (0-1) | - | 1 | 2 |
| Aphonia | - | 1 (0-1) | 1 | - | - | - | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **General ailments with unspecific symptoms** | **535 (168-184)** | **248 (76-90)** | **783** | **172 (31-93)** | **111 (21-63)** | **283** | **1066** |
| Fever | 300 (91-108) | 196 (58-75) | 496 | 141 (25-70) | 88 (14-54) | 229 | 725 |
| Headache | 180 (54-67) | 23 (4-11) | 203 | 6 (1-4) | 6 (0-4) | 12 | 215 |
| General malaise | 19 (0-19) | 22 (4-12) | 41 | 20 (0-19) | 12 (0-9) | 32 | 73 |
| Energizing | 36 (9-14) | 7 (2-3) | 43 | 5 (1-3) | 5 (1-2) | 10 | 53 |
| **Pregnancy, birth and puerperium** | **160 (32-71)** | **346 (106-123)** | **506** | **231 (51-91)** | **170 (6-87)** | **401** | **907** |
| Birth | 73 (17-31) | 116 (32-44) | 189 | 85 (20-37) | 54 (4-28) | 139 | 328 |
| Breastfeeding | 53 (8-27) | 107 (33-38) | 160 | 63 (10-27) | 61 (2-42) | 124 | 284 |
| Postpartum | 23 (3-13) | 95 (22-39) | 118 | 72 (17-31) | 53 (0-30) | 125 | 243 |
| Abortive | 11 (1-6) | 28 (4-13) | 39 | 11 (3-4) | 2 (0-2) | 13 | 52 |
| **Nervous system and mental health** | **372 (115-131)** | **222 (59-92)** | **594** | **154 (44-63)** | **107 (14-66)** | **261** | **855** |
| Insomnia | 158 (45-58) | 73 (16-30) | 231 | 55 (5-27) | 29 (3-21) | 84 | 315 |
| Sadness | 106 (32-37) | 86 (20-34) | 192 | 31 (6-14) | 45 (4-27) | 76 | 268 |
| Stress | 93 (29-34) | 50 (8-23) | 143 | 49 (5-22) | 32 (6-18) | 81 | 224 |
| Mental stimulant | 15 (4-6) | 7 (1-4) | 22 | 11 (0-9) | 1 (0-1) | 12 | 34 |
| Epilepsy | - | 6 (1-3) | 6 | 8 (0-4) | - | 8 | 14 |
| **Infections and infestations** | **129 (34-48)** | **300 (81-123)** | **429** | **237 (52-103)** | **79 (7-52)** | **316** | **745** |
| Intestinal parasites | 116 (32-43) | 73 (21-27) | 189 | 94 (12-47) | 44 (1-28) | 138 | 327 |
| Chickenpox | - | 82 (18-42) | 82 | 40 (8-19) | 2 (0-1) | 42 | 124 |
| Fleas | - | 54 (12-23) | 54 | 20 (1-14) | 20 (0-18) | 40 | 94 |
| UTA, leishmaniasis | 4 (0-3) | 14 (1-9) | 18 | 40 (6-20) | 2 (0-1) | 42 | 60 |
| Malaria | 1 (0-1) | 38 (4-20) | 39 | 6 (0-5) | 1 (0-1) | 7 | 46 |
| Insect bite | - | 15 (3-8) | 15 | 13 (2-8) | 5 (0-4) | 18 | 33 |
| Tick bite | 1 (0-1) | 14 (3-6) | 15 | 18 (1-13) | - | 18 | 33 |
| Yellow fever | 7 (1-4) | 5 (0-3) | 12 | 4 (0-4) | 1 (0-1) | 5 | 17 |
| Lice | - | 2 (0-2) | 2 | 1 (0-1) | 1 (0-1) | 2 | 4 |
| Herpes | - | - | - | - | 3 (0-3) | 3 | 3 |
| Smallpox | - | 3 (0-3) | 3 | - | - | - | 3 |
| Tuberculosis | - | - | - | 1 (0-1) | - | 1 | 1 |
| **Reproductive system and reproductive health** | **117 (30-46)** | **272 (60-121)** | **389** | **144 (41-61)** | **93 (13-47)** | **237** | **626** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Menstruation disorders | 101 (26-38) | 177 (35-97) | 278 | 105 (31-43) | 85 (11-42) | 190 | 468 |
| Menopause | - | 36 (7-16) | 36 | 20 (5-12) | 1 (0-1) | 21 | 57 |
| Fertility | - | 26 (4-15) | 26 | 7 (1-4) | 6 (0-5) | 13 | 39 |
| Impotence | - | 21 (4-13) | 21 | 2 (0-1) | 1 (0-1) | 3 | 24 |
| Vaginal infection | 16 (3-9) | 3 (0-3) | 19 | 4 (0-4) | - | 4 | 23 |
| Contraceptive | - | 6 (1-3) | 6 | 5 (0-5) | - | 5 | 11 |
| Aphrodisiac | - | 3 (0-3) | 3 | - | - | - | 3 |
| Sexual infections | - | - | - | 1 (0-1) | - | 1 | 1 |
| **Muscular-skeletal system** | **197 (36-88)** | **188 (53-80)** | **385** | **161 (45-59)** | **72 (19-33)** | **233** | **618** |
| Broken bones | 80 (20-36) | 89 (23-41) | 169 | 62 (16-27) | 43 (5-27) | 105 | 274 |
| Rheumatism | 86 (11-38) | 82 (25-32) | 168 | 63 (18-24) | 23 (7-10) | 86 | 254 |
| Joint sprains | 13 (2-9) | 6 (1-4) | 19 | 11 (3-4) | 1 (0-1) | 12 | 31 |
| Bones hardening | 11 (1-7) | 1 (0-1) | 12 | 13 (0-12) | - | 13 | 25 |
| Hernia | 1 (0-1) | 10 (1-6) | 11 | 12 (1-9) | - | 12 | 23 |
| Muscle cramps | 6 (2-2) | - | 6 | - | - | - | 6 |
| Lumbago | - | - | - | - | 5 (0-5) | 5 | 5 |
| **Sensory system** | **174 (56-61)** | **193 (57-74)** | **367** | **116 (15-53)** | **82 (1-59)** | **198** | **565** |
| Visual disorders | 154 (50-52) | 118 (35-44) | 272 | 64 (7-29) | 38 (0-27) | 102 | 374 |
| Hearing disorders | 20 (5-9) | 75 (22-30) | 95 | 52 (8-25) | 44 (1-32) | 96 | 191 |
| **Blood and cardio-vascular system** | **19 (6-7)** | **135 (37-52)** | **154** | **114 (19-53)** | **65 (5-39)** | **179** | **333** |
| High pressure | 10 (1-7) | 35 (7-20) | 45 | 45 (2-24) | 29 (2-16) | 74 | 119 |
| Anemia | 1 (0-1) | 55 (16-21) | 56 | 30 (2-15) | 17 (1-14) | 47 | 103 |
| Low pressure | - | 22 (7-8) | 22 | 15 (3-11) | 10 (0-5) | 25 | 47 |
| Hemorrhoids | 2 (0-1) | 10 (1-6) | 12 | 16 (3-9) | 6 (1-4) | 22 | 34 |
| Blood infection | 3 (0-3) | 6 (0-6) | 9 | 6 (1-3) | - | 6 | 15 |
| Varicose veins | - | 7 (0-4) | 7 | 2 (0-2) | 3 (0-2) | 5 | 12 |
| Blood purifying | 3 (0-3) | - | 3 | - | - | - | 3 |
| **Dental health** | **12 (2-7)** | **87 (20-36)** | **99** | **58 (9-27)** | **43 (0-22)** | **101** | **200** |
| Toothache | 1 (0-1) | 87 (20-36) | 88 | 57 (8-27) | 43 (0-22) | 100 | 188 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cavity | 8 (0-5) | - | 8 | 1 (0-1) | - | 1 | 9 |
| Gingivitis | 2 (0-2) | - | 2 | - | - | - | 2 |
| Oral sores | 1 (0-1) | - | 1 | - | - | - | 1 |
| **Metabolic system and nutrition** | **22 (1-15)** | **56 (7-31)** | **78** | **54 (16-20)** | **48 (7-30)** | **102** | **180** |
| Weight loss | 11 (0-7) | 56 (7-31) | 67 | 49 (13-20) | 48 (7-30) | 97 | 164 |
| Whet | 11 (1-8) | - | 11 | 5 (0-5) | - | 5 | 16 |
| **Ritual and magic uses** | **43 (10-17)** | **2 (0-2)** | **45** | **50 (6-23)** | **9 (0-8)** | **59** | **104** |
| Remove envy | 30 (8-13) | 2 (0-2) | 32 | 2 (0-1) | 8 (0-8) | 10 | 42 |
| Curse | 3 (0-3) | - | 3 | 26 (5-11) | 0 (0-0) | 26 | 29 |
| Bring good luck | - | - | 0 | 22 (0-11) | 1 (0-1) | 23 | 23 |
| Witchcraft | 9 (0-9) | - | 9 | 0 (0-0) | 0 (0-0) | 0 | 9 |
| Hallucinogen | 1 (0-1) | - | 1 | 0 (0-0) | 0 (0-0) | 0 | 1 |
| **Endocrine system** | **4 (0-2)** | **28 (5-16)** | **32** | **29 (4-16)** | **5 (1-3)** | **34** | **66** |
| Diabetes | 4 (0-2) | 28 (5-16) | 32 | 28 (3-16) | 5 (1-3) | 33 | 65 |
| Goiter | - | - | - | 1 (0-1) | 0 (0-0) | 1 | 1 |
| **Other uses** | **63 (16-25** | **59 (17-23)** | **122** | **61 (10-28)** | **34 (3-28)** | **95** | **217** |
| Hair loss | 48 (12-21) | 32 (8-13) | 80 | 35 (6-18) | 9 (0-8) | 44 | 124 |
| Cancer | 7 (1-4) | 21 (4-11) | 28 | 25 (3-12) | 24 (2-19) | 49 | 77 |
| Hangover | 2 (0-2) | 6 (0-5) | 8 | 1 (0-1) | 1 (0-1) | 2 | 10 |
| Deodorant | 3 (0-3) | - | 3 | - | - | - | 3 |
| Altitude sickness | 2 (0-2) | - | 2 | - | - | - | 2 |
| Anesthesia | 1 (0-1) | - | 1 | - | - | - | 1 |