The applicability of similarity indices in an ethnobotanical study of medicinal plants from three localities of the Yunga district, Moquegua region, Peru

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Research

Abstract

Background: From ethnobotanical research carried out in the southern region of Peru, the need for further investigation is evident, especially in Moquegua; given this, an ethnobotanical exploration is presented that includes a validation of medicinal plants through the reports of three focus groups and the analysis of similarity or concordance of medicinal species from three nearby localities in the district of Yunga, Moquegua, using two coefficients already known and one new in ethnobotany.

Methods: Medicinal plants were collected with the help of experts, which were shown to three separate focus groups (Exchaje, La Pampilla and Yunga), whose composition was representative and decided by local authorities, who established the medicinal quality of the collected plants. For agreement analysis, two similarity coefficients were used, Jaccard (Cj) and Sørensen (Cs), and the use of the Cohen kappa Index (CKI) and Fleiss (FKI) is incorporated and proposed, for which purpose the validation of medicinal species was written in binary; statistical analysis was done using Stata 15 software.

Results: Of 61 species of plant collected from experts, 36 were validated as medicinal by the focus groups, naming a total of 127 use reports. The Asteraceae are the most abundant with 18 species, followed by Lamiaceae with

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three, among others. The medicinal bush yareta (*Azorella compacta,* Apiaceae) had 11 reports of use. The predominant habit of validated medicinal species was shrub (47.2%). The so-called warm plants were the most abundant (58%) compared to the cold and temperate ones. Digestive system disorders are the category with the most reports (27). La Pampilla and Yunga presented the highest values of similarity (Cj=0.61; Cs=0.76; CKI =0.6) and the FKI showed a concordance value of 53% for the three localities.

Conclusions: Traditional knowledge about medicinal plants still exists in Yunga, Moquegua. This is evidenced through the use of medicinal species identified by experts. Interesting ancestral concepts are observed around the quality of plants, about their thermal properties, such as hot, cold and temperate plants; with Digestive System Disorders being those most frequently reported. The Kappa Index is a suitable tool to show the level of agreement between localities, whose values, compared through a scale, allow greater objectivity in the analysis, in comparison with the Jaccard and Sorensen coefficients. The concordances between the evaluated localities becomes almost perfect (values closer to one) when they are influenced by factors such as their proximity, and social and cultural interrelation.

Keywords: Agreement, ethnobotany, Jaccard, kappa, medicinal plants, similarity, Sørensen, traditional medicine, Yunga, Moquegua.

Resumen

Introducción: De las investigaciones etnobotánicas realizadas en la región sur del Perú, se evidencia la necesidad de mayor investigación, especialmente en Moquegua; ante esto, se presenta una exploración etnobotánica que incluye una validación de plantas medicinales a través de los reportes de tres grupos focales y el análisis de similitud o concordancia de especies medicinales de tres localidades cercanas en el distrito de Yunga, Moquegua, utilizando dos coeficientes ya conocidos y uno novedoso en etnobotánica.

Métodos: Se procedió a colectar plantas medicinales con ayuda de expertos, las cuales fueron mostradas a tres grupos focales por separado (Exchaje, La Pampilla and Yunga), cuya conformación fue representativa y estuvo a cargo de las autoridades locales, quienes establecieron la calidad de medicinal de las plantas colectadas. Para el análisis de similitud se emplearon dos coeficientes de similitud, de Jaccard (Cj) y de Sørensen (Cs) y se incorpora y propone el uso del Índice kappa de Cohen (IKC) y Fleiss (IKF), para cuyo fin se procedió a escribir en binario la validación de especies medicinales; el análisis estadístico fue hecho utilizando el software Stata 15.

Resultados: De 61 plantas colectadas con expertos, 36 fueron validadas como medicinales por los grupos focales, nombrándose un total de 127 reportes de uso. Las Asteraceae son las más abundantes con 18 especies, seguida de Lamiaceae con tres, entre otras. El arbusto medicinal yareta (*Azorella compacta,* Apiaceae) presentó 11 reportes de uso y los géneros *Baccharis*, *Caiophora* y *Senecio* fueron los más representados. El hábito predominante fue el arbustivo (47.2%) frente a las hierbas y sub arbustos. Las plantas denominadas cálidas fueron las más abundantes (58%) en comparación a las frías y templadas. Los Trastornos del Sistema Digestivo es la categoría con más reportes (27). La Pampilla y Yunga presentaron los valores más altos de similitud (Cj=0.61; Cs=0.76; IKC=0.6) y el IKF mostró un valor de concordancia de 53% para las tres localidades.

Conclusiones: El conocimiento tradicional sobre las plantas medicinales está vigente en Yunga, Moquegua. Esto se evidencia a través del uso de especies medicinales identificadas por expertos. Se observan interesantes concepciones ancestrales en torno a la calidad de las plantas, sobre sus propiedades térmicas, como plantas calientes, frías y templadas; siendo los Trastornos del Sistema Digestivo los más frecuentemente reportados. El Índice Kappa es una herramienta adecuada para mostrar el nivel de concordancia entre localidades, cuyos valores, comparados a través de una escala, permiten una mayor objetividad en el análisis, en comparación con los coeficientes de Jaccard y Sørensen. Las concordancias entre las localidades evaluadas se vuelven casi perfectas (valores más cercanos a uno) cuando están influenciadas por factores como su proximidad e interrelación social y cultural.

Palabras clave: Concordancia, etnobotánica, Jaccard, kappa, medicina tradicional, plantas medicinales, similitud, Sørensen, Yunga, Moquegua.

Background

Traditional Medicine brings together knowledge and health practices that protect the integral well-being of the person, for which plant, animal and mineral resources are used, these are managed through a special therapeutic repertoire treatment, both by healers (individuals who enjoy community recognition to exercise the practice and who can diversify into various specialties) and by members of households, who are part of an interesting traditional family health system.

Roersch (1994), conducted a study of medicinal plants in the southern Andean zone of Peru, and mentions that traditional knowledge has been transmitted from generation to generation, in oral and written form; the same author mentions that the process of loss of information about traditional uses is relentless, in the face of the alienation of some communities, and in the face of the death, whether cultural or physical, of many connoisseurs and wise men of traditional medicine. Given this, the work of the ethnobotanist gains strength, facing the challenge of revaluing and rescuing traditional knowledge associated, the results of which, as in the present study, have been returned to the participating localities.

In a publication made in 2006 about a number of ethnobotanical studies that were reported for different regions of the Andean zone of Peru, it was observed that in Cuzco, Ayacucho and Arequipa 63 studies were generated for the southern zone, in Ancash and Lima 37 studies for the central zone and, in Lambayeque, Cajamarca and La Libertad 48 studies for the north zone (La Torre & Albán 2006). On the other hand, there is little ethnobotanical information, and especially on medicinal plants, both from the Moquegua region, and specifically from the Yunga district (Montesinos-Tubée 2011a, 2013) and nearby regions (Reynel 1988, Cáceda & Rossel 1993, Roersch 1994); these studies show that the Asteraceae family is the one that more species reports, followed by Fabaceae, Solanaceae, Lamiaceae, among others.

Medicinal plants, as explained by Roersch (1994) based on the context of the southern Andean culture, have the quality of being hot, cold (fresh) or temperate, this classification being important when treating diseases or ailments; a disease caused by cold will be combated by a hot plant and vice versa. He mentions that temperate plants do not harm the body, since our body is temperate, and can make use of these to soften both a hot plant and a fresh one. In his study, he reported that hot plants prevail (187 species), followed by fresh ones (112) and then temperate ones (36); 106 remained without denomination.

Some studies address this issue, highlighting the existing duality in traditional health systems in America, mentioning that this worldview is particular to this side of the world, without Spanish contributions or interference (Colson & De Armellada 1983). For Peru, similar applications are reported in the use of medicinal plants on the coast and northern highlands; for example, one article highlights the use of hot and cold medicinal species, mentioning that the latter are more beneficial to health, and could be potential candidates for the treatment of COVID-19 (Mostacero *et al.* 2020). An investigation carried out in Tabasco, Mexico, proposes the existence of hot and cold plants, but adds that medicinal plants with both characteristics are also found simultaneously (Álvarez *et al.* 2017).

Ethnobotanical data quality is a priority for a good analysis of the information. To guarantee this, it must be taken into account, from the language spoken by the community where the studies are carried out, the instrument for data collection, and the empathy and respect that must arise between researchers and informants. Kvist *et al.* (2001) in a study about medicinal plants in the Peruvian Amazon, detail eight methods for collecting ethnobotanical information; the first was called "qualitative ethno-botanical study" and report that the method does not perform evaluations of the value or relative importance of the different medicinal plants; as an example, they report that in a collection carried out in 1993, and with the help of one informant, 120 medicinal plants and 210 uses were recorded. In this study, the other seven methods also contemplate interviews and registration of uses, although categorization processes are added, which is why they are called quantitative.

Hoffman & Gallaher (2007) when explaining the use of quantitative methodology for the calculation of Relative Cultural Importance Indices, highlight the value of mastering basic ethnographic methods for collecting information, in addition to knowing statistical tools, ranging from the calculation of samples to statistical analysis. Due to the above, we emphasize that, for the application of a specific statistical test, it must first be determined if the variables of our study are of a qualitative or quantitative type, and for the first case, it would be appropriate to carry out a categorization that allows the statistical analysis to be selected for the present study.

The categorization of qualitative information allows, in addition to grouping and comparing data, a more efficient management of information, however, special attention is required on what categories are used, these being conceived from the approaches of researchers or elaborated from the information provided by the informants themselves (Hoffman & Gallaher 2007). Cook (1995), proposes 13 levels to categorize useful plants; level 11 is called "medicines" and consists, in turn, of 24 categories. Gruca *et al.* (2014), report the validity of Cook's work, mentioning the acceptance of this publication by some researchers; however, when trying to classify some medicinal uses of rural or indigenous communities, they found that the categories proposed by Cook were insufficient, mainly because there are no equivalences between some practices or activities related to the health of indigenous peoples with those of western or academic medicine; given this, they propose the addition of two more categories to Cook's level 11: Cultural Diseases and Disorders, and Ritual/Magical Uses.

Measurement is a *sine qua non* condition in research activities, which can be cited from relatively simple actions to more complex ones, and which ultimately guarantees the quality of the information generated, so it is important to know and correctly apply the indices used in the calculation (Abraira 2000); in this regard, agreement is the extent to which two or more analysts agree with each other; we understand it as the proportion of agreements between the total number of encoders (Torres & Perera 2009). As for the measurement instrument, it must be precise and avoid failures that can be attributed to it, which are referred to validity and precision; regarding the first, it is about being sure that the instrument is measuring what it should measure, in this case, establishing if a plant is medicinal. Given this, a focus group of local experts, duly convened, knowledgeable about the medicinal flora of their localities, can issue a verdict, that is, they are able to express whether a plant is medicinal or not, as indicated by a representative sample of informants. Regarding precision, it not only consists of answering yes or no to the question, is this a medicinal plant?, but also the report of the medicinal use of the plant under observation by the measuring instrument (Abraira 2000). In this context, various questions and understandings are generated based on this research.

How much do the opinions of two or more observers, who judge the same event, agree or coincide? Or, how much agreement is there between two or more lists or reports on the same fact, such as lists of medicinal plants from two or more locations, near or far, or about species sold in different markets, or plants used by patients in health institutions? Some ethnobotanical studies have used the Jaccard or Sørensen Coefficients in their research to compare relationships between market reports, for example, and analyze how similar they are; the same to find out the agreement or similarity between useful plants of localities, whether they are near or far (Castañeda 2019, Ghorbani *et al.* 2012, Jiménez *et al.* 2019, Luján & Martínez 2017); however, it is noted that these coefficients do not filter out coincidences that occur by chance.

Faced with this, the use of the Cohen and Fleiss kappa index is proposed, which does filter coincidences attributable to chance, and allows confirming or complementing the aforementioned coefficients (Abraira 2000, Cerda & Villarroel 2008, Landis & Koch 1977). On the other hand, how subjective could a researcher's opinion be when analyzing similarity results? To avoid results or conclusions that refer to particular terms such as low, high, and that cannot be compared, the use of a scale or value scale is proposed, that allows readers to better understand the conclusions and, at the same time, a more objective evaluation and comparable results (Landis & Koch 1977).
The present study seeks to understand and publicize the state of knowledge of medicinal flora and report on their use in the Yunga district, Moquegua region, Peru; likewise, carry out the analysis of the similarity, concordance or agreement, considering that the nearby towns and/or with common history, should present greater similarity in the use of medicinal plants, decreasing with geographical distance or another factor. It also proposes the use of the Cohen and Fleiss Kappa indices as useful tools to carry out the concordance analysis between the values reported by the inhabitants of the Yunga, Exchaje and La Pampilla communities, testing its validity for ethnobotanical research.

Material and Methods

Study area

The district of Yunga belongs to the province of General Sánchez Cerro, located in the department of Moquegua, Peru. The district presents altitudes from 3,500 to 5,000 meters above sea level. The climate is temperate dry with an average temperature of: 22 °C high, -1 °C low; the rainy season runs from January to April, and for the period September 2021 to August 2022, 207 mm of rainfall was recorded (Eurochron portable station, Yunga: https://www.wunderground.com/dashboard/pws/IYUNGA1).

The vegetation components that include the species evaluated of the study area form part of the prepuna, puna and superpuna phytosociological units described for Yunga district represented by *Echinopsio schoenii-Proustietea cuneifoliae* Montesinos, Cleef & Sýkora 2012 which is rich is endemisms (Montesinos-Tubée *et al.* 2012) as well as in *Argyrochosmo niveae-Neowerdermannion peruvianae* Montesinos, Cleef & Sýkora 2015, *Hypochaerido mucidae-Loricarion graveolentis* Montesinos, Cleef & Sýkora 2015 and *Parastrephietalia lepidophyllae* Navarro 1993 (Montesinos-Tubée *et al.* 2015) distributed among puna grasslands and rock crevices, and finally in *Calamagrostio trichophyllae-Azorelletum compactae* Montesinos, Cleef & Sýkora 2021 and *Nototrichietosum erinaceae* Montesinos, Cleef & Sýkora 2021 (Montesinos-Tubée *et al.* 2021) from subnival puna environments.

The Yunga district consists of three populated centers (Exchaje, La Pampilla and Yunga) and three small towns (Aquina, Arapa and Lojeta). In the town of Yunga there is the district municipality; the district health facility, which is type I-3 (with the presence of doctors and various health professionals); as well as an educational institution that includes the initial, primary and high school levels. The three most populous localities, Yunga, La Pampilla y Exchaje, participated in the study. (Figure 1).

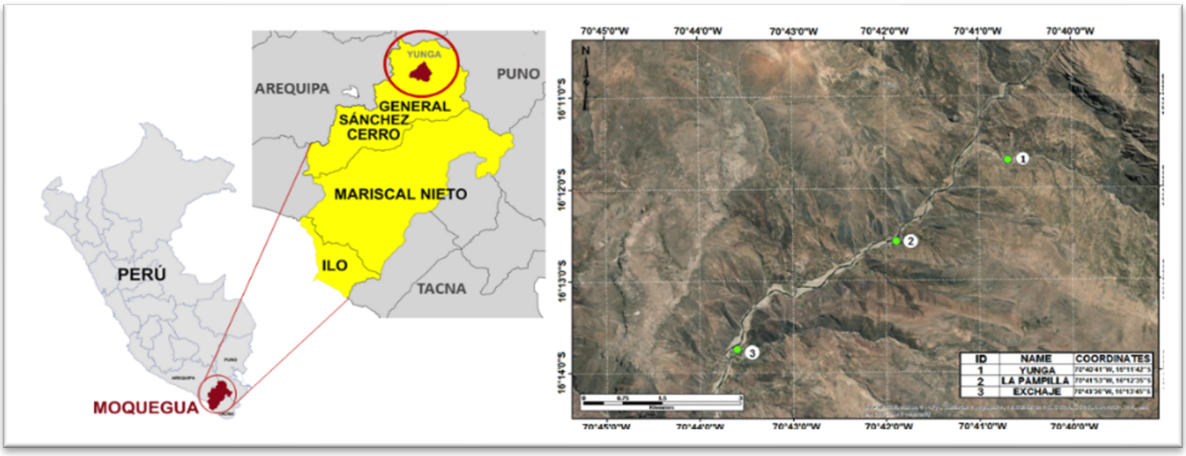

Figure 1. Location of the study area; own elaboration.

Population and participants selection (INEI 2018)

The population of the Yunga district is made up of 864 inhabitants, comprising 436 men and 428 women. The inhabitants, mostly, are dedicated to agriculture (corn, beans, potatoes, garlic, fruit trees, among others) and livestock (camelids, sheep, cattle, small animals, among others).

Most of the attendees to the focus groups were over 45 years old and were selected by the local authorities: mayor, aldermen and community presidents of each of the participating localities, based on their community experiences. The selection criteria of the chosen participants were that they be knowledgeable about the medicinal plants of the place, adults (over 18 years of age), and with an equitable distribution between men and women.

Ethnobotanical collecting with experts and focus groups

Before carrying out the field work, the participating localities were asked for Prior Informed Consent (PIC) to carry out the investigation, according to instructions from the National Forestry and Wildlife Service (SERFOR) of the Republic of Peru. Medicinal plants (61) were collected with the help of three to five experts, who, following their criteria, were in charge of establishing which plants were medicinal (information that emerges from the first stage of work of the innovation project to implement a seed bank, year 2019). As a result of this field work, an initial or baseline list of likely/candidate medicinal plants was drawn up. This same list was shown, through images on slides projected with a multimedia and using a portable herbarium, to three focus groups each made up of 12 to 15 residents of: Exchaje, La Pampilla and Yunga, with an equitable distribution between men and women; during the meetings, Quechua (predominant language among women) and Spanish were used. These participants were in charge of validating the medicinal quality of the plants shown, through the report of the traditional medicinal uses they made, by consensus of the entire focus group. During the dialogue process that was established, no limits were placed on the information that could be provided, as long as it is related to the medicinal use of plants. Four questions were fundamentally those that were made: is this a medicinal plant? What is the name of the plant? What diseases or illnesses is it used for? How is it used? Then, we proceeded to categorize, in an Excel table, the opinions expressed about the nature of the plants of the basal list (field work), in terms of whether they are medicinal or not. A 0 (zero) was recorded if the plant was not considered medicinal and 1 (one) if it was considered medicinal.

Identification and deposit of specimens
Specimens were identified using specialized literature on the flora of the area (Montesinos 2011b, 2013), reviewing online herbaria (http://apps.kew.org/herbcat/navigator.do ; https://plantidtools.fieldmuseum.org/es/rrc/5581 and https://www.tropicos.org/home) and the opinion of experts in studies of the flora of southern Peru.

The field collected samples were prepared and deposited in the herbarium of the Universidad Nacional Mayor de San Marcos (USM) by deposit certificate N° 002-2021-USM-MHN and 003-2021-USM-MHN. Duplicates were also sent to the Kew Herbarium (K) and Herbarium of Medicinal Plants of the National Institute of Health (HINS). The specimens' codes are shown in the results (Table 2).

Similarity coefficients
For the assessment of the similarity or overlapping of species between the three localities under study, the Jaccard Similarity Coefficient (Cj) and the Sørensen Similarity Coefficient (Cs) were used. The similarity indices or coefficients are used to find out if there are common species in two evaluated areas, or how similar they are in their composition. In this sense, the Cj and Cs stand out in the evaluation of similarity using binary data, whose results can help, for example, in the estimation of conservation areas (Real R & Vargas J 1996). The calculation of Indices or Coefficients of Similarity allow us to reduce the relationship between two communities, populations, lists, etc, to a numerical value (Matteucci & Colma 1982). The use of these coefficients can be seen in some national and global ethnobotanical evaluations. The results of the evaluation with both coefficients range between zero and one (Castañeda 2019, Ghorbani *et al.* 2012, Hoft *et al.* 1999, Jiménez *et al.* 2019, Luján & Martínez 2017, Moreno 2001).

Jaccard similarity coefficient

$$\boldsymbol{Cj = \frac{c}{a + b + c}}$$

Sørensen similarity coefficient

$$\boldsymbol{Cs = \frac{2c}{a + b + 2c}}$$

where:

a = number of species present only at site A
b = number of species present only at site B
c = number of species present at both sites A and B.

To analyze the agreement between the data from the three localities, the Cohen's Kappa Index was used for pairings of two, and the Fleiss' Kappa Index, for three, in addition to establishing comparisons of the indices found with the similarity coefficients of Jaccard and Sørensen. For the execution of the Kappa Index (by Cohen and Fleiss), Stata 15 software was used. To establish the strength of concordance or agreement between the values found, a scale was used, initially proposed to analyze epidemiological information and establish the analysis of ranges of similarity. Table 1 (Landis & Koch 1977):

Table 1. Mean of the Kappa Index value.

Kappa Index Value	Strength of Agreement
<0.00	Poor
0.00-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Almost perfect

Results

Collection with experts (Field work)

With the help of experts, botanists and the community, 61 plant species were collected, which correspond, in quantity, to the families Asteraceae, Caprifoliaceae, Caryophyllaceae, Lamiaceae, among others; and 49 botanical genera, being the ones with the most species *Senecio*, *Valeriana*, *Baccharis*, *Caiophora*, *Mutisia*, *Paronychia*, *Phacelia*, among others.

Focus groups

The three focus groups reported 36 species as medicinal and 127 traditional health uses; *Azorella compacta* (Apiaceae), called yareta, presented 11 reports and was mentioned as medicinal in the three localities; species with more medicinal reports are show in Figure 2.

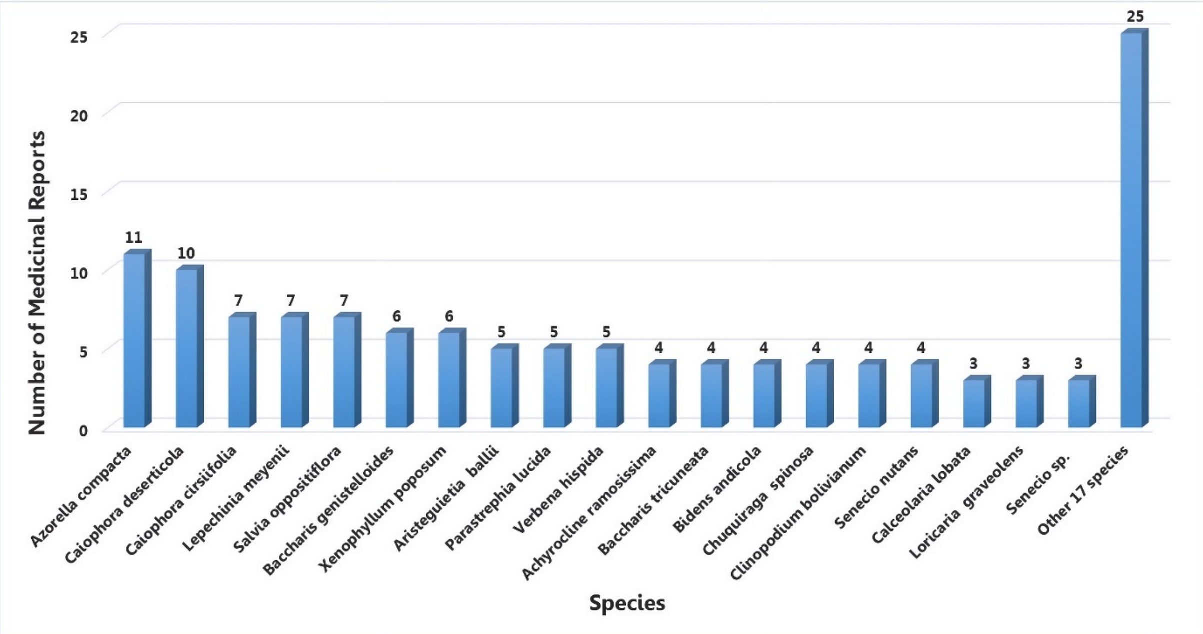

Figure 2. Number of Medicinal Reports for Species. Focus groups.

The Asteraceae family included 18 medicinal species, followed by Lamiaceae with three medicinal species, Loasaceae with two, among others. Of a total of 32 genera, the most represented were *Baccharis*, (Asteraceae) *Caiophora* (Loasaceae) and *Senecio* (Asteraceae). Shrubs had 17 representatives, followed by herbs with 14 species and sub-shrubs with five species. Images of six species named in the three localities as medicinal are shown in Figure 3.

From the categorization of the traditional medicinal uses mentioned during the focus groups, following the proposal of Cook (1995) and Gruca *et al.* (2014), 127 reports were registered. The Digestive System Disorders category obtained the highest number of use reports, followed by Respiratory System Disorders, Genitourinary System Disorders, Muscular-Skeletal System Disorders, Cultural Diseases and Disorders, among others (Figure 4).

Regarding its quality: 21 plants were Hot (more than a half), six are Cold (Fresh) and nine Temperate. Asteraceae family, the most in species, had a majority hot plants (Figure 5).

About the state of conservation, eight medicinal plants presented some type of categorization about their conservation status: three Endemics, three Vulnerable and two Near Threatened. The full list of Botanical Families, Scientific Names, Common Names, Deposit Codes in Herbaria, Habit, Medicinal Categories, Quality of the plants, and State of Conservation is shown at Table 2.

Figure 3. Medicinal plants of Yunga district. A: *Azorella compacta*, "yareta"; B: *Senecio nutans*, "chachacoma"; C: *Caiophora cirsiifolia*, "ortiga colorada"; D: *Baccharis genistelloides*, "kimsacuchu"; E: *Xenophyllum poposum*, "pora pora"; F: *Aristeguietia ballii*, "wiraqjalo". Photos: Jorge Cabrera.

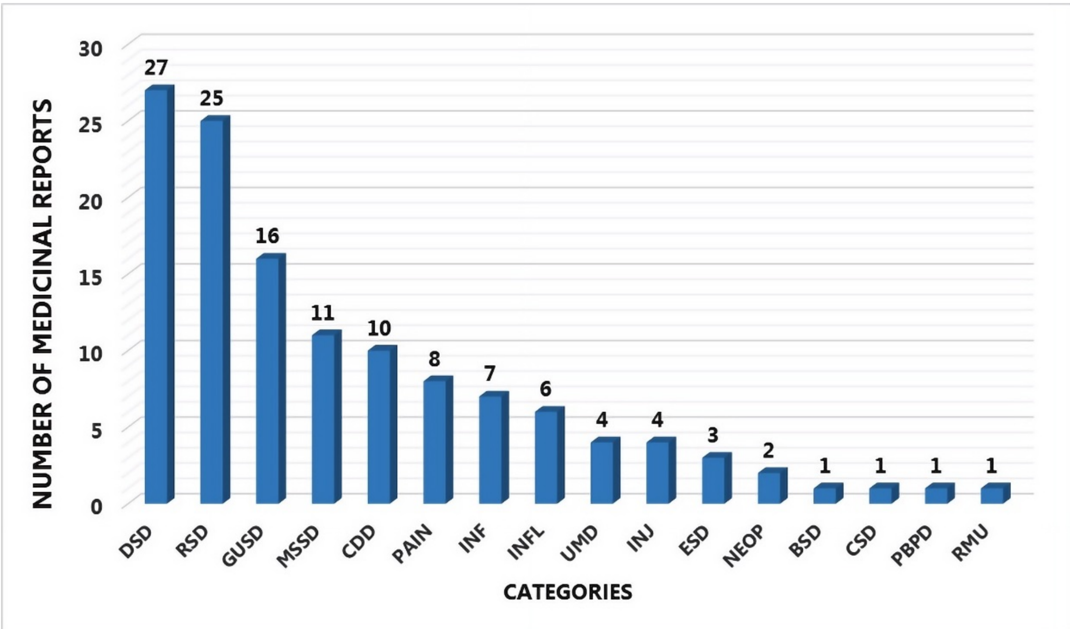

Figure 4. Number of Medicinal categories reported in the focus groups. DSD: Digestive System Disorders; RSD: Respiratory System Disorders; GUSD: Genitourinary System Disorders; MSSD: Muscular-Skeletal System Disorders; CDD: Cultural Diseases and Disorders; PAIN: Pain; INF: lnfections/Infestations; INFL: Inflammation; UMD: Unspecified Medicinal Disorders; INJ: Injuries; ESD: Endocrine System Disorders; NEOP: Neoplasms; BSD: Blood System Disorders; CSD: Circulatory System Disorders; PBPD: Pregnancy/Birth/Puerperium Disorders; RMU: Ritual/Magical Uses.

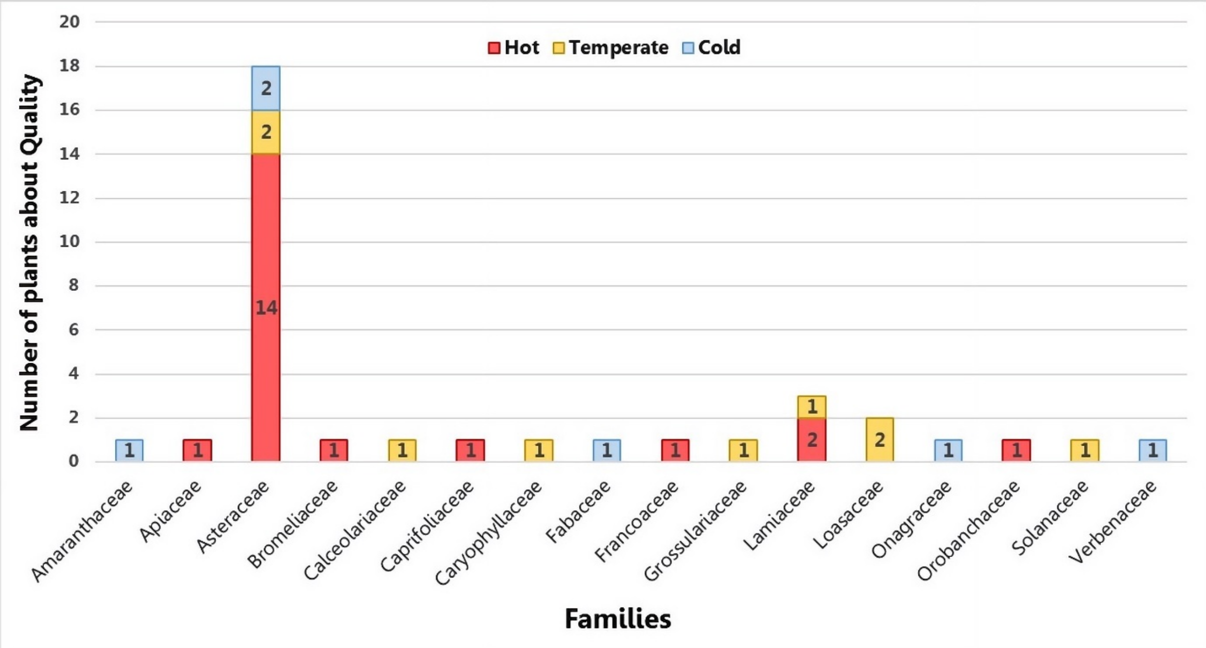

Figure 5. Quality of medicinal plants by Families. Focus groups.

Calculation of Similarity and Agreement Indices

Jaccard's Similarity Coefficient (Cj) and Sørensen's Similarity Coefficient (Cs)

The values of the indices are shown in Table 3, as well as the values of exclusive and coincident plants, which were used for the calculation.

Cohen's and Fleiss' Kappa Index

To analyze the agreement with the Cohen and Fleiss Kappa index, the three lists of each focus group were written in binary, one (1) corresponding to the presence of the characteristic and zero (0) to its absence. The results of the comparisons between localities are shown in the Table 3. The p-value obtained in all cases, is less than 0.05, this indicates that there is statistically significant agreement. The strength of the correspondence is Moderate (Table 3).

Table 2. Medicinal plants reported in the three focus groups.

Family	Species	Common Name			Deposit Code in Herbaria: K, USM & HINS	Habit	Medicinal Categories			Quality	State of conservation	
		LP	EX	YU			LP	EX	YU		Endemism (León 2006)	D.S. N° 043-2006-AG (Ministerrio de Agricultura 2006)
Amaranthaceae	*Chenopodium petiolare* Kunth	___	___	Kalachapi, liqcha	CENSI BS 03	H	___	___	DSD	C	___	___
Apiaceae	*Azorella compacta* Phil.	Yareta	Yareta	Yareta	CENSI BS 18	S	MSSD, DSD, RSD, INFL	DSD, ESD, PAIN, INJ	CSD, ESD, INF	H	___	Vulnerable (VU)
Asteraceae	*Achyrocline ramosissima* Britton	Wira wira	Wira wira	___	CENSI BS 09	Ss	RSD, INF	MSSD, INFL	___	H	___	___
Asteraceae	*Ageratina glechonophylla* (Less.) R.M.King & H.Rob.	___	Sunchari	___	CENSI BS 55	S	___	RSD	___	H	___	___
Asteraceae	*Aristeguietia ballii* (Oliv.) R.M.King & H.Rob.	Llinqui llinqui, wiraqjallo	Wiraqjalo, chaucala, llinqui llinqui	Wiraqjallo, wiswijalo	CENSI BS 32	S	INJ	MSSD, ESD, RSD	GUSD	H	Endemic (AR, LI). Near threatened (NT)	___
Asteraceae	*Baccharis genistelloides* (Lam.) Pers.	Kimsa chucu chucu,	Kimsa cucho	Kimsa cuchu	CENSI BS 26	S	UMD, GUSD, RSD, INF	GUSD	RSD	H	___	Near threatened (NT)
Asteraceae	*Baccharis tricuneata* (L.f.) Pers.	Papa tola	___	Papa tola	CENSI BS 57	S	MSSD	___	MSSD, RSD, INFL	H	___	___
Asteraceae	*Belloa piptolepis* (Wedd.) Cabrera	Ocje jorita	___	___	CENSI BS 19	H	CD	___	___	T	___	___
Asteraceae	*Bidens andicola* Kunth	Kiko	Chiriro, misico	Misico	CENSI BS 29	H	DSD	DSD	BSD, GUSD	C	___	___
Asteraceae	*Chersodoma jodopappa* (Sch.Bip.) Cabrera	Ocje tola	Q'ita cunucja	___	CENSI BS 23	S	RSD	RSD	___	H	___	___
Asteraceae	*Chuquiraga spinosa* Less.	Otor gallo	Huamanpinta, doctor gallo	Tutur Gallo	CENSI BS 33	S	GUSD	NEOP, GUSD	RSD	C	___	Near threatened (NT)
Asteraceae	*Diplostephium meyenii* Wedd.	___	Q'ita romero	___	CENSI BS 04	S	___	PAIN, RSD	___	H	___	___
Asteraceae	*Gochnatia arequipensis* Sandwith	Acjata	___	___	CENSI BS 61	S	DSD	___	___	H	___	___
Asteraceae	*Loricaria graveolens* (Sch.Bip.) Wedd.	Wallpa chaqui	___	Wallpa chaqui	CENSI BS 52	S	CD, MRU	___	CD	H	___	___

Asteraceae	*Ophryosporus heptanthus* (Sch.Bip. ex Wedd.) R.M.King & H.Rob.	Sunchari	___	Sunchari	CENSI 06	BS	S	CD	___	MSSD	H	___	___
Asteraceae	*Parastrephia lucida* (Meyen) Cabrera	Pia calla tola	Piacal tola	Piacatola	CENSI 44	BS	S	DSD, RSD, CD	DSD	INFE	H	___	___
Asteraceae	*Proustia cuneifolia* D.Don	Yara	___	___	CENSI 36	BS	S	PAIN	___	___	T	___	___
Asteraceae	*Senecio nutans* Sch.Bip.	Chachacoma	Chachacoma	Chachacoma	CENSI 58	BS	S	DSD	DSD	DSD	H	___	Vulnerable (VU)
Asteraceae	*Senecio sp.*	Pampajarilla	Pampa jarilla	Chucu chucu	CENSI 49	BS	ND	GUSD	RSD	MSSD	H	___	___
Asteraceae	*Xenophyllum poposum* (Phil.) V.A.Funk	Pura pura	Pura pura	Pura pura, cuti pura pura	CENSI 43	BS	Ss	MSSD	DSD, RSD, INFE	DSD, RSD	H	___	___
Bromeliaceae	*Puya ferruginea* (Ruiz & Pav.) L.B.Sm.	Chahuara	___	___	CENSI 13	BS	Ss	MSSD, INFL	___	___	H	___	___
Calceolariaceae	*Calceolaria lobata* Cav.	Zapatilla blanca	Zapatilla blanca	Zapatilla tica	CENSI 25	BS	H	GUSD	UMD	GUSD	T	___	___
Caprifoliaceae	*Valeriana nivalis* Wedd.	___	Cjata	___	CENSI 42	BS	H	___	UMD	___	H	___	Vulnerable (VU)
Caryophyllaceae	*Cerastium behmianum* Muschl.	___	Chankalawa, chancoroma	___	CENSI 14	BS	H	___	GUSD, RSD	___	T	___	___
Fabaceae	*Otholobium pubescens* (Poir.) J.W.Grimes	Wallwa	___	___	CENSI 62	BS	S	DSD	___	___	C	___	___
Francoaceae	*Balbisia meyeniana* Klotzsch	___	Qapo	___	CENSI 37	BS	Ss	___	RSD	___	H	___	___
Grossulariaceae	*Ribes brachybotrys* (Wedd.) Jancz.	Qita manzana	___	___	CENSI 20	BS	S	DSD	___	___	T	___	___
Lamiaceae	*Clinopodium bolivianum* (Benth.) Kuntze	Muña	Chinimuya, chinimuña	Chili muña, muña	CENSI 30	BS	S	DSD	DSD	DSD, RSD	H	___	___
Lamiaceae	*Lepechinia meyenii* (Walp.) Epling	Salvilla, Salvía	Salvia, salwilla	Salvia, salwilla	CENSI 47	BS	H	DSD, INFL, CD	DSD, RSD	DSD, RSD	T	___	___
Lamiaceae	*Salvia oppositiflora* Ruiz & Pav.	Uchulila	Uchulila, Suchulila	Suchulila,	CENSI 07	BS	Ss	DSD, PAIN, CD	DSD, PAIN, CD	INFE	H	___	Near threatened (NT)
Loasaceae	*Caiophora cirsiifolia* C.Presl	China ortiga	Ortiga blanca, ortiga macho, cjamanchina	Ortiga, cjaminchina	CENSI 24	BS	H	MSSD, DSD, PAIN, GUSD	GUSD	GUSD, CD	T	Endemic (AN, AP, AR, AY, CA, HV, LI, MO, TA.) Least Concern (LC)	___
Loasaceae	*Caiophora desertícola* Weigend & Mark.Ackermann	Ortiga	Ortiga	Jatun china, cjamanchina, ortiga macho	CENSI 01	BS	H	MSSD, DSD, PAIN, GUSD	GUSD, PBPD, INF	NEOP, GUSD, RSD	T	___	___

Onagraceae	*Epilobium fragile* Sam.	___	Yawar chonja	Yawar chonja	CENSI 51	BS	H	___	INJ	INJ	C	___	___
Orobanchaceae	*Neobartsia diffusa* (Benth.) Uribe-Convers & Tank	Chancorumi	Zapatilla, zapatilla de Dios	___	CENSI 17	BS	H	RSD	UMD	___	H	___	___
Solanaceae	*Solanum excisirhombeum* Bitter	Ñucchu	___	Ñucchu	CENSI 48	BS	H	___	RSD	INFL	T	___	___
Verbenaceae	*Verbena hispida* Ruiz & Pav.	Verbena, werwena	Verbena	___	CENSI 60	BS	H	DSD, CD	DSD, PAIN, RSD	___	C	___	___

La Pampilla (LP), Exchaje (EX) & Yunga (YU). Habit: S=Shrub, Ss=Sub shrub, H=Herb. Medicinal Categories: BSD: Blood System Disorders; CSD: Circulatory System Disorders; CD: Cultural diseases; DSD: Digestive System Disorders; ESD: Endocrine System Disorders; GUSD: Genitourinary System Disorders; INF: lnfections/Infestations; INFL: Inflammation; INJ: Injuries; MRU: Magical Religious Uses; MSSD: Muscular-Skeletal System Disorders; NEOP: Neoplasms; PAIN: Pain; PBPD: Pregnancy/Birth/Puerperium Disorders; RSD: Respiratory System Disorders; UMD: Unspecified Medicinal Disorders. Quality: Hot=H, Cold=C, Temperate=T.

Table 3. Similarity Values Indices for the three localities

	Number of medicinal species	Exclusive	Coincident	Jaccard's Similarity Coefficient	Sørensen's Similarity Coefficient	Cohen Kappa Index	Fleiss Kappa Index
La Pampilla **Exchaje**	28 23	10 6	19	0.54 Moderate	0.7 Substantial	0.47 Moderate	-
La Pampilla **Yunga**	28 21	10 2	19	0.61 Substantial	0.76 Substantial	0.60 Moderate	-
Exchaje **Yunga**	23 21	9 5	16	0.53 Moderate	0.7 Substantial	0.51 Moderate	-
La Pampilla **Exchaje** **Yunga**	29 25 21	6 5 1	15	-	-	-	0.53 Moderate

Discussion

It is striking that Moquegua has few studies on useful plants; ethnobotanical research in regions around Moquegua could show little attention to this area of the country, despite the fact that it has communication with Arequipa and Puno; for this reason, the present study, which has been carried out through the execution of an innovation project to implement a seed bank of medicinal plants, provides interesting data on the state of knowledge regarding medicinal plants that exist in Yunga, Moquegua, also noting that more ethnobotanical research is required in this area of the country, where mining activity and the presence of an active volcano (Ubinas), make it necessary to conserve natural resources and associated knowledge.

The results highlight the difference found between the collection with experts, who have pre-established ideas and conceptions, compared to the validation carried out by a group of Yunga residents, who are knowledgeable about medicinal plants, through three focus groups; of 61 plants collected, 36 were validated during the meetings held in three locations in Yunga, this is a little more than half. This fact or action of accrediting a plant as medicinal is an important contribution of this work, namely, the validation of the uses that the inhabitants themselves gave by consensus about their medicinal plant resources. In the study, the predominance of species of the Asteraceae family and, *Senecio* and *Baccharis* genera, is observed for the reports given by the three localities; this coincides with studies for the area that show the abundance of plants of this family, both in general vascular flora and medicinal plants (Montesinos 2011, Montesinos *et. al* 2015, Roersch 1994). Moreover, similar results are observed in research in Peru and worldwide, which agree that the Asteraceae family has a greater number of medicinal species. This shows that species of the family in question are traditionally considered important for health care and promising for the development of natural products and new medicines, both in our country and in the world (Arteta 2008, Faruque *et al.* 2018, Kumar *et al.* 2019, Montesinos 2013, 2011, Roersch 1994, Wat *et al.* 1980). However, something interesting happens with the Poaceae family (of which *Jarava ichu* Ruiz & Pav. known as ichu), which is abundant in inventories of vascular flora for the region (Montesinos 2011), but it is non-existent in the study; this confirms that the abundance of representatives of a family is not decisive for its predominance in medicinal species, as in the case of Asteraceae.

The species with the most reports of use in the three focus groups in Yunga, Moquegua, was the yareta (*A. compacta*), a shrub that has reported various medicinal uses in the high Andean region of southern Peru (Roersh 1994), which is consistent with its importance in the health care in the three locations studied; the aforementioned coincides with information from other authors who also mention its value (Caceres *et al.* 2016, Roersh 1994, Villagrán *et al.* 2003). In our study, plants with a bushy habit predominated; shrubs, and plants with wood in general, have the possibility of carrying a greater number of uses since they are present throughout the year, which allows the population to have them permanently, unlike herbs that have a period of life subject to the two seasons of the year in the area, dry and rainy (Castillo Vera, 2018; Tardío & Pardo-De-Santayana, 2008); however, the aforementioned is not to the detriment of the fact that there are studies where the predominant plants are herbs (Angulo *et al.* 2012). For this reason, prioritizing the use of shrubs, in contrast to herbs, would be more profitable and manageable, since herbaceous plants are more susceptible to predation, since in their use the entire plant is used, in addition to the problems that its propagation and cultivation entails, practices evidenced in the localities of Yunga.

The warm plants, predominant in our study, are used by the population to relieve colds (which are manifested in respiratory, muscular and joint, and digestive problems), information that coincides with that mentioned by Álvarez et al. (2017) and Roersch (1994); in addition, the information agrees with Álvarez and Roersch in the report of three categories of plants in terms of their quality (warm, cold or fresh, and temperate); this contrasts with research in other areas of the country and the world, where, when referring to aspects of duality, hot and cold, or opposite characteristics (Mostacero *et al.* 2020, Colson & De Armellada 1983), only two categories are mentioned. In Yunga it is interesting how the population acts against warm plants, of which care must be taken in excessive use, likewise temperate plants gain importance, since they play an important role in community health care. Thus, due to the results observed, there is a relationship in the predominance of the categories of medicinal plants with the most reports and their uses to alleviate or cure cold-related ailments, and coincidence, with ethnobotanical research that have reported the prevalence of medicinal species for the digestive, respiratory and skeletal muscle systems (Castañeda 2019; Hurtado 2016, 2018, Roersch 1994). For this study, the ethnobotanical data compiled in the focus group meetings were easily categorized, following what was proposed by Cook (1995) and Gruca *et al.* (2014).

The categorization of qualitative information has made it possible to quantify data and analyze them with similarity coefficients and with statistical programs. For the investigation, the kappa index was chosen, since it evaluates qualitative variables, such as the data collected in the study, referring to medicinal uses of plants. Information on the application of this index in the field of ethnobotany is scarce, however, medical disciplines use it with some frequency in the comparison of the results of some diagnostic method against a gold standard (Carvalho *et al.* 2021, Rücker *et al.* 2012). In the case of the concordance of lists of useful plants, and for this study the medicinal ones, the importance of statistically verifying the level of agreement that may exist between two or more localities is highlighted, in the face of the possible occurrence of subjective opinions to show how much two or more populations agree in their reports. In contrast to this, the kappa index offers tangible values, eliminating the correspondence or agreement attributed to chance, in contrast to the Jaccard and Sørensen coefficients (Cerda & Villarroel 2008), showing lower value results in their analysis (Abraira 2000). On the other hand, Sørensen's similarity coefficient provided higher values than Jaccard's, because he considers twice as many common species in the numerator and denominator of his formula. Variations exist for the Jaccard and Sørensen formulas; however, it was preferred to follow the indication of Real & Vargas (1996) and Hoft *et al.* (1999), since the value of the species present in one locality and absent in the other was taken, and vice versa, excluding repetitions (and thus avoiding the value of zero in the denominator) (Hoft *et al.* 1999, Martínez & Luján 2011, Rahman *et al.* 2019). However, the use of a scale allows standardizing criteria, as long as its use is promoted in related research, such as ethnobotany, thus seeking to be more objective in terms of interpreting the values obtained in the calculation of indices (Landis & Koch 1977). Although the proposed scale was initially used for epidemiological studies, its application can be extended to other disciplines, as proposed in this study.

The results of this study show that there is "Moderate" agreement between the lists of the three focus groups. This concordance is related to the proximity of the three places (they are close); in addition, the populations of the three localities share common routes on a daily basis, towards Puno, Arequipa and Lloque (Moquegua), for example; in the same way, they have in common cultural aspects that link them ancestrally, such as festivities, community work, exhibition of stories, poems and ancestral songs, activities supported and promoted by the local government, through contests and calls via social networks, but which are also strengthened through sharing in homes or during tasks in the fields (Jiménez *et al.* 2015, Oficina de Comunicaciones de la Municipalidad Distrital de Yunga 2022). However, it is important to note that dissimilarities are also found in Yunga district, because the medicinal flora of a region has peculiarities, such as the species that make it up, genera, families, uses, etc. Related to this, the particularity about the way to use a plant or what it is used for, can vary even between localities, as close as those reported in this article.

It was observed that the localities of La Pampilla and Exchaje (both rural) show greater agreement with Yunga (with some urban characteristics), but less correspondence between them, having to consider that residents of these two localities come to Yunga frequently as a common destination, motivated to carry out some legal procedure or perform some salaried job (the municipal seat is in the town of Yunga), giving rise to social relations with residents of the main town. The locality of La Pampilla was the one that validated or reported the most medicinal species, followed by Exchaje and then Yunga; both, La Pampilla and Exchaje, do not have their own health facility, but must travel a few kilometers to Yunga; this fact would motivate them to resort to the natural resources of their farms, before moving to the capital. This behavior of the population shows that the presence and influence of a health facility or the habit of resorting to drugs from academic medicine to treat ills is important and would have repercussions on the state of knowledge of medicinal plants, either by increasing use, or reducing it (Gil 2007). In addition, the agreement shown by Cohen's kappa index between the Pampilla and Yunga stands out, which is 60.04%, considering moderate strength of agreement; however, this value is at the upper limit, according to the proposed scale, and is very close to the results with the Sørensen and Jaccard Similarity Coefficients, so we could conclude that the greatest agreement between the three localities occurs between La Pampilla and Yunga, being of the Substantial type. Therefore, it is convenient to consider that the similarity or dissimilarity between localities will be related to their geographical location, their ecosystems, their histories and ancestral cultures (Castañeda 2019, Ghorbani *et al.* 2012, Luján & Martínez 2017).

Conclusions

The Yunga district, in the Moquegua region, has an interesting background of knowledge associated with the ancestral use of medicinal plants, a fact corroborated through the reports made by local residents.

Shrubby medicinal plants prevailed over herbaceous ones, enabling sustainable conservation and management practices of these medicinal species, considering the categorization of some medicinal plants in Yunga.

The localities of Yunga, Exchaje and La Pampilla show percentages of agreement of the Moderate type between their reports of medicinal plants, considering the values of the coefficients of Similarity of Jaccard, Sørensen and the Kappa index of Cohen and Fleiss; being related to factors such as: the distance between locations, culture, language, environmental and geographic characteristics, and the presence of a health facility.

The Kappa Index is a valid method to establish the level of agreement between the ethnobotanical knowledge of localities or ethnic groups, one of its strengths being the elimination of the agreement attributed to chance, offering lower values than those shown by the Jaccard and Sørensen coefficients. The proposed scale makes it easier to adopt a more objective approach to the values found.

In Yunga, the use of medicinal plants is current and occurs, mainly, at family level; which results in the richness of the use of medicinal plants; the agreements between the localities are likely to be due to their proximity and social and cultural interrelation.

Declarations

List of abbreviations: Not applicable.

Availability of data and material: Traditional uses are protected; other data can be requested by email.

Ethics approval and consent to participate: This research was approved by the National Institute of Health with Resolution No. 234-2019-DG-OGITT-OPE/INS; approved by community authorities and residents (Prior Informed Consent) and authorized for collect and research purposes by the National Forest and Wildlife Service (SERFOR/Ministry of Agriculture and Irrigation) with RDG No. 310-2019-MINAGRI-SERFOR.

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