Ministerio del Poder Popular para la Salud
Boletín de Malariología y Salud Ambiental
ISSN: 1690 - 4648

Septiembre - Octubre 2022, Vol. LXII (5), 1055-1066

Original Article

Diversity, abundance and ecological importance of plant species for medical use in tropical forest of Tingo Maria, Peru

Diversidad, abundancia e importancia ecológica de especies vegetales de uso medicinal de la selva tropical en Tingo María, Perú

https://doi.org/10.52808/bmsa.7e6.625.020

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Recibido: 02/06/2022

Aceptado: 19/09/2022

ABSTRACT

Peru is a megadiverse country due to the large number of animal and plant species. Its diversity derives from the different ecoregions present that developed with geological evolution. Much of its plant diversity is contained in the Peruvian Amazon, which includes a large proportion of plant species, many of them endemic. Of this diversity, many plants have been underestimated, and it is believed that more than 50% of them have not been recorded. These scientific gaps also address medicinal plants, their taxonomic identification, phytochemical bioactives produced, mechanisms of action of phytochemicals, and the metabolic pathways involved. These medicinal plants are active against common diseases such as: protozoa, with emphasis on malaria and leishmania, diabetes, inflammation, hypertension, cancer, infectious diseases (viral, bacterial, and fungal), kidney, liver, diarrhea and other health problems. This work is based on the study of a forest area in the district of Rupa Rupa called Reserve Forest of the Universidad Nacional Agraria de la Selva (BRUNAS) in Tingo María, Peru, which is being highly pressured by the people who live in the surroundings of this forest ecosystem for domestic use, so it is urgent to sensitize the population linked to this natural resource and make known the plants found there with high medicinal potential for the use of the locals, the nation and the world.

Keywords: Medicinal plants, Peruvian Amazon, Plant diversity, health.

RESUMEN

El Perú es un país megadiverso debido a la gran cantidad de especies de animales y plantas. Su diversidad se deriva de las diferentes ecorregiones presentes que se fueron desarrollando con evolución geológica. Mucha de su diversidad vegetal está contenida en la Amazonía Peruana que incluye una gran proporción de especies de plantas, muchas de ellas, de carácter endémico. De esta diversidad, muchas plantas han sido subestimada, y se cree que más del 50% de ellas no han sido registrada. Estas lagunas científicas también abordan también a las plantas medicinales, su identificación taxonómica, bioactivos fitoquímicos producidos, mecanismos de acción de los fitoquímicos y las vías metabólicas involucradas. Estas plantas medicinales son activas a enfermedades comunes como: protozoos, con énfasis en la malaria y leishmania, diabetes, inflamación, hipertensión, cáncer, enfermedades infecciosas (virales, bacterianas, y hongos), afecciones renales, hepáticas, diarrea y otros problemas de salud. Este trabajo se basa en el estudio de una zona boscosa del distrito de Rupa Rupa denominada Bosque de Reserva de la Universidad Nacional Agraria de la Selva (BRUNAS) en Tingo María, Perú, la cual esta siendo muy presionada por los pobladores que viven en los alrededores de este ecosistema forestal para uso domésticos, por lo que es urgente sensibilizar a la población vinculada a dicho recurso natural y dar a conocer las plantas allí encontradas con alto potencial medicinal para el uso de los lugareños, de la nación y el mundo.

***Palabras clave**: Plantas medicinales, Amazonía Peruana, Diversidad vegetal, salud.*

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Introduction

Peru is a megadiverse country due, in part, to the great diversity of species in plants (Cardoso *et al.*, 2017). Its diversity is attributed to the different scenarios or ecoregions present in the country, which developed with geological evolution (Hoorn *et al*., 2010). Much of the plant diversity is contained in the Peruvian Amazon, which includes a large proportion of plant species, many of which are endemic (van de Werff & Consiglio, 2004). However, this diversity continues to be underestimated because a complete and up-to-date inventory of these plant species is lacking, and according to some estimates, more than 50% remain unknown to science (Joppa *et al*., 2011). These scientific gaps also address medicinal plants, their taxonomic identification, bioactive phytochemicals produced, mechanisms of action of phytochemicals, and the metabolic pathways involved. Most ethnopharmaceutical surveys have focused on plant species for the treatment of protozoa, with an emphasis on malaria and leishmania (Vásquez-Ocmín *et al*., 2018); but it is known that these medicinal plants can also treat other diseases such as diabetes, inflammation, hypertension, cancer, infectious diseases (viral, bacterial, and fungal), kidney, liver, diarrhea and other health problems. Consequently, it is essential to implement strategies to overcome these limitations and close these large knowledge gaps. Recently, a partial database of medicinal plants from the Peruvian Amazon was developed based on a few available ethnobotanical studies (Rainer & Douglas, 2015). The database includes 1410 species belonging to 157 plant families; which were verified according to the Plant List Database. Of these, the top 10 families by number of medicinal plant species are Fabaceae (137), Asteraceae (80), Rubiaceae (57), Araceae (53), Piperaceae (51), Solanaceae (51), Euphorbiaceae (47), Apocynaceae (39), Bignoniaceae (39) and Clusiaceae (32). In addition, this database revealed that the plant families with the highest number of medicinal uses are Fabaceae (272), Asteraceae (244), Rubiaceae (197), Euphorbiaceae (180), Piperaceae (179) and Solanaceae with more than 166 medicinal uses (Castro *et al*., 2022).

Despite the great social, economic, environmental and health benefits of this diversity of medicinal plants, human activities are attributed the responsibility for both flora and fauna species becoming extinct more quickly to the present day (Wilson, 1992). Said extinction in exorbitant amounts was caused by changes in land use, destructive effects on habitats, almost irreversible impacts in different biogeochemical periods, as well as biological invasion (Vila, 1998). There is a group of biotic species that have a high risk of extinction, this occurs due to their susceptibility when their environment is degraded and also due to genetic erosion due to their low population size (Lubchenco *et al*., 1991; García, 2002), characteristics existing morphological and spatial characteristics of the biotic and abiotic component (Acosta *et al*., 2006). Carrying out studies corresponding to the structure of a set of trees is included as a very important component when analyzing biological diversity (Staudhammer & LeMay, 2001), this is coined because the size, as well as the structure in the different groups of plants results from the needs of a species and the environmental characteristics (Valerio, 1997).

The reports of the permanent measurement plots (PMP) are insignificant compared to other lines of research focused on forests, because a PMP generates information with the purpose of increasing the knowledge of botany regarding its flora composition and the horizontal structure that the forest ecosystems of the Amazon presently have, with these reports some subsequent intervention of the forest framed in the sustainable development approach would be planned.

In that sense, in the district of Rupa Rupa there is a wooded area of which there is not much information called Reserve Forest of the National Agrarian University of the Jungle (BRUNAS) in Tingo María, Peru, which is being very pressured by the inhabitants who live in the surroundings of this forest ecosystem for domestic use, for which it is urgent to sensitize the population linked to said natural resource and to make known the plants found there with high medicinal potential for the use of the locals, of the nation and the world.

Materials and methods

General characteristics of the study area

The study area consisted of two permanent measurement plots located in the BRUNAS. The evaluated plots are located in the Rupa Rupa District, Leoncio Prado Province, Huánuco Department. Peru. The aforementioned ecosystem covers some 217.22 hectares of land, registering only 185 hectares with forest cover. The average annual rainfall was 3019.8, average temperature of 25.7 °C and 82.5% relative humidity during the 2016 period (UNAS, 2017).

Materials and equipment

In the data collection, metric and diametric tape were used to measure the characteristics of the plant species. The subplots were delimited by means of wooden stakes, raffia rolls for bales and polyvinyl chloride (PVC) tubes. In the collection and herbalism, telescopic scissors, indelible markers, masking tape, a polyethylene bag, a wooden botanical press and newspaper were used, in addition to equipment such as cameras, GPS, inclinometer and compass, and records to record the dasometric data and characteristics of the plot.

Data collection stage

The study units (PPM I and PPM IV) were installed in 2002 with the purpose of making annual records of the dasometric variables of trees and natural regeneration in the BRUNES; the areas of the plots were similar (100 x 100 m) that were divided into 25 quadrants (20 x 20 m). Once located at the vertex of the plot, the perimeter of both the quadrants and the global plot was limited, where 2-inch-diameter raffia and polyvinyl chloride tubes were used. In addition, a metal plate fastened with a steel nail was placed 30 cm from the optimal measurement point in the plant individuals whose

Ministerio del Poder Popular para la Salud
Boletín de Malariología y Salud Ambiental
ISSN: 1690 - 4648

diameter at the height of the stem chest was equal to and/or greater than 10.0 cm. Correlatively listed within the 25 quadrants in both plots. Subsequently, the qualities of the plant individuals were recorded, such as their total height, the diameter of the stem measured at breast height (generally located at 1.30 m above the ground) and the diametral area of the crown. In the identification of the species, the botanist Rodolfo Vásquez Martínez and the engineer Yahn C. Soto Shareva helped, who determined the category of genus and species. Plants not identified at the time were conditioned and botanical samples (leaf, flower and fruit) were transferred to the HOXA herbarium located in the city of Oxapampa.

Data analysis and interpretation

The formulas recommended by Acosta *et al*., (2006) for indicators such as absolute and relative abundance (Aa and Ar respectively), absolute and relative dominance (Dai and Dr respectively), absolute and relative frequency (Fa and Fr respectively) and degree of homogeneity (H). The importance value index was determined, as expressed by the authors Curtis & McIntosh, (1951), applied by Pool *et al*., (1977) and Cox, (1981). In order to know the horizontal structure, the Morisita index (1959) was calculated. The coverage value was obtained following what was indicated by Acosta *et al.*, (2006). The data collected was tabulated, analyzed and interpreted following the criteria of descriptive statistics, taking into account arithmetic mean, standard error and coefficient of variation expressed in percentage terms.

Results

Density of the arboreal vegetation of the BRUNAS

During the study carried out, 109 plant species were identified in the PPM I subplot, of which the most abundant (12 species) are indicated in Table 1. The forest species with the highest proportion was *Parkia panurensis Benth. ex HC Hopkins* with a number of individuals per hectare of 65±23 corresponding to 10.06% of the total identified forest with a dbh greater than or equal to 10 cm for the PPM I subplot (Table 1). The less abundant species were: *Pourouma minor*, *Qualea amoena*, *Pavonis ferrule*, *Helicostylis tomentosa*, *Schizocalyx sterculioides*, *Laetia procera* and *Theobroma subincanum* with percentages less than 4%; while in the PMP IV subplot, 122 species were identified, with 15 being the most abundant. The forest species *Senefeldera inclinata* Müll. Arg. registered the highest average (155.00 ± 36.88 individuals/ha), representing more than 12.18% of the total registered trees, with a dbh greater than or equal to 10 cm. The rest of the 14 identified species presented percentages lower than 9%.

Table 1. Descriptive statistics for the density and "n" frequency tree vegetation in PPM I y PPM IV of BRUNAS

Study units	Species	Density ± SE (ind./ha)	CV (%)	Density (%)	Absolute frequency (Fa)	Relative frequency (%)
PPM I	*Parkia panurensis*	65.00 ± 22.97	79.01	10.06	1	2.07
	Senefeldera inclined	57.00 ± 25.48	99.94	8.82		
	Casearia ulmifolia	48.00 ± 15.30	71.26	7.43	1	2.07
	Pourouma minor	31.00 ± 12.29	88.64	4.80	1	2.07
	Qualea amoena	28.00 ± 7.18	57.31	4.33	1	2.07
	Pavonis ferrule	27.00 ± 6.44	53.35	4.18	1	2.07
	Helicostylis tomentosa	21.00 ± 6.40	68.18	3.25	1	2.07
	Schizocalyx sterculioides	20.00 ± 4.18	46.77	3.10	1	2.07
	Laetia procera	18.00 ± 8.89	110.41	2.79	1	2.07
	Theobroma subincanum	13.00 ± 5.39	92.63	2.01		
	Alchornea glandulosa				0.8	1.66
	Marila tomentosa				1	2.07
	Others (97 species)	----	----	49.23		79.67
PPM IV	*Senefeldera inclineda*	3.68±0.75	45.60	12.18	1	2.17
	Cedrelinga cateniformis	2.91±1.77	135.71	9.64	0.8	1.74
	Pourouma minor	1.86±0.54	65.05	6.16	1	2.17
	Osteophloeum platyspermum	1.44±0.81	125.87	4.77		
	Hevea guianensis	1.38±0.75	120.40	4.58	1	2.17
	otoba parvifolia	1.11±0.50	99.48	3.68		
	Dacryodes nitens	1.11±0.34	68.35	3.67	0.8	1.74
	Cecropia sciadophylla	1.06±0.54	113.05	3.52	1	2.17
	Guatteria guentheri	0.98±0.49	113.25	3.23		
	Vochysia biloba	0.70±0.48	152.01	2.32		
	Theobroma subincanum				1	2.17
	Batocarpus orinocensis				0.8	1.74
	Neea divaricata				0.8	1.74
	Otoba parvifolia				0.8	1.74
	Other species (107 species)			46.26		80.43

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Dominance of the arboreal vegetation of the BRUNAS

The Parkia panurensis species obtained an average of 4.16 ± 1.22 m2/ha, being the most predominant species, representing more than 17.32% of the total basal area in the permanent plot. The same way, the 10 most dominant plant species represented 50.12% of the basal area, while the remaining 97 species only registered 49.88% due to smaller stem diameters. Within these 10 species, a high variability of the results was recorded with respect to the basal area, with 37.62% for *Qualea amoena*, up to 137.45% that was observed in the species *Tachigali macbridei* (Table 2).

In the PPM IV subplot, among the 10 species with the highest average in terms of dominance, *Senefeldera inclinata* was found with a value of 3.68±0.75m2/ha, with 95% confidence interval values of 2.21 to 5.15 m2/ha; In addition, this species represented 12.18% of the total average value; while in 25% less there is the species *Cedrelinga cateniformis* with 2.91±1.77m2/ha and they represent only 9.64% of the total average (Table 2).

Frequency of the arboreal vegetation of the BRUNAS

Keeping in mind the five transects in PPM I, it was recorded that nine species were the most frequent: *Casearia ulmifolia, Helicostylis tomentosa, Laetia procera, Marila tomentosa, Parkia panurensis, Pourouma minor, Qualea amoena, Schizocalyx sterculioides* and *Virola Pavonis*; each of these species represented 2.07% of the relative frequency of the plot under study. *Alchornea glandulosa* was found in tenth place, which was absent in one of the five transects evaluated for PMP I. This species represented 1.66% with respect to relative frequency (Table 2).

Table 2. Descriptive for the dominance e IVI of vegetation in PPM I y PPMIV of BRUNAS

Study units	Species	dominance			IVI			
		BA ± SE (m^2/ha)	CV (%)	BA (%)	Ar (%)	dr (%)	Fr (%)	IVI (%)
PPM I	*Parkia panurensis*	4.16 ± 1.22	65.53	17.32	10.06	17.32	2.07	29.46
	Casearia ulmifolia	1.30 ± 0.37	63.16	5.40	7.43	5.40	2.07	14.90
	Copaia Jacaranda	1.12 ± 0.46	93.03	4.65	1.39	4.65	1.66	7.70
	Senefeldera inclined	1.03 ± 0.44	95.52	4.29	8.82	4.29	1.24	14.36
	Pavonis ferrule	0.99 ± 0.27	60.04	4.14	4.18	4.14	2.07	10.40
	Pourouma minor	0.87 ± 0.39	101.46	3.62	4.80	3.62	2.07	10.49
	Tapirira guianensis	0.74 ± 0.31	93.17	3.10				
	Schefflera morototoni	0.72 ± 0.33	101.95	2.99				
	Tachigali macbridei	0.56 ± 0.34	137.45	2.32				
	Qualea amoena	0.55 ± 0.09	37.62	2.28	4.33	2.28	2.07	8.69
	Helicostylis tomentosa				3.25	2.24	2.07	7.56
	Laetia procera				2.79	2.17	2.07	7.03
	Schizocalyx sterculioides				3.10	1.58	2.07	6.75
	Other species (97 species)			49.88				182.66
PPM IV	*Senefeldera inclined*	3.68±0.75	45.60	12.18	28.49	12.18	2.17	42.85
	Cedrelinga cateniformis	2.91±1.77	135.71	9.64				
	Pourouma minor	1.86±0.54	65.05	6.16	4.23	6.16	2.17	12.56
	Osteophloeum platyspermum	1.44±0.81	125.87	4.77	1.10	4.77	1.30	7.18
	Hevea guianensis	1.38±0.75	120.40	4.58	2.02	4.58	2.17	8.78
	otoba parvifolia	1.11±0.50	99.48	3.68				
	Dacryodes nitens	1.11±0.34	68.35	3.67	2.21	3.67	1.74	7.61
	Cecropia sciadophylla	1.06±0.54	113.05	3.52	3.13	3.52	2.17	8.82
	Guatteria guentheri	0.98±0.49	113.25	3.23	1.47	3.23	1.30	6.00
	Vochysia biloba	0.70±0.48	152.01	2.32				
	Cedrelinga cateniformis				0.92	9.64	1.74	12:30
	otoba parvifolia				2.76	3.68	1.74	8.18
	Tapirira guianensis				2.02	1.88	1.74	5.64
	Other species (107 species)			46.26				180.09

The arboreal vegetation of the BRUNAS with dap greater than 10 cm that presented highest frequency in PPM IV, was constituted by five species: *Cecropia sciadophylla*, *Hevea guianensis*, *Pourouma minor*, *Senefeldera inclinata* and *Theobroma subincanum*, which represented each the 2,17 % of the relative frequency. In the case of the plant species that appeared in four of the five evaluated transects, they were represented by 13 species, of which the first five were: *Batocarpus orinocensis*, *Cedrelinga cateniformis*, *Dacryodes nitens*, *Neea divaricata* and *Otoba parvifolia* (Table 1).

Homogeneity of the arboreal vegetation of the BRUNAS

PMP I obtained 21 species that were distributed among the four (0.8) or five (1.0) transects of the five considered to be evaluated, which was superior to PPM IV, which was only represented by 18 species with dap ⩾ 10 cm. In the case of the degree of homogeneity for the two permanent measurement plots, it was recorded that PPM I was more homogeneous because the value obtained was -0.18 (closer to unity), while PPM IV was less homogeneous at obtain a homogeneity index equal to -0.36 (Table 3).

Table 3. Degree of homogeneity of the two permanent measurement plots in BRUNAS.

variables	PPM I	PPM IV
Species between 80-100% Fa	21	18
Species between 0-20% Fa	40	60
Total is species	107	117
Degree of homogeneity (H)	-0.18	-0.36

PPM: Permanent plot of measurement.

Value index of ecological importance of the arboreal vegetation of the BRUNAS

The importance of each species in the set of arboreal vegetation of BRUNAS in PPM I was represented by the species Parkia panurensis, which registered an importance value of 29.46%; the next nine species were: *Casearia ulmifolia*, *Senefeldera inclinata*, *Pourouma minor*, *Virola pavonis*, *Qualea amoena*, *Jacaranda copaia*, *Helicostylis tomentosa*, *Laetia procera* and *Schizocalyx sterculioides*. In addition, it was recorded that the highest values of the IV components for the first 10 most important species were represented by the relative abundance, with the exception of the species: *Parkia panurensis*, *Jacaranda copaia* and *Schizocalyx sterculioides*, because the first species obtained the highest relative dominance, while the last species was lower than the other components of the importance value index (Table 2).

Of the 10 species of arboreal vegetation existing in PPM IV, Senefeldera inclinata obtained the highest representation, reaching a value of 42.85% for IV, while the rest of species was conformed by: *Pourouma minor*, *Cedrelinga cateniformis*, *Cecro-pia sciadophylla*, *Hevea guianensis*, *Otoba parvifolia*, *Dacryodes nitens*, *Osteophloeum platyspermum*, *Guatteria guentheri* and *Tapirira guianensis* with an accumulated value of 77.06%. The other 107 species found in PPM IV represented 180.09 % (Table 2).

Moorish structure of the arboreal vegetation of Las BRUNAS

PPM I presented 646 individuals with dap greater than 10 cm, while the spatial distribution corresponds to the random classification for presenting a Morisita index value equal to unity (1.00); while in the case of PPM IV it presented 544 individuals and the spatial distribution was categorized as regular or uniform when registering a Morisita index of 0.9963 (Table 4).

Table 4. Morisita index of tree vegetation in PPM I and IV of BRUNAS

plots	Transects (individuals)						Morisite Index (Iδ)
	1	two	3	4	5	Total	
PPM I	118	125	152	115	136	646	1.0047
PPM IV	101	105	106	112	120	544	0.9963

Iδ: also called spatial distribution index.

Vegetal tree cover of the BRUNAS

Regardless of whether the trees appear isolated or in groups (frequency), the coverage value for PPM I indicates that among the 10 species with the highest coverage, *Parkia panurensis* is found, representing 13.69%; while the nine species included among: *Casearia ulmifolia*, *Senefeldera inclinata*, *Pourouma minor*, *Virola Pavonis*, *Qualea amoena*, *Jacaranda copaia*, *Helicostylis tomentosa*, *Laetia procera* and *Schizo-calyx sterculioides*, represented 35.23% of the coverage value (Table 5).

In PPM IV and without taking into account whether the trees appear isolated or in groups (frequency), it was recorded that Senefeldera inclinata had the highest cover (20.34%); while the remaining nine species of the top 10 were represented by: *Pourouma minor*, *Cedrelinga cateniformis*, *Cecropia sciadophylla*, *Hevea guianensis*, *Otoba parvifolia*, *Dacryodes nitens*, *Osteophloeum platyspermum*, *Guatteria guentheri* and *Tapirira guianensis* (Table 5).

Table 5. Coverage value of tree vegetation in PPM I and PPM IV of BRUNAS

Study unit	Species	relative abundance (%)	relative dominance (%)	CV (%)
PPM I	*Parkia panurensis*	10.06	17.32	13.69
	Casearia ulmifolia	7.43	5.40	6.41
	Senefeldera inclined	8.82	4.29	6.56
	Pourouma minor	4.80	3.62	4.21
	Pavonis ferrule	4.18	4.14	4.16
	Qualea amoena	4.33	2.28	3.31
	Copaia Jacaranda	1.39	4.65	3.02
	Helicostylis tomentosa	3.25	2.24	2.74
	Laetia procera	2.79	2.17	2.48
	Schizocalyx sterculioides	3.10	1.58	2.34
	Other 97 species			51.08
PPM IV	*Senefeldera inclined*	28.49	12.18	20.34
	Pourouma minor	4.23	6.16	5.19
	Cedrelinga cateniformis	0.92	9.64	5.28
	Cecropia sciadophylla	3.13	3.52	3.32
	Hevea guianensis	2.02	4.58	3.30
	otoba parvifolia	2.76	3.68	3.22
	Dacryodes nitens	2.21	3.67	2.94
	Osteophloeum platyspermum	1.10	4.77	2.94
	Guatteria guentheri	1.47	3.23	2.35
	Tapirira guianensis	2.02	1.88	1.95
	Other 107 species			49.17

CV: Coverage value

Table 6. Medicinal properties of the vegetative species of PPM I and PPM IV in the forest reserve in Tingo María

Species	Common name	Medicinal Use			Source
		Use	Components	Pathology	
Alchornea glandulosa	Tapia	cataplasm	leaf	Helicobacter pylori infection	Bonacorsi *et al.*, (2013)
Cecropia sciadophylla	Yarumo	Extract	leaf	Diabetes mellius	Quintana Arias, (2012)
Cedrelinga cateniformis	Tornillo	Infusion	Plants	kidney disease	López *et al.*, (2002)
Helicostylis tomentosa		Cataplasm	leaf	wounds and ulcers	Buckley *et al.*, (1973)
Hevea guianensis	Cannonball tree	Cataplasm	leaf	Leishmaniasis and other skin parasites	Alvarado Cabrera, (2006)
Jacaranda copaia	bignonia	Cataplasm Infusion dust	leaf bark bark	Leishmaniasis and ringworm Intestinal parasites Syphilis	Rocha *et al.,* (2005); Florura digital, (2022)
Laetia procera	Manga larga	Extract	bark	Leishmaniasis due to L. amazonensis; P. falciparum malaria	UICN, (2019)
Marila tomentosa	Castaño	Cataplasm	leaf	ringworm	Alvarado Cabrera, (2006)
Osteophloeum-platyspermum	Caracolí	Extract	fruits	benign prostate Hyperplasia	Fo *et al.*, (1984); Wilt *et al.*, (2000)
Otoba parvifolia	Doncel	Extract Extract	Plant bark	Borrelia burgdorfei loxoscelism Leishmaniasis due to *L. amazonensis* and *L. braziliensis*	Weiss, (2018) Weniger *et al.*, (2001)
Parkia panurensis	tamarindo	Cataplasm	leaf	Scabies	Minam, (2015)
Tapirira guianensis	Cedrillo	Extract	Plant	Squamous cell carcinoma of the head and neck	Silva-Oliveira *et al.*, (2016)

As a vital part of this research, genera and species with medicinal properties were identified in both PPM I and PPM IV subplots of the Tingo María forest reserve (Tables 6 and 7). Studies show that it is possible to use various parts of plants: leaves, stems, bark, flowers and fruits for the preparation of brews, infusions, extracts or poultices to treat various diseases or ailments such as: bacterial infections (*Helicobacter pylori,* Leishmaniasis), diabetes mellitus, kidney infections, wounds and ulcers, intestinal parasites, syphilis, ringworm, benign prostatic hyperplasia, malaria, loxoscelism, cancer, scabies, mycosis, Zika, liver damage and others. Some of these genera and species are in high proportion among the plants identified as: *Alchornea glandulosa*, *Jaracanda copaia*, *Marila tomentosa*, *Laetia procera*, *Parkia panurensis* or *Tapiria guianensis*. Other species were in smaller proportion but with specific and interesting medicinal properties (Tables 6 and 7).

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Boletín de Malariología y Salud Ambiental
ISSN: 1690 - 4648

Table 7. Medicinal properties of genera associated with the vegetative diversity of PPM I and PPM IV in the forest reserve in Tingo María

Genus	Species	Medicinal Use			source
		Use	Component	Pathology	
Alchornea	*A. laxiflora*	Infusion	Roots	Malaria due to *P. falciparum* and *P. berghei*	Okokon *et al.*, (2017)
Casearia	*C. sylvestris*	Extract	leaf	Mycoses due to *Saccharomyces cerevisiae*, *Candida albicans*, *C. glabrata* and *C. krusei*	Pereira *et al.*, (2017)
	C. sylvestris; C. decandra	Extract	Plant	Mycoses due to *Trametes villosa* and *Pycnoporus sanguineus*	Bento *et al.*, (2014)
Dacryodes	*D. edulis*	Extract	leaf	Malaria due to *P. berghei*	Uzor *et al.*, (2021)
Guatteria	*G. latifolia*	Extract	branches; leaf	Leishmaniasis due to *L. amazonensis*	Ferreira *et al.*, (2017)
	G. dumetorum	Extract	Plant	Leishmaniasis due to *L. mexicana* and *L. panamensis*	Montenegro *et al.*, (2003)
Marila	*M. laxiflora*	Extract	leaf	Leishmaniasis due to *L. amazonensis* and *L. braziliensis*	Weniger *et al.*, (2001)
Neea	*N. theifera*	Extract	root	Leishmania due to *L. amazonensis* and dermatofitosis due to *Trichophyton* spp.	da Costa *et al.*, (2014)
Pourouma	*P. guianensis*	Extract	leaf	Leishmaniasis due to *L. amazonensis*	Torres-Santos *et al.*, (2004)
Psychotria	*P. viridis*	Extract	Plant	Zika virus	Moraes *et al.*, (2021)
Qualea	*Q. parviflora*	Extract	bark	*Helicobacter pylori* infection	Mazzolin *et al.*, (2010)
Schefflera	*Schefflera* spp.	Extract	Plant	Malaria and other parasites	Wang *et al.*, (2013); Wang *et al.*, (2021)
Schizocalyx	*S. cuspidatus*	Extract	leaf	Hepatic injury	Gonçalves *et al.*, (2016)

Discussion

In developing countries, biodiversity makes them rich, therefore the Convention on Biological Diversity (CDBa) can be defined as the sovereignty that national governments have over their bioresources, since the treaty allows them to recognize their right to govern and receive financial support if any foreign agent wishes to access its biodiverse resources. With this treaty, the paradigm of the "common heritage" that made foreign countries have unlimited access to bioresources is supplanted, balancing the way in which all interested and involved groups can make use of biodiversity through their recognition of economic values, sociocultural and environmental. In the same way, Peru is recognized for having more than five hundred and ten plants with pharmaceutical and medicinal properties, and this only includes the northern area of Peru. These species are often used for the treatment of various ills ailments, using a part of the plant or all of it as whole. Thus, for example, some nervous disoders are usually attacked in various ways, topically (catasplam or bath) or orally (ingestion of extracts or infusion of plants). Thus, above 2499 different uses were recorded for the 510 species found, with some 207 plants useful for treatment of various ailments (40.4%), 91 species (18.5%) to deal with respiratory problems, 98 species (19.1%) to treat psychosomatic and nervous problems. Kidney and urinary tract diseases, 96 species (16.6%), rheumatism and arthritis 55 species (8.8%) were mentioned, and infectons of the female organs are treated with 105 species (20.9%) (Baussmann & Sharon, 2016).

In this way, this study covered two important aspects in the conservation of the Reserve Forest of the National Agrarian University of the Jungle (BRUNAS) in Tingo María in the jungle area of the Peruvian Amazon: on the one hand, a description was made of the different types of plants referred to the BRUNAS, and on the other hand, an in-depth study of the plants with medicinal potential was made, all with the conservationist purpose of the place, and to make the locals understand the purpose of preserving this natural pharmacy alive.

In the national park in the BRUNAS, it was found that Senefeldera inclinata predominates to a certain extent in the density of the species, finding 57 ind./ha in plot I and 155 ind./ha in plot IV, this predominance of individuals per area it is still found in points where high voltage towers were installed in the same forest under study (Gutiérrez *et al*., 2021) when reporting densities of 16 ind./ha, which confirms that this species is rustic in addition to presenting abundant natural regeneration by the dissemination of abundant seeds and its high germination rate. Furthermore, in the Brazilian jungle in the Purus National Forest, they found two species of the same genus, *Senefeldera* sp. and S. *macrophylla*, whose population densities ranged between 15.67 ind./ha and 18.33 ind./ha, respectively (Christo *et al*., 2020), this variation can be attributed to the difference in the age of the forests. Another species that predominated in the density of plot I was *Parkia panurensis*, which is extremely important in tropical forests since its fruits serve as food for birds and mammals such as primates (Rimachi *et al*., 2019), This specification maintains the dynamics of the forests and is an indicator that there is already an adequate balance of restoration between the different living beings existing in the BRUNAS. Regarding the variability found between the quadrants for the species in the two permanent plots, a close to 38.03% is observed, characteristic of the dynamics of the forests that are in transition to primary forest. The fluctuations of these parameters are of great importance since they allow to have knowledge of the place to develop and execute a management plan. Likewise, the study in both subplots, 107 and 117 species per hectare were determined (Tables 1 and 2), these values indicate that the secondary forest is diverse with slight variations between the observation points, this is advantageous since it maintains a balance to the diversity of living beings that inhabit this study area (Tapia *et al.*, 2019). This abundance of species is an important source to reach natural regeneration and establish restoration activities near the study area (López *et al.*, 2019).

On the other hand, according to Tables 6 and 7, twelve vegetative species with medicinal properties were identified: *Alchornea glandulosa, Cecropia sciadophylla, Cedrelinga cateniformis, Helicostylis tomentosa, Hevea guianensis, Jacaranda copaia, Laetia procera, Marila tomentosa, Osteophloeum- platyspermum, Otoba parvifolia, Parkia panurensis and Tapirira guianensis, and eleven genera, also with medicinal properties, such as: Alchornea, Caseria, Dacryodes, Guaterria, Marila, Neea, Pourouma, Psychotria, Qualea, Schefflera* and *Schizocalyx*. Both of these species and genera can be used parts of the plant such as leaves, stems, bark, flowers and fruits for the preparation of brews, infusions, extracts, cataplasm for the treatment of various diseases and ailments such as: bacterial infections (*Helicobacter pylori,* Leishmaniasis), diabetes mellitus, kidney infections, wounds and ulcers, intestinal parasites, syphilis, ringworm, benign prostatic hyperplasia, malaria, loxoscelism, cancer, scabies, mycosis, Zika, liver damage and others.

A study carried out by the World Health Organization indicates that plant-based medicines can be derived from various parts of the plant, this includes leaves, flowers, fruits, seeds, stem or bark of the tree (WHO, 2000). It is said that 80% of the world population depends on medicinal plants (Brazil, 2006) and in developing countries they are much more dependent on these natural resources to access, in the first instance, health (Ekor, 2014). This reliance on plants with health was recognized by the WHO in the 1970s and therefore strategies were implemented with the help of all member countries to integrate herbal medicines in order to make health accessible for everyone (Brazil, 2012). The use of medicinal plants for the treatment of various diseases has been traced from its earliest beginnings dating back to 8,500 BC (Leite *et al*., 2021), with the Chinese, through Traditional Medicine and Ayurvedic, two of the practices more deeply rooted and that continue with high prestige today (Patwardhan *et al*., 2005). On the other hand, medicinal plants have served as inspiration for the synthesis of a large number of conventional drugs currently on the market, used to treat acute and chronic diseases (Leite *et al*., 2021). However, this growing industry of conventional medicines has also deteriorated the gradual traditional knowledge that was had of how to use medicinal plants, all this based on skepticism towards medicinal herbs and industrial interest in scaling production, something easier to do with synthetic drugs (Leite *et al*., 2021). However, there are nations that have prospered from their integration of traditional knowledge. China is an example where ancient practices have been transformed into a regulatory framework for herbal medicines, rooted in science (Patwardhan *et al*., 2005).

The Covid-19 pandemic has offered a sober reminder of the importance of herbal medicines as they are vital in the race to develop effective medicines and further extend public health care to all. Phytotherapy has several advantages, such as being applicants for new antivirals, which often have fewer side effects than synthetic drugs and have a remarkable ability to prevent the reproduction or synthesis of the genome of some virus. Also, a recent clinical study showed better recovery from Covid-19 and its side effects, such as shortness of breath when supplementing conventional medications with herbal medicines. Additionally, having the possibility of expanding access to health, herbal-based medicines play a role in different spheres of social, economic and environmental sustainability. Growing socioeconomic inequalities and the threatening effects of climate change worldwide have made medicinal herbs a hot topic also on the production side (Palhares *et al*., 2021). The cultivation of medicinal plants can be used as a strategy to support income generation, to conserve biodiversity and promote local economic development in a way that keeps forests standing (Malhi *et al*., 2008). The conservation of forests, in turn, is essential to avoid runaway climate change. The Amazon, for example, is key to the regional and global water cycle and a key carbon sink, in addition to its local sociocultural value (Bastos Lima *et al*., 2021; Lovejoy & Nobre, 2018). Drastic changes in land use, particularly those associated with large-scale deforestation and forest degradation, have been shown to have a severe impact on precipitation patterns, not only locally but globally (Chagnon & Bras, 2005), causing the Appreciation of medicinal herbs and their potential to stop the destruction of forests is more important than ever. The value of phytotherapy for the promotion of a bioeconomy has also been recognized, since it encompasses economic activities and value chains based on biodiversity (Bastos Lima, 2022, Palhares *et al*., 2021, Martvall & Lindberg, 2022).

Conflict of interests

No conflict of interest is reported.

Acknowledgments

To our educational institutions.

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