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Article

Vegetación arbórea del Cerro Tres Puntas de Pilasca, (Salas-Motupe), Lambayeque, Perú

Arboreal vegetation of the *Cerro Tres Puntas de Pilasca, (Salas-Motupe), Lambayeque, Perú*

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Resumen:

De marzo a junio de 2018 se estudió el bosque estacionalmente seco en Cerro Tres Puntas de Pilasca (Salas-Motupe, Lambayeque, Perú) con la finalidad de obtener información sobre su estructura y composición florística. En un transecto lineal de 11.4 ha, aproximadamente, se evaluaron especímenes de plantas leñosas con DAP ≥ 5.0 cm. Se registraron 410 individuos que representan a 17 especies, 17 géneros y 10 familias. Los taxones más abundantes fueron *Vachellia macracantha* (Fabaceae 154 individuos) y *Celtis iguanaea* (Cannabaceae 55 individuos) y las familias mejor representadas corespondieron a Fabaceae, con siete especies y Malvaceae, con dos. El área basal total fue de 343.86 m^2 ha^{-1}, en la que destacan *Ficus obtusifolia* con 139.23 m^2 ha^{-1} y *Beilschmiedia sulcata* con 120.90 m^2 ha^{-1}. El Índice de Valor de Importancia alcanzó los mayores valores en *F. obtusifolia* (49.34), *V. macracantha* (46.75) y *C. ruizii* (41.57); en tanto que el Índice de Valor de la Familia fue más alto para Fabaceae, con 111.86, seguida de Moraceae (46.74) y Lauraceae (45.33). Si bien, los resultados muestran que este bosque es una versión precaria de los existentes en la región, todavía se identificó la presencia de individuos de *F. obtusifolia* entre 35 - 39.9 m de altura y DAP de 210 a 219.9 cm. El presente estudio contribuirá a desarrollar un programa de conservación, y de reforestación eficaz para mejorar el bosque del Cerro Tres Puntas, ubicado en una de las áreas más pobres del país.

Palabras clave: Área basal, bosque estacionalmente seco, distribución diamétrica, diversidad florística, estructura florística, Lambayeque.

Abstract:

From March to June, 2018 the seasonally dry forest *Cerro Tres Puntas* of *Pilasca (Salas-Motupe, Lambayeque, Perú*) was studied, in order to obtain information on its structure and its floristic composition. In a linear transect, about 11.4 ha, specimens of woody plants with DBH ≥ 5.0 cm were assessed. 410 individuals representing 17 species, 17 genera and 10 families were recorded. The most abundant species were *Vachellia macracantha* (Fabaceae 154 individuals) and *Celtis iguanaea* (Cannabaceae 55 individuals). The families with the highest number of species were Fabaceae (7) and Malvaceae (2). The basimetric area was 343.86 m^2 ha^{-1} highlighting *Ficus obtusifolia* with 139.23 m^2 ha^{-1} and *Beilschmiedia sulcata* with 120.90 m^2 ha^{-1}. The Importance Value Index for the species reached the main values in *F. obtusifolia* (49.34), *V. macracantha* (46.75) and *B. sulcata* (41.57), while the Family Value Index was widely higher in the Fabaceae family (111.86). While these results show that this forest is a precarious version of the region's, *F. obtusifolia* individuals between 35-39.9 m high and 210-219.9 cm DBH were found. This study will help to accomplish an efficient conservation and reforestation program in order to improve the *Cerro Tres Puntas* forest, located in one of the poorest areas of the nation.

Key words: Basimetic area, seasonally dry forest, diametric distribution, floristic diversity, floristic structure, *Lambayeque*.

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Introduction

The seasonally dry forest (BES, for its acronym in Spanish)) in the Neotropics are distributed from northern Mexico to southern Brazil and make up 66.7 % of this type of vegetation in the world (Miles *et al.,* 2006). In *Perú*, BES are threatened and under-studied ecosystems and comprise several subtypes (Linares-Palomino, 2006; Linares-Palomino and Pennington, 2007). The mountain and plain BES of the north coast are very fragile; they extend from the *Peninsula Santa Elena*, in southern *Ecuador*, to several regions of northwestern *Perú*, among which are *Tumbes, Piura, Lambayeque* and northern *La Libertad*, as well as the lower layer of the *Marañón* Valley. These two areas communicate through the *Porculla* Pass, although they are distinct phytogeographic units (Brack and Mendiola, 2004). It is also known as the *Tumbesina* endemism region, which is shared by *Ecuador* and *Perú*, and it is considered one of the most important areas worldwide for this reason (Aguirre *et al*., 2006).

Some studies have revealed the large number of endemic species present in the BES of northern and northwestern *Perú*, with about 26 % of them disseminated in various communities, such as *Prosopis limensis* Benth. (*carob*) and *Colicodendron scabridum* Seem. (*zapote*) (Sagástegui *et al.,* 1999). But not only the levels of diversity and endemism refer to plants but also to vertebrates such as *Tremarctos ornatus* Cuvier, 1825 (Spectacled bear), *Lagidium Perúanum* Meyen, 1833 (V*izcach*a), *Penelope albipennis* Taczanowski, 1878 (*Pava aliblanca*) and *Bothrops barnetti* Parker, 1994 (*Macanche*), among others (Aguilar, 1994).

The works on the BES, although not very abundant, have been significant, among which those carried out by Weberbauer (1922; 1930; 1936; 1945) are particularly interesting, as he contributed floristic and phytogeographic aspects of the flora of *Perú* and elaborated a map of vegetation, hitherto unsurpassed, with emphasis on BES. In the past decade, the annotated list of woody species and plant formations in the BES of the *Tumbesian* Endemic Region of *Ecuador* and *Perú* (Aguirre *et al*., 2006) as well as woody plants as a new online tool for taxonomic ecological and biodiversity studies stand out (Linares-Palomino and Pennington, 2007).

Based on data from forest inventories, the structure and diversity patterns of the BES of two conservation areas of the Northwest Biosphere Reserve (*Perú*), the *Cerros de Amotape* National Park and the *Tumbes* Reserved Zone were analyzed and discussed (Leal-Pinedo and Linares-Palomino, 2005). Also addressed were the spatial distribution patterns of tree species such as *Eriotheca ruizzii* (K. Schum.) A. Robyns (*pasayo), Bursera graveolens* Triana & Planch. (*palo santo*), *Caesalpinia glabrata Kunth (charán*) and *Cochlospermum vitifolium* (Willd.) Spreng. (*polo polo*), in a BES of the *Cerros de Amotape* National Park, in northwestern *Perú* (Linares-Palomino, 2005). In the surroundings of *Jaén (Cajamarca, Perú*), in relicts of the seasonally dry tropical forest, eight inventories were made on woody vegetation, endemisms and conservation status (Marcelo-Peña, 2008).

On the other hand, in order to design maps and classify vegetation in seasonal ecosystems of the dry forests of *Piura (Perú*), with data from floristic inventories, six groups of vegetation were identified, of which five coincided with types of vegetation described 100 years ago by Weberbauer (1922; 1930; 1936; 1945) (La Torre-Cuadros and Linares-Palomino, 2008). In the *Ayabaca* province (*Piura*), the edaphic characteristics and floristic composition of *La Menta* and *Timbes* BES were evaluated (Rasal *et al*., 2011).

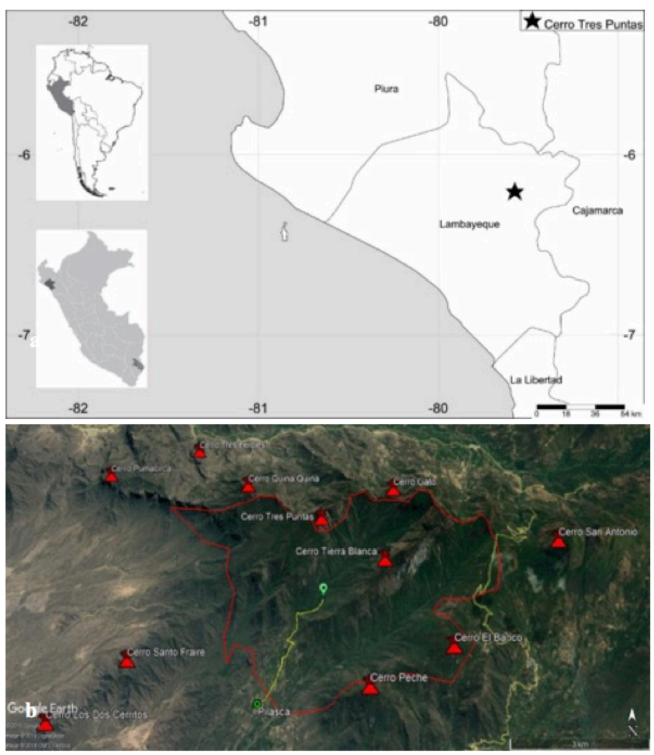
In the *Lambayeque* region (*Perú*), some studies have also been carried out at the BES. In the *Chaparrí* Ecological Reserve, which is part of the *Tumbes-Chocó-Magdalena* hot spot of biodiversity, a structural pattern and floristic inventory was developed, from which a fairly impoverished forest became evident, in relation to other BES in the region (Linares-Palomino and Ponce-Álvarez, 2009). In this same *Chaparrí* Private Ecological Reserve, the phenology (vegetative development, flowering and fruiting) of 17 plant species that feed the white wing turkey (*pava aliblanca*), an endemic species seriously threatened (Martos *et al*., 2009), was assessed.

Based on the above, in addition to the fact that the natural forests of *Perú* have been poorly studied, that the anthropic pressure that leads to their predation is increasing, that climate change continues to alter the patterns of plant distribution, among other factors (Steffen *et al.,* 2011), the present work was carried out with the aim to determine the floristic composition of the BES of *Cerro Tres Puntas* with the purpose of facilitating the elaboration of reforestation, conservation and utilization plans and, thus, contributing to the knowledge of the natural ecosystems of the country.

Materials and Methods

Study area

The study area is located between 6°14'16.23" S - 79°35'34.81" W and 6°12'46.46" S - 79°33'59.58" W, and includes *Cerro Tierra Blanca* (1 986 masl), *Cerro Gato* (1 545 masl), both belonging to the *Salas* district, and *Cerro Tres Puntas* (1 590 masl), from the *Motupe* district, in the province and region of *Lambayeque, Perú* (Figures 1a-b); these three hills cover around 2 975 ha.



Source: Google Earth (2019).

Figure 1. a) Map of the *Lambayeque* region where *Cerro Tres Puntas* is located and the village of *Pilasca* is indicated with a star. b) Area comprising the *Tierra Blanca, Cerro Gato* and *Cerro Tres Puntas* of the BES (*Salas-Motupe, Lambayeque, Perú*).

The *Pilasca* village is one of the poorest in *Lambayeque* (Gobierno Regional de Lambayeque, 2013) where the maize agriculture (*Zea mays* L.), yucca (*Manihot esculenta* Crantz) and fruit trees, as well as cattle and goat breeding is for subsistence; it grows in small clearings in the forest, where there is no seed selection, fertilizers or control of pests and diseases. The peasants of *Pilasca* have used the forest species since ancient times for the manufacture of furniture, construction of rustic houses and pens as well as firewood as fuel, which is why *Loxopterygium huasango* Spruce ex Engl. (*hualtaco*), *Handroanthus chrysanthus* (Jacq.) S. O. Grose (yellow *guayacán*), *Colicodendron scabridum* (Kunth) Seem. (*zapote*), *Prosopis limensis* Benth. (carob tree) and *Cedrela* sp. (cedar) practically no longer exist.

In the geological aspect, the study area corresponds to the litho-stratigraphic unit *Salas* Group (Oi) of the Paleozoic or *Salas* Formation, (Pi-s) Lower Ordovician (480 to 470 million years) (Gobierno Regional de Lambayeque, 2013; López, 2013).

The area in which the research was conducted is a seasonally dry semi-dense forest ecosystem of hill and mountain (Bes-cm) (Minam, 2019). The data was collected in a place between 373 and 720 masl; the extreme point A corresponds to the entrance of the *Pilasca* village (373 m), where the evaluation began, to the extreme point E (720 masl), where it ended, whose topography is rugged with huge boulders and deep ravines, dry and scarce stony clearings. The temperature, relative humidity and precipitation data were taken from the *Jayanca* CO-Meteorological Station (LA Vic) (78 masl), the closest to *Cerro Tres Puntas de Pilasca*, from which the following data were recorded: maximum and minimum temperature and relative humidity of March 2018, 34.0 and 19.0 ºC and 78.4 %, respectively, while in June 2018, 26.2 and 15.0 ºC and 79.1 %, respectively. In these four months of evaluation, the precipitation was 0.0 mm day^{-1} (Senamhi, 2018).

Sampling

Field work was carried out from March to June 2018 and the method proposed by Gentry (1982; 1995a) was used for the sampling of woody plants, with substantial modifications from the difficult access and dangerous geography of the land. A linear sampling was applied taking as a baseline a relatively safe trail that the locals use to occasionally access the top of *Cerro Tres Puntas de Pilasca* (Figure 2).

Figure 2. Study area showing the *Cerro Tres Puntas* (*Salas-Motupe, Lambayeque, Perú).*

Four sampling units were established in a total area of 3 801 m, designated with points A (373 masl) -B (456 masl), BC (565 masl), CD (677 masl) and DE (720 masl), which covered 958 m, 961 m, 968 m and 914 m, respectively. From the center of the trail were measured 15 m to the right and 15 m to the left, making a total of 30 m which allowed to evaluate about 114 030 m^2, with a GPS Garmin 60CSX and a measuring tape. All woody individuals whose DBH (1.3 m from the base of the trunk) was ≥ 5.0 cm were recorded, taken as a measure of the basimetric area with a measuring tape.

For individuals with branched trunks, the diameter of each branch was measured at a height of 1.3 m from the base of the trunk, with a diametric tape Forestry Suppliers, Inc. (Modelo 283D/5M). As the species evaluated were known, only botanical samples were taken for registration and deposit in the Herbarium of the *Universidad Nacional Pedro Ruiz Gallo de Lambayeque* (HPR Herbarium). Likewise, herbaceous species, present in the collection area, were picked up and pressed for subsequent taxonomic identification. For families, the phylogenetic postulates of the Phylogeny Group of Angiosperms were followed (APG, 2009; 2016).

Information processing and analysis

To determine the abundance or density of the sampled species, the classification of Maleheiros and Rotta (1982) was used, which classifies as rare or scarce species with 1-6 individuals, not very abundant with 7-25 and abundant with more than 25 specimens. The horizontal structure of the forest was described from the distribution of the number of trees by diameter and height class (Hawley and Smith, 1972). Phytosociological analyzes were done through the FITOPAC 2.1 freeware (Shepherd, 2010). With this support, the following parameters were calculated: Relative Density (DER), Relative Frequency (FER), Relative Basimetric Area (AB) or Relative Coverage (COB), Importance Value Index (IVI) and Importance Value for the Family (VIF), formulas that were described by Rangel and Velásquez (1997).

Results

Floristic composition

In the 114 030 m^2 studied, 410 individuals of trees and shrubs with DAP≥5.0 cm were inventoried, corresponding to 17 species, 17 genera and 10 families, registered in 47 sampling units (Table 1). To these arboreal and shrub species were added numerous herbaceous plants with different growth habits such as vines, epiphytes, sub-shrubs, flowers, among others, collected with flowers and fruits in May 2018, among which can be mentioned: *Salvia occidentalis* Sw. (Lamiaceae), *Psittacanthus chanduyensis* Eichler (Loranthaceae), *Croton pavonis* Müll. Arg. (Euphorbiaceae), *Scutia spicata* (Wild.) Weberb. (Rhamnaceae), *Alternanthera pubiflora* Kuntze (Amaranthaceae), *Dalechampia scandens* L. (Euphorbiaceae), *Cordia macrocephala* (Desv.) Kunth (Boraginaceae), *Plumbago scandens* L. (Plumbaginaceae), *Heliotropium angiospermum* Murray (Boraginaceae), *Waltheria ovata* Cav. (Malvaceae), *Wedelia latifolia* DC. (Asteraceae), *Cardiospermum corindum* L. (Sapindaceae), *Tessaria integrifolia* Ruiz & Pav. (Asteraceae), *Pseudogynoxys cordifolia* (Cass.) Cabrera (Asteraceae), *Tetramerium nervosum* Nees (Malvaceae), *Scoparia dulcis* L. (Scrophulariaceae)´and *Cestrum auriculatum* L'Hér. (Solanaceae).

Table 1. Main tree mensuration features of the species present at the assessed area of *BES Cerro Tres Puntas (Salas-Motupe, Lambayeque, Perú).*

Family/Species	Common name	Growth hab.	Num. indiv./%	Sampling unit	DBH (cm)	Total height (m)	Crown diam. (m)
Anacardiaceae							
Loxopterygium huasango Spruce ex Engl.	*Hualtaco*	Tree	20/ 4.9	4	27.79	12.83	8.84
Boraginaceae							
Cordia lutea Lam.	*Overo*	Tree/☐ Shrub	29/ 7.1	3	1.83	5.97	6.52
Burseraceae							
Bursera graveolens (Kunth) Triana & Planch.	*Palo santo*	Tree	4/ 1.0	2	22.45	11.00	6.88
Fabaceae							
Albizia multiflora (Kunth) Barneby & J.W. Grimes	*Angolo*	Tree	8/ 2.0	4	33.39	14.75	11.43
Caesalpinia glabrata Kunth	*Charán*	Tree	5/ 1.2	1	11.92	7.00	6.92
Erythrina smithiana Krukoff	*Frejolillo*	Tree	32/ 7,8	3	36.03	11.69	9.14
Pithecellobium excelsum (Kunth) Mart.	*Chaquiro*	Tree/☐ Shrub	21/ 5.1	4	11.04	7.33	9.64
Prosopis limensis Benth.	*Algarrobo*	Tree	9/ 2.2	1	37.31	16.56	12.89
Senna atomaria (L.) Irwing & Barneby	*Chapa*	Tree	15/ 3.7	2	9.83	5.47	4.23

Vachellia macracantha (Willd.) Seigler & Ebinger	*Faique*	Tree/☐ Shrub.	154/ 37.6	4	16.34	8.54	8.99
Lauraceae							
Beilschmiedia sulcata (Ruiz & Pav.) Kosterm	*Palta de zorro*	Tree	1/ 0.2	1	124.10	12.00	22.10
Malvaceae							
Eriotheca ruizii (K. Schum.) A. Robyns	*Pasayo*	Tree	6/ 1.5	1	31.3	10.58	7.37
Guazuma ulmifolia Lam.	*Guazumo*	Tree	11/ 2.7	3	27.42	12.83	10.52
Moraceae							
Ficus obtusifolia Kunth	*Higuerón*	Tree	17/ 4.2	4	120.06	19.35	24.00
Olacaceae							
Ximenia americana L.	*Ciruelillo*	Tree	17/ 4.2	3	11.40	10.06	5.9
Sapindaceae							
Sapindus saponaria L.	*Choloque*	Tree	6/ 1.5	3	17.6	10.00	6.45
Cannabaceae							
Celtis iguanaea (Jacq.) Sarg.	Palo blanco	Tree	55/ 13.4	4	38.48	14.62	12.99
Total			410	47	26.20	10.45	9.81

Growth hab. = Growth habit; Num. indiv. = Number of individuals; DBH=Diameter at l Breast Height; Crown diam. = Crown diameter.

Structure

Of the 17 inventoried species, few specimens of *Cordia lutea* Lam., *Vachellia macracantha* (Willd.) Seigler & Ebinger and *Pitecellobium excelsum* (Kunth) Benth. showed bush growth habit with more than 10 shafts per individual, in some cases. Of the total recorded species, only six - *L. huasango, V. macracantha, P. excelsum, Albizia multiflora* (Kunth) Barneby & J.W. Grimes, *Ficus obtusifolia* Kunth and *Celtis iguanaea* (Jacq.) Sarg.-were found in the four sampling units, while *Caesalpinia glabrata* Kunth, *P. limensis, E. ruizii* and *Beilschmiedia sulcata* (Ruiz & Pav.) Kosterm. were only found in one of them.

The largest number of the 410 inventoried individuals corresponded to the third sampling unit (565-677 masl) with 194 (47.32 %), which is attributed to the fact that it is a very rugged and stony territory, where it is not possible to develop agricultural activities ; in contrast, in the second sampling unit (456-565 masl) the lowest number was counted, 42 individuals (10.24 %), which can be explained because it is the area with the greatest agricultural vocation, which has led to a dramatic depredation of this part of the forest (Table 2).

Table 2. Distribution per sampling unit of the individuals from the species found in the assessed area of the *BES Cerro Tres Puntas (Salas-Motupe, Lambayeque, Perú).*

Species	Sampling units							
	1		2		3		4	
	N°	%	N°	%	N°	%	N°	%
Beilschmiedia sulcata (Ruiz & Pav.) Kosterm	0	0.0	0	0.0	0	0.0	1	1.56
Bursera graveolens Triana & Planch.	2	1.82	0	0.0	2	1.03	0	0.0
Caesalpinia glabrata Kunth	0	0.0	0	0.0	5	2.58	0	0.0
Celtis iguanaea (Jacq.) Sarg.	9	8.18	7	16.67	23	11.86	16	25.00
Cordia lutea Lam.	10	9.10	2	4.76	17	8.76	0	0.0
Erythrina smithiana Krukoff	0	0.0	1	2.38	26	13.40	5	7.81
Eriotheca ruizii (K. Schum.) A. Robyns	0	0.0	0	0.0	6	3.09	0	0.0
Ficus obtusifolia Kunth	1	0.91	1	2.38	3	1.55	12	18.75
Guazuma ulmifolia Lam.	4	3.64	5	11.90	2	1.03	0	0.0
Loxopterygium huasango Spruce ex Engl.	2	1.82	4	9.52	12	6.19	2	3.13
Pithecellobium excelsum (Kunth) Mart.	11	10.0	4	9.52	5	2.58	1	1.56
Albizia multiflora (Kunth) Barneby & J.W. Grimes	2	1.82	2	4.76	2	1.03	2	3.13
Prosopis limensis Benth.	9	8.18	0	0,0	0	0.0	0	0.0
Sapindus saponaria L.	1	0.91	3	7.14	2	1.03	0	0.0
Senna atomaria (L.) Irwing & Barneby	9	8.18	6	14.29	0	0.0	0	0.0
Vachellia macracantha (Willd.) Seigler & Ebinger	47	42.73	7	16.67	81	41.75	19	29.69
Ximenia americana L.	3	2.73	0	0.0	8	4.12	6	9.38
Total = 410 individuals	110	26.83	42	10.24	194	47.32	64	15.61

The upper canopy consisted of dominant trees of *F. obtusifolia* and *P. limensis*, although with very dispersed individuals. The tallest trees were *F. obtusifolia* with a height of 19.35 m followed by *P. limensis* (with 16.56 m), *P. excelsum* (with 14.75 m) and *C. iguanaea*, (with 14.62 m) in a distribution of heights that is not quite an inverted "J", as expected for natural forests and regular forests.

The crown diameter was larger in *F. obtusifolia* (with 24.00 m) followed by *B. sulcata* (with 22.10 m) (Table 3). In a similar way, in the horizontal structure of the forest, it was determined that in transect 4, individuals of greater height (13.59 m) and diameter (48.99 cm) were registered, which is much greater than the diameter recorded in transect 1 with 20.11 cm, which is half of its size (Table 4).

Table 3. Distribution of individuals by diametric class, height class and density of the species present in the assessed area of the BES *Cerro Tres Puntas (Salas-Motupe, Lambayeque, Perú).*

Diametric class (cm)	Individuals (Number)	Diametric class (m)	Individuals (Number)	Density	Species (Number)
5 – 9.9	86	0 – 4.9	9	Abundant	4
10 – 19.9	128	5 – 9.9	205	Little abundant	8
20 – 29.9	77	10 – 14.9	129	Rare o scarce	5
30 – 39.9	53	15 – 19.9	44		
40 – 49.9	29	20 – 24.9	15		
50 – 59.9	17	25 – 29.9	5		
60 – 69.9	4	30 – 34.9	2		
70 – 79.9	2	35 – 39.9	1		
80 – 89.9	2				
90 – 99.9	0				
100 – 109.9	1				
110 – 119.9	2				
120 – 129.9	3				
130 – 139.9	1				
140 – 149.9	0				
150 – 159.9	0				
160 – 169.9	1				
170 – 179.9	1				
180 – 189.9	0				
190 – 199.9	1				
200 – 209.9	0				
210 – 219.9	2				
Total	410		410		17

Table 4. Horizontal structure of the forest from the distribution of tree species by height and diameter class of the species present at the transects of the assessed area of the *BES Cerro Tres Puntas (Salas-Motupe, Lambayeque, Perú).*

Transect	**Number of individuals**	**Height (m)**	**Diameter (cm)**
		Mean ± sd	**Mean ± sd**
1	110	10.21 ± 4.35	20.11 ± 12.28
2	42	10.33 ± 4.99	21.65 ± 12.52
3	194	9.58 ± 3.74	23.11 ± 24.25
4	64	13.59 ± 6.71	48.99 ± 44.92

Density

The species with the highest number of individuals and, thus, with the highest relative density (DER) was *V. macracantha,* con 154 (37.6 %), followed by *C. iguanaea* with 55 (13.4 %) and *Erythrina smithiana* Krukoff. with 32 (7.8 %); therefore, Fabaceae (59.4 %) and Cannabaceae (13.1 %) accomplished the highest values, while fue *B. sulcata* (0.2 %) had the lowest (Tables 1 and 4). Relative frequency (FER) achieved the greatest value (8.51) in several species, in addition to *V. macracantha*, en *L. huasango*, *P. excelsum*, *A. multiflora*, *F. obtusifolia* and *C. iguanaea*. Four species, *V. macracantha*, *C. lutea*, *E. smithiana* and *C. iguanaea* have been considered abundant, eight little abundant and five, rare or scarce, such as *B. graveolens*, *C. glabrata*, *E. ruizii*, *C. iguanaea* and *B. sulcata*, the latter just with one specimen (Table 3).

Basimetric area

The maximum value of DAP corresponded to *B. sulcata* with 124.10 cm followed by *F. obtusifolia*, (120.06 cm), C. iguanaea (38.48 cm) and *P. limensis* (37.31 cm), although *B. sulcata* only recorded one individual and *P. limensis,* eight (Table 1). With the exception of the 5-9.9 cm DAP class with 86 individuals, the analysis of the diametric distribution indicated that trees in the transects were in the 10-19.9 cm DAP (205) and 20-29.9 cm DAP classes (129), whose proportion decreased as the diameters increased (Table 3). The accumulated value of the basimetric area was 343.86 m^2 ha^{-1} from *B. sulcata* 139.28 m^2 ha^{-1} and *F. obtusifolia* (120.90 m^2 ha^{-1}) The largest relative coverage (COB) or wider relative basal area coincides with the same species (*B. sulcate* with 39.19 and *F. obtusifolia* with 36.68), followed very distantly, by *C. iguanaea* (3.77), *P. limensis* (3.54) and *E. smithiana* (3.30), and at the family level, Lauraceae (39.19), Moraceae (36.68) and Fabaceae (11.28) were outstanding (Table 5).

Table 5. Ecological variables of the species present in the assessed area of the BES *Cerro Tres Puntas (Salas-Motupe, Lambayeque, Perú).*

Family/Species	Number of species	Number of individuals	DER	FER	Basimetric area (m^2)	Relative basimetric area (COB)	IVI	VIF
Anacardiaceae								
Loxopterygium huasango Spruce ex Engl.		20	4.88	8.51	6.06	1.97	15.35	
Total Family	1	20	4.88	8.51	6.06	1.97	15.35	12.73
Boraginaceae								
Cordia lutea Lam.		29	7.07	6.38	0.92	0.30	13.74	
Total Family	1	29	7.07	6.38	0.92	0.30	13.74	13.27
Burseraceae								
Bursera graveolens (Kunth) Triana & Planch.		4	0.98	4.26	3.95	1.28	6.53	
Total Family	1	4	0.98	4.26	3.95	1.28	6.53	8.16
Fabaceae								
Albizia multiflora (Kunth) Barneby & J.W. Grimes		8	1.95	8.51	8.75	2.84	13.30	
Caesalpinia glabrata Kunth		5	1.22	2.13	1.11	0.36	3.71	
Erythrina smithiana Krukoff		32	7.80	6.38	10.19	3.30	17.49	
Pithecellobium excelsum (Kunth) Mart.		21	5.12	8.51	0.96	0.31	13.94	
Prosopis limensis Benth.		9	1.95	2.13	10.93	3.54	7.62	
Senna atomaria (L.) Irwing & Barneby		15	3.66	4.26	0.76	0.25	8.16	
Vachellia macracantha (Willd.) Seigler & Ebinger		154	37.56	8.51	2.09	0.68	46.75	
Total Family	7	244	59.40	40.50	34.79	11.28	110.97	111.86
Lauraceae								
Beilschmiedia sulcata (Ruiz & Pav.) Kosterm		1	0.24	2.13	120.90	39.19	41.57	
Total Family	1	1	0.24	2.13	120.90	39.19	41.57	45.33
Malvaceae								
Eriotheca ruizii (K. Schum.) A. Robyns		6	1.46	2.13	9.74	2.49	6.80	
Guazuma ulmifolia Lam.		11	2.68	6.38	6.53	1.91	10.98	
Total Family	2	17	4.16	8.52	16.27	4.40	17.78	20.32
Moraceae								
Ficus obtusifolia Kunth		17	4.16	8.51	139.28	36.68	49.34	
Total Family	1	17	4.16	8.53	139.28	36.68	49.34	46.74
Olacaceae								
Ximenia americana L.		17	4.15	6.38	0.92	0.33	10.86	
Total Family	1	17	4.15	6.38	0.92	0.33	10.86	10.38
Sapindaceae								
Sapindus saponaria L.		6	1.46	6.38	2.69	0.79	8.63	
Total Family	1	6	1.46	6.38	2.69	0.79	8.63	8.15
Cannabaceae								
Celtis iguanaea (Jacq.) Sarg.		55	13.41	8.51	13.38	3.77	25.70	
Total Family	1	55	13.41	8.51	13.38	3.77	25.70	23.08
Total	17	410	100	100	343.86	100	300	300

Importance Value Index per Species (IVI) and Importance Value Index per Family (VIF)

The IVI analysis of the 17 assessed speciesEl análisis del IVI de las 17 especies highlighted *F. obtusifolia* (49.34) over *V. macracantha* (46.75) and *C. ruiziana* (41.57) y, and so, Fabaceae (110.97), Moraceae (49.34) and Lauraceae (41.57) (Table 5). These same families recorded the highest VIF (Fabaceae, 111.86; Moraceae, 46.74 and Lauraceae, 45.33), while those ewith the loest numbers were Burseraceae (8.16) and Sapindaceae (8.15) (Table 5).

Discussion

The sampling area is classified as seasonally dry mountain forests on the north coast that covers the BES over 500 masl, and covers the western flanks of the *Andes* in the *Tumbes, Piura* and *Lambayeque* regions to *La Libertad,* including part from *Cajamarca* (Linares-Palomino and Pennington, 2007). However, as indicated by La Torre-Cuadros and Linares-Palomino (2008), this altitudinal limit is quite variable, debatable and depends on several factors. As sampling began at 373 masl, it engulfed a small area of the plain BES on the north coast that covers the BES below 500 masl along the western flanks of the *Andes* from *Tumbes* to *La Libertad* (Linares- Palomino and Pennington, 2007). This would be the reason why, under the conditions of *Pilasca*, there was little presence of *carob (P. limensis*) and only a single specimen of *zapote (C. scabridum*) and others of *vichayo* (*Beautempsia avicennifolia* (Kunth) Gaudich.); the latter outside the sampling area.

These authors also pointed out, that the dry mountain BES at the north coast as those of the interandine system of the *Marañón* river, are the richest in woody species with 193 and 184, respectively. Such information has been confirmed by the study conducted in the seasonally dry tropical forest (BTES) of the *Marañón* valley, in northern *Perú*, in which 440 woody species, and 143 (33 %) endemic, as well as two endemism centers were identified within the valley, with 56 % of species and 78 % of genera found in Peruvian BTES (Marcelo-Peña *et al.,* 2016).

In the analysis of species diversity patterns ─4660 woody plant species─ of BTES from Latin America and the Caribbean, it was determined that the outstanding floristic rotation observed implies the need to establish multiple conservation areas to protect such a great flora diversity (DRYFLOR *et al.*, 2016).

Even though an annotated list of the BES of Ecuador and other related studies (Svenson, 1946; Gentry, 1995b; Aguirre *et al.,* 2006) indicated that the BES of Ecuador and *Perú*, especially those of the coast, formed a single geographical unit, with a high number of endemic species (Tumbesino Endemic Center), the few species (17), genera (17) and families (10), inventoried in the *Cerro Tres Puntas de Pilasca*, would demonstrate a high degree of depredation of the original flora. This would confirm what has already been observed in other BES such as *Chaparrí* in *Lambayeque* (Linares-Palomino and Ponce-Álvarez, 2009; Martos *et al*., 2009) and *La Menta* and *Timbes* in *Piura* (Rasal *et al.,* 2011).

On the other hand, other factors such as the diversity and density of species and precipitation gradients, which decrease as the BES extend south, should be considered, including the *Lambayeque* and *La Libertad* regions.

Starting from the rugged and dangerous topography of the land, the linear sampling that was used in the present investigation made it possible to evaluate a large area that covered 11.4 ha, a sampling that has already been used in the rapid botanical inventories (IBR) in which it woody vegetation, endemisms and the conservation status of the BES of Jaén (*Perú*) were addressed (Marcelo-Peña, 2008), based on the methodology of Hawthorne and Abu-Juam (1995) and Gordon *et al*. (2004).

In spite of the interest in BES in recent years (Espinosa *et al*., 2012; Aguirre and Geada-López, 2017), in the few works carried out in *Ecuador* and *Perú* it was observed that the sampling methods were very variable between the use of rectangular transects and linear sampling, as well as in the size of the sample units, from 0.25 to 6.5 hectares and in the DAP of the sampled species, from ≥ 1.0 to 10 cm. The difference between the number of individuals, species, genera and families should be added, which is usually higher in protected natural areas such as the *Cerros de Amotape* National Park (Linares-Palomino, 2005) and very depressed in other historically depredated areas, as the *Chaparrí* Ecological Reserve (Linares-Palomino and Ponce-Álvarez, 2009).

From all of them, the closest to the described one here is that used in *La Menta* and *Timbes* in *Piura* (Rasal *et al*., 2011), where, despite the fact that woody species with only DAP ≥ 1.0 cm were registered, the number of inventoried individuals was significantly smaller, although there was quite similarity in the number of species, genera and families.

In their study at the *Chaparrí* Ecological Reserve, Linares-Palomino and Ponce-Álvarez (2009) pointed out the complication of establishing comparisons of inventories in the seasonally dry forests of the region, from the great variation between the sampling methodologies used, altitudinal floors, total sampling area, DAP of the sampled specimens, conservation status and depredation of the sampling area at the time of its realization, and even in the prioritization of the information collected, among other factors.

The previous arguments are confirmed by several studies in *Perú* such as those in the forests of *Jaén, Cajamarca* (Marcelo-Peña, 2008), *La Menta* and *Timbes* in *Ayabaca, Piura* (Rasal *et al*., 2011),Biosphere Northeaster Reserve of *Perú* (*Cerros de Amotape* National Park and *Tumbes* Reserved Zone) (Leal-Pinedo and Linares-Palomino, 2005), *Piura* coastal plains (La Torre-Cuadros and Linares-Palomino, 2008), *Cerros de Amotape* National Park (Linares-Palomino, 2005) and *Chaparrí* Ecological Reserve, *Lambayeque* (Linares-Palomino and Ponce-Álvarez, 2009); however, it has not been possible to establish rigorous patterns of comparison between all this valuable information and the study carried out at the *Cerro Tres Puntas de Pilasca.*

In the plant formations of the BES of *Ecuador* and *Perú*, lists of many woody species were made for the deciduous forest, semi deciduous dry forest mixed with evergreen species, deciduous forest and the dry thorny thicket (Aguirre *et al*., 2006; Aguirre and Kvist, 2009); however, in the actual work, only eight species were recorded: *P. limensis,* *C. lutea, P. excelsum, C. glabrata, V. macracantha, E. smithiana, B. graveolens* and *L. huasango*, which somehow, would indicate the strong pressure that *Cerro Tres Puntas de Pilasca* has suffered in recent years, even though it was possible to find sporadic individuals from *Bougainvillea peruviana* Nees & Mart., *Bauhinia aculeata* L., *C. vitifolium* and *C. scabridum* although they were outside the linear transect.

The trend of distribution of heights that does not fit exactly with the inverted "J", described by Lamprecht (1990) and Günter *et al*. (2011), would exhibit the succession characteristic of the forest from the constant and selective disturbances exerted by the local inhabitants, keeping it in a secondary succession stage (Rasal *et al*., 2012). Although the referred experience did not include individuals with DAP <5.0 cm, although with a plant height <4.9 m, its results allow a thorough understanding of the regeneration process of the species present in the higher diameter and height classes, as recommended by García *et al.* (2010) studying the structure and floristic diversity of two natural forests in *Cauca, Colombia.*

In BES *La Menta* and *Timbes* of *Piura (Perú)*, about 55.0 % of the sampled individuals had a DAP between 0-10.0 cm with some *L. huasango* and *B. graveolens* trees with DAP between 50-60 cm for *La Menta*, and *Ceiba trischistandra* Bakh. and E*. ruizii* with DAP between 80-90 cm for *Timbes* (Rasal *et al*., 2011). Regarding these five indicated species, at BES *Cerro Tres Puntas* only *E. ruizii* was found. Likewise, of the 410 registered individuals, 196 had DAP ≥ 20.0 cm, where three species, *V. macracantha, C. iguanaea* and *E. smithiana* contributed 58.8 % of the total.

Very few studies conducted in the dry forests of *Perú* have collected information or performed analyzes related to AB (Basimetric Area), IVI (Importance Value Index) and VIF (Importance Value for the Family); however, Linares-Palomino and Ponce-Álvarez (2009) calculated an AB of 11.74 m^2, in which *E. ruizii* and *L. huasango* stood out with 4.40 and 4.12 m^2, respectively in the *Chaparrí* Ecological Reserve (*Lambayeque).* In the dry forests of *La Menta* and *Timbes (Piura*), Rasal *et al*. (2011) estimated an AB of 128.86 m^2 in *La Menta*, in which *L. huasango* (45.97 m^2) and *B. graveolens* (34.69 m^2) stood out, and in *Timbes* an AB of 196.63 m^2 was obtained, with special contribution from *E. smithiana* (47.16 m^2) and *C. trischistandra* (38.88 m^2). In both cases, the AB was much lower than the one reported in the current study in which the AB was 343.86 m^2 ha^{-1}, which indicated that despite the fact that *the Cerro Tres Puntas* forest has suffered a strong anthropic pressure, it has not been as dramatic as what happened in *Chaparrí a*nd *La Menta* and *Timbes*, where even the *Chaparrí* forest was defined as an impoverished version of the seasonally dry forests of the region (Linares- Palomino and Ponce-Álvarez, 2009).

In this same community, four species recorded IVI numbers over 30.0: *E. ruizii* (58.22), *L. huasango* (44.93), *C. lutea* (33.76) and *B. graveolens* (30.08), which belong to the Malvaceae, Anacardiaceae, Boraginaceae and Burseraceae families, respectively (Linares-Palomino and Ponce-Álvarez, 2009); while in *La Menta*, *B. graveolens* (50.0), L. *huasango* (43.0) and *C. lutea* (36.0) had the highest values, and in *Timbes*, *C. lutea* (62.0), *E. smithiana* (40.0) and *C. trischistandra* (25.0) (Rasal *et al*., 2011); also, as mentioned above, in the work in the dry forests of the province of *Loja*, Aguirre *et al.* (2013). defined the five species with the highest IVI: *C. trischistandra, Simira ecuadorensis* (Standl.) Steyerm., *Tabebuia chrysantha* G. Nicholson, *E. ruizii* and *Terminalia valverdeae* A. H. Gentry, although no quantitative information was provided. When comparing these results with those of the present study, notorious differences are observed since the species that stood out were *F. obtusifolia* (49.34), *V. macracantha* (46.75) and *B. sulcata* (41.57), which were relevant in other seasonal forests. It is possible to hypothesize that the depredation of the species of these forests has not followed a definite pattern, and this would have been subject to the preference for the most valuable timber species and to the same protection that would have given them the local inhabitants, where, certainly, on the *Cerro Tres Puntas*, predation has been more selective.

The VIF results of the research described for the *Cerro Tres Puntas de Pilasca*, in which the families Fabaceae (111.86), Moraceae (46.74) and Lauraceae (45.33) stood out, disagree widely with those referred to *Chaparrí* (Linares-Palomino and Ponce-Álvarez, 2009), *La Menta* and *Timbes* (Rasal *et al*., 2011), since none of the families listed in these works has been recorded in the study carried out in the area of interest.

Conclusions

The study in *Cerro Tres Puntas de Pilasca (Salas-Motupe, Lambayeque*) contributes to the knowledge of the natural ecosystems of *Perú*, specifically that of seasonally dry forests, by determining their floristic structure and composition. In the context of biodiversity, the results obtained describe its plant richness, which is a valuable contribution to the conservation and management of these resources, and ecological data as a preliminary approach to the dynamics of the BES in the region.

It is suggested to extend the studies to other areas in the same *Tres Puntas* Hill, in adjacent geographical areas, in other BES of *Lambayeque* such as those of *Tongorrape, Ñaupe* and *Tocmoche* and even increase the altitude range of sampling. Also, conduct carbon capture assessments and identify the species that would most contribute to mitigate climate change and thus, to promote their large-scale multiplication for reforestation purposes.

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Conflict of interests

The authors declare no conflict of interests.

Contribution by author

Guillermo E. Delgado Paredes: planning and supervision of the project, writing of the manuscript; Cecilia Vásquez Díaz: field data collection; Fernando Tesén Núñez: field data collection; Boris Esquerre Ibáñez: field data collection and data analysis support; Felipe Zuñe Da Silva: data analysis and review of the manuscript; Consuelo Rojas-Idrogo: planning of the project, writing and review of the manuscript.

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