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DETERMINATION OF THE PHYTOGEOGRAPHIC AFFINITY INDEX OF THE TATACOA DESSERT ECO-REGION WITH OTHER COLOMBIAN DRY TROPICAL WOODLAND ZONES

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ABSTRACT

The main objective of this paper is the determination of the phytogeographic affinity index of the Ecological Region (eco-region) Tatacoa Dessert with other zones of tropical dry woodland in Colombia (TDW). This goal was achieved by conducting an extensive bibliographic review of both the number of existing vegetal species and their registration in the studied zone a common species to other countrywide territory in order to build a consolidated and to determine the similarity indexes by means of multivariate regression analysis techniques. The obtained results allowed us to establish the most suitable species in this living zone for their application to regreening labor, promoting the conservation of the native species which are appropriate for the tropical dry woodland in the Tatacoa dessert. This also calls for permitting to know the existing phytogeographic affinity among other zones in the Colombian nation so the plant cover in all the affected areas can be improved.

Keywords: Jaccard similarity index, tropical dry woodland, Tatacoa dessert.

1. INTRODUCTION

The Tatacoa is a region belonging to the Villavieja Township. It is located in the north part of the Huila State (about 200 miles southwest from Bogota) in the Magdalena river valley. This zone presents dry and erosive conditions for which the native plants are adapted by both morphological and physiological characteristics. According to the bioclimatic system proposed by Holdridge (1967), the Tatacoa belongs to tropical dry woodland zones and very dry tropical woodland, Espinal (1990) and Olaya (1995).

As per some studies performed by the High Madgalena River Chamber (CAM), Universidad Surcolombiana and Gobernación del Huila (2006), the Tatacoa dessert vegetation is represented by 102 species, 79 genres and 33 families; from theses, five families of the central Tatacoa dessert stand out: the *Cacti* which is represented by 7 species, *Leguminous* crops with three species, *Euphorbiaceas* with 4 species, *Burseraceas* with three species and Convolvulaceas with a single species. An emphasis is seen in *Cacti* species, especially *Stenocereus griseus, Opuntia schumannii, Melocactus curvispinus*, by their looking, morphologic characteristics and beauty of their flowers.

The above-mentioned kind of woodland are especially found in the Colombian inter-Andean valleys of the Magdalena, Patía and Chicamocha Rivers, Llanos (2001). Thus affirmation is verified in the research conducted by Suarez *et al.* (2004) who mentions that the Colombian tropical dry woodlands is originally distributed in the regions of the Caribbean planes and inter-Andean valleys of the Magdalena and Cauca rivers in altitudes going from 0 to 1000 m, in the following zones: San Andrés and Providencia islands, north región of the Guajira península, Santa Marta, in Gamarra, Chicamocha river canyon, Convención and Ocaña towns; surroundings of Cúcuta, Dagua canyon, Tatacoa dessert and Patía river valley.

Phytogeographic studies can be conducted through the knowledge of the existing vegetal species in each place this typical living zone is presented. According to Gama and Quintero (2004), a comparative phytogeographic study allows the following: to know the existing flora, if they are endemic or restricted distribution, if they find some protective status, etc. Based in these studies it can be also determined the given changes suffered by these zones throughout the years. In the case of an environmental disaster (where a great part of the vegetation is lost) to be able to know the kind of species can be re-introduced and where to find them. Also, to be able to determine the geocomplex fragmentation levels, to know their conservation status, or, if possible, to propose the creation of biological corridors to favor the gen interchange of the species. All of this contributes to the care and protection of the nature.

Jaccard index is one of the methods contributing to the determination of the phytogeographic affinity among the eco-regions. It is characterized by being a statistical tool used for comparing the similarity and diversity among a serie of samples only taking into account the species number found in a given zone, Castro (2012).

The goal of this research is to determine the phytogeographic affinity index in the eco-region of the Tatacoa dessert using the Jaccard similarity index to establish affinity patterns of the vegetal species among the Colombian geographical zones in the living of tropical dry Woodlands.

2. METHODOLOGY

This study has both descriptive and explorative characters. It is based on collecting information and applying statistical tools to achieve the objectives.

2.1. Information gathering

A consolidate of the dessert species was built based on the research report given by CAM *et al.* (2006) and Llanos (2001). This consolidates was classified according the species presence in the living zone: tropical dry woodland. The information of species common to other areas in the Colombia were taken from the researches conducted by the Alexander Von Humbolt Institute (1998) and Morales and Sarmiento (2008). Google Earth online version was used to get the geographical coordinates of the Colombian zones with presence of tropical dry woodlands. The coordinates were then geo-referenced in a map of the national territory by means of the geographical system information software Argis 5.1.

2.1.1 Jaccard index (I_j)

This index measures the similarity of the vegetal presented species which exist in the tropical dry Woodland zones, using Equation (1).

$$I_i = c/(a+b+c) \quad (1)$$

being;
a species number in zone 1,
b species number in zone 1 2
c common species number in both zones.

SPSS Statistics 17.0 software was then used to generate a *n*x*P* matrix (102x9), where the vegetal species from the Tatacoa dessert represented the 102 rows (*n*) and the areas where the living zones of Colombian tropical dry woodlands correspond to nine columns (*P*). The Jaccard similarity index is binary which indicates that for the matrix generation, number 1 was set if the species is presented and number 0 was given if the species was absent. Abbreviations were employed to facilitate and to manage the information presentation for each eco-region as shown in Table-1.

Table-1. Eco-regions abbreviation.

Eco-region	Abbreviation
Tatacoa	T
San Andrés and Providencia	SAP
Guajira Peninsula	PG
Santa Marta	SM
Gamarra	G
Chicamocha canyon	CCh
Dagua canyon	CD
Convención Ocaña	CO
Patía river valley	VRP

The similarity matrix of the Tatacoa dessert to other Colombian biogeographical zones was obtained. It were also obtained the respective dendogram and the establishment of zones having the higher amount of common species.

2.1.2 Phytogeographic affinity index

This index was esrimated with Equation (2) according the methodology proposed by Herrmann and Tappan (2012):

$$PAI = \sum_{i=0}^{n}(PA_i * AC_i) / \sum_{i=0}^{n}(AC_i) \quad (2)$$

Where *n* is the number of insi-tu species, *PA* is the similarity index and *AC* is the abundance cathegory (Rare: 1, Scarce: 2, Common: 3, Very Common, 4, Native: 5). The results of this index allowed establishing what species are more tolerant in the studied zone and what species can be planted in other bio-geographical Colombian zones.

3. RESULTS

Table-2 presents the eco-regions geographic coordinates having living zone of tropical dry woodlands in Colombia which were object of this research.

These coordinates were geo-referenced in the physical map of the Colombian territory as reported in Figure-1 where it is observed that the tropical dry woodlands are distributed in the regions of the Caribbean plains and inter-Andean valleys of the Magdalena and Cauca rivers and covers the states of Valle del Cauca, Cauca, Huila, Santander, Norte de Santander, Cesar, Magdalena, San Andrés and Providencia and Guajira. According to Sarmiento (1975) and Hernández (1992) cited by Alexander Van Humboldt Institute (1998), the dry woodlands of the inter-Andean valleys possess components coming from the dry vegetation of the Caribbean plains which shows that in the past these regions were probably connected with the same type of vegetation and owned similar climatic conditions.

Table-3 shows the Jaccard similarity matrix for the Tatacoa dessert with other eight Colombian eco-regions which have the living zone of tropical dry Woodland. As proposed by Castor (2006), the obtained results with any binary similarity go from zero (there is no similarity among the samples) to one (similarity among simple is 100 %).

In the matrix given in Table-3 can be evidenced that there exists a medium similarity between the Tatacoa dessert and the Guajira Peninsula with a coefficient of 0.5 and lower with 0.412 with the zone of the Chicamocha canyon. It is important to remark that among other Colombian zones the similarity index is greater. It means, among Santa Marta zone and the San Andrés and Providencia and Gamarra zone the similarity is high with a coefficient value of 0.6 and with the Dagua canyion is médium with a value of 0.53. by the same token, between the Guajira pensinsula and Chicamocha canyon zones, there is a high similarity with a coefficient of 0.76.

Table-2. Eco-regions coordinate of tropical dry Woodland living zones in Colombia.

	T	SAP	PG	SM	G	CCh	CD	CO	VRP
N	3°13'	12°35'37"	10°23'	11°14'10"	8°20'	6°45'	3°39'27"	8°28'05" and 8°14'46"	2°06'51"
W	75°10'	81°40'49"	71°06'	74°12'06"	73°45'	73°02'	76°41'30"	73°20'13" and 73°21'19"	76°58'59"

Table-3. Matriz de similitud de Jaccard.

	T	SAP	PG	SM	G	CCh	CD	CO	VRP
T	1.000	0.088	0.500	0.147	0.088	0.412	0.078	0.029	0.098
SAP	0.088	1.000	0.176	0.600	1.000	0.085	0.308	0.333	0.188
PG	0.500	0.176	1.000	0.245	0.176	0.755	0.157	0.059	0.173
SM	0.147	0.600	0.245	1.000	0.600	0.163	0.533	0.200	0.190
G	0.088	1.000	0.176	0.600	1.000	0.085	0.380	0.333	0.188
CCh	0.412	0.085	0.755	0.163	0.085	1.000	0.163	0.071	0.209
CD	0.078	0.308	0.157	0.533	0.308	0.163	1.000	0.375	0.200
CO	0.029	0.333	0.059	0.200	0.333	0.071	0.375	1.000	0.300
VRP	0.098	0.188	0.173	0.190	0.188	0.209	0.200	0.300	1.000

Figure-1. Geo-referenciation of the Colombian zones with tropical dry woodland.

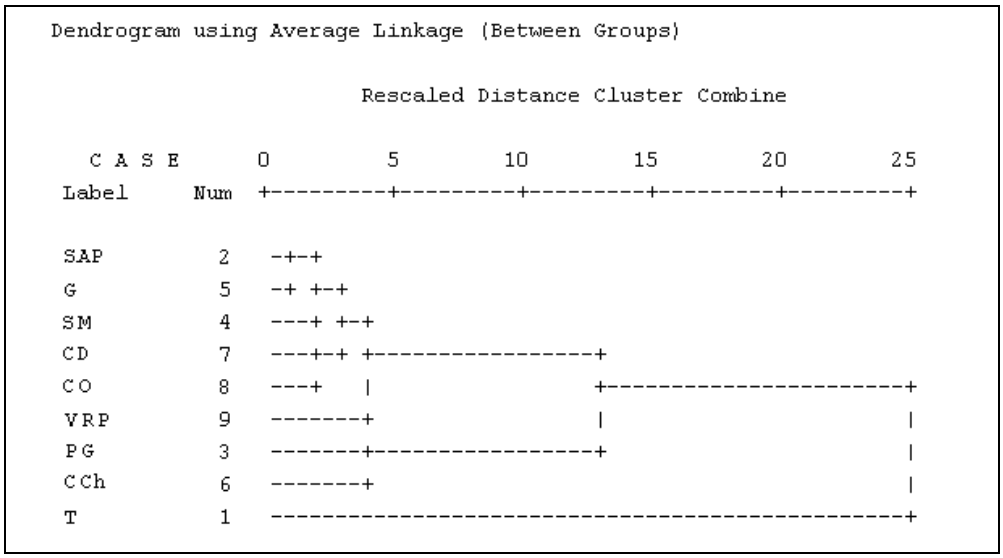

Figure-2. Similarity dendogram of the species among the tropical dry Woodland zones.

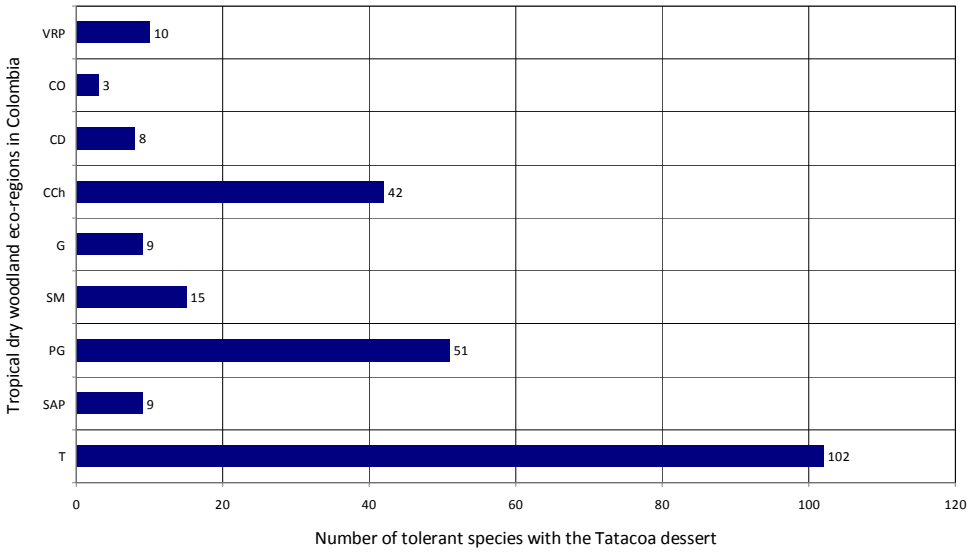

Figure-3. Number of tolerant species with the Tatacoa dessert.

The zones having the higher similarity index with respect to the Tatacoa dessert are: Guajira Peninsula and the Chicamocha canyon; in the dendogram given in Figure-2 can be seen a well-defined grouping among the three zones. The found similarity coefficients evidence the potential of these zones for building a re-population with vegetal native species of tropical dry Woodland and with adaptation facilities since they belong to the same eco-region. This permits a more effective regreening compared to foreign vegetal species. It is also observed that the corresponding zones to the grouping formed by Convención and Ocaña and Patía river valley possess very low similarity coefficients with values ranging from 0.03 to 0.38 and 0.10 to 0.30, respectively. This shows a low similarity with other tropical dry woodland zones under consideration.

Figure-3 shows the number of species that registered a phytogeographic affinity index of tolerant species with respect to the Tatacoa dessert. The zone corresponding to Convención and Ocaña has three tolerant species to the Tatacoa dessert conditions: Pseudosamanea guachapele (Kunth) Harás. Gliricidia sepium (Jacq.) Kunth ex Walp y Gynandropsis gracilis (T and P) Killip.

It was found for the Dagua canyon the following tolerant species: Bauhinia guianensis Aubl. Gliricidia sepium (Jacq.) Kunth ex Walp. Gynandropsis gracilis (T and P) Killip. Pseudosamanea guachapele (Kunth) Harás. Senna pallida (Vahl) Irwin and Barneby. Senna obtusifolia (L.) H.S. Irwin and Barneby. Senna spectabilis (DC.) H.S. Irwin and Barneby. Senna tomentosa Batka.

Nine species with phytogeographic affinity were found in the Gamarra and San Andrés-Providencia zones.

The tolerant species for Gamarra are: Bauhinia guianensis Aubl. Capparis odoratissima Jacq. Gliricidia sepium (Jacq.) Kunth ex Walp.. Gliricidia sepium (Jacq.) Kunth ex Walp. Gynandropsis gracilis (T and P) Killip. Machaerium capote Triana ex Dugand. Paullinia densiflora Smith. Pseudosamanea guachapele (Kunth) Harás. Randia armata (Sw.) DC. Randia aculeata L.; para San Andrés y Providencia son: Bauhinia guianensis Aubl. Capparis odoratissima Jacq. Gliricidia sepium (Jacq.) Kunth ex Walp. Gynandropsis gracilis (T and P) Killip. Machaerium capote Triana ex Dugand. Paullinia densiflora Smith. Pseudosamanea guachapele (Kunth) Harás. Randia armata (Sw.) DC. Randia aculeata L.

The follwoing tolerant species were found in the Patio river valley: Croton ferrugineus Kunth. Croton glabellus L. Gliricidia sepium (Jacq.) Kunth ex Walp. Guazuma ulmifolia Lam. Gynandropsis gracilis (T and P) Killip. Ipomoea sp. Ipomoea carnea Jacq. Pseudosamanea guachapele (Kunth) Harás. Sida jamaicensis L. Sida SP. En Santa Marta se encuentran quince especies tolerantes: Bauhinia guianensis Aubl. Capparis odoratissima Jacq. Ficus sp. Gliricidia sepium (Jacq.) Kunth ex Walp. Guazuma ulmifolia Lam. Gynandropsis gracilis (T and P) Killip. Machaerium capote Triana ex Dugand. Paullinia densiflora Smith. Pseudosamanea guachapele (Kunth) Harás. Randia armata (Sw.) DC. Randia aculeata L. Senna pallida (Vahl) Irwin and Barneby. Senna obtusifolia (L.) H.S. Irwin and Barneby. Senna spectabilis (DC.) H.S. Irwin and Barneby. Senna tomentosa Batka.

42 tolerant species were found in Chicamocha canyon and two tolerant species were found with Tatacoa dessert eco-region: Abutilon giganteum (Jacq.) Sweet. Acacia decurrens Willd. Acacia farnesiana (L.) Willd. LEG. Acanthocereus tetragonus (L.) Hummelinck. Bastardia bivalvis (Cav.) Kunth ex Griseb. Bouteloua sp. Caesalpinia cassioides Willd. Cereus hexagonus (L.) Mill. Cortaderia sp. Croton ferrugineus Kunth. Desmodium adscendens (Sw.) DC. Desmodium incanum DC. Gliricidia sepium (Jacq.) Kunth ex Walp. Gynandropsis gracilis (T and P) Killip. Hylocereus undatus (Haw.) Britton and Rose. Ipomoea sp. Ipomoea carnea Jacq. Jatropha gossypiifolia L. Jatropha urens L. Lonchocarpus punctatus H.B.K. Machaerium capote Triana ex Dugand. Maclura tinctoria (L.) D. Don ex Steud. Macroptilium atropurpureum (Sessé and Moc. Ex DC.)Urb. Malvastrum americanum (L.) Torr. Melocactus curvispinus Pfeiff. Opuntia depauperata Britton and Rose. Opuntia schumannii F.A.C. Wever ex A. Berjer. Parkinsonia aculeata L. Pedilanthus tithymaloides (L.) Poit. Pithecellobium dulce (Roxb.) Benth. Praecereus euchlorus (F.A.C. Weber) N.P. Taylor. Prosopis juliflora (Sw.) DC. Pseudosamanea guachapele (Kunth) Harás. Rhynchelytrum roseum (Nees) Stapf and C.E. Hubb. Senegalia huilana Britton and Killip. Senna pallida (Vahl) Irwin and Barneby. Senna obtusifolia (L.) H.S. Irwin and Barneby. Senna tomentosa Batka. Sida jamaicensis L. Sida SP.

The zone with the greatest similarity index presents more phytogeographic affinity. This is the case of the Guajira Peninsula which possesses 51 tolerant species: Abutilon giganteum (Jacq.) Sweet. Acacia decurrens Willd. Acacia farnesiana (L.) Willd. LEG. Acanthocereus tetragonus (L.) Hummelinck. Bauhinia guianensis Aubl . Bastardia bivalvis (Cav.) Kunth ex Griseb. Bouteloua sp. Caesalpinia cassioides Willd.. Calotropis procera (Aiton) W.T. Aiton. Capparis odoratissima Jacq. Cereus hexagonus (L.) Mill. Cortaderia sp. Croton ferrugineus Kunth. Desmodium adscendens (Sw.) DC. Desmodium incanum DC. Gliricidia sepium (Jacq.) Kunth ex Walp. Gynandropsis gracilis (T and P) Killip. Hylocereus undatus (Haw.) Britton and Rose. Ipomoea sp. Ipomoea carnea Jacq. Jacquemontia sphaerostigma (Cav.) Rusby. Jatropha gossypiifolia L. Jatropha urens L. Lonchocarpus punctatus H.B.K. Machaerium capote Triana ex Dugand. Macroptilium atropurpureum (Sessé and Moc. Ex DC.)Urb. Malvastrum americanum (L.) Torr. Melocactus curvispinus Pfeiff. Merremia dissecta (Jacq.) Hallier F. Merremia umbellata (L.) Hallier F. Opuntia depauperata Britton and Rose. Opuntia schumannii F.A.C. Wever ex A. Berjer. Paullinia densiflora Smith. Parkinsonia aculeata L. Pithecellobium dulce (Roxb.) Benth. Praecereus euchlorus (F.A.C.Weber) N.P. Taylor. Prosopis juliflora (Sw.) DC. Pseudosamanea guachapele (Kunth) Harás. Randia armata (Sw.) DC. Randia aculeata L. Rhynchelytrum roseum (Nees) Stapf and C.E. Hubb. Sarcostemma clausum (Jacq.) Schult. Senegalia huilana Britton and Killip. Senna pallida (Vahl) Irwin and Barneby. Senna obtusifolia (L.) H.S. Irwin and Barneby. Senna tomentosa Batka. Sida jamaicensis L. Sida SP. Stenocereus griseus (Haw.) Buxb.

Beased upon the former statements, the zones with greater phytogeografic affinity with the Tatacoa dessert are given in order of importance: the Guajira Peninsula with 51 species and Chicamocha canyon with 42 tolerant species. It is followed by Santa Marta zone with 15 species, the Patio river valley with ten species, Gamarra and San Andres- Providencia with nine tolerant species in each zone. Dagua canyon has eight species while Convención and Ocaña have three tolerant species.

4. CONCLUSIONS

a) It was possible to establish the number of more tolerant species in the living zones of tropical dry woodlands which are important for regreening activities promoting the conservation of native species in the Tatacoa dessert. Also, this research permits other Colombian zones to know the phytogeographic affinity existing among them and to work as a team to improve the plant cover in all the affected zones.
b) Effective regreening processes can be undertaken in the Tatacoa dessert with the tolerant species existing in the Guajira Peninsula and the Chicamocha canyon. These vegeta native species of tropical dry Woodland present adaptation facilities since they come for the same eco-regions.
c) This study also allowed the identification the existence od high similarity index among the eco-regions: Among the Santa Marta zone and San Andrés-Providencia islands and Gamarra, and the

Guajira Peninsula zone and the Chicamocha canyon. The similarity index has a medium value between the Santa Marta Dagua zones.

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