SHILAP Revista de lepidopterología, 45 (180) diciembre 2017: 533-549 eISSN: 2340-4078 ISSN: 0300-5267
https://doi.org/10.57065/shilap.871

Parsimony analysis of butterflies communities in the Dominican Republic: assessing relationships among butterflies assemblages (Lepidoptera: Papilionoidea)

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Abstract

Following researches carried out for a period of seven years on two far-away localities in the Dominican Republic, a hypothesis of relationships among some butterflies communities was made. A data matrix of 132 taxa has been compiled coding the presence / absence of the taxa in the sample sites and areas investigated. The data matrix was run with a cladistic method and a single most parsimonious tree was obtained. The hierarchical relationships among the butterflies communities were discussed in the light of various hypotheses.

KEY WORD: Lepidoptera, Papilionoidea, butterflies communities, hierarchical relationships, Dominican Republic.

Análisis de parsimonia de las comunidades de mariposas en la República Dominicana: evaluación de las relaciones entre las asociaciones de mariposas (Lepidoptera: Papilionoidea)

Resumen

A raíz de las investigaciones realizadas durante un período de siete años en dos localidades distantes de la República Dominicana, se realizó una hipótesis de relación entre algunas comunidades de mariposas. Se ha compilado una matriz de datos de 132 taxa codificando la presencia / ausencia de taxones en los sitios de muestra y áreas investigadas. La matriz de datos se realizó con un método cladístico y se obtuvo un árbol más parsimonioso. Las relaciones jerárquicas entre las comunidades de mariposas se discutieron a la luz de varias hipótesis.

PALABRAS CLAVE: Lepidoptera, Papilionoidea, comunidades de mariposas, relaciones jerárquicas, República Dominicana.

Introduction

This study deals with an analysis regarding a hypothesis of relationships among some butterflies communities along an altitudinal transect in the provinces of Pedernales and San Juan, Dominican Republic. In the last forty years, knowledge of the butterfly fauna of this island was improved according to the studies by some authors (e.g. SCHWARTZ, 1983; SCHWARTZ, 1989; SMITH *et al*., 1994; TAKIZAWA *et al*., 2003). Recent investigations in the last seven years on the island and information gathered from literature allow us to present this preliminary analysis. As introduced elsewhere (RACHELI & RACHELI, 2005), the powerful information included in faunal studies cannot be limited to their static value of provisional list (SCHWARTZ, 1987; GUERRERO, 1996; DOMÍNGUEZ, 1997; BASTARDO, 2007; RODRÍGUEZ *et al.,* 2014). Indeed, their use for analyses like that presented in this study is the one of the most interesting aspect of the research. Using a parsimonious-based approach (NEL *et al*., 1998; PELLENS *et al*., 2005), a hypothesis about the relationships among these species communities have been obtained. A detailed discussion about differences among the commonly used phenetic analysis and the approach using parsimony were given by RIBICHICH (2005) and WENZEL & LUQUE (2008). Although the use of parsimony in the analysis of communities is still very occasional, the present study is a further attempt aimed at introducing this kind of approach and its usefulness. Both animal and plant assemblages were used in this kind of analysis but WENZEL & LUQUE (2008) carried out the first parsimony analysis using butterflies communities in Costa Rica focusing also differences among wet and dry seasons.

Material and methods

ANALYSIS OF THE SELECTED SPECIES COMMUNITIES IN THE SAN JUAN AND PEDERNALES PROVINCES: DESCRIPTION OF THE STUDY AREAS, COLLECTING METHODOLOGY AND SOURCE DATA

The analysis of the butterflies species communities presented here is based on 2 areas for a total of 7 sites along altitudinal transects in the provinces of San Juan and Pedernales, respectively (Figs. 1-3). All these sites and areas have been surveyed during our field expeditions to the Dominican Republic from 2010 to 2016. Lists of butterflies and their ecology recorded for these sites have been exhaustively treated by SCHWARTZ (1989). His data, from 1979 to 1988 from the Sierra de Baoruco were pooled together with our data. The study areas are found in two far away and ecologically diverse sites. In Pedernales province, along the road Cabo Rojo-El Aceitillar, southern slope of the Sierra de Baoruco, which encompasses a quite different set of habitats, and in San Juan province, near Arroyo Cano, on the southern slope of the Cordillera Central, along a deep natural gully (Table 1, Fig. 2).

Table I.– The Study areas.

SITES SIERRA DE BAHORUCO
B1= 2-12,5 km road NE Cabo Rojo, 0-70 m
B2 = 16,5-18 km road NE Cabo Rojo, 300 m (Mirador) - 366 m (Entrada al Parque)
B3= 19-23 km road NE Cabo Rojo, 427-488 m
B4 = 24.5-25 km road NE Cabo Rojo, 656-680 m
B5 = 26-31 km road NE Cabo Rojo (km 26, 700-740 m; km 28, 950 m; km 31, La Charca, 1123 m)
SITES ARROYO CANO
Loc A 450-470 m Loc B 471-500 m

THE STUDY AREAS (Figs 1, 2, 3)

Geographically, Hispaniola shows a series of parallel east-westwards mountain chains separated by inter-mountains xeric lowlands valleys. The positions of these cordilleras are important in influencing the distribution of precipitations and constitute barriers against the trade winds which carry humid Atlantic air masses from NE to SW, causing differences in precipitation up to 2400 mm between the northeastern and southwestern sides of the Cordillera Central (IZZO *et al*., 2010).

The geological history of Hispaniola is complex. We give only a few notes: the fusion of at least three blocks of the proto-Antilles gave rise to the present configuration of Hispaniola some 9 million year ago. These three blocks are known as the two “paleo-islands”: the north from the joining of the two first blocks, and the south formed by the third block. The South Island is further composed by two elements of different geological origins (WOODS & OTTENWALDER, 1992), and it seems likely that the La Selle-Baoruco chains have been isolated islands until early Pliocene (MAURRASSE *et al.,* 1980).

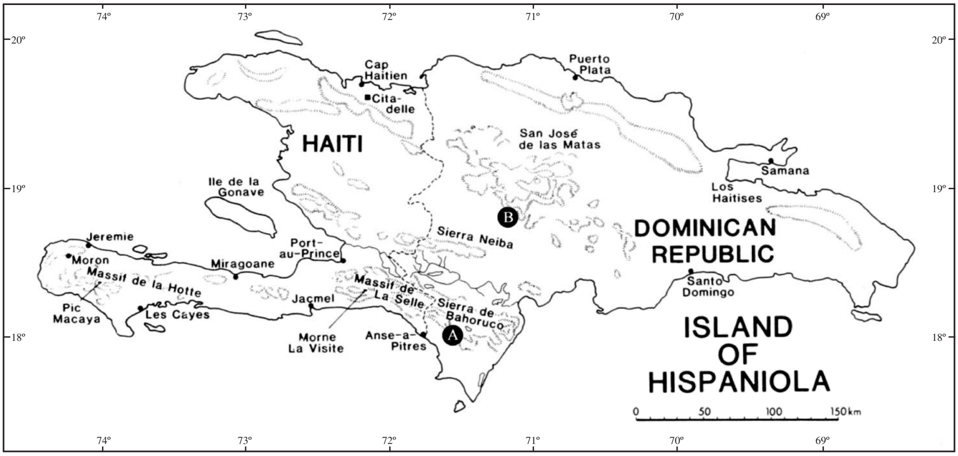

Figure 1.– Map of Hispaniola Island with study sites: **A)** Sierra de Baoruco; **B)** Arroyo Cano (Redrawn from WOODS, 1989)

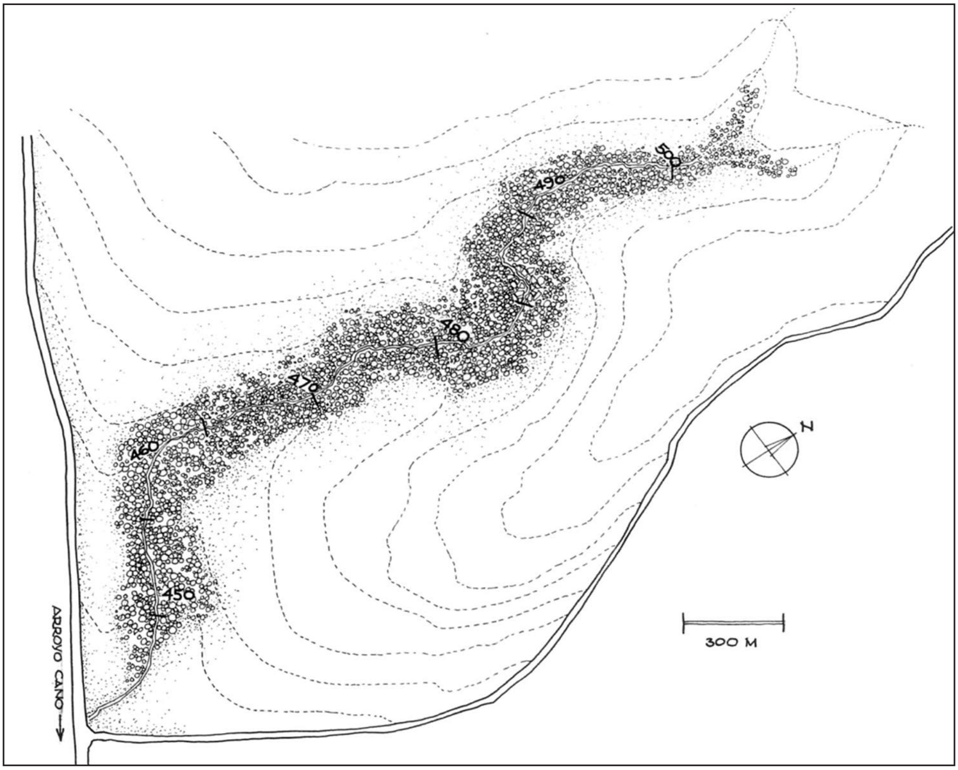

Figure 2.– Sketch of the gully with altitudes near Arroyo Cano, San Juan Province. Circles indicate the forested area.

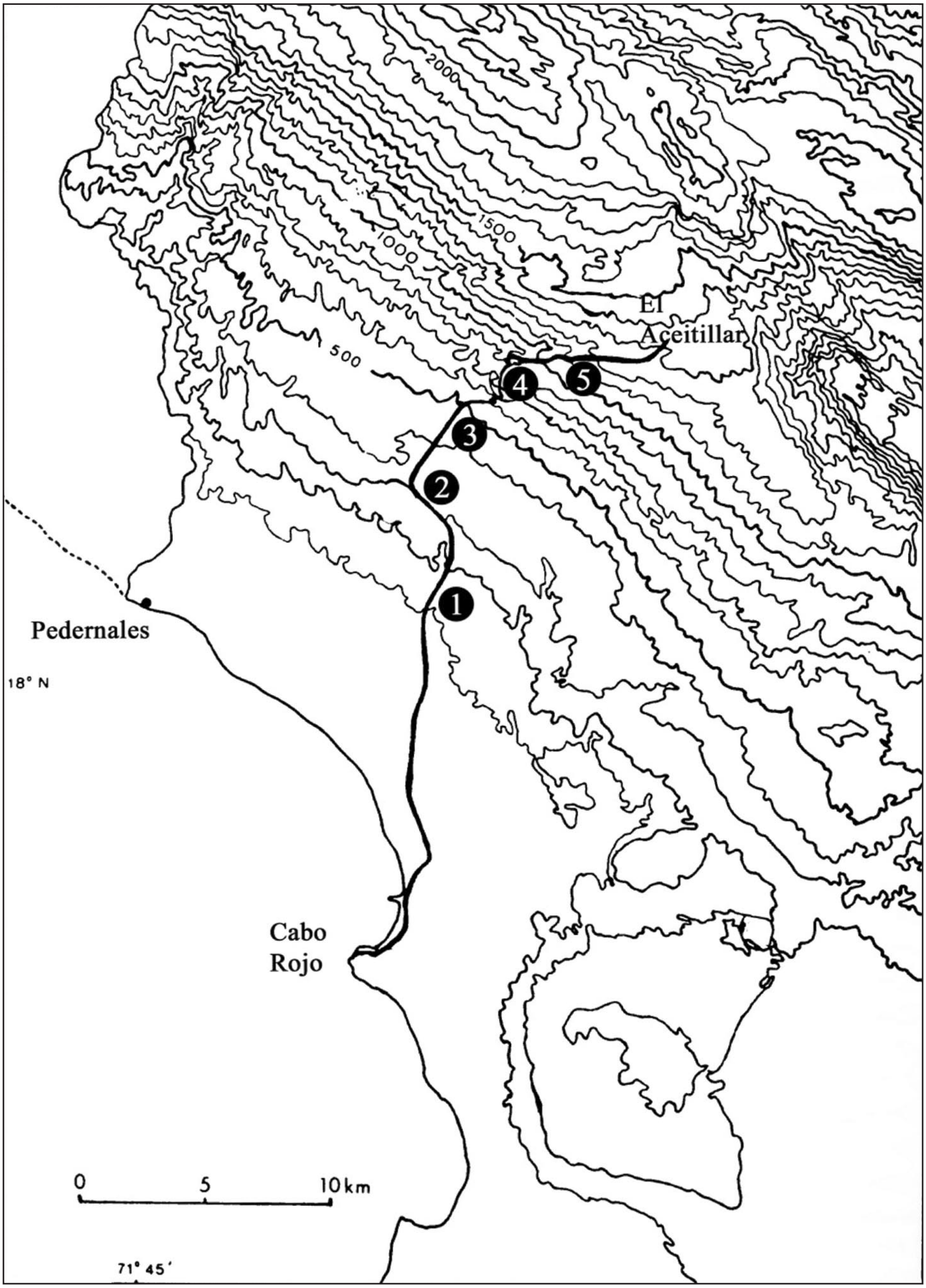

Figure 3.– Map of Barahona Peninsula and study sites (Redrawn from FISHER-MEEROW & JUDD, 1989)

SITE A - SIERRA DE BAORUCO, SOUTHERN SLOPE (Fig. 3)

The study area is located in the southwestern part of the Dominican Republic, Pedernales Province, on the southern slope of the Sierra de Baoruco. The sites were located along the paved road from Cabo Rojo leading to El Aceitillar where in the past the Alcoa mines were dug for bauxite. Before the entrance to the Park, at the crossway for Las Mercedes, recently a vast area was exploited for bauxite extractions by another mine company. The area is relatively undisturbed however, fires are a frequent problem in the pine forests and hurricanes sweep off often the area. Five sites were chosen to best represent the range of variation in vegetation types along the altitudinal gradient (Figs 1, 3). Floristic and climatological information are from FISHER-MEEROW & JUDD (1989) and BOLAY (1997).

Description of Vegetation and Ecology of Study Sites

The study sites are described in order from low to high elevation as it is shown on Fig. 3. The HOLDRIDGE's (1967) system of vegetation classification was used. An annotated bibliography of the vegetation and flora of Hispaniola is available in ZANONI *et al*. (1985).

SITE 1: SUBTROPICAL THORN WOODLAND

This study site B1, is located along the road Cabo Rojo-Aceitillar, 2-12,5 km 0-70 m. Rainfall has been estimated below 750-500 mm and it is highly seasonal with two rain maxima in May-June, and in September-October.

Representative species: *Burca hispaniolae* Bell & Comstock, 1948; *Gesta gesta* (Herrich-Schäffer, 1863); *Copaeodes stillmani* (Bell & Comstock, 1948); *Strymon acis petioni* Comstock & Huntington, 1943; *Electrostrymon angelia boyeri* Comstock & Huntington, 1943; *Calisto franciscoi* Gali, 1985.

SITE 2: SUBTROPICAL DRY FOREST

This study area B2 = 16,5-18 km road NE Cabo Rojo, 300 m (Mirador) - 366 m (Entrada al Parque). Rainfall here has been estimated between 750-1000 mm.

Representative species: *Protographium zonaria* (Butler, 1869); *Heraclides aristor* (Godart, 1819).

SITE 3: SUBTROPICAL MOIST FOREST

This study area B3 = 19-23 km road NE Cabo Rojo, 427-488 m. Rainfall average 1100-1250 mm per year. The limestone soil support well developed forests with *Prunus myrtifolia* and *Ficus citrifolia.* Vegetation here begins to present a closed canopy with shady and moister biotopes.

Representative species: *Panoquina ocola* Edwards, 1883; *Pyrgus crisia* Herrich-Schäffer, 1865; *Eurema lucina priddyi* (Lathy, 1898); *Strymon bazochii gundlachianus* Bates, 1935.

SITE 4: SUBTROPICAL LOWER MONTANE MOIST FOREST

This study area B4 = 24.5-25 km road NE Cabo Rojo, 656-680 m. This is the ecotone with the beginning of the pine forest.

Representative species: *Cyclargus thomasi noeli* (Comstock & Huntington, 1943); *Heraclides pelaus imerius* (Godart, 1824).

SITE 5 SUBTROPICAL LOWER MONTANE MOIST FOREST + PINE FOREST

This study area B5 = 26-31 km road NE Cabo Rojo (km 26, 740 m; km 28, 950 m; km 31, La Charca, 1123 m). Rainfall averages about 1300 mm per year.

Representative species: *Battus zetides* (Munroe, 1971); *Argon* sp.; *Panoquina lucas* (Fabricius, 1793); *Fountainea johnsoni* (Avinoff & Shoumatoff, 1941); *Memphis verticordia* (Hübner, 1831); *Myscelia aracynthia* (Dalman, 1823).

SITE B Arroyo Cano, southern slope of Cordillera Central (Fig. 2)

The research was carried out along the gully (called locally Arroyo Calabaza) which is characterized by a variable amount of water over the years but always moist. This site constitutes a sort of gallery forest given that on the outside, on both sides, there are only open grassland or cultivated fields. The gully is present on both sides of the main road leading to the small town of Arroyo Cano, some 300 m before the entrance of the village. The surveyed gully has a length of ca 2,5 km at a height of 450-500 m. It extends also on the other side of the main road for 1,5 km but here is much disturbed by human presence and quite deforested: only remnants of mixed woods and shrubs.

Methods

Collecting methodology

Butterflies were netted, identified and released, observed at banana baits, and seldom attracted with the use of traps with rotten fruits, meat or fish. The traps were located between 2 and 10 m of height along trails on both sides along the main road. Only in a few case specimens for genital inspection were retained.

The collecting and / or identification activities were made from 9 am to 4 pm spanning over a period of 7 consecutive years from 2010 to 2016, covering each month of the year.

Analysis of the species communities: introduction to methods, data analysis and the parsimonious-based approach

The majority of the ecological analyses are based on assumption that the contemporary-based explanations are enough in explaining the relationships among and within the structure of species communities (GRANDCOLAS, 1998). Although the inadequacy of the phenetic clusterings in interpreting the evolutionary relationships also of ecological communities has been debated extensively (e.g. DE QUEIROZ & GOOD, 1997; NEL *et al*., 1998; PELLENS *et al*., 2005) and the availability of phylogenetic hypotheses of diverse organisms are increasing, the popularity of similarity-based methods in the analysis of species communities is not decreasing. In any case, the potential of using phylogenies in the study of community ecology is becoming a new tool (WEBB *et al.,* 2002) but the efforts in presenting probabilistic-based approaches modified from similarity-based methods seem to be infinite (e.g. CHAO *et al*., 2005).

Although the criticisms to the evolutionary ecologists view in the study of communities given by BROOKS & MCLENNAN (2002: 418-421) are careful and accurate, it must be pointed out that their approach was not taken into consideration in the present study for different reasons. Indeed, phylogenetic hypotheses on different lineages of various Neotropical butterflies are available but they are difficult to be used for several reasons (different taxonomic categories sampled; incomplete sample of taxa, etc.). For this reason, the application of the Brooks & Mclennan's approach or other similar approaches (e.g. LOSOS, 1996) cannot be used for the above-mentioned reasons. Given this premise, the present analysis deals with an application of a parsimonious-based approach using some Papilionoidea species communities of selected sites along an altitudinal transect (Sierra de Baoruco) with the addition of a further site (Arroyo Cano). The parsimonious-based approach used herein can be considered a modified version of the biogeographical method named PAE, Parsimony Analysis of Endemicity (ROSEN, 1988; CRACRAFT, 1991; MORRONE & CRISCI, 1995; MORRONE, 2014).

The first application of this method in the study of ecological communities refers to that originally outlined by NEL *et al.* (1998).

The choice to use a parsimonious based approach is not a justification given the intrinsic soundness of parsimony but mostly because cladistics produces hypotheses of hierarchical units showing common origin and based on comparable evidence. Indeed, the use of this method is also based on the objective limitations of the other methods commonly used in the analysis of species communities. This means that the choice to use a parsimony method is given and supported by an objective evaluation of the available methods (parsimony vs. narrative, or phenetic and / or probabilistic methods) (see also RIBICHICH, 2005 and WENZEL & LUQUE, 2008).

Data analysis

A data matrix of 132 taxa has been compiled coding the presence / absence of the taxa in the sample sites and areas investigated (see Table II) where “0” indicates the absence of the taxa from the area, and “1” the presence in the area. An outgroup (a hypothetical area where no taxa occur) with all “0” is included in the matrix to root the tree. In a synecological analysis, species are used as characters to obtain cladograms then species presence is regarded as derived and species absence as primitive. The localities B1, and also B2, were pooled together as B2, and also the localities A + B of Arroyo Cano. Regarding the data matrix of the species found in the altitudinal transect in the Sierra de Baoruco, new records / species were added in respect to the data given by SCHWARTZ (1989).

The program TNT (GOLOBOFF *et al*., 2008) was used to analyse the data matrix and option i.e. (implicit enumeration) was run to find all the most parsimonious trees.

Table II.– The stucture of each species community analyzed: a matrix with 0 and 1 (absence / presence) in the selected sites or areas along the altitudinal transects.

Taxa	**B1**	**B2**	**B3**	**B4**	**B5**	**A**	**B**	**Habitat types / ecological tolerance**
Proteides mercurius sanchesi Bell & Comstock, 1948	0	0	0	0	0	0	1	Mesic
Polygonus leo (Gmelin, 1790)	0	0	0	0	1	0	0	Mesic
Chioides ixion (Plötz, 1880)	0	1	0	1	0	0	0	Mesic / broadleaf forest
Aguna asander haitensis (Mabille & Boullet, 1912)	1	0	1	1	1	0	0	Mesic / broadleaf forest
Urbanus proteus domingo (Scudder, 1872)	0	0	1	1	1	1	1	Open areas
Urbanus dorantes cramptoni Comstock, 1944	0	1	1	1	1	1	1	Open areas
Astraptes talus (Cramer, 1777)	0	0	0	1	1	0	1	Mesic
Astraptes habana heriul (Mabille & Boullet, 1912)	0	0	0	0	0	0	1	Mesic
Astraptes xagua christyi (Sharpe, 1898)	0	0	0	0	0	0	1	Mesic / pinewoods
Cabares potrillo (Lucas, 1857)	0	0	0	0	0	0	1	Mesic
Burca stillmani Bell & Comstock, 1948	1	0	0	0	0	1	1	Xeric

Burca hispaniolae Bell & Comstock, 1948	1	0	0	0	0	0	0	Mesic / broadleaf forest
Gesta gesta (Herrich-Schäffer, 1863)	1	0	0	0	0	0	1	Mesic / xeric
Ephyriades zephodes (Hübner, 1825)	1	0	1	0	1	1	0	Mesic / xeric
Eantis papinianus (Poey, 1832)	0	1	0	0	1	0	1	Mesic
Pyrgus oileus (Linnaeus, 1767)	1	1	1	1	0	1	1	Open areas
Pyrgus crisia Herrich-Schäffer, 1865	0	0	1	0	0	0	1	Mesic / xeric / pine woods
Perichares philetes (Gmelin, 1790)	0	0	0	0	0	1	1	Mesic
Copaeodes stillmani (Bell & Comstock, 1948)	1	0	0	0	0	0	0	Xeric
Argon sp. (Schwartz, 1989: 67)	0	0	0	0	1	0	0	Mesic / broadleaf forest
Panoquina nero (Fabricius, 1798)	0	0	0	1	1	0	0	Mesic / pine woods
Panoquina ocola Edwards, 1883	0	0	1	0	0	0	0	Open areas / mesic
Panoquina lucas (Fabricius, 1793)	0	0	0	0	1	0	0	Mesic / xeric
Synapte malitiosa adoceta Schwartz & Sommer, 1986	0	0	0	0	0	0	1	Wooded areas
Cymaenes tripunctus (Herrich-Schäffer, 1865)	0	0	1	0	0	0	0	Mesic / xeric
Hylephila phyleus (Drury, 1773)	0	0	0	1	1	0	0	Open areas
Hesperia nabokovi (Bell & Comstock, 1948)	1	0	0	0	0	0	0	xeric
Wallengrenia otho druryi (Latreille, 1824)	0	0	1	0	0	0	1	Mesic / pine woods
Choranthus haitensis Skinner, 1920	0	0	0	1	0	0	0	Mesic
Choranthus melissa Gali, 1983	0	0	0	0	1	0	1	pine woods
Choranthus schwartzi Gali, 1983	0	0	0	0	0	0	1	Mesic
Pyrrhocalles antiqua (Herrich-Schäffer, 1863)	1	0	0	0	1	0	0	Mesic
Nyctelius nyctelius (Latreille, 1824)	1	0	1	0	0	0	0	Mesic / xeric
Battus zetides (Munroe, 1971)	0	0	0	1	1	0	0	Mixed pine-hardwoods
Battus polydamas polycrates (Hopffer, 1865)	1	0	1	1	1	1	1	Ecological tolerant
Protographium zonaria (Butler, 1869)	1	1	0	0	0	1	0	Xeric
Papilio demoleus malayanus Wallace, 1865	0	0	1	1	0	0	1	mesic

Heraclides androgeus epidaurus (Godman & Salvin, 1890)	0	0	1	1	0	1	1	Mesic / woods
Heraclides aristodemus (Esper, 1794)	1	0	1	0	1	0	0	xeric
Heraclides machaonides (Esper, 1796)	1	1	0	1	1	0	1	woods
Heraclides aristor (Godart, 1819)	0	1	1	0	1	0	0	xeric
Heraclides pelaus imerius (Godart, 1824)	0	0	0	0	1	0	1	Mesic / woods
Dismorphia spio (Godart, 1819)	0	0	0	1	1	1	1	woods
Kricogonia lyside (Godart, 1819)	1	1	1	1	1	0	1	xeric
Nathalis iole Boisduval, 1836	0	0	0	0	1	0	0	Open areas
Eurema lisa euterpe Ménétriés, 1832	1	0	0	1	1	0	0	Mesic / xeric
Eurema daira palmira (Poey, 1852)	1	0	1	1	1	0	0	Mesic
Eurema elathea (Cramer, 1777)	1	0	0	1	1	1	1	Xeric
Eurema lucina priddyi (Lathy, 1898)	0	0	1	0	0	0	1	Mesic / xeric
Pyrisitia nise larae (Herrich-Schäffer, 1862)	0	0	0	1	1	0	1	Mesic
Pyrisitia dina mayobanex Bates, 1939	0	0	0	0	1	0	0	Mesic / pine woods
Pyrisitia leuce memula Butler, 1871	0	0	0	0	1	1	0	Mesic
Pyrisitia proterpia (Fabricius, 1775)	0	0	1	1	1	1	1	Mesic
Pyrisitia pyro (Godart, 1819)	0	1	0	1	1	1	0	Mesic
Abaeis nicippe (Cramer, 1779)	0	0	1	1	0	0	0	Mesic / xeric
Abaeis nicippiformis Munroe, 1947	0	0	1	1	1	0	1	Ecological tolerant
Zerene cesonia cynops (Butler, 1873)	1	0	1	1	1	0	0	Mesic / xeric
Anteos clorinde (Godart, 1824)	1	1	1	1	1	1	0	Ecological tolerant
Anteos maerula (Fabricius, 1775)	1	0	1	1	1	1	0	Ecological tolerant
Phoebis agarithe antillia Brown, 1929	0	0	1	1	0	1	1	Xeric
Phoebis argante rorata (Butler, 1869)	1	0	1	0	1	1	1	Mesic
Phoebis editha (Butler, 1870)	1	0	1	1	1	1	0	Mesic / xeric
Phoebis philea thalestris (Illiger, 1801)	1	0	1	1	1	1	1	Mesic / xeric

Phoebis sennae (Linnaeus, 1758)	1	0	1	1	1	1	1	Mesic / xeric
Aphrissa godartiana (Swainson, 1821)	1	0	1	1	1	1	1	Mesic forests
Aphrissa orbis browni (Munroe, 1947)	1	0	1	1	1	1	0	Mesic
Glutophrissa drusilla boydi (Comstock, 1943)	0	1	1	0	1	0	0	Mesic / xeric
Ascia monuste eubotea (Godart, 1819)	1	0	1	0	1	1	0	Open areas / mesic
Ganyra josephina (Godart, 1819)	1	0	1	0	1	1	0	Xeric
Chlorostrymon maesites (Herrich-Schäffer, 1862)	1	0	0	0	0	0	0	Xeric
Allosmaitia fidena Hewitson, 1867	1	0	0	0	1	0	0	Mesic
Electrostrymon angelia boyeri Comstock & Huntington, 1943	1	0	0	0	0	0	0	Open areas / mesic
Strymon acis petioni Comstock & Huntington, 1943	1	0	0	0	0	0	0	Xeric
Strymon bazochii *gundlachianus* Bates, 1935	0	0	1	0	0	0	0	Mesic / xeric
Strymon istapa cybira Hewitson, 1874	1	0	1	1	1	0	0	Open areas
Strymon toussainti (Comstock & Huntington, 1943)	1	0	0	0	0	0	0	Xeric
Strymon limenia (Hewitson, 1868)	1	0	1	0	0	0	0	Open areas
Ministrymon azia (Hewitson, 1873).	1	0	0	1	1	0	0	Mesic / xeric
Leptotes cassius theonus (Lucas, 1857)	1	0	1	0	1	0	0	Mesic / xeric
Brephidium exilis isophthalma (Herrich-Schäffer, 1862)	1	0	0	0	0	0	0	Xeric
Pseudochrysops bornoi (Comstock & Huntington, 1943)	1	0	0	0	0	0	0	Xeric
Cyclargus thomasi noeli (Comstock & Huntington, 1943)	0	0	0	1	0	0	1	Xeric
Cyclargus sorpresus Johnson & Matusik, 1992	0	1	0	0	0	0	0	Mesic
Hemiargus hanno ceraunus (Fabricius, 1793)	1	1	1	1	1	0	0	Open areas
Libytheana terena (Godart, 1819)	0	0	1	0	1	1	0	Ecological tolerant
Danaus cleophile (Godart, 1819)	0	0	1	1	1	1	1	Mesic woods
Danaus plexippus megalippe (Hübner, 1826)	1	0	1	1	1	0	0	Ecological tolerant
Danaus eresimus tethys Forbes, 1944	0	0	0	1	1	0	0	Xeric
Danaus gilippus cleothera (Godart, 1819)	1	0	1	1	1	0	0	Ecological tolerant

Lycorea halia cleobaea (Godart, 1819)	1	0	1	0	0	1	1	Mesic woods
Anetia briarea (Godart, 1819)	0	0	1	1	1	0	0	Mesic woods
Anetia pantheratus (Martyn, 1797)	1	0	1	1	1	0	1	Mesic / xeric
Adelpha fessonia lapitha Hall, 1929	0	0	0	0	0	0	1	Xeric
Adelpha gelania (Godart, 1824)	1	0	0	0	1	0	0	Mesic / xeric
Agraulis vanillae insularis Maynard, 1889	1	0	1	1	1	1	0	Ecological tolerant / migrant
Dryas iulia fucatus (Boddaert, 1783)	1	0	1	1	1	1	1	Ecological tolerant
Eueides isabella melphis (Godart, 1819)	0	0	0	0	0	0	1	Mesic woods
Heliconius charithonia churchi Comstock & Brown, 1950	1	0	1	1	1	0	1	Ecological tolerant
Euptoieta claudia (Cramer, 1779)	1	0	1	1	1	0	0	Mesic / xeric
Euptoieta hegesia (Cramer, 1779)	1	0	1	0	0	0	0	Mesic / xeric
Asterocampa idyja (Geyer, 1828)	0	0	1	0	1	0	0	Mesic / xeric
Doxocopa thoe (Godart, 1824)	0	0	0	0	1	0	0	Mesic / xeric
Archimestra teleboas (Ménétriés, 1832)	1	0	1	1	1	0	1	Mesic / xeric
Eunica monima (Cramer, 1782)	1	0	1	0	0	0	0	Mesic / xeric
Eunica tatila tatilista Kaye, 1926	0	0	1	0	0	0	0	Ecological tolerant
Myscelia aracynthia (Dalman, 1823)	0	0	0	0	1	0	1	Mesic / xeric
Lucinia cadma torrebia (Ménétriés, 1832)	1	0	1	0	1	0	0	Xeric
Hamadryas amphichloe diasia (Fruhstorfer, 1916)	1	0	1	1	1	1	1	Mesic / xeric
Dynamine serina zetes (Ménétriés, 1832)	0	0	1	0	1	0	0	Mesic / xeric
Marpesia chiron (Fabricius, 1775)	0	0	1	0	1	0	0	Mesic
Marpesia eleuchea dospassosi Munroe, 1971	1	0	0	0	1	0	1	Mesic / xeric
Historis odius (Fabricius, 1775)	0	0	1	1	1	0	1	Forested areas
Colobura dirce wolcotti (Comstock, 1942)	1	0	0	1	1	0	1	Mesic
Hypanartia paullus (Fabricius, 1793)	0	0	1	0	0	0	1	Mesic
Vanessa virginiensis (Drury, 1773)	0	0	1	0	1	0	0	Pinewoods

Anartia jatrophae saturata Staudinger, 1884	0	1	1	0	0	1	1	Open areas
Anartia lytrea (Godart, 1819)	0	0	0	0	0	0	1	Wet woods
Siproeta stelenes (Linnaeus, 1758)	0	0	1	0	0	1	1	Mesic
Junonia evarete (Cramer, 1779)	0	0	0	0	1	1	0	Mesic / xeric
Junonia genoveva (Cramer, 1780)	0	0	0	1	1	1	1	Xeric
Anthanassa frisia (Poey, 1832)	0	0	1	0	0	0	0	Mesic
Antillea pelops (Drury, 1773)	0	0	0	0	0	0	1	Mesic / xeric
Archaeoprepona demophoon insulicola(Godart, 1823)	0	0	1	1	1	0	1	Forested areas
Anaea troglodyta (Fabricius, 1775)	1	0	1	1	1	1	0	Mesic / xeric
Fountainea johnsoni (Avinoff & Shoumatoff, 1941)	0	0	0	0	1	0	0	Xeric
Memphis verticordia (Hübner, 1831)	0	0	0	0	1	0	0	Xeric
Calisto pulchella Lathy, 1899	0	0	0	0	1	0	0	Pine forest
Calisto franciscoi Gali, 1985	1	0	0	0	0	0	0	Xeric
Calisto schwartzi Gali, 1985	0	0	0	0	1	0	0	Pine forest
Calisto confusa Lathy, 1899	0	0	1	1	1	0	1	Open areas
Calisto obscura Michener, 1943	1	0	1	0	1	0	0	Open areas
Calisto eleleus Bates, 1935	0	0	1	0	1	0	0	Pine forest
Total number of species / per site = **132**	**60**	**14**	**70**	**55**	**83**	**36**	**56**	
	B1	B2	B3	B4	B5	A	B	

Results

The analysis yielded a single most parsimonious tree (CI= 0.67, RI = 0.34, length= 197) (Fig. 4) showing a pectinate cluster of butterflies communities. The Arroyo Cano community is basal to the remaing communities. Indeed, the communities of the altitudinal transect of the Sierra de Baoruco along the altitudinal transect are related as follows: (((B4, ((B5, (B3 and B2).

It is to underline that the low RI could be an expression, as RIBICHICH (2005) noted in plant communities, of the influence of chance in the organization of butterfly assemblages.

Discussion

A community structure is the result of multiple influences including historical and contemporary factors. The present characteristics of each habitat are the most simple explanation (a contemporary-based hypothesis) to explain the relationships among species communities and their structures. As a matter of fact, similarities or differences among communities can be seen as the result of immigration, extinction or persistence of species (WRIGHT & REEVES, 1992).

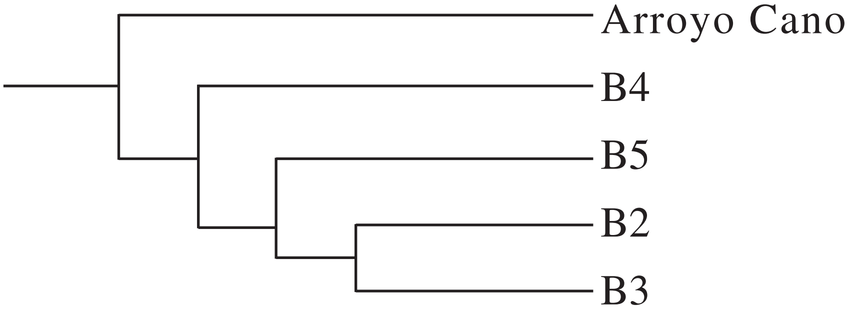

Figure 4.– The single most parsimonious tree of the butterfly communities of Arroyo Cano and Sierra de Baoruco

As RIBICHICH (2005) argued, in a spatio-temporal scenario, there are brief assemblages of species, in an ancestor-descendant progression which last in the present communities.

The topology of the resulting tree may mirror the effects of glacial and interglacial periods during the late Pleistocene, with raising and lowering of sea levels coupled with environmental changes and isolation events. The cyclic climate changes in the Pleistocene may have shaped the butterflies communities of the "north" and "south" islands. It can also be hypothesized that vicariant events among these "islands" and the unique presence in each study site - excluding their ranges in the whole Hispaniola - of the skippers *P. mercurius sanchesi*, *Astraptes xagua christyi* in the North Island, and that of *Argon* sp., *Aguna asander haitensis*, and *Panoquina nero* in the South Island, should be the result. The play of extinction and dynamic contemporary invasions shall be considered as further roles in shaping the relationships among the communities found in the present results.

It is interesting to note that the crown cluster (B2 + B3) of the Sierra de Baoruco mirrors the dry communities from 300 to 488 m (just before and immediately after the entrance to the National Park) which constitutes the ecotonal area to the higher and more structured broad-leaved forests. The two sites B4 and B5 define ecologically the broad-leaved and pine forests environments. This result which apparently seems paradoxical for the hierarchical position of the dry communities more evolved in respect to the moist or pine forests, can be read as a recent result of climatic changes. Indeed, palynological studies carried out in Haiti, Lake Miragoane on Tiburón Peninsula (HODELL *et al.*, 1991; HIGUERA-GUNDY, 1991; HIGUERA-GUNDY *et al.,* 1999) provided a continuous record of the vegetational and climatic history of Hispaniola from the late Pleistocene to present. Extremely dry conditions characterized Hispaniola during the late Pleistocene, > 10,230 - 9,700 B.P., and early Holocene, 9,700 - 7,000 B.P., with temperatures cooler than today persisting until ca 8,600 B.P. The vegetation around Miragoane, and possibly throughout Hispaniola, consisted of xeric and shrubby communities and small, fragmented forests. Hispaniola's most mesic vegetation flourished in the mid Holocene (7,000 - 2,800 B.P.) under a wet, warm, seasonal climate. Successional mesic forests predominated until 4,800 B.P. and later co-existed with mature forests until 2,800 B.P. Climatically dry conditions returned around 2,800 B.P. Since then, the watershed's vegetation has consisted of dry communities and relict moist forests. Agricultural activity at Miragoane dates from 1,100 B.P., but the greatest deforestation took place during the last five centuries.

HIGUERA-GUNDY *et al*. (1999) suggest that the 150 km strip of lowland dry forest that lies among the Haitian Massifs de la Hotte and de La Salle (see Fig. 1) was covered by mesic vegetation between ca 5,4 and 2,5 kyr BP. It is not unlike that the same phenomenon occurred in the Sierra de Bahoruco and the Barahona Peninsula. Opportunistic species can be easily adapted to the new environments and to-day re-adapted to the actual dry environments or otherwise they should be extinct. Therefore, the vicariant hypothesis on the patterns and evolution of Caribbean butterflies does not fit at least the picture of the butterflies of the Sierra de Baoruco. According to our results, the relationships among these butterflies communities can be likely explained by most recent cyclic climatic and environmental changes. On a broader spectrum, cyclic successions, analogous to taxon cycles and taxon pulses, marked by immigration, adaptation, speciation and extinction, took place several times in the Barahona Peninsula and in the Sierra de Baoruco. The actual composition of the butterfly assemblages along the transect is the result.

The high species richness of Arroyo Cano site can be due to a simple and ecological phenomenon namely the persistence of “species-packages” in the different micro habitats along the gully. Immigration from the pastures and crops cultivations running along the gallery forest is negligible for the paucity of species present in these lands. However, immigration can be hypothesized from the highest points of the gully (600-900 m) where the gallery forest disappears. Indicator species such as *Prepona*, *Myscelia* and *Dismorphia* demonstrate the good health of the site and constitutes one of the best species-richness site in Hispaniola. It is also to note that some species are extremely localized and were found on only one spot over the years. For example, *Proteides mercurius sanchesi, Astraptes habana heriul, Astraptes xagua christyi, Cabares potrillo, Choranthus schwartzi, Anetia pantheratus, Adelpha fessonia lapitha, Eueides isabella melphis* and *Archimestra teleboas* are found in biotope B (471-500 m) whereas *Synapte malitiosa adoceta, Ephyriades zephodes, Pyrisitia pyro, Libytheana terena* and *Anaea troglodyta* in biotope A (450-470 m).

SCHWARTZ (1989: 505) listed four Hispaniola localities which were “repeatedly rewarding”. (Table III). Unfortunately, the biotopes one and two are at present very much disturbed for different reasons, biotope three is still in good condition, and we have no information on biotope four located in Haiti. Arroyo Cano will be famous not only for the birth place of the Dominican Republic President, Sr Danilo Medina but also with 70 species almost 35% of the whole butterfly fauna, one of the richest places for butterflies in Hispaniola.

Table III.– Biotopes reported by SCHWARTZ (1989) compared with that of Arroyo Cano.

Biotope 1 - 52 sp. - Altagracia. 16 km NE La Romana, 61 m
Biotope 2 - 55 sp. - La Vega, 1 km S Constanza, 1098 m
Biotope 3 - 84 sp. - Independencia, 4-7 km NE El Aguacate, 519-824 m
Biotope 4 - 68 sp. - Haiti, Dépt. de l’Ouest, Boutilliers road, 266- 915 m
Biotope 5 - 70 sp. - San Juan, Arroyo Cano 450-500 m

Conclusion

As stated above, the present study is an attempt aimed at presenting a parsimonious-based analysis using some butterflies species communities. For this reason, comparisons with other type of analyses are likely to be unfruitful - although useful per se - because all the previous studies on other butterflies species communities of Hispaniola have all been based on phenetic hypotheses or on narrative-based explanations (e.g. RODRÍGUEZ *et al.,* 2014). On the other hand, a powerful tool of this kind of analysis is not only linked to the possibility of a re-analysis of the data within a few years - with the opportunity of addition of new records or to verify the absence of a taxon already recorded due to extinction by urbanization or by other natural or non-natural causes (RIBICHICH, 2005; WENZEL & LUQUE, 2008). Furthermore, our records like those of SCHWARTZ (1989) can be used for analogous analysis in other sites on the island. The present analysis is only an example aimed at stimulating further analogous attempts of investigation over the years, and specially to test the impact of deforestation, hurricanes or human exploitations as they occurred, and sadly still occur, in the Sierra de Baoruco and in other localities on Hispaniola.

Acknowledgements

Thanks are due to Dr. Bautista Rojas Gómez, Ministro de Medio Ambiente y Recursos Naturales, Santo Domingo for allowing us with permits for research, and to Sr. Antonio Trinidad, Vice President of FUNDACIPE, Pedernales for very useful suggestions. Our appreciation goes to Dr. Antonio Vives Moreno for editing the paper, and to reviewers who made valuable comments. Last, but by no means, least we thank Francesco Fontemaggi and Valentina Racheli for the drawings.

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(Recibido para publicación / *Received for publication* 28-II-2017)
(Revisado y aceptado / *Revised and accepted* 30-III-2017)
(Publicado / *Published* 30-XII-2017)