SHILAP Revista de lepidopterología, 49 (194) junio 2021: 327-349 eISSN: 2340-4078 ISSN: 0300-5267
https://doi.org/10.57065/shilap.303

Butterflies diversity from a remnant of semiurban Caatinga, Septentrional Sertaneja Depression Ecoregion, Patos, Paraíba, Brazil (Lepidoptera: Papilionoidea)

A. Ferreira-Júnior

Abstract

In order to perform a concise characterization and evaluation of the butterflies taxocenosis structure of the Rural Health and Technology Center (CSTR) of the Federal University of Campina Grande (UFCG), a semiurban area of the Caatinga biome, Semiarid region, in the Septentrional Sertaneja Depression Ecoregion, a species inventory with entomological net was conducted. There were recorded 81 species of butterflies, distributed in a general abundance of 2531 individuals; among them, 808 specimens were captured and collected, and none of the individuals marked with nontoxic pen and released were recaptured. The list of species was complemented by adding nine more butterflies species, mostly Hesperiidae, from collection before and after the sampling period, constituting a total of 90 species. Many of the butterflies species found in the CSTR are new records for Paraíba state and only four species are considered for the Northeast geographic region, based on other checklists for areas of Atlantic Forest, Caatinga, Cerrado and Amazon biomes in this region: *Junonia genoveva infuscata* Felder & Felder, 1867, *Staphylus melangon epicaste* Mabille, 1903, *Clito sompa* Evans, 1953 and *Lerema ancillaris* (Butler, 1877).
KEY WORDS: Lepidoptera, Papilionoidea, species list, urban ecology, semiarid, seasonally dry tropical forest, Brazil.

Diversidad de mariposas de un remanente de Caatinga semiurbana, Ecorregión de la Depresión Sertaneja Septentrional, Patos, Paraíba, Brasil (Lepidoptera: Papilionoidea)

Resumen

Para caracterizar y evaluar rápidamente la estructura de taxocenosis de mariposas del Centro de Salud y Tecnología Rural (CSTR) de la Universidad Federal de Campina Grande (UFCG), un área semiurbana del bioma Caatinga, región Semiárida, Ecorregión de Depresión Sertaneja Norteña, fue realizado un inventario de especies con red entomológica. Fueron registradas 81 especies de mariposas, distribuidas en una abundancia general de 2.531 individuos; de estos, 808 especímenes fueron capturados y colectados, ninguno de los individuos marcados con pluma no tóxica y liberados fueron recapturados. La lista de especies se complementó agregando nueve especies de mariposas más, principalmente Hesperiidae, de las recopilaciones antes y después del período de muestreo, lo que ha constituido un total de 90 especies. Muchas de las especies de mariposas encontradas en el CSTR son nuevos registros para el estado de Paraíba y solo cuatro especies se mencionan como nuevos registros para la región geográfica Noreste, basado en otros inventarios para las áreas de los biomas Bosque Atlántico, Caatinga, Cerrado y Amazonas de esta región: *Junonia genoveva infuscata* Felder & Felder, 1867, *Staphylus melangon epicaste* Mabille, 1903, *Clito sompa* Evans, 1953 y *Lerema ancillaris* (Butler, 1877).

PALABRAS CLAVE: Lepidoptera, Papilionoidea, lista de especies, ecología urbana, semiárido, bosque tropical estacionalmente seco, Brasil.

Introduction

Brazil is cited as one of the main megadiverse countries, housing a significant number of terrestrial invertebrates (LEWINSOHN & PRADO, 2005). However, knowledge of the diversity of this group, especially butterflies, is still incipient and unequally distributed among the political (geoeconomic) and biogeographic divisions, with evident negligence for the Northeastern Semiarid region (LEWINSOHN *et al.*, 2005; CARNEIRO *et al.*, 2008; FREITAS & MARINI-FILHO, 2011; SANTOS *et al*., 2011). Thus, it is required to acquire knowledge of biodiversity for its contribution and development of multiple conservation approaches, mitigation strategies and compensation of the various environmental impacts, given the growing pace of imbalance of natural ecosystems, habitat loss, extinction of species and the devastating effects of the global warming (WILSON, 1997; CHAPIN *et al*., 2000; BONEBRAKE *et al*., 2010; WARREN *et al*., 2013; GARCÍA-ROBLEDO *et al*., 2016; MELLO *et al*., 2016).

The term diversity, commonly used in works focusing on Community Ecology and Conservation Biology, represents the variety of living beings and may include information on richness and equitativity, this last expressing the relative importance of each species through abundance in sampling (MELO, 2008). Information about the diversity of butterflies in a given habitat, even those considered urban or with varied anthropogenic disturbance, can contribute to their conservation and understanding landscape connectivity, quali-quantitative monitoring and as a starting point for detecting spatial or temporal environmental changes, in addition to supporting biogeographic studies and specific patterns (HARDING *et al*., 1995; BROWN-JUNIOR & FREITAS, 1999; SOGA & KOIKE, 2012).

Specifically, the species richness (A, B, C, D, E or 1, 2, 3, 4, 5) does not express the number of individuals, a function of the abundance (A, A, A, A, A or 1, 1, 1, 1, 1, or yet A1, A2, A3, A4, A5, ... AN, or eventually for the composition A1, B1, B2, B3, B4, C1, C2, C3, D1, D2, E1, structure of distinct qualities with equal or different quantities of individuals), and consist of key metrics in the various fields of research in Ecology that generally underestimate the counts in samples of different characteristics (homogeneous and heterogeneous), with two large structural groups of statistical tests, parametric and non-parametric models, and two approaches to infer species richness based on data measures (computational simulations), incidence (absence 0 or ≥ 1 presence), numbers of uniques (1 sample) and duplicates (2 samples), and abundance (0 or ≥ 1), numbers of singletons (1 individual) and doubletons (2 individuals), - as expressed by KHALIGHIFAR *et al*. (2020), with more details, depending of the disposition and conformation, the data of binary incidence, 0 or 1, cannot be permuted into abundance finite data, however, the contrary transformation is possible - asymptotic and non-asymptotic approaches, that can be compared to the multiple assemblies (convergents/divergents, similars/dissimilars) and arrive at a theoretical (speculative) and experimental relationship of the appropriate real number of the richness (statistical approximation theory) in certain environments with possible undetected species, hypotheses that can be proven indispensably through the standardized application of collection protocols (sample integrity) and the sampling effort, once again highlighting the support to the understanding of the arbitrators to the causes of biodiversity phenomena and the consequences of unsustainable human exploration for making decisions based on a well-founded environmental policy (CHAO & CHIU, 2016a; 2016b; CHAO & COLWELL, 2017).

Considering the ontological and ontogenetic mutability of the linguistic sign "species", this word can express multiplicity of significant (among the various idioms and languages of the human species) and significances (concept) according to the dialectical contextual insertion in the systems (analogy, minor valence relationship, and homology, major valence relationship, of

Aristotelian origin applied over time), introduced and felt between enunciator (emitter) and enunciatory (receptor) through of the channels of enunciation of the enunciated (D'SAUSSURE, 2012). Species can be defined in the stricto sensu as a biological taxonomic category that includes its taxa by the unified concept of species, - genophenotypic (intrinsically) and/or phenogenotypic (extrinsically) living beings/organisms - segments of metapopulational lineages evolving separately, possible common denominator, through secondary and primary contingent properties used as operational criteria of the point of cut and circumscription of the lines of speciative evidence, with the metamorphosis occurring at the level of anagenesis and the speciation in the dimension of cladogenesis, analyzed by the robustness of integrated methods (emphasize for the phylogenetic-cladistic with your inferences) by genetic scrutineers (coalescence theory), phylogeographic, morphological, physiological and behavioral, among other aspects of the evolutionary biological taxonomic systematic (organization of knowledge), conducted and legislated by associations and commissions with yours consolidated international nomenclature codes, botanical (IAPT, 1950; TURLAND *et al*., 2018) and zoological (ICZN, 1895; ICZN, 1999), in addition to international committees and codes for the nomination of prokaryotes (ICSP, 2020; PARKER *et al*., 2019) and viruses (ICTV, 2018; ICTV, 2019); aditional groups with their supra and infracategorical epithets, inter and intraspecific interactions, evolutionarily involved throughout natural history through the various types of speciation with potential gene introgressions, parallel speciation and hybridizations in the flow of genetic pools (*e.g.*, ecotypes zones with semipermeable reproductive barriers and occurrence of at least two sympatric subspecies of the same species of butterfly that do not evolve completely apart), followed by heuristic, syntactic-semantic, nomenclatural-terminological conflicts (controversies), subject to the reviews and adequations submitted to the scientific community consensus or dissent (see MAYDEN, 1997; D'QUEIROZ, 2007; ALEIXO, 2007; HAUSDORF, 2011; NAOMI, 2011; BRABY *et al*., 2012 for more details of the heated debate about delimitation and conceptualization parameters of species and subspecies).

While the identity of the "species" can be applied to objects and subjects, living and non-living beings, memes, money banknotes, agents, patients, epidemiological cases (medical science), bugs in software programs (computer science and information technologies), characters that make up the atomicity of numbers and letters in different languages in the websites, books and physical-digital-virtual articles (Literature), genes or alleles of the genetic code and other discrete, elementary and substantial entities, contents within of categorical continents of the monistic hierarchical organization, not only of biological sciences, trans-interdisciplinary topics in the spectrum of conceptual applications and discussions of information theory (CHAO & CHIU, 2016a; 2016b); including not only the pertinent contemporary philosophical-anthropological-sociological reflections (considering other perspectives, see DANOWSKI & D'CASTRO, 2014), that together with Biology representatives (Zoology, Ecology, etc.) try to restructure and balance the coexistence of desires among beings for a more reasonable, tolerable, peaceful and just world during the probable most prominent viral pandemic of the 21st century, probably caused by the random events, misfortunes of the consequence by the human hyper-impaction on wild biodiversity, through the unpredictable strains of high mutagenic power transversely the species of the new coronavirus (SIDDELL *et al*., 2020) of Chiroptera origin (ZHOU *et al*., 2020), etiological agent Sars-Cov-2 (CSG/ICTV, 2020) that infects millions of individuals of the human species expressing ample deadly power pathogenic by the Covid-19 disease (ICTV, 2019).

Various environmental factors, biotic and abiotic, can influence relatively on the distribution and structure of neotropical butterfly communities, such as different latitude and altitude gradients, topographic, floristic and microhabitat heterogeneity, seasonality, microclimatic conditions and varying degrees of fragmentation and vegetative disturbance, thus the assemblies may have different composition, richness and abundance (BROWN-JUNIOR, 1991; BROWN-JUNIOR & FREITAS, 2000a, b; BROWN-JUNIOR & FREITAS, 2002).

Specifically, the effects of urbanization gradient and other anthropogenic disturbances in natural ecosystems, associated on butterfly assemblages, can lead to forest fragmentation, modification of habitats and species composition, through the emergence of exotic or cultivated species and the loss of native species, with consequent decrease in diversity (BROWN, 1989; RUSZCZYK & SILVA, 1997; HARDY & DENNIS, 1999; NEW & SANDS, 2002; FAHRIG, 2003; MCKINNEY, 2008). So, the presence or absence and population density of a particular species may serve as bioindicators of the conservation level and quality of the environmental landscapes, as they are insects characteristic of this assessment and susceptible to such impacts (FREITAS *et al*., 2003; FREITAS *et al*., 2006; OLIVEIRA *et al.,* 2018).

In contrast, urban environments, with green areas that maintain considerable vegetation and favorable weather conditions, even provide shelter and resources for the establishment and survival of adults and butterfly larvae, also becoming refuge for birds, reptiles and other insects, highlighting the importance of these remnants for the study and conservation of the biodiversity (RUSZCZYK, 1986a, 1986b, 1986c, 1986d; MURPHY, 1997; BROWN-JUNIOR & FREITAS, 2002; KOH & SODHI, 2004; COLLIER *et al*., 2006; CLARK *et al*., 2007). From this perspective, there is a tendency in the reduction of butterfly dispersion and diversity in relation to the increased degree of urbanization and alteration, where less impacted semiurban and peripheral areas present greater richness compared to more altered central urban green areas, with few exceptions (RUSZCZYK & ARAÚJO, 1992; FORTUNATO & RUSZCZYK, 1997; RUSZCZYK, 1998; HARDY & DENNIS, 1999; NEW & SANDS, 2002; HOGSDEN & HUTCHINSON, 2004; OLIVEIRA *et al.,* 2018; TZORTZAKAKIA *et al*., 2019).

Most of the Brazilian works developed with butterflies in fragments of urban and semiurban vegetation are described for areas of plazas, cemeteries, university campuses, municipal parks and other conservation units for the Atlantic Forest (sensu lato), involving the listing of species through active and/or passive collection, and various ecological analysis, with greater representativeness for the Southern (RUSZCZYK, 1986a, b, c, d, e; RUSZCZYK, 1987; RUSZCZYK & ARAUJO, 1992; LEMES *et al*., 2008; SACKIS & MORAIS, 2008; BONFANTTI *et al*., 2009; BONFANTTI *et al*., 2011; LEMES *et al*., 2015; FAVRETTO *et al*., 2015; PEREIRA *et al*., 2015) and Southeast regions (RODRIGUES *et al*., 1993; FORTUNATO & RUSZCZYK, 1997; RUSZCZYK & SILVA, 1997; VANINI *et al*., 1999; BROWN-JUNIOR & FREITAS, 2002; SILVA *et al*., 2007; PEREIRA *et al*., 2011; SILVA *et al*., 2012; SOARES *et al*., 2012). Few inventories can be cited for Midwest region (PINHEIRO *et al*., 2008; BOGIANI *et al.,* 2012), Northern region (GARCIA *et al*., 1990; GARCIA & BERGMANN, 1994) and Northeast region, described for Cerrado and Amazon (MARTINS *et al*., 2017; PEREIRA *et al*., 2018), Atlantic Forest (KESSELRING & EBERT, 1982; VASCONCELOS *et al*., 2009; OLIVEIRA *et al.,* 2018; MELO *et al*., 2019) and Caatinga urban areas (COSTA *et al*., 2013; ROQUE *et al*., 2014), where very few butterfly studies are known for the urban locations of the Semiarid region, demonstrating the importance of this survey work.

The present study was developed to contribute to the knowledge and conservation of the butterflies fauna of the Semiarid region of Northeastern Brazil through the elaboration of a species list and characterization of alpha diversity in an area of semiurban xerophytic caatinga located in the town of Patos, state of Paraíba. It is noteworthy that the area covered by the municipality is considered of extreme biological importance for the invertebrate group and priority for knowledge and conservation of the Caatinga biome biodiversity (MMA/SBF, 2002; SILVA *et al*., 2003).

Material and methods

Study area

The Health and Rural Technology Center (CSTR) of the Federal University of Campina Grande (UFCG) is located on the outskirts of the urban area of Patos town, Paraíba state (07º03’32” S e 37º16’29” W), it has an average altitude of 250 meters, rocky outcrops and an approximate area of 220 m^2, inserted in the Caatinga biome, Semiarid region, Septentrional Sertaneja Depression Ecoregion (VELLOSO *et al*., 2002). The regional climate is semiarid, BSh, according to the classification of Köppen, marked by a dry and a rainy season (ÁLVARES *et al*., 2014). The annual average temperature is around 25ºC, while the relative humidity 65,9% and the rainfall has an annual average of inferior 1000 mm (SOUSA *et al*., 2019), being irregularly distributed between the months of the year. It is in a high degree of anthropization, with much of the total area occupied by constructions. However, it has an area that concentrates a relatively considerable vegetation, where is inserted a forest vivarium with seedlings, next to one of the largest and oldest water reservoir of the municipality, Jatobá weir; besides extensions with ruderal vegetation spots, especially during the rainy season, and shrub-tree caatinga, which undergo periodic weeding and pruning. Both places provide food and oviposition substrates to butterflies, where native angiosperm species of different habits are present, mostly represented by families Fabaceae, Anacardiaceae, Bignoniaceae, Euphorbiaceae and Myrtaceae (SOUSA *et al*., 2019), Convolvulaceae, Malvaceae, Rubiaceae, Apocynaceae, Asteraceae, in addition to exotic and native ornamental species of others families located in regularly irrigated flower beds.

SAMPLING

The butterflies were captured with the aid of an entomological net, identified in the field when possible, marked with a nontoxic pen and released or collected. Visual counts were also performed of individuals of species with population explosions, once per transect and without net capture, mostly some species of Pieridae and Nymphalidae. At the time of the catch the transect was recorded. Registries were made in ruderal open areas, shrub and tree vegetation spots, within three transects proportional to the campus length and explored from February 2011 to December 2011 (10 months), except October, one day per month, from 08 am to 04 pm, alternately, 2:40 hours per transect, totaling a sampling effort of 80 hours/net/collector with one more auxiliary for spreadsheet annotations and marking of the entomological envelopes. Also, butterfly species that were not captured during the sampling period, but they have records for the study area, were added to complement the richness of the CSTR.

Specimens (vouchers) were deposited in the butterfly Collection of the Caatinga Insect Ecology and Interactions Laboratory (CLEIIC) of the Federal University of Campina Grande (UFCG), Patos, Paraíba, Brazil.

The systematic follows the one proposed by LAMAS (2004, 2008) and ESPELAND (2018). For the suprageneric categories of Nymphalidae, WAHLBERG *et al*. (2009), Riodinidae, SERAPHIM *et al*. (2018) and Hesperiidae, WARREN *et al*. and LI *et al*. (2019). Many identifications were obtained through physical (BROWN-JUNIOR, 1992; CANALS, 2003) and digital guides (WARREN *et al*., 2013), consulting specialists when needed.

DATA ANALYSIS

Are described richness data, absolute and relative frequencies by abundance of species, subfamilies and families, as well as the presence and absence of species in the rainy and dry seasons of the year. In sequence, to evaluate the collection effort, richness extrapolations (previsions) were performed through the nonparametric estimators that quantify rarities, Bootstrap, Jackknife 1, 2 and Chao 1, 2 (DIAS, 2004), using the software PAST 3.24 (HAMMER *et al*., 2019), comprising only the information for the 10 months of sampling.

The constancy of the butterfly species was obtained through the relation between the proportion of the samples in which a given species was registered and the total number of samples, through the formula C = p.100/N, being p the number of sampling occasions recorded for each species and *N* the total of sampling occasions, categorizing the species as constant, present in more than 50% of the collections (6-10 months), accessory, between 25 and 50% (3-5 months), and accidental, in less than 25% of the collections (1-2 months) (BODENHEIMER, 1955; SILVEIRA-NETO *et al*., 1976); while the dominance was calculated from the relative abundance of each species using the formula D = (i/t).100, being *i* the total of individuals of a species and *t* the total of sampled individuals, characterized as eudominant > 10%, dominant > 5-10%, subdominant > 2-5%, recessive = 1-2% and rare < 1% (FRIEBE, 1983).

Simple comparisons of richness and composition were also made with the intention to achieve some similarity with other available inventories for urban green areas in the Pampa, Cerrado and Atlantic Forest biomes (SILVA *et al*., 2007; SACKIS & MORAIS, 2008; PINHEIRO *et al.,* 2008; BONFANTTI *et al.,* 2009; VASCONCELOS *et al*., 2009; BONFANTTI *et al.*, 2011; SOARES *et al*., 2012; BOGIANI *et al.*, 2012; PEREIRA *et al*., 2015; LEMES *et al*., 2015; MELO *et al*., 2019), and with the other inventories developed in the northeastern Semiarid region (NOBRE *et al*., 2008; PALUCH *et al*., 2011; ZACCA & BRAVO, 2012; LIMA & ZACCA, 2014; KERPEL *et al*., 2014; RAFAEL *et al*., 2017). New records for the Northeast region were obtained from the inventories available in scientific literature (CARDOSO, 1949; KESSELRING & EBERT, 1982; NOBRE *et al*., 2008; ZACCA *et al*., 2011; PALUCH *et al*., 2011; ZACCA & BRAVO, 2012; LIMA & ZACCA, 2014; KERPEL *et al*., 2014; PALUCH *et al*., 2016; RAFAEL *et al*., 2017; MARTINS *et al*., 2017; PEREIRA *et al*., 2018; MELO *et al*., 2019).

Results and Discussion

Eighty-one (81) butterfly species were recorded distributed in 30 species of Hesperiidae (37%), 26 of Nymphalidae (32%), 13 of Pieridae (16%), eight of Lycaenidae (10%), three of Papilionidae (4%) and one species of Riodinidae (1%) (Table I). The list of species was complemented by adding nine more species, mostly Hesperiidae, from anterior and posterior collections to the sampling period, constituting a total of 90 species: *Historis acheronta* (Fabricius, 1775) (Nymphalidae); *Anteos clorinde* (Godart, [1824]) (Pieridae); *Electrostrymon endymion* (Fabricius, 1775), *Strymon crambusa* (Hewitson, 1874), *Pseudolycaena marsyas* (Linnaeus, 1758) (Lycaenidae); *Aguna megaeles* (Mabille, 1888), *Staphylus* sp., *Staphylus melangon epicaste* Mabille, 1903, *Heliopetes arsalte* (Linnaeus, 1758) (Hesperiidae) (Table I).

For the general abundance a total of 2531 individuals were registered, represented by 987 of Nymphalidae (39%), 945 of Pieridae (37.3%), 331 of Hesperiidae (13%), 239 of Lycaenidae (9.4%), 22 of Riodinidae (1%) and seven of Papilionidae (0.3%) (Table II). Among these records, 808 specimens were captured and collected, none of the marked and released individuals were recaptured.

Among the most representative families in number of species are Hesperiidae, Nymphalidae, Pieridae and Lycaenidae, respectively. Such representativeness was not maintained in relation to the proportion of the number of individuals, there was an inversion between the first three families, showing Nymphalidae as the most abundant, followed by Pieridae, Hesperiidae and Lycaenidae, while Papilionidae was the least abundant family and Riodinidae obtained the lowest proportion of richness, a single species, *Aricoris campestris* (H. Bates, 1868) - common in open vegetation and with characteristic distribution to the northeastern Semiarid region (NOBRE *et al*., 2008; PALUCH *et al*., 2011; ZACCA & BRAVO, 2012; KERPEL *et al*., 2014; RAFAEL *et al*, 2017) and in an area of Cerrado and Amazon of the Maranhão state (MARTINS *et al*., 2017) - being slightly higher to the total proportion of the number of individuals of the three species recorded for Papilionidae.

The most significant subfamilies in richness are Hesperiinae (13 species, 16%), Coliadinae (10 species, 12%), Pyrginae (9 species, 11%), Eudaminae (8 species, 10%), Nymphalinae and Theclinae (6 species, 7% each), respectively; when it comes to abundance, Coliadinae (845 specimens, 33.39%), Heliconiinae (329 specimens, 13%), Nymphalinae (272 specimens, 10.75%), Biblidinae (245 specimens, 9.68%) and Polyommatinae (206 specimens, 8.14%) are the prominent ones (Table II).

Table II.– Absolute and relative frequencies of the richness and abundance by butterfly families and subfamilies, and for the different seasons of the sampling period at the Health and Rural Technology Center (CSTR), Patos, Paraíba, Brazil, between February 2011 and December 2011, except October. Legend: S = richness, N = abundance; RAI = rain period (Feb-Jun), DRY = dry period (Jul-Dec).

Families/ subfamilies	S	%	N	%	Season (N)			
					RAI	%	DRY	%
Papilionidae	3	4	7	0.3	4	0.3	3	0.2
Papilioninae	3	4	7	0.28	4	0.3	3	0.2
Pieridae	13	16	945	37.3	430	36.3	515	38.3
Coliadinae	10	12	845	33.39	376	31.7	469	34.8
Pierinae	3	4	100	3.95	54	4.6	46	3.4
Lycaenidae	8	10	239	9.4	148	12.5	91	6.8
Theclinae	6	7	33	1.3	29	2.4	4	0.3
Polyommatinae	2	3	206	8.14	119	10	87	6.5
Riodinidae	1	1	22	1	5	0.4	17	1.3
Riodininae	1	1	22	0.87	5	0.4	17	1.3
Nymphalidae	26	32	987	39	384	32.4	603	44.8
Libytheinae	1	1	1	0.04	1	0.1	0	0
Danainae	5	6	75	2.96	25	2.1	50	3.7
Heliconiinae	4	5	329	13	169	14.3	160	11.9
Biblidinae	5	6	245	9.68	34	2.9	211	15.7
Cyrestinae	1	1	44	1.74	29	2.4	15	1.1
Nymphalinae	6	7	272	10.75	109	9.2	163	12.1
Charaxinae	2	3	12	0.47	10	0.8	2	0.1
Satyrinae	2	3	9	0.36	7	0.6	2	0.1
Hesperiidae	30	37	331	13	214	18.1	117	8.7
Eudaminae	8	10	120	4.74	50	4.2	70	5.2
Pyrginae	9	11	144	5.69	125	10.5	19	1.4
Hesperiinae	13	16	67	2.65	39	3.3	28	2.1
Total	**81**	**100**	**2531**	**100**	**1185**	**100**	**1346**	**100**

Of the 81 sampled species, 67 are recorded for the rainy season, 20 exclusive species, and 61 for the dry period, 14 exclusive species, with slightly more than half shared between both seasons, 47 species or 58% (Table I), with the highest peak of richness and abundance for the month of June (42 species, 406 individuals), followed by the richness of September (41 species, 267 individuals), April (40 species, 193 individuals), March (39 species, 179 individuals), February (38 species, 190 individuals), July and August (37 species each, 277 and 294 individuals), May (36 species, 217 individuals), November (31 species, 293 individuals) and December (29 species, 215 individuals); different from the total registered individuals, divided into 53% for the dry season, 1346 individuals, and 47% for the rainy season, 1185 individuals (Table II). Such findings between the different periods and among the months of sampling can express a seasonal fluctuation in the frequency of individuals and transience of species in the studied community, showing active individuals of different species in both seasons.

Potentially, the irregularity of the smallest number of individuals for the rainy season in the CSTR (Table II) results of the discontinuity of collections during the sampling year, possible differences in the collection effort during the samples (CALDAS & ROBBINS, 2003), inconstant and extemporaneous rains, in addition to other local characteristics.

Comparatively, for a more conserved area in the Caatinga, VASCONCELLOS *et al*. (2010) quantified and qualified Lepidoptera as the seventh order of the most abundant and representative insects for the rainy season, collected mainly with the malaise trap (independent of the collector's effort) at Fazenda Almas, Paraíba, where they registered the significance of the precipitation and relative humidity as fundamental predictors of the patterns of abundance and activity in most insect orders in this conservation unit. There are experiments to the identification of the specific patterns of the seasonal and spatial distribution of insects, however, they continue with incipient definitions for the butterflies and moths of the Semiarid, needing stimuli and more traction to acquire knowledge and resolutions of the contingents. The greater abundance recorded in the CSTR for the most adverse dry period (Table II) can be considered an anomaly to the logic of the greater availability of resources by the favorable climatic conditions through the months of greater precipitation and consequent vegetal mass increase, also followed by the increase of the insect populations of many species, among the evident population explosions of Pieridae, with relatively robust wings and involved in characteristic migrations in the Semiarid of the Northeast region, not exclusive to Brazil (SEMIÁRIDOS, 2013), during the rainy season, being influenced by an exo-endogenous geomagnetic compass (biological clock), assessed through of the degrees of angles between the solar zenith (positive phototropism) and the directional azimuth of the individuals (OLIVEIRA *et al*., 1998), masses and air currents, large scale climatic phenomena such as El Niño-Southern Oscillation (ENSO) (its oscillation is the main factor of temperature and continental precipitation) and La Niña, which occurred at the moderate level for the sampling year of 2011 (CPTEC/INPE, 2016), and by the climatic seasons that drive higher primary productivity and stimulates the phenology of host plants, mainly Fabaceae for pierids (BECCALONI *et al*., 2008), with annual migrations of butterflies from wet tropical forests for the drys (SRYGLEY *et al*., 2006; SRYGLEY *et al*., 2010), and presumably, during the interval of greatest precipitations in the Caatinga ecoregions, at least in the Septentrional Sertaneja Depression, areas located between Ecuador and the parallel of the Tropic of Capricorn.

For the year of 2020, in the urban zone of the city of Brejo do Cruz, Paraíba, distant about of 100 km from Patos, many Pieridae were seen following a constant flow at different hours of the day, with flight direction from west to east, with a considerable reduction in the number of individuals in April, coinciding with the rainfall reduction. SRYGLEY *et al.* (2014), expresses that the influence of the environment, oriented by the frequency and amplitude of the ENSO cycle, acts in the phenology of larvae and adult butterflies, in the frequencies and amplitudes of insects population outbreaks and physiological-behavioral changes related to migration, with a consequent increase or decrease in the herbivory rate, making it possible to predict through modeling how the plants and insects of wet and dry neotropical forests may respond to climate change. It should be noted that for the Semiarid region of the Caatinga biome the rainy period match around the seasons of the summer (beginning on December 22 - solstice, highest pluviosity) and autumn (beginning on March 21 - equinox), while the dry period corresponds around of the seasons of winter (beginning on June 21 - solstice) and spring (beginning on September 23 - equinox); see BEDAQUE & BRETONES (2020) for more elucidations.

The richness estimators Jackknife 1 and 2 returned a result of 98 and 104 species, Bootstrap predicted 89 species, while the Chao 1 and 2 revealed an extrapolation of 105 and 92 species, indicating that more species can be recorded if a greater collection effort is employed. This observation can be supported by the register of nine additional species outside the sampling, as well as a new species of Riodinidae described for Caatinga, *Pheles caatingensis* Callaghan & Nobre, 2014 (CALLAGHAN & NOBRE, 2014), later transferred to another genus, *Melanis caatingensis* (Callaghan & Nobre, 2014) (DIAS *et al*., 2015), with the record of one individual killed, in a spider web in the middle of a house bell on João Soares Street, on the way to the work in Diocesan Social Action of Patos (Ação Social Diocesana de Patos - ASDP), in the Brasília neighborhood, near the degraded riparian forest of the polluted extension of the Espinharas River, that runs through the town, about five kilometers from the CSTR.

The non-parametric estimator that responded best to the results found was the Chao 2, 92 species, - richness prediction based on incidence, presence or absence of species that define rarity, number of uniques (species found only in one sample) and duplicates (species found in only two samples) - considering only the data of the heterogeneous distribution of the 81 species in the sampling period between February and December 2011 (except October), and the addition of 9 registered species, part before and after of the sample period in the CSTR, totaling 90 species. These 90 species are added with *Melanis caatingensis* (Callaghan & Nobre, 2014) and more the visual record of a single individual of a non-resident clearwing butterfly, observed passing through the city center, plaza of the Bandstand I (Coreto I), hypothetically flying in direction to the Pico do Jabre State Park, where it is relatively common (FERREIRA-JÚNIOR *et al*., in prep.), both species registered outside the CSTR, but obviously within the city of Patos, resulting in the totality of 92 species that match the 92 species predicted by the estimator Chao 2 (asymptote).

CHAO & JOST (2012) express that a sample of a certain size may be sufficient to fully characterize a low diversity assembly and insufficient to represent a rich assembly (see Table III) because if there are many undetectable species (“invisibles”) in an assemblage with high diversity it will be statistically impossible to obtain a good estimate of species richness; therefore, a precise lower limit is usually more practical than an inaccurate point estimate, with the need of uniques/duplicates (incidence) and singletons/doubletons (abundance), basic concept of intuitive design in the non-parametric estimation of the species richness that will be detected in samples showing that abundant species contain almost no information about the richness of undetected species, while rare species, which are unlikely to be recorded or rarely seen, contain almost all information about the richness of undetected species; consequently, most non-parametric estimators of the number of undetected species are based on the lower-order frequency counts (CHAO & CHIU, 2016b).

However, considering the relationship of the richness and the proximity between the caatinga environments of the CSTR and Tamanduá Farm (approximately 20 km distance), with 24 species that were not registered for the CSTR, and knowing that in the adult phase many species of Lepidoptera are migratory and remain in metapopulations during the seasons (seasonality) through the high dispersion capacity by the flight and other survival strategies, such as diapause, it becomes probable in time that part of this difference in the species composition can move from one environment to another and be recorded, according to the specificity of habitat inherent to each species, expressing possible faunistic transient interchangeability in space and time (turnover). In the future, perhaps the cumulative number of the butterflies richness of the CSTR or town of Patos undergo changes, being able to increase and achieve momentary equality and temporarily with the previsions of the other estimators, with least chance of overmatch the Chao 1 because of the tendency of landscape modification by the anthropic actions, while possible resamples by monitoring can express different results for a comparative diagnosis, in addition to possible changes by the taxonomic revisions. In the worst case, a considerable decrease in the number of species if effective conservation programs are not properly implemented in the conservation units and ecological buffer zones surrounding the CSTR, ideally reinforcing them or creating new units for the maintenance of wild flora and fauna.

Species constancy revealed a value of 31 accidental species, 27 constants and 23 accessory (Table I). There are twelve species, mainly Pieridae, among the most common constant that were present throughout the sampling period: *Anteos menippe* (Hübner, [1818]), *Phoebis philea* (Linnaeus, 1763), *Phoebis sennae marcellina* (Cramer, 1777), *Eurema elathea flavescens* (Chavannes, 1850), *Pyrisitia leuce* (Boisduval, 1836), *Pyrisitia nise tenella* (Boisduval, 1836) and *Ascia monuste orseis* (Godart, 1819) (Pieridae), *Euptoieta hegesia meridiania* Stichel, 1938, *Anartia jatrophae* (Linnaeus, 1763), *Hamadryas februa* (Hübner, [1823]) and *Marpesia petreus* (Cramer, 1776) (Nymphalidae), *Hemiargus hanno* (Stoll, 1790) (Lycaenidae).

Regarding dominance, 72% of the species were categorized as rare (58 species), most of them represented by Hesperiidae (26 species), Nymphalidae (16 species), Lycaenidae (7 species), Pieridae (5 species), Papilionidae (3 species) and Riodinidae (1 species), respectively, reaching only 13% of the total abundance sampled, 338 individuals (Table I). Only one species of Pieridae was considered eudominant, *E. elathea flavescens*, with 12% of the sampled (310 individuals); particularly, due to population explosions, visual counts were made of many individuals of this species, not all of them captured and marked, which may have resulted in a lack of recaptures. While five species were characterized as dominant, totaling 39% and the majority of the sample, 974 individuals: two of Nymphalidae, *A. jatrophae* (248 individuals) and *E. hegesia meridiania* (205 individuals), one of Lycaenidae, *H. hanno* (198 individuals), and two of Pieridae, *A. menippe* (178 individuals) and *P. sennae marcellina* (145 individuals).

It is noted that the CSTR environment is home to a butterfly fauna characteristic of the northeastern Semiarid region (81 shared species), representing approximately 20% of the registered species by the largest butterfly survey of this region (KERPEL *et al*., 2014), and more distinct from green areas of the Atlantic Forest (65 shared species), Cerrado (60 shared species) and Amazon (26 shared species), in the Northeast region of Brazil (Table I and IV).

The richness obtained in the present study is nearly (SILVA *et al*., 2007; SACKIS & MORAIS, 2008; PEREIRA *et al*., 2015) or it is bigger (VASCONCELOS *et al*., 2009; SOARES *et al*., 2012; BOGIANI *et al*., 2012) than many of the major urban butterfly inventories in Brazil, conducted with sampling effort and relatively distinct methodologies in the Pampa, Cerrado and Atlantic Forest biomes, and it is much lower in five of the eleven works used for comparison (PINHEIRO *et al*., 2008; BONFANTTI *et al*., 2009, 2011; LEMES *et al*., 2015; MELO *et al*., 2019); it is observed that less than half of the CSTR species have distribution records for these urban areas, except one, described in Table III. In compensation, most of the recorded species are shared with the available inventories for the Caatinga biome, Semiarid region, carried out in different phytophysiognomies of the ecoregions of Meridional Sertaneja Depression, Borborema Plateau, Chapada Diamantina Complex, Ibiapaba-Araripe Complex and Campo Maior Complex; although they have a considerably larger number of species, because they are more conserved environments and, also, they are outside the urban matrix (Table IV). Moreover, there is a good similarity between the richness and species composition of the CSTR with a more conserved caatinga area, Tamanduá Farm, and very close to the campus, approximately 20 km distance, where the applied collection effort was practically doubled, being that share 76% of all recorded species in both localities, 68 species, with 22 exclusive species to the CSTR and 24 exclusive species to the Tamanduá Farm (FERREIRA-JÚNIOR *et al*., in prep.).

Table III.– Simple comparison of the richness and composition butterflies at the Health and Rural Technology Center (CSTR) with the main urban butterfly inventories developed with sampling effort and relatively different methodologies and available for Brazil. Legend: FAT = Atlantic Forest, CER = Cerrado, CAA = Caatinga, PAM = Pampa; N = entomological net, T = bait traps.

Work	State	City	Biome	Method	Effort	Richness	Shared species
Present study CSTR	PB	Patos	CAA	N	80 h/net	81 (90)	-
SILVA *et al*. (2007)	MG	Belo Horizonte	FAT CER	N (T)	72 h/net	83 (91)	33
SACKIS & MORAIS (2008)	RS	Santa Maria	PAM	N	113 h/net	89	26
PINHEIRO *et al*. (2008)	DF	Brasília	CER	N (T)	-	128 (-)	35
BONFANTTI *et al*. (2009)	RS	Frederico Westphalen	FAT	N	80 h/net	161	24
VASCONCELOS *et al*. (2009)	BA	Salvador	FAT	N (T)	144 h/net	55 (70)	26
BONFANTTI *et al*. (2011)	PR	Curitiba	FAT	N (T)	240 h/net	166 (-)	17
SOARES *et al*. (2012)	MG	Belo Horizonte	FAT	N (T)	104 h/net	64 (78)	25
BOGIANI *et al*. (2012)	MS	Campo Grande	CER	N (T)	100 h/net	62 (-)	25
PEREIRA *et al*. (2015)	PR	Curitiba	FAT	N	120 h/net	85	15
LEMES *et al*. (2015)	RS	Santa Maria	FAT	N	360 h/net	130	27
MELO *et al*. (2019)	PE	Recife	FAT	N	464 h/net	273 (288)	58

Many of the butterfly species found in the CSTR are new records for the state of Paraíba and practically all of them can be considered for this locality in the Semiarid portion of the state. Only four species are appointed as new records for the Northeast region, *S. melangon epicaste* Mabille, 1903, *Clito sompa* Evans, 1953, *Lerema ancillaris* (A. Butler, 1877) (Hesperiidae) and *Junonia genoveva infuscata* C. Felder & R. Felder, 1867 (Nymphalidae), based on the other inventories available for Atlantic Forest, Caatinga, Cerrado and Amazon biomes of this geographic region; although types of *C. sompa* and *J. genoveva infuscata* are described for states of this region (LAMAS 2004; WARREN *et al.,* 2013). It is also noteworthy the registration of *Fountainea halice moretta* (H. Druce, 1877), considered an endemic species of the Semiarid region and commonly mentioned for other areas of Caatinga and high altitude wetlands in Northeast (ZACCA & BRAVO, 2012; NOBRE *et al*., 2008; LIMA & ZACCA, 2014; KERPEL *et al*., 2014).

Just a single individual of *Mechanitis lysimnia nesaea* Hübner, [1820] (Ithomiini) and *Lycorea halia discreta* Haensch, 1909 (Danaini) was registered, and only two frugivorous species of Satyrinae, *Pharneuptychia phares* (Godart, [1824]) (Satyrini) and *Opsiphanes invirae* (Hübner, [1808]) (Brassolini). The low representativeness of Ithomiini and Satyrini can presumably demonstrate that the richness of these tribes is considered low for the Septentrional Sertaneja Depression and to other specific areas of the Semiarid, due to the high anthropogenic disturbance of the CSTR, as well as adverse microclimatic and vegetative conditions, absence of food resources for adults and immatures, essential to the survival of other representatives of these groups (NOBRE *et al*., 2008, 2012). There is a strong specificity of occurrence of these groups with the food resources for the Satyrini adults, butterflies restricted to the frugivorous diet, and Solanaceae host plants, almost exclusive for the oviposition of the immatures (coevolution) of Ithomiini (BECCALONI *et al.*, 2008). These taxa or clades between parentheses, specifically Satyrini and Ithomiini, together with other species of Riodinidae, are more common and well distributed in areas of high altitude wetland, Atlantic Forest, Cerrado and Amazon of the Northeast (PALUCH *et al*., 2011; ZACCA *et al*., 2011; ZACCA & BRAVO, 2012; LIMA & ZACCA, 2014; KERPEL *et al*., 2014; PALUCH *et al*., 2016; RAFAEL *et al*., 2017; MARTINS *et al*., 2017).

Table IV.– Simple comparison of the richness and composition butterflies at the Health and Rural Technology Center (CSTR) with available butterfly works developed in the Semiarid region of the Brazilian Northeast. Legend: DSS = Septentrional Sertaneja Depression, DSM = Meridional Sertaneja Depression, PBO = Borborema Plateau, CHD = Chapada Diamantina Complex, CIA = Ibiapaba-Araripe Complex, CCM = Campo Maior Complex; N = entomological net, T = bait traps.

Work	State	Altitude	Caatinga Ecoregion	Effort	Richness	Shared species
Present study CSTR	PB	250 m	DSS	80 h/one collector/N	81 (90)	-
NOBRE *et al*. (2008)	PE	600-1000 m	PBO e DSM	360 h/one collector/N (T)	121 (15)	63
PALUCH *et al*. (2011)	PE	840 m	PBO	216 h/two collectors/N (T)	197	55
ZACCA & BRAVO (2012)	BA	480-1290 m	CHD	392 h/one collector/N (T)	169	52
LIMA & ZACCA (2014)	BA	400-1020 m	CHD	97 h/one collector/N (T)	121 (24)	44
KERPEL *et al*. (2014)	PI, CE, PB, PE e BA	Varied	DSM, PBO, CHD, CIA	N (T)	389	79
RAFAEL *et al*. (2017)	CE	450-854 m	CIA e CCM	49 h/N (T)	107	42

Only one individual of *Vanessa myrinna* (E. Doubleday, 1849) was registered and apparently not a Nymphalinae resident butterfly, since its occurrence is usually cited in the Atlantic Forest and high altitude wetland from Northeast (ZACCA *et al*., 2011; PALUCH *et al*., 2011; KERPEL *et al*., 2014; MELO *et al*., 2019), and so far there are no records of their Asteraceae host plants, *Achyrocline* sp. and *Gamochaeta* sp. (BECCALONI *et al*., 2008), for the study area and surroundings. Also, a single frugivorous individual of Nymphalinae, *H. acheronta*, was captured at

CSTR in the rainy season after the sampling year. According to NOBRE *et al*. (2012), it is a non-resident species, as its larvae feed on *Cecropia* sp. (BECCALONI *et al.*, 2008), characteristic plant of Atlantic Forest and without natural records for the Meridional and Septentrional Sertaneja Depression Ecoregions. Nevertheless, a higher incidence of individuals of this species had been recorded with bait traps for frugivorous butterflies in the Pico do Jabre State Park (S. M. Kerpel, unpublished data), high altitude wetland in the Borborema Plateau Ecoregion and approximately distant 47 km from the CSTR, where there is no record of this host plant genus as well (AGRA *et al*., 2004). A single individual of *A. megaeles* was also recorded after the sampling period in the rainy season and its host plant species, *Bauhinia forficata* Link (BECCALONI *et al.*, 2008), is registered in the campus (SOUSA *et al*., 2019).

Although the CSTR is a very altered environment, as its vegetation is composed of abundant invasive ruderal plants, with less diverse fauna compared to more conserved areas, and more species characteristic of open and flexible environments, disturbance tolerants and more generalists (44 species), with lower habitat specificity; their irrigated flower beds provides floral resources in both seasons, maintainers of many characteristic species from the Brazilian northeastern semiarid. Thereby, necessary actions are proposed to stimulate the cultivation of native plants, with potential supply of food resources (fruits and nectar), oviposition (plant tissues) and shelter (shaded places) for the turnover, establishment and maintenance of the lepidopteran guilds and other floral visitors/residentes from this area, as an efficacious management strategy to increment and expand the value of urban and periurban green areas of zones predominantly urban, intermediate and predominantly rural (IBGE, 2017) for conservation of biodiversity, and as a maintenance source of colonizers and pollinators, better ecosystem functionality and faunal connectivity of the Caatinga landscapes, reducing dispersion barriers.

Acknowledgements

To the colleagues from the Caatinga Insects Biogeography and Ecology Laboratory (LEBIC) of the Federal University of Campina Grande (UFCG), Dilcemar Ferreira de Almeida Filho, Valdelúcia de França Costa, Rafael Pereira Rodrigues, Pedro Elias Santos Neto, Erlane Fábia Moura da Silva, Iara Patrícia Ferreira de Sousa, for field and laboratory help, and Edna Mariza Rangel da Silva also for capturing the *Vanessa myrinna* in a field class for science teachers in the public school system of the microregion of Patos through the extension project (PROBEX/UFCG). To friend José Caroca da Silva Monteiro for the assistance in one collection. To Dr. Fernando César Vieira Zanella, former holder coordinator of the Caatinga Insects Biogeography and Ecology Laboratory (Laboratório de Ecologia e Biogeografia de Insetos da Caatinga - LEBIC), for his precious help and encouragement in the development of this study. To the Dr. André Victor Lucci Freitas and Dr. Lucas Augusto Kaminski for the identification and confirmation of many species. To Dr. Mirna Martins Casagrande for the opportunities given and Dr. Eduardo Carneiro dos Santos for the suggestion. To Dr. Olaf Hermann Hendrik Mielke for the identification and confirmation of many species, and the review of the article, that thanks for the fellowship with the CNPq, process nº 304639/2014-1. To Dr. Solange Maria Kerpel for the teachings, contributions along that journey and the review of the article. To the Semiarid PPBio (PPBio Semiárido), for the financial and material support to the LEBIC, process nº 183682/ 2011-4. To the CNPq, process nº 134335/ 2017-1, for the study and research scholarship. To Jossely Bezerra Martins de Oliveira Leite for reviewing the English version of this work. To the referees who conducted the blind review.

BIBLIOGRAPHY

AGRA, M. F., BARBOSA, M. R. V. & STEVENS, W. D., 2004.– Levantamento Florístico Preliminar do Pico do Jabre, Paraíba, Brasil.– *In* K. C. PORTO, J. J. P. CABRAL & M. TABARELLI (orgs.). *Brejos de Altitude em*

Pernambuco e Paraíba: História Natural, Ecologia e Conservação: 123-138. Série Biodiversidade, 9. Ministério do Meio Ambiente, Brasília.

ALEIXO, A., 2007.– Conceitos de espécie e o eterno conflito entre continuidade e operacionalidade: uma proposta de normatização de critérios para o reconhecimento de espécies pelo Comitê Brasileiro de Registros Ornitológicos.– *Revista Brasileira de Ornitologia*, **15**(2): 297-310.

ALVARES, C. A., STAPE, J. L., SENTELHAS, P. C., GONÇALVES, J. L. M. & SPAROVEK, G., 2014.– Köppen's climate classification map for Brazil.– *Meteorologische Zeitschrift*, **22**(6): 711-728.

BECCALONI, G. W., VILORIA, Á. L., HALL, S. K. & ROBINSON, G. S., 2008.– *Catalogue of the hostplants of the Neotropical butterflies / Catálogo de las plantas huésped de las mariposas Neotropicales*: 536 pp. Monografias Tercer Milenio, 8. The Natural History Museum, Instituto Venezolano de Investigaciones Científicas & S. E. A., RIBES-CYTED, Zaragoza.

BEDAQUE, P. & BRETONES, P. S., 2020.– O Sol está sempre a pino ao meio-dia?.– *Revista Brasileira de Ensino de Física*, **42**: 1-13.

BODENHEIMER, F. S., 1955.– *Precis d'écologie animale*: 315 pp. Payot, Paris.

BOGIANI, P. A., ARANDA, R. & MACHADO, C. O. F., 2012.– Riqueza de Borboletas (Lepidoptera) em um Fragmento Urbano de Cerrado em Mato Grosso do Sul, Brasil.– *EntomoBrasilis*, **5**(2): 93-98.

BONEBRAKE, T. C., PONISIO, L. C., BOGGS, C. L. & EHRLICH, P. R., 2010.– More than just indicators: A review of tropical butterfly ecology and conservation.– *Biological Conservation*, **143**(8): 1831-1841.

BONFANTTI, D., DI MARE, R. A. & GIOVENARDI, R., 2009.– Butterflies (Lepidoptera: Papilionoidea and Hesperioidea) from two forest fragments in northern Rio Grande do Sul, Brazil.– *Check List*, **5**(4): 819-829.

BONFANTTI, D., LEITE, L. A. R., CARLOS, M. M., CASAGRANDE, M. M., MIELKE, E. C. & MIELKE, O. H. H., 2011.– Riqueza de borboletas em dois parques urbanos de Curitiba, Paraná, Brasil.– *Biota Neotropica*, **11**(2): http://dx.doi.org/10.1590/S1676-06032011000200025.

BRABY, M. F., EASTWOOD, R. & MURRAY, N., 2012.– The subspecies concept in butterflies: has its application in taxonomy and conservation biology outlived its usefulness?.– *Biological Journal of the Linnean Society*, **106**: 699-716.

BROWN, J. H., 1989.– Patterns, modes and extent of invasions by vertebrates.– *In* J. A. DRAKE, H. A. MOONEY, F. DI CASTRI, R. H. GROVES, F. J. KRUGER, M. REJMÁNEK & M. WILLIAMSON (eds.). *Biological invasions: A global perspective*: 85-109. Wiley, Chichester.

BROWN-JUNIOR, K. S., 1991.– Conservation of Neotropical environments: Insects as indicators.– *In* N. M. COLLINS & J. A. THOMAS (eds.). *The conservation of insects and their habitats*: 350-404. Academic Press, London.

BROWN- JUNIOR, K. S., 1992.– Borboletas da Serra do Japi: Diversidade, Habitats, Recursos Alimentares e Variação Temporal.– *In* L. P. C. MORELLATO (ed.). *História natural da Serra do Japi: ecologia e preservação de uma área florestada no sudeste do Brasil*: 142-186. UNICAMP, Campinas.

BROWN-JUNIOR, K. S. & FREITAS, A. V. L., 1999.– Lepidoptera.– *In* C. R. F. BRANDÃO & E. M. CANCELLO (eds.). *5. Invertebrados terrestres*: 225-243.– *In* C. A. JOLY & C. E. M. BICUDO (orgs.). *Biodiversidade do Estado de São Paulo, Brasil: Síntese do Conhecimento ao Final do Século XX*. FAPESP, São Paulo.

BROWN-JUNIOR, K. S. & FREITAS, A. V. L., 2000a.– Atlantic Forest Butterflies: indicators for landscape conservation.– *Biotropica*, **32**(4b): 934-956.

BROWN-JUNIOR, K. S. & FREITAS, A. V. L., 2000b.– Diversidade de Lepidoptera em Santa Teresa, Espírito Santo.– *Boletim do Museu de Biologia Mello Leitão* (Nova Série), **11/12**: 71-118.

BROWN-JUNIOR, K. S. & FREITAS, A. V. L., 2002.– Butterfly communities of urban forest fragments in Campinas, São Paulo, Brazil: Structure, instability, environmental correlates, and conservation.– *Journal of Insect Conservation*, **6**: 217-231.

CALDAS, A. & ROBBINS, R. K., 2003.– Modified pollard transects for assessing tropical butterfly abundance and diversity.– *Biological Conservation*, **110**: 211-219.

CALLAGHAN, C. J. & NOBRE, C. E. B., 2014.– A new species of *Pheles* Herrich-Schaeffer from Northeast Brazil (Lepidoptera, Riodinidae).– *Zootaxa*, **3780**(3): 558-566.

CANALS, G., 2003.– *Mariposas de Misiones*: 476 pp. L.O.L.A., Buenos Aires, Argentina.

CARDOSO, A., 1949.– Lepidópteros de Alagoas.– *Revista de Entomologia*, **20**(1-3): 427-436.

CARNEIRO, E., MIELKE, O. H. H. & CASAGRANDE, M. M., 2008.– Butterfly inventories in Brazil: the state of art and the priority-areas model research aiming at conservation.– *Natureza & Conservação*, **6**(2): 178-200.

CHAO, A. & JOST, L., 2012.– Coverage-based rarefaction and extrapolation: standardizing samples by completeness rather than size.– *Ecology*, **93**(12): 2533-2547.

CHAO, A. & CHIU, C. H., 2016a.– *Species richness: estimation and comparison*.– Wiley StatsRef: Statistics Reference Online.

CHAO, A. & CHIU, C.-H., 2016b.– *Nonparametric estimation and comparison of species richness*.– John Wiley & Sons, Chichester.

CHAO, A. & COLWELL, R. K., 2017.– Thirty years of progeny from Chao's inequality: Estimating and comparing richness with incidence data and incomplete sampling.– *Statistics and Operations Research Transactions - SORT*, **41**(1): 3-54.

CHAPIN, F. S., ZAVALETA, E. S., EVINER, V. T., NAYLOR, R. L., VITOUSEK, P. M., REYNOLDS, H. L., HOOPER, D. U., LAVOREL, S., SALA O. E., HOBBIE, S. E., MACK, M. C. & DÍAZ, S., 2000.– Consequences of changing biodiversity.– *Nature*, **405**: 234-242.

CLARK, P. J., REED, J. M. & CHEW, F. S., 2007.– Effects of urbanization on butterfly species richness, guild structure, and rarity.– *Urban Ecosystems*, **10**(3): 321-337.

COLLIER, N., MACKAY, D. A., BENKENDORFF, K., AUSTIN, A. D. & CARTHEW, S. M., 2006.– Butterfly communities in South Australian urban reserves: Estimating abundance and diversity using the Pollard walk.– *Austral Ecology*, **31**(2): 282-290.

COSTA, T. R. A. A., SOBREIRA, J. A. D. C., MESQUITA, K. O. & FURTADO, I. P., 2013.– Butterflies of Cariri: Papilionoidea and Hesperioidea in the slopes of the Chapada do Araripe in Ceará, Brazil.– *Cadernos de Cultura e Ciência*, Ano VIII, **12**(1): 16-23.

CPTEC/INPE, 2016.– *Condições da última semana: Monitoramento do El Niño durante NDJ-2019/2020*. Available from http://enos.cptec.inpe.br/ (accessed 10th May 2020). INPE - Instituto Nacional de Pesquisas Espaciais, CPTEC - Centro de Previsão de Tempo e Estudos Climáticos, Brasil.

CSG/ICTV, 2020.– The species *Severe acute respiratory syndrome-related coronavirus*: classifying 2019-nCoV and naming it SARS-CoV-2. Coronaviridae Study Group of the International Committee on Taxonomy of Viruses.– *Nature Microbiology*, **5**: 536-544.

DANOWSKI, D. & D'CASTRO, E. V., 2014.– *Há mundo por vir? Ensaio sobre os medos e os fins*: 176 pp. Cultura e Barbárie, Florianópolis, SC e Instituto Socioambiental (ISA), São Paulo.

D'QUEIROZ, K., 2007.– Species concepts and species delimitation.– *Systematic Biology*, **56**(6): 879-886.

D'SAUSSURE, F., 2012.– *Curso de Linguística Geral*: 312 pp. C. BALLY & A. SECHEHAYE; com a colaboração de A. RIEDLINGER. Tradução de A. CHELINI, J. P. PAES & I. BLIKSTEIN. 28ª ed. Cultrix, São Paulo.

DIAS, S. C., 2004.– Planejando estudos de diversidade e riqueza: uma abordagem para estudantes de graduação.– *Acta Scientiarum - Biological Sciences*, **26**(4): 373-379.

DIAS, F. M. S., DOLIBAINA, D. R., MIELKE, C. G. C., MIELKE, O. H. H. & CASAGRANDE, M. M., 2015.– Description of two new species of *Pheles* Herrich-Schäffer, [1853] and notes on the taxonomic position of two species hitherto included in the genus (Riodinidae: Riodininae).– *Zootaxa*, **3981**(2): 275-283.

EMERY, E. O., BROWN-JUNIOR, K. S. & PINHEIRO, C. E. G., 2006.– As borboletas (Lepidoptera, Papilionoidea) do Distrito Federal, Brasil.– *Revista Brasileira de Entomologia*, **50**(1): 85-92.

ESPELAND, M., BREINHOLT, J., WILLMOTT, K. R., WARREN, A. D., VILA, R., TOUSSAINT, E. F. A., MAUNSELL, S. C., ADUSE-POKU, K., TALAVERA, G., EASTWOOD, R., JARZYNA, M. A., GURALNICK, R., LOHMAN, D. J., PIERCE, N. E. & KAWAHARA, A. Y., 2018.– A Comprehensive and Dated Phylogenomic Analysis of Butterflies.– *Current Biology*, **28**(5): 770-77.

FAHRIG, L., 2003.– Effects of habitat fragmentation on biodiversity.– *Annual Review of Ecology, Evolution, and Systematics*, **34**: 487-515.

FAVRETTO, M. A., PIOVESAN, M., ORLANDIN, E. & SANTOS, E. B., 2015.– Lepidoptera em um fragmento florestal urbano no sul do Brasil.– *Scientia Plena*, **11**(3).

FORTUNATO, L. & RUSZCZYK, A., 1997.– Comunidades de Lepidopteros frugívoras em áreas verdes urbanas e extraurbanas de Uberlândia, MG.– *Revista Brasileira de Biologia*, **57**(1): 79-87.

FREITAS, A. V. L., FRANCINI, R. B. & BROWN-JUNIOR, K. S., 2003.– Insetos como indicadores ambientais.– *In* L. CULLEN-JUNIOR, C. VALLADARES-PÁDUA & R. RUDRAN (orgs.). *Métodos de estudos em biologia da conservação e manejo da vida silvestre*: 125-151. Editora da UFPR, Curitiba.

FREITAS, A. V. L., LEAL, I. R., UEHARA-PRADO, M. & IANNUZZI, L., 2006.– Insetos como indicadores de conservação da paisagem.– *In* C. F. D. ROCHA, H. G. BERGALLO, M. VAN-SLUYS & M. A. S. ALVES (eds.). *Biologia da Conservação: essências*: 357-384. RiMa Editora, São Carlos.

FREITAS, A. V. L. & MARINI-FILHO, O. J., 2011.– *Plano de Ação Nacional para Conservação dos Lepidópteros Ameaçados de Extinção*: 124 pp. ICMBio, Brasília.

FRIEBE, B., 1983.– Zur Biologie eines Buchenwaldbodens. 3. Die Kaferfauna.– *Carolinea*, **41**: 45-80.

GARCIA, I. P., BERGMANN, E. C. & RODRIGUES-NETO, S. M., 1990.– Diversidade mensal de borboletas na ilha de São Luís (MA).– *Arquivos do Instituto Biológico*, **57**(1-2): 39-44.

GARCIA, I. P. & BERGMANN, E. C., 1995.– Borboletas da ilha de São Luís (MA).– *O Biológico*, **56**(1-2): 37-38.

GARCÍA-ROBLEDO, C., KUPREWICZ, E. K., STAINES, C. L., ERWIN, T. L. & KRESS, W. J., 2016.– Limited tolerance by insects to high temperatures across tropical elevational gradients and the implications of global warming for extinction.– *Proceedings of the National Academy of Sciences of the United States of America*, **113**(3): 680-685.

HAMMER, Ø., HARPER, D. A. T. & RYAN, P. D., 2001.– PAST: Paleontological statistics software package for education and data analysis.– *Palaeontologia Electronica*, **4**(1).

HARDING, P. T., ASHER, J. & YATES, T. J., 1995.– Butterfly Monitoring: 1 - Recording the changes.– *In* A. S. PULLIN (ed.). *Ecology and conservation of Butterfies*: 3-22. Chapman & Hall, London.

HARDY, P. B. & DENNIS, R., 1999.– The impact of urban development on butterflies within a city region.– *Biodiversity and Conservation*, **8**(9): 1261-1279.

HAUSDORF, B., 2011.– Progress toward a general species concept.– *Evolution*, **65**(4): 923-931.

HOGSDEN, K. L. & HUTCHINSON T. C., 2004.– Butterfly assemblages along a human disturbance gradient in Ontario, Canada.– *Canadian Journal of Zoology*, **82**(5):739-748.

IAPT, 1950.– *International Association for Plant Taxonomy*. Available from https://www.iaptglobal.org/ (accessed 13th May 2020).

IBGE, 2017.– *Classificação e caracterização dos espaços rurais e urbanos do Brasil - Uma primeira aproximação*: 84 pp. Instituto Brasileiro de Geografia e Estatística, Coordenação de Geografia, Rio de Janeiro.

ICSP, 2020.– *International Committee on Systematics of Prokaryotes*. Available from http://www.the-icsp.org/ (accessed 13th May 2020).

ICTV, 2018.– *The International Code of Virus Classification and Nomenclature*. Available from https://talk.ictvonline.org/information/w/ictv-information/383/ictv-code (accessed 13th May 2020).

ICTV, 2019.– *International Committee on Taxonomy of Viruses*. Available from https://talk.ictvonline.org/ (accessed 12th May 2020).

ICZN, 1895.– *International Commission on Zoological Nomenclature*. Available from https://www.iczn.org/ (accessed 13th May 2020).

ICZN, 1999.– *International Code of Zoological Nomenclature*. Available from https://www.iczn.org/the-code/the-international-code-of-zoological-nomenclature/the-code-online/ (accessed 13th May 2020).

KERPEL, S. M., ZACCA, T., NOBRE, C. E. B., FERREIRA-JÚNIOR, A., ARAÚJO, M. X. & FONSECA, A., 2014.– Borboletas do Semiárido: conhecimento atual e contribuições do PPBIO.– *In* F. BRAVO & A. CALOR (orgs.). *Artrópodes do Semiárido: biodiversidade e conservação*: 245-272. Printmídia, Feira de Santana.

KESSELRING, J. & EBERT, H., [1982].– Relação das borboletas encontradas na “Mata do Buraquinho”, João Pessoa, Estado da Paraíba, Brasil.– *Revista Nordestina de Biologia*, **2**(1/2): 105-118.

KHALIGHIFAR, A., JIMÉNEZ, L., NUÑEZ-PENICHET, C., FREEMAN, B., INGENLOFF, K., JIMÉNEZ-GARCÍA, D. & PETERSON, T., 2020.– Inventory statistics meet big data: complications for estimating numbers of species.– *PeerJ*, **8**: 1-13.

KOH, L. P. & SODHI, N. S., 2004.– Importance of reserves, fragments, and parks for butterfly conservation in a tropical urban landscape.– *Ecological Applications*, **14**(6): 1695-1708.

LAMAS, G., 2004.– Checklist: Part 4A, Hesperioidea-Papilionoidea.– *In* J. HEPPNER (ed.). *Atlas of Neotropical Lepidoptera*: 479 pp. Association for Tropical Lepidoptera, Scientific Publishers, Gainesville.

LAMAS, G., 2008.– La sistemática sobre mariposas (Lepidoptera: Hesperioidea y Papilionoidea) em el mundo: Estado actual y perspectivas futuras.– *In* J. LLORENTE & A. LANTERI (eds.). *Contribuciones taxonómicas en órdenes de insectos hiperdiversos*: 57-70. Universidad Nacional Autónoma de México, México, DF.

LEMES, R., RITTER, C. D. & MORAIS, A. B. B., 2008.– Borboletas (Lepidoptera: Hesperioidea e Papilionoidea) visitantes florais no Jardim Botânico da Universidade Federal de Santa Maria, Santa Maria, RS, Brasil.– *Biotemas*, **21**(4): 91-96.

LEMES, R., CARVALHO, A. P. S., RIBEIRO, T. C. & MORAIS, A. B., 2015.– Borboletas de áreas verdes urbanas de Santa Maria, Sul do Brasil (Lepidoptera: Papilionoidea).– *SHILAP Revista de lepidopterología*, **43**(169): 95-111.

LEWINSOHN, T. M., FREITAS, A. V. L. & PRADO, P. I., 2005.– Conservação de Invertebrados terrestres e seus hábitats no Brasil.– *Megadiversidade*, **1**(1): 62-69.

LEWINSOHN, T. M. & PRADO, P. I., 2005.– How Many Species Are There in Brazil?.– *Conservation Biology*, **19**(3): 619-624.

LI, W., CONG, Q., SHEN, J., ZHANG, J., HALLWACHSC, W., JANZEN, D. H. & GRISHIN, N. V., 2019.– Genomes of skipper butterflies reveal extensive convergence of wing patterns.– *PNAS*, **116**(13): 6232-6237.

LIMA, J. N. R. & ZACCA, T., 2014.– Borboletas (Lepidoptera: Hesperioidea e Papilionoidea) de uma Área de Semiárido na Região Nordeste do Brasil.– *EntomoBrasilis*, **7**(1): 33-40.

MARTINS, L. P., ARAUJO-JUNIOR, E. C., MARTINS, A. R. P., COLINS, M. S., ALMEIDA, G. C. F. & AZEVEDO, G. G., 2017.– Butterflies of Amazon and Cerrado remnants of Maranhão, Northeast Brazil.– *Biota Neotropica*, **17**(3): 1-11.

MAYDEN, R. L., 1997.– A hierarchy of species concept: the denouement in the saga of the species problem.– *In* M. F. Claridge, H. A. Dawah & M. R. Wilson (eds.). *Species: The units of Biodiversity*: 381-424. Chapman & Hall, London.

MCKINNEY, M. L., 2008.– Effects of urbanization on species richness: A review of plants and animals.– *Urban Ecosystems*, **11**(2): 161-176.

MELO, A. S., 2008.– O que ganhamos “confundindo” riqueza de espécies e equabilidade em um índice de diversidade?.– *Biota Neotropica,* **8**(3): 21-27.

MELLO, K., TOPPA, R. H. & CARDOSO-LEITE, E., 2016.– Priority areas for forest conservation in an urban landscape at the transition between Atlantic Forest and Cerrado.– *Cerne*, **22**(3): 277-288.

MELO, D. H. A., DUARTE, M., MIELKE, O. H. H., ROBBINS, R. K. & FREITAS, A. V. L., 2019.– Butterflies (Lepidoptera: Papilionoidea) of an urban park in northeastern Brazil.– *Biota Neotropica*, **19**(1): 1-10.

MIELKE, O. H. H., CARNEIRO, E. & CASAGRANDE, M. M., 2010.– Lepidopterofauna (Papilionoidea e Hesperioidea) do Parque Estadual do Chandless e arredores, Acre, Brasil.– *Biota Neotropica*, **10**(4): 1-15.

MMA/SBF, 2002.– *Avaliação e identificação de áreas e ações prioritárias para a conservação, utilização sustentável e repartição dos benefícios da biodiversidade nos biomas brasileiros*: 404 pp. Secretaria de Biodiversidade e Florestas, Ministério do Meio Ambiente, Brasília.

MURPHY, D. D., 1997.– Desafios à diversidade biológica em áreas urbanas.– *In* O. E. WILSON (org.). *Biodiversidade*: 657 pp., 89-97. Nova Fronteira, Rio de Janeiro.

NAOMI, S.-I., 2011.– On the integrated frameworks of species concepts: Mayden’s hierarchy of species concepts and de Queiroz’s unified concept of species.– *Journal of Zoological Systematics and Evolutionary Research*, **49**(3): 177-184.

NEW, T. R. & SANDS, D. P. A., 2002.– Conservation concerns for butterflies in urban areas of Australia.– *Journal of Insect Conservation*, **6**(4): 207-215.

NOBRE, C. E. B., SCHLINDWEIN, C. & MIELKE, O. H. H., 2008.– The butterflies (Lepidoptera: Papilionoidea and Hesperioidea) of the Catimbau National Park, Pernambuco, Brazil.– *Zootaxa*, **1751**(1): 35-45.

NOBRE, C. E. B., IANNUZZI, L. & SCHLINDWEIN, C., 2012.– Seasonality of Fruit-Feeding Butterflies (Lepidoptera, Nymphalidae) in a Brazilian Semiarid Area.– *ISRN Zoology,* **112**: 1-8.

OLIVEIRA, E. G., SRYGLEY, R. B. & DUDLEY, R., 1998.– Do Neotropical migrant butterflies navigate using a solar compass?.– *The Journal of Experimental Biology*, **201**: 3317-3331.

OLIVEIRA, I. F., LIONA, M. B. & CARDOSO, M. Z., 2018.– A plaza too far: High contrast in butterfly biodiversity patterns between plazas and an urban reserve in Brazil.– *Landscape and Urban Planning*, **180**: 207-216.

PALUCH, M., MIELKE, O. H. H., NOBRE, C. E. B., CASAGRANDE, M. M., MELO, D. H. A. & FREITAS, A. V. L., 2011.– Butterflies (Lepidoptera: Papilionoidea and Hesperioidea) of the Parque Ecológico João Vasconcelos Sobrinho, Caruaru, Pernambuco, Brazil.– *Biota Neotropica*, **11**(4): 229-238.

PALUCH, M., MIELKE, O. H. H., LINHARES, L. M. & SILVA, D. C., 2016.– Butterflies (Lepidoptera: Papilionoidea and Hesperioidea) of the Private Reserve of Natural Heritage Fazenda Lontra/Saudade, Itanagra, Northern Coast of Bahia, Brazil.– *Biota Neotropica*, **16**(1): 1-7.

PARKER, C. T., TINDALL, B. J. & GARRITY, G. M., 2019.– International Code of Nomenclature of Prokaryotes.– *International Journal of Systematic and Evolutionary Microbiology*, **69**(1): 1-111.

PEREIRA, H. A., SILVA, J. R., MARQUES, G. D. V., GERMANOS, E., CAMARGO, A. J. A. & STEFANI, V., 2011.– Levantamento de lepidópteros (Insecta: Lepidoptera) diurnos em mata mesófila semi decídua de um fragmento urbano.– *Bioscience Journal*, **27**(5): 839-848.

PEREIRA, L. L., LEITE, L. A. R. & BRUGIOLO, S. S. S., 2015.– Riqueza de Lepidoptera (Papilionoidea e

Hesperioidea) em dois fragmentos urbanos de Floresta Ombrófila Mista no Campus da Universidade Federal do Paraná (Curitiba, Paraná, Brasil).– *Revista Brasileira de Zoociências*, **16**: 105-121.

PEREIRA, S., REZENDE, W. M. A. & CÂMARA, J. T., 2018.– Borboletas (Lepidoptera: Papilionoidea e Hesperioidea) da Reserva Biológica do Gurupi, Maranhão, Brasil.– *EntomoBrasilis*, **11**(2): 124-138.

PINHEIRO, C. E. G. & EMERY, E. O., 2006.– As borboletas (Lepidoptera: Papilionoidea e Hesperioidea) da Área de Proteção Ambiental do Gama e Cabeça de Veado (Distrito Federal, Brasil).– *Biota Neotropica*, **6**(3): 1-15.

PINHEIRO, C. E. G., MALINOV, I. C., ANDRADE, T. O., MARAVALHAS, J., MOUSSALLEM, M., DEUS, L. P. A., PEDROSA, L. G. P. & ZANATTA, G., 2008.– As borboletas (Lepidoptera, Papilionoidea) do Campus Universitário Darcy Ribeiro (Distrito Federal, Brasil).– *Biota Neotropica*, **8**(4): 139-144.

RAFAEL, J. A., OLIVEIRA, M. L., SOUZA, U. R. M., GALILEO, M. H. M., SILVA, A. S., VAZ-DE-MELO, F. Z., LEIVAS, F., ARRIAGADA, G., GROSSI, P. C., ALE-ROCHA, R., MAEDA-TAKIYA, D., CÂMARA, J., ALMEIDA-MARQUES, D. W., FREITAS-SILVA, R., SOUZA-JUNIOR, E. A, MENDES, I. S., SOUSA T. T. A., MENDES, L. L., PINTO-JUNIOR, J. S., ALVES-REIS, G., PALADIN, A., CAVICJIOLI, R. R., CONÇALVES, C. C., SOUZA, S. P., CARVALHO, R. A., SOMAVILLA, A., MIELKE, O. H. H., CASAGRANCE, M. M., CARNEIRO, E., RODRIGO-DOLIBANIA, D., SILVA-DIAS, F. M., BARROS, C. F., LIMA, T. M. A., PEREIRA, S., SILVA, K. M. O. E., MIELKE, C. G. C., SANTOS, A. P. M., MARTINS, G. A., OLIVEIRA, A. L. H. & LIMEIRA-DE-OLIVEIRA, F., 2017.– Insetos dos Parques Nacionais de Sete Cidades e de Ubajara.– *In* W. MANTOVANI, R. F. MONTEIRO, L. ANJOS & M. O. CARIELLO (orgs.). *Pesquisas em Unidades de Conservação no Domínio da Caatinga: Subsídios à gestão*: 605 pp. Edições UFC, Fortaleza.

RODRIGUES, J. J. S., BROWN-JUNIOR, K. S. & RUSZCZYK, A., 1993.– Resources and conservation of Neotropical butterflies in urban forest fragments.– *Biological Conservation*, **64**(1): 3-9.

ROQUE, M. G., LEITÃO, Â. T., SIMPLICIO, A. A. F. & FERREIRA, J. T. P., 2014.– Diversidade de borboletas na zona rural e urbana do Cariri cearense.– *Agrarian Academy*, **1**(1): 275-284.

RUSZCZYK, A., 1986a.– Organização das comunidades de borboletas (Lepidoptera) nas principais avenidas de Porto Alegre, Rio Grande do Sul.– *Revista Brasileira de Entomologia*, **30**(2): 265-269.

RUSZCZYK, A., 1986b.– Hábitos Alimentares de Borboletas Adultas e sua Adaptabilidade ao Ambiente Urbano.– *Revista Brasileira de Biologia*, **46**(2): 419-427.

RUSZCZYK, A., 1986c.– Ecologia urbana de borboletas, I. O gradiente de urbanização e a fauna de Porto Alegre, RS.– *Revista Brasileira de Biologia*, **46**(4): 675-688.

RUSZCZYK, A., 1986d.– Ecologia urbana de borboletas, II. Papilionidae, Pieridae e Nymphalidae em Porto Alegre, RS.– *Revista Brasileira de Biologia*, **46**(4): 689-706.

RUSZCZYK, A., 1986e.– Mortality of *Papilio scamander scamander* (Lepidoptera: Papilionidae) pupae in four districts of Porto Alegre (S. Brazil) and the causes of superabundance of some butterflies in urban áreas.– *Revista Brasileira de Biologia*, **46**(3): 567-579.

RUSZCZYK, A., 1987.– Distribution and abundance of butterflies in the urbanization zones of Porto Alegre, Brazil.– *Journal of Research on the Lepidoptera*, **25**(3): 157-178.

RUSZCZYK, A., 1998.– Borboletas: indicadoras da qualidade ambiental.– *In* R. MENEGAT (coord.). *Atlas ambiental de Porto Alegre*: 69-70. Editora da Universidade/UFRGS, Porto Alegre.

RUSZCZYK, A. & ARAÚJO, A. M., 1992.– Gradients in butterfly species diversity in an urban area in Brazil.– *Journal of the Lepidopterists' Society*, **46**: 255-264.

RUSZCZYK, A. & SILVA, C. F., 1997.– Butterflies select microhabitats on building walls.– *Landscape and Urban Planning*, **38**(1-2): 119-127.

SACKIS, G. D. & MORAIS, A. B. B., 2008.– Borboletas (Lepidoptera: Hesperioidea e Papilionoidea) do campus da Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul.– *Biota Neotropica*, **8**(1): 151-158.

SANTOS, J. C., LEAL, I. R., ALMEIDA-CORTEZ, J. S., FERNANDES, G. W. & TABARELLI, M., 2011.– Caatinga: the scientific negligence experienced by a dry tropical Forest.– *Tropical Conservation Science*, **4**(3): 276-286.

SEMIÁRIDOS, 2013.– *Plataforma Semiáridos: América Latina*. Available from https://www.semiaridos.org/en/semiarid-regions/ (accessed 10th May 2020). Fundación para el desarrollo en justicia y paz (FUNDAPAZ), International Land Coalition: América Latina y El Caribe (ILC-AL).

SERAPHIM, N., KAMINSKI, L. A., DE VRIES, P. J., PENZ, C., CALLAGHAN, C., WAHLBERG, N., SILVA-BRANDÃO, K. L. & FREITAS, A. V. L., 2018.– Molecular phylogeny and higher systematics of the metalmark butterflies (Lepidoptera: Riodinidae).– *Systematic Entomology*, **43**(2): 407-425.

SIDDELL, S. G., WALKER, P. J., LEFKOWITZ, E. J., MUSHEGIAN, A. R., DUTILH, B. E., HARRACH, B.,

HARRISON, R. L., JUNGLEN, S., KNOWLES, N. J., KROPINSKI, A. M., KRUPOVIC, M., KUHN, J. H., NIBERT, M. L., RUBINO, L., SABANADZOVIC, S., SIMMONDS, P., VARSANI, A., ZERBINI, F. M. & DAVISON, A. J., 2020.– Binomial nomenclature for virus species: a consultation.– *Archives of Virology*, **165**: 519-525.

SILVA, J. M. C., TABARELLI, M. & FONSECA, M. T., 2003.– Invertebrados: áreas e ações prioritárias para a conservação da Caatinga.– *In* J. M. C. SILVA, M. TABARELLI, M. T. FONSECA & L. V. LINS (orgs.). *Biodiversidade da Caatinga: áreas e ações prioritárias para a conservação*: 382 pp. Universidade Federal de Pernambuco, Conservation International do Brasil, Fundação Biodiversitas, Embrapa Semi-Árido, Ministério do Meio Ambiente, Brasília.

SILVA, A. R. M., LANDA, G. G. & VITALINO, R. F., 2007.– Borboletas (Lepidoptera) de um fragmento de mata urbano em Minas Gerais, Brasil.– *Lundiana*, **8**(2): 137-142.

SILVA, A. R. M., CASTRO, C. O., MAFIA, P. O., MENDONÇA, M. O. C., ALVES, T. C. C. & BEIRÃO, M. V., 2012.– Borboletas frugívoras (Lepidoptera: Nymphalidae) de uma área urbana (Área de Proteção Especial Manacial Cercadinho) em Belo Horizonte, Minas Gerais, Brasil.– *Biota Neotropica*, **12**(3): 292-297.

SILVEIRA-NETO, S., NAKANO, O., BARBIN, D. & NOVA, N. A. V., 1976.– *Manual de ecologia de insetos*: 419 pp. Agronomica Ceres, São Paulo.

SOARES, G. R., OLIVEIRA, A. A. P. & SILVA, A. R. M., 2012.– Borboletas (Lepidoptera: Papilionoidea e Hesperioidea) de um parque urbano em Belo Horizonte, Minas Gerais, Brasil.– *Biota Neotropica*, **12**(4): 209-217.

SOGA, M. & KOIKE, S., 2012.– Relative importance of quantity, quality and isolation of patches for butterfly diversity in fragmented urban forests.– *Ecological Research*, **27**(2): 265-271.

SOUSA, R. R., ARAÚJO, L. H. B., BORGES, C. H. A., SOUTO, P. C. & SOUTO, J. S., 2019.– Diagnóstico da arborização do campus de Patos-PB.– *BIOFIX Scientific Journal*, **4**(1): 43-51.

SRYGLEY, R. B., DUDLEY, R., OLIVEIRA, E. G. & RIVEROS, A. J., 2006.– Experimental evidence for a magnetic sense in Neotropical migrating butterflies (Lepidoptera: Pieridae).– *Animal Behaviour*, **71**: 183-191.

SRYGLEY, R. B., DUDLEY, R., OLIVEIRA, E. G., AIZPRÚA, R., PELAEZ, N. Z. & RIVEROS, A. J., 2010.– El Niño and dry season rainfall influence hostplant phenology and an annual butterfly migration from Neotropical wet to dry forests.– *Global Change Biology*, **16**: 936-945.

SRYGLEY, R. B., DUDLEY, R., OLIVEIRA, E. G. & RIVEROS, A. J., 2014.– El Niño, host plant growth, and migratory butterfly abundance in a changing climate.– *Biotropica*, **46**(1): 90-97.

TURLAND, N. J., WIERSEMA, J. H., BARRIE, F. R., GREUTER, W., HAWKSWORTH, D. L., HERENDEEN, P. S., KNAPP, S., KUSBER, W.-H., LI, D.-Z., MARHOLD, K., MAY, T. W., MCNEILL, J., MONRO, A. M., PRADO, J., PRICE, M. J. & SMITH, G. F. (eds.)., 2018.– International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile 159. Glashütten: Koeltz Botanical Books. https://doi.org/10.12705/Code.2018.

TZORTZAKAKI, O., KATI, V., PANITSA, M., TZANATOS, E., GIOKAS, S., 2019.– Butterfly diversity along the urbanization gradient in a densely-built Mediterranean city: Land cover is more decisive than resources in structuring communities.– *Landscape and Urban Planning,* **183**: 79-87.

VANINI, F., BONATO, V. & FREITAS, A. V. L., 2000.– Polyphenism and population biology of *Eurema elathea* (Lepidoptera: Pieridae) in a disturbed environment in Tropical Brazil.– *Journal of the Lepidopterists' Society*, **53**(4): 159-168.

VASCONCELOS, R. N., BARBOSA, E. C. C. & PERES, M. C. L., 2009.– Borboletas do Parque Metropolitano de Pituaçu, Salvador, Bahia, Brasil.– *Sitientibus Série Ciências Biológicas*, **9**(2): 158-164.

VASCONCELLOS, A., ANDREAZZE, R., ALMEIDA, A. M., ARAUJO, H. F. P., OLIVEIRA, E. S. & OLIVEIRA, U., 2010.– Seasonality of insects in the semi-arid Caatinga of northeastern Brazil.– *Revista Brasileira de Entomologia*, **54**(3): 471-476.

VELLOSO, A. L., SAMPAIO, E. V. S. B. & PAREYN, F. G. C., 2002.– *Ecorregiões propostas para o bioma caatinga*: 75 pp. Associação Plantas do Nordeste, Instituto de Conservação Ambiental, The Nature Conservancy do Brasil, Recife.

WAHLBERG, N., LENEVEU, J., KODANDARAMAIAH, U., PEÑA, C., NYLIN, S., FREITAS, A. V. L. & BROWER, A. V. Z., 2009.– Nymphalid butterflies diversify following near demise at the Cretaceous/ Tertiary boundary.– *Proceedings of the Royal Society B*, **276**(1677): 4295-4302.

WARREN, A. D., OGAWA, J. R. & BROWER, A. V. Z., 2009.– Revised classification of the family Hesperiidae

(Lepidoptera: Hesperioidea) based on combined molecular and morphological data.– *Systematic Entomology*, **34**(3): 467-523.

WARREN, A. D., DAVIS, K. J., STANGELAND, E. M., PELHAM, J. P. & GRISHIN, N. V., 2013.– *Illustrated Lists of American Butterflies*. Available from http://www.butterfliesofamerica.com (accessed 18th September 2019).

WARREN, R., VANDERWAL, J., PRICE, J., WELBERGEN, J. A., ATKINSON, I., RAMIREZVILLEGAS, J., OSBORN, T. J., JARVIS, A., SHOO, L. P., WILLIAMS, S. E. & LOWE, J., 2013.– Quantifying the benefit of early climate change mitigation in avoiding biodiversity loss.– *Nature Climate Change*, **3**(7): 678-682.

WILSON, E. O., 1997.– A situação atual da diversidade biológica.– *In* E. O. WILSON (ed.). *Biodiversidade*: 657 pp. Nova Fronteira, Rio de Janeiro.

ZACCA, T., BRAVO, F. & ARAÚJO, M. X., 2011.– Butterflies (Lepidoptera: Papilionoidea and Hesperioidea) from Serra da Jibóia, Bahia State, Brazil.– *EntomoBrasilis*, **4**(3): 139-143.

ZACCA, T. & BRAVO, F., 2012.– Borboletas (Lepidoptera: Papilionoidea e Hesperioidea) da porção norte da Chapada Diamantina, Bahia, Brasil.– *Biota Neotropica*, **12**(2): 117-126.

ZHOU, H., CHEN, X., HU, T., LI, J., SONG, H., LIU, Y., WANG, P., LIU, D., YANG, J., HOLMES, E. C., HUGHES, A. C., BI, Y. & SHI, W., 2020.– A novel bat coronavirus closely related to SARS-CoV-2 contains natural insertions at the S1/S2 cleavage site of the spike protein.– *Current Biology*, **30**: 1-8.

*A. F. J.
Laboratório de Ecologia e Biogeografia de Insetos da Caatinga (LEBIC)
Centro de Saúde e Tecnologia Rural (CSTR)
Unidade Acadêmica de Ciências Biológicas (UACB)
Universidade Federal de Campina Grande (UFCG)
Av. Universitária, S/N, Santa Cecília
CEP 58708-110, Patos, Paraíba
BRASIL / *BRAZIL*
*E-mail: aurinofj@gmail.com
https://orcid.org/0000-0003-3781-1694

*Autor para la correspondencia / *Corresponding author*

(Recibido para publicación / *Received for publication* 9-XII-2019)
(Revisado y aceptado / *Revised and accepted* 8-X-2020)
(Publicado / *Published* 30-VI-2021)

Table I.– List of butterfly species sampled at the Health and Rural Technology Center (CSTR), Patos, Paraíba, Brazil, between February 2011 and December 2011, except October, and total frequencies. Legend: S = richness, N = abundance, AF = absolute frequency, RF = relative frequency; D = dominance of species, EU = eudominant, DO = dominant, SU = subdominant, RE = recessive, RA = rare; C = species constancy, CON = constant, ACE = accessory, ACI = accidental; RAI = rainy season (Feb-Jun), DRY = dry season (Jul-Dec); species that have been also recorded for at least one of the works described for the biomes and the apostrophe (’) means records of different subspecies or just the same species for the 1 = Caatinga (NOBRE *et al*., 2008; PALUCH *et al*., 2011; ZACCA & BRAVO, 2012; LIMA & ZACCA, 2014; KERPEL *et al*., 2014; RAFAEL *et al*., 2017), 2 = Atlantic Forest (CARDOSO, 1949; KESSELRING & EBERT, 1982; ZACCA *et al*., 2011; PALUCH *et al*., 2016; MELO *et al*., 2019), 3 = Cerrado (EMERY *et al*., 2006; PINHEIRO & EMERY, 2006; MARTINS *et al*., 2017), 4 = Amazon (MIELKE *et al*., 2010; MARTINS *et al*., 2017; PEREIRA *et al*., 2018); * = butterfly species out of sampling and with records for the CSTR; ** = new records for the Northeast region of Brazil.

Taxa (S)	AF (N)	RF (%)	D	C	Season		Biomes
					RAI	DRY	
PAPILIONOIDEA (90)							
PAPILIONIDAE (3)							
Papilioninae							
Troidini							
Battus polydamas (Linnaeus, 1758)	1	0.03	RA	ACI		X	1/2/3/4
Papilionini							
Heraclides anchisiades capys (Hübner, [1809])	4	0.1	RA	ACE	X	X	1/2/3/4’
Heraclides thoas brasiliensis (Rothschild & Jordan, 1906)	2	0.1	RA	ACI	X	X	1/2/3/4’
PIERIDAE (14)							
Coliadinae							
Anteos clorinde (Godart, [1824])*							1/2/3
Anteos menippe (Hübner, [1818])	178	7	DO	CON	X	X	1/2/3/4
Eurema albula (Cramer, 1775)	32	1	RE	CON	X	X	1/2/3/4
Eurema arbela gracilis (Avinoff, 1926)	1	0.03	RA	ACI	X		1/3’/4’
Eurema deva (E. Doubleday, 1847)**	2	0.1	RA	ACI		X	2’/3’/4
Eurema elathea flavescens (Chavannes, 1850)	310	12	EU	CON	X	X	1/2/3’/4’
Phoebis argante (Fabricius, 1775)	1	0.03	RA	ACI	X		1/2/3/4
Phoebis philea (Linnaeus, 1763)	39	1	RE	CON	X	X	1/2/3/4
Phoebis sennae marcellina (Cramer, 1777)	145	6	DO	CON	X	X	1/2/3/4
Pyrisitia leuce (Boisduval, 1836)	32	1	RE	CON	X	X	1/2/3/4
Pyrisitia nise tenella (Boisduval, 1836)	105	4	SU	CON	X	X	1/2/3
Pierinae							
Pierini							
Ascia monuste orseis (Godart, 1819)	92	4	SU	CON	X	X	1/2/3
Ganyra phaloe endeis (Godart, 1819)	5	0.2	RA	ACI		X	1
Glutophrissa drusilla (Cramer, 1777)	3	0.1	RA	ACI		X	1/2/4
LYCAENIDAE (11)							
Theclinae							
Eumaeini							
Allosmaitia strophius (Godart, [1824])	1	0.03	RA	ACI	X		1/2/3
Chlorostrymon simaethis (Drury, 1773)	4	0.1	RA	ACE	X		1
Electrostrymon endymion (Fabricius, 1775)*							1/2/3
Kisutam syllis (Godman & Salvin, 1887)	2	0.1	RA	ACI	X		1/2/3
Pseudolycaena marsyas (Linnaeus, 1758)*							1/2/3/4
Strymon astiocha (Prittwitz, 1865)	10	0.4	RA	ACE	X	X	1/2/3

Strymon bubastus (Stoll, 1780)	6	0.2	RA	ACE	X	X	1/2/3
Strymon crambusa (Hewitson, 1874)*							1/3
Strymon rufofusca (Hewitson, 1877)	10	0.4	RA	ACE	X		1/2/3
Polyommatinae							
Hemiargus hanno (Stoll, 1790)	198	8	DO	CON	X	X	1/2/3’/4’
Leptotes cassius (Cramer, 1775)	8	0.3	RA	ACE	X	X	1/2/3
RIODINIDAE (1)							
Riodininae							
Nymphidiini							
Aricoris campestris (H. Bates, 1868)	22	1	RA	CON	X	X	1/3/4
NYMPHALIDAE (27)							
Libytheinae							
Libytheana carinenta (Cramer, 1777)	1	0.03	RA	ACI	X		1/2/3’/4
Danainae							
Danaini							
Danaus eresimus plexaure (Godart, 1819)	4	0.1	RA	ACE	X	X	1/2/3/4’
Danaus erippus (Cramer, 1775)	35	1	RE	CON	X	X	1/2/3
Danaus gilippus (Cramer, 1775)	34	1	RE	CON	X	X	1/2/3/4’
Lycorea halia discreta Haensch, 1909	1	0.03	RA	ACI		X	1/2/3/4’
Ithomiini							
Mechanitis lysimnia nesaea Hübner, [1820]	1	0.03	RA	ACI		X	1/2/3’/4’
Heliconiinae							
Argynnini							
Euptoieta hegesia meridiania Stichel, 1938	205	8	DO	CON	X	X	1/2/3/4’
Heliconiini							
Agraulis vanillae maculosa (Stichel, [1908])	26	1	RE	CON	X	X	1/2/3/4’
Eueides isabella dianasa (Hübner, [1806])	7	0.3	RA	ACE	X	X	1/2/3/4’
Heliconius erato phyllis (Fabricius, 1775)	91	4	SU	CON	X	X	1/2/3/4
Biblidinae							
Biblidini							
Biblis hyperia nectanabis (Fruhstorfer, 1909)	21	1	RA	CON	X	X	1/2/3/4’
Catonephelini							
Eunica tatila bellaria Fruhstorfer, 1908	5	0.2	RA	ACI	X	X	1/3/4
Ageroniini							
Hamadryas februa (Hübner, [1823])	113	4	SU	CON	X	X	1/2/3’/4’
Hamadryas feronia (Linnaeus, 1758)	74	3	SU	CON	X	X	1/2/3/4’
Callicorini							
Callicore sorana (Godart, [1824])	32	1	RE	ACE		X	1/2/3
Cyrestinae							
Cyrestini							
Marpesia petreus (Cramer, 1776)	44	2	RE	CON	X	X	1/2’/3’/4’
Nymphalinae							
Coeini							
Historis acheronta (Fabricius, 1775)*							1/2/3/4
Nymphalini							
Vanessa myrinna (Doubleday, 1849)	1	0.03	RA	ACI		X	1/2/3
Victorinini							
Anartia jatrophae (Linnaeus, 1763)	248	10	DO	CON	X	X	1/2/3/4

Junoniini							
Junonia genoveva infuscata C. Felder & R. Felder, 1867**	15	1	RA	ACI	X		
Melitaeini							
Anthanassa hermas (Hewitson, 1864)	4	0.1	RA	ACI	X		2/3
Ortilia ithra (Kirby, 1900)	3	0.1	RA	ACI	X		1/2/3
Phystis simois (Hewitson, 1864)	1	0.03	RA	ACI	X		1/3
Charaxinae							
Anaeini							
Fountainea halice moretta (H. Druce, 1877)	10	0.4	RA	ACE	X	X	1/4’
Hypna clytemnestra forbesi Godman & Salvin, 1884	2	0.1	RA	ACI	X		1/2/3’/4’
Satyrinae							
Brassolini							
Opsiphanes invirae (Hübner, [1808])	3	0.1	RA	ACI	X	X	1’/2’/3’/4
Satyrini							
Pharneuptychia phares (Godart, [1824])	6	0.2	RA	ACE	X		1/3/4
HESPERIIDAE (34)							
Eudaminae							
Aguna megaeles (Mabille, 1888)*							1/2
Astraptes anaphus (Cramer, 1777)	17	1	RA	ACE	X	X	1/2
Chioides catillus (Cramer, 1779)	13	1	RA	CON	X	X	1/2/3/4
Cogia calchas (Herrich-Schäffer, 1869)	18	1	RA	CON	X	X	1/2/3
Epargyreus exadeus (Cramer, 1779)	4	0.1	RA	ACI		X	1/2/3
Typhedanus undulatus (Hewitson, 1867)	3	0.1	RA	ACI	X	X	1/2/3
Urbanus dorantes (Stoll, 1790)	26	1	RE	CON	X	X	1/2/3/4
Urbanus procne (Plötz, 1881)	30	1	RE	CON	X	X	1/2/3/4
Urbanus proteus (Linnaeus, 1758)	9	0.3	RA	ACE	X	X	1/2/3/4’
Pyrginae							
Carcharodini							
Staphylus sp.*							1
Staphylus melangon epicaste Mabille, 1903***							3/4’
Nisoniades macarius (Herrich-Schäffer, 1870)	7	0.3	RA	ACE	X	X	1/2/3/4
Erynnini							
Gesta gesta (Herrich-Schäffer, 1863)	7	0.3	RA	ACE	X		1/2/3
Mylon cristata Austin, 2000	1	0.03	RA	ACI	X		2
Pyrgini							
Clito sompa Evans, 1953**	1	0.03	RA	ACI	X		3
Heliopetes macaira orbigera (Mabille, 1888)	9	0.3	RA	ACE	X	X	1/3
Heliopetes arsalte (Linnaeus, 1758)*							1/2/3/4
Heliopyrgus domicella willi (Plötz, 1884)	44	2	RE	CON	X	X	1
Pyrgus orcus (Stoll, 1780)	60	2	SU	CON	X	X	1/2/3/4
Pyrgus veturius Plötz, 1884	4	0.1	RA	ACE	X		1/2/4
Zopyrion evenor thania Evans, 1953	11	0.4	RA	ACE	X		1/2/3’
Hesperiinae							
Incertae-sedis							
Perichares adela (Hewitson, 1867)	1	0.03	RA	ACI		X	1’/2’/3’
Thymelicini							
Copaeodes jean favor Evans, 1955	4	0.1	RA	ACE		X	1
Calpodini							
Panoquina lucas (Fabricius, 1793)	8	0.3	RA	ACI	X	X	1/2/3’
Synale hylaspes (Stoll, 1781)	1	0.04	RA	ACI		X	1/2/3

Anthoptini							
Synapte malitiosa equa Evans, 1955	4	0.1	RA	ACE	X	X	1/2
Moncini							
Callimormus saturnus (Herrich-Schäffer, 1869)	6	0.2	RA	ACE	X	X	1/3
Cymaenes tripunctus theogenis (Capronnier, 1874)	20	1	RA	ACE	X	X	1/2/3/4
Lerema ancillaris (A. Butler, 1877)**	1	0.03	RA	ACI	X		
Lerodea erythrostictus (Prittwitz, 1868)	4	0.1	RA	ACE	X	X	1/3
Methionopsis ina (Plötz, 1882)	1	0.04	RA	ACI		X	1/3
Hesperiini							
Hylephila phyleus (Drury, 1773)	12	1	RA	CON	X	X	1/2
Quinta cannae (Herrich-Schäffer, 1869)	4	0.1	RA	ACI	X		1/2
Wallengrenia otho clavus (Erichson, [1849])	1	0.03	RA	ACI		X	1/2'/3'
Total	**2531**	**100**	**81**	**81**	**67**	**61**	**83/70/74/46**