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Communities of Lepidoptera along an elevational gradient in the Brazilian Atlantic Forest (Lepidoptera: Papilionoidea)

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Abstract

The diversity and composition of Lepidoptera communities vary along an elevational gradient, with richness and abundance generally decreasing as elevation increases. In Brazil, however, there is a lack of data on the topic and many elevation zones remain unexplored. This study aimed to examine the effect of elevation variation on the richness, frequency, abundance, and composition of Lepidoptera in an Atlantic Forest region in southern Minas Gerais State, Brazil, and we also present the first species list of Lepidoptera of the Fernão Dias Environmental Protection Area. The study was conducted between October 2019 and March 2020, and sampling was performed with the same sampling effort at three elevation levels by active (nets) and passive (bait trap) methods. A total of 622 Lepidoptera individuals, belonging to 154 species, were sampled. The family Nymphalidae exhibited the highest richness and abundance. The highest elevation zone showed the greatest number of exclusive species. Richness and abundance were highest at middle elevation, but differences between elevation zones were not statistically significant. Richness estimators indicated a mean sampling efficiency of 64.97%. In contrast to the expected pattern, species richness was highest in middle and high elevation zones, which might reflect the greater degree of conservation of these areas. The findings reported here contribute to a better understanding of the diversity of Lepidoptera in higher elevation zones of Atlantic Forest regions in Brazil.

KEY WORDS: Lepidoptera, Papilionoidea, altitude, insect conservation, inventory, biodiversity, species richness, Brazil.

Comunidades de Lepidoptera a lo largo de un gradiente de elevación en el bosque atlántico brasileño (Lepidoptera: Papilionoidea)

Resumen

La diversidad y composición de las comunidades de Lepidoptera varían a lo largo de un gradiente de elevación y, la riqueza y abundancia, generalmente disminuyen a medida que aumenta la elevación. En Brasil, sin embargo, hay una falta de datos sobre el tema y muchas zonas de elevación permanecen sin explorar. Este estudio tuvo como objetivo examinar el efecto de la variación de elevación sobre la riqueza, frecuencia, abundancia y composición de los Lepidoptera en una región del bosque atlántico en el sur del Estado de Minas Gerais, Brasil, y también presentamos la primera lista de especies de Lepidoptera de Fernão Dias Ambiental Área de Protección. El estudio se realizó entre octubre de 2019 y marzo de 2020 y el muestreo se realizó con el mismo esfuerzo de muestreo en tres niveles de elevación por métodos activos (redes) y pasivos (trampa de cebo). Se muestrearon un total de 622 individuos de Lepidoptera, pertenecientes a 154 especies. La familia Nymphalidae exhibió la mayor riqueza y abundancia. La zona de mayor elevación mostró el mayor número de especies exclusivas. La riqueza y abundancia fueron más altas en la elevación media, pero las diferencias entre las zonas de elevación no fueron estadísticamente significativas. Los estimadores de riqueza indicaron una eficiencia muestral media del 64,97%. En contraste con el patrón esperado, la riqueza de especies fue mayor en las zonas de elevación media y alta, lo que podría reflejar el mayor grado de conservación de estas áreas. Los hallazgos indicados aquí, contribuyen a una

mejor comprensión de la diversidad de Lepidoptera en zonas de mayor elevación de las regiones del Mata Atlántica en Brasil.
PALABRAS CLAVE: Lepidoptera, Papilionoidea, altitud, conservación de insectos, inventario, biodiversidad, riqueza de especies, Brasil.

Introduction

Butterflies, together with moths, belong to the order Lepidoptera and are represented in Brazil by about 3,487 described species (CASAGRANDE & DUARTE, 2021), currently grouped into seven families (Hesperiidae, Lycaenidae, Nymphalidae, Papilionidae, Pieridae, Riodinidae, and Hedylidae) (MITTER *et al.*, 2017). These insects are considered excellent biological indicators because they have short life cycle, show high sensitivity to environmental changes, are easy to sample at all times of the year, and are well known taxonomically (BROWN, 1991; FREITAS *et al.*, 2006; BOGIANI *et al.*, 2012). Lepidoptera are also important pollinators, sometimes more efficient than bees in high-altitude environments (GIULIETTI *et al.*, 1987; MOTA *et al.*, 2016; PIRES *et al.*, 2020), being used as flag species for biodiversity conservation (HENRIQUES *et al.*, 2019).

The composition, diversity, and distribution of Lepidoptera communities vary along environmental gradients and are influenced by several environmental factors, including elevation (LIEN & YUAN, 2003; FREITAS *et al.*, 2007; FERNANDES *et al.*, 2016). An increase in elevation influences abiotic conditions such as temperature, humidity, atmospheric pressure, solar radiation, wind speed and direction, among others, affecting the development, feeding, and general behaviour of insects (HODKINSON, 2005). The most commonly observed pattern for insect communities is a reduction in richness and abundance at higher elevations, with greater diversity in low or mid zones (FERNANDES *et al.*, 2016; PIRES *et al.*, 2020), and such trend also applies to Lepidoptera. Studies carried out in different environments demonstrated that low elevations host a greater diversity of Lepidoptera, with more uniform species distribution (SPARROW *et al.*, 1994; ISMAIL *et al.*, 2018). Other investigations found greater diversity in mid-elevation zones, where temperature and rainfall levels were within the optimal range for butterfly survival (STEFANESCU *et al.*, 2004; ILLÁN *et al.*, 2010; ABRAHAMCZYK *et al.*, 2011).

Previous studies evaluated the composition and diversity of Lepidoptera along elevational gradients in Brazil (CARNEIRO *et al.*, 2014; FERNANDES *et al.*, 2016; PEREIRA *et al.*, 2017; HENRIQUES *et al.*, 2019; BEIRÃO *et al.*, 2020; PIRES *et al.*, 2020). However, data related to the influence of elevation on Lepidoptera communities in Brazil are still scarce and many elevation zones remain to be studied (HENRIQUES *et al.*, 2019), especially considering its large territorial extension. From this perspective, this study aimed to examine the effects of elevation variation on the richness, frequency, abundance, and composition of a butterfly community in an Atlantic Forest region in southern Minas Gerais State, Brazil. It was hypothesized that species richness and abundance are lower at higher elevations, with richness decreasing as elevation increases or diversity peaking at mid-elevation, following the commonly observed pattern of species distribution for Lepidoptera and other terrestrial insects (FERNANDES *et al.*, 2016; PIRES *et al.*, 2020). This study also includes the first species list of Lepidoptera of the Fernão Dias Environmental Protection Area, Minas Gerais State, Brazil.

Material and methods

Study area

This study was conducted in the Fernão Dias Environmental Protection Area, located in the municipality of Gonçalves (22º30’13”S 45º31’24”W, Fig. 1), southmost part of Minas Gerais State, Mantiqueira Mountain region, Brazil. The area is covered by semideciduous and mixed seasonal forest formations, typical phytophysionomies of the Atlantic Forest domain (OLIVEIRA FILHO, 2006). The climate is temperate rainy (Köppen classification: Cwb), the average annual rainfall is approximately 1500 mm, the average temperature is 14-19 ºC, and elevations range from 880 to 1670 m (MELO & SALINO, 2007).

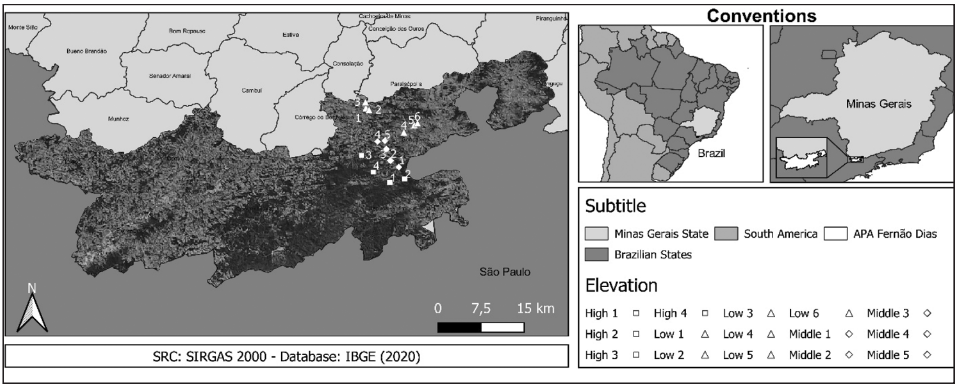

Figure 1.– Map of the location of the Fernão Dias Environmental Protection Area, southern Minas Gerais State, Brazil, and the location of the sampling sites along the elevational gradient, at every 160 meters of altitude.

Data sampling

Sampling was carried out in the rainy season during four campaigns (October and December 2019 and January and March 2020) of four consecutive days each at 160 m elevation increments in three (low, middle, and high) elevation zones ranging from 880 to 1670 m above sea level. Elevation zones were associated with different plant covers and degrees of conservation, which were assessed by field observation (for example, presence of Bromeliaceae and pasture). Characterization was also performed on the basis of information provided by the municipality of Gonçalves (presence of hiking trails, waterfalls, and tourist accommodation) (Table I). Google Earth satellite images were used to determine the degree of habitat fragmentation.

Table I.– Ecological, social, and economic characteristics of the three elevational zones in the Fernão Dias Environmental Protection Area, southern Minas Gerais State, Brazil.

Variable	Low elevation	Middle elevation	High elevation
Elevation	880 to 1090 m	1250 to 1410 m	1570 to 1670 m
Phytophysiognomy	Semideciduous forest	Mixed and semideciduous forest	Mixed forest
Fragmentation	More fragmented	Moderately fragmented	Less fragmented
Regeneration stage	Early and intermediate	Intermediate	Advanced
Canopy formation	Rare	Less frequent	More frequent
Pasture areas	Many	Few	Few
Eucalyptus cultivation	Present	Present	Present
Ecotourism	Low	High	High
Riparian zone width	<5 m	5–10 m	>10 m
Residential areas	Many	Many	Few

Sampling was performed by passive and active methods. Passive sampling consisted of the use of three van Someren-Rydon traps baited with banana and sugarcane broth fermented for 48 h per elevation zone (UEHARA-PRADO *et al.*, 2009). Nine baited traps were kept in the field for 4 consecutive days (96 h) during each campaign, totaling 1,632 h of trap sampling. Active sampling was performed for 17 days by using entomological nets during the same period of the day, between 8:00 and 16:00 h (8 h/day), with sampling times distributed equally between elevation zones, totaling 136 net-hours and a sampling effort of 1,738 h.

All sampled individuals were sacrificed in the field and stored in entomological envelopes labeled with locality, date, collector's name, type of collection, and elevation zone. Subsequently, samples were sent to the Laboratory of Butterfly Ecology and Systematics of the University of Campinas (LABBOR/UNICAMP) for identification. One part of the material was deposited in the collection of butterflies and moths of the Museum of Zoology of the University of Campinas (ZUEC-LEP, UNICAMP) and the other in the collection of the Laboratory of Zoology of the Federal Institute of Education, Sciences, and Technology of Southern Minas Gerais (IFSULDEMINAS), Inconfidentes campus, Brazil.

Data analysis

The frequency distribution of butterfly species was assessed by classifying rare species as singletons (only one individual recorded in one sample), doubletons (two individuals recorded), unique (species recorded in only one sample), and duplicates (species recorded in two samples). Differences in richness and abundance between elevation zones were tested by generalized linear models, using richness and abundance as response variables and elevation as an explanatory variable. The diversity of each zone was measured by Shannon's diversity (H'), Pielou's evenness (J, calculated from H'), and Simpson's dominance (D) indices. Sampling efficiency and the total number of butterfly species in the experimental area were estimated from the mean values of Jackknife 1, Jackknife 2, and Chao 2 estimators, with 1000 randomizations. Analyses were performed using PAST software version 3.24 (HAMMER *et al.*, 2001) and R software (R Development Core Team, 2017).

Results

In this study, we recorded 622 butterfly individuals, distributed in 154 species belonging to 6 families (Table II). Nymphalidae was the family with the highest species richness (89 species, 57.79% of the species sampled, Fig. 2), followed by Hesperiidae (31 species, 20.13%), Pieridae (15 species, 9.74%), Papilionidae (7 species, 4.55%), and Lycaenidae and Riodinidae (6 species each, 3.9% each). Nymphalidae was also the most abundant family, accounting for well over half of the collected individuals (n = 438, 70.42%, Fig. 2), followed by Pieridae (n = 66, 10.61%), Hesperiidae (n = 63, 10.13%), Papilionidae (n = 26, 4.18%), Lycaenidae (n = 15, 2.41%), and Riodinidae (n = 14, 2.25%). Of the 89 butterfly species belonging to the family Nymphalidae, 14 (15.7%) were sampled exclusively by using attractive traps.

The most abundant species were *Hermeuptychia* sp. (Nymphalidae: Satyrinae, n = 54), *Forsterinaria necys* (Godart, [1824]) (Nymphalidae: Satyrinae, n = 30), *Tegosa* sp. (Nymphalidae: Nymphalinae, n = 20), *Mechanitis lysimnia* (Fabricius, 1793) (Nymphalidae: Danaine, n = 19), and *Anartia amathea roeselia* (Eschscholtz, 1821) (Nymphalidae: Nymphalinae, n = 17), which together accounted for 22.5% of the sampled Lepidoptera. *M. lysimnia* (Fabricius, 1793) was the most frequent species, collected on 11 of the 17 days of sampling. A total of 20 species were found in all elevation zones (13.64% of the sampled community). Furthermore, 60 species were represented by only one individual (singletons) and 28 species by two individuals (doubletons), indicating that more than half of the recorded species (57.14%) can be classified as rare, 70 as unique (captured once), and 28 as duplicates (captured twice).

In comparing elevation zones (Fig. 2), it was found that the middle elevation had the highest richness (n = 91, 59%), abundance (n = 268, 48%), and diversity (H' = 4.084), whereas the high elevation zone showed the highest number of exclusive species (n = 37, 24%); however, differences between elevation zones were not significant for richness (P = 0.46, R^2 = 0.56) or abundance (P = 0.58, R^2 = 0.38). All zones exhibited higher evenness than dominance, with the low elevation having the highest evenness (J = 0.9462) and the high elevation having the highest dominance (D = 0.03409) (Table II). Middle and high elevations had the greatest number of species in common (n = 25, 16%), whereas low and high elevations exhibited a lower number of common species (n = 4, 3%) (Fig. 3). Moreover, 16 species from the low elevation zone, 18 from the middle elevation zone, and 26 from the high elevation zone were singletons.

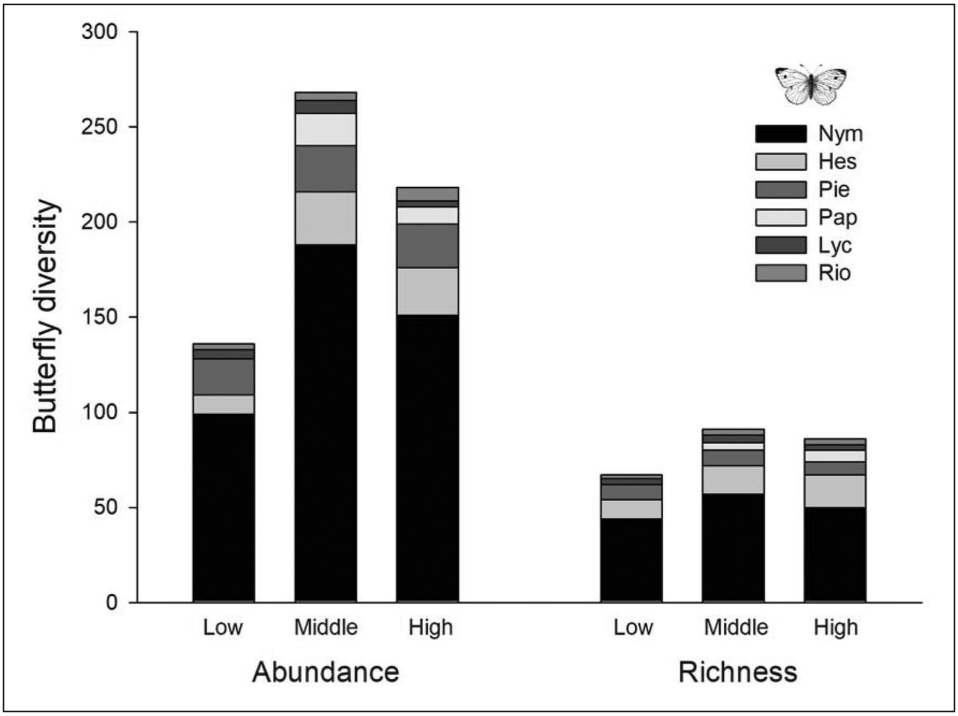

Figure 2.– Abundance and richness of the butterfly community, separated by families, in three elevational zones (low, middle and high) of the Fernão Dias Environmental Protection Area, southern Minas Gerais State, Brazil. Nym = Nymphalidae, Hes = Hesperiidae, Pie = Pieridae, Pap = Papilionidae, Lyc = Lycaenidae, Rio = Riodinidae.

Richness estimators indicated that 237 species of Lepidoptera could be found in this mountainous region (83 more than were sampled), corresponding to a sampling efficiency of 64.97%. Analysis by elevation zone revealed that low, middle, and high elevations had 111, 143, and 163 butterfly species, respectively, and sampling efficiencies of 60.97, 63.36, and 52.76%, respectively (Table II).

Discussion

The richness of butterfly species in the Atlantic Forest region of the Fernão Dias Environmental Protection Area was higher than that observed in some studies (RITTER *et al.*, 2011; BORDIN *et al.*, 2019; BERTINOTI *et al.*, 2020; SILVA *et al.*, 2020) and lower than that reported in others (BONFANTTI *et al.*, 2011; BELLAVER *et al.*, 2012; VIEIRA *et al.*, 2020). Nevertheless, results were within the expected range for forest regions in Brazil, given the differences in the size of experimental sites, sampling methods and efforts between studies. It is expected that the species accumulation curve will not reach the asymptote in studies with insects, even when small areas are sampled, because this group is extremely diverse (BEUTEL *et al.*, 2017). The Jackknife 1 richness estimator showed that the sample included 70.03% of the butterfly species occurring in the Environmental Protection Area; this result is in line with previous studies assessing forest regions, which found sampling efficiencies greater than 60% by using the same estimator as that used here (BORDIN *et al.*, 2019; MELO *et al.*, 2019; GUERATTO *et al.*, 2020; BERTINOTI *et al.*, 2020; VIEIRA *et al.*, 2020; ARAÚJO *et al.*, 2021).

Nymphalidae was the richest and most abundant family (see Fig. 2), as also observed in previous surveys carried out in southern Minas Gerais (ANDRADE & TEIXEIRA, 2017; OLIVEIRA *et al.*, 2018; VIEIRA *et al.*, 2020), followed by Hesperiidae. Nymphalidae are found in almost all ecosystems (DEVRIES, 1987), have several food niches (BROWN JUNIOR *et al.*, 1999), and can be efficiently captured by baited traps (FREITAS *et al.*, 2003; UEHARA-PRADO *et al.*, 2007; VIEIRA *et al.*, 2020), which may explain its numerous captures. In addition to Nymphalidae, it was expected that a large number of Hesperiidae individuals would be sampled, as these families have some of the highest species' richness in Brazil (BONFANTTI *et al.*, 2009).

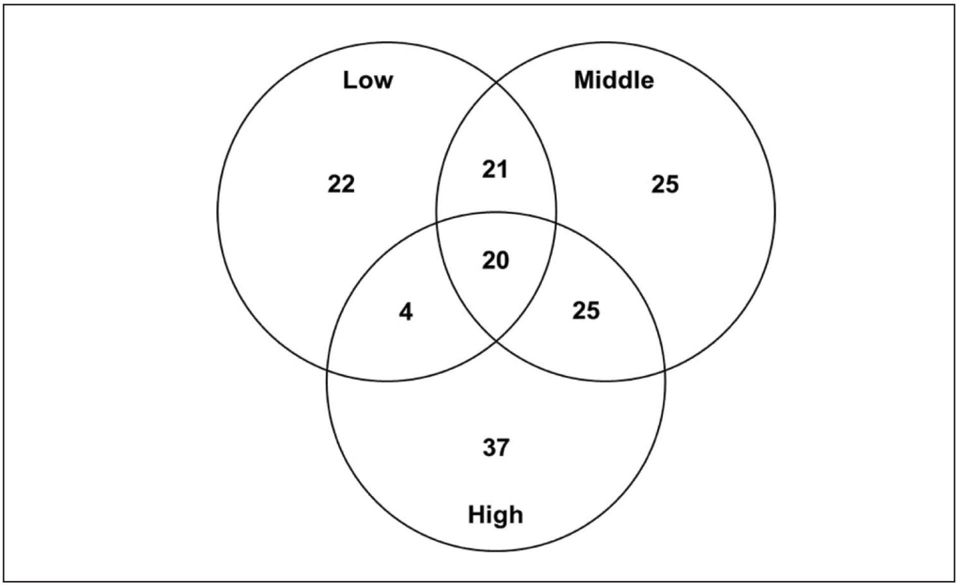

Figure 3.– Venn diagram of the butterfly community in three elevational zones (low, middle and high) of the Fernão Dias Environmental Protection Area, southern Minas Gerais State, Brazil.

F. necys (Godart, [1824]), *M. lysimnia* (Fabricius, 1793), and *A. amathea roeselia* (Eschscholtz, 1821), belonging to the family Nymphalidae, were the most abundant species in the Environmental Protection Area. These Lepidoptera are predominantly found in secondary forests, disturbed habitats, and anthropic environments (DEVRIES, 1987; BROWN, 1992), suggesting that the study area has been negatively affected by human action and is undergoing a process of regeneration. According to BROWN (1992), *F. necys* (Godart, [1824]) inhabits forests at elevations above 900 m and its larvae are associated with grasses, which are common in the study area. *A. amathea roeselia* (Eschscholtz, 1821) shows a preference for humid environments, such as bogs and river banks. The three butterfly species are common in *Eucalyptus* and *Pinus* forests (BROWN, 1992), trees found at the sampling sites, which may be related to the abundance of these Lepidoptera. *M. lysimnia* (Fabricius, 1793) is found at different elevations, most commonly in the forest canopy (BROWN, 1992). In the current study, the species was sampled along the entire elevational gradient, exhibiting greater abundance at low and middle elevations.

Contrary to our expectation, the low elevation zone had a lower number of butterfly species and individuals than the other elevation zones, although differences in richness or abundance were not significant. Several studies found a decrease in richness with increasing elevation or a peak in diversity at mid-elevations (CARNEIRO *et al.*, 2014; FERNANDES *et al.*, 2016; PIRES *et al.*, 2020 and references therein), but there are also some studies that found greater diversity in high elevation zones (SHRESTHA *et al.*, 2020). In the current study, forests in middle and high elevation zones were more continuous, less fragmented, and at more advanced stages of regeneration than forest fragments occurring at low elevation (Table I), having greater availability of resources, which probably exerts a strong influence on the foraging and nesting activity of the butterfly community and may explain the observed patterns of species diversity.

The high elevation zone had a greater number of singletons and unique species than the other elevations, suggesting that the composition of the butterfly community is different at the mountain top, more represented by unique species than by common ones. These results may be related to differences in conservation level, given that high elevation zones are less influenced by anthropogenic activities such as pasturing and cropping (see Table I).

Elevation alone has no significant effect on insect populations; therefore, other biotic and abiotic factors should be considered when trying to understand the occurrence of species along an elevational gradient (SABU *et al.*, 2008; FERNANDES *et al.*, 2016). Several environmental conditions, such as temperature, wind speed, atmospheric pressure, and vegetation cover, exert a great influence on the distribution of insect communities in mountainous environments (HODKINSON, 2005; FERNANDES *et al.*, 2016). The richness of butterfly communities is strongly influenced by the diversity of host plants, and weather conditions and elevation may act as secondary factors in defining community structure (PIRES *et al.*, 2020). Thus, it is believed that the vegetation cover of middle and high elevation zones provided more favorable conditions for the growth and survival of these Lepidoptera.

Minas Gerais State has a large territory covered by three different biomes: Caatinga, Cerrado, and Atlantic Forest (DRUMONND *et al.*, 2005). Few butterfly inventories have been undertaken in the state, despite its great biodiversity and numerous Conservation Units. Some studies focused on Cerrado regions (SILVA *et al.* 2007; PASETO *et al.*, 2014; LUCENA *et al.*, 2018; HENRIQUES *et al.*, 2019), others on areas of transition from Caatinga to different phytophysionomies (GOZZI, 2012; NERY *et al.*, 2014; BEIRÃO *et al.*, 2017), and some on the Atlantic Forest (ANDRADE & TEIXEIRA, 2017; OLIVEIRA *et al.*, 2018; VIEIRA *et al.*, 2020). This study contributed to reducing the knowledge gap regarding butterfly diversity along elevational gradients in protected forest areas in Brazil, acting as a basis for the development of conservation strategies for butterfly communities in the Fernão Dias Environmental Protection Area.

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Table II.– List of butterfly species from the elevational gradient of the Fernão Dias Environmental Protection Area, southern Minas Gerais State, Brazil, and ecological indices.

FAMILY/Subfamily (number of species)	**Species**	**Low elevation**	**Middle elevation**	**High elevation**
HESPERIIDAE (31)				
	Hesperiidae sp. 1	0	0	1
	Hesperiidae sp. 2	0	0	1
	Hesperiidae sp. 3	0	1	0
	Hesperiidae sp. 4	0	0	1
	Hesperiidae sp. 5	0	0	1
HESPERIINAE (5)				
	Anthoptus epictetus (Fabricius, 1793)	0	3	1
	Polites vibex catilina (Plötz, 1886)	0	2	0
	Vettius diversa lyrcea (Plötz, 1882)	0	1	1
	Vehilius clavicula (Plötz, 1884)	1	0	0
	Vettius ploetzii (Capronnier, 1874)	0	0	1
PYRGINAE (20)				
	Autochton integrifascia (Mabille, 1891)	0	1	0
	Autochton zarex (Hübner, 1818)	1	1	1
	Celaenorrhinus eligius punctiger (Burmeister, 1878)	0	1	0
	Chioides catillus (Cramer, 1779)	0	1	0
	Diaeus lacaena (Hewitson, 1869)	0	0	1
	Heliopetes omrina (A. Butler, 1870)	1	2	0
	Nisoniades bipuncta (Schaus, 1902)	0	1	0
	Nisoniades macarius (Herrich-Schäffer, 1870)	1	0	0
	Noctuana diurna (A. Butler, 1870)	0	0	1
	Phocides pialia maximus (Mabille, 1888)	0	0	5
	Polythrix octomaculata (Sepp, [1844])	1	0	0
	Pyrgus orcus (Stoll, 1780)	1	5	3
	Pythonides lancea (Hewitson, 1868)	0	1	1
	Staphylus ascalon (Staudinger, 1876)	1	0	0
	Staphylus cf. *coecatus*	0	0	2
	Theagenes dichrous (Mabille, 1878)	0	0	1
	Urbanus dorantes (Stoll, 1790)	1	1	0
	Urbanus simplicius (Stoll, 1790)	1	1	0
	Urbanus teleus (Hübner, 1821)	0	6	2
	Xenophanes tryxus (Stoll, 1780)	1	0	0
PYRRHOPYGINAE (1)				
	Mimoniades versicolor (Latreille, [1824])	0	0	1
LYCAENIDAE (6)				
POLYOMMATINAE (1)				
	Elkalyce cogina (Schaus, 1902)	1	4	1
THECLINAE (5)				
	Arawacus meliboeus (Fabricius, 1793)	3	1	1
	Atlides cosa (Hewitson, 1867)	0	0	1
	Contrafacia imma (Prittwitz, 1865)	0	1	0
	Strymon astiocha (Prittwitz, 1865)	1	0	0
	Strymon rana (Schaus, 1902)	0	1	0
NYMPHALIDAE (89)				
BIBLIDINAE (7)				
	Diaethria candrena (Godart, [1824])	2	0	1
	Diaethria eluina (Hewitson, [1855])	0	0	2
	Ectima thecla (Fabricius, 1796)	2	0	0
	Epiphile orea (Hübner, [1823])	0	0	2

	Eunica margarita (Godart, [1824])	2	0	0
	Hamadryas epinome (C. Felder & R. Felder, 1867)	3	1	0
	Hamadryas fornax (Hübner, [1823])	0	0	1
CHARAXINAE (8)				
	Archaeoprepona chalciope (Hübner, [1823])	0	3	8
	Archaeoprepona demophoon antimache (Hübner, [1819])	1	0	0
	Fountainea ryphea phidile (Geyer, 1837)	2	1	1
	Hypna clytemnestra huebneri A. Butler, 1866	1	0	0
	Memphis acidalia victoria (H. Druce, 1877)	0	1	0
	Memphis appias (Hübner, [1825])	1	2	1
	Memphis otrere (Hübner, [1825])	0	0	7
	Zaretis strigosus (Gmelin, [1790])	0	2	0
CYRESTINAE (1)				
	Marpesia chiron marius (Cramer, 1779)	1	0	0
DANAINAE (19)				
	Aeria olena olena Weymer, 1875	2	0	0
	Danaus erippus (Cramer, 1775)	1	1	1
	Danaus gilippus (Cramer, 1775)	1	1	0
	Dircenna dero (Hübner, [1823])	2	1	0
	Episcada striposis Haensch, 1909	0	0	1
	Epityches eupompe (Geyer, 1832)	2	2	4
	Hypothyris euclea laphria (E. Doubleday, 1847)	1	0	0
	Hypothyris ninonia daeta (Boisduval, 1836)	6	5	0
	Ithomia agnosia zikani d'Almeida, 1940	2	0	0
	Ithomia drymo Hübner, 1816	7	0	1
	Lycorea halia discreta Haensch, 1909	1	0	0
	Lycorea ilione (Cramer, 1775)	0	1	0
	Mechanitis lysimnia (Fabricius, 1793)	7	9	3
	Mechanitis polymnia casabranca Haensch, 1905	3	0	1
	Methona themisto (Hübner, 1818)	0	0	2
	Placidina euryanassa (C. Felder & R. Felder, 1860)	2	2	0
	Pseudoscada acilla quadrifasciata Talbot, 1928	2	1	0
	Pseudoscada erruca (Hewitson, 1855)	0	2	3
	Pteronymia carlia Schaus, 1902	1	0	1
HELICONIINAE (14)				
	Actinote canutia (Hopffer, 1874)	0	2	0
	Actinote carycina Jordan, 1913	0	2	5
	Actinote conspicua Jordan, 1913	0	0	1
	Actinote genitrix d'Almeida, 1922	0	0	1
	Actinote pellenea Hübner, [1821]	1	2	3
	Actinote pyrrha (Fabricius, 1775)	2	3	1
	Actinote sp.	3	4	7
	Agraulis vanillae maculosa (Stichel, [1908])	1	1	0
	Dryadula phaetusa (Linnaeus, 1758)	2	0	0
	Dryas iulia alcionea (Cramer, 1779)	1	0	0
	Eueides aliphera (Godart, 1819)	0	1	0
	Heliconius besckei (Ménétriés, 1857)	0	4	1
	Heliconius erato phyllis (Fabricius, 1775)	2	6	1
	Heliconius ethilla narcaea (Godart, 1819)	0	2	3
LIMENITIDINAE (2)				
	Adelpha serpa (Boisduval, 1836)	0	0	1
	Adelpha syma (Godart, [1824])	0	6	4
NYMPHALINAE (12)				
	Anartia amathea roeselia (Eschscholtz, 1821)	5	12	0

	Anartia jatrophae (Linnaeus, 1763)	3	1	0
	Eresia lansdorfi (Godart, 1819)	0	1	0
	Hypanartia bella (Fabricius, 1793)	1	1	0
	Hypanartia lethe (Fabricius, 1793)	0	1	0
	Junonia sp.	0	4	0
	Ortilia sejona (Schaus, 1902)	0	1	0
	Ortilia velica (Hewitson, 1864)	0	1	0
	Smyrna blomfildia (Fabricius, 1781)	1	2	0
	Tegosa sp.	1	12	7
	Telenassa teletusa (Godart, [1824])	0	2	1
	Vanessa braziliensis (Moore, 1883)	0	5	0
Satyrinae (26)				
	Blepolenis batea (Hübner, [1821])	0	1	1
	Caligo arisbe fulgens Rothschild, 1916	0	0	2
	Carminda griseldis (Weymer, 1911)	0	1	0
	Cissia eous (A. Butler, 1867)	4	2	0
	Cissia phronius (Godart, [1824])	3	2	1
	Eryphanis reevesii (E. Doubleday, [1849])	0	0	2
	Eteona tisiphone (Boisduval, 1836)	0	4	2
	Forsterinaria necys (Godart, [1824])	1	10	19
	Forsterinaria pronophila (A. Butler, 1867)	0	0	4
	Forsterinaria quantius (Godart, [1824])	0	2	1
	Godartiana muscosa (A. Butler, 1870)	0	0	1
	Hermeuptychia atalanta (A. Butter, 1867)	0	2	5
	Hermeuptychia fallax marinha Anken, 1994	0	1	0
	Hermeuptychia gisella (Hayward, 1957)	0	0	1
	Hermeuptychia sp.	5	25	24
	Moneuptychia castrensis (Schaus, 1902)	1	1	0
	Moneuptychia cf. *viviana* (Romieux, 1927)	0	0	1
	Moneuptychia soter (A. Butler, 1877)	0	7	1
	Moneuptychia vitellina Freitas & Barbosa, 2015	0	0	1
	Morpho helenor achillides C. Felder & R. Felder, 1867	5	2	0
	Morpho portis kaysi Le Moult & Réal, 1962	0	1	1
	Opoptera syme (Hübner, [1821])	0	0	1
	Pseudodebis ypthima (Hübner, [1821])	0	2	2
	Taydebis peculiaris (A. Butler, 1874)	1	10	1
	Taygetis laches (Fabricius, 1793)	0	1	0
	Yphthimoides ochracea (A. Butler, 1867)	1	3	4
PAPILIONIDAE (7)				
Papilioninae (7)				
	Eurytides bellerophon (Dalman, 1823)	0	2	3
	Eurytides dolicaon deicoon (C. Felder & R. Felder, 1864)	0	0	1
	Heraclides hectorides (Esper, 1794)	0	0	2
	Mimoides lysithous (Hübner, [1821])	0	3	1
	Parides bunichus (Hübner, [1821])	0	7	0
	Parides proneus (Hübner, [1831])	0	5	1
	Pterourus cleotas (G. Gray, 1832)	0	0	1
PIERIDAE (15)				
Coliadinae (8)				
	Colias lesbia mineira J. Zikán, 1940	0	0	12
	Eurema agave pallida (Chavannes, 1850)	4	2	0
	Eurema albula sinoe (Godart, 1819)	5	4	1
	Eurema deva (E. Doubleday, 1847)	3	1	0
	Eurema elathea flavescens (Chavannes, 1850)	3	2	0
	Phoebis sennae marcellina (Cramer, 1777)	1	0	0

	Pyrisitia leuce (Boisduval, 1836)	1	0	0
	Pyrisitia nise tenella (Boisduval, 1836)	1	0	0
Dismorphiinae (2)				
	Dismorphia thermesia (Godart, 1819)	0	1	4
	Enantia lina psamathe (Fabricius, 1793)	1	1	0
Pierinae (5)				
	Catasticta bithys (Hübner, [1831])	0	0	1
	Leptophobia aripa balidia (Boisduval, 1836)	0	8	0
	Pereute antodyca (Boisduval, 1836)	0	0	1
	Pereute swainsoni (G. Gray, 1832)	0	0	1
	Theochila maenacte itatiayae (Foetterle, 1902)	0	5	3
RIODINIDAE (6)				
Riodininae (6)				
	Charis cadytis Hewitson, 1866	0	2	3
	Emesis ocypore zelotes Hewitson, 1872	0	1	3
	Eurybia pergaea (Geyer, 1832)	0	0	1
	Panara soana bacana Callaghan, 1997	1	0	0
	Stichelia bocchoris (Hewitson, 1876)	0	1	0
	Synargis paulistina (Stichel, 1910)	2	0	0
ECOLOGICAL INDICES				
	Richness	67	91	86
	Abundance	136	268	218
	Exclusive species	22	25	37
	Dominance (D)	0.02325	0.02592	0.03409
	Shannon's diversity (H')	3.978	4.084	3.94
	Pielou's evenness (J)	0.9462	0.9053	0.8845
	Jackknife 1	102,667	135,571	138
	Jackknife 2	123,879	158,516	174,132
	Chao 2	108,059	134,643	175,375