Original Article

Seasonal analysis of Saturniidae (Insecta: Lepidoptera: Bombycoidea) in a remaining Atlantic Forest in the State of Espírito Santo, Brazil

Análisis estacional de Saturniidae (Insecta: Lepidoptera: Bombycoidea) en un remanente de Bosque Atlántico en el Estado de Espírito Santo, Brasil

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ZooBank: urn:lsid:zoobank.org:pub:C21E8BCD-19F0-4843-80DF-00715096B22F
https://doi.org/10.35249/rche.48.1.22.10

Abstract. The Lepidoptera family Saturniidae is commonly utilized as a bioindicator for ecosystem monitoring. During six years of sampling, the study explored the dynamics of the Shannon-Wiener, Simpson, species richness, Pielou equity, dominance, and abundance ecological parameters under the effect of seasonality. The research took place in the Atlantic Forest remnants at Vale Natural Reserve in Linhares, Espirito Santo, Brazil. Blacklight traps were used to collect the samples. 1,445 specimens were collected and classified into four subfamilies, 30 genera, and 48 species. There is a large difference in richness and abundance due to temperature in different seasons. When the temperature drops, the abundance declines. When comparing years, equitability and dominance are not significant. During periods of more rainfall, there is a higher abundance of species (richness). Despite variations in abundance and diversity throughout the years, the Saturniidae are known for their low resistance and strong resilience.

Keys words: Biodiversity; bioindicator; blacklight traps; ecosystem monitoring; seasonality.

Resumen. La familia Saturniidae (Insecta: Lepidoptera), es comúnmente la más utilizada como bioindicador en el monitoreo de ecosistemas. Durante seis años de muestreo, el estudio exploró la dinámica de los parámetros ecológicos de riqueza de especies, Shannon-Wiener, Simpson, equidad de Pielou, dominancia y abundancia, bajo el efecto de la estacionalidad. Se desarrolló en los remanentes de la Mata Atlántica en la Reserva Natural Vale en Linhares, Estado de Espírito Santo, Brasil. Se

Received 23 November 2021 / Accepted 2 February 2022 / Published online 28 February 2022
Responsible Editor: José Mondaca E.

utilizaron trampas de luz negra para recolectar las muestras. Se recolectaron 1.445 especímenes representados en cuatro subfamilias, 30 géneros y 48 especies. En los diferentes períodos estacionales, se encontró una gran diferencia en riqueza y abundancia debido a la temperatura, por lo tanto, cuando bajaba la temperatura, la abundancia disminuía. Al comparar los seis años de muestreo, la equidad y el dominio no fueron significativos. Durante los períodos de mayor precipitación, hubo una mayor abundancia de especies (riqueza). A pesar de las variaciones en abundancia y diversidad a lo largo de los años, los Saturniidae son conocidos por su baja resistencia y fuerte resiliencia.

Palabras clave: Biodiversidad; bioindicador; estacionalidad; monitoreo de ecosistemas; trampas de luz negra.

Introduction

The flora of Espírito Santo is the Atlantic Forest's most diverse hub of plant species (Thomaz 2010). Linhares and Sooretama municipalities have the most considerable forest cover (Silva 2014). The importance of the Vale Nature Reserve biodiversity, Linhares, is that it includes the biome Atlantic Forest, which is a priority in the American Nation Biodiversity Protection Program (Mittermeier *et al*. 1998; Myers *et al*. 2000). The Vale Nature Reserve and the Sooretama Biological Reserve are the only forest sets that have been conserved and given the designation "Floresta de Tabuleiro" (Board Forest) (Amorim 1984).

The research in VNR focuses on Lepidoptera because of their close relationship with their specific host plants, which permits moths to be useful bio-indicators (Kitching *et al*. 2000; Kristensen *et al*. 2007). The Saturniidae were chosen because of their low power displacement, which makes them ideal for evaluating a region's conservation status.

This family is one of the few well-studied Neotropical Lepidoptera families that permit easy identification and can therefore be useful in ecological, biodiversity, and biogeographic research because of their ability to quickly adjust to environmental changes and ecological succession processes (Camargo and Becker 1999; New 2004).

In a fragment of the Atlantic Forest, Linhares, we evaluated the hypothesis that seasonality influences the structure of the Saturniidae assembly, as well as the stability of structural alterations that occur between seasonal periods over six years. As a result, the ecological parameters (richness, frequency, abundance, dominance, and diversity) were examined.

Saturnid adults present a variety of sizes, from large to medium. They feature a variety of wings that vary in patterns, shape, ornamentation, and coloration. The moths are characterized by robust bodies, some having lobed wings, dense pilosity, and shortened mouthparts. They lack a frenulum and the hindwings overlap the forewings for flight synchronization. Saturniids have translucent spots or areas on their wings that are occasionally vividly colored. Males can be distinguished from females by their larger, broader antennae, which vary by species (Lemaire 1978; Rafael *et al*. 2012). There are over 400 species of Saturniidae in Brazil, and they belong to the subfamilies Arsenurinae, Ceratocampinae, Hemileucinae, Oxyteninae, and Saturniinae (Duarte *et al*. 2012; Camargo *et al*. 2021).

Material and Methods

Study area

The research took place in the Vale Nature Reserve (RNV), which is located north of Espírito Santo (Figs. 1A-B) and covers approximately 23.000 hectares. The RNV, along with the Sooretama Biological Reserve, the Nature Heritage Private Reserves (RPPNs), Anta

Refuge, and Black Mutum, represent most of the Atlantic Forest (about 50.000 ha) (Rolim *et al*. 2016). According to Garay *et al*. (2016) and Köppen (1948), the climate of the RNV is of the type (Awi), which is a hot climate with well-defined seasonality of rainy season in summer and drought in winter. The average annual temperature in the region is 23.3 °C, with temperatures ranging from 14.8 °C to 34 °C, and with an average annual rainfall of 1,202 mm, which varies greatly between years (Jesus and Rolim 2005).

Sampling

The survey was conducted for 6 consecutive years between January 1987 and December 1992. Two blacklight traps were employed to sample (19°09′ – 19°08′ N and 40°02′ – 40°04′ W) (Fig. 1C). Each has a 15-watt fluorescent black light (F15T8BL) placed at a height of 2 meters (Ferreira and Martins 1982). The traps were activated every ten days, from 18:00 at night to 6:00 am the next day. There were 181 nights and 2,172 hours of sampling at two locations in Vale (Fig. 1C). Insect envelops were used to store the entomological material. After being labeled, the envelops were sealed in cans containing solid naphthalene and solid paraformaldehyde. The material was processed at the Federal University of Viçosa's Regional Museum of Entomology (UFVB) in Minas Gerais State, Brazil, and the Vale Natural Reserve's Entomology Collection in Linhares, ES, Brazil (RNV).

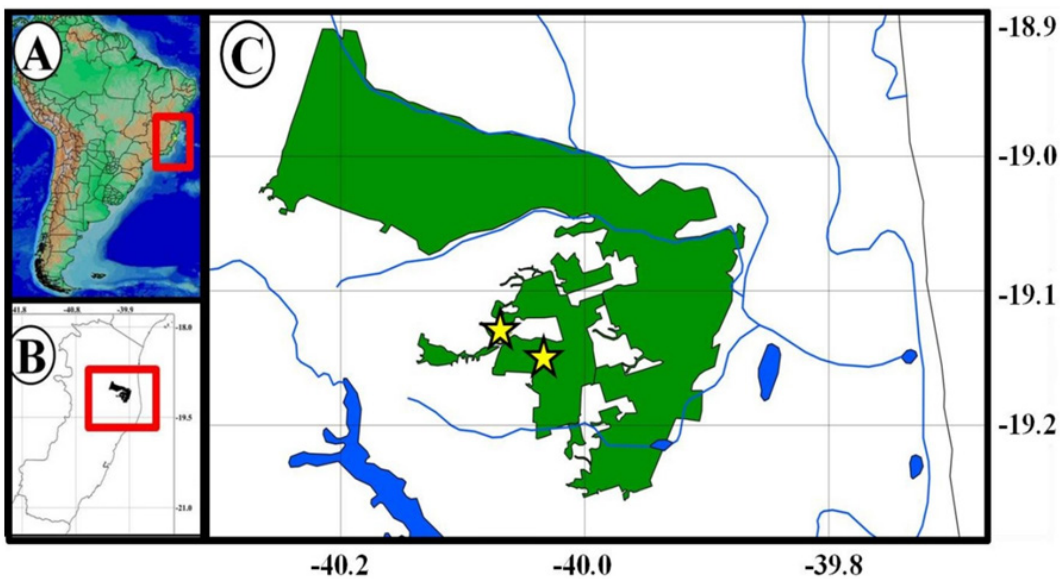

Figure 1. Study area. A) Location in South America. B) Location in the state of Espírito Santo. C) Location of sampled points (yellow stars). Vale Nature Reserve, municipality of Linhares-ES. / Área de estudio. A) Ubicación en América del Sur. B) Ubicación en el Estado de Espírito Santo. C) Ubicación de los puntos muestreados (estrellas amarillas). Reserva Natural de Vale, municipio de Linhares-ES.

Material identification

The specimens were identified by the co-author Carlos Guilherme Costa Mielke. All saturniid specimens are housed at the Vale Natural Reserve's entomological collection (RNV) and the Regional Museum of Entomology at the Federal University of Viçosa (UFVB).

A Nikon D3100 digital camera was used to photograph Saturniidae species.

Data analysis

The seasonal and annual periods were analyzed by temporal comparisons of biotic variables as a function of the diversity indices of Shannon-Wiener (H') and Simpson (C), species Richness (S), Pielou equitability (J), Dominance (l), and Abundance (P). To make the analysis, the PAST software version 2.03 (Hammer *et al*. 2001) was employed.

For the seasonal distribution, two distinct periods were considered: a rainy one, between the months of October and March, and a dry one, which covers the months of April to September (Nóbrega *et al*. 2008). Six months were considered a single sample, and years as replicates for each period.

The comparative test used for seasonal periods and years was the Kruskal-Wallis, and paired comparisons were made using the Mann-Whitney test, which verified whether there were statistically significant differences in the relationship between ecological parameters and seasonal periods and years. These tests were chosen because the data did not meet the necessary assumptions for parametric tests. The tests were performed using software *Statistica* version 7.1 (Statsoft 2005). The association between ecological characteristics and seasonal/year period was found to be significantly different in both studies.

The temperature and rainfall were obtained at the Vale Nature Reserve weather station, which operates continuously 24 hours a day. The three daily minimum and maximum readings for both abiotic factors were used. To calculate the daily temperature averages, the compensated average used by INMET (Ramos *et al*. 2009) was adopted and carried out for the six representative months of each period over the six years. In the same approach, the average rainfall was assumed.

Results

Specimens from four subfamilies were collected over the course of six years, with no representatives from Oxyteninae. They include 30 genera, 48 species, and 1,445 specimens (Tab. 1).

The most abundant subfamily is Hemileucinae, which has 523 specimens (36.19%), followed by Ceratocampinae, with 491 specimens (33.98%), and Arsenurinae, with 415 specimens (28.72%). With only 16 specimens, the Saturniinae have the lowest abundance (1.11%). With almost 200 specimens each, the most abundant genera are *Titaea* Hübner, 1823, *Adeloneivaia* Travassos, 1940, and *Automeris* Hübner, 1819. *Citioica* Travassos & Noronha, 1965; *Psilopygida* Michener, 1949; *Dirphia* Hübner, 1819; *Copaxa* Walker, 1855, are the least abundant genera, each with only one specimen. *Titaea tamerlan* (Maassen, 1869) (Fig. 7C), with 270 specimens, and *Adeloneivaia subangulata* (Herrich-Schäffer, [1855]) (Fig. 8C), with 144 specimens, are the species with the highest abundance. The species with the least abundance are *Citioica anthonilis* (Herrich-Schäffer, 1854) (Fig. 8F), *Psilopygida walkeri* (Grote, 1867) (Fig. 9E), *Dirphia triangulum* Walker, 1855, and *Copaxa decrescens* Walker, 1885 (Fig. 12A), all of which have only one specimen each (Tab. 1).

The means of collections of the variables were correlated with the results of the ecological parameters that showed significant differences ($p<0.05$) to determine a possible correlation in the variation of the species collected. Almost all analyses found that richness and abundance were significant. Shannon-Wiener and Simpson tests revealed significance when comparing rainy and dry periods over all years and may explain variation in the correlation of collected species. Since the data did not meet the criteria for parametric analysis, the Spearman correlation test was applied.

Table 1. List of Saturniidae species collected at Vale Natural Reserve, Linhares, ES, Brazil, in dry season (D) and rainy season (R) from January 1987 to December 1992. / Lista de las especies de Saturniidae recolectadas en la Reserva Natural Vale, Linhares, ES, Brasil, por estación seca (D) y estación lluviosa (R) entre enero de 1987 a diciembre de 1992.

Subfamily / Genus / Species	Number of individuals per period												Total	
	1987		1988		1989		1990		1991		1992			
	R	D	R	D	R	D	R	D	R	D	R	D	R	D
Arsenurinae														
Arsenura armida (Cramer, 1779)	1	3	1	0	2	3	0	0	0	0	0	0	4	6
Arsenura sylla (Cramer, 1779)	0	2	0	0	0	0	0	0	0	1	0	0	0	3
Arsenura ponderosa Rothschild, 1895	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Copiopteryx semiramis phoenix (Deyrolle, 1869)	6	0	1	0	0	0	0	0	0	0	0	0	7	0
Loxolomia serpentina Maassen, 1869	4	0	8	0	0	0	0	1	0	0	0	0	12	1
Paradaemonia pluto (Westwood, 1854)	8	0	18	4	16	9	8	3	10	1	4	0	64	17
Rhescyntis hippodamia (Cramer, 1777)	0	0	0	0	5	0	0	0	0	0	0	0	5	0
Rhescyntis pseudomartii Lemaire, 1976	12	1	5	2	0	2	1	0	1	0	1	0	20	5
Titaea tamerlan (Maassen, 1869)	32	17	44	7	20	10	22	18	49	1	27	23	194	76
Subfamily Total	**63**	**24**	**77**	**13**	**43**	**24**	**31**	**22**	**60**	**3**	**32**	**23**	**306**	**109**
Ceratocampinae														
Adeloneivaia boisduvalii (Doûmet, 1859)	0	0	0	0	0	0	0	0	1	0	0	3	1	3
Adeloneivaia fallax (Boisduval, 1872)	18	13	23	1	9	9	4	5	13	8	6	8	73	44
Adeloneivaia subangulata (Herrich-Schäffer, 1855)	13	9	39	1	6	8	23	7	31	5	2	0	114	30
Adelowalkeria flavosignata (Walker, 1865)	0	0	3	0	0	0	3	0	0	0	0	0	6	0
Citheronia phoronea (Cramer, 1779)	15	0	1	0	4	0	2	0	2	0	5	0	29	0
Citioica anthonilis (Herrich-Schäffer, 1854)	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Dacunju jucunda (Walker, 1855)	14	1	1	0	4	11	1	5	0	1	0	0	20	18
Eacles ducalis (Walker, 1855)	3	2	1	0	0	6	0	0	7	1	1	1	12	10
Eacles i. magnifica (Drury, 1773)	3	0	5	0	0	1	0	0	1	0	0	0	9	1
Oiticella convergens (Herrich-Schäffer, 1855)	17	2	14	1	3	3	2	0	2	0	0	0	38	6
Othorene purpurascens (Schaus, 1905)	2	9	3	0	1	7	0	0	4	2	2	0	12	18
Psilopygida walkeri (Grote, 1867)	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Schausiella arpi (Schaus, 1892)	4	0	1	0	8	1	0	0	0	0	4	1	17	2
Syssphinx molina (Cramer, 1780)	4	1	3	0	4	2	2	0	5	0	2	3	20	6
Subfamily total	**93**	**38**	**94**	**3**	**39**	**49**	**37**	**17**	**66**	**17**	**22**	**16**	**351**	**140**
Hemileucinae														
Automeris bilinea tamphilus (Schaus, 1892)	7	41	10	0	3	2	6	2	21	3	7	6	54	54
Automeris illustris (Walker, 1855)	0	1	0	0	0	2	0	0	4	3	6	5	10	11
Automeris larra (Walker, 1855)	1	2	0	0	0	0	0	0	2	0	4	0	7	2
Automeris melanops (Walker, 1865)	14	6	6	8	3	4	2	3	9	5	14	11	48	37

Subfamily / Genus / Species	Number of individuals per period												Total	
	1987		1988		1989		1990		1991		1992			
	R	D	R	D	R	D	R	D	R	D	R	D	R	D
Dirphia triangulum Walker, 1855	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Dirphiopsis multicolor (Walker, 1855)	0	3	0	3	1	1	0	1	0	0	0	1	1	9
Gamelia anableps (Felder & Rogenhofer, 1874)	1	2	0	0	0	0	0	0	0	0	1	0	2	2
Hylesia falcifera (Hübner, 1825)	1	0	0	0	0	0	0	0	0	0	1	0	2	0
Hylesia nanus (Walker, 1855)	0	1	0	1	0	0	0	1	0	0	0	0	0	3
Hylesia nr. *remex* Dyar, 1913	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Hylesia rufex Draudt, 1929	0	3	1	0	0	0	0	1	0	1	0	3	1	8
Hyperchiria incisa incisa Walker, 1855	2	1	4	4	4	0	2	0	3	0	7	1	22	6
Lonomia nr. *achelous* (Cramer, 1777)	0	4	0	2	0	2	1	0	1	1	0	1	2	10
Lonomia obliqua Walker, 1855	0	4	1	1	0	5	0	1	2	6	7	2	10	19
Molippa sabina Walker, 1855	2	1	1	0	0	1	0	0	3	0	2	14	8	16
Periga nr. *falcata* (Walker, 1855)	0	1	2	0	1	1	0	1	3	1	11	7	17	11
Periga nr. *insidiosa* (Lemaire, 1972)	0	4	1	0	1	0	1	0	3	1	6	5	12	10
Periga sp.	0	0	0	0	0	0	0	0	1	0	2	2	3	2
Pseudautomeris erubescens (Boisduval, 1875)	1	13	0	1	1	3	0	5	0	10	24	52	26	84
Pseudautomeris lata (Conte, 1906)	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Pseudautomeris subcoronis Lemaire, 1967	0	0	0	0	0	2	0	0	0	0	0	2	0	4
Travassosula subfumata (Schaus, 1921)	0	3	0	0	2	1	0	0	0	0	0	1	2	5
Subfamily total	**30**	**91**	**27**	**20**	**16**	**24**	**12**	**15**	**52**	**31**	**92**	**113**	**229**	**294**
Saturniinae														
Copaxa decrescens Walker, 1855	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Rothschildia arethusa arethusa (Walker, 1855)	3	1	3	0	0	0	1	0	0	0	0	0	7	1
Rothschildia aurota (Cramer, 1775)	2	0	0	0	0	1	0	0	1	1	1	0	4	2
Rothschildia belus (Maassen, 1873)	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Subfamily total	**5**	**3**	**3**	**0**	**0**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**11**	**5**
Total													**897**	**548**

The abundance (Fig. 2) shows that the efficiency of the sampling method can lead to an asymptote. In other words, the number of species collected by the traps is very close to those existing in the study area. In comparative analyses between seasonal periods (rainy and dry), there were significant variations in species richness ($p = 0.048$) and abundance ($p = 0.035$) (Fig. 3).

In the correlation between the biotic and abiotic parameters, only the correlation between abundance and temperature was found to have a positive significance ($p = 0.001$) ($r = 0.55$). There were significant differences in abundance ($p = 0.003$), species richness ($p = 0.001$), Shannon-Wiener ($p = 0.004$), and Simpson ($p = 0.007$) when comparing biotic

data between rainy and dry periods over all years (Fig. 4). Only species richness (p = 0.04) and abundance (p = 0.02) between the rainy and dry seasons of 1988 were found to be significantly different when paired.

Significant variations were identified among years in terms of dominance diversity (p = 0.036), species richness (p = 0.021), Shannon-Wiener (p = 0.013), and Simpson (p = 0.008) (Fig. 5). Only dominance exhibited a significant association (p = 0.01) in a paired comparison with environmental factors, with precipitation being the only one that was negative (r = -0.17).

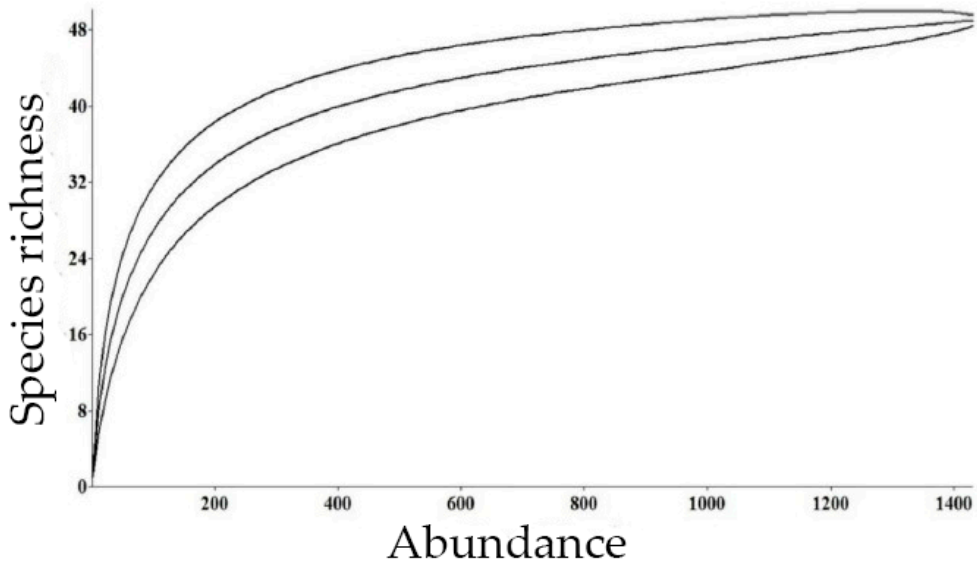

Figure 2. Collector curve for samplings from 1987 to 1992. The median line is representing the mean and external lines the standard deviation. Vale Nature Reserve, Linhares, ES, Brazil. / Curva colectora para muestreos de 1987 a 1992. La línea mediana representa la media y las líneas externas la desviación estándar. Reserva Natural Vale, Linhares, ES, Brasil.

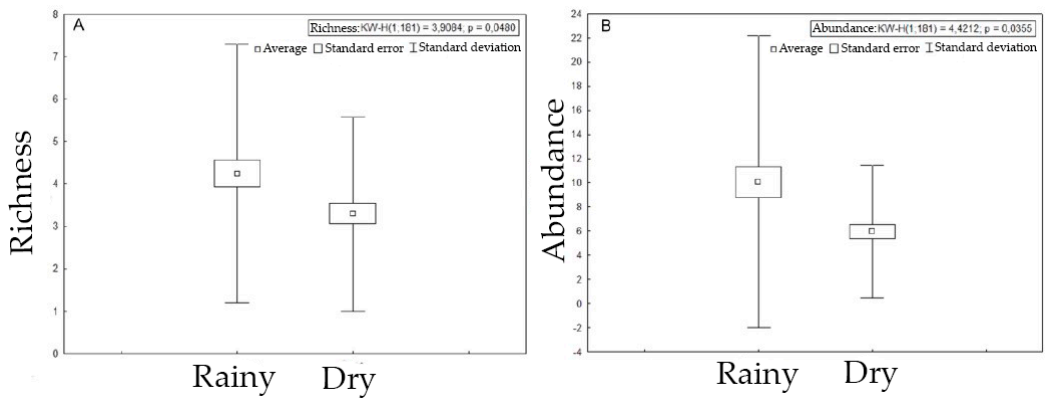

Figure 3. Kruskal-Wallis comparative analysis of ecological parameters with significant values for Saturniidae assemblage structure between rainy and dry periods from January 1987 to December 1992. Richness (A) and Abundance (B). Vale Nature Reserve, Linhares, ES, Brazil. / Análisis comparativo de Kruskal-Wallis de parámetros ecológicos con valores significativos para la estructura del ensamblaje de Saturniidae entre períodos lluviosos y secos desde enero de 1987 a diciembre de 1992. Riqueza (A) y Abundancia (B). Reserva Natural Vale, Linhares, ES, Brasil.

Discussion

In studies conducted in Ecuador (Racheli and Racheli 2005, 2006), Colombia (Amarillo-Suárez 2000), and Mexico (Lara-Pérez *et al*. 2017), the assembly composition followed a similar pattern. All of them had a high species richness of Hemileucinae and an abundance of Ceratocampinae, Arsenurinae, and Saturniinae. Regarding the ecological structure between seasonal periods, the richness and abundance parameters exhibited significant differences, as well as a significant relationship between abundance and temperature. In this relationship, it can be observed that there is a tendency for a decrease in abundance with a reduction in temperature; that is, this abiotic factor directly affects population fluctuation, decreasing it in colder periods (Tab. 1). According to Janzen (1984), temperature effects population fluctuations in various habitats, with higher temperatures resulting in increased abundance and lower temperatures resulting in decreased abundance. Long periods of dryness, where most species are pupae, show a clear reduction in population. As a result, these variables may be able to explain how they affect abundance during the rainy season (Figs. 3B, 4A).

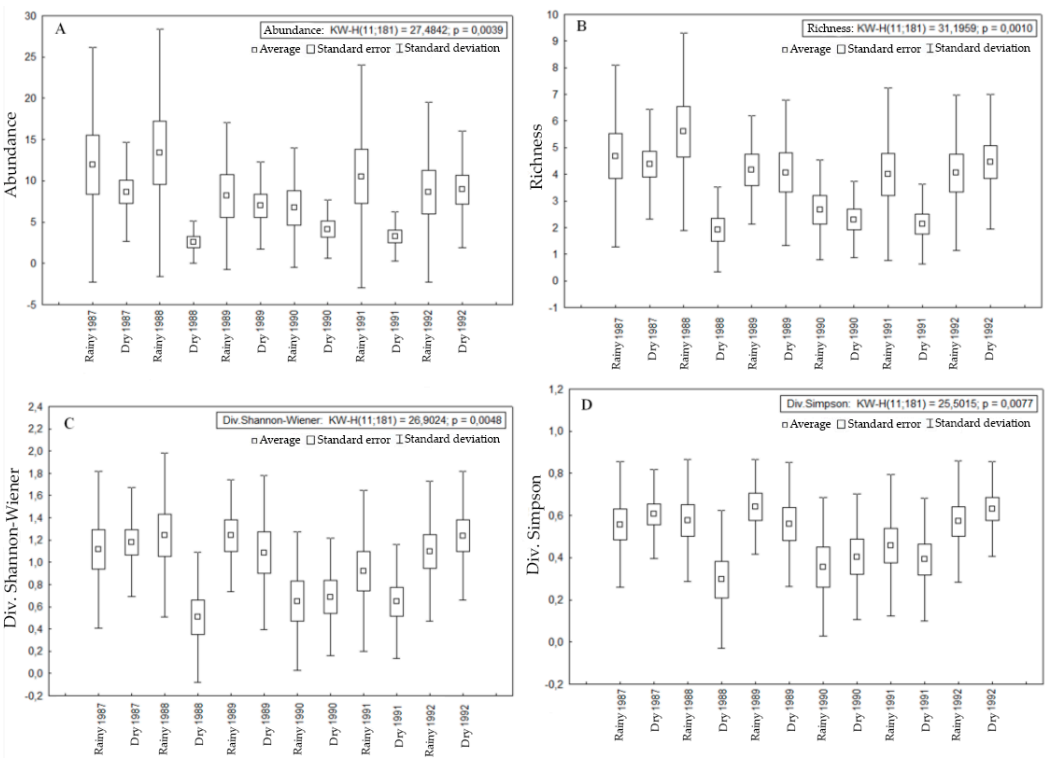

Figure 4. Kruskal-Wallis comparative analysis of ecological parameters with significant values for Saturniidae assemblage structure between rainy and dry periods from January 1987 to December 1992. Abundance (A), Species Richness (B), and Diversity Shannon-Wiener (C) and Simpson (D). Vale Nature Reserve, Linhares, ES, Brazil. / Análisis comparativo de Kruskal-Wallis de parámetros ecológicos con valores significativos para la estructura de ensamblaje de Saturniidae entre períodos lluviosos y secos desde enero de 1987 a diciembre de 1992. Abundancia (A), riqueza de especies (B) y diversidad Shannon-Wiener (C) y Simpson (D). Reserva Natural Vale, Linhares, ES, Brasil.

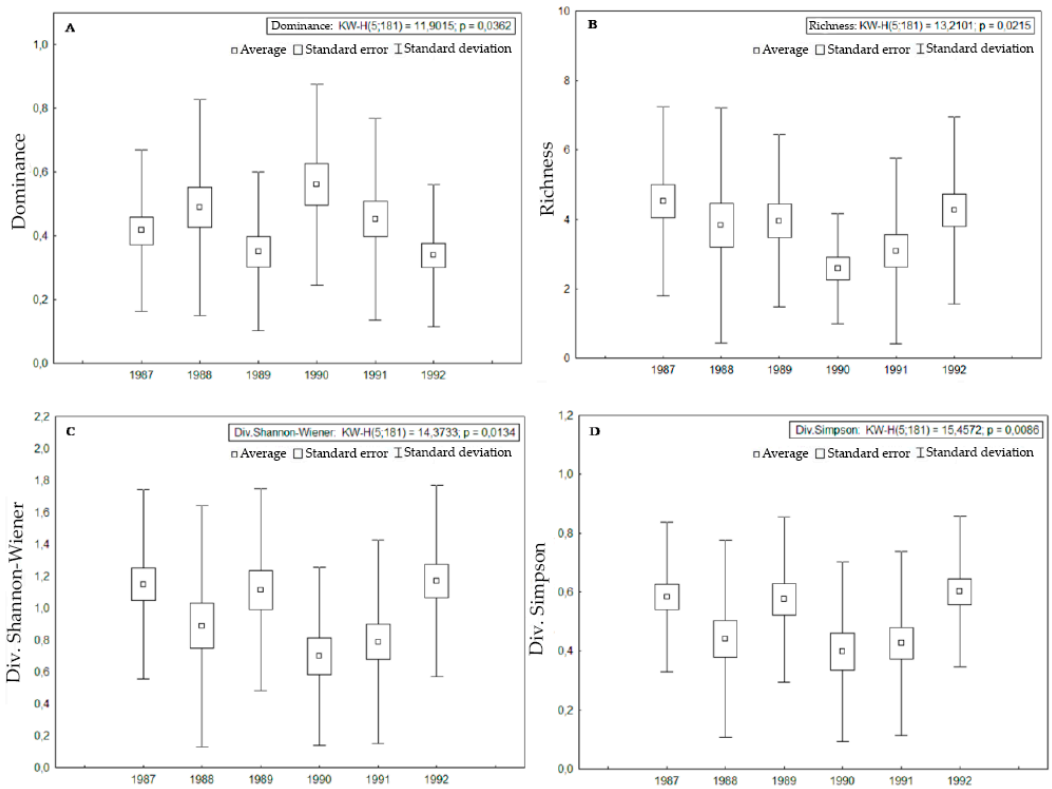

Figure 5. "Kruskal-Wallis" comparative analysis of ecological parameter with significant values for the assembly structure of Saturnidae collected at Vale Natural Reserve, Linhares, ES, Brazil, between the dry and rainy seasons of January 1987 to December 1992. Dominance (A), Wealth (B), Shannon-Wierner diversity (C) and Simpson diversity (D) / Análisis comparativo "Kruskal-Wallis" de parámetros ecológicos con valores significativos para la estructura de ensamblaje de Saturnidae recolectados en la Reserva Natural Vale, Linhares, ES, Brasil, entre las estaciones seca y lluviosa de enero de 1987 a diciembre de 1992. Dominancia (A), Riqueza (B), diversidad de Shannon-Wierner (C) y diversidad de Simpson (D).

In a single year, however, the species *Titaea tamerlan* (Maassen, 1869) have different development cycles. The data revealed that the abundance of adults rises in the month of October (increasing more than 100%, from 297 to 622 specimens) (Fig. 7C). *T. tamerlan* is a bivoltine species that makes up a substantial component of observed adult abundance (Travassos and Ferreira D'Almeida 1937). The first generation occurs from December to March, and the second from September to December. Seasonal generations thus boost species abundance, which is especially evident in Linhares with higher rainfall (INCAPER 2017). From 1982 through 1992, the anomalous year of 1988 had the lowest precipitation rate, falling below the average. This is due to the differences in abundance and richness between the dry and rainy seasons. As a result, no statistical significance was found in the relationship between richness, abundance, and precipitation. The sudden decline in precipitation may have influenced desiccation avoidance strategies such as remaining in the pupal stage for an extended period of time (Janzen 1982). Other variables that have yet to be investigated (e.g. humidity, duration of insolation, predation rate, parasitism rate, etc.) that may be linked to the oscillation of the ecological parameter should be investigated in the future.

Hemileucinae was shown to be responsible for a large variation in assembly structure during structural analyses of subfamilies. Ecological parameters were altered by changes in abundance, which resulted in significant variation between periods. Hemileucinae species pupate above ground (Lemaire 2002), which could limit the occurrence of some species owing to desiccation during periods of low rainfall (Janzen 1987). Ceratocampinae and Arsenurinae pupae, on the other hand, remain hidden in soil for long periods of drought to ensure their survival (Janzen 1982, 1987; Lemaire 1980, 1988). As a result, the species' abundance fluctuates very little. The findings with Saturniidae corroborate those of Wolda (1988) and Pinheiro *et al*. (2002), who found that seasonal fluctuations in insect abundance and diversity are related to rainfall.

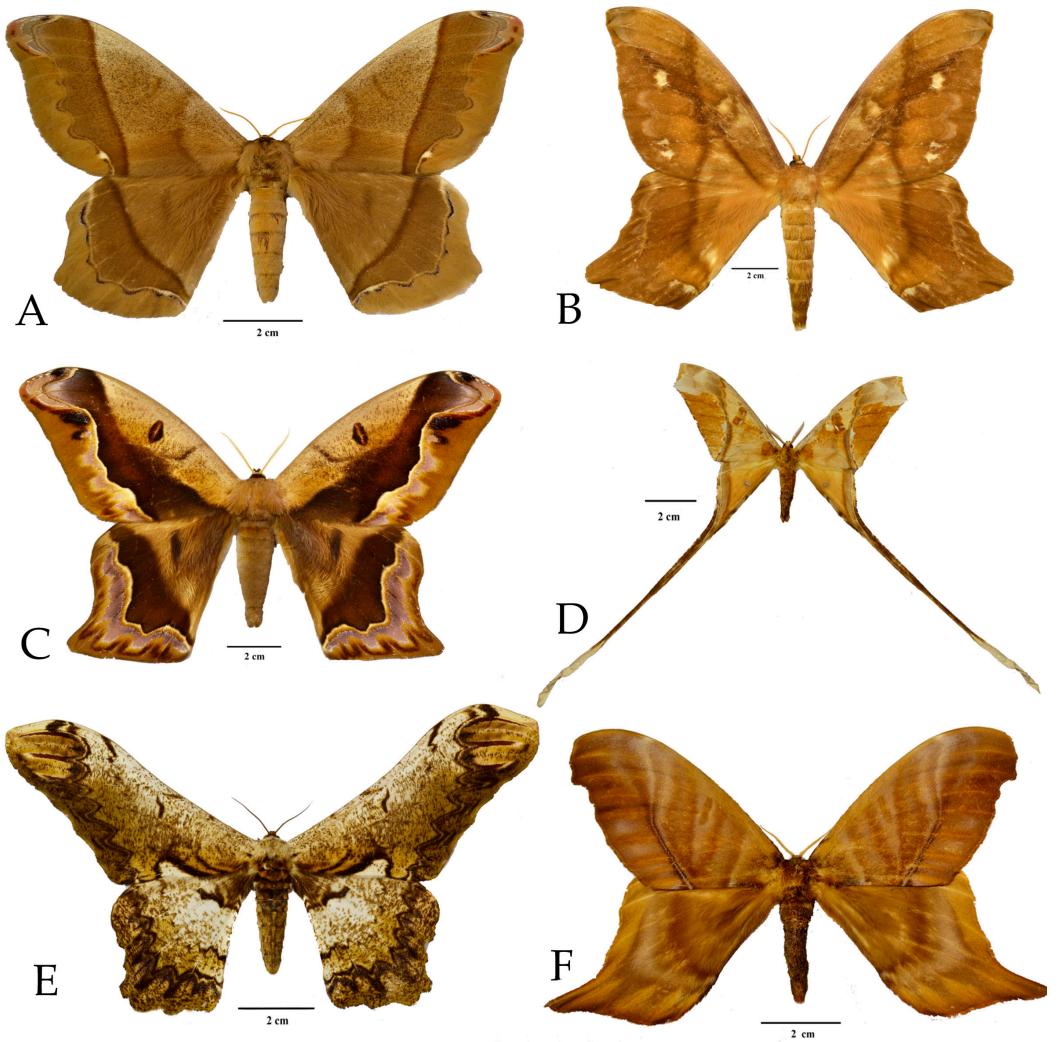

Figure 6. Arsenurinae subfamily found in the Vale Nature Reserve, Linhares, Espírito Santo, Brasil. Scale: 2 cm. / Subfamilia Arsenurinae encontrado en la Reserva Natural Vale, Linhares, Espírito Santo, Brasil. A) *Arsenura armida* (Cramer, 1779). B) *Arsenura ponderosa ponderosa* Rothschild, 1895. C) *Arsenura sylla* (Walker, 1855). D) *Copiopteryx semiramis phoenix* (Deyrolle, 1869). E) *Loxolomia serpentina* Maassen, 1869. F) *Paradaemonis pluto* (Westwood, 1854). Escala: 2 cm.

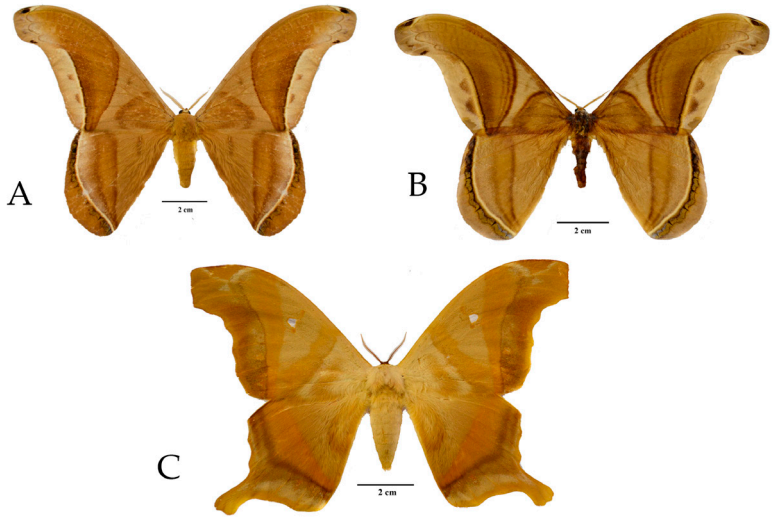

Figure 7. Arsenurinae subfamily found in the Vale Nature Reserve, Linhares, Espírito Santo, Brasil. Scale: 2 cm. / Subfamilia Arsenurinae encontrado en la Reserva Natural Vale, Linhares, Espírito Santo, Brasil. A) *Rhescyntis hippodamia gigantea* (Bouvier, 1930). B) *Rhescyntis pseudomartii* Lemaire, 1976. C) *Titaea tarmelan tarmelan* (Maassen, 1869). Escala: 2 cm.

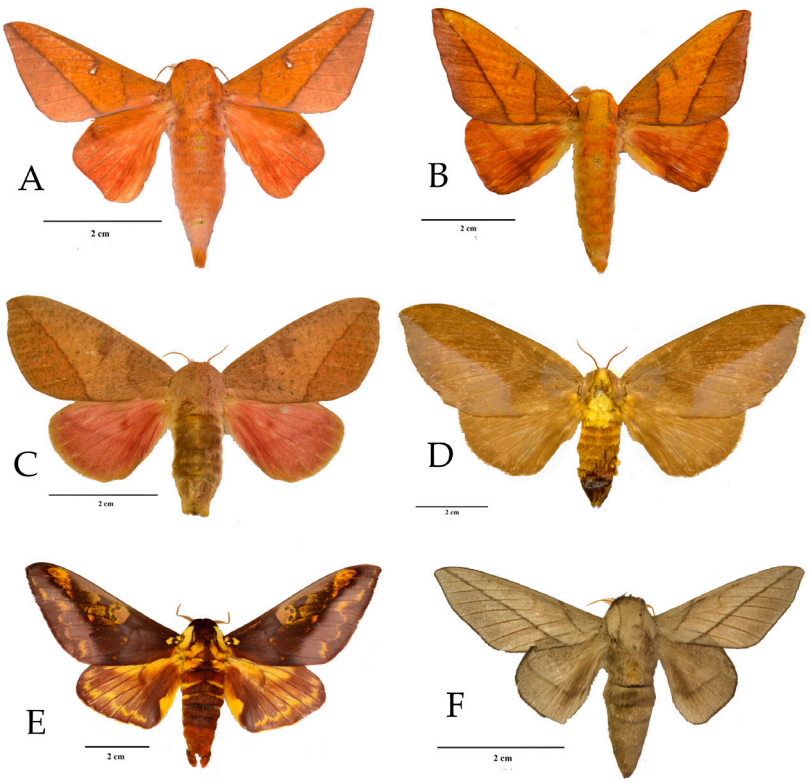

Figure 8. Ceratocampinae subfamily found in the Vale Nature Reserve, Linhares, Espírito Santo, Brasil. Scale: 2 cm. / Subfamilia Ceratocampinae encontrado en la Reserva Natural Vale, Linhares, Espírito Santo, Brasil. A) *Adeloneivaia boisduvalii* (Dumet, 1859). B) *Adeloneivaia fallax* (Boisduval, 1872). C) *Adeloneivaia subangulata subangulata* (Herrich-Schaffer, 1855). D) *Adelowalkeria flavosignata* (Walker, 1856). E) *Citheronia phoronea* (Cramer, 1779). F) *Citioica anthonilis* (Herrich-Schaffer, 1854). Escala: 2 cm.

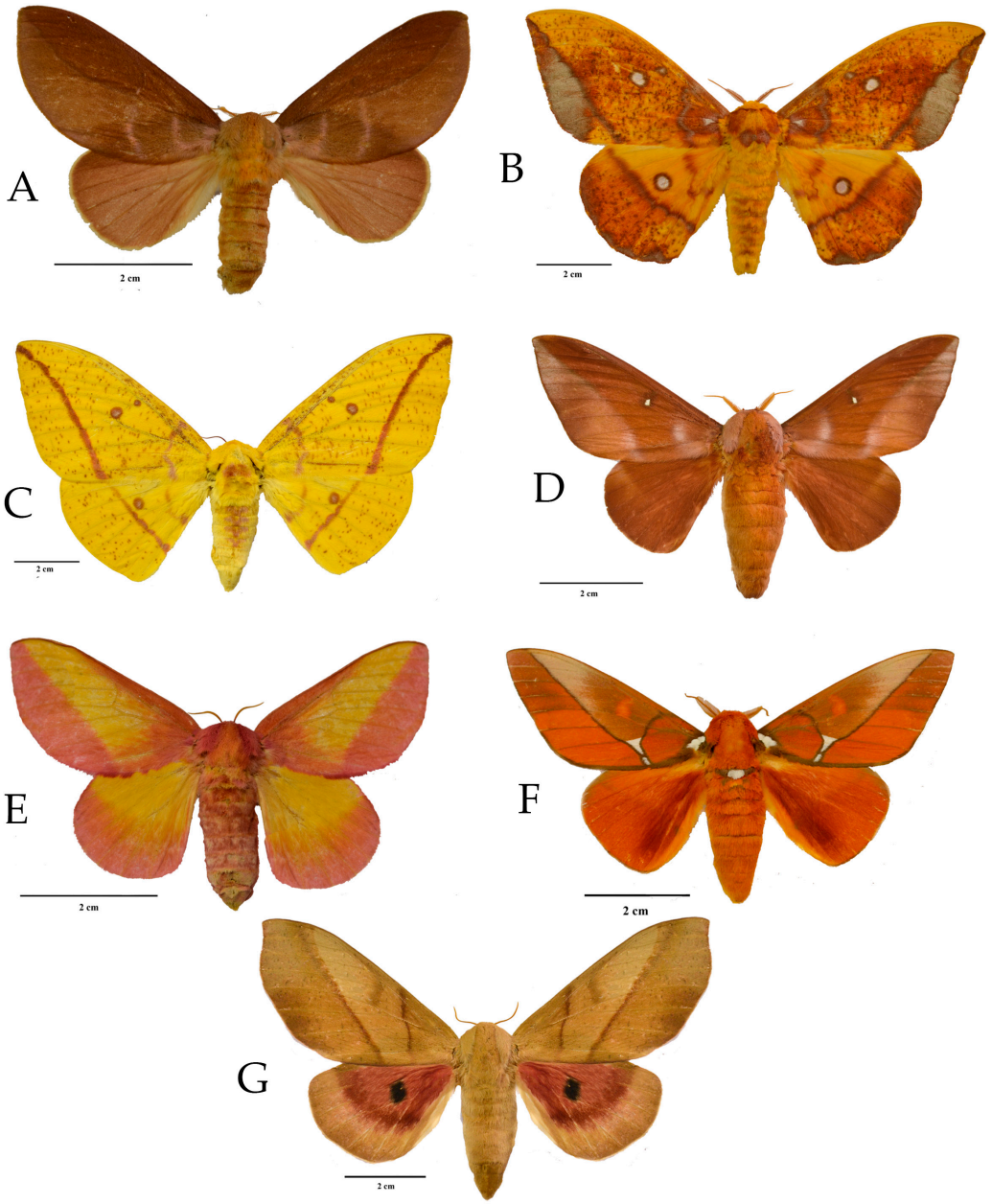

Figure 9. Ceratocampinae subfamily found in the Vale Nature Reserve, Linhares, Espírito Santo, Brasil. Scale: 2 cm. / Subfamilia Ceratocampinae encontrado en la Reserva Natural Vale, Linhares, Espírito Santo, Brasil. A) *Dacunju jucunda* (Walker, 1855). B*) Eacles ducalis* (Walker, 1855). C) *Eacles imperialis magnifica* Walker, 1855. D*) Othorene purpurascens* (Schaus, 1905). E) *Psigida walkeri* (Grote, 1867). F) *Schausiella arpi* (Schaus, 1892). G) *Syssphinx molina* (Cramer, 1780). Escala: 2 cm.

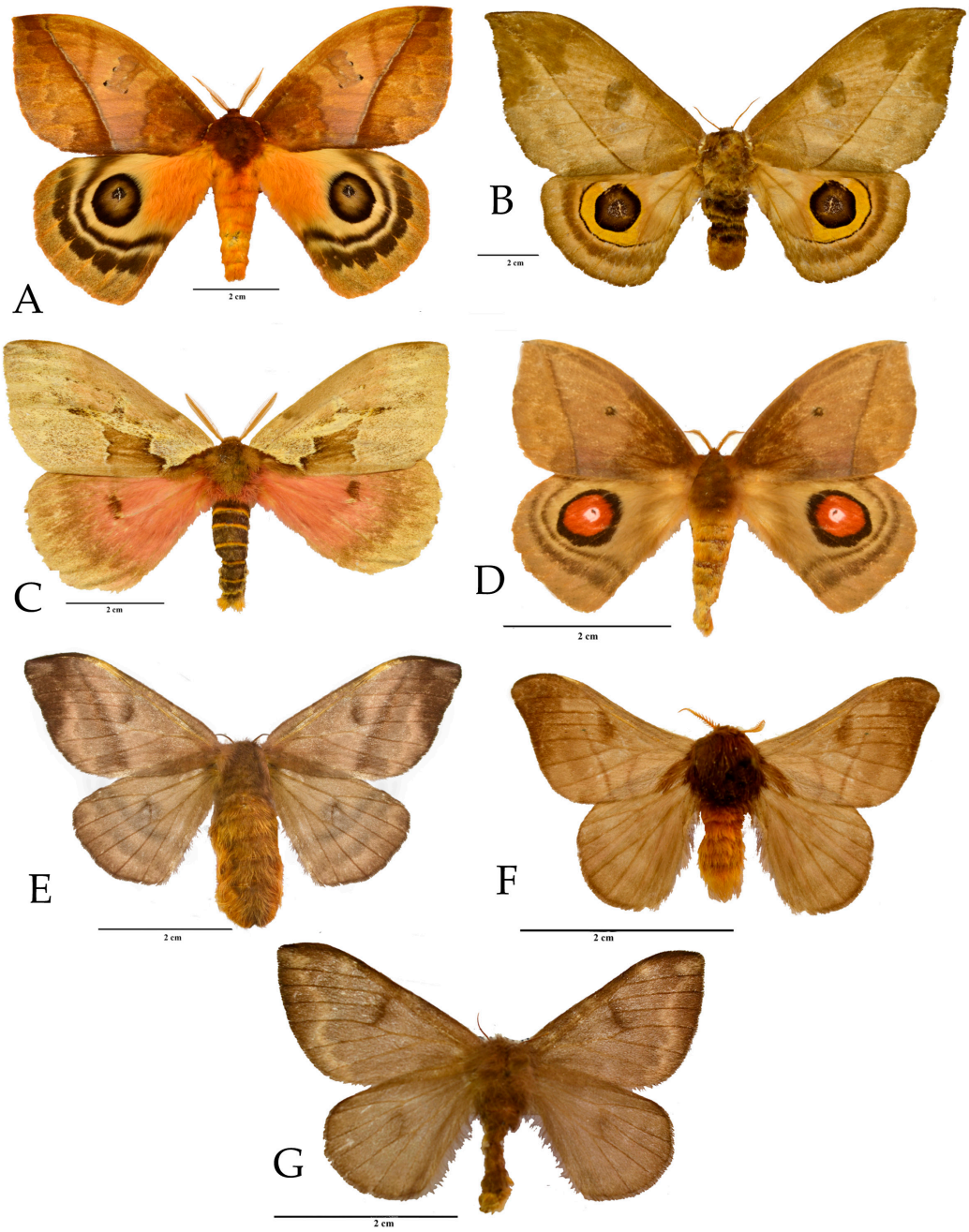

Figure 10. Hemileucinae subfamily found in the Vale Nature Reserve, Linhares, Espírito Santo, Brasil. Scale: 2 cm. / Subfamilia Hemileucinae encontrado en la Reserva Natural Vale, Linhares, Espírito Santo, Brasil. A) *Automeris larra* (Walker, 1855). B) *Automeris melanops* (Walker, 1865). C) *Dirphiopsis multicolor* (Walker, 1855). D) *Gamelia anableps* (R. Felder & Rogenhofer, 1874). E) *Hylesia nanus* (Walker, 1855). F) *Hylesia remex* Dyar, 1913. G) *Hylesia rufex* Draut, 1929. Escala: 2 cm.

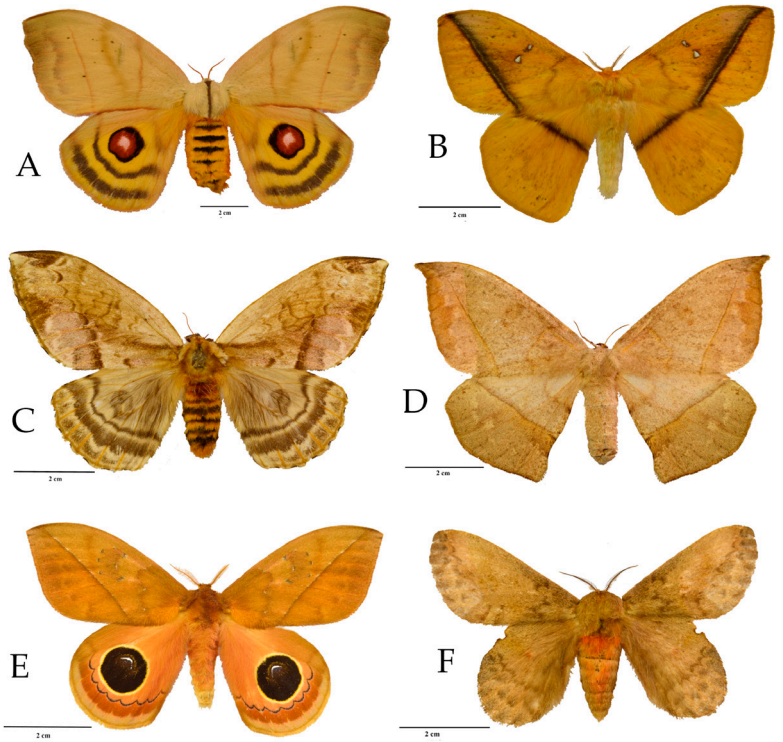

Figure 11. Hemileucinae subfamily found in the Vale Nature Reserve, Linhares, Espírito Santo, Brasil. Scale: 2 cm. / Subfamilia Hemileucinae encontrado en la Reserva Natural Vale, Linhares, Espírito Santo, Brasil. A) *Hyperchiria incisa incisa* Walker, 1855. B) *Lonomia obliqua* Walker, 1855. C) *Molippa sabina* Walker, 1855. D) *Periga falcata* (Walker, 1855). E) *Pseudautomeris subcoronis* Lemaire, 1967. F) *Travassosula subfumata* (Schaus, 1921). Escala: 2 cm.

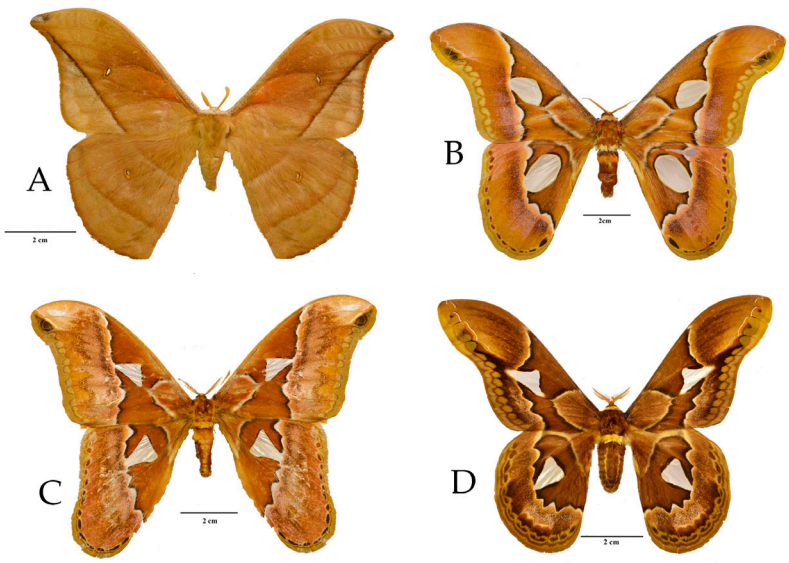

Figure 12. Saturniinae subfamily found in the Vale Nature Reserve, Linhares, Espírito Santo, Brasil. Scale: 2 cm. / Subfamilia Saturniinae encontrado en la Reserva Natural Vale, Linhares, Espírito Santo, Brasil. A) *Copaxa decrescens* Walker, 1855. B) *Rothschildia arethusa arethusa* (Walker, 1855). C) *Rothschildia aurota* (Cramer, 1775). D) *Rothschildia belus* (Maassen, 1873). Escala 2 cm.

Conclusion

Saturniidae species found in the Atlantic Forest of Vale Nature Reserve in northern Espírito Santo include those that are sensitive to water regimes, humid environments, and higher temperatures. The number of species and their abundance fluctuated slightly from year to year, with the highest concentrations of abundance occurring during the wet season. Prolonged periods of cold and drought directly affect the composition of subfamilies. The pupal stage, which is more resistant, likely allows these moths to survive these dryer and colder situations, and so subfamilies that pupate in less exposed areas (*e.g.*, under ground) are therefore more abundant. Other abiotic and biotic elements should be studied in order to verify correlations with changes in ecological traits, particularly richness and abundance. The Saturniidae have "little resistance" due to significant changes in abundance and diversity in rainfall patterns. This causes a large oscillation in values between periods that directly affects the values of ecological parameters and, consequently, the entire assembly of Saturniidae.

Due to the following facts, it leads to the belief that Saturniidae species have "high resilience" with the ability to tolerate disturbance and restore itself: a strategy to remain in the pupal stage for an extended period of time during unfavorable climatic conditions, remaining in the ecosystem; little dispersal ability; individuals who are not physiologically versatile to explore other environments; the tendency to reach an asymptote, that is, the recovery of the community in the face of fluctuations during the years analyzed.

Acknowledgments

The "Coordenação de Aperfeiçoamento de Pessoal de Nivel Superior" awarded the first author a scholarship (CAPES). To the Vale Natural Reserve's José Simplício dos Santos ("Zezão") technician for their logistical aid in the insect samples (RNV-Linhares). The authors also like to thank Dr. Edwin Ernesto Domínguez Núñez of the Department of Zoology, Escuela de Biología, Universidad de Panamá for his contribution and suggestions on the text.

Literature Cited

Amarillo-Suárez, A.R. (2000) Polillas satúrnidas (Lepidoptera: Saturniidae) de Colombia. *Biota Colombiana*, *1*: 177-186.

Amorim, H.B. (1984) Florestas nativas dos Estados do Rio de Janeiro e Espírito Santo. *Inventário Florestal Nacional*. Brasília, Instituto Brasileiro do Desenvolvimento Florestal - IBDF. 204 pp.

Bernardi, O., Garcia, M.S., Silva, E.J.E., Zazycki, L.C.F., Bernardi, D. and Finkenauer, É. (2011) Levantamento populacional e análise faunística de lepidoptera em *Eucalyptus* spp. no município de Pinheiro Machado, RS. *Ciência Florestal*, *21*: 735-744.

Camargo, A.J.A. and Becker, V.O. (1999) Saturniidae (Lepidoptera) from the Brazilian Cerrado: Composition and biogeographic relationships. *Biotropica*, *4*: 696-705.

Camargo, A.J.A., Duarte, M., Mielke, C.G.C. and Santos, F.L. (2021) Saturniidae in *Catálogo Taxonômico da Fauna do Brasil*. PNUD. Avaliable from: http://fauna.jbrj.gov.br/fauna/faunadobrasil/2727. Accessed in: 28 December 2021

Duarte, M., Marconato, G., Specht, A. and Casagrande, M.M. (2012) Lepidoptera. *In*: Rafael, J.A., Melo, G.A.R., Carvalho, C.J.B. DE., Casari, A.S. and Constantino, R. (Eds.). *Insetos do Brasil: diversidade e taxonomia*. Holos, Ribeirão Preto, p. 625-682.

Ferreira, P.S.F. and Martins, D. dos S. (1982) Contribuição ao método de captura de insetos por meio de armadilha luminosa, para obtenção de exemplares sem danos morfológicos. *Revista Ceres*, *29*: 538-543.

Garay, I., Kindel, A., Louzada, M., Rizzini, M.C. and Vidal Perez, D. (2016) Formas de húmus como indicador funcional de ecossistemas emergentes na Floresta de Tabuleiro. *In*: Rolim. S.M., Menezes, l.f.t. and Srbek-araújo, A.C. (Eds.), *Floresta Atlântica de Tabuleiro: diversidade e endemismos na Reserva Natural Vale*, p. 101-128.

Hammer, O., Harper, D.A.T. and Ryan, P.D. (2001) PAST: Paleontological Statistic software package for education and data analysis. *Paleontologia Eletronica*, *4*(1): 1-9.

INCAPER [Instituto Capixaba de Pesquisa, Assistencia Técnica e Extensao Rural] **(2017)** Gráficos da Série Histórica - Linhares/ES. Governo do Estado do Espírito Santo. Secretaria de Estado da Agricultura, Abastecimento, Aquicultura e Pesca. Avaliable from: https://meteorologia.incaper.es.gov.br/graficos-da-serie-historica-linhares. Accessed in December 2021.

Janzen, D.H. (1982) Guia para la identificacion de mariposas nocturnas de la familia Saturniidae del Parque Nacional Santa Rosa, Guanacaste, Costa Rica. *Brenesia*, *19*: 255-299.

Janzen, D.H. (1984) Dispersal of small seeds by big herbivores: foliage is the fruit. *The American Naturalist*, *123*: 338-353.

Janzen, D.H. (1987) How moths pass the dry Season in Costa Rican dry forest. *Insect Science Applied*, *8*: 489-500.

Jesus, R.M. and Rolim, S.G. (2005) Fitossociologia da Floresta Atlântica de Tabuleiro em Linhares (ES). *Boletim Técnico da Sociedade de Investigação Florestal*, *19*: 1-149.

Kitching, R.L., Orr, A.G., Thalib, L., Mitchell, H., Hopkins, M.S. and Graham, A.W. (2000) Moth assemblages as indicators of environmental quality in remnants of upland Australian rain forest. *Journal of Appli ed Ecology*, *37*: 284-297.

Köppen, W. (1948) Climatologia: com um estúdio de los climas de la tierra. *Climatology*. Laboratory of Climatology, New Gersey, 104 pp.

Kristensen, N.P., Scoble, M.J. and Karsholt, O. (2007) Lepidoptera phylogeny and systematics: the state of inventorying moth and butterfly diversity. *Zootaxa*, *1668*: 699-747.

Lara-Pérez, L.A., Campos-Domínguez, J., Díaz-Fleischer, F., Adame-García, J.E. and Andrade-Torres, A. (2017) Species richness and abundance of Saturniidae (Lepidoptera) in a tropical semi-deciduous forest of Veracruz, Mexico and the influence of climatic variables. *Revista Mexicana de Biodiversidad*, *88*: 173-182.

Lemaire, C. (1978) *Les Attacidae américains* (= Saturniidae). Attacinae. Édition C. Lemaire, Neuilly-sur-Seine, France, 238 pp.

Lemaire, C. (1980) *Les Attacidae Americains* (= Saturniidae) Arsenurinae. Edition C. Lemaire, 199 pp.

Lemaire, C. (1988) *Les Attacidae Américains* (= Attacidae). Ceratocampinae. San José: Museo Nacional de Costa Rica, 480 pp.

Lemaire, C. (2002) *Saturniidae of America: Hemileucinae*. Part A. Goecke E Evers, Keltern, Germany, 688 pp.

Mittermeier, R.A., Myers, N., Thomsen, J.B., DA Fonseca, G.A.B. and Olivieri, S. (1998) Biodiversity hotspots and major tropical wilderness areas: approaches to setting conservation priorities. *Conservation Biology*, *12*: 516-520.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. and Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, *403*: 853-858.

New, T.R. (2004) Moths (Insecta: Lepidoptera) and conservation: background and perspective. *Journal of Insect Conservation*, *8*: 79-94.

Nobrega, N.E.F., Silva, J.G.F. da, Ramos, H.E. dos A. and Pagung, F. dos S. (2008) Análise da distribuição sazonal e espacial da precipitação na Norte do Estado do Espírito Santo. *In*: *Congresso Brasileiro de Meteorologia*. A meteorologia e a cidade. São Paulo: SBMET, 5.

Pinheiro, F., Diniz, I.R., Coelho, D. and Bandeira, M.P.S. (2002) Seasonal pattern of insect abundance in the Brazilian cerrado. *Austral Ecology*, *27*: 132-136.

Racheli, L. and Racheli, T. (2005) An update checklist of the Saturniidae of Ecuador. Part I: Hemileucinae (Lepidoptera: Saturniidae). *SHILAP Revista de Lepidopterología*, *33*: 203-223.

Racheli, L. and Racheli, T. (2006) An update checklist of the Saturniidae of Ecuador. Part II: Arsenurinae, Ceratocampinae. *SHILAP Revista de Lepidopterología*, *34*: 197-211.

Rafael, J.A., Melo, G.A.R., Carvalho, C.J.B., Casari, S.A. y Constantino, R. (2012) *Insetos do Brasil. Diversidade e Taxonomia,* v.1, 810 pp.

Ramos, A.M., Santos, L.A.R. and Fortes, L.T.G. (2009) Normais Climatológicas do Brasil 1961-1990. Brasília, DF: *Instituto Nacional de Meteorologia - INMET*, 465 pp.

Rolim, S.G., Menezes, L.F.T. and Srbek-Araujo, A.C. (2016) Floresta Atlântica de Tabuleiro: diversidade e endemismos na Reserva Natural Vale. *Rona*, Belo Horizonte, 496 pp.

Silva, A.G. (2014) A importância da Reserva Natural Vale para a conservação das florestas tropicais nativas do Norte do Estado do Espírito Santo, Brasil. *Natureza online*, *12*: 206-211.

Statsoft, INC. (2005) Statistica for Windows (data analysis software system), version 7.1. *Statsoft*, Tulsa, Oklahoma (USA).

Thomaz, L.D. (2010) A Mata Atlântica no estado do Espírito Santo, Brasil: de Vasco Fernandes Coutinho ao século 21. *Boletim do Museu de Biologia Mello Leitão*, *27*: 5-20.

Travassos, L. and Ferreira D'Almeida, R. (1937) Contribuição para o conhecimento da bionomia de alguns lepidopteros brasileiros. *Memórias do Instituto Oswaldo Cruz*, *4*: 499-516.

Wolda, H. (1988) Insect seasonality: Why? *Annual Review of Ecology and Systematic*, *19*: 1-18.