ARTÍCULO DE INVESTIGACIÓN ORIGINAL

FAUNAL AND SEASONAL COMPOSITION OF THE COMMUNITY OF APIONINAE (COLEOPTERA: BRENTIDAE) IN THE TROPICAL RAINFOREST OF THE SIERRA EL MADRIGAL IN STATE OF TABASCO, MEXICO

Esbeidy Jazmín De la O-López[1], Aracely De la Cruz-Pérez[1], Jesús Luna-Cozar[2], Robert S. Anderson[3] and Manuel Alberto Hernández-May[1*]

Universidad Juárez Autónoma de Tabasco, División Académica de Ciencias Biológicas, Villahermosa, Tabasco, México[1].
Universidad Autónoma de Querétaro, Facultad de Ciencias Naturales, Juriquilla, Querétaro, México[2].
Research Division, Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, ON. Canadá [3].

esbeidy1606@gmail.com[1]
aracely.delacruz@ujat.mx[2]
jesus.luna@uaq.mx[3]
RAnderson@nature.ca[4]
manuel.hz.may@gmail.com[5]

manuel.hz.may@gmail.com[5]

Carr. México-Texcoco km 36.5, 56230, Montecillo, Estado de México, México.

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FAUNAL AND SEASONAL COMPOSITION OF THE COMMUNITY OF APIONINAE (COLEOPTERA: BRENTIDAE) IN THE TROPICAL RAINFOREST OF THE SIERRA EL MADRIGAL IN STATE OF TABASCO, MEXICO

COMPOSICIÓN FAUNÍSTICA Y ESTACIONAL DE LA COMUNIDAD DE APIONINAE (COLEOPTERA: BRENTIDAE) EN EL BOSQUE TROPICAL HÚMEDO DE LA SIERRA EL MADRIGAL EN EL ESTADO DE TABASCO, MÉXICO

Esbeidy Jazmín De la O-López[1], Aracely De la Cruz-Pérez[1], Jesús Luna-Cozar[2], Robert S. Anderson[3] and Manuel Alberto Hernández-May[1*]

Universidad Juárez Autónoma de Tabasco, División Académica de Ciencias Biológicas, Villahermosa, Tabasco, México[1].
Universidad Autónoma de Querétaro, Facultad de Ciencias Naturales, Juriquilla, Querétaro, México[2].
Research Division, Canadian Museum of Nature, P.O. Box 3443, Station D, Ottawa, ON. Canadá[3].

*Autor de correspondencia: manuel.hz.may@gmail.com

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ABSTRACT. Apioninae (Coleoptera: Curculionoidea: Brentidae) are beetles commonly known as seed or clover weevils, and all species are phytophagous and important in natural ecosystems. The main objective of this study was to record the faunal and seasonal composition of the Apioninae community in the tropical rainforest of Tabasco, Mexico. Sampling was carried out in 12 sites of the ecosystem during an annual cycle (January-December 2021), using the method of beating the vegetation with an entomological net. We collected 1,191 specimens belonging to 33 species and nine genera. *Apion panamense* Sharp, *Coelocephalapion accentor* (Kissinger), *C. iteratum* (Kissinger) and *Neapion cretaceicolle* (Sharp) are new records for Tabasco. The genus *Trichapion* (Wagner) was the richest species. *Apionion* sp2 was the most abundant species. The highest richness, abundance and diversity (^{0}D, ^{1}D and ^{2}D) were recorded during the dry season. Twelve species were recorded only in the dry season and two in the winter rainy season. Fluctuations in richness and abundance showed a maximum peak in April, the month with the lowest rainfall. Shaded sites had the highest richness (32 species) and abundance (861 individuals). This study contributes to the knowledge of Apioninae by providing new ecological information on the subfamily. However, further studies of these beetles are needed to determine their geographic distribution and systematics.

Key words: Beetles, weevils, pear-shaped weevils, diversity, richness, jungle.

RESUMEN. Los Apioninae (Coleoptera: Curculionoidea: Brentidae) son escarabajos comúnmente conocidos como gorgojos de la semilla o del trébol, siendo todas las especies fitófagas e importantes en los ecosistemas naturales. El objetivo principal de este estudio fue registrar la composición faunística y estacional de la comunidad de Apioninae en el bosque tropical húmedo de Tabasco, México. El muestreo se realizó en 12 sitios en el ecosistema durante un ciclo anual (enero-diciembre, 2021), utilizando el método de golpeo de la vegetación con una red entomológica. Se colectaron 1,191 ejemplares pertenecientes a 33 especies y nueve géneros. *Apion panamense* Sharp, *Coelocephalapion accentor* (Kissinger), *C. iteratum* (Kissinger) y *Neapion cretaceicolle* (Sharp) representan nuevos registros para Tabasco. El género *Trichapion* (Wagner) fue el más rico en especies y *Apion* sp2 fue la especie más abundante. La mayor riqueza, abundancia y diversidad (^{0}D, ^{1}D y ^{2}D) se registró en la estación seca. Doce especies se registraron únicamente en la estación seca y dos en la estación de lluvias de invierno. Las fluctuaciones en riqueza y abundancia mostraron su máximo pico en abril, el mes con la menor precipitación. Los sitios con sombra presentaron la mayor riqueza (32 especies) y abundancia (861 individuos). Este estudio contribuye al conocimiento de Apioninae aportando nueva información ecológica sobre la subfamilia. Sin embargo, se necesitan más estudios sobre estos escarabajos para determinar su distribución geográfica y su sistemática.

Palabras clave: Escarabajos, gorgojos, gorgojos con forma de pera, diversidad, riqueza, selva.

INTRODUCTION

Beetles of the subfamily Apioninae (Coleoptera: Curculionoidea: Brentidae) are orthocerus weevils with approximately 2,200 described species included in 205 genera worldwide (Alonso-Zarazaga and Wanat, 2014; Oberprieler *et al*., 2007). These beetles are widely distributed in all non-polar regions of the world, from high altitudes to sea level. In Mexico, a total of 172 species are reported, classified in 13 genera (Alonso-Zarazaga, 2004).

Apionines are relatively small (0.75-13 mm) (Anderson and Kissinger, 2002; De Sousa *et al*., 2019) and both adults and larvae are phytophagous and specific to their host plant (Alonso-Zarazaga, 2004). Immature stages develop and feed on leaves, inflorescences, seeds of Euphorbiaceae, Leguminosae, and other dicotyledons (Arcaya *et al*., 2020), they also consume shoots and roots where they form gall-like structures (Alonso-Zarazaga, 2004; Anderson and Kissinger, 2002; Marvaldi and Lanteri, 2005; Vergara-Pineda *et al*., 2015), and adults feed on all plant tissues of plants (De Sousa *et al*., 2019).

The study of insect communities and seasonality is particularly important in tropical rainforests, as this ecosystem is considered one of the least protected and most endangered (Hernández-May *et al*., 2024). Furthermore, the Neotropical region is considered one of the richest and most diverse in the world (Lewis *et al*., 2015). Changes in vegetation could modify the seasonality of these forests, resulting in changes in abundance, diversity, and loss of species (Brook *et al*., 2008). In this context, knowledge of seasonal patterns in a specific ecosystem can provide important information for the development of strategies and conservation plans to maintain ecosystem functionality.

In Mexico, most of the available literature focuses on taxonomic studies (Acevedo-Hernández, 2009; Kissinger, 1968, 1989, 1990, 1992, 1998, 1999a, b; O'Brien and Wibmer, 1982), host studies (Kissinger, 1990; Ordóñez-Reséndiz *et al*., 2006). Currently, there are only two papers investigating regional apionine species diversity: Jones *et al*. (2012) in the El Cielo Biosphere Reserve in northeastern Mexico and the study by Castro-Martínez (2019) in the Sierra de Taxco-Huautla, Mexico.

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Undoubtedly, there is a deficit and absence of research that addresses the biological and ecological aspects (e.g. seasonal patterns, effects of climate and interactions with plants) of Apioninae in many ecosystems of the state and the country. The following study presents an analysis of the community structure (richness, abundance and diversity) and seasonality of the subfamily Apioninae in a tropical rainforest site located in the Sierra El Madrigal (SM) in the state of Tabasco, Mexico. A very diverse and important ecosystem for the maintenance and conservation of biodiversity.

Materials and Methods

Study area

The study was conducted in a site composed of tropical rainforest in the Sierra El Madrigal (SM) in the municipality of Teapa, Tabasco, Mexico. The SM has an area of 3,462 ha, with a warm humid tropical climate with year-round rainfall (Af), the mean annual temperature ranges between 23 and 26 °C, and the total annual precipitation varies between 2,900 and 3,600 mm (Fig. 1). This Sierra is composed of domical and conical hills from 50 to 1,000 masl. and has three climatic seasons: dry (March, April, May, and June), rainy (July, August, September, and October), and winter rainy (November, December, January, and February) (Hanan-Alipi *et al*., 2019; Hernández-May *et al*., 2024; Salazar *et al*., 2004).

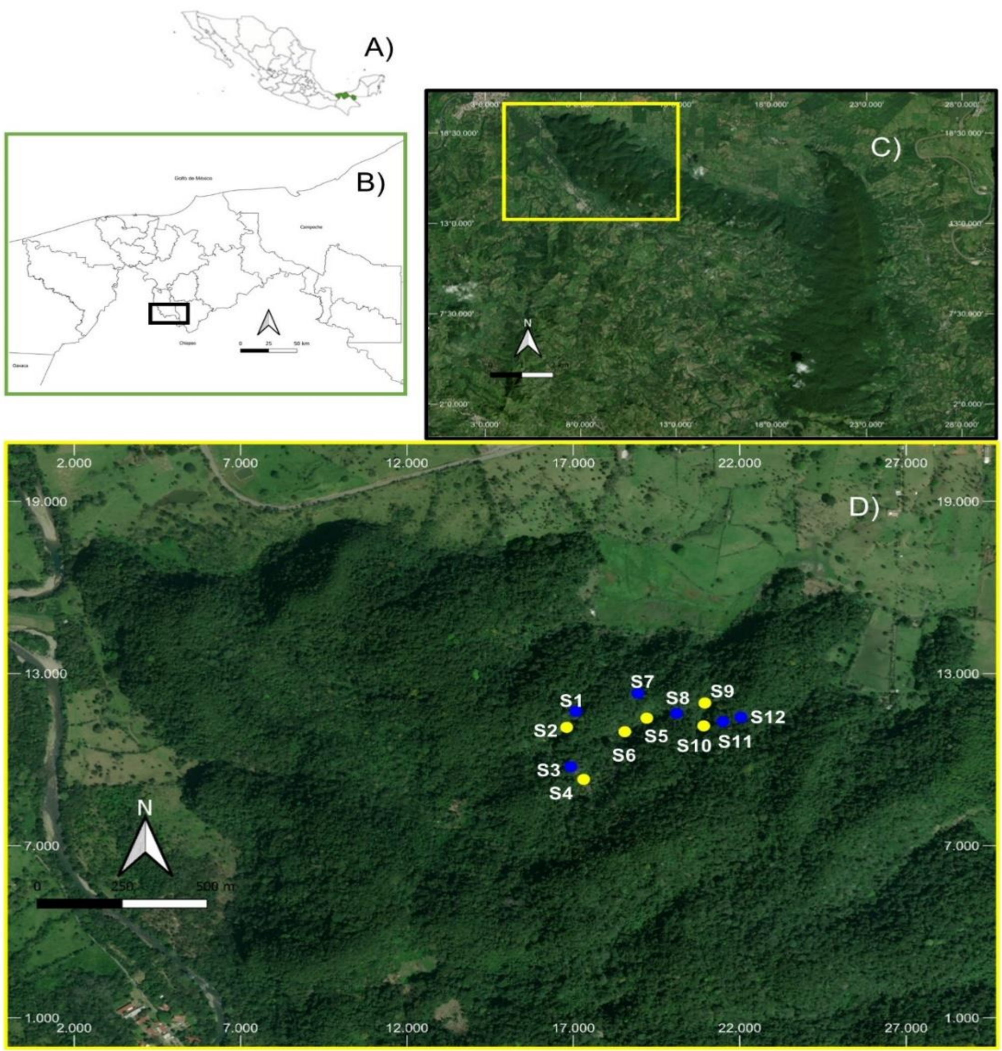

Figure 1. Geographical location of the study site. A) Mexico; B) State of Tabasco; C) Sierra El Madrigal; D) sampling sites in Sierra El Madrigal. Blue circles: shaded sites; yellow circles: sun-exposed sites.

Sampling design

Monthly visits were made during the new moon period of an annual cycle (January to December 2021), with two people using five effective days to collect beetles from 10:00 am to 1:00 pm. Climatic variables (humidity and temperature) were also recorded using a Kestrel 4000 portable weather station.

Apioninae were collected using an entomological beating net (40 cm diameter ring and 2 m handle), which was used to beat herbaceous and shrubby vegetation 200 times (Jones et al., 2012) at six sites in the sun and six sites in the shade. Each site was separated by approximately 500 m. The sun sites consisted of areas with abundant grasses and no tree cover and were used for local activities such as planting maize and tubers; the shade sites consisted of large trees over 30 meters tall, native palms, and sparse grasses, and no local agricultural activities were found. Samples from the monthly vegetation sampling per site were placed in a plastic bag in which the insects were sacrificed with ethyl acetate, a substance that maintains the insects soft for the mounting process. All samples were labeled in the field with the corresponding biological and geographic data. Taxonomic keys (Acevedo-Hernández, 2009; Alonso-Zarazaga, 2004; Anderson and Kissinger, 2002; De Sousa and Anderson, 2022; Kissinger,1968; Morrone, 2000) were used for species, morphospecies and genus determination, and specimens were deposited at the Insect Collection of the Universidad Juárez Autónoma of Tabasco (CIUT-UJAT).

Statistical analysis

The true diversity indices of order 0 (^0D), 1 (^1D) and 2 (^2D) were calculated with the program PAST: Paleontological Statistics Software Package (Hammer et al., 2001), for each climatic season (dry, rainy, and winter rainy), and for the SM sites. Zero order (^0D) refers to species or taxonomic richness in a sample, community, or ecosystem, the first-order (^1D), diversity measure considers all species in the diversity value, weighted proportionally according to their abundance in the community, ^1D is equal to the exponential of Shannon's index, and the second-order (^2D), diversity measure considers the most common species, and species with higher abundance are favored, ^2D is equal to the inverse of Simpson's dominance index (Jost, 2006, 2007; Moreno et al., 2011; Tuomisto, 2010, 2011). The iNext program was used to calculate and estimate the sampling efficiency per collection site by randomizing the sampling unit 100 times (Chao and Jost, 2012; Chao *et al*., 2016; Colwell, 2013).

Using the program STATGRAPHICS Centurion 19, Pearson correlations were performed to determine the relationship between the richness and abundance of Apioninae with respect to the environmental variables of humidity, temperature and precipitation. This correlation is used to evaluate the linear relationship between two variables and its main objective is to determine whether there is a direct or inverse relationship between the variables and how strong this relationship is, expressed by a coefficient (r) ranging from -1 to 1.

Based on the assumption that the collected species do not represent the total richness of the community, the EstimateS 9.0 program was used to estimate species richness using non-parametric incidence-based estimators: Chao 1 and Jacknife 1 (Colwell and Coddington, 1994). These estimators require only presence or absence data and are among those that have shown the highest precision and lowest bias with small samples, obtaining a better approximation of true species richness (Hortal et al., 2006; Willie *et al*., 2012).

RESULTS

A total of 1,191 individuals of Apioninae were collected, representing nine genera and 33 species. Of the total species, only five were determined to species level, the rest to genus level but separated to morphospecies. *Apion panamense* Sharp, *Coelocephalapion accentor* (Kissinger), *C. iteratum* (Kissinger), and *Neapion cretaceicolle* (Sharp) are new records for the state of Tabasco.

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The genera with the highest species richness were *Trichapion* (Wagner) with 11 species, followed by *Coelocephalapion* (Wagner) with nine species. *Alocentron* (Schilsky) and *Neapion* (Alonso-Zarazaga), both with three species, were the genera with the lowest species richness. The most abundant species were *Apionion* sp2 with 279 specimens, representing 23.43% of the total number of apionines collected, followed by *Coelocephalapion* sp3 with 256 (21.49%) and *Coelocephalapion* sp4 with 247 (20.47%), and together these species represent 65.39% of the total collection (Table 1).

Table 1. Taxonomic list of Apioninae Schoenherr, 1823 collected in the SM in Tabasco.

Species	**Abundance**	**(%)**
Alocentron sp1	1	0.08
Alocentron sp2	1	0.08
Alocentron sp3	2	0.17
Apion panamense Sharp, 1890*	3	0.25
Apion sp1	3	0.25
Apionion sp1	15	1.26
Apionion sp2	279	23.43
Chrysapion chrysocomum (Gerstaecker, 1854)	16	1.34
Coelocephalapion accentor (Kissinger, 1968)*	31	2.60
Coelocephalapion iteratum (Kissinger, 1974)*	3	0.25
Coelocephalapion sp1	2	0.17
Coelocephalapion sp2	18	1.51
Coelocephalapion sp3	256	21.49
Coelocephalapion sp4	247	20.74
Coelocephalapion sp5	1	0.08
Coelocephalapion sp6	2	0.17
Coelocephalapion sp7	7	0.59
Heterapion sp1	10	0.84
Kissingeria sp1	6	0.50
Neapion cretaceicolle (Sharp, 1890)*	5	0.42
Neapion sp1	2	0.17
Neapion sp2	1	0.08
Trichapion sp1	7	0.59
Trichapion sp2	13	1.09
Trichapion sp3	1	0.08
Trichapion sp4	194	16.29
Trichapion sp5	3	0.25
Trichapion sp6	25	2.10
Trichapion sp7	10	0.84
Trichapion sp8	21	1.76
Trichapion sp9	1	0.08
Trichapion sp10	4	0.34
Trichapion sp11	1	0.08
Richness	**33**	
Genera	**9**	
Total	**1191**	**100**

(%): relative abundance, * new records for the state of Tabasco.

Of the 33 species reported for the Apioninae community, 22 species (67%) are represented by more than three individuals and 11 species (33%) are represented with low abundance, considered rare species, i.e. represented by one and two individuals (Table 1).

The dry season showed the highest diversity in order ^{0}D =31 species, followed by the rainy season with ^{0}D =17 species and the winter rainy with ^{0}D =15 species. The maximum diversity of orders between ^{1}D and ^{2}D was recorded in the dry season with ^{1}D =7.3 and ^{2}D =4.9, followed by winter rain with ^{1}D =6.3 and ^{2}D =3.9, and the rainy season was the one that recorded the lowest diversity with ^{1}D =5.3 and ^{2}D =2.6. The highest abundance was recorded in the dry season with 942 (79.1%) individuals, followed by winter rainy with 134 (11.3%) and the rainy season with 115 (9.7%) individuals (Table 2).

Fourteen species (42.4%) were recorded only in one season, of which twelve species (36.4%) were present in the dry season. *Neapion* sp2 and *Trichapion* sp3 (6.1%) were only present in the winter rainy season. Eight species were present in two seasons (24.2%), and 11 (33.3%) species did not show a marked seasonality, being present in all three recorded seasons (Table 2).

Table 2. Seasonality and diversity (^{0}D, ^{1}D and ^{2}D) of Apioninae by season (dry, rainy and winter rainy) in the SM in Tabasco, Mexico.

Species	Seasons		
	Dry	**Rains**	**Winter rainy**
Alocentron sp1	1	0	0
Alocentron sp2	1	0	0
Alocentron sp3	2	0	0
Apion panamense	1	2	0
Apion sp1	3	0	0
Apionion sp1	13	1	1
Apionion sp2	260	11	8
Chrysapion chrysocomum	10	0	6
Coelocephalapion acentor	26	4	0
Coelocephalapion iteratum	1	2	1
Coelocephalapion sp1	2	0	0
Coelocephalapion sp2	18	0	0
Coelocephalapion sp3	234	3	19
Coelocephalapion sp4	227	4	16
Coelocephalapion sp5	1	0	0
Coelocephalapion sp6	1	1	0
Coelocephalapion sp7	1	6	0
Heterapion sp1	7	2	1
Kissingeria sp1	4	2	0
Neapion cretaceicolle	5	0	0
Neapion sp1	2	0	0
Neapion sp2	0	0	1
Trichapion sp1	7	0	0
Trichapion sp2	12	0	1
Trichapion sp3	0	0	1
Trichapion sp4	63	69	62

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Trichapion sp5	2	1	0
Trichapion sp6	15	3	7
Trichapion sp7	7	1	2
Trichapion sp8	13	2	6
Trichapion sp9	1	0	0
Trichapion sp10	1	1	2
Trichapion sp11	1	0	0
^{0}D	**31**	**17**	**15**
^{1}D	**7.3**	**5.3**	**6.3**
^{2}D	**4.9**	**2.6**	**3.9**
Abundance	**942**	**115**	**134**

The fluctuation of the richness and abundance of these beetles showed its maximum peak in April with 23 (69.7%) species and 545 (45.8%) individuals. April is the month with the lowest rainfall (31.5 mm) in the annual cycle. The lowest richness was recorded in the month of August with three species (9.1%), a month that documented high precipitation (291.3 mm), and the lowest abundance was recorded in the month of January with ten (0.8%) individuals, January recorded an average precipitation with 112.1 mm (Fig. 2).

The highest richness (^{0}D) of Apioninae was documented in S7 (20 species), followed by S11 and S12, both with 17 species. The highest abundance was recorded in S12 with 363 organisms, followed by S7 (159) and S8 (123). The highest diversity (^{1}D and ^{2}D) was obtained in S11 (^{1}D =10.4, ^{2}D =7.5), followed by S8 (^{1}D =8.3, ^{2}D =6.4). S4 with two species, three organisms was the site that recorded the lowest richness and abundance and documented the lowest diversity with ^{1}D =1.9 and ^{2}D =1.8 (Table 3). According to the sampling coverage, sites S1, S2, S3, S6, S7, S8, S9, S10, and S12 documented more than 90% of the apionine richness, and sites S4, S5, and S11 recorded more than 80% of the richness, which shows a good sampling effort (Table 3).

Pearson's correlation coefficient with probability (p >0.05) showed that richness had no statistically significant relationship with precipitation (r =-0.129), temperature (r =0.2294) and humidity (r =-0.0169); similarly, abundance of apionines was not related to the variables of precipitation (r =-0.2006), temperature (r =0.2539) and humidity (r =-0.235).

The estimated richness values for Chao 1 (37 species) and Jacknife 1 (41 species) were higher than the 33 species observed, suggesting or recommending an increase in sampling effort (time) to record most of the species of these beetles living in the rainforest.

Figure 2. Fluctuation of the richness and abundance of Apioninae with respect to precipitation (mm) in the SM, in Tabasco, Mexico.

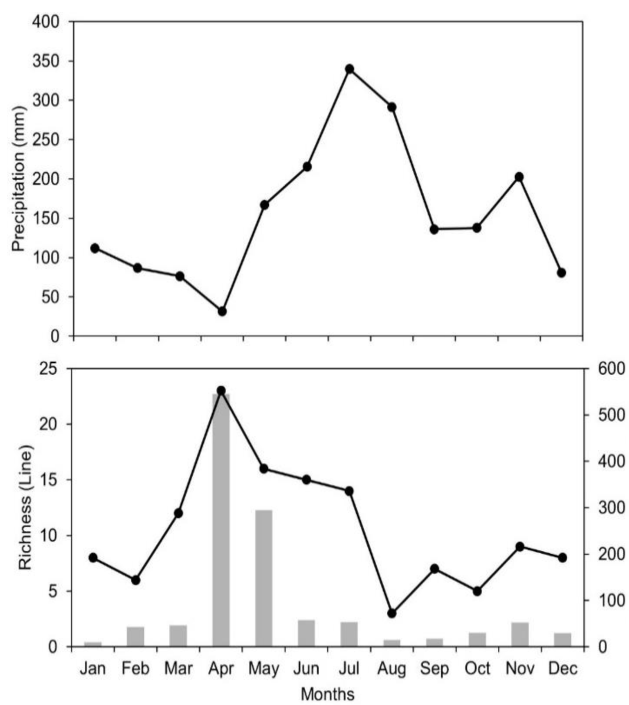

Table 3. Richness (^{0}D), abundance, diversity (^{1}D and ^{2}D), and sampling coverage of Apioninae by site, and exposure (sun, and shade) in the SM in Tabasco, Mexico.

	SUN							SHADE						
Sites	**S2**	**S4**	**S5**	**S6**	**S9**	**S10**	**TOTAL**	**S1**	**S3**	**S7**	**S8**	**S11**	**S12**	**TOTAL**
Richness (^{0}D)	13	2	12	9	9	12	22	10	11	20	16	17	17	32
^{1}D	5.6	1.9	4.9	4.2	5.0	6.6	6.2	4.8	4.6	6.5	8.3	10.4	4.9	8.3
^{2}D	3.7	1.8	3.2	3.3	3.8	4.7	3.9	3.4	2.7	4.1	6.4	7.5	2.9	5.6
Abundance	72	3	46	99	50	60	330	82	67	159	123	67	363	861
SC	0.90	0.83	0.81	0.96	0.92	0.90		0.96	0.94	0.94	0.94	0.87	0.99	

Discussion

Studies on the diversity and seasonality of the Apioninae are scarce, and in general, the group has not been adequately studied in Mexico. It is believed that many apionines remain undescribed. In the present study, it represents the first systematic contribution of Apioninae in a tropical rainforest in the state of Tabasco. We report 33 apionine species for the SM, representing 96.9% of the fauna for Tabasco, in accordance with that reported by (Alonso-Zarazaga, 2004; Jones *et al*., 2012), 19% for Mexico (Alonso-Zarazaga, 2004), and 0.05% for the world (Oberprieler et al., 2007). Of the 33 species, only 15% were determined to species level, and 85% at the genus or morphospecies level, due to the limited information, ecological and biological studies, in addition to the absence of taxonomic keys, or represent undescribed taxa.

Comparing our richness with other faunal studies of Apioninae in Mexico, we observed that the richness of apionines in the SM is low compared to that recorded in the northeast of the country in the state of Tamaulipas with 51 species (Jones et al., 2012), to that documented in the Sierra de Huautla, in the state of Morelos with 89 morphospecies (Castro-Martínez, 2019), and comparable to the 29 species reported for the state of Queretaro (Jones and Luna-Cozar, 2007). The species *N. cretaceicolle* and *Chrysapion chrysocomun* occur in both the SM and El Cielo Biosphere Reserve, and *C. chrysocomun* occurs in the SM and Sierra de Huautla (Castro-Martínez, 2019). These species represent 6.1% of the total fauna for the SM and have a very wide distribution according to the literature. *Neapion cretaceicolle* is distributed in Mexico in the states of Tamaulipas and Guatemala. *C. chrysocomun* is distributed in Mexico in the states of Chiapas, Morelos, San Luis Potosí, Tabasco, and Veracruz, with additional records in Guatemala, Honduras, El Salvador, and Panama (Alonso-Zarazaga, 2004; Castro-Martínez, 2019; Jones *et al*., 2012). *Trichapion* and *Coelocephalapion* were the most species-rich genera for the SM. According to Jones et al. (2012) and Castro-Martínez (2019), these genera are the ones that register the highest richness and distribution for the country, as they have a Nearctic or Neotropical affinity (Alonso-Zarazaga and Lyal, 1999). Therefore, their presence in SM and in studies conducted in other regions could be due to their generalist habits, as they can exploit different types of vegetation and food resources.

The 33% proportion of species considered rare in the Apioninae community in this study can be considered as a common pattern in studies of tropical arthropods (Coddington *et al*., 2009; Lucky et al., 2002; Novotný and Basset, 2000) and may be related to ecological processes regulating populations, communities and biological traits of species. Similarly, it could be due to undersampling, diffuse rarity, body size, resource availability and emergence outside their typical period of activity, or that the sampling dates did not coincide with the actual population peaks of these species (Coddington *et al*., 2009;

Reyes-González *et al*., 2021; 2024). In addition, since these species have not been completely identified, information is limited or non-existent, complicating more specific inferences.

Most of the species were present during the dry season in April and May, coinciding with what was reported in the study by Jones et al. (2012). In this season, low rainfall and high temperature were documented, which may coincide with the greater availability of resources, since the dry season includes the spring, and this is the season that records the highest flowering and seed production in plants, resulting in food resources for apionines. Similarly, in this season, apionines can be found in their adult stage, on various plants that are not considered reproductive hosts, and consequently occupy all available habitats in ecosystems (Alonso-Zarazaga, 2004; Jones *et al*., 2012). The dry season provides an ideal temperature or climate for dispersal and establishment in the middle (shrubs and low branches) and low (herbs) strata, which could cause the greatest presence of these beetles and the greatest record or collection in the SM.

The rainy and winter rainy seasons were the ones with the lowest richness. These stations registered climatic factors such as abundant rain, low temperature and high wind intensity; these environmental variables are very important because they limit the distribution of organisms in natural ecosystems (Janzen, 1987).

In addition to the above, there are other biological factors that influence the presence or absence of many beetles during the climatic seasons. First, due to environmental conditions, many Apioninae are in a larval stage during the humid and rainy seasons, and therefore the record of adults was less. With the onset of rains, the production of shoots, leaves and branches of plants increases, which represents a greater availability of food for the developing immatures (Alonso-Zarazaga, 2004; Jones *et al*., 2012; Novotný and Basset, 1998; Herzog-Viana and Ribeiro-Costa, 2013; Wolda, 1978). The literature mentions that some species of Apioninae use and form galls on branches at the beginning of the rainy season (Vergara-Pineda *et al*., 2015). Similarly, the increase in foliage during the rainy and winter rainy seasons provides greater refuge and shelter for apionines, reducing the likelihood of collecting individuals by beating the vegetation.

The differences recorded in the presence of apionines by sites with sun or shade exposure may be due to site conservation, fragmentation, food availability, microclimatic conditions and land use, as well as the increase in cultivated land (Hallmann *et al*., 2017; Rainio and Niemelä, 2003; Sánchez-Bayo and Wyckhuys, 2019). The sites presented different characteristics, the shaded sites had the highest density of plants, and species characteristic of the rainforest, such as, trees over 30 meters high, palms, ferns and few grasses. In contrast, the sites exposed to the sun had more fragmented vegetation, consequently the lower stratum had more grasses, and these sites are used for crops or monocultures, in addition, in these sites the use of herbicides is not controlled.

The richness estimates suggest that more collection effort is needed to document the true richness of Apioninae in the SM. Furthermore, because Apioninae have very diverse host plants and can be found not only on leaves, branches, flowers and seeds, but also in leaf litter and plant fruits, it is necessary to use not only vegetation beating, but also different collection methods to complete the sampling and allow a better representation of these beetles in the ecosystems. For example, leaf litter collection (Jones and Luna-Cozar, 2007), seed collection (De la Cruz-Pérez *et al*., 2013), gilled branch collection (Jones and Luna-Cozar, 2007; Vergara-Pineda *et al*., 2015), and direct collection on flowers and fruits (Arcaya *et al*., 2020).

This study provides new biological and ecological information on the subfamily Apioninae, a poorly studied group of weevils. However, further studies on this group of insects are needed to determine geographic distribution, associations, and to clarify important aspects of ecology, systematics, and control. Furthermore, the results of this research provide additional evidence that the SM is a species-rich ecosystem, important in the structure of biological cycles, and provide information that can support the conservation and protection of this important ecosystem.

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