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Original article

Structural subniche of *Parachondria neglectus* (Littorinimorpha: Annulariidae) in Manzanillo, Cuba

Subnicho estructural de *Parachondria neglectus* (Littorinimorpha: Annulariidae) en Manzanillo, Cuba

Subniche estrutural de *Parachondria neglectus* (Littorinimorpha: Annulariidae) em Manzanillo, Cuba

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ABSTRACT

Parachondria neglectus is a terrestrial mollusk endemic of Cuba. This species constitutes the only report of the Annulariidae family in the municipality of Manzanillo, Granma province. In the present study, the temporal dynamics of the structural subniche of a population of *P. neglectus* was characterized. Thirty expeditions were carried out between December 2013 and February 2015. 83.9 % of the mollusks were found on the ground (around the base of trees and shrubs) and 16.1 % used the trunk of eight plant species as diurnal resting substrate. The test of independence performed using a 2×2 contingency table with Yates correction showed that in the population the frequency of using one substrate or another depends on the occurrence or not of rainfall ($\div^2$ = 214.88; P = 0.0001). This species was found at an average trunk distance of 13 ± 6.42 cm. The C-index values indicated marked preference of this mollusk for *Swietenia mahagoni* during all climatic periods sampled. During the rainy season this species also showed statistically significant preferences for *Cordia gerascanthus*, *Ehretia tinifolia* and *Bursera simaruba*. For the population, the height above the ground presented a mean value of 153.5 ± 71.3 cm. The heights above the ground reached by this species on rainy and non-rainy days showed statistically significant differences (U = 21519.5; P < 0.001).

Keywords: Land snails; Ecological niche; *Parachondria neglectus*; Plant-animal relationship.

RESUMEN

Parachondria neglectus es un molusco terrestre endémico de Cuba. Esta especie constituye el único reporte de la familia Annulariidae para el municipio Manzanillo, en la provincia de Granma. El presente estudio se caracterizó la dinámica temporal del subnicho estructural de una población de *P. neglectus*. Se realizaron 30 expediciones entre diciembre de 2013 y febrero de 2015. El 83,9 % de los moluscos se encontraron en el suelo (alrededor de la base de árboles y arbustos) y el 16,1 % empleó el tronco de ocho especies de plantas como sustrato de reposo diurno. La prueba de independencia realizada mediante una tabla de contingencia 2×2 con corrección de Yates demostró que en la población la frecuencia de utilización de un sustrato u otro depende de la ocurrencia o no de las precipitaciones ($\div^2$ = 214,88; P = 0,0001). Esta especie fue encontrada a una distancia al tronco promedio de 13 ± 6,42 cm. Los valores del índice C indicaron preferencia marcada de este molusco por *Swietenia mahagoni* durante todos los períodos climáticos muestreados. Durante el período lluvioso esta especie también mostró preferencias estadísticamente significativas por *Cordia gerascanthus*, *Ehretia tinifolia* y *Bursera simaruba*. Para la población, la altura sobre el suelo presentó un valor medio de 153,5 ± 71,3 cm. Las alturas sobre el suelo alcanzadas por esta especie en los días lluviosos y no lluviosos mostraron diferencias estadísticamente significativas (U = 21519,5; P < 0,001).

Palabras clave: Caracoles terrestres; Nicho ecológico; *Parachondria neglectus*; Relación planta-animal.

RESUMO

Parachondria negligiectus é um molusco terrestre endêmico para Cuba. Esta espécie é o único relatório da família Annulariidae do município de Manzanillo, província de Granma. Na presente investigação, foi caracterizada a dinâmica temporal do subniche estrutural de uma população de P. Neglectus. Trinta expedições foram realizadas entre dezembro de 2013 e fevereiro de 2015. 83,9% dos moluscos foram encontrados no solo (ao redor da base das árvores e arbustos) e 16,1% utilizaram o tronco de oito espécies vegetais como substrato de repouso diurno. O teste de independência usando uma tabela de contingência 2×2 com correção Yates mostrou que na população a freqüência de uso de um ou outro substrato depende da ocorrência ou não de chuva (÷2 = 214,88; P = 0,0001). Esta espécie foi encontrada a uma distância média de 13 ± 6,42 cm do tronco. Os valores do índice C indicavam uma marcada preferência deste molusco pelo mahagoni Swietenia mahagoni durante todos os períodos climáticos amostrados. Durante o período chuvoso, esta espécie também mostrou preferências estatisticamente significativas para Cordia gerascanthus, Ehretia tinifolia e Bursera simaruba. A altura média acima do solo para a população era de 153,5 ± 71,3 cm. As alturas acima do solo alcançadas por esta espécie em dias chuvosos e não chuvosos mostraram diferenças estatisticamente significativas (U = 21519,5; P < 0,001).

Palavras-chave: Caracóis terrestres; Nicho ecológico; Negligência de Parachondria; Relação planta-animal.

INTRODUCTION

The frequent speciation processes, which occur in most of the islands, are manifested in the high diversity of terrestrial mollusks of the Cuban archipelago, perhaps as in no other group of the Cuban fauna. Evidence of this are the 476 terrestrial species of *Neritimorpha* and *Caenogastropoda* described for Cuba, with an endemism of 99.1 % (Hernández *et al*., 2018).

Of the six families of Cuban terrestrial mollusks, currently arranged in *Neritimorpha* and *Caenogastropoda*, *Annulariidae* is the most extensive, with 352 species grouped in 37 genera (Hernández *et al*., 2018). According to the catalog of Espinosa and Ortea (1999) this family in Granma is represented by 19 species included in five genera (three endemic).

Inventories of Cuban terrestrial malacofauna currently available indicate that *Parachondria (Parachondria neglectus*) (Pfeiffer 1858) is presumably the only representative of this family in Manzanillo (Sariego 2010).

In this geographic area, excluding inland waters, the proportion covered by forest in relation to the total land area has been estimated at 27.1 % (ONEI 2018). Likewise, the extent of occurrence for this species does not exceed 1 091 km² (Sariego 2006). This confirms the importance of its ecological study for conservation purposes.

Terrestrial mollusks, due to the micro-localization and strict ecological requirements of many of their species, are ideal for biodiversity assessments and studies about the history of communities of organisms in space and time (Fontenla *et al*., 2013).

The ecological niche is a term widely used in ecological and evolutionary theory. It is a conception that attempts to represent the function of organisms in nature and their interactions with the environment (Fontenla 2001). Its study is of great importance to understand the interactions and competitive relationships of species. It also provides important elements for the management and conservation of fauna. According to Silva and Berovides (1982), the determination of the ecological niche should be the central unit of population studies, including terrestrial mollusks.

In order to plan restoration projects or to make conservation decisions, it is essential to have baseline information as well as reference data to develop statistically reliable temporal analyses and predictions. Long-term observations are necessary to answer theoretical questions in ecology, such as reducing uncertainties about the irreversibility of structural changes and ensuring the success of restoration and conservation programs (Díaz-Delgado, 2016).

For the above reasons, the present study characterized the temporal dynamics of the structural subniche of a population of *P. neglectus* in the municipality of Manzanillo, Granma province, Cuba.

MATERIALS AND METHODS

Study area

The municipality of Manzanillo located in the province of Granma has a surface area of 498.95 km^2 (ONEI, 2017) and is located in the Cauto-Guacanayabo plain. The city is bordered by limestone heights of up to 80 masl and the southern end of the municipal territory goes into the foothills of the Sierra Maestra (Sariego 2010). The locality studied is located between 20°20'29.77''N -77°05'00.37''W, belongs to the Blanquizal village and has an approximate area of 20 500 m^2. Its floristic characterization was carried out in the herbarium of the Eastern Center of Ecosystems and Biodiversity (BIOECO) and it is part of the results of this study. The criteria of Greuter and Rankin (2016) were used for the order and nomenclature of the species and botanical families.

Structural subniche of *P. neglectus*

The terminology used for the study of the structural subniche is that suggested by Silva and Berovides (1982), taking into account the subdivisions proposed by Berovides *et al*. (1988). The presence of the retracted peristome allowed the identification of adults. To characterize the temporal dynamics of the structural sub-niche of the *P. neglectus* population, two monthly samplings were carried out (in 3 x 3 m plots) during the period from December 2013 to February 2015.

Daytime resting substrates

The specimens observed on the ground and on the trunks of trees and shrubs in the locality were quantified to determine the preferential substrate of the population, as well as their monthly frequency of use.

Distance from the trunks

In all specimens that used soil as substrate, the distance from the trunk, which was measured from the region of the shell closest to the base of the tree, was determined in (cm) with a three-meter professional Thorsen flexometer.

Height above ground and strata

In the mollusks that were observed on the trunk of trees and shrubs, the height above the ground was measured in centimeters as well. The individual data of heights above ground were grouped into the following classes or strata: I- (0.1 to 50 cm), II- (50.1 to 100 cm), III- (100.1 to 150 cm), IV- (150.1 to 200 cm), V- (200.1 to 250 cm), VI- (250.1 to 300 cm), VII- (300.1 to 350 cm) and VIII- (350.1 to 400 cm).

Plant-animal relationship

The study was carried out through direct observation of the individuals and the species of plant that served as substrate. Paths were taken to determine the plants used by *P. neglectus*. The methodology used by Reyes-Tur (2004) was followed in order to study the seasonal dynamics of the availability and use of plant species. During each sampling, 50 points were randomly selected throughout the work area. At each point, a 3 m long and 5 cm wide bar was placed and the contacts of the bar with the different plant species, available used as resting substrate, were noted. In addition, to determine the number of times each plant was used, observations, made within the work area but outside the selected points, were considered. From the data collected, the C index (Pearre 1982) was calculated for the plant species used as substrate by *P. neglectus*. This index was calculated according to the formula (Equation 1).

$$C = \pm\left[\frac{\left(|A_d B_m - B_d A_m| - n/2\right)^2}{ABDM}\right]^{\frac{1}{2}} \quad (1)$$

Where A_d is the number of individuals of species A used as resting substrate; A_m is the number of individuals of species A available; B_d is the number of individuals of the rest of the species used as resting substrate; B_m is the number of individuals of the rest of the species available; A equals $A_d + A_m$; B equals $B_d + B_m$; D equals $A_d + B_d$; M equals $A_m + B_m$ and n equals $A_d + B_d + A_m + B_m$.

The C index, based on $\div^2$ allows the significance of the degree of preference or rejection to be established for any sample size. Its value ranges from -1 to +1, positive values indicate preference, negative values indicate rejection, and C = 0 indicates random use. The significance criterion for this test was $P < 0.05$. Tabulated values of $\div^2$ were used with one degree of freedom as suggested by Pearre (1982).

The values of this index were determined taking into account rainy and low rainfall seasons. To establish both periods, the monthly average values of millimeters of rainfall reported by the Manzanillo Meteorological Station and published by ONEI (2017) were analyzed. The study covered the following periods: low rainfall period (December 2013 to April 2014), rainy period (May to October 2014), low rainfall period (November 2014 to February 2015).

All statistical calculations were performed with the STATISTICA 13.0 program (Statsoft 2015). Through the calculation of the mean, standard deviation and coefficient of variation, the distances to the trunk and the heights above the ground of the mollusks were statistically characterized. A test of independence was carried out with a 2 x 2 contingency table with Yates correction to determine whether the frequency of use of one substrate or another depends on the occurrence or not of rainfall in the population studied. The Kolmogorov-Smirnov test was used to analyze the distributions by substrate in both juvenile and adult individuals. The Mann-Whitney U test allowed to compare the distances from the trunk between juvenile and adult individuals, as well as the distances from the trunk and the heights above the ground reached by this species in the rainy and low rainfall periods on a monthly basis.

RESULTS AND DISCUSSION

Daytime resting substrates

In general, 83.9 % of the individuals were detected on the ground, around the base of trees and shrubs, the rest used trunks as a diurnal resting substrate. The monthly frequency of this species on both substrates is shown in Figure 1. Although ground use was higher, the highest proportion of individuals on this substrate was recorded in October 2014 (Figure 1).

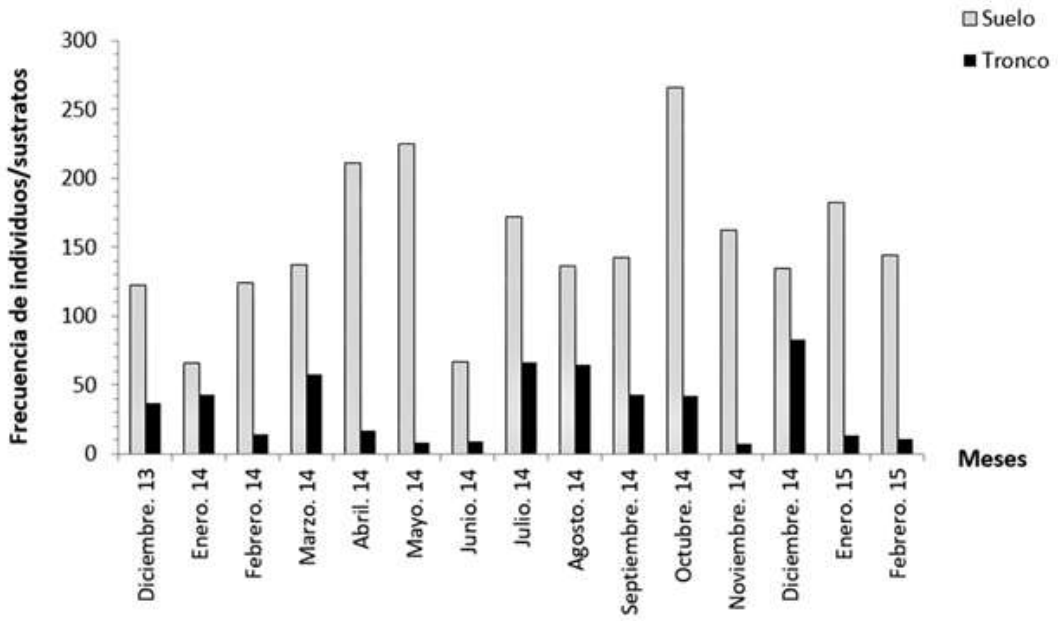

Figure 1. - Monthly frequency by substrate of individuals of the studied population of *P. neglectus* in Manzanillo

The Kolmogorov-Smirnov test indicated the existence of significant statistical differences between the distributions of juveniles on soil and trunk (DN = 0.87; P = 0.0003). In adults, there were also significant statistical differences during the analysis of substrate distributions (DN = 0.82; P = 0.0001). However, no statistical differences were found

related to soil usage by juveniles and adults (DN = 0.45; P = 0.18). There were also no significant statistical differences in trunk utilization by both age groups (DN = 0.37; P = 0.24).

The test of independence performed by means of a 2×2 contingency table with Yates correction showed that in the population the frequency of substrate usage depends on the occurrence or not of rainfall ($\div^2$ = 214.88; P = 0.0001).

During the field work, mollusks of *Parachondria neglectus* were never observed on the stones, as found by Gundlach in this same municipality, according to Arango (1878) referring to the synonym *Chondropoma revinctum* (Poey *in* Pfeiffer 1858). The genus *Chondropoma* was already reported by Mesa (1986) within the classification of arboreal mollusks of Cuba. In the book of terrestrial mollusks of Cuba by Espinosa and Ortea (2009), subsequent to the most updated revision of terrestrial mollusks of this family in the Caribbean (Watters, 2006), this species is mentioned under the name *Chondropoma neglectum* (Gundlach *in* Pfeiffer 1856).

Nevertheless, these authors report that many species of terrestrial mollusks are capable of adapting to the temporary occupation of space according to the vital needs of their biological cycle, the earth, stones and vegetation can be part of their life cycle.

Soil substrate

Distance from the trunk

The mean distance to the trunk was 13 ± 6.42 cm. 22.7 % of the mollusks were observed around and at the base of trees and shrubs. Temporal variation in distances to the trunk of juveniles and adults (Table 1).

Table 1. - Temporal variation of distances to the trunk (cm) of juvenile and adult individuals of the studied population of *P. neglectus* in Manzanillo

Months	Distance to trunk (cm)		
	Youth $\bar{X}$ ± SD	Adults X $\bar{X}$ ± SD	U test (P)
Diciembre de 2013	11,27 ± 6,66	11,14 ± 5,60	921,5 (0,52)
Enero de 2014	10,90 ± 5,64	12,70 ± 6,10	395,0 (0,85)
Febrero de 2014	14,72 ± 8,18	11,63 ± 5,99	1027,5 (0,13)
Marzo de 2014	12,08 ± 6,24	8,53 ± 4,72	246,0 (0,29)
Abril de 2014	7,41 ± 3,89	8,03 ± 4,18	3792,5 (0,67)
Mayo de 2014	8,39 ± 4,03	5,60 ± 2,57	3903,0 (0,11)
Junio de 2014	18,83 ± 9,29	13,04 ± 6,82	180,5 (0,27)
Julio de 2014	18,28 ± 8,86	16,79 ± 9,85	1465,5 (0,52)
Agosto de 2014	13,47 ± 6,83	14,12 ± 8,66	1013,5 (0,98)
Septiembre de 2014	12,38 ± 7,35	16,12 ± 8,69	932,5 (0,04) *
Octubre de 2014	10,43 ± 5,16	14,89 ± 7,91	11402,5 (0,0005) *
Noviembre de 2014	14,46 ± 6,18	14,86 ± 6,99	2717,5 (0,75)
Diciembre de 2014	18,02 ± 8,81	16,39 ± 7,88	2188,0 (0,36)
Enero de 2015	20,36 ± 10,60	19,58 ± 10,24	2843,0 (0,74)

Febrero de 2015	14,35 ± 6,61	13,04 ± 6,43	1888,5 (0,51)

X: **-** Mean, **DS -** standard deviation. **U test:** Mann-Whitney U test with associated probability, * significant differences at 5 %

Only in the months of September and October 2014 the distances to the trunk between the two age groups were statistically different. The results of the Mann-Whitney U Test indicated that, in the rainy and low rainfall periods, the distances from the trunk for the population were not statistically significant (U = 472; P = 0.11).

According to Sariego *et al*. (2018) for this species the trunk of shrubs and trees is the preferential substrate for reproduction. These authors indicated that in the months of September and October occurred the recruitment period in the population. From the above, it is possible to infer that the significant statistical differences between the distances to the trunk of juveniles and adults. These two months could indicate that egg hatching occurs more successfully in favorable conditions at the base of trees and shrubs.

Substrate trunk

Height above ground and strata

The height above the ground showed a mean value of 153.5 ± 71.3 cm and a maximum of 394 cm. During rainy days, the frequency of *P. neglectus* mollusks on the trunk increased. A greater number of active individuals was also observed on this substrate (Figure 2).

Figure 2. - Illustrative image of the external morphology of *P. neglectus* during diurnal activity on the trunk of *Swietenia mahagoni* favored by rainfall at the locality

Juveniles showed a preference for the lowest stratum (55.6 %) and occupied five of the eight established strata. Twenty-five percent of the adults were concentrated in stratum IV. In general, adults were distributed on the trunk occupying all strata (Figure 3). The heights above the ground reached by this species on rainy and non-rainy days showed statistically significant differences (U = 21519.5; P < 0.001) (Figure 3).

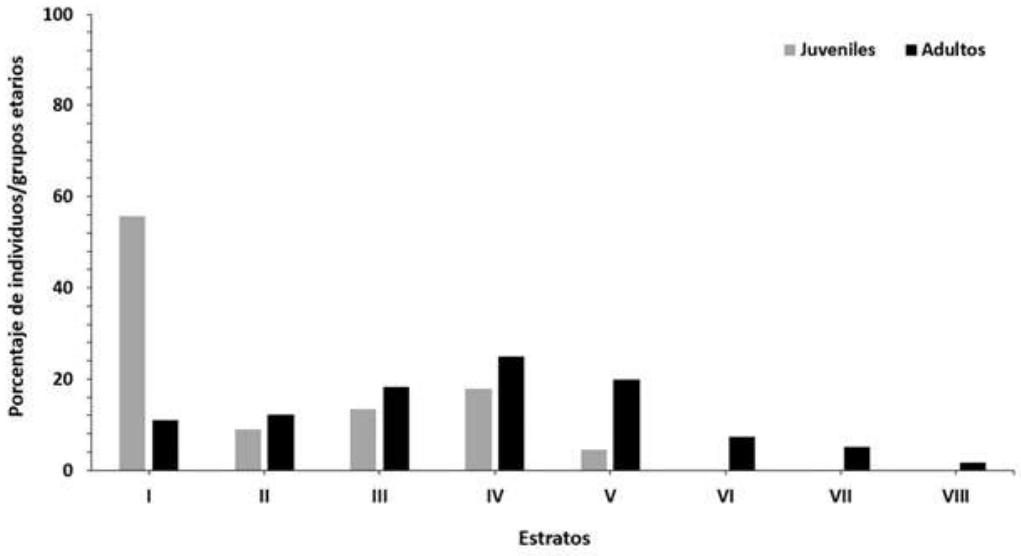

Figure 3. - Percentage of juvenile and adult individuals by strata in the trunk of trees and shrubs used by *P. neglectus* in the studied locality

During diurnal rest, individuals were observed attached to the trunk by a short band of dry mucus (no longer than two millimeters) with visible longitudinal folds extending from the substrate along the inner surface of the shell to the operculum. According to Watters (2014), the propensity of mollusks of this family to suspend themselves from mucous threads has been reported for species from Jamaica, Haiti, Dominican Republic, the Netherlands Antilles and Cuba. The author also suggested that this behavior could indicate a very ancient trait of an antipredator strategy or a strategy to dissipate heat.

From the energetic point of view, the locomotion of mollusks is slow and complex due to the secretion of mucus. Taking this criterion into account, it is logical to interpret that in favorable conditions of temperature and humidity, their activity and ascent up the trunk increases. It has also been reported that in some species of terrestrial mollusks, the daily and annual activity cycles are synchronized and interact with various environmental factors (Reyes-Tur *et al*., 2018).

The climatic periods studied and established according to reports by ONEI (2017) for Manzanillo coincided with the two well-defined seasonal periods throughout the Cuban territory. A rainy one that runs from May to October and a low rainfall one that extends from November to April (Durán 2016).

Plant-animal relationship

The floristic inventory of the studied locality allowed the identification of 35 species (19 families) of higher plants (16 herbaceous, 5 lianas, 1 epiphyte, 8 shrubs and 5 trees). However, *P. neglectus* was observed on 8 plant species (5 trees and 3 shrubs) as a diurnal resting substrate.

The C index values showed significant preference for *Swietenia mahagoni* during all the climatic periods sampled. For *Cordia gerascanthus*, *Ehretia tinifolia* and *Bursera simaruba* there were statistically significant preferences in the rainy period. In the low rainfall period for these three species, as well as for *Gastrococos crispa*, *Bourreria virgata*, *B. taylorii* and *Pisonia aculeata* (in all climatic periods) the values of the C index were not significant (C, P > 0.05) (Table 2).

Terrestrial gastropods have numerous plant species in their environment, of which they can use the trunk as a resting and/or feeding substrate, which is why they are usually considered generalist herbivores (Reyes-Tur 2004).

Regardless of this generalist behavior in relation to the use of plants as resting substrates, there are species capable of developing life strategies in terms of plant preference and rejection. The characteristics of these strategies are mainly related to the availability of plant species and their physical features (morpho-anatomical) (Reyes-Tur 2004).

In the locality studied, *P. negletus* showed a preference for three tree species and one large shrub. However, the preference found for large plants cannot be considered a peculiarity of the species. It has been observed in other localities in Manzanillo associated with erect poaceae, as well as the following plant species: *Amphilophium gnaphalanthum* (liana), *Turbina corymbosa* (climber), *Leucaena leucocephala* (shrub), *Sideroxylon foetidissimum* (tree) and *Cocos nucifera* (tree) (Sariego 2010) (Table 2).

Table 2. - Floristic list of families and species with the values of the C index (Pearre 1982) for plant taxa used by *P. neglectus* in the studied locality

Family/species	Biological type	INDEX C		
		Low rainfall period (61 mm)1 Dec/2013-April/2014	**Rainy period (115 mm)[1]** May-Oct/2014	**Low rainfall period (26 mm)[1]** Nov/2014-Feb/2015
Acanthaceae				
***Ruellia blechum* L.**	Hierba			
Amaranthaceae				
***Achyranthes aspera* L.**	Hierba			
***Amaranthus spinosus* L.**	Hierba			
Apocynaceae				
***Echitesum bellatus* Jacq.**	Liana			
***Rauvolfia tetraphylla* L.**	Arbusto			
Arecaceae				

***Gastrococos crispa* (Kunth) H. E. Moore**	Árbol	0,01 NS	0,04 NS	0,03 NS
Asteraceae				
***Bidens pilosus* L.**	Hierba			
Bignoniaceae				
***Amphilophium gnaphalanthum* (A. Rich.) L. G. Lohmann**	Liana			
Boraginaceae				
***Bourreria virgata* (Sw.) G. Don**	Arbusto	0,03 NS	0,09 NS	0,05 NS
***Bourreria taylorii* Britton**	Arbusto	0,04 NS	0,06 NS	0,02 NS
***Cordia gerascanthus* L.**	Árbol	0,11 NS	0,14*	0,08 NS
***Ehretia tinifolia* L.**	Árbol	0,10 NS	0,17*	0,07 NS
Bromeliaceae				
***Tillandsia recurvata* (L.) L.**	Epífita			
Burseraceae				
***Bursera simaruba* (L.) Sarg.**	Árbol	0,07 NS	0,16*	0,03 NS
Euphorbiaceae				
***Acalypha alopecuroides* Jacq.**	Hierba			
***Acalypha havanensis* Müll. Arg.**	Hierba			
***Euphorbia cyathophora* Murray**	Arbusto			
***Jatropha gossypiifolia* L.**	Hierba			
***Platygyna hexandra* (Jacq.) Müll. Arg.**	Hierba			
Fabaceae				
***Aeschynomene americana* L.**	Hierba			
***Centrosema virginianum* (L.) Benth.**	Liana			
***Vachellia farnesiana* (L.) Wight &Arn.**	Arbusto			
***Desmanthus virgatus* (L.) Willd.**	Hierba			
Malpighiaceae				
***Malpighia suberosa* Small**	Arbusto			
***Stigmaphyllon sagranum* A. Juss.**	Liana			
Sparmanniaceae				
***Corchorus siliquosus* L.**	Arbusto			
Malvaceae				
***Sida ulmifolia* Mill.**	Hierba			
Meliaceae				
***Swietenia mahagoni* (L.) Jacq.**	Árbol	0,19*	0,39*	0,14*
Nyctaginaceae				
***Pisonia aculeata* L.**	Arbusto	0,03 NS	0,07 NS	0,04 NS
Passifloraceae				
***Passiflora suberosa* L.**	Liana			
Poaceae				
***Axonopus compressus* (Sw.) P. Beauv.**	Hierba			
***Bothriochloa pertusa* (L.) A. Camus**	Hierba			
***Cynodon dactylon* (L.) Pers.**	Hierba			
***Paspalum fimbriatum* Kunth**	Hierba			
Rubiaceae				
***Spermacoce laevis* Lam.**	Hierba			

NS: no statistical significance; *****: P < 0.05;**[1]**: Monthly average of accumulated mm of rainfall in Manzanillo in the studied climatic periods obtained from ONEI (2017).

CONCLUSIONS

According to the observations made on the use of substrates in the locality studied in the municipality of Manzanillo, Granma, it is possible to infer that *P. neglectus* is a terrestrial mollusk associated with vegetation.

In the studied population of *P. neglectus,* the frequency of utilization of one substrate or another depended on the occurrence or not of rainfall; under favorable conditions of temperature and humidity these mollusks increased their activity and ascent up to the trunk.

The C index values showed significant preference of *P. neglectus* for *Swietenia mahagoni* (mahogany) during all climatic periods sampled. For *Cordia gerascanthus*, *Ehretia tinifolia* and *Bursera simaruba* there were statistically significant preferences in the rainy period.

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