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## ORIGINAL ARTICLE /ARTÍCULO ORIGINAL

# ENVIRONMENTAL INFLUENCE ON THE ABUNDANCE OF TWO POPULATIONS OF *PHYSELLA ACUTA* (PULMONATA: PHYSIDAE) FROM CAMAGÜEY (CUBA)

# INFLUENCIA AMBIENTAL EN LA ABUNDANCIA DE DOS POBLACIONES DE *PHYSELLA ACUTA* (PULMONATA: PHYSIDAE) DE CAMAGÜEY (CUBA)

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## ABSTRACT

*Physella acuta* Draparnaud is a species extremely abundant in places where they appear to carry out a certain controlling action on other undesirable species of mollusks. The influence of some abiotic factors on two populations of this species from Camagüey, Cuba was determined by a canonical correspondence analysis. The samples were taken once a month using a sieve, as well as, the strata of vegetation in a time unit (15 min) without repositioning the specimen. The mollusks were classified into 10 classes of shell height. In the Tínima River, only the larger-sized classes were influenced by weather conditions. In the Canal Palomino, the only classes that proved sensitive to climatic changes were the larger-size ones. The above consideration indicates that this widely distributed species perhaps by its capacity of tolerating of great variability of the chemical quality of water, successfully facing extreme values in the physical and chemical parameters. This situation undoubtedly has permitted this species to colonize with success very unstable habitats, similar to those analyzed in the present studies that were carried out in the eastern region of Cuba.

**Keywords:** Ecological studies - ecology - environmental factors - freshwater snail - Physidae - seasonal variation.

## RESUMEN

*Physella acuta* Draparnaud 1805 es una especie muy abundante en los lugares donde parece llevar a cabo una determinada acción de control sobre otras especies indeseables de moluscos. Se determinó mediante un análisis de correspondencia canónica la influencia de algunos factores abióticos en dos poblaciones de esta especie en Camagüey, Cuba. Las muestras se tomaron una vez al mes usando un tamiz para remover los estratos y la vegetación por unidad de esfuerzo (15 min) sin reposición. Los moluscos fueron clasificados en 10 clases de altura de la concha. En el río Tínima, las clases de mayor tamaño fueron influenciadas por las condiciones climáticas, no así las clases medianas; pero en El Canal  Palomino, las únicas clases que resultaron sensibles a los cambios climáticos fueron las de mayor tamaño. La consideración anterior indica que esta especie con una amplia distribución tal vez por su capacidad de tolerar de gran variabilidad de la calidad química del agua, enfrenta con éxito valores extremos en los parámetros físicos y químicos, esta situación, sin duda, ha permitido a esta especie colonizar con éxito hábitats muy inestables, similares a los analizados en el presente estudio llevado a cabo en la región oriental de Cuba.


**Palabras clave**: caracoles de agua dulce - ecología - estudios ecológicos - factores ambientales - Physidae - variación estacional.

## INTRODUCTION

The family Physidae is very controversial in reference to the species that compose it (Yong *et al*., 1994; Iannacone & Caballero, 2002; Ibáñez & Alonso, 2003) and for this reason; it has received some attention in Cuba.

Moreover, the bladder snail *Physella acuta* Draparnaud 1805 (synonymy of *P. cubensis*) is wrongly considered the *Fasciola hepatica* (Linnaeus, 1758) a snail host, as laboratory investigations have demonstrated that this is not possible (Morales *et al*., 1987). This species is reported as the commonest freshwater mollusk in Cuba (Aguayo, 1938). Furthermore, it is present in Bahamas, Jamaica, Puerto Rico, West Indies, Honduras and the Florida peninsula, with worldwide distribution (Burch, 1989; Ibáñez & Alonso, 2003; Semenchenko *et al*., 2008; Banha *et al*., 2014).

*Physella acuta* is described as colonizing different habitats with a wide spectrum of organic matter (Ibáñez & Alonso, 2003). This species is extremely abundant in places where they appear to carry out a certain controlling action on other undesirable species of mollusks (Perera *et al*., 1995). *P. acuta* lives in all types of freshwater environments, especially in low current places, and can survive in polluted water (Ibáñez & Alonso, 2003). This makes it possible to carry out auto- and demo-ecological studies in natural conditions to enrich the knowledge existing on this species.

The aim of this paper is to show the environmental influence on the abundance of two populations of *P. acuta* (Pulmonata: Physidae) from Camagüey (Cuba) that could be used as biological control agent.

## MATERIAL AND METHODS

The studies were conducted in two habitats from the capital of Camagüey province (Fig. 1) from January 2014 to January 2015 (21°20'N; 78°00'W).

*Tínima River*: In the studied section, the water is very clear, the aquatic vegetation is mainly composed of *Eichornia crassipes* (Mart.) Solm., whose individuals cover 10% of the area. The stream speed was of 4 m·sec$^{-1}$. The deepest part has a depth of 2m.

*Canal Palomino*: With approximately 100m of length, its water is very turbid and receives the liquid waste from numerous neighboring houses. The stream speed is approximately 0.60 m·sec$^{-1}$ and the aquatic vegetation is represented by *Cyperus rotundus* L. and gramineous. The bottom is muddy. The deepest part has a depth of 30cm.

The samples were taken once a month using a sieve covering the bottom; as well as, the strata of vegetation in a time unit (15 min) during the morning and always by the same person without repositioning the specimen.

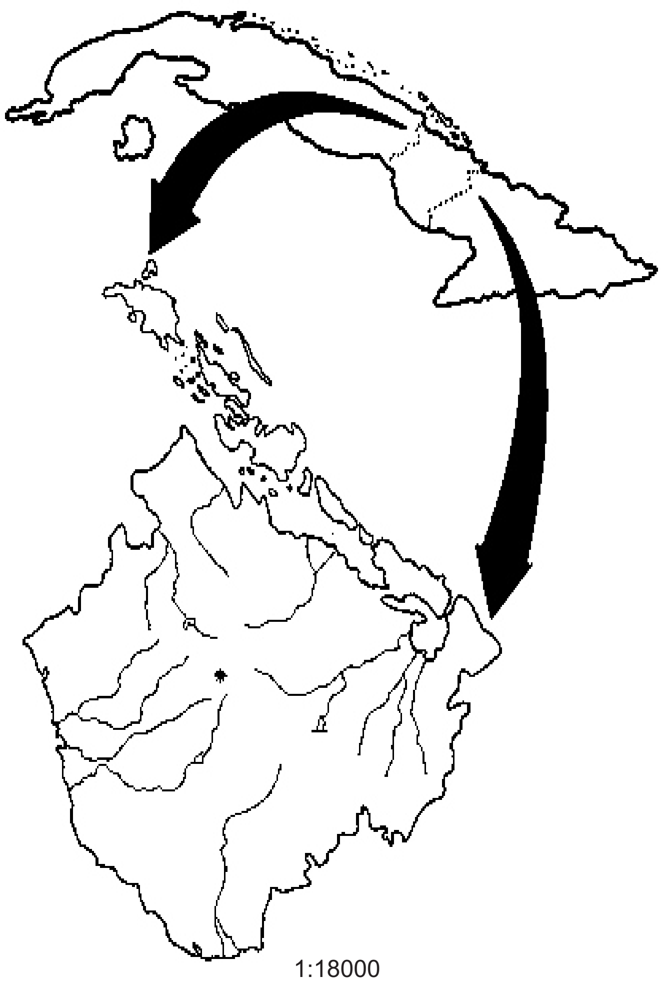


**Figure 1**. Map of Cuba showing the Camagüey province and its capital with the same name (*).

The following factors were measured: temperature (T) *in situ*, pH, calcium (Ca), chlorides (Cl), nitrates ($NO_3$), nitrites ($NO_2$), total hardness (HAR), magnesium (Mg) and dissolved oxygen ($O_2$) by spectrophotometer in the chemical laboratory from the Provincial Center of Hygiene and Epidemiology in Camagüey, Cuba.

The live mollusks were measured with a micrometer caliper with a 0.01 mm allowance to determine the maximum height of the shell. The mollusks were classified into 10 classes of shell height: class 1 (<3.9 mm), class 2 (4-4.9 mm), class 3 (5-5.9 mm), class 4 (6-6.9 mm), class 5 (7-7.9 mm), class 6 (8-8.9 mm), class 7 (9-9.9 mm), class 8 (10-10.9 mm), class 9 (11-11.9 mm) and class 10 (>12 mm) (Vasileva, 2011).

Specimens of *P. acuta* were identified according to Nuñez (2011). Voucher specimens have been deposited in the Malacological Collection of the "Provincial Unit of Surveillance and Antivectorial Fight" in Camagüey, Cuba.

The ordinating diagram of the canonical correspondence analysis was performed to show the relation between the abiotic influences on the monthly variation of the abundance of *P. acuta* in both habitats studied, considering that in Cuba there are two climatic seasons: the dry season (November-April) and the rainy season (May-October) (Samek & Travieso, 1968).

## RESULTS

The abundance of higher classes of *P. acuta*, as well as the abiotic factor values in the Tínima River and Canal Palomino, respectively is shown in the Table 1 and 2.

**Table 1.** Values of abundance of classes of shell height of *Physella acuta* and the abiotic factors measured in the Tínima River, during the period studied. The shell height: 1 (<3.9 mm), 2 (4-4.9 mm), 3 (5-5.9 mm), 4 (6-6.9 mm), 5 (7-7.9 mm), 6 (8-8.9 mm), 7 (9-9.9 mm), 8 (10-10.9 mm), 9 (11-11.9 mm) y 12 (>12 mm). Abiotics factors: T= temperature ($^0$C), pH= pH, Cl= chlorides (mg·L$^{-1}$), Ca= calcium (mg·L$^{-1}$), Mg= magnesium (mg·L$^{-1}$), $O_2$= dissolved oxygen (mg·L$^{-1}$), HAR= total hardness (mg·L$^{-1}$), $NO_3$= nitrate (mg·L$^{-1}$) y $NO_2$= nitrite (mg·L$^{-1}$). Months: JAN1=January 2014 and JAN2= January 2015.

| | Classes of shell height | | | | | | | | | | | Abiotics factors | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL | HAR | Cl | pH | T | $O_2$ | Ca | Mg | $NO_3$ | $NO_2$ |
| JAN1 | 0 | 6 | 6 | 10 | 19 | 17 | 9 | 6 | 1 | 4 | 78 | 356 | 6 | 0.12 | 19.4 | 7.2 | 0 | 42.1 | 90 | 30.3 |
| FEB | 1 | 1 | 1 | 2 | 0 | 3 | 4 | 5 | 6 | 17 | 40 | 261.5 | 3.7 | 0.08 | 21.1 | 7 | 0 | 49.4 | 52.5 | 43.2 |
| MAR | 26 | 13 | 17 | 13 | 14 | 19 | 21 | 18 | 2 | 2 | 145 | 450 | 2.8 | 0.02 | 21.1 | 6.9 | 0 | 72.3 | 95 | 51.7 |
| APR | 0 | 1 | 3 | 4 | 5 | 4 | 3 | 2 | 2 | 2 | 26 | 352 | 7.2 | 0.51 | 24 | 7.1 | 0 | 54 | 183 | 52.1 |
| MAY | 1 | 2 | 0 | 1 | 5 | 4 | 12 | 7 | 3 | 1 | 36 | 274 | 8.6 | 0.4 | 25.5 | 6.9 | 0.66 | 69.1 | 72 | 46.9 |
| JUN | 0 | 2 | 8 | 22 | 18 | 17 | 7 | 2 | 0 | 0 | 76 | 338 | 2.8 | 0.14 | 24.6 | 7.1 | 0.25 | 63.2 | 91 | 66.4 |
| JUL | 2 | 2 | 0 | 27 | 32 | 70 | 60 | 20 | 0 | 2 | 215 | 351 | 5.5 | 0 | 24.1 | 7 | 0 | 40.8 | 87.5 | 30.3 |
| AGO | 0 | 0 | 0 | 1 | 2 | 12 | 42 | 51 | 52 | 4 | 164 | 409 | 6.65 | 0.65 | 24.7 | 7.3 | 0.28 | 60.1 | 113 | 53.6 |
| SEP | 32 | 2 | 22 | 34 | 84 | 54 | 32 | 10 | 1 | 2 | 273 | 266 | 3.7 | 1.13 | 24.7 | 7.1 | 0 | 52.1 | 97.5 | 40.1 |
| OCT | 2 | 7 | 6 | 16 | 30 | 26 | 23 | 4 | 0 | 0 | 114 | 272 | 4.7 | 3.35 | 22.6 | 6.7 | 0 | 58.4 | 76 | 57.5 |
| NOV | 0 | 2 | 1 | 2 | 12 | 6 | 2 | 1 | 0 | 0 | 26 | 407 | 4.3 | 0.18 | 23.4 | 7.4 | 0 | 71.2 | 112 | 55 |
| DEC | 93 | 4 | 2 | 32 | 85 | 82 | 52 | 22 | 7 | 3 | 382 | 303 | 8.75 | 0.01 | 23,6 | 7.1 | 0.005 | 56.1 | 161.5 | 48.1 |
| JAN2 | 0 | 1 | 0 | 0 | 0 | 4 | 8 | 2 | 3 | 4 | 22 | 256 | 4,8 | 0.01 | 23.5 | 6.5 | 0 | 57.6 | 72 | 26.8 |

**Table 2.** Values of abundance of shell height classes of *Physella acuta* and the abiotic factors measured in the Canal Palomino, during the period studied. The shell height: 1 (<3.9 mm), 2 (4-4.9 mm), 3 (5-5.9 mm), 4 (6-6.9 mm), 5 (7-7.9 mm), 6 (8-8.9 mm), 7 (9-9.9 mm), 8 (10-10.9 mm), 9 (11-11.9 mm) y 12 (>12 mm). Abiotics factors: T= temperature ($^{0}$C), pH= pH, Cl= chlorides (mg·L-1), Ca= calcium (mg·L$^{-1}$), Mg= magnesium (mg·L$^{-1}$), $O_2$= dissolved oxygen (mg·L$^{-1}$), HAR= total hardness (mg·L$^{-1}$), $NO_3$= nitrate (mg·L$^{-1}$) y $NO_2$= nitrite (mg·L$^{-1}$). Months: JAN1=January 2014 and JAN2= January 2015.

| | Classes of shell height | | | | | | | | | | | Abiotics factors | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | TOTAL | HAR | Cl | pH | T | $O_2$ | Ca | Mg | $NO_3$ | $NO_2$ |
| JAN1 | 0 | 3 | 0 | 12 | 17 | 0 | 6 | 0 | 2 | 17 | 57 | 103 | 60 | 7 | 21 | 14,5 | 40.1 | 51.4 | 0 | 0 |
| FEB | 3 | 25 | 1 | 54 | 80 | 4 | 15 | 11 | 23 | 16 | 232 | 251 | 76.5 | 6.85 | 21.9 | 2.1 | 45.1 | 57.3 | 0,05 | 0 |
| MAR | 2 | 28 | 1 | 62 | 132 | 205 | 179 | 112 | 115 | 152 | 988 | 230 | 100 | 7 | 21.8 | 21 | 52.1 | 66.3 | 0.8 | 0 |
| APR | 1 | 9 | 1 | 17 | 34 | 23 | 53 | 29 | 18 | 40 | 225 | 220 | 142 | 7 | 23.7 | 12.7 | 61 | 42.9 | 0.33 | 0 |
| MAY | 28 | 94 | 8 | 102 | 70 | 0 | 7 | 1 | 1 | 28 | 339 | 360 | 107 | 6.9 | 24.2 | 4.3 | 48.1 | 64.4 | 0.05 | 0 |
| JUN | 8 | 82 | 6 | 135 | 133 | 4 | 56 | 38 | 13 | 79 | 554 | 275 | 150 | 7.2 | 24.7 | 8 | 55.9 | 55.6 | 0.28 | 0.01 |
| JUL | 9 | 38 | 15 | 109 | 138 | 22 | 56 | 30 | 109 | 58 | 584 | 260 | 105 | 7 | 24.8 | 7.7 | 56.1 | 60 | 0 | 0.15 |
| AGO | 10 | 24 | 2 | 89 | 57 | 65 | 6 | 24 | 35 | 28 | 340 | 230 | 66.7 | 7.2 | 25.1 | 3.3 | 51.8 | 52.8 | 0 | 0.1 |
| SEP | 13 | 4 | 0 | 34 | 52 | 0 | 4 | 0 | 1 | 34 | 142 | 282 | 75 | 7.4 | 25.2 | 6.8 | 56.8 | 59.2 | 0.06 | 0.25 |
| OCT | 2 | 11 | 0 | 85 | 28 | 48 | 14 | 17 | 18 | 29 | 252 | 290 | 85 | 7.1 | 23.8 | 6.9 | 50.4 | 85.4 | 0 | 0 |
| NOV | 1 | 6 | 0 | 43 | 64 | 1 | 4 | 3 | 3 | 33 | 158 | 303 | 60 | 7.3 | 23.7 | 4.9 | 38.4 | 49.7 | 0 | 0 |
| DEC | 0 | 6 | 0 | 40 | 55 | 12 | 4 | 9 | 6 | 27 | 159 | 250 | 87.5 | 6.9 | 25.9 | 14.9 | 49.7 | 25.6 | 0.08 | 1.9 |
| JAN2 | 0 | 7 | 0 | 32 | 37 | 28 | 8 | 16 | 6 | 39 | 173 | 260 | 82 | 6.8 | 24.1 | 4.4 | 59.2 | 26.8 | 0.01 | 0 |

The ordinating diagram of the canonical correspondence analysis performed in the Tínima River is shown in Fig. 2. For classes 8 and 9, the highest scores were reached by $NO_3$ and HAR, but not so for class 1, which is not favored in order of importance by $NO_3$, HAR, pH, Ca and T.

The individuals with sizes between 4-4.9 mm (Class 2) and 7-9.9 mm (class 5, 6 and 7) are indifferent to the increase of the values analyzed. However, class 10 is strongly influenced by $O_2$, Mg and $NO_2$.

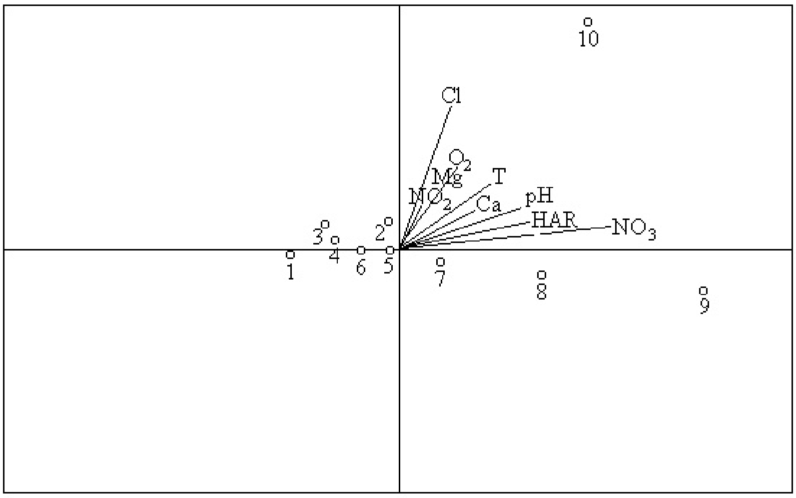


**Figure 2.** Ordination diagram of the canonical correspondence analysis performed in the Tínima River with the 10 classes shell height of *Physella acuta* (o) and abiotic factors (—). The shell height: 1 (<3.9 mm), 2 (4-4.9 mm), 3 (5-5.9 mm), 4 (6-6.9 mm), 5 (7-7.9 mm), 6 (8-8.9 mm), 7 (9-9.9 mm), 8 (10-10.9 mm), 9 (11-11.9 mm) y 12 (>12 mm). Abiotics factors: T= temperature (°C), pH= pH, Cl= chlorides (mg·L$^{-1}$), Ca= calcium (mg·L$^{-1}$), Mg= magnesium (mg·L$^{-1}$), $O_2$= dissolved oxygen (mg·L$^{-1}$), HAR= total hardness (mg·L$^{-1}$), $NO_3$= nitrate (mg·L$^{-1}$) y $NO_2$= nitrite (mg·L$^{-1}$).

The abiotic influence on the abundance of the 10 classes of higher shells of *P. acuta* in the Canal Palomino can be observed in Fig. 3, where the variables Mg, $NO_3$, pH and T influenced negatively on the smaller classes (classes 1,2 and 3), while T favored the presence of classes 6 and 7, principally the last one. In the second quadrant is observed the favorable influence of $O_2$ and $NO_2$ on the intermediate classes and inverse on those of HAR in higher values and the Cl in the lower values. The first factor is strongly associated with the presence of classes 8 and 9 in a lower degree with classes 7 and 10. Ca exhibits a positive relation with classes smaller than of 6.9 mm, because in proportion with the increase of this ion, the presence of the number of individuals of these classes also increases.

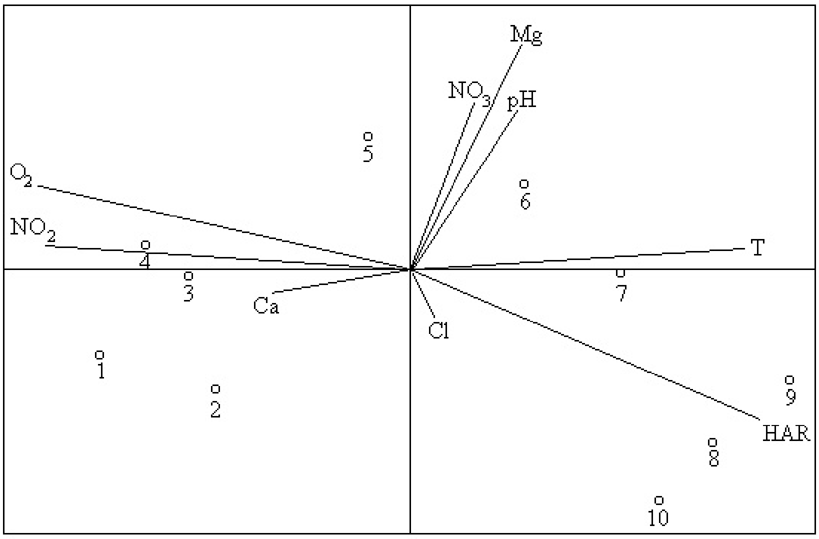


**Figure 3.** Ordination diagram of the canonical correspondence analysis performed in the Canal Palomino with the 10 classes shell height of *Physella acuta* (o) and abiotic factors (—). The shell height: 1 (<3.9 mm), 2 (4-4.9 mm), 3 (5-5.9 mm), 4 (6-6.9 mm), 5 (7-7.9 mm), 6 (8-8.9 mm), 7 (9-9.9 mm), 8 (10-10.9 mm), 9 (11-11.9 mm) y 12 (>12 mm). Abiotics factors: T= temperature ($^0$C), pH= pH, Cl= chlorides (mg·L-1), Ca= calcium (mg·$L^{-1}$), Mg= magnesium (mg·$L^{-1}$), $O_2$= dissolved oxygen (mg·$L^{-1}$), HAR= total hardness (mg·$L^{-1}$), $NO_3$= nitrate (mg·$L^{-1}$) y $NO_2$= nitrite (mg·$L^{-1}$).

In the Figure 4 we can see the ordination of canonical analysis performed to show the temporal dispersion in the Tínima River. The highest abundance of smaller mollusks was at the end of the dry season (March and April) while the intermediate classes were represented indistinctly during all the year studied. Nevertheless, the highest quantity of individuals with larger size was strongly associated with the end of the dry season (February) and the start of the rainy season (May).

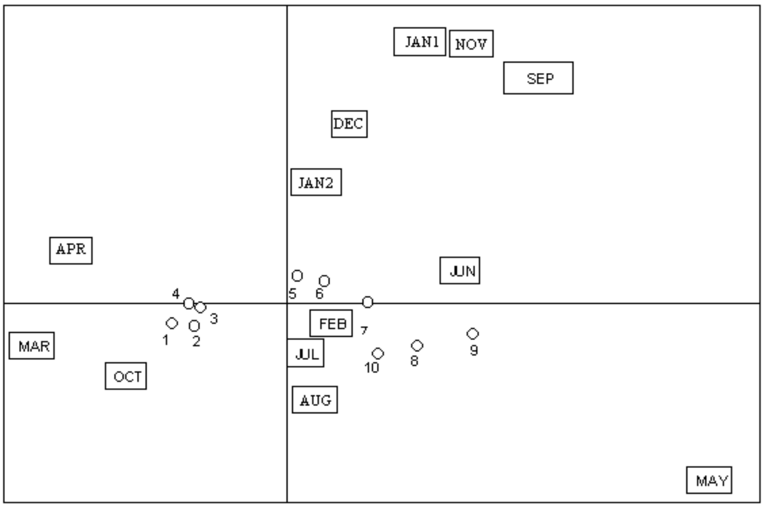


**Figure 4**. Ordination diagram of the canonical correspondence analysis performed in the Tínima River showing the temporal dispersion of 10 classes of shell height of *Physella acuta*. The shell height: 1 (<3.9 mm), 2 (4-4.9 mm), 3 (5-5.9 mm), 4 (6-6.9 mm), 5 (7-7.9 mm), 6 (8-8.9 mm), 7 (9-9.9 mm), 8 (10-10.9 mm), 9 (11-11.9 mm) y 12 (>12 mm). Abiotics factors: T= temperature ($^0$C), pH= pH, Cl= chlorides (mg·L$^{-1}$), Ca= calcium (mg·L$^{-1}$), Mg= magnesium (mg·L$^{-1}$), $O_2$= dissolved oxygen (mg·L$^{-1}$), HAR= total hardness (mg·L$^{-1}$), $NO_3$= nitrate (mg·L$^{-1}$) y $NO_2$= nitrite (mg·L$^{-1}$). Months: JAN1=January 2014 and JAN2= January 2015.

The situation in the Canal Palomino is presented in Fig.5. The individuals smaller than 9.9 mm. of shell height were represented all the year round, but the classes 8 and 9 had preference for the rainy months. The mollusks with sizes higher than 12 mm presented a strong positive association with the months at the end of the dry season.

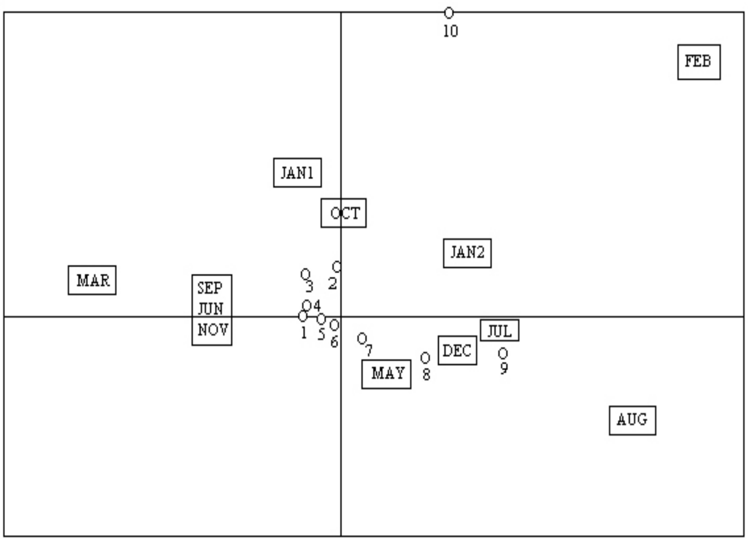


**Figure 5**. Ordination diagram of the canonical correspondence analysis performed in the Canal Palomino showing the temporal dispersion of 10 classes of shell height of *Physella acuta*. The shell height: 1 (<3.9 mm), 2 (4-4.9 mm), 3 (5-5.9 mm), 4 (6-6.9 mm), 5 (7-7.9 mm), 6 (8-8.9 mm), 7 (9-9.9 mm), 8 (10-10.9 mm), 9 (11-11.9 mm) y 12 (>12 mm). Abiotics factors: T= temperature ($^0$C), pH= pH, Cl= chlorides (mg·L-1), Ca= calcium (mg·L$^{-1}$), Mg= magnesium (mg·L$^{-1}$), $O_2$= dissolved oxygen (mg·L$^{-1}$), HAR= total hardness (mg·L$^{-1}$), $NO_3$= nitrate (mg·L$^{-1}$) y $NO_2$= nitrite (mg/l). Months: JAN1=January 2014 and JAN2= January 2015.

## DISCUSSION

In Cuba there are studies carried out about the environmental influence in the presence and distribution of freshwater mollusks (Perera & Yong, 1984; Yong *et al.,* 1987; Diéguez *et al.,* 1992, 1997; Gómez, 1995; Fimia-Duarte *et al.*, 2014a, b). In some cases we can observe the favorable or limiting influence of some species. Other authors have indicated that the quality of water exerts a marked influence, due to the sensitivity of some species to the changes that occur in numerous aquatic ecosystems (Vasileva, 2011).

According to Yong *et al.* (1987) and Diéguez *et al*. (1992) in studies performed on *Tarebia granifera* (Lamarck, 1822), more population density has been found in aquatoriums without running water in comparison to those that have it, because it produces a drag of nutriment and therefore the availability of food is smaller. In the Tínima River (1597 individuals) the water stream was stronger than in Canal Palomino (4203 individuals); moreover this last habitat received the liquid wastes from numerous neighboring houses, therefore this canal has better conditions for the reproduction and development of *P. acuta* in comparison with the Tínima River, due to a greater presence of organic material in decomposition.

Some authors have demonstrated that this species colonizes contaminated water bodies with notable success (Pino & Morales, 1982; Ferrer *et al.,* 1985, 1989; Perera & Yong, 1991; Fernández, 1994; Diéguez *et al.,* 1997; Semenchenko *et al*., 2008), an aspect which corroborates the present study.

The abiotic factors can favor, limit or exclude some species of mollusks, in our case the undesirable influence of pH and T in both habitats was proved mainly with the smaller individuals. These results coincide with other authors since these variables are greatly related to the distribution, reproduction and growth of mollusks in general (Appleton, 1976; Sturrock & Sturrock, 1972; Perera & Yong, 1991; Iannacone *et al*., 2003; Semenchenko *et al*., 2008 & Pino *et al*., 2010). Although the higher intermediate classes did not receive a strong abiotic influence, we can explain this because according to Margalef (1977) these classes have the capacity to tolerate extremely adverse environmental conditions.

The largest classes were strongly influenced by T, pH, $NO_2$, Mg and Ca. Boycott (1934), Hubendick (1958), Diéguez *et al*. (1992) and Okland (1983) said that the Ca ion has a positive influence on mollusks, because it favors the shell formation.

The analysis of the spatial and seasonal variations of the malacological communities has shown the importance of environmental factors. In Cuba some investigations have indicated that there are two climatic seasons, but malacological populations depend mainly on the dry periods, which can be extremely variable in frequency and duration (Perera, 1996; Vasileva, 2011).

In the population studies, in the Canal Palomino the seasonal influence was practically null except on the highest classes, but in the Tínima River the smaller and the larger mollusks received climatic influence (Vasileva, 2011).

The above consideration indicates that *P. acuta* is a species with a wide distribution perhaps by its tolerance capacity of great variability of the chemical quality of water, successfully facing extreme values in the physical and chemical parameters (Semenchenko *et al*., 2008; Vasileva, 2011; Banha *et al*., 2014), this situation undoubtedly has permitted this specie to colonize with success very unstable habitats, similar to those analyzed in the present studies carried out in the central region of Cuba.

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