Arquivos de Ciências do Mar

FEEDING BEHAVIOR OF *Nassarius vibex* (GASTROPODA: NASSARIIDAE)

Comportamento alimentar de *Nassarius vibex* (Gastropoda: Nassariidae)

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ABSTRACT

Many studies on Nassariidae have focused on species that live in the intertidal zone, that are very well adapted to scavenger behavior for presenting an ability of chemoreception at a very long distance. The objectives of this study were to record the time spent by Nassarius vibex *feeding on the field, to investigate its correlation with the shell size and to analyze the response time to stimulation by the feeding depending on the duration of hunger under laboratory conditions. Five pieces of fish were placed to serve as bait, and every five minutes, from the time of the bait until 50 minutes later, the number of individuals attracted to these was registered. The early feeding of* N. vibex *was considered when its proboscis was extended on the bait and end when the animal left the bait. This procedure was repeated for 111 individuals distributed in three days of observation, in January, February and March of 2007. Forty individuals divided into four groups of 10 animals each, which were placed in an tank containing 1 liter of seawater, salinity 30 and constant aeration. At the experiment day 0, food was offered to all groups, thus standardizing the level of hunger and every seven days a different group was fed again so that each group fasted for different periods time. In the field,* N. vibex *had a six-minute period of food consumption, with 76% of individuals feeding for up to 8 minutes. There was no correlation between feeding time and shell length. In the laboratory, the response time to the presence of food depended on the duration of hunger, with the animals that fasted for longer periods responding more quickly to the presence of food.*

***Keywords**:* Nassarius vibex*, feeding behavior, index of hunger, chemoreception, saprophagic.*

RESUMO

Muitos estudos sobre Nassariidae têm focalizado espécies que vivem na zona entre-marés e que são bem adaptadas ao hábito saprófago por apresentarem uma habilidade de quimiorrecepção a longas distâncias. O presente trabalho teve como objetivos, registrar o tempo despendido por Nassarius vibex *na alimentação, investigar a existência de correlação com o tamanho da concha e aumento no número de animais atraídos até o alimento e analisar se o tempo de resposta ao estímulo alimentar varia em função do tempo de duração do jejum, sob condições de laboratório. Cinco porções de peixe foram colocadas para servir como isca e, cada 5 minutos, o número de* indivíudis *atraídos até estas foi registrado. O início da alimentação de* N. vibex *foi considerado quando sua probóscide era estendida sobre a isca e o fim quando o indivíduo abandonava a isca. Este procedimento foi repetido para 111 indivíduos, distribuídos em três dias de observação, nos meses de janeiro, fevereiro e março de 2007. Quarenta indivíduos foram separados em quatro grupos de 10 indivíduos cada. Cada grupo foi colocado em um aquário contendo cerca de 1L de água do mar, com salinidade 30 e aeração constante. No início do experimento dia 0, foi oferecido alimento a todos os grupos, padronizando assim o nível de fome e a cada sete dias um grupo diferente foi novamente alimentado de modo que ao final de 22 dias, cada grupo estava em jejum a diferentes períodos de tempo. No campo,* N. vibex *apresentou um período de consumo de alimento curto, com duração média de 6 minutos, com 76% dos indivíduos se alimentando por um período de até 8 minutos. Não se registrou a existência de correlação entre o tempo de alimentação e o comprimento da concha de* N. vibex. *Em laboratório, o tempo de resposta a presença de alimento dependeu do tempo de duração do jejum, com os animais mantidos em jejum por períodos mais longos respondendo mais rapidamente à presença de alimento.*

Palavras-chaves: Nassarius vibex*, comportamento alimentar, grau de apetência, quimiorrecepção, saprófago.*

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INTRODUCTION

The species within the family Nassariidae are distributed worldwide on the ocean bed, being more common in protected bays in the tropics and subtropics (Morton, 2006). Britton & Morton (1993), studying this family, showed that less than 5% of the species are adapted to rocky environment, soft substrates and little exposure to wave energy.

The species of Nassariidae reveal a wide adaptive radiation in terms of behavior, particularly in relation to food (Morton 2003). Morton & Chan (1997) reported that among Nassariidae species can be herbivorous, carnivorous and scavengers. *Bullia digitalis* feeds on dead organic matter deposited by the waves and *Nassarius obsoletus* feeds on organic material (plant or animal) deposited in the intertidal zone (Morton, 2003). *Nassarius pyrrhus* feeds on moribund molluscs, fishes and decapod crustaceans (Britton & Morton, 1992).

Another type of behavior, especially well documented for *N. festivus* (Britton & Morton, 1994a) and also presented by *N. vibex* (Figure 1), is the one in which individuals remain at rest in the sediment, with only the siphon out (Morton & Chan, 1999) but, after detecting the dead organic matter, the Nassariidae emerge immediately from its home and move quickly toward the food.

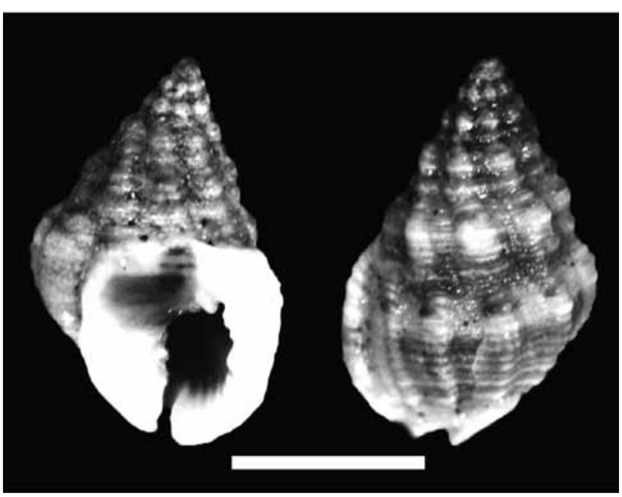

Figure 1 - Adult individuals of *Nassarius vibex* from the Ceará River estuary, Ceará State: A - ventral view; B - dorsal view (scale bar = 5 mm).

The detection of the "prey" can occur from a distance of several meters, specially with respect to intertidal Nassariidae. *N. pyrrhus* and *N. festivus* can detect food at a distance of 1.5 m and 2.0 m, respectively (Morton & Britton, 1991; Britton & Morton, 1992).

The Nassariidae can have rapid locomotion and rapid consumption of large amounts of food in relation to their body weight (Morton & Yuen, 2000; Britton & Morton, 1992) consuming between 50 to 60% of body weight for the intertidal species *N. festivus* and (Cheung, 1994; Morton & Chan, 1999), in which the feeding period lasts on average 8 minutes for *Nassarius festivus* and 12 minutes for *Nassarius siquijorensis* (Morton & Chan, 1999).

According to Morton *et al*. (1995), in a study of predation risk versus food satiation in *N. festivus*, the adopted strategy works towards minimizing the risk of predation, so that the eating behavior is a reflection of the time when they had their last meal and the degree of satiation achieved this. Thus, the time spent by individuals of *N. pauperatus* during feeding is related to the level of hunger, and this is reflected in the degree of food supply. In areas where these animals showed high levels of hunger, many individuls were attracted to food, there is a intraspecific competition for space for food around the carrion. However, the rate at which *N. siquijorensis* and *N. festivus* move toward food is the same for the conditions of fasting and well sated (Mckillup & Butler, 1983; Morton *et al*., 1995; Morton & Chan, 1999).

Nassarius vibex inhabits mud or sandy-muddy substrate that are periodically exposed at low tide in estuaries, as observed to occur from the states of Pará to Santa Catarina (Rios, 2009), and in Northeast Brazil is quite common, forming large concentrations, being found in shallow areas of estuaries.

The objectives of this study were to record in the field, the time spent by *N. vibex* feeding and to investigate the correlation with the shell size, and to analyze the response time to stimulation by the food in *N. vibex* depending on the duration of hunger under laboratory conditions.

MATERIAL AND METHODS

This study was carried out in the Ceará River estuary, located on the western side of Ceará State's coast, on the border of Fortaleza and Caucaia counties (Figure 2).

In Ceará river estuary along the sandy-muddy banks, in areas with little current, five pieces of fish (approximately 5g) were placed to serve as bait. Each piece was positioned to one meter away from each other and were identified by wooden sticks (Figure 3).

During a period of 50 minutes the numbers of *N. vibex* attracted by the bait was registered every five minutes. To determine the index of hunger, the time when each individual reached the bait and the

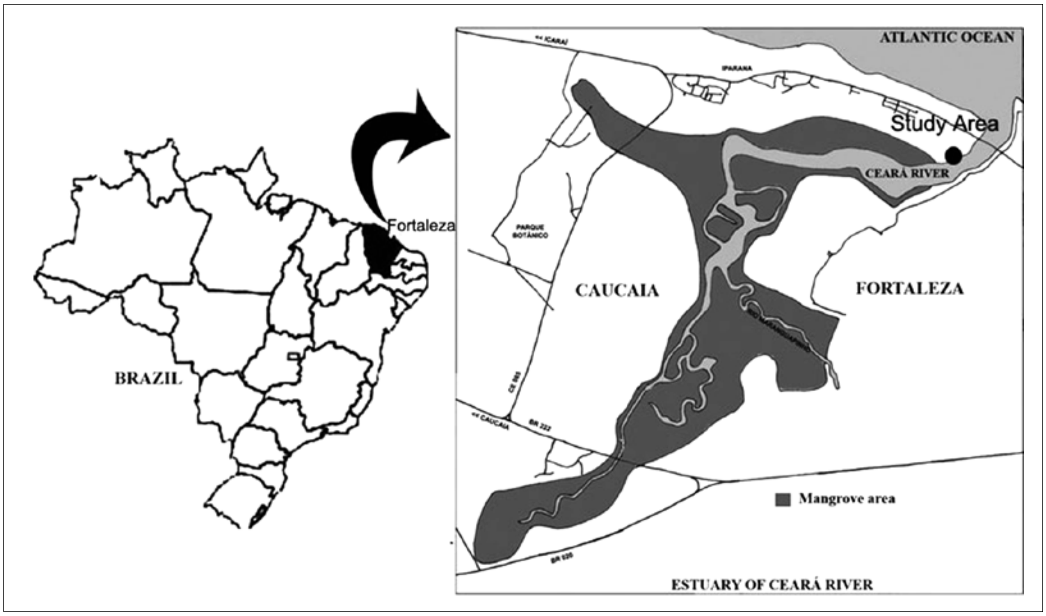

Figure 2 - Study area in the Ceará River estuary, Ceará State (adapted from Barroso & Matthews-Cascon, 2009).

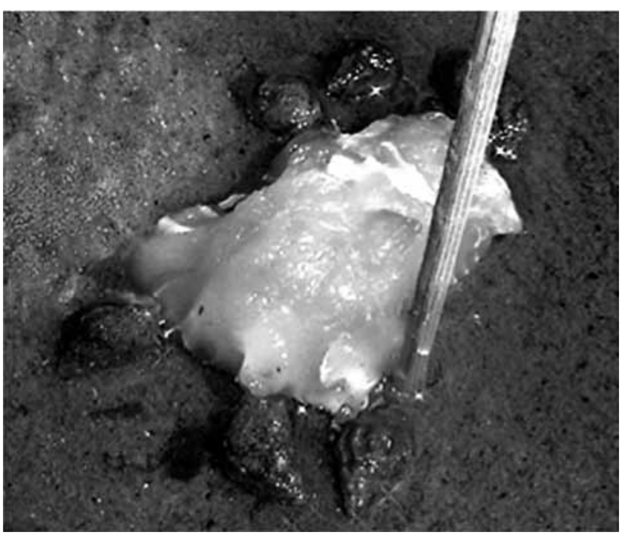
Figure 3 - Individuals of *Nassarius vibex* around the bait.

time it left were recorded. The time spent feeding each individual was then calculated and the length of its shell measured with a caliper accurate to 0.1 mm. *N. vibex* started eating when his proboscis was extended to the bait and ended when left the bait. This procedure was repeated for 111 individuals distributed in 3 days of observation, in January, February and March of 2007.

The non parametric Analysis of Variance by Kruskal-Wallis test was performed. To determine the relationship between hunger index and shell length of individuals were used correlation tests using the Spearman correlation coefficient. All statistical analyses were performed in software GraphPad INSTATversion 3.0.

Forty individuals were collected in March and May of 2007 and brought to laboratory, and then randomly divided into four groups (A, B, C and D) with 10 individuals. Each group was placed in a tank (22 x 15 x 14 cm) containing 1 liter of seawater, salinity 30 and with constant aeration.

At the beginning of the experiment (day 0), food was offered to all groups, thus standardizing the level of hunger each. Every seven days a different group was fed, group A fed on day 0; the B on day 7; the C and D 14 days to 21 days, respectively.

At 22 days, 24 hours after feeding the latter group, in a tank (22 x 15 x 14 cm) containing 500 mL of sea water, fishbait (5g) were offered to the groups randomly with five animals, that there was no competition for space around the bait.

Initially, the bait was placed on the tank, and then waiting 10minutes for the body fluids of fish spread through the water. After this period, the animals were placed in the tank at a distance of 20 cm from the bait. During a period of 30 minutes the numbers of *N. vibex* feeding was registered every five minutes. The percentage of the total number of individuals feeding over time was calculated.

RESULTS

In the experiment conducted under field conditions, the presence of food attracted instantly *N. vibex* with individuals approaching the bait in the beginning of the experiment. The highest number of animals was recorded during the first 10 minutes, and in two of three experiments, animals were attracted to the bait in five minutes (Table I). The maximum number of *N. vibex* present around the bait, at the same time was 10 individuals for every day of the experiment.

Table I - Number of individuals of *Nassarius vibex* over time, in three experiments.

Time (min)	Exp. 1	Exp. 2	Exp. 3	Total	Mean
5	6	0	7	13	4,3 ± 3,8
10	8	10	10	28	9,3 ±1,2
15	7	8	7	22	7,3 ± 0,6
20	10	4	8	22	7,3 ± 3,1
25	6	1	9	16	5,3 ± 4,0
30	9	4	3	16	5,3 ± 3,2
35	10	3	0	13	4,3 ± 5,1
40	5	3	0	8	2,7 ± 2,5
45	3	2	0	5	1,7 ± 1,5

At the beginning of the experiments, individuals approached in greater numbers and showed the first peak in the number of animals, after which it decreased soon to a new peak, lower than the first, except for one experiment, in which the second peak had a size equal to the first one (Figure 4).

In all, 111 individuals were recorded over three months for which the shell size had a recorded average of 12.25 mm in length. The smallest individual, 6.0 mm, was recorded in February and the highest, with 17.6 mm in March (Table II). The size of the individuals did not vary significantly ($p = 0.0791$) during the study period and the size class with the highest frequency was 14-15 mm long, with 27.03% of total numbers (Table III).

On average, individuals of *N. vibex* spent 6.38 minutes eating, over a range of 1-18 minutes (Table II), with 75.68% of the individuals feeding for a period of up to 8 minutes, with the highest relative frequency (11.71%) at 6 minutes (Table IV).

There was no correlation between the index of hunger and shell length ($r = 0.106$; $p = 0.2658$) (Figure 5).

In the presence of food, individuals of *N. vibex* of all groups (A, B, C and D) were found to eat, but the interest in the food varied between groups and over time. In all groups, the majority of animals (≥ 50%) started eating at the first 10 minutes of the experiment (Figure 6).

Group A, which was not fed for 22 days showed a growing interest in food, having the largest number of animal feeding (60%) at 15

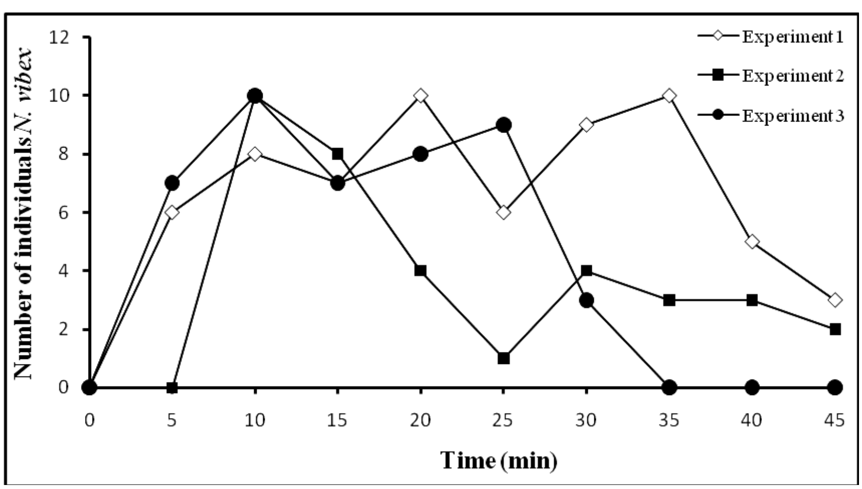

Figure 4 - Graph of the number of *Nassarius vibex* attracted to the food versus time (min).

Table II - Number, shelll size and time of *Nassarius vibex* feeding during the three months of experiment.

Month	Number	Shell length (mm)			Feeding time (min)		
		Min	Max	Mean	Min	Max	Mean
January	42	6.8	15.4	12.53 ± 2.40	2	18	8.1 ± 3.9
February	35	6.,0	15.1	11.60 ± 2.15	1	18	4.6 ± 3,6
March	34	6.4	17.6	12.58 ± 2.83	1	15	6.1 ± 3,1
Total	111	6.0	17.6	12.25 ± 2.48	1	18	6.4 ± 3.8

minutes and was was the only one to present the majority of individuals feeding after the first five minutes. In group B (without food for15 days) on 5 minutes, 55% of individuals were feeding and their numbers decreased to 40% at 20 minutes and 20% at the end of the experiment, 30 minutes. Group C (no food for 8 days) showed a huge interest in the food at the beginning of the experiment, with 85% of individuals feeding at 5 minutes, but soon that number dropped to 10% at 20 minutes. Group D (without food for a day) was the group with the least interest to the presence of food: in the beginning of the experiment (5 minutes), 50% of individuals were feeding, but rapidly the interest in the food diminished, with the percentage dropping to 25% at 15 minutes.

Table III - Frequency distribution of the shell length of *Nassarius vibex*.

Length class (mm)	Absolute frequency	Relative frequency (%)
6┤7	4	3.60
7┤8	3	2.70
8┤9	6	5.41
9┤10	6	5.41
10┤11	11	9.91
11┤12	14	12.61
12┤13	10	9.01
13┤14	19	17.12
14┤15	30	27.03
15┤16	5	4.50
16┤17	1	0.90
17┤18	2	1.80
Total	111	100.00

Table IV - Frequency of *Nassarius vibex* between feeding periods (min).

Time (min.)	Absolute frequency	Relative frequency (%)
1	8	7.21
2	10	9.01
3	10	9.01
4	12	10.81
5	10	9.01
6	13	11.71
7	11	9.91
8	10	9.01
9	4	3.60
10	6	5.41
11	7	6.31
12	3	2.70
13	0	0.00
14	3	2.70
15	2	1.80
16	0	0.00
17	0	0.00
18	2	1.80
Total	111	100.00

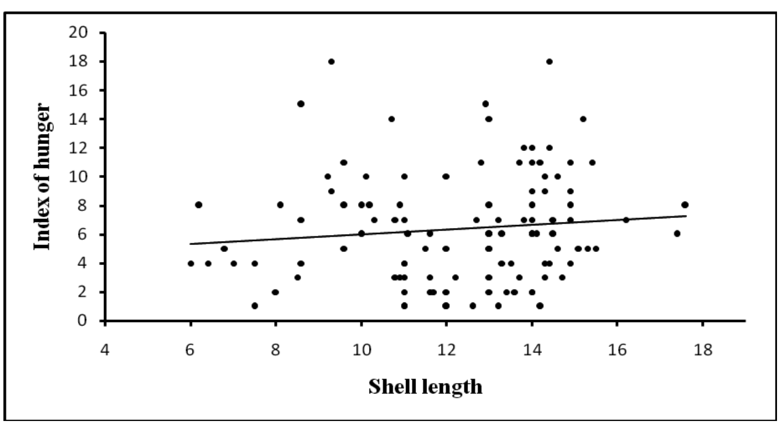

Figure 5 - Graph of the correlation between index of hunger and shell length of *Nassarius vibex* (r = 0.106; p = 0.2658).

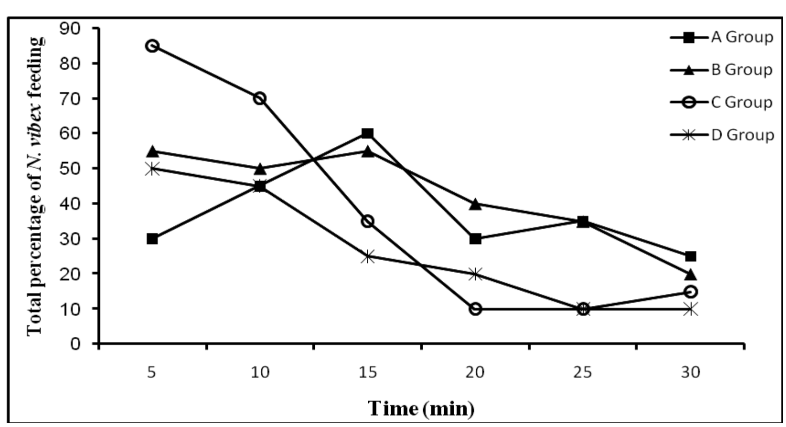

Figure 6 - Graph of the total percentage of *Nassarius vibex* feeding over time at different levels of hunger.

DISCUSSION

Members of Nassariidae family were shown to respond to the presence of food, emerging from the rest in the sediment and moving up to the food (Morton *et al*., 1995). *Nassarius vibex* was quickly attracted to food, with a instantaneous response to the fluid of the fish so that in a period of less than 10 minutes, individuals had been attracted to the bait.

In the laboratory, *N. nodifier*, in waster-flow an environment reached the bait (fish tissue) in a 20.8-minute time and according to Morton (2006), saprophagous species seek a speedy arrival at the food, thus increasing the chances of obtaining sufficient nutrients to maintain their energy balance.

The number of *N. vibex* attracted to baits over time results in line graph with an M-shape, where the first peak is caused by the greater number of individuals that come to the bait and the second, possibly by competition between the Nassariidae around the bait, after an aggregating behavior.

Populations of Nassariidae are also regulated by intraspecific competition. This has been identified for *Nassarius festivus*, under field conditions, where individuals gather around the "carrion" in such numbers as to be unable to eat (Cheung, 1994). The prey is not often available naturally in the intertidal zone, so the competition for this action is intense (Britton & Morton, 1994*b*).

The average shell length of *N. vibex* was 12.25 mm, with most individuals in the range of 14 - 15 mm. Since *N. vibex* reaches maturity at about 15 mm (Demaintenon, 2001), most of the sampled individuals (92.80%) were juveniles with shells smaller than 15 mm, and in the three-month study, the shell length showed no statistically-significant change (p = 0.0791).

The Nassariidae, as opportunistic eaters of dead organic matter, engage themselves in a rapid consumption of large amounts of food in relation to their body weight (Morton & Yuen, 2000; Britton & Morton, 1992). *N. vibex* presented on the field an average index of hunger of 6.38 minutes, ranging between 1 and 18 minutes and 75.68% of the animals were shown to feed for a period of up to eight minutes, with the highest frequency (11.71%) at 6 minutes.

Nassarius festivus consumes between 50 and 60% of their body weight over a period of 8 minutes (Morton & Chan, 1999; Cheung, 1994) and *N.siquijorensis* consumes 61% of body weight in an average of 12 minutes (Morton & Chan, 1999).A rapid consumption of large amounts of food decreases the risk of predation, since animals clustered around the food are a potential food source for predators (Morton *et al*., 1995).

This study did not show a significant correlation (r = 0.106; p = 0.2658) between the index of hunger and shell length of *N. vibex*, indicating that both adults and juveniles can feed for similar periods. These results can be explained by the fact that individuals in the natural environment probably have an erratic food supplement and also by intraspecific competition (Cheung, 1994). According to McKillup & Blut (1983), the attractiveness is related to the degree of food supply, and a reflection of the time in which individuals had their last meal and the degree of satiation through feeding (Morton *et al*., 1995).

Under certain conditions, like in polluted areas and/or those where there is a great deal of "carrion" due to wasteful fishing techniques, the number of Nassariidae can become high. This way, more individuals compete for the same food source, increasing the level of hunger (Mckillup & Butler, 1983) Morton & Chan (2003) found that the greater the amount of nutrients in the water column, the greater the amount of organic matter and the higher the index of hunger in *Nassarius festivus*. We observed the occurrence of a large accumulation of trash in the Ceará River estuary, but it was not clear how that would bear upon the increase in the amount of organic matter in the region.

More studies are necessary on the index of hunger in *N. vibex* and its relation to the amount of organic matter deposited in the estuary and so is to investigate other estuaries as a way to compare possible differences in the index of hunger on the grounds that this should be likely used for measuring human impact on estuaries.

The feeding behavior of *N. vibex* varied between the different levels of hunger. The time required for 50% of animals in each group to initiate feeding was similar. The groups with up to 15 days of hunger (groups B, C and D) began feeding within five minutes.Only group A, which had increased hunger time (22 days), required about 10 minutes for 50% of individuals initiate feeding. According to Morton (2006), fast movement involves a large energy cost, thus the "delay" of group A to reach the food, compared with other groups, may have been caused by lack of sufficient energy to achieve it quickly.

Group B, with one week less of fasting than group A, showed 55% of individuals feeding once the first five minutes of experiment. Thus, *N. vibex* probably spent the energy contained in a single meal between 15 and 22 days. A meal to satiation allows *N. festivus* to get power for 20 days (Cheung, 1994) which will be mainly used in respiration, since Nassariidae do not forage for food, except *Bullia* species (Morton & Chan, 1999).

The behavior exhibited by groups B, C and D to feed in the beginning of the experiment can be explained by the fact that nassariids move around at a constant rate, even in varied conditions of fasting. The rate at which *N. siquijorensis* and *N. festivus* move toward food is the same for the conditions of fasting and well satisfied (Morton *et al*., 1995). Group D showed the lowest percentage of individuals feeding at the same time, which was 50% what is explained by the fact that its individuals had had only 24 hours of fasting, which is supposed to be a very short period to induce a stronger response of *N .vibex* for the presence of food. Individuals of this group had a huge interest in food, with 85% of them feeding at 5 minutes, but this percentage drops sharply, probably because they had gone through eight days of fasting and after a meal in which satiation was achieved, future meals tend to become smaller. The upshot is that a period of eight days may not be long enough to cause a high level of hunger, making individuals to feel satisfied, a behavior that was not true of group B.

This study presented data on the behavior of *Nassarius vibex* under different conditions of hunger, but others studies are needed about this subject, such as determining the rate of energy consumption to define the period in which individuals consume energy gained in one meal.

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