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Article

Evaluation of the stomach contents of *Eriphia gonagra* from a rocky shore in the southeastern Brazilian coast

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ABSTRACT. The rocky shores of Praia Grande, in Ubatuba (São Paulo, Brazil), are formed by rock and Sabellaridae polychaete sandy reefs. These microenvironments offer shelters and foraging areas for several marine organisms and attracts many tourists. The crab *Eriphia gonagra* (Fabricius, 1781) inhabits these structures and can be used as a bioindicator, since they may be affected by anthropogenic actions. This study evaluated the stomach contents and characterized the feeding habits of an *E. gonagra* population, inhabiting the rocky shores from Praia Grande, taking into account the sex, size, and microhabitat. Monthly samplings were performed in 1996 and 1997 and the crabs were manually captured on the rocky surface or into of the sand reefs. So, the specimens sampled were characterized according to their capture site (microhabitat) as rocky (RO) or sand reef (SR). The most abundant food items were Mollusca, algae, Polychaeta, and Crustacea, being observed the importance of these groups as a nutritive resource in the studied environment. Mollusks were more abundant in the stomachs of crabs sampled on the rocks, while the other items increased in the sand reefs crabs. In the specimens sampled in the SR, polychaetes were the item food more common, indicating that this biotope is also used as a rich source of protein. The proportion of items differed also between size classes. Knowledge of such habits is essential for nutritional requirements studies, monitoring relationships among organisms, as well as assessing future environmental impacts in consolidated coastal regions.

KEYWORDS. *Phragmatopoma* sp., foraging, Crustacea, Brachyura, food selection.

RESUMO. Avaliação do conteúdo estomacal de caranguejos *Eriphia gonagra* provenientes de uma praia do litoral sudeste brasileiro. O costão rochoso de Praia Grande (Ubatuba, SP) é formado por matacões rochosos e recifes de areia formados por poliquetas sabelarídeos. Essas estruturas oferecem abrigo e área de forrageamento para diversos organismos marinhos, e atraem muitos turistas. O caranguejo *Eriphia gonagra* (Fabricius, 1781) habita essas estruturas, podendo ser utilizado como bioindicador, uma vez que estas podem ser afetadas por ações antrópicas. Por meio deste estudo avaliou-se o conteúdo estomacal e caracterizou-se os hábitos alimentares de uma população de *E. gonagra*, levando em consideração o sexo, tamanho e microhabitat. Amostragens mensais foram realizadas em 1996 e 1997 e os caranguejos foram capturados manualmente na Praia Grande. Assim, os espécimes amostrados foram caracterizados de acordo com o local de captura (microhabitat) como recife rochoso (RO) ou de areia (SR). Os itens mais abundantes foram moluscos, algas, poliquetos e crustáceos, sendo observada a importância destes grupos como recurso alimentar no ambiente estudado. Os moluscos foram mais abundantes nos estômagos dos caranguejos amostrados no RO, enquanto os demais item aumentavam nos caranguejos dos recifes de areia. Dentre os espécimes amostrados no SR, poliquetos foi o alimento foi mais comum, indicando que esse biótopo também é utilizado como fonte rica em proteínas. A proporção de itens diferiu também entre classes de tamanho. Conhecer tais hábitos é essencial para estudos de requisitos nutricionais, monitoramento de relações entre organismos, bem como para avaliação de impactos ecossistêmicos em costões rochosos.

PALAVRAS-CHAVE. *Phragmatopoma* sp., forrageamento, Crustacea, Brachyura, seleção alimentar.

Decapods crustaceans and other marine invertebrates colonize habitats with different structural features. Usually, juveniles establish in certain places, and, throughout the life cycle, they can migrate to areas where food is more adequate for growth and development (Andrade *et al.*, 2014). The occupation of nursery areas, *i.e.*, areas used specifically for settlement during thefirst post-larvae stages, is very common in Brachyura. In this group, the spatial separation between juveniles and adults is caused by a heterogeneous habitat use, which reflects the need of different resources along ontogeny, especially those related to feeding (Flores & Negreiros-Fransozo, 1998).

Sand reefs formed by sabellariid polychaetes host a diverse community of decapod crustaceans (Coull & Bell, 1983). It offers small shelters for the infauna, whereas crevices on the rocky surfaces offer foraging areas and larger shelters (Wilson, 1979). Almaça (1990) observed the structure and interactions of a crab community inhabiting the sand tubes and revealed the importance of trophic relationships between crabs and polychaetes. Polychaetes are food resource for many other benthic and demersal marine species (Petti *et al.*, 1996). Gore *et al.* (1978) observed that 90% of crustaceans associated with *Phragmatopoma caudata* (Kröyer, 1856) reefs in Florida used the worm itself as a food resource. Moreover, *P. caudata* reefs are an important substrate for decapod crustaceans, being that juveniles and small individuals share the substrate, searching for diverse food resources and shelter from the waves.

To understand the relationships between the organisms of a given community it is necessary to know their feeding habits. In marine ecosystems along the continental shelf, studies on the diet of brachyurans help to understand their role in the food webs. It is important considering that brachyuran crabs are the main component of the benthic epifauna in terms of density, frequency, and biomass (Petti & Nonato, 1990). Decapod crustaceans exhibits a variety of feeding behaviors including predation, saprophagy, detritivory, and filter-feeding, and thus occupy many trophic levels in aquatic food webs (Carqueija & Gouvêa, 1998).

Crabs of the genus *Eriphia* Latreille, 1817 belongs to the Eriphiidae family and are common members on rock shores of in tropical and temperate regions (Reynolds & Reynolds, 1977; Zisper & Vermeij, 1978; Vannini & Gherardi, 1988). There are few studies on food habits for this genus, the one on *E. smithi* diet (Vannini *et al.*, 1989), and the one on prey selection by *Eriphia gonagra* (Fabricius, 1781) carried out in laboratory by R. C. Nalesso (unpubl. data). *Eriphia gonagra* inhabits the intertidal and can be found in rocky crevices and shelters or associated with sand reefs formed by the polychaete *P. caudata* (Read & Fauchald, 2020). According to Melo (1996), the geographical distribution of *E. gonagra*is restricted to the Western Atlantic, from North Carolina (USA) down to Santa Catarina (Brazil).

Soltan *et al.* (2001), analyzed the environmental vulnerability of macroalgae, affirmed that populations from the upper sublittoral—which thrive in rocky shores and sand reefs—were more affected than benthonic species since urban and industrial effluents accumulate in the water surface. Lopes *et al.* (1997) corroborated this observation with experiments involving the application of oil on the rocky shores of São Sebastião (São Paulo, Brazil), reporting the death of many *E. gonagra* and other invertebrates. However, Duran & Castilla (1989) highlight the scarcity of studies on anthropogenic effects that can disturb invertebrates and cause cascading effects in their community structure and functioning. Thus, studies on these populations can support future evaluations of the water quality (Fairweather, 1990) and human impact on coastal ecosystems (Sanchez-Cabeza & Druffel, 2009). In this context, this study aimed at characterizing the feeding habits of *E. gonagra* through the analyses of stomach contents, and to investigate its feeding preferences by sex and size classes.

MATERIAL AND METHODS

Sampling area. The rocky shores of Praia Grande beach, in Ubatuba, São Paulo have uncountable rocky surfaces and sand reefs which attract a high number of tourists (Burone & Pires-Vanin, 2006). The place chosen for collection is located on the right side, for those looking at the continent, between Praia Grande and Tenório beaches (Fig. 1).

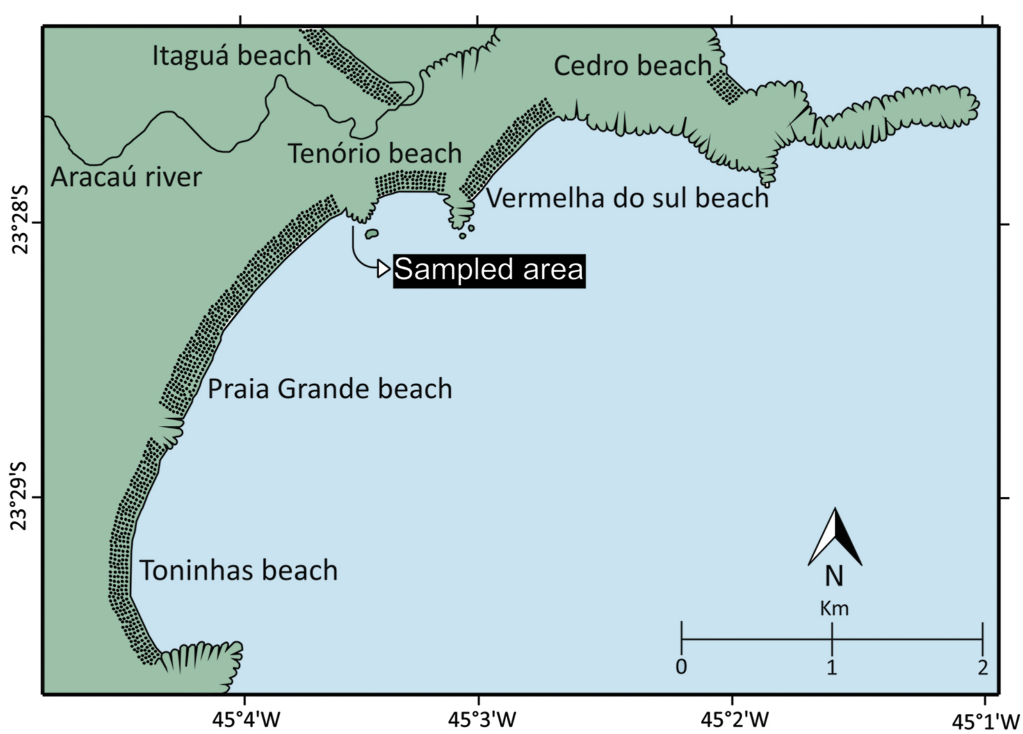

Fig. 1. Map of Ubatuba Bay with the sampling area between Praia Grande and Tenório beaches, state of São Paulo, Brazil.

Animals. Crabs were captured manually once a season (February - Summer; May - Autumn; August - Winter; November - Spring). The sampling area comprised two sites (microhabitats), the "rocky surfaces" (RO) formed by rocks of varying sizes, and the "sand reefs" (SR) formed by the tubes of *P. caudata*.

All crabs were placed in plastic bags and frozen *in situ*. Crustacean freezing is a technique advocated by several researchers who evaluate food items in the animals' stomachs. ALBERTONI *et al.* (2003) used and defended the technique in shrimp; MANTELATTO & CHRISTOFOLETTI (2001) approved the technique in the study of *Callinectes ornatus* (Ordway, 1863) (Portunidae) and SOKOLOWICZ *et al.* (2007) used in *Aegla longirostri* Bond-Buckup & Buckup, 1994, obtaining excellent results.

In the laboratory, they were sexed and measured (carapace width, CW). The stomachs were dissected and labeled according to sex, size class, and site of sampling. Each stomach was classified as empty/partially full (0 – 50%) or full (50 – 100%), and only full stomachs were considered in the following analyses. The stomach contents were evaluated using the percentage method (WEAR & HADDON, 1987; WOODS, 1993; MANTELATTO & PETRACCO, 1997) and frequency of occurrence (MCLAUGHLIN & HEBARD, 1961; GONZÁLEZ-GURRIARÁN, 1978). The contents of difficult identification, due to advanced mechanical and chemical digestion, were considered as digested material (NASCIMENTO, 1993). Food breaks can occur during the period when the crabs are moulting (BERNÁRDEZ *et al.*, 2000) or when females are embryonic (NORMAN & JONES, 1992; MANTELATTO & CHRISTOFOLETTI, 2001; SOKOLOWICZ *et al.*, 2007). Thus, individuals in soft moult stage and breeding females were not considered in this study.

Data analysis. Size classes were established using the method of STURGES (1926), which was adapted to allow the comparison of the demographic groups captured in the two sites (RO and SR). The normality and homoscedasticity of the data were checked with the tests of Kolmogorov-Smirnov and Levene, respectively. The frequency of occurrence of food items throughout the seasons was tested by Anova-2 criteria ($\alpha<0.05$). The frequency of the most relevant food item at different sampling points by sex was analyzed by a Correspondence Analysis (CA). In this analysis, the association of both variables (food item and sampling points by sex) was summarized in a contingency table. Therefore, the data were graphically positioned in points with an area proportional to the abundance of the contingency table. The statistical significance of the axis value was obtained by a chi square test with simulated p (based on 2000 randomizations) (NENADIC & GREENACRE, 2007). The statistical software R v 3.2.0 (R Development Core Team) was utilized for this analysis, with "ca" package (NENADIC & GREENACRE, 2007) routines.

RESULTS

In total, 492 stomachs of *E. gonagra* were analyzed. Most of them, 283, came from crabs captured in the sand reefs, while 209 came from the rocky surfaces.

Stomach content of crabs males and females captured on rocky surfaces were related to algae and mollusks, while those collected on sand reefs are related to Polychaeta (Fig. 2). The crabs were grouped in 11 size classes of 4 mm amplitude. In general, larger individuals were more abundantin RO, and the smaller, in SR.

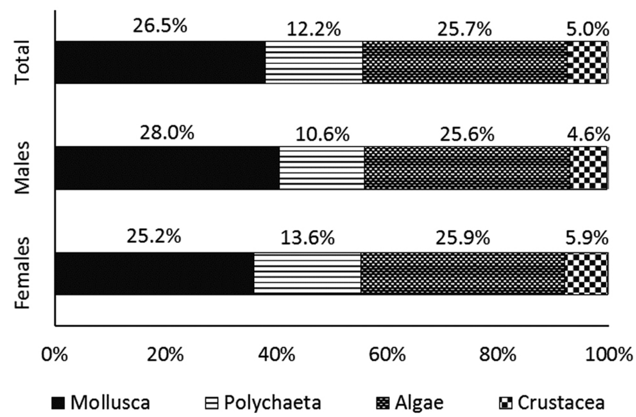

Fig. 2. Percentage of the main food items found in the stomachs of males, females and total population of *Eriphia gonagra* (Fabricius, 1781) captured on the rocky shore of Praia Grande beach, Ubatuba, São Paulo, Brazil.

The most common diet items were Mollusca, with 38.02% (26.51 ± 25.82%), followed by algae, with 36.91% (25.74 ± 28.62%), Polychaeta, with 17.52% (12.22 ± 21.92%) and Crustacea, with 7.21% (5.02 ± 16.72%). Only these items were considered in the statistical tests. Foraminifera, Echinodermata, and fishes were also found, but they represented only 0.35% of the total (Fig. 3). There were no variations in food items over the seasons, either RO ($F = 0.14$, $p> 0.93$) or SR ($F = 0.11$, $p> 0.95$). However, the same analysis showed a difference in the percentage of food items, both in RO and SR ($p <0.01$)(see Fig. 4).

Digested materials represented 24.48% of all contents, and sand represented 5.69%. Nylon threads were found in 26 stomachs, with no significant differences between sites (T-Test; p=0.19). The stomach contents differed between areas: Mollusks were more abundant in stomachs from RO, whereas algae were more abundant in those from SR (Fig. 5).

There were also differences between size classes: Mollusks were more consumed by crabs of intermediate to larger sizes, whereas smaller crabs consumed more algae and polychaetes (Fig. 6). Sand was the item present in greater quantity in the crab of the first size class (30%), in larger animals this percentage did not exceed 8.5% (Tab. I).

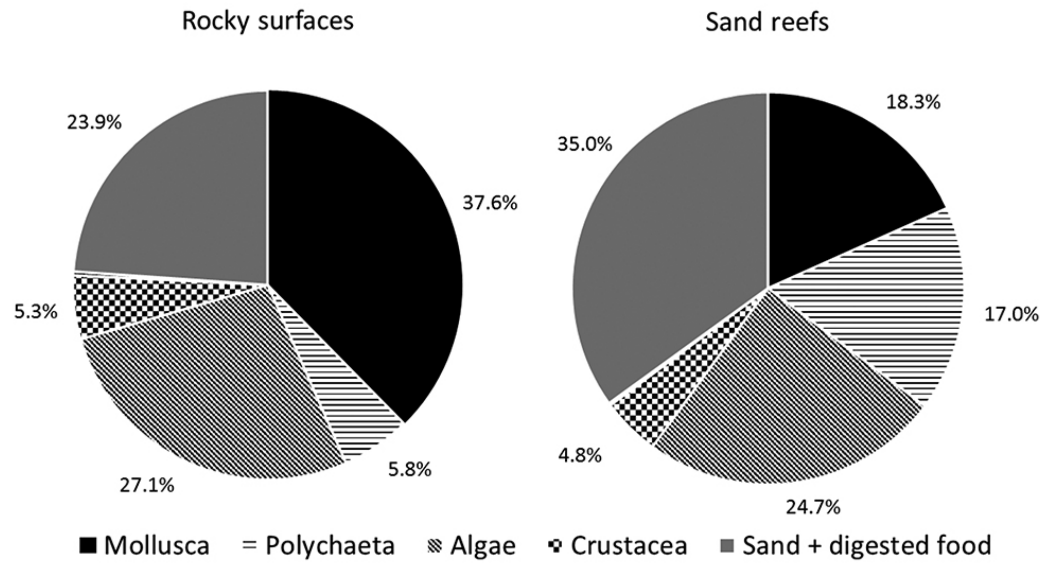

Fig. 3. Percentage of itens found in the stomachs of *Eriphia gonagra* (Fabricius, 1781) captured in the rocky shores (RO) and sand reefs (SR) of Praia Grande, Ubatuba (São Paulo, Brazil). Other animals on RO (0.3%) and SR (0.2%), as well as the presence of nylon threads (RO = 0.05%; SR = 0.06%) are not visible in the figure.

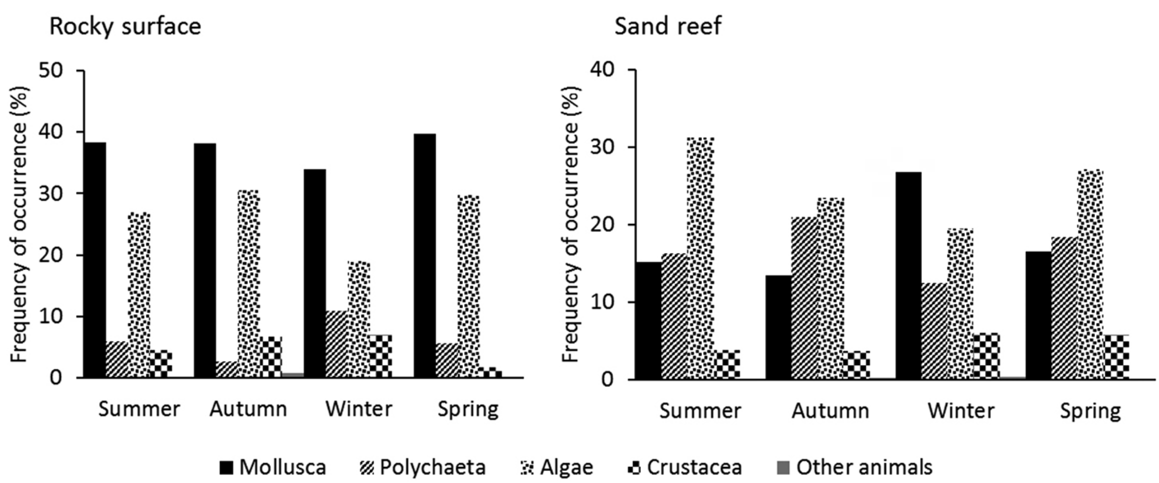

Fig. 4. Percentage of itens found in the stomachs of *Eriphia gonagra* (Fabricius, 1781) captured over the seasons in the rocky shores (RO) and sand reefs (SR) of Praia Grande, Ubatuba (São Paulo, Brazil).

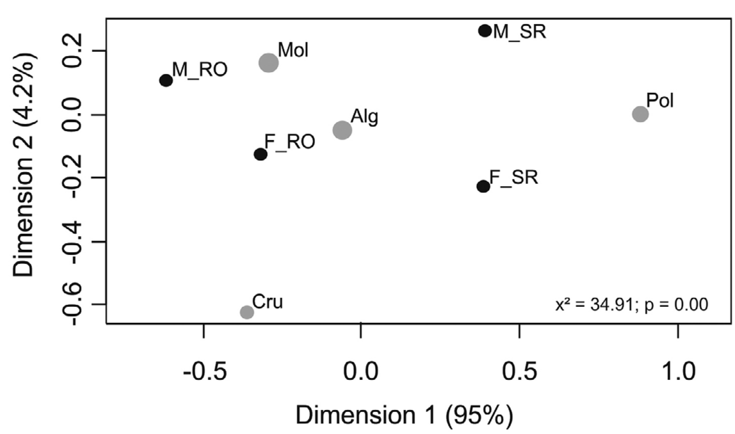

Fig. 5. Correspondence Analysis (CA) of frequency of the most relevant food item in the stomachs of males and females of *Eriphia gonagra* (Fabricius, 1781) at different sampling points of Praia Grande beach, Ubatuba, São Paulo, Brazil.

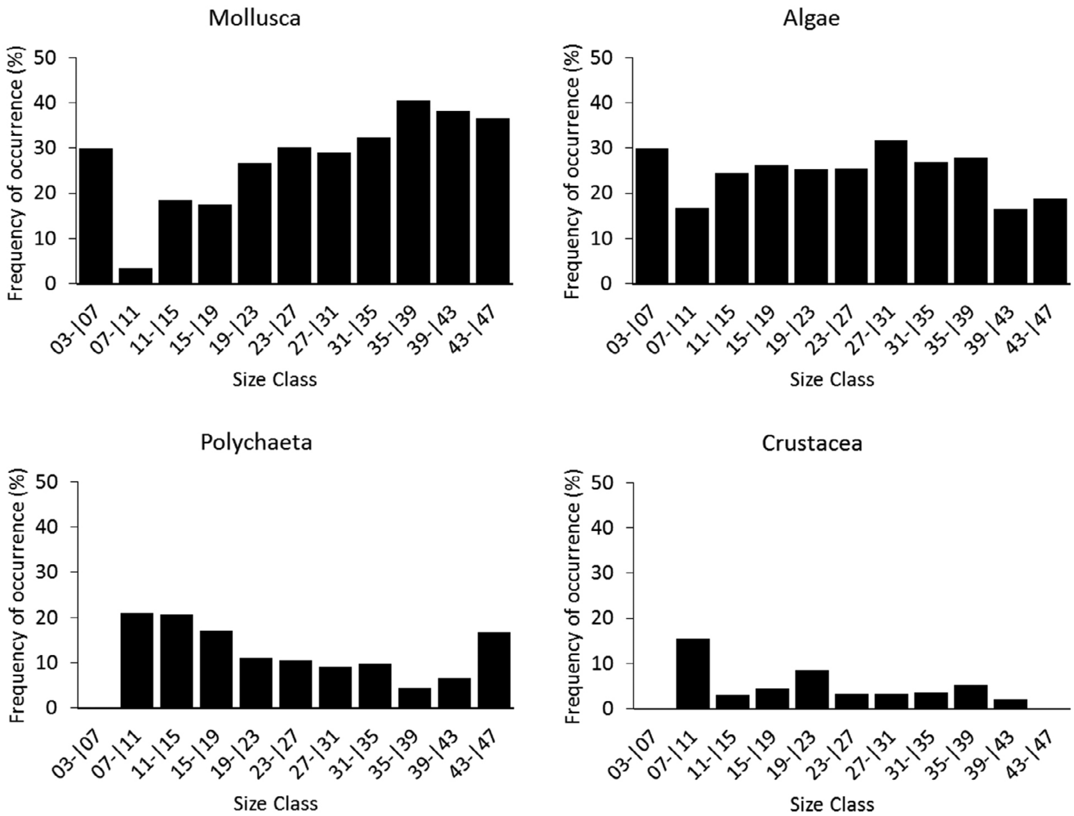

Fig. 6. Frequency of the composition of the main items of the *Eriphia gonagra* (Fabricius, 1781) diet, according to size classes.

Tab. I. Frequency of the composition and main items of *Eriphia gonagra* (Fabricius, 1781) diet, according to size classes.

	Frequency of occurrence (%)							
Size Class (mm)	Mollusca	Algae	Polychaeta	Crustacea	Digested food	Other animals	Sand	Nylon
03-|07	30.0	30.0	00.0	00.0	10.0	00.0	30.0	00.0
07-|11	03.5	16.6	21.1	15.6	34.2	00.5	08.5	00.1
11-|15	18.4	24.5	20.6	03.1	27.1	00.7	05.5	00.1
15-|19	17.4	26.3	17.1	04.0	27.2	00.1	07.5	00.1
19-|23	26.7	25.2	11.0	08.5	21.8	00.0	06.7	00.1
23-|27	30.1	25.5	10.5	03.2	23.2	00.0	07.4	00.1
27-|31	28.9	31.7	09.2	03.2	22.6	00.1	04.2	00.1
31-|35	32.2	26.8	09.7	03.6	22.8	00.1	04.6	00.1
35-|39	40.4	27.9	04.4	05.2	17.5	01.2	03.3	00.1
39-|43	28.2	16.4	06.6	02.1	35.6	00.0	01.2	00.0
43-|47	36.7	18.9	16.7	0.0	25.2	00.0	02.6	00.0

DISCUSSION

Mollusks and algae were the main food items found in the stomachs of *E. gonagra* from the rocky shores of Ubatuba, indicating that these organisms are important food resources in this environment. The food preference of brachyurans was studied by many authors, and, among them, ROPES (1989) was one of the first to identify a preference for Bivalves. Other authors pointed to mollusks as the main item of the diet of brachyurans. For instance, HAEFNER (1990) found they represented 21% of the stomach contents of *C. ornatus*, but also recorded the occurrence of crustaceans, plants, polychaetes, and fishes. BRANCO & VERANI (1997) found the predominance of mollusks, and especially the bivalve *Anomalocardia brasiliana* (Gmelin, 1791), in the diet of *Callinectes danae* Smith, 1869. CARQUEIJA & GOUVÊA (1998) also pointed to mollusks as the preferred food of *Callinectes larvatus* Ordway, 1863 captured in the mangroves of Jiribatuba. Nonetheless, not all crustaceans prefer to feed on mollusks. As showed by OGAWA (1977), the diet of

Pachygrapsus transversus (Gibbes, 1850), which coexists with *E. gonagra* in Praia Grande beach, included algae and animal carcasses. Also, Branco (1993) considered *Ucides cordatus* (Linnaeus, 1763) as an omnivorous crab which feeds on plants, animals, and detritus. Therefore, the feeding habits can vary according to the environmental conditions or with the specific needs of each period. Indeed, Kulesh (2015) indicated that the degree of assimilation by decapods varies according to the temperature, *i.e.*, environmental conditions may also affect the food preference.

The consumption of algae is considered by Wolcoot (1978) as accidental since brachyurans are mainly carnivorous. Indeed, Seed *et al.* (1981) showed that algae provide support for mollusks, polychaetes, and crustaceans and can be ingested with these items. D'Incao *et al.* (1990) mention that, although detritivore crustaceans do not assimilate all plants, they may benefit from the microorganisms or other compounds from them. However, J. D. L. Santana (unpubl. data), who also studied *E. gonagra*'s feeding behavior, says that this species is omnivorous, since several items were found in its diet, such as algae, mollusks, crustaceans, ascidians, echinoderms, among others. In our study, algae were the second most found item in the stomachs of *E. gonagra*.

In addition to the dominance of mollusks and algae, the diet of *E. gonagra* from the sand reefs also included the polychaetes building reefs. According to Nonato *et al.* (1990), polychaetes are an essential link in the trophic webs of Ubatuba, and Andrade *et al.* (2014) showed that *E. gonagra* juveniles use the sand reefs both as shelter and food. These studies reinforced the idea that this biotope isused as a food source, mainly protein. Studies of J. D. L. Santana (unpubl. data) showed that, at the laboratory, the preference of *E. gonagra* was divided between filamentous macroalgae, preferring these items to mobile prey such as mollusks, sea urchins and polychaetes. On the other hand, the crabs collected in the rocky surfaces eat more mollusks, probably because they are more abundant in this environment. By feeding on this abundant resource, the crabs can save energy and spend less time exposed to predators.

Remains of crustaceans were also found in the stomachs of *E. gonagra*, however in low percentages. According to Carqueija *et al.* (1995), they could also have been ingested accidentally, since some crustacean species are commensals of mollusks and polychaetes. However, J. D. L. Santana (unpubl. data) states that females of *E. gonagra* showed cannibal behavior in a laboratory environment, possibly due to territorial dispute or stress. Vannini *et al.* (1989) already described this behavior in *Eriphias mithi* MacLeay, 1838, in which adults ingested juveniles. This fact may be related to the choice of habitat by size classes (according to Andrade *et al.*, 2014) of the individuals studied and the crustacean remains found in the stomachs. However, in the Fortaleza Bay of Ubatuba, crustaceans were the main food item in the stomachs of *Hepatus pudibundus* (Herbst, 1785) (Mantelatto & Petracco, 1997). As the percentage of crustaceans in the diet of *E. gonagra*was slightly higher than 5% in all seasons in our study, this ingestion cannot be considered as accidental, as well as rated by Andrade *et al.* (2014).

Besides the edible items, sand grains were also an expressive part of the stomach contents, representing about the same percentage of crustaceans. This has been observed by other authors such as Ogawa (1977), Branco (1993), Carqueija & Gouvêa (1998), who considered the sand as a diet item. Also, Haefner (1990) affirmed that sand is a source of carbonates, and therefore, an important diet item. On the contrary, J. C. Hillesheim (unpubl. data) affirms that sand is ingested accidentally with other preys, since it adheres to particulate organic matter, microorganisms, benthonic organisms, algae etc. (D'Incao *et al.*, 1990). Due to the high amount of sand found in all the sampled crabs, we do not believe that this item is there by accident. Corroborating with Pires *et al.* (2017), who stated that Ca, in the form of calcium carbonate, in addition to chitin and proteins, is the main constituent of the structure of the crustacean exoskeleton, and Nedzarek *et al.* (2019) who claim that Ca and Mg are elements found in high concentration in the exoskeletons; Zanotto & Pinheiro (2009) pointed out that the crab *Sesarma rectum* excreted crystals of calcium carbonate (CaCO3), to the new exoskeleton, in direct proportion to the amount of calcium ingested.

Fish scales, foraminiferans, and ossicles of echinoderms were also found in the stomachs of *E. gonagra*, however contributing to less than 1% of the total. The presence of fish scales may be explained by consumption of fishes trapped in small ponds during the low tides or discarded by fishermen. Fish scales are more common in the stomachs of sublittoral crabs, as observed by Barros *et al.* (2008) in the diet of *Libinia spinosa* (H. Milne Edwards, 1834) in Ubatuba. Also in Ubatuba, fishes were the second most important diet item of the crab *H. pudibundus* (Mantelatto & Petracco, 1997). Echinoderms and foraminifera were found in low abundance in the stomachs of *E. gonagra*, which appears to have a close link diet with the abundance and availability of prey in the habitat. According to Bernárdez *et al.* (2000), the diet is determined by the availability of the prey, which is in turn, conditioned by both the abundance, by mobility and by the hardness characteristics of the potential prey.

Research by Mantelatto & Petracco (1997) with the crab *H. pudibundus*, Bueno (2004) with eglids and Bernardéz *et al.* (2000) with the spider crab *Maja squinado* (Herbst, 1788), revealed temporal variability in the diet of the aforementioned crustaceans. Even though mollusks were the most consumed item, prevailing only in winter, and algae were more consumed in summer, autumn, and spring, no significant temporal variability of the diet was observed in the present study. This also leads us to believe that scales of fish, foraminifera and ossicles of echinoderms, mentioned in the previous paragraph, are occasional items or with low availability in the environment in which *E. gonagra* crabs were collected.

Insects are commonly found in the diet of intertidal and freshwater crabs, however none was found in the stomachs of *E. gonagra*. Insects were among the most consumed items by *Ocypode quadrata* (Haefner, 1990) — which was later confirmed by J. C. Hillesheim (unpubl. data) — and by the freshwater crabs *Aegla platensis* (Schmitt, 1942) and *Aegla ligulata* (Bond-Buckup & Buckup, 1994). Bueno (2004) noted that species of *Aegla* prefer insect larvae. The absence of insects in the diet of *E. gonagra* may be related to the low availability of this resource in intertidal regions with strong waves, which is the case of Praia Grande.

The feeding habits of *E. gonagra* juveniles were not evaluated in this study, however, we believe that this species, like *C. ornatus*, has low mobility or is almost sedentary. Juveniles are more abundant in the sand reefs made by the polychaetes *P. caudata*, which are used as shelters and food (Andrade *et al.*, 2014). Brogim & Lana (1997) suggested that the feeding habit of an animal may vary depending on the habitat, and Barutot *et al.* (2011)suggested that a given species may occupy different trophic levels in different environments, since the availability of a given resource may influence the feeding behavior.

The absence of differences between the diets of males and females may be explained by the fact that both sexes occupied the same habitats. Branco (1996) also did not find any differences between the sexes of *C. danae* but suggested that feeding preferences were related to size (juveniles vs. adults). However, the assimilation efficiency is independent of age and fairly stable (Kulesh, 2015). Andrade *et al.* (2014) showed that most *E. gonagra* juveniles inhabit the reefs, which are considered as nursery areas, whereas the adults were equally distributed in the sand reefs and rocky shores. Thus, differences in the diet are likely unrelated to thesex but due to the differential habitat use.

The presence of nylon threads in the stomachs of marine animals has been frequently recorded in the scientific literature. Ramos *et al.* (2012) evaluated the feeding habits of three fish species belonging to the Gerreidae family in the estuary of the Rio Goiana, Brazil, and observed the ingestion of nylon threads, indicating a contamination of these animals at the site. Later, P. S. Albuquerque (pers. commun.) revealed that 100% of the *Mugil liza* Valenciennes, 1836 fish collected had ingested some type of plastic. Macedo *et al.* (2011) found that there was a predominance of residues of fishery origin such as nylon threads and ropes in the digestive tract of sea turtles of the species *Chelonia mydas* (Linnaeus, 1758) and *Eretmochelys imbricata* (Linnaeus, 1766). Later, Edris *et al.* (2018) demonstrated the existence of plastic material in abundance within the digestive tract of 70% of dead sea turtles on the beaches of the southern coast of São Paulo state, Brazil.

In Crustaceans, the first Brazilian registration was carried out by Góes *et al.* (2009), who found nylon threads in the stomachs of lobsters *Panulirus echinatus* Smith, 1869. More recently, J. D. L. Santana (unpubl. data) detected plastic waste in 75.59% of the crabs *E. gonagra* collected in the state of Alagoas, coast of northeastern Brazil; having registered that in only one individual, nylon was found at a frequency of 0.48% of the content ingested.

Cases like these have probably occurred due to improper disposal of fishing objects and lack of maintenance of the area, leaving nylon threads available for intake. The presence of fishery artefacts in the environment was reported by Slip & Burton (1991), which highlighted the damage that these materials can cause to large and small species. Despite the appearance of plastics in the stomachs, the frequency that were found indicates that plastics have low values in relation to the total volume of food found of the stomachs of *E. gonagra*. This shows that the species has been suffering with residues of anthropic activities at Ubatuba, and although is not a mortality factor right now, may be in the future if the amount of trash increase on the environment.

Thus, our results reveal important aspects of the feeding habits of *E. gonagra* which may be used to support future investigations on anthropogenic effects on this species, provide subsidies for the creation of new areas of preservation, in addition encourage education and awareness activities of the population for the conscious use of plastic and recycling actions. The strongest impact in the area is due to a high number of tourists, which may affect the crab communities directly and indirectly, by affecting the sand reefs which constitute their nursery areas and food.

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