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Morphological aspects related to feeding of two marine skates *Narcine brasiliensis* Olfers and *Rhinobatos horkelli* Müller & Henle

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ABSTRACT. *Narcine brasiliensis* and *Rhinobatos horkelli* live in coastal waters close to the sea bottom and are commonly found in the same places. Feeding and some body measures of these species such as relative height and width and mouth width were studied. Results showed significant differences for stomach contents composition. *N. brasiliensis* feeds mainly on burrowing crustaceans and polychaets, whilst *R. horkelli* feeds on free living crustaceans. Body proportions show also significantly distinct results between the species. The former presents greater height and width, suggesting a slower species. Besides, this species uses electric discharges to detect its food and has a protruding mouth to catch it. On the other hand, the latter shows morphological features which apparently give it higher swimming speed to catch moving organisms faster than those explored by *N. brasiliensis*.

Key words: external anatomy, feeding, *Narcine brasiliensis, Rhinobatos horkelli,* skates.

RESUMO. Aspectos morfológicos relacionados à alimentação de duas raias marinhas *Narcine brasiliensis* Olfers e *Rhinobatos horkelli* Müller & Henle. *Narcine brasiliensis* e *Rhinobatos horkelli* vivem em águas costeiras próximas ao fundo, sendo encontradas nos mesmos locais. Essas espécies foram estudadas quanto à alimentação e algumas medidas corpóreas como altura e largura relativas do corpo e largura relativa da boca. Os resultados revelaram diferenças significativas na composição de seus conteúdos estomacais. *N. brasiliensis* alimenta-se principalmente de crustáceos e poliquetos fossoriais, enquanto *R. horkelli* alimenta-se mais freqüentemente de crustáceos de vida livre. As proporções corporais também apresentaram resultados significativamente diferentes entre as espécies. *N. brasiliensis* tem largura e altura relativa do corpo maiores, sugerindo ser uma espécie menos veloz. Além desse fato, essa espécie utiliza-se de descargas elétricas para detectar o alimento e boca protrátil para facilitar sua captura. *R. horkelli*, por sua vez, apresenta características morfológicas que aparentemente a capacitam a atingir maiores velocidades de natação, permitindo que capture organismos também mais rápidos que os explorados por *N. brasiliensis.*

Palavras-chave: alimentação, anatomia externa, *Narcine brasiliensis*, raias, *Rhinobatos horkelli*.

Although the study of the feeding habits of most Brazilian marine fishes has made great advances, there are relatively few papers related to skates. Pires (1987), Pires and Queiroz (1988), Soares *et al.* (1992) are worth mentioning. Studying South African skates, Smale and Cowley (1992) and Ebert *et al.* (1991) observe feeding ecology of this group, but there are relatively few works about the species. One of the reasons may be that skates or rays are rarely caught in great numbers as other kinds of fish are by the usual means. Low density per catch is a bad stimulus for the study. One would expect a more representative number of stomachs to evaluate the principal food of each species. Skates show low commercial attractiveness too, and such a fact could be related to the few studies known, at least with regard to skates in Brazilian coastal waters. However, some studies related to general biological aspects exist (Rounet, 1987; Harris *et al.*, 1988).

Studies on the feeding habits of skates and rays, at least for Brazilian species, may be improved. However, some general biological studies have been made all around the world (Bigelow and Schroeder, 1953; Castro, 1965). For feeding studies, Hess (1961) tried to find out the existence of competition among *Dasyatis* species. This is one of the few studies in which feeding of distinct species of skates is compared.

Skates are animals which occur at relative low densities when compared to other fishes caught by

conventional means, such as coastal trawlings. So, feeding habit studies would be interesting if undertaken with other observations, such as some morphological measurements. *Narcine brasiliensis* (Narcinidae) and *Rhinobatos horkelli* (Rhinobatidae) belong to distinct families and are also different in shape. Besides, the former bears a structure known as electric organ, which helps in detecting food organisms. *Rhinobatos* and other skates bear the Lorenzini ampullae which are also used to detect electric fields around living organisms, but only Torpediniformes present structures for electric discharges. Similar way of feeding has been studied by Lowe *et al.* (1994) for the *Torpedo*, a near relative of narcinids, which in turn were studied in captivity by Rudloe (1989). The external shape of *Narcine* suggests a relative condition for slow movements, while *Rhinobatos*'s resembles that of the shark and would be able to develop a higher speed.

The food composition of these two species, which live so closely to each other, and some external anatomic aspects are studied in order to observe possible adaptations which could be reflected by the composition of their stomach contents. Research is justified because references to generalized feeding on benthic organisms are normally the only available in the literature (Ebert *et al.,* 1991; Smale and Cowley, 1992).

Materials and methods

The skates were caught in the northern coast of São Paulo state (Ubatuba) by coastal trawlings in May, July and September, 1989. Identification followed Figueiredo (1977). They were fixed with a 10% formalin solution. Their total length (mm) was obtained.

For better observation of stomach, the liver of each individual was removed. The digestive tract was opened longitudinally and food contents were washed out with a 70% ethanol solution. Stomach contents were identified following Kaestner (1970), Amaral and Nonato (1981) and Rupert and Barnes (1996).

The analysis of the food contents followed Hyslop (1980). Identified items were counted and their occurrence and numerical frequencies measured. For comparison, both occurrence and numerical relative frequencies were plotted using the method of Kawakami and Vazzoler (1980), which reveals the relative importance of prey by graphical analysis.

Measurements of external structures have also been made to get information to compare relative size of each species. Such a procedure provides a better means to compare structures of individuals of both species, notions on hydrodynamic aspects and, at least, distinct possibilities to obtain food (Aleev, 1969; Alexander, 1974; Chao and Musick, 1977; Webb, 1984; Videler, 1993; Jobling, 1994). Measurements comprised body width, height and mouth width, all related to body length, as suggested by Drake and Arias (1984). For comparisons among measurements, Kruskal-Wallis test was applied to values obtained (α=5%).

Results

N. brasiliensis (136-367 mm) was represented by 34 individuals and *R. horkelli* (303-422 mm) by 22.

The point sets in Figures 1 and 2 for both species show that *N. brasiliensis* exhibits larger proportional body widths and heights than *R. horkelli* for all lengths examined. On the other hand, mouths of *R. horkelli* are relatively wider (Fig.3). Applied to their morphological aspects, Kruskal-Wallis test revealed significant differences for the three measurements ($p<0.05$).

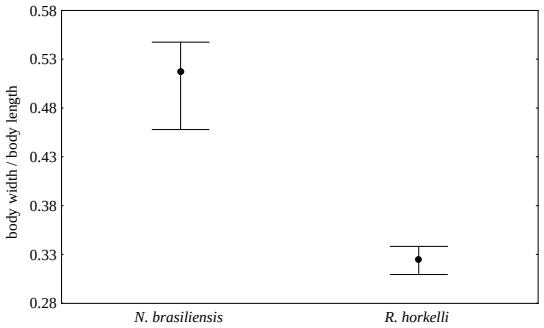

Figure 1. Median (•) and range values of relative body width of the two species

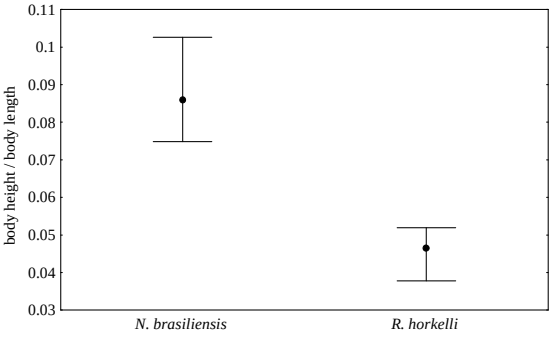

Figure 2. Median (•) and range values of relative body height of the two species

As shown in Table 1, *N. brasiliensis* feeds mainly on polychaets but some crustaceans are also common among its stomach contents. Among the crustaceans the most common belong to Isopoda, Stomatopoda and the Callianassidae and Albuneidae families. These are absent in stomachs of *R. horkelli*. The latter shows a diet restricted to crustaceans of which the most important are Caridea, some non-identified crustaceans, Decapoda and Mysidacea.

Figure 4 shows the areas formed by interrelating numerical and occurrence frequency values of the food items.

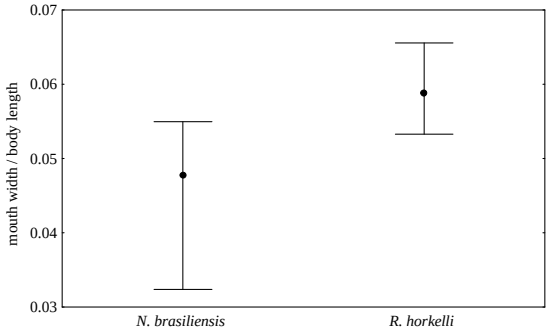

Figure 3. Median (•) and range values of relative mouth width of the two species

Table 1. Composition of the stomach contents of the skates represented by their numerical and occurrence percentage

	N. brasiliensis		*R. horkelli*	
Food items	abundance (%)	occurrence (%)	abundance (%)	occurrence (%)
Caridea	4.76	6.12	28.10	95.45
Callianassidae	6.67	7.56	-	-
Albuneidae	0.95	1.91	-	-
Penaeidea	-	-	1.04	13.64
Other decapods	3.81	6.12	23.01	90.91
Mysidacea	-	-	20.79	72.73
Isopoda	1.90	1.91	-	-
Stomatopoda	0.95	1.91	-	-
Other crustaceans	7.62	12.38	26.14	95.45
Glyceridae	4.76	10.12	-	-
Nereididae	1.90	3.96	-	-
Onuphidae	7.62	6.12	-	-
Lysateridae	7.62	6.12	-	-
Arabellidae	2.86	1.91	-	-
Eunicidae	0.95	1.91	-	-
Capitellidae	8.57	3.96	-	-
Flabelligeridae	2.86	3.96	-	-
Other polychaets	35.24	54.21	0.52	18.18
Anguilliformes	0.95	1.91	-	-
Other fishes	-	-	0.40	13.64

Discussion

The distinct external aspect of the skates suggests that a difference in their way of life and thus in the feeding habit may exist. External shape has something to do with this fact (Keast and Webb, 1966; Chao and Musick, 1977), but each case should be discussed. This statistical artifact shows what happens during growth of both species, maintaining a certain equidistant general aspect during this phase, and possibly during the others. It has also been used because the specimens collected were of distinct sizes.

An important fact to be observed is that *N. brasiliensis*, a supposedly slower moving skate, may use a mouth protrusion ability, associated to electric detection of preys whose burrowing habits are not sufficient to avoid predation. A similar conclusion was reached by Rudloe (1989) when studying experimentally *N. brasiliensis*, indicated to be a preferred model for research in neurochemistry. This is a common fact to Torpediniformes (Bray and Hixon, 1978; Rudloe, 1989; Lowe *et al.* 1994). *R. horkelli* does not present buccal protrusion. However, the mouth opening is relatively larger and may permit the skate to catch swimming or crawling organisms, known to present this kind of movement (Rupert and Barnes, 1996). The relative distinct velocities of both species have not been evidently measured, but the concepts follow Aleev (1969) and Jobling (1994), whose arguments help one to justify difference in movement as a consequence of distinct external shapes. Such an approach suggests a further study on the hydrodynamic issue. If *R. horkelli* presents a proportionally lesser width and height, significantly distinct from the other species, this fact may suggest a relative higher velocity, facilitating the capture of the organisms found only in its stomach contents. As stated by Rupert and Barnes (1996), decapods, including penaeideans and carideans, although living near the sea bottom, may crawl or swim at least during nocturnal periods. The same happens with mysidaceans, some of them being more permanent swimmers.

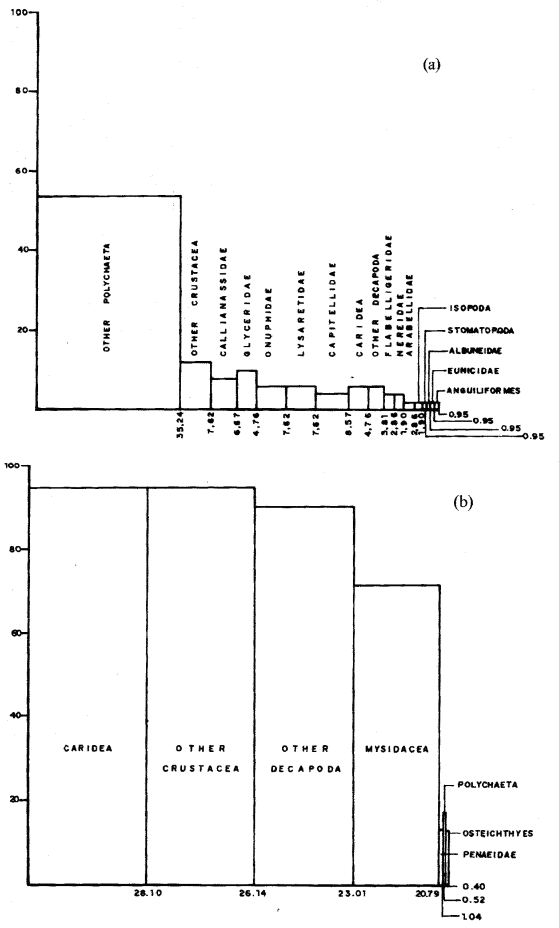

Figure 4. Numerical and occurrence frequency values of the food items for *N. brasiliensis* (a) and *R. horkelli* (b)

On the other hand, burrowers, some of them presenting slow movements when not immobile,

may only be perceived by the other species in question. Glyceridae, Arabellidae, Capitellidae and Flabelligeridae live in bottom galleries. Nereididae and Lysateridae are crawling polychaets, and Onuphidae and Eunicidade, being bottom dwellers, construct tubes to live inside.

The current use of occurrence and numerical frequency methods (Hyslop, 1980), although imperfect, as stated by McDonald and Green (1983), who believe that combination of these methods add little and exhibit redundant information, helps one to evaluate the importance of items in stomach contents. Zavala-Camin (1996) even states that occurrence methods are really the only ones which should be used with reliability. Results clearly distinguish the kind of organisms present in the stomachs of the two species.

The original methods (Hyslop, 1980) or their derivatives, such as the alimentary index (Kawakami and Vazzoler, 1980), shown in Figure 4, using only occurrence and numerical frequencies, are still the best means for an instantaneous inspection of stomach contents. It avoids a precipitated conclusion, which could happen if only one of the methods (numerical or occurrence) were used. Although the table shows clearly differences in food contents, it is illustrative of the diets of both species. It represents areas formed by percentage values which show better the importance of polychaets and burrowing crustaceans for *N. brasiliensis* and of free living crustaceans for *R. horkelli*. A more sophisticated methodology employed by Labropoulou and Eleftheriou (1997) should only be indicated if subtle differences occurred. However, this is not the case. Although they are clearly distinct, one analysis using Costello's method (Costello, 1990) would show *R. horkelli* and *N. brasiliensis* diets and indicate levels of specialization in the way of feeding. For such an analysis a higher number of specimens should be necessary. However, the food composition of *N. brasiliensis* stomach contents indicates a feeding spectrum based mainly on bottom dwelling invertebrates. This could reveal a kind of specialization, distinct from that of the other species.

It can also be observed that *N. brasiliensis* uses a more diversified group of organisms for food. This fact reflects only a higher number of groups of animals inhabiting the sea ground, a great part of them burrowing organisms (Amaral and Nonato, 1981). Nonetheless, differences in food composition are sufficiently clear, because organisms present in the stomachs of both species are taxonomically and anatomically distinct, as are also their ways of living.

In spite of the low number of skates studied, the different diets of these neighbor species should be related to differences in their external anatomies.

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