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RESEARCH ARTICLE

Diet of *Raja asterias* (Delaroche, 1809) caught along the Mediterranean part of the Moroccan coast (Northern Morocco)

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Abstract

This study was conducted on the diet of 367 individuals and included 165 males and 202 females of *Raja asterias* caught between April 2013 and March 2014 at M'diq port (Mediterranean Moroccan coast). Their body size varied from 20 to 66.5 cm for males and from 20 to 72cm for females. *R. asterias* caught in this region showed clear preference for crustaceans and fish. The average emptiness coefficient was 29.61% and varied depending on the size and sex. We also observed dietary differences depending on the size of the animal.

Keywords: *Raja asterias*, feeding ecology, Mediterranean, Morocco

Introduction

Skates live in coastal waters and along with sharks constitute a key component in marine benthic ecosystem. *Raja asterias* (Delaroche, 1809) is common in the whole Mediterranean Sea with probable exclusion of the Black Sea (Fischer *et al.* 1987; Relini *et al*. 2000). It has been recorded along the Atlantic coast of northern Morocco and in southern Portugal (Whitehead *et al*. 1984). In general terms, *R. asterias* can be considered as a Mediterranean endemic species. It generally inhabits the sandy bottom of coastal waters ranging from 2 to 200 m of depth, and is found to be most common between 20 and 50 m of depth. This species grows to about 80 cm in total length (TL) (Serena *et al.* 2010). In Morocco, they are incidentally caught by fisheries targeting benthic species with high market value but it is the main ray species exploited in the study area. It dominates the Rajiformes group in all landings at the northern Moroccan ports. In this study, we investigated the diet of *R. asterias* caught at the M'diq port (Mediterranean Moroccan coast) using two approaches: a qualitative approach and the systematic nature of ingested prey; and a quantitative approach that uses

monthly monitoring of changes in the emptiness coefficient in function of the size, seasons and the analysis of stomach contents based on the certain food indices.

Materials and Methods

In total 367 individuals of *R. asterias* were collected between April 2013 and March 2014 at the M'diq port, northern region of Morocco (Figure 1). They included 165 males and 202 females with their size varying from 20 to 66.5 cm and from 17 to 72 cm, respectively. They were captured by artisanal fishermen using trawls, long-line hooks and gill nets. The dissection of the specimens was performed with the incision from the anus to the mouth with a pair of scissors. The content of the digestive tract was taken and kept in 60% ethanol solution. Each stomach was cut longitudinally and emptied of its contents. The number of empty stomachs was recorded. Ingested prey was identified, counted, weighed and recorded using a dissecting microscope. The ingested prey was determined to the lowest possible taxonomic level according to FAO (1998), Serena (2005), Ajayi (1982). Quantitative analysis of stomach content was reflected in the calculation of the following indices: Emptiness coefficient: VI = (empty stomach number / examined stomachs number) ×100. Following Hyslop (1980) frequency of occurrence, number, and weight indices were calculated for each prey category. Frequency of occurrence (F) was calculated by dividing the number of stomachs containing a particular prey item or category by the total number of stomachs containing prey multiplied by 100. This index reflects the number of predators which utilize that prey resource, or the homogeneity of the foraging strategy. The percentage of a particular prey (N) was calculated by dividing the total number of prey items within the category by the total number of individual prey items in non-empty stomachs multiplied by 100; this index can reflect abundance or size of the prey. The gravimetric index (W) was obtained by dividing the total weight of a prey category by the total weight of all prey items multiplied by 100; this index can reflect the energetic importance of a prey item (Cortés 1997). The food factor was calculated using this formula: Q = (N x W). The index of relative importance (IRI) (Pinkas *et al.* 1971), which combines the frequency of occurrence of the prey (F), its coefficient number (N) and its weight coefficient (W): IRI = (N+ W) ×F gives a more accurate picture of the diet. It also allows the prioritization of the consumed prey. Main Power Index or Index Main Food MFI (Zander 1982) was calculated as below.

$$MFI = \sqrt{\left(\frac{\mathrm{N} + f}{2}\right)} \text{ x W}$$

We estimated the degree of preference for different prey by applying Hureau (1970) and Geistdoerfer (1975) prey classification methods.

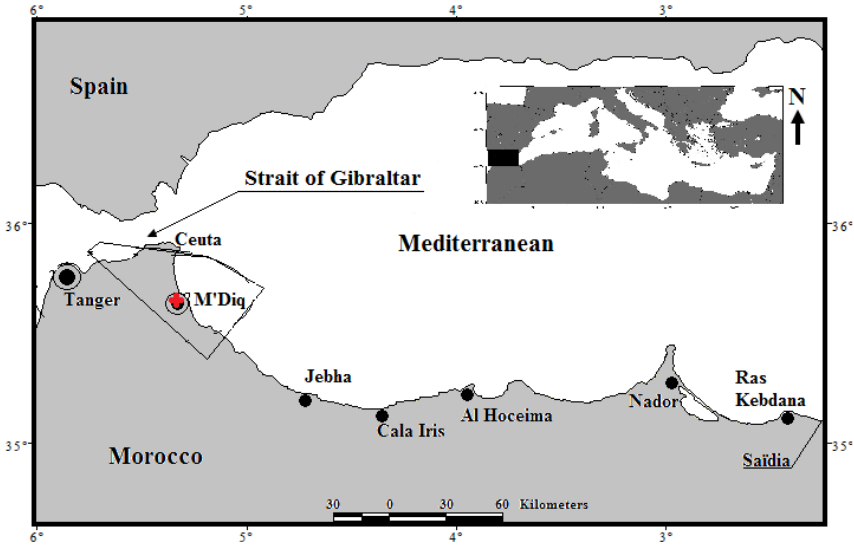

Figure 1. The study area (Modified from centre INRH/Nador 2006)

Results

In the examined samples, we found the total of 473 prey items. The analysis of these prey items shows that this species has a variable diet that includes various zoological groups (crustaceans, fish, polychaetes and molluscs). Arthropods are represented by crustaceans (decapods, isopods and amphipods) and Annelids (polychaetes) whose taxonomic determination has proved to be difficult. The diet includes molluscs such as cephalopods and bivalves. Vertebrates are represented by whole or partly digested fish belonging to Clupeidae, Carangidae and Sparidae, Engraulidae. This analysis indicates that *R. asterias* in the studied area of the Mediterranean Moroccan coast has a diverse diet. It also indicates that the qualitative composition of the prey depends not only on their preference for crustaceans and fish, but also on the abundance and availability of such food.

Vacuity index (%VI)

Among 368 individuals investigated, 109 had empty stomachs; this gives a mean vacuity index (%VI) 26.09%. This coefficient varied slightly with sex; 23.46% for male and 28.52% for females. However, variations of this coefficient depend on the size of the fish, meaning that it is larger for individuals of average size. Analysis of monthly variation of emptiness coefficient shows that the maximum values are recorded between May and July, and in December (Figure 2). Subsequently, there is decreasee in the coefficient of emptiness in March and April coinciding with the pre-spawning period. The fish seems to feed more intensively to complete the maturity.

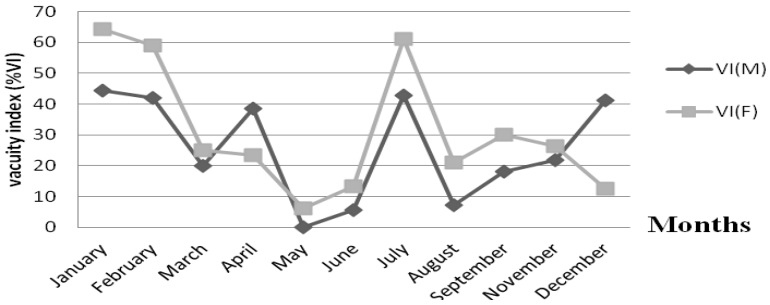

Figure 2. Monthly variation of vacuity index (%VI) of *Raja asterias* in the Mediterranean Moroccan coast

In total 248 full stomachs contained 473 prey items, weighing 480.07g which was equal to an average of 2 preys per stomach and an average weight of 1.01 g per prey. The classification of the prey is shown in Table 1. According to the classification method by Hureau (1970), the crustaceans and fish are the most preferred prey, whereas annelids and molluscs belong to the secondary prey group. According to the method described in Geistdoerfer (1975), it appears that *R. asterias* in the Mediterranean Moroccan coast feeds mainly on crustaceans and fish (preferred prey), whereas molluscs and annelids are additional prey (occasional prey). Zander (1982) classification shows that crustaceans and fish are essential prey (primary food) whereas annelids and molluscs are accessories prey (insignificant food). We summarize as *R. asterias* is carnivorous and has a relatively broad food spectrum. This species feeds mainly on crustaceans and fish.

Variations in diet in function to the size

We classified the individuals in two size categories: small (LT $\leq$ 42cm) and large (LT > 42 cm). Analysis of the diet changes depending on the size (Figure 2) shows that the frequency (F) and the percentage by number (N) of the crustaceans significantly decrease with the size. The same gradient was observed for dietary factor (Q) and the main power index (MFI). For fish, we found that the frequencies and percentages were greater in the large individuals (LT > 42 cm), whereas the weight percentages were significantly higher in the large individuals; this can be explained by the fact that predators, as they increase in size, ingest increasingly large sized prey. The values of Q and MFI are also in favor of large individuals. Annelids and molluscs constituted less frequency and a smaller percentage in weight.

Table 1. Values of prey indices found in the diet of *Raja asterias*: %F (frequency of occurrence), %N (percentage by number), % W (percentage in weight of prey items), Q: food coefficient and MFI: Main food index

	%F	%N	%W	Q: food coefficient	MFI: Main food index
Crustaceans	60.3	68.71	56.73	3897.91	455.62
Decapods	49.59	32.72	22.94	750.59	147.16
Amphipods	22.17	23.25	11.54	268.30	54.99
Isopods	19.38	21	13.95	292.95	62.54
Fish	29.43	26.42	41.45	1095.01	219.03
Clupéiformes	14.11	16.70	26.03	434.70	102.16
Perciformes	5.24	5.28	11.45	60.45	26.26
Annélids	6.85	2 .95	3.54	10 .44	7.88
Nématods	1.41	1.26	0.10	0.126	0.11
Polychaetes	0.80	1.05	0.06	0.063	0 .05
Molluscs	3.22	1.90	0.20	0.38	0. 32
Céphalopods	2.01	0.84	0.08	0.067	0.07

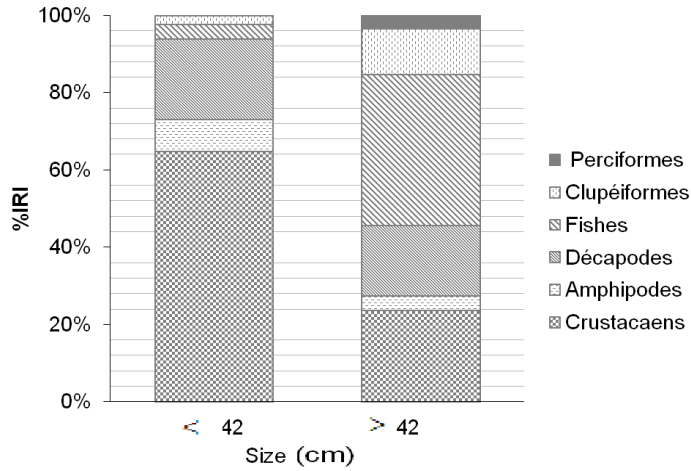

Figure 3. Changes in index of relative importance (%IRI) by size class of *Raja asterias*

Seasonal variation in diet

The ingested prey by *R. asterias* showed little variation throughout the year. We found crustaceans, fishes, annelids, and molluscs in all four seasons. The relative importance of different prey presents some variation depending on the season. In general, the percentage by the number of prey varied significantly for crustaceans and fish for the summer and fall seasons. The weight percentage changed only slightly over the four seasons. Annelids were observed only in three seasons (autumn, winter and summer), while the molluscs was not found in summer. The percentage by the number of fish was significantly higher during the summer season and autumn, while the values of the weight

percentages were slightly higher during the summer seasons and almost the same for the other seasons. Crustaceans were found throughout the year, but were significantly more abundant in the number and weight during summer and autumn. The fishes were also found throughout the year although their importance varied slightly with the seasons. The percentages were greater during the summer. We also found that over the four seasons, crustaceans and fish were still the most preferred preys in comparison to annelids (polychaetes) and molluscs.

Discussion

Our results showed that *R. asterias* caught off the Moroccan Mediterranean coast has relatively varied diet, consisting mainly of crustaceans, decapods, amphipods isopods, and fish. Molluscs and annelids were not significant. Our results are comparable to those obtained by other authors. Serena (2005) showed that the diet of *R. asterias* along the Italian coasts varies and consists essentially of shellfish, fish, polychaetes and molluscs. The major prey items are benthic species, although some pelagic species were also isolated from the stomachs of Mediterranean starry ray, which demonstrated that this ray species, as reported by Orlov (2003), is able to feed in some distance from the bottom. In our study area, the diet composition of rays consisted mainly of crustaceans (Brachyura, Natantia, Amphipods, Isopods, Thalassinidea) and fish (Ostéichtyen perciforme, Pleuronectiforme and Gobidae). Besides, we also identified prey items belonging to Mollusca, Cephalopoda and Echinodermata (Ophiuroidea). Moreover, we recorded a higher proportion of fish items in adult ray stomachs, which can be explained by their greater experience and subsequent better success in fish predation. Similar diet among various size groups of rajids have been reported from other seas (Holden and Tucker *et al.* 1974; Ajayi 1982; Orlov *et al*. 1998; Orlov 2003). High degree of similarity in diet of male and female individuals was found. Our results agreed with previous studies conducted in the Central and South-Central Mediterranean Sea (Capape and Quignard 1977; Cuoco *et al.* 2005; Serena *et al*. 2005; Romanelli *et al*. 2007), confirming the starry ray as a crustacean feeder.

Acknowledgements
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References

Ajayi, T.O. (1982) Food and feeding habits of *Raja* species (Batoidei) in Carmarthen Bay, Bristol Channel. *J. Mar.Biol. Ass. U.K*. 62 : 215-223.

Capapé, C., Quignard, J. (1977) Contribution à la biologie des Rajidae des cotes tunisiennes. 6. *Raja asterias* Delaroche, 1809. Régime alimentarie. *Bull Inst Natl Sci Tech Oceanogr Peche Solammbò* 4: 319–332.

Cortés, E. (1997) A critical review of methods of studying fish feeding based on analysis of stomach contents: application to elasmobranch fishes. *Can. J. Fish. Acquat. Sci.* 54: 726-738.

Cuoco, C., Mancusi, C., Serena, F. (2005) Studio sulle abitudini alimentari di *Raja asterias* Delaroche, 1809 (Chondrichthyes, Rajidae). *Biol Mar Medit* 12: 504–508.

FAO (1998) Guide d'identification des espèces pour les besoins de la pêche. Guide d'Identification des Ressources Marines Vivantes du Maroc, FAO, Rome. 28 planches en couleur. 263 pp.

Fischer, W., Bouchot, M.L., Schneider, M. (1987) Fishes FAO d'identification des especes pour les besoins de la pêche. (Revision 1). Mediterranee et Mer Noire. Zone de peche 37, Vol. II. Rome, FAO,Vertebres, 847–876.

Geistdoerferp. (1975) Ecologie alimentaire des Macrouridae, Teleostéens Gadiformes. Thèse de doctorat. Univ. Paris 6. 315 pp.

Holden, M.J., Tucker, R.N. (1974) The food of *Raja clavata* Linnaeus 1758, *Raja montagui* Fowler 1910, *Raja naevus* Muller and Henle 1841 and *Raja brachyura* Lafont 1873 in British waters. *J. Cons. Int. Explor. Mer* 35(2): 189-193.

Hureau, J.C. (1970) Biologie compareé de quelques poissons antarctique (Nototheniidae). *Bulletin du Institute Océanographique de Monaco* 68(1391): 1-250.

Hyslop, E.J. (1980) Stomach contents analysis: a review of methods and their application. *J.Fish Biol.* 17: 411-429

Relini, G., Biagi, F., Serena, F., Belluscio, A., Spedicato, M.T., Rinelli, P., Follesa, M.C., Piccinetti, C., Ungaro, N., Sion, L., Levi, D. (2000) I selaci pescati con lo strascico nei mari italiani. Biologia Marina del Mediterranaeo 7(1): 347–384.

Orlov, M. A. (1998) The diet and feeding habits of some deep-water benthic skates (Rajidae) in the Pacific waters off the northern Kuril Island and southeastern Kamchatka. *Alaska Fishery research Bulletin* 5: 1-17.

Orlov, M. A. (2003) Diets, feeding habits, and trophic relations of six deep-benthic skates (Rajidae) in the western Bering Sea. *Aqua* 7: 45-60.

Pinkas, L.M., Oliphant, S., Iverson, I.L.K. (1971) Food habits of albacore, bluefin tuna, and bonito in Californian waters. *California Fish and Game* 152:1-105.

Romanelli, M., Colasante, A., Scacco, U., Consalvo, I., Finoia, M.G., Vacchi, M. (2007) Commercial catches, reproduction and feeding habits of *Raja asterias* (Chondrichthyes: Rajidae) in a coastal area of the Tyrrhenian Sea (Italy, northern Mediterranean). *Acta Adriat* 48: 57–71.

Serena, F. (2005) Field Identification Guide to the Sharks and Rays of the Mediterranean and Black Sea. In: FAO Species Identification Guides for Fishery Purposes, FAO, Rome. 136 pp.

Serena, F., Barone. M., Mancusi, C. (2010) Field identification guide to the skates (Rajidae) of the Mediterranean Sea. Guidelines for data collection and analysis. *Marina Mediterranea* 17(2): 204 pp.

Serena, F., Barone, M., Mancusi, C., Abella, A.J. (2005) Reproductive biology, growth and feeding habits of Raja asterias (Delaroche, 1809), from the North Tyrrhenian and South Ligurian Sea (Italy), with some notes on trends in landing. Theme Session on Elasmobranch Fisheries Science CM2005/N: 12. 2005 ICES Annual Science Conference 20–24 September 2005.

Whitehead, P.J.P., Bauchot, M.L., Hureau, J.C., Nielsen, J., Tortonese, E. (1984) Fishes of the North-Eastern Atlantic and Mediterranean (FNAM), Vol. I. UNESCO, Paris, 510 pp.

Zander, C.D. (1982) Feeding Ecology of littoral go biid and plennioid fish of the Banyls area (Mediterranean Sea). Item Main food and trophic dimension of niche and ecotope. *Vie et Milieu* 32 : 1-10.

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