FEEDING ECOLOGY OF SOME BENTHIC FISH SPECIES FROM THE ROMANIAN BLACK SEA COAST (AGIGEA-EFORIE NORD AREA)

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Abstract. The present study investigates the feeding ecology of round goby (*Neogobius melanostomus* Pallas, 1818) as compared to other benthic fish coexisting on rocky bottom of the Black Sea: knout goby (*Mesogobius batrachocephalus* Pallas, 1814) and black scorpionfish (*Scorpaena porcus* Linnaeus, 1758). The most important prey items were: bivalves (*Lentidium mediterraneum*, *Cerastoderma edule*, *Mytilaster lineatus*, *Mytilus galloprovincialis*), decapods (*Xantho poressa*), amfipods, ispods (*Idotea balthica*), gastropods (*Rissoa* sp., *Bittium* sp., *Setia* sp., *Hydrobia* sp.), chrionomid larvae, fishes and unidentified fragments. Both gobiids seem to share the same diet, with some small differences; the round goby females prefer organisms from fine sand community while males prefer those from the rocky mussel community. The round goby exhibited a generalistic feeding strategy with a relative broad niche width. The trophic niche of knout goby is narrower than that of the round goby. The trophic niches of the gobiids are broader than that of black scorpionfish. The trophic niches of round goby and black scorpionfish overlap in a proportion of 77.4%. Pianka's dietary overlap shows that the trophic niches of both gobiids analysed overlap in a proportion of approximately 90%. These results may indicate a high level of interspecific competition.

Keywords: round goby, knout goby, black scorpionfish, Black Sea, feeding ecology, benthos.

Rezumat. Ecologia hrănirii la unele specii de peşti bentonici de la litoralul românesc al Mării Negre (sectorul Agigea-Eforie Nord). Studiul de faţă prezintă date privind ecologia hrănirii la strunghil (*Neogobius melanostomus*) comparativ cu alte două specii ce populează substratul dur: hanosul (*Mesogobius batrachocephalus*) şi scorpia de mare (*Scorpaena porcus*). În hrana speciilor analizate au fost identificate bivalve (*Lentidium mediterraneum*, *Cerastoderma edule*, *Mytilaster lineatus*, *Mytilus galloprovincialis*), decapode (*Xantho poressa*), amfipode, izopode (*Idotea balthica*), gasteropode (*Rissoa* sp., *Bittium* sp., *Setia* sp., *Hydrobia* sp.), larve de chironomide, peşti şi fragmente neidentificate datorită gradului avansat de digestie. Rezultatele cercetărilor au arătat că ambele specii de gobiide prezintă acelaşi regim trofic, cu mici diferenţe; femelele de strunghil preferă organismele ce populează substratul nisipos, în timp ce masculii preferă organismele de pe substrat dur. În ceea ce priveşte nişa trofică, s-a constatat că strunghilul prezintă o strategie de hrănire de tip generalist, în timp ce scorpia de mare a manifestat un grad ridicat de selectivitate. Nişele trofice ale strunghilului şi scorpiei de mare se suprapun în proporţie de 77.4%. Conform indicelui Pianka, gradul de suprapunere a nişelor trofice ale celor două specii de gobiide este de aproximativ 90%, ceea ce ar putea indica un nivel ridicat de competiţie interspecifică.

Cuvinte cheie: strunghil, hanos, scorpie de mare, Marea Neagră, ecologia hrănirii, bentos.

Introduction

The studies of feeding behaviour and diet are the key for understanding many aspects of the biology, ecology, physiology and behaviour of fish (Rosecchi & Nouazi, 1987; Gonclave & Erzini, 1998). Given the inherent difficulties of *in situ* observations of feeding behaviour of each species, the analysis of gastrointestinal contents has become the most widely used method for studying the fish diet. Fish have the potential to integrate different characteristics of their habitats at spatial/or temporal scales because of their mobility and longevity. Thus, fish diet reflects the prey availability and a fish can be considered as a "sampling tool" whereby its gastrointestinal content represents a sample of the prey items available in the aquatic environment (Wootton, 1990).

Feeding ecology research is a fundamental tool for understanding fish roles within their ecosystems since they indicate relationships based on feeding resources and

indirectly indicate the community energy flux (Hajisamaea *et al*., 2003) which allows inferring competition and predation effects on community structure. Other resources, such as space and time are also important for understanding the community ecology and the ecological theory predicts that resource partitioning at spatial, temporal and trophic level may increase tolerance of niche overlap, reducing competition pressure between co-occurring species. Ross (1986) identified that in aquatic environments food is the main limiting factor and that its partition defines functional groups within the community which get together in guilds according to trophic similarity. These trophic guilds seem to be a consequence of such resource partitioning which could explain how several species can coexist in the same space by differing in use of several resource dimensions. Several studies have focused on competitive exclusion and resource partitioning in teleost fish and have found that habitat partitioning could be related to high dietary overlap among competing species or to interactive competition where competing species have the same preference for preys (Jansen *et al*., 2002).

In general, habitat and diet are the most important niche dimensions separating coexisting fish species (Ross, 1986); both high and low overlap in these dimensions could be indicative of competition (Hansson, 1995; Raborn *et al*., 2004)

The round goby (*Neogobius melanostomus*) is one of the most abundent and frequent benthic fish species feeding on Agigea-Eforie Nord area of the Black Sea. The round goby occupies a variety of habitat types including coarse gravel as well as shell and sandy inshore areas (Skora, 1993). Round gobies have a high tendency for site fidelity in rocky habitats. Larger round gobies may induce smaller fish to leave preferred rock habitats and move to sand habitats from which they disperse (Ray & Corkum, 2001). *Scorpaena porcus* is a shallow water species which is believed to lie motionless during the day among rocks on the seabed and feed mainly at night (Bascinar & Salgam, 2009).

The aim of this study is to investigate the feeding ecology of the round goby compared with two other benthic fish coexisting on rocky substrate of the same area: the knout goby (*Mesogobius batrachocephalus*) and the black scorpionfish (*Scorpaena porcus*) in order to present their diet, the way they use different types of bottoms their niche characteristics (niche width, the degree of extra-& interspecific overlap) with the purpose of their rational exploitation and protection.

Material and methods

The present study was carried out in the Agigea-Eforie Nord area of the Black Sea (Fig. 1). Fish were sampled with a trap net placed at the depth of 9m (Agigea) and 12m (Eforie Nord), from 10^{th} to 20^{th} of June and 10^{th} to 20^{th} of September 2008, from 4 to 7 a.m.

For each species there were sampled 100 individuals. In the laboratory the sampled fish were identified, counted, measured and weighted. Sex was determined by external observation and confirmed by gonadal examination. For dietary analysis fishes were dissected and the gastrointestinal tracts were drawn out and immediately preserved in absolute ethyl alcohol in order to prevent tissues damages. Then the gastrointestinal tracts were longitudinally sectioned, the gastrointestinal content of each individual was weighted using an analytical balance and the prey items were identified to the lowest taxonomic level possible using a stereomicroscope Novex AP-Range. A high level of prey identification (LPI) was reached for most of the items up to family; niche breadth value could be influenced by such LPI. The use of LPI could underestimate species dietary breadth in the same way those values of dietary overlap could have been overestimated by the LPI (Hansson, 1998).

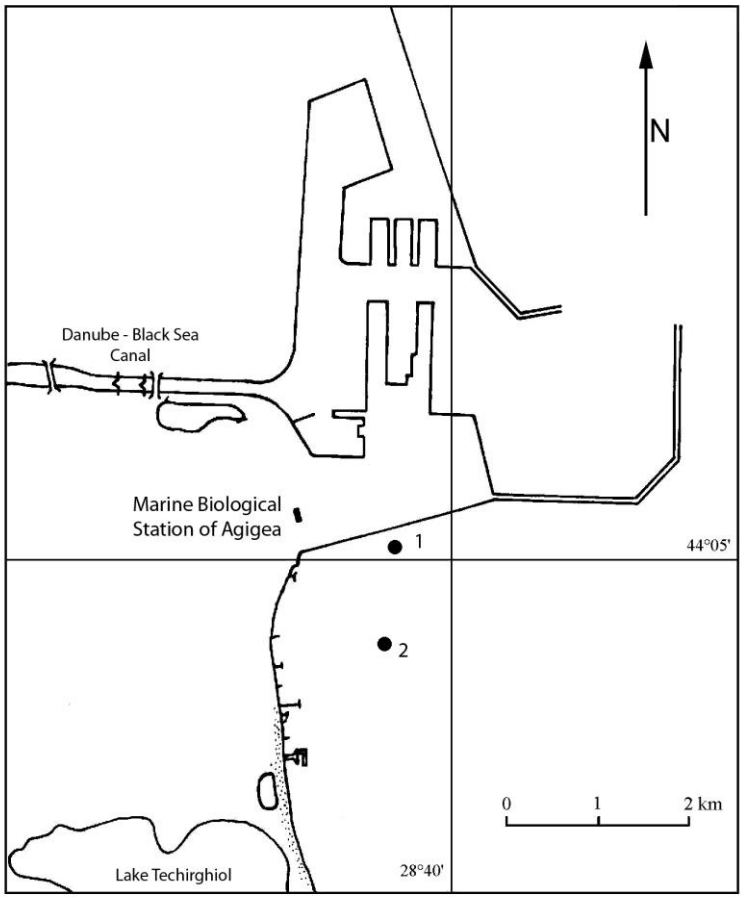

Figure 1. Map of the Agigea-Eforie Nord area, indicating the location of the sampling sites.

The dietary components were wet-weighted and preserved in 70% ethanol. The empty gastrointestinal tracts were also counted. In order to determine the importance of each food category to the diet of the gobiid weight percent (%*W*), frequency of occurrence (%*F*), Hureau feeding coefficient (*B*'), Levins-Hulbert index for niche breadth (*B*, B_A), Pianka's dietary overlap (*B*) were calculated (Gomoiu & Skolka, 2001).

The Levins index for niche breadth is:

$B = 1/\Sigma p_i^2$ where,

B is Levins measure for niche breadth; p_i is the proportion of individuals that use the resource *i* or the proportion of diet of each individual composed of *i*.

Then B was standardized on a scale from 0 to 1 using Hulbert index:

$B_A = (B\text{-}1)/(n\text{-}1)$ where,

B_A is Levins standardized index; *B* is Levins index for niche breadth; *n* is the number of possible resources (Gomoiu & Skolka, 2001).

The Pianka's index:

$O_{1,2} = \Sigma\ (p_{i1} \times p_{i2})/\sqrt{\Sigma p_{i1}^2 \times \Sigma p_{i2}^2}$ where,

p_{i1}, p_{i2} are the proportions of the *i* resource used by specie 1 and 2.

This measure of overlap ranges from 0 (no habitats used in common) to 1 (complete overlap).

Results and discussion

The diet of analysed species consists of: bivalves (*Lentidium mediterraneum*, *Cerastoderma edule*, *Mytilaster lineatus*, *Mytilus galloprovincialis*), decapods (*Xantho poressa*), amphipods (*Amphithoe* sp., *Ampelisca* sp.), isopods (*Idotea balthica*), gastropods (*Rissoa* sp., *Hydrobia* sp.*)*, chironomid larvae, fish fragments, algae and undefined fragments (Fig. 2). Empty gastrointestinal tracts occurred in 15% of samples for the round goby, 18% of samples for the knout goby and 35% for black scorpionfish. An explanation may be found in the variation of the environment conditions (temperature, turbidity). Both gobiid species feed on organisms inhabiting fine sand community dominated by *Lentidium mediterraneum* (also *Cerastoderma edule* and amphipods) but equally consume elements characteristic for rocky mussels' community (as *Mytilaster lineatus*, *Mytilus galloprovincialis* and *Xantho poressa*), while black scorpionfish's diet was based on organisms inhabiting the rocky bottom. The results of the present study are similar to those obtained for the same species from the Black Sea by different researchers with small differences related to the difference between prey availability in different areas of the sea (Table 1).

The frequency of bivalve was higher than 50%. Four species were the most abundant: *Lentidium mediterraneum*, *Cerastoderma edule*, *Mytilus galloprovincialis* and *Mytilaster lineatus*. The highest frequency of occurrence had *Lentidium mediterraneum* which was found in 55% of the gastrointestinal tracts. The highest weight percent of the prey items from the gobiid diet had *Lentidium mediterraneum* (Fig. 1) - as previously reported in the literature (Băcescu *et al*., 1965) and confirmed by the present results. It was 27% for round goby and 23% for the knout goby; it was also the main prey for females (50.5%) but not for males (12.3%). Males of round goby prefer *Mytilaster lineatus* (15.4%) more than females (2.1%) (Table 2).

Crustaceans were represented by *Xantho poressa* and various amphipods. *Xantho poressa*'s frequency of occurrence was estimated at 10% for *Neogobius melanostomus*, 11.6% for *Mesogobius batrachocephalus* and 23% for *Scorpaena porcus*. The weight contribution of this species ranged from 15.24% for round goby, to 14.15% for knout goby and up to 41% for black scorpionfish. We found a high percent of amphipods (up to 16.6% frequency of occurrence for round goby), especially *Ampelisca diadema* who lives in tubes and migrates during the night in search for food, which explains the fact that amphipods become an easy prey for the fish

Small snails from genus *Rissoa* sp., *Hydrobia* sp., *Setia* sp. and *Bittium* sp. also played an important role in round goby's diet (frequency of occurrence 22.2%, weight contribution 2.59%). Their weight contribution was not important, but their frequency of occurrence was up to 32% for round goby males.

The isopod *Idotea balthica* play an important role in these fish diet. It is frequency of occurrence was almost the same for round goby (11.3%) and for knout goby (11.2%). The weight contribution was also very small (2.82% for round goby, 5.2% for knout goby and 7.12% for black scorpionfish).

Chironomid larvae were also observed in the food of gobiids and their frequency of occurrence varied from 30% for round goby to 13% for knout goby; their weight contribution was also very low, 1% for each gobiid species.

We found also a high level of fish fragments for all the three analyzed species (up to 27% weight contribution for black scorpionfish). These gobiid species present also the cannibalism phenomenon as previously was reported in the literature (Porumb, 1961).

Both gobiids seemed to have the same diet with some small differences; round goby females prefer organisms from fine sand community, while males prefer organisms from rocky mussels' community.

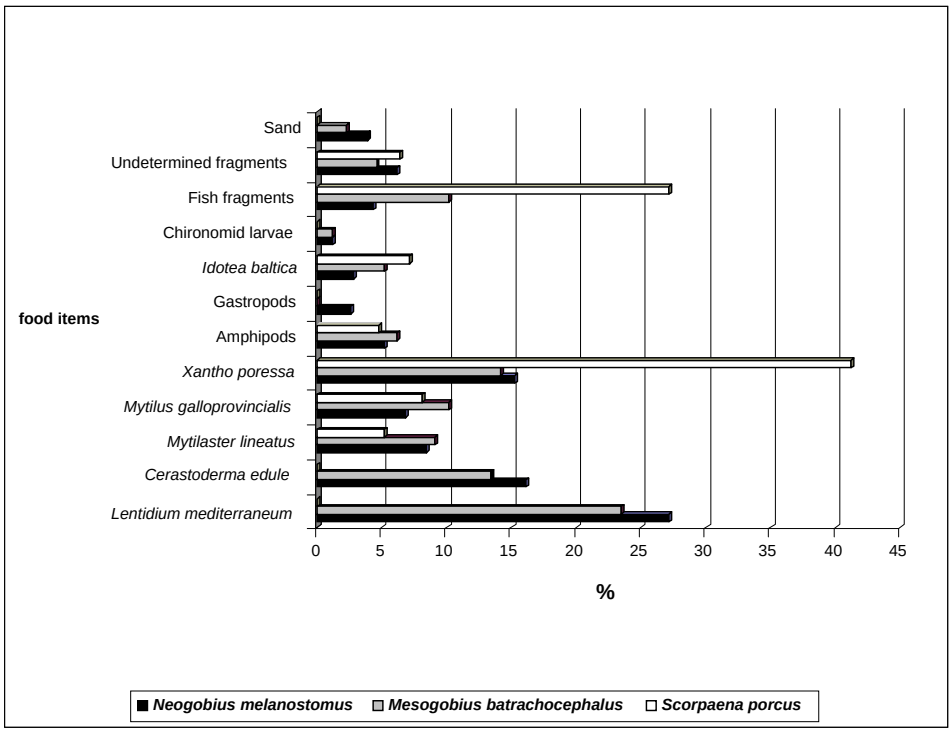

Figure 2. Food items from the gastrointestinal tracts of the round goby, knout goby and black scorpionfish (*%W* = weight percent).

Table 1. Diet of *Neogobius melanostomus*, *Mesogobius batrachocephalus* and *Scorpaena porcus* – scientific literature data. The data marked with * are taken from Stergiou & Karpouzi, 2002.

Food items	Area	Year	Reference
Neogobius melanostomus			
Fish, *Mytilus* sp., *Palemon*, *Xantho* sp., *Idotea* sp., amphipodes	Black Sea	1956-1958	Porumb, 1961
Bivalves, isopodes, amphipodes, fish, chironomid larvae	Black Sea	1953-1964	Bănărescu , 1964
M. trossulus, *I. balthica*, *Hydrobia* sp., *B. improvisus*, *N. diversicolor*	Gulf of Gdansk	1995-1996	Skora & Rzeznik, 2001
Polychaeta, Oligochaeta, Crustacea, Bivalvia, Gastropoda, Pisces, Chironomidae, Gobiidae	Gulf of Gdansk	2001	Wandzel, 2003
Bivalves, decapodes, isopodes, amphipodes, polychaetes	Black Sea	1996-2000	Mihălcescu, 2005
D . polymorpha, detritus, plant	Sapanka Lake	2006	Gaygusuz *et al*., 2007
Bivalves, polychaetes, gastropods	G. Gdansk	2004	Karlson *et al*., 2007
Macrophytes, polychaetes, bivalves,amphipodes, isopodes, decapodes, fish	Black Sea	2004-2006	Bănaru, 2008
Nereis diversicolor, Amphipoda, Chironomidae	Curonian Lagoon	2002	Rakauskas *et al*., 2008
Polychaeta, *Mytilus* sp., *Corbula* sp., Amphipods	Black Sea	2004-2006	Bănaru & Harmelin-Vivien, 2009

Food items	Area	Year	Reference
Mesogobius batrachocephalus			
Polychaetes, *Gobius* sp, *Palaemon* sp.	Black Sea	1956-1958	Porumb, 1961
Decapods, bivalves, fish	Black Sea	1953-1964	Bănărescu, 1964
Fish, decapodes, isopodes, bivalves, amphipodes, gastropodes	Black Sea	1996-2000	Mihălcescu, 2005
Fish, decapods, *Mytilus*, *Cyclope*	Black Sea	2003-2005	Crețeanu & Papadopol, 2006
Scorpaena porcus			
Fish, decapods	Black Sea	1953-1964	Bănărescu, 1964
Brachyurans (*Xantho* sp., *Portunus* sp.), decapods, fish	Cyclades Islands	-	Kyrtatos, 1982*
Fish, appendicularians, copepods, other	G.Lions	1981	Khoury, 1984*
Fish, brachiurans, decapods, other	G.Gabes	-	Bradai & Bouain, 1990*
Brachyurnas, fish, decapods, other	G.Lions	1980-1986	Harmelin-Vivien *et al.*, 1989*
Fish, crustaceans, other	G.Mareseille	1980	Bell & Harmelin-Vivien, 1983*
Brachyurans, fish, decapods, other	G.Palermo	1981-1983	Arculeo *et al.*, 1989, 1993*
Brachyurans, fish, decapods, stomatopods, other	Adriatic Sea	1987-1991	Pallaoro & Jardas, 1990*
Decapods, crustaceans, brachyurans	G S Evvoikos	1992-1993	Petrakis *et al.*, 1993*
Fish, crustaceans, molluscs, algae	Black Sea	2003-2004	Bascinar & Saglam, 2009
Crustacea, fish, Gastropoda	Black Sea	2002-2003	Demirhan & Can, 2009

Table 2. Frequency of occurrence of food items for the analyzed fish species (F - females, M - males, T - total).

	***Neogobius* sp.**			***Mesogobius* sp.**			***Scorpaena* sp.**		
Trophic resources	**F**	**M**	**T**	**F**	**M**	**T**	**F**	**M**	**T**
Lentidium sp.	21.3	21.2	12.3	23.8	21.4	22.9	-	-	-
Cerastoderma sp.	30.1	76.5	55	14.3	7.1	11.4	-	-	-
Mytilaster sp.	21.7	5.9	7.5	7.1	28.6	20	12.3	15.1	14.2
Mytilus sp.	8.7	5.9	7.5	7.1	23.8	17.1	8.9	10.2	9.6
Xantho sp.	17.4	0	10	7.8	14.3	11.6	21.3	24.5	23
Amphipods	12.1	18.5	16.6	11.3	6.3	9.1	3.5	2.5	2.9
Gastropods	22.3	32.4	22.2	-	-	-	-	-	-
Idotea sp.	10.1	12.2	11.3	9.3	13.4	11.2	6.9	10.4	8.3
Fish	26.1	29.4	27.5	10.1	15.1	12.3	11.3	10.5	10.9
Undet. fragments	17.4	11.8	15	10.4	15.1	13.4	10.5	4.2	7.8
Chironomids	33.5	38.8	30	12.3	15.4	13.8	-	-	-

The Hureau feeding coefficient (Table 3) for round goby varies during the summer between 0 (empty gastrointestinal tracts) and 50.6%. The same coefficient varies between 0 and 48.9% for the knout goby and between 0 and 27.5% for the black scorpionfish. The feeding coefficient is higher for the gobiids maybe because they are very mobile, using resources from different type of bottoms.

The mean value of the feeding coefficient for both species of gobiids is higher for females then for males because females are eating more than males (they are

accumulating energy for gonads development).

Table 3. Hureau feeding coefficient values calculated for each species. Number within brakets indicates number of preys for each species.

Species	***%FI***
Neogobius melanostomus	0 – 50.6 (12)
Mesogobius batrachocephalus	0 – 48.9 (11)
Scorpaena porcus	0 – 27.5 (7)

Levins-Hulbert niche breadth index showed that the round goby exhibited a generalistic feeding strategy with a relative broad niche breadth. The trophic niche of knout goby (0.62) is narrower than that of the round goby (0.68). Both gobiids trophic niches are broader than that of black scorpionfish (0.45).

MacArthur’s niche overlap coefficient shows that between the two species of gobiids there is an overlap of 89% (between round goby and knout goby) and 91% (between knout goby and round goby). The trophic niche of round goby and black scorpionfish overlap in a proportion of 77.4% (the inverse ratio is 70%). The trophic niches of the knout goby and black scorpionfish overlap in a proportion of 65.7% (the inverse ratio is 67%) (Table 4).

Table 4. Dietary overlap values between the studied species.

	Neogobius sp.	*Mesogobius* sp.	*Scorpaena* sp.
Neogobius sp.	-	0.89	0.77
Mesogobius sp.	0.91	-	0.65
Scorpaena sp.	0.70	0.67	-

Pianka’s dietary overlap shows that the trophic niches of both gobiids analysed overlap in a proportion of approximately 90%. All the values obtained for MacArthur&Levins and Pianka index are higher than 0.6 indicating a high level of interspecific competition between these species.

Conclusions

The diet of analysed species (*Neogobius melanostomus*, *Mesogobius batrachocephalus* and *Scorpaena porcus*) consists of: bivalves (*Lentidium mediterraneum*, *Cerastoderma edule*, *Mytilaster lineatus*, *Mytilus galloprovincialis*), decapods (*Xantho poressa*), amphipods (*Amphithoe* sp., *Ampelisca* sp.), isopods (*Idotwa balthica*), gastropods (*Rissoa* sp., *Hydrobia* sp.), chironomid larvae, fish fragments, algae and undefined fragments.

The gobiids feed on rocky and sandy bottom, but black scorpionfish prefer the resources from the rocky bottom. Also gobiids males prefer rocky bottom while females prefer the sandy one.

The feeding coefficient is higher for females than for males because they need more energy for their gonad development.

Both gobiids trophic niches are broader than that of black scorpionfish.

The trophic niches of the 3 species overlap in a high proportion which may indicate a high level of interspecific competition.

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