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Muricid *Rapana venosa* (Valenciennes, 1846) in the Black Sea

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Abstract

Population structure and morphological variability as well as consumption rates and prey preferences of the muricid whelk *Rapana venosa* in the Black sea studied. The largest rapana specimens are found in the localities with enough food available. Rapana in the rest of the samples have lack of food and sizes several times smaller. The age structure of populations is characterized by lack of juvenile specimens. Results showed an average consumption of about 1 bivalve prey per day (or 0,789 g wet weight per day). Predation was species and size selective towards large specimens of *Mytilus galloprovincialis*.

Introduction

At the moment, the benthic fauna of the Black Sea undergoes drastic changes. The leading role in these processes plays euthrofication and introduction of non-indigenous species from other areas (Sorokin, 1982). The Asian whelk *Rapana venosa* (Valenciennes, 1846) (Gastropoda: Neogastropoda: Muricidae), being tolerant to wide variations in temperature, salinity and oxygen concentration (Zolotarev, 1996; Mann and Harding, 2003), successfully settled down in the Black Sea as well as along the Northern Adriatic, American Atlantic (Chesapeake Bay) (Harding and Mann, 1999) and the South Atlantic oceans (Pastorino *et al*., 2000). This large predatory gastropod has been causing the depletion of large stocks of commercial bivalves (oysters and mussels) in the Black Sea, resulting as a dominant species in the benthic ecosystems. At the moment, due to detriment to its forage reserve, the quantity of *Rapana* whelks diminished, and its population stays in oppressed condition. Due to huge role of introduced species in the functioning of isolated marine ecosystems, such as the Black Sea, the forecast of further development of their populations in new conditions is very important.

The main purpose of the project carried out on the base of the Southern branch of P. P. Shirshov Institute of Oceanology RAS is to compile information about changes in the condition of *Rapana venosa* population since its appearance in the Black Sea till the present time and to suppose possible strategies of its further development. Despite the long history of *Rapana* invasion in the Black Sea, there is still no idea about variability of morphological and biological characters of its population in this area. In the framework of this project morphological and biological variability of populations from different localities as well as an investigation of consumption rates and food preferences were done. The preliminary results on these studies are presented in this paper

Material and Methods

I. Population structure and morphological variability. During May-September 2009 *Rapana* specimens from 8 points of the Northern and North-Eastern part of the Black Sea coast were collected (Fig. 1 and Table 1). In total, 447 specimens were analyzed.

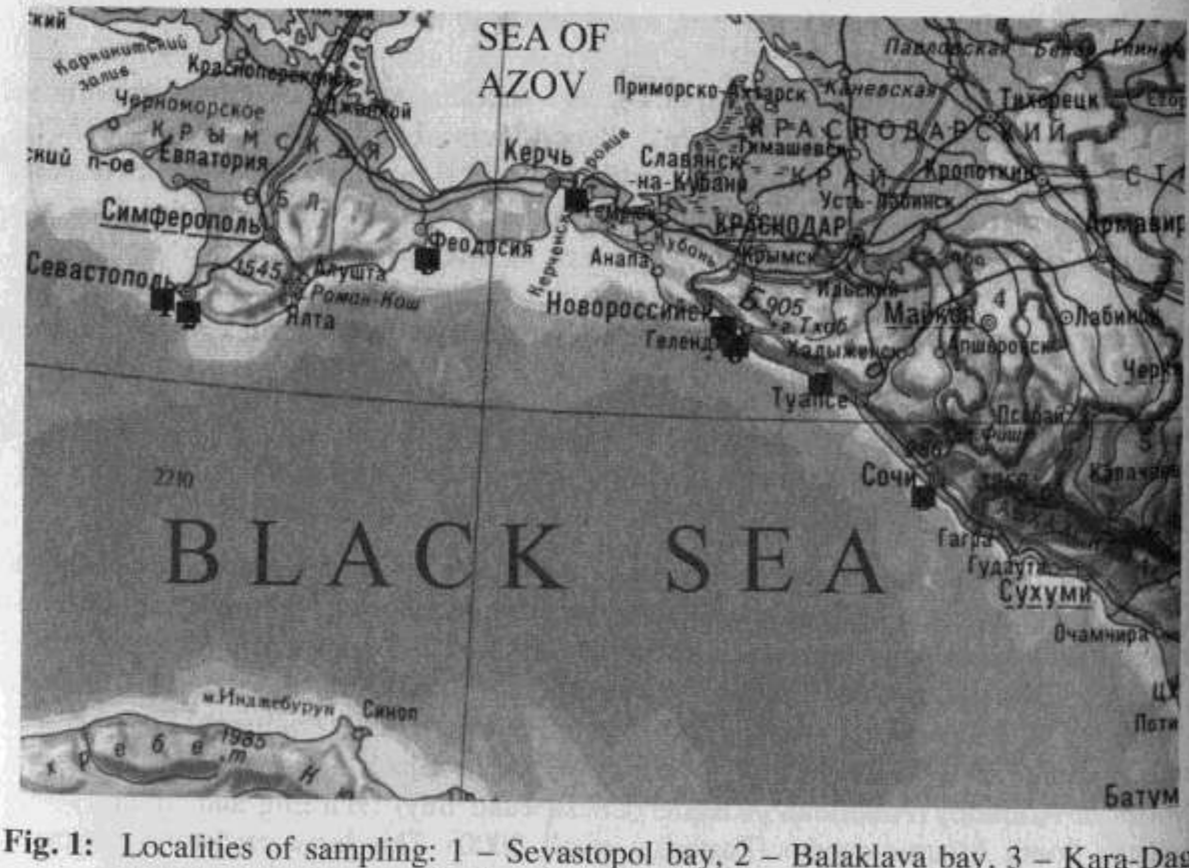

Fig. 1: Localities of sampling: 1 – Sevastopol bay, 2 – Balaklava bay, 3 – Kara-Dag reserve, 4 – Tuzla spit, 5 – Kabardinka, 6 – Blue bay (Gelendzhik), 7 – Orlyonok (pioneer camp), 8 – Sochi.

Table 1: Material of the study

Locality	Sevastopol Bay	Balaklava Bay	Kara-Dag reserve	Tuzla spit	Kabardinka	Blue Bay	Orlyonok	Sochi
Date of collection	24.06.09	23.06.09	26.06.09	30.06.09	21.05.09	12.06.09	01.09.09	30.08.09
No in sample	69	46	25	102	21	83	51	50
Substrate and prey items	Rocks with mussels	Rocks with mussels	Rocks with mussels	Sand with *Anadara* and *Chamelea*	Sand with *Chamelea* between rocks	Rocks with small mussels	Sand between rocks and rocks with small mussels	Artificial piers with small mussels
Depth, m	5-10	5-12	3-5	3	15	20	0.5-3	0-1

Samples were fixed in 4% formalin or 70% alcohol, brushed, individually measured (shell length, length of the last whorl, length of the aperture, diameter of the aperture, width of the aperture, mm) and weighed prior the removal of the soft tissue. Soft tissue was weighed (wet weight, g) to the nearest 0.01 g. Age was approximately identified by counting spawning marks on operculums. The sex was identified by presence (males) or absence (females) of a penis. Diagrams of the size, sex and age structure were created using Microsoft Excel.

II. Consumption rates and prey preferences of *Rapana venosa* in the Black Sea. The study was conducted along the coast of the Blue Bay (Gelendzhik, Russia) (Fig.1), a hard bottom habitat with random sandy sections. The hard bottom macrobenthic community is dominated by the bivalve *Mytilus galloprovincialis*, while the soft bottom – by the bivalve *Chamelea gallina*. During June–July 2009, five experimental cages (50 x 50 x 50 cm – 0.5 cm mesh) were positioned under a pier and fixed to the sea bottom at 6-7 m depth. Five *R. venosa* specimens (50–55 mm shell length) were kept starving for 48 h prior to the start of the experiment in order to standardise hunger levels. *M. galloprovincialis* and *C. gallina,* common representative of the local shallow water bivalve community, were selected as prey for the experiment. Prey were collected from neighbourhood of the experimental site by scuba diving and were put into each cage, divided in two length size classes (class 1; class 2) as follows:

1. *Mytilys galloprovincialis*: 10 ind. class 1 = 15–30 mm shell length; 10 ind. class 2 = 31–60 mm shell length;
2. *Chamelea gallina*: 7 ind. class 1 = 5–7 mm shell length; 7 ind. class 2 = 8–15 mm shell length.

Starting from June 20th 2009, for an experimental period of 40 days, cages were examined once a week by scuba diving, removing and measuring (calliper: 0.1 mm) the empty shells of all prey eaten. In the same occasions, bivalves consumed were replaced with prey of similar dimensions thus maintaining constant prey/size availability.

A size range of 50 *Mytilus* specimens (shell length 17-51 mm) was collected, individually measured (shell length, mm) and weighed prior the removal of the soft tissue; soft tissue was weighed (wet weight, g) to the nearest 0.01 g. Data were utilized for elaborating prey size/weight relationships. Data analysis was performed utilizing Microsoft Excel.

Results

I. Population structure and morphological variability. The size structure of collected samples is represented on Figures 2-9. Maximum shell length (102.2 mm) and weight (227.64 g) was found in *Rapana* specimen from Tuzla Spit, minimum (22.3 mm and 1.93 g respectively) – in specimen from Sochi. The bulk of the specimens from Tuzla Spit had 60-90 mm shell Fig. 3). The bulk of the specimens from Kara-Dag had 50-80 mm shell length, from the Sevastopol Bay – 40-80 mm, from the Balaklava bay – 40-50 mm, from Kabardinka – 40-50 mm, from the Blue Bay – 40-50 mm, from Orlyonok – 30-50 mm, from Sochi – 30-40 mm.

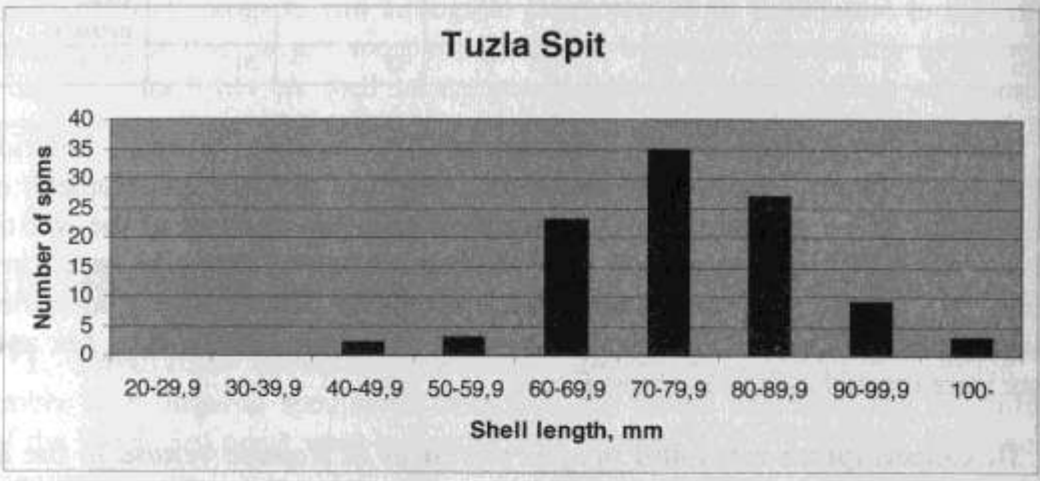

Fig. 2: Size structure of *Rapana venosa* from Tuzla spit, 30.06.2009

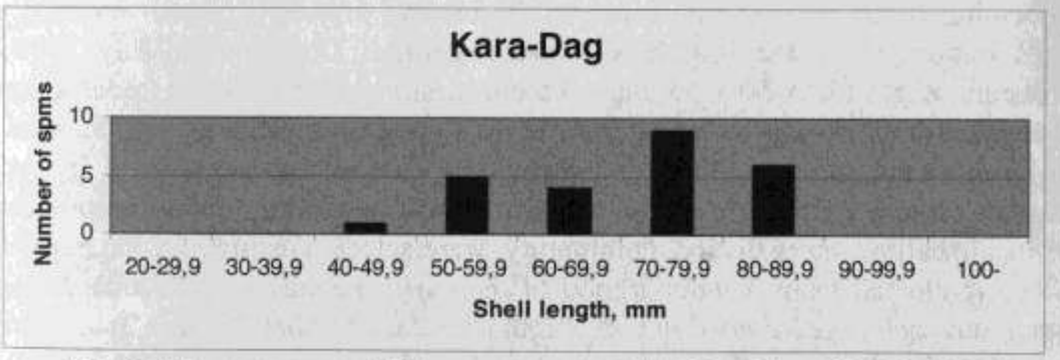

Fig. 3: Size structure of *Rapana venosa* from Kara-Dag, 26.06.2009

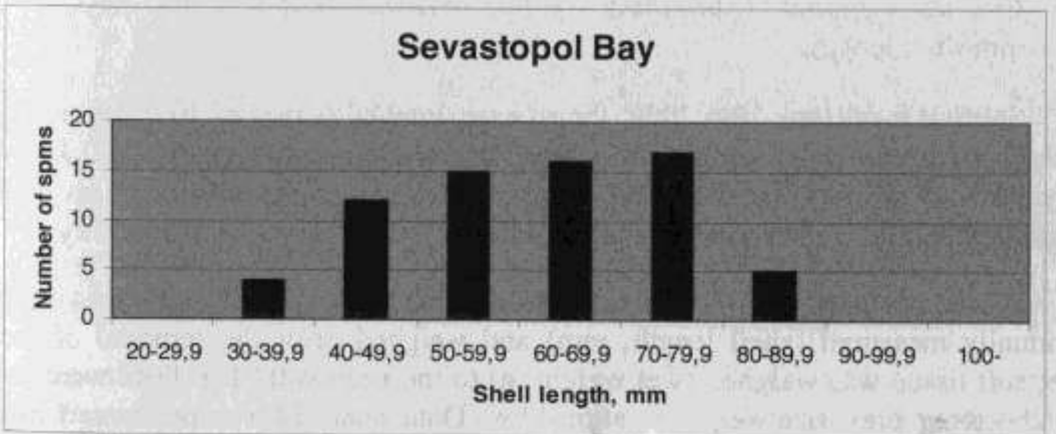

Fig. 4: Size structure of *Rapana venosa* from the Sevastopol Bay, 24.06.2009

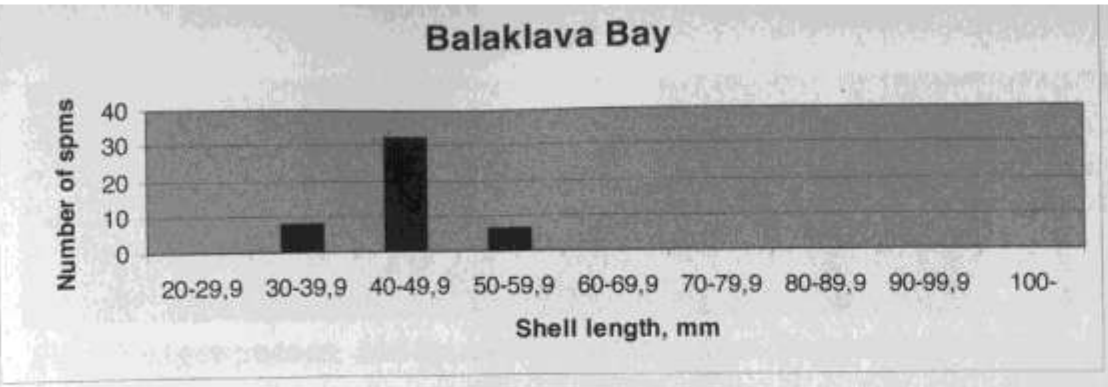

Fig. 5: Size structure of *Rapana venosa* from the Balaklava Bay, 23.06.2009

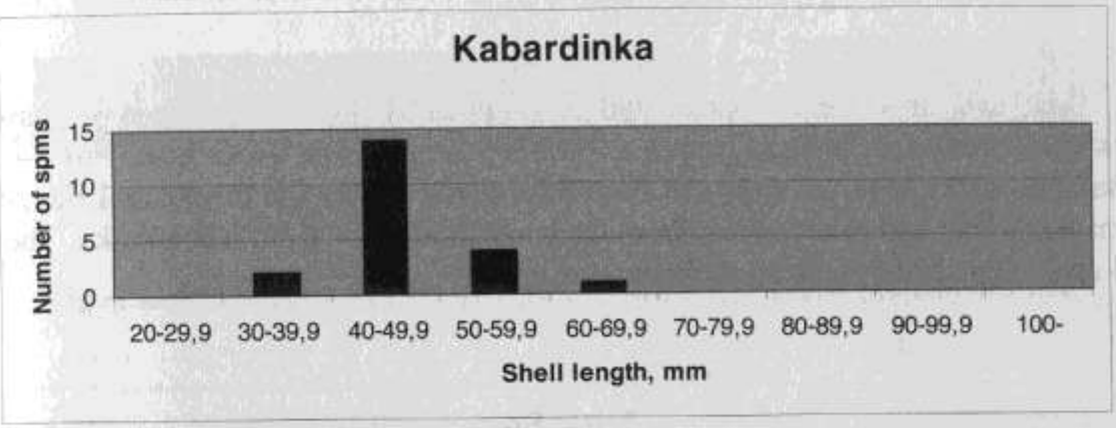

Fig. 6: Size structure of *Rapana venosa* from Kabardinka, 21.05.2009

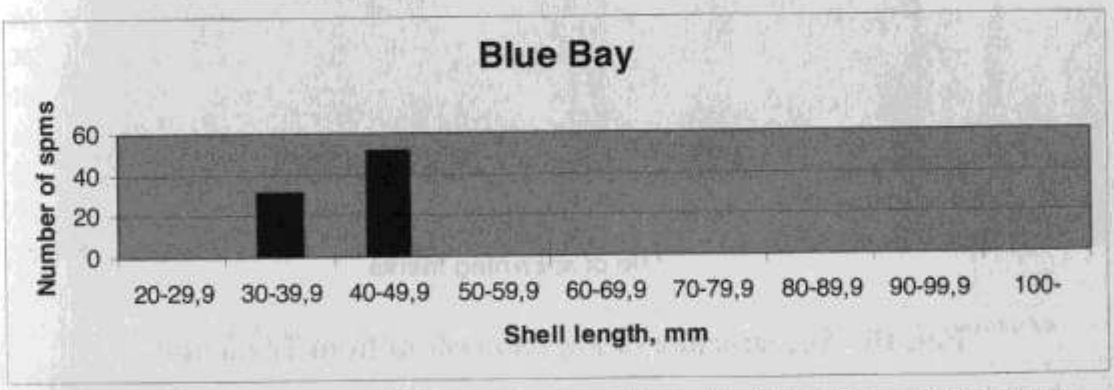

Fig. 7: Size structure of *Rapana venosa* from the Blue Bay, 12.06.2009

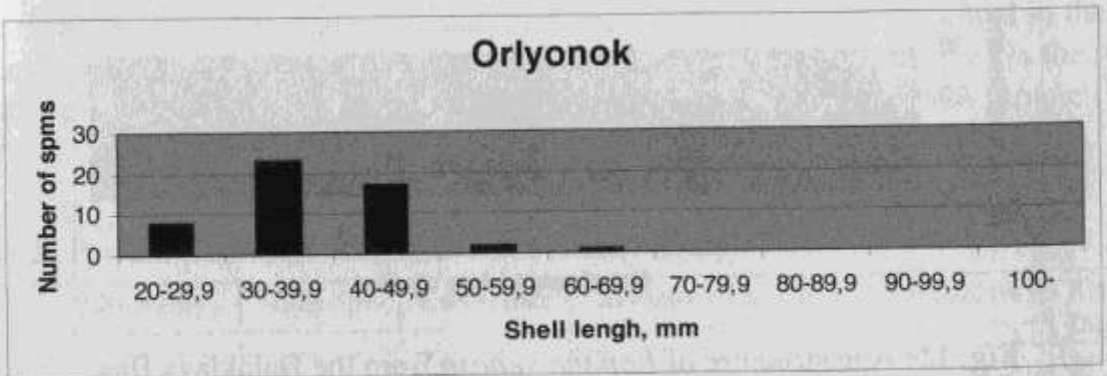

Fig. 8: Size structure of *Rapana venosa* from Orlyonok pioneer camp, 01.09.2009

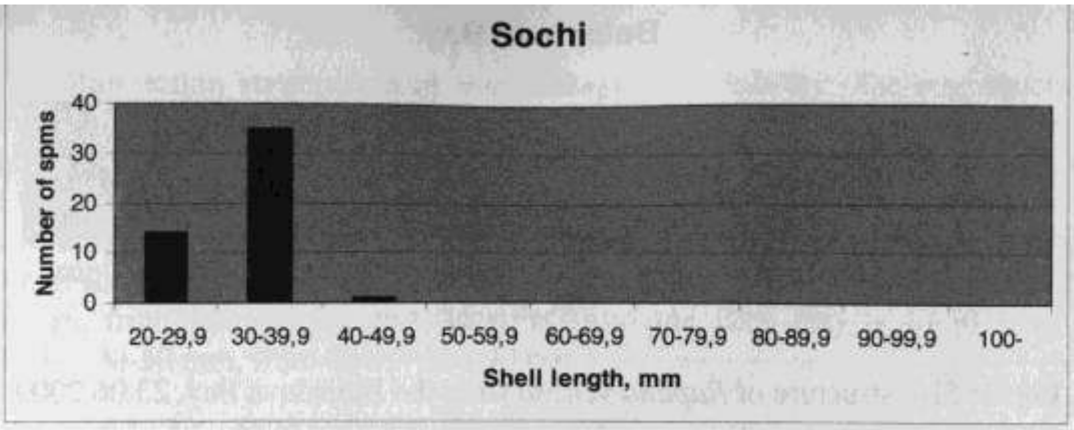

Fig. 9: Size structure of *Rapana venosa* from Sochi, 30.08.2009

The age structure is represented on Figures 10-14. The number of spawning marks on operculums changed from 3 to 8 in the sample from Tuzla Spit, 1 to 7 – from the Balaklava Bay, 2 to 7 – from the Blue Bay, 4 to 8 – from the Sevastopol Bay, 4 to 7 – from Kara-Dag and Sochi, 4-6 – from Orlyonok and 4-5 – from Kabardinka. The bulk of all specimens had 5 lines on their operculums.

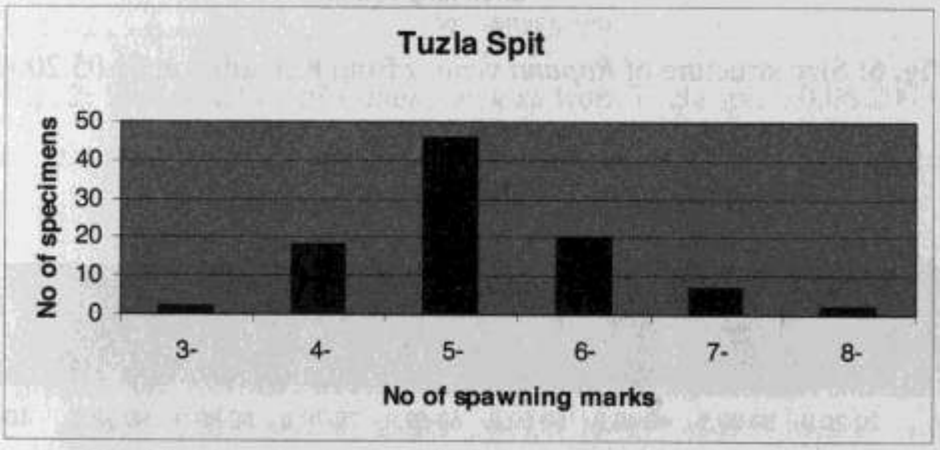

Fig. 10: Age structure of *Rapana venosa* from Tuzla Spit

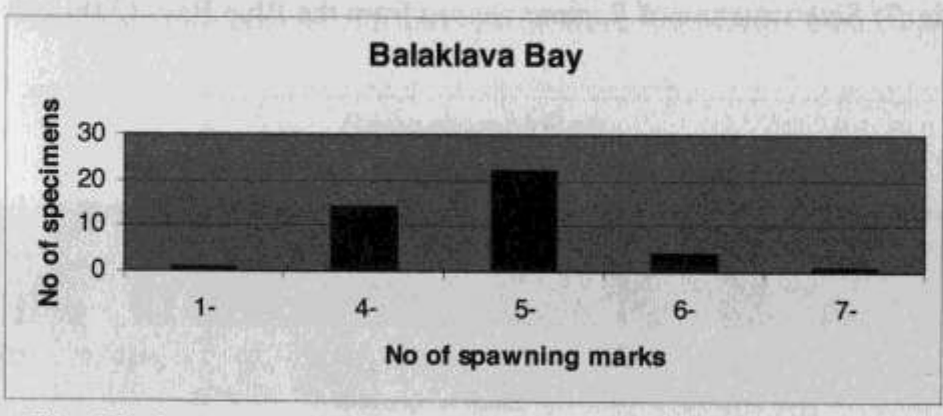

Fig. 11: Age structure of *Rapana venosa* from the Balaklava Bay

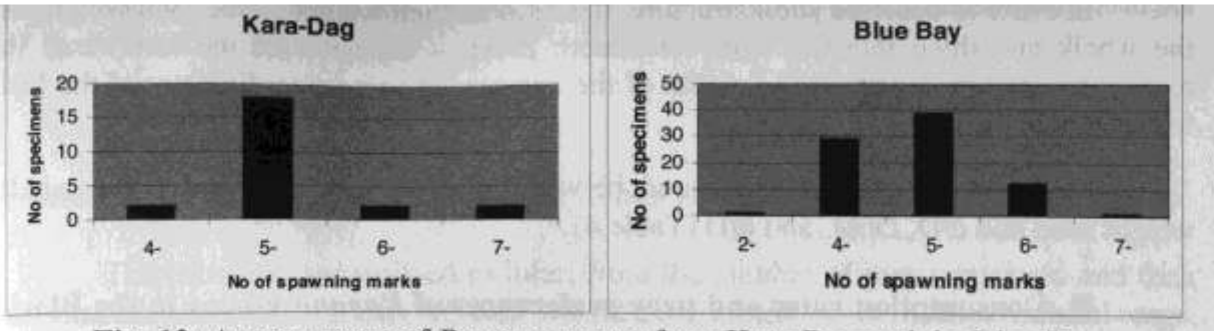

Fig. 12: Age structure of *Rapana venosa* from Kara-Dag and the Blue Bay

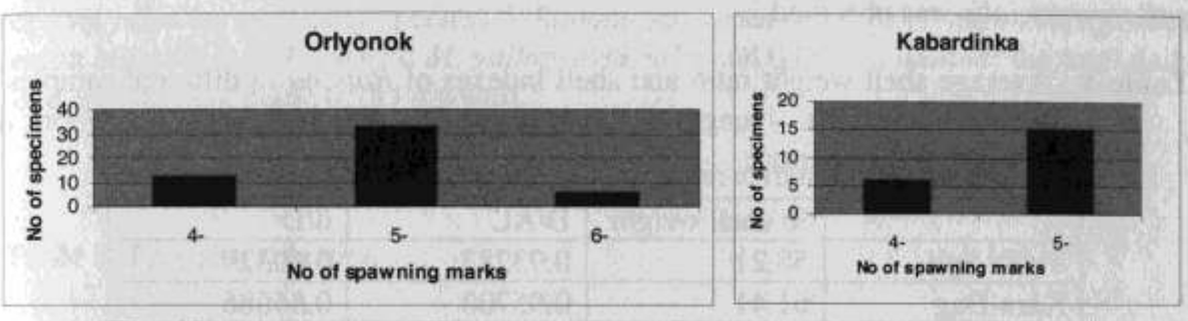

Fig. 13: Age structure of *Rapana venosa* from Orlyonok and Kabardinka

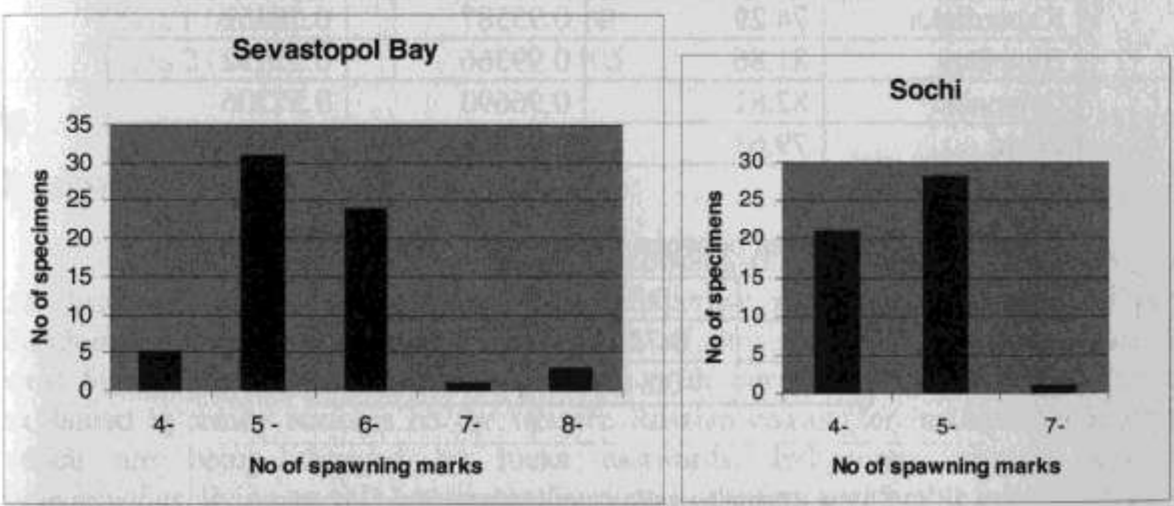

Fig. 14: Age structure of *Rapana venosa* from Sevastopol Bay and Sochi

The percent of females and males (Table 2) was approximately equal in the Blue Bay and Tuzla Spit; in Kabardinka females were almost 2/3 of the sample; in the rest of the samples males prevailed over females, sometimes consisting ¾ of the sample (Kara-Dag).

Table 2: Percent of females and males in different samples

	Blue Bay	Tuzla Spit	Kabardinka	Orlyonok	Sochi	Balaklava	Kara-Dag
Females	52	44	62	31	36	35	24
Males	48	56	38	69	64	65	76

In order to describe shell structure, the ratio of shell weight to the total weight of the whelk and three indexes were calculated: D/AL – diameter of the last whorl in respect to aperture length, d/D – width of the aperture in respect to diameter of the last whorl (Table 3).

Moderate correlation was found between shell weight ratio and D/AL, shell weight ratio and d/D, D/AL and d/D (Table 4).

II. Consumption rates and prey preferences of *Rapana venosa* in the Black Sea. A total of 171 bivalves (165 *Mytilus galloprovincialis* and 6 *Chamelea gallina*) were consumed by five *Rapana* individuals (Fig. 15). A clear preference for *M. galloprovincialis* was observed.

Table 3: Average shell weight ratio and shell indexes of *Rapana* in different samples. Abbreviations: AL – length of the aperture, D – diameter of the last whorl, d – width of the aperture.

	% shell weight	D/AL	d/D
Tuzla Spit	58.21	0.93283	0.60329
Kara-Dag	61.41	0.95700	0.55686
Sevastopol Bay	80.43	0.96034	0.55836
Balaklava Bay	81.55	1.00621	0.54467
Kabardinka	74.29	0.95587	0.56352
Blue Bay	81.86	0.99366	0.52932
Orlyonok	82.81	0.96690	0.57206
Sochi	79.63	0.97363	0.54891

Table 4: Correlation between shell weight ratio and shell indexes

	D/AL	d/D
%	0.72998	-0.64442
d/D	-0.84177	1

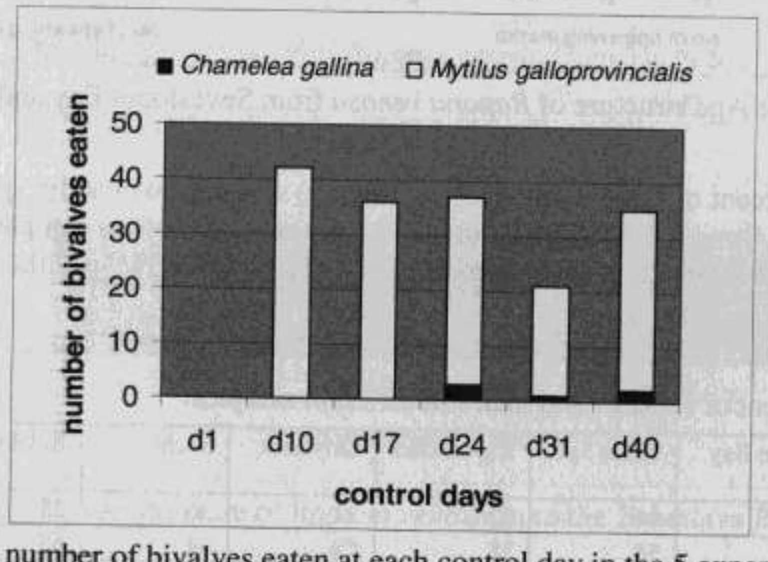

Fig. 15: Total number of bivalves eaten at each control day in the 5 experimental cages

Linear relationship was found between wet weight (g) and shell length (mm) for *M. galloprovincialis*:

$$wwt = -1.28051+0.066524H \quad (1)$$

where wwt is wet weight of the mussel, H – shell length of the mussel.

The equation was utilized to infer, from the number of prey consumed and their dimensions, biomass (grams of wet weight) consumed in each experimental cage. Dividing the average biomass consumed during the experimental period by the duration of the experiment (40 days) and number of cages (5) we obtained mean values of daily feeding rates for each prey species. A *Rapana* specimen of 51.6±1.7 mm average shell length ate daily 0.787 g wwt/d *M. galloprovincialis* and 0.002 *C. gallina*; the total daily food requirement being 0.789 g wwt/d.

Results showed a clear preference for larger size mussels and clams (Table 5).

Table 5: Prey size selection

Species	*Mytilus galloprovincialis*	*Chamelea gallina*
Total N of prey eaten	165	6
Class 1 (small)	60	0
Class 2 (large)	105	6

Discussion

I. Population structure and morphological variability. According to conclusions of the Governmental Ecological Expertise, in 2004-2006, average sizes of *Rapana* specimens permanently diminished in all sites of the Russian coast from the west to the east. This goes in concordance with our data (Figs. 2-9) and can be explained by sandy bottoms on the western Russian coasts (for instance Tuzla Spit), which are being changed by rocks eastwards. Indigenous bivalve *Anadara inaequivalvis*, living on soft bottoms and serving as the most preferable prey for *Rapana* (Savini and Occhipinti-Ambrogi, 2006), is still abundant and still of large size in this area (personal observation). The sample from the Ukrainian Kara-Dag reserve, collected from hard substrate, had also relatively large average sizes, comparing to those from Tuzla Spit. That is probably caused by less human pressing and better ecological conditions for mussel growth in this protected area. Young mussels with 15-20 mm shell length serving as prey items on rocky bottom in all other samples, do not allow reaching large sizes for *Rapana*, feeding on them.

(1984) mentioned that slowly growing rapana whelks have thicker shells than normally growing. Due to our data, the average percent of shell weight was the smallest in the sample from Tuzla, a bit higher in Kara-Dag, and a bit higher – in Kabardinka (sandy bottom). The highest, roughly the same percent had the rest of samples, collected on rocky bottom with juvenile mussels (Table 3). Correlation of average percent of shell weight with average d/D and D/AL indexes (Table 4), reflecting relative diminishing of the aperture sizes against increasing shell mass, may be also explained by diminishing size of the soft body, producing the shell. Thus, these indexes may be used as markers of the physiological condition.

The age of rapana specimen can be roughly identified by the number of spawning marks on the operculum (Chuhchin, 1984). On size diagrams (1973-1974), he noted well-pronounced cusps of 0-1 year-old whelks with 20-40 mm shell length. In 2009, the bulk of the specimens were 4-6 years old, sometimes 7 and 8. Only a few specimens were 1-2 years old. This rareness of occurrence of juvenile specimens can be caused 1) by general growth decrease of the shells, which has been especially noticeable in the last five years, so that small juveniles do not hit the sample, and 2) by worse conditions for spawning and settlement than 30 years ago. Probably, both of these reasons present. It must be mentioned that it is absolutely impossible to recognize the age of the whelk only by its shell length: very often specimens of one age (i. e. having equal number of spawning marks on their operculums) had shells differing in length twice and more times.

II. Consumption rates and prey preferences of *Rapana venosa* in the Black Sea. Results of the experiment showed clear preference of *Mytilus galloprovincialis*. This is different from similar experiment taken in the Northern Adriatic Sea (Savini and Occhipinti-Ambrogi, 2006), where among three prey items – *A. inaequivalvis*, *Tapes philippinarum* and *M. galloprovincialis*, *M. galloprovincialis* was the least preferable. Despite belonging *Tapes philippinarum* and *Chamelea gallina* to one family (Veneridae), in our experiment *C. gallina* was almost ignored. Nevertheless, on sandy bottom without mussels we found several *Rapana* specimens with *Chamelea* pulled in their shells. Obviously, *Chamelea* are used as alternative prey when mussels are inaccessible. We did not observe size selective predation towards small prey, as it was found by Savini & Occhipinti-Ambrogi (2006). On the contrary, almost 2/3 of all eaten mussels had shell length more than half of *Rapana* shell length. The bulk of mussels living on hard substrates in all studied localities (Table 1) have less than 20 mm shell length; thus, *Rapana* in these habitats cannot completely satisfy their food requirements and grow extremely slowly, what was shown in the first part of the present study.

Acknowledgements

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References

Chuhchin, V. D. (1984), "*Ecology of the Gastropod Molluscs of the Black Sea*", Acad. Sc. USSR, Naukova Dumka, Kiev, 175 pp.

Harding, J. M. and Mann, R. (1999), "Observations on the biology of the veined Rapa Whelk, *Rapana venosa*, (Valenciennes, 1846) in the Chesapeake Bay", *J. Shellfish Res.*, 18, 9–17.

Mann, R. and Harding, J. M. (2003), "Salinity tolerance of larval *Rapana venosa*: implications for dispersal and establishment of an invading predatory gastropod on the North American Atlantic coast", *Biol. Bull.*, 204, 96–103.

Pastorino, G., Penchaszadeh, P. E., Schejter, L. and Bremec, C. (2000), "*Rapana venosa* (Valenciennes, 1846) (Mollusca: Muricidae): a new Gastropod in South Atlantic Waters". *J. Shellfish Res.*, 19, 897–899.

Savini, D. and Occhipinti-Ambrogi, A. (2006), "Consumption rates and prey preference of the invasive gastropod *Rapana venosa* in the Northern Adriatic Sea", *Helgol. Mar. Res.*, 60, 153-159.

Sorokin, Yu. I. (1982), *"The Black Sea"*, Nauka, Moscow, 216 pp.

Zolotarev, V. (1996), "The Black Sea ecosystem changes related to the introduction of new mollusc species", *PSZNI: Mar. Ecology*, 17, 227–236.