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# Predation mechanisms of *Rapana venosa* (Gastropoda: Muricidae) in different biotopes along the Black Sea coast

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ABSTRACT

Mechanisms of feeding by the invasive gastropod *Rapana venosa* from different biotopes of 11 sites along the Black Sea coast are discussed. Two methods – edge-drilling and suffocation – are used, but the prevailing method in a particular biotope depends on the type of bivalve prey. Drill signs were present on almost all shells of *Chamelea gallina*, captured by rapa whelks in field conditions, while in a field experiment, only 11% of all empty *Mytilus galloprovincialis* had drilling signatures. The degree of radula abrasion was also dependent on the available bivalves: it was the highest in biotopes with *C. gallina* and juvenile mussels, and the lowest in biotopes with large mussels. Intermediate degrees of abrasion were observed in biotopes with mixed prey: *C. gallina* and *Anadara kagoshimensis*, *C. gallina* and mussels, or small and large mussels. Since we observed only initial signs of drilling, simultaneous application of boring and suffocation could take place.



## 1. Introduction

The Asian whelk *Rapana venosa* (Valenciennes, 1846) (Gastropoda: Neogastropoda: Muricidae) successfully settled down in the Black Sea more than 60 years ago (Drapkin, 1953) and eventually became one of the dominant species in the benthic ecosystem. It inhabits all types of bottoms all over the Black Sea, demonstrating a wide spectrum of morphological modifications and feeding behavior. According to literature data, juvenile and small-sized *R. venosa* are feeding by drilling through the bivalve shell, whereas large snails can attack and consume bivalves without leaving drill-holes (Chukhchin, 1984; Harding et al., 2007). They grasp the shell of prey along the margin, cover it in mucus and, when the valves gape, insert the proboscis (Harding and Mann, 1999).

Chukhchin (1970) presumed that the mucus of hypobranchial gland contains the poisonous secretions of purple cells (e.g. murexin), as many muricids produce toxins impairing neuro-muscular transmission in bivalves. *R. venosa* has been shown to accumulate toxins responsible for paralytic shellfish poisoning (PSP). The toxins are produced by phytoplankton species *Alexandrium tamarense* Lebour (Balech), 1995, which also occurs in Black Sea waters (Vershinin et al., 2006). The algae are ingested by suspension-feeding bivalves, and these are then consumed by the rapa whelk (Ito et al., 2004). On the other hand, high mortality of *R. venosa* has been recorded during a bloom of the toxic alga *Alexandrium monilatum* in Chesapeake Bay (Harding et al., 2009).

Size structure variability of *R. venosa* subpopulations along the Black Sea coast is very high. Average shell height is decreasing from the North (sandy bottoms) to the South (rocky bottoms) and may differ three times in the whelks of the same age from Tuzla Spit and Sochi (Kosyan, 2013). Mussels *Mytilus galloprovincialis* Lamarck, 1819 are the preferred prey on hard bottoms (Kosyan, 2009), but their number have significantly decreased during the last ten years (Shurova and Stadnichenko, 2002; Gudimov, 2008; Bondarev, 2010). On soft bottoms, rapa whelks feed on still abundant *Chamelea gallina* (Linnaeus, 1758) and *Anadara kagoshimensis* (Tokunaga, 1906). Thus, the high size variability may be connected with prey availability, which is very unequal in different biotopes (Kosyan, 2013).

The objectives of this study were to investigate the peculiarities of the feeding process of *R. venosa* in different biotopes of the Black Sea. For that purpose:

- a comparative description of radula morphology of whelks from several sites with different bottom types and prey items was conducted;
- the study of drilling activity in the field experiment on mussels for a size range of the predator and prey was provided.

## 2. Materials and methods

### 2.1. Field examinations

Rapa whelks for radulae examinations were collected from eleven sites on the Black Sea coast (Fig. 1) in 2009–2012. Shell height was

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**Fig. 1.** Map of sampling sites. Marking "Blue Bay" contains two sampling sites: center of Blue Bay and pier in Blue bay.

measured from the apex to the basis of the aperture using caliper, age determined by counting spawning lines on the shell (Chukhchin, 1961; Kosyan and Antipushina, 2011), and sex – by presence or absence of the penis. Parallel to these investigations, additional examination of clams *C. gallina*, captured by rapa whelks, were conducted on Anapa coast and Tuzla Spit in 2011–2012. *C. gallina* were removed from the rapa whelk's foot and investigated for abrasions. About 50 *C. gallina* were examined.

Radulae were manually dissected, cleaned in liquid bleach, washed out in distilled water, air-dried, coated with gold and examined in Tescan TS5130MM scanning electron microscope (IPEE RAS). The most anterior, working part of the radula, usually bent under the odontophore, was investigated. About 70 radula preparations were studied.

### 2.2. Experiment

Rapa whelks were sampled in two sites with different bottom types and prey items: Tuzla Spit (sandy bottom with *C. gallina* and *A. kagoshimensis*) and under the pier in Blue Bay (hard piles of the pier covered with mussels *M. galloprovincialis* of 20–60 mm shell length) (Table 1). The whelks were reared in six 50 × 50 × 25 cm cages covered with 5 × 5 mm mesh at 22 m depth in the center of Blue Bay from 27.06.2012 to 31.08.2012. Each cage contained one rapa whelk. Animals were fed small (shell length SL ⩽ 35 mm) and large (SL > 35 mm) mussels in a way that each rapa whelk permanently had available about ten mussels of each size class. Every 7–10 days empty mussel shells were replaced by live mussels of the same size class and examined for drill-signs in the laboratory. Empty shells without drill-signs were treated

**Table 1**
Characteristics of biotopes, shells and examined radulae of *R. venosa*.

| Site | No. of radulae with abraded:not abraded anterior teeth (% of abraded radulae) | Shell length range (mm) | Age range, years | Bottom | Prey items | Biotope type (see text) |
|---|---|---|---|---|---|---|
| Tarkhankut | 1:1 (50%) | 44–57 | 4–5 | Sand and rocks | Small mussels and *C. gallina* | 4 |
| Sevastopol Bay | 2:2 (50%) | 43–80 | 7–16 | Rocks | Small and large mussels | 4 |
| Balaklava Bay | 2:0 (100%) | 43–48 | – | Rocks | Small mussels | 3 |
| Donuzlav | 3:0 (100%) | 64–69 | 3–5 | Sand | *C. gallina* | 1 |
| Tuzla Spit | 3:2 (60%) | 47–68 | 3–7 | Sand | *C. gallina* and *A. kagoshimensis* | 4 |
| Anapa | 6:0 (100%) | 10–68 | 0–12 | Sand | *C. gallina* | 1 |
| Utrish | 6:1 (86%) | 10–15 | 0 | Sand and rocks | *C. gallina* | 1 |
| Blue Bay | 6:12 (33%) | 26–56 | 2–7 | Sand and rocks | Small mussels and *C. gallina* | 4 |
| Pier in Blue Bay | 1:7 (13%) | 58–86 | 4–10 | Rocks | Large mussels | 2 |
| Orlyonok camp | 2:4 (33%) | 24–54 | 2–12 | Sand and rocks | Small mussels and *C. gallina* | 4 |
| Sochi | 4:1 (80%) | 20–37 | 0–10 | Rocks | Small mussels | 3 |