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Short Communication

Diel feeding periodicity, gastric emptying, and estimated daily food consumption of whelk (*Rapana venosa)* in the south eastern Black Sea (Turkey) marine ecosystem

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Gastric emptying, food consumption and feeding periodicity of *Rapana venosa* were investigated under laboratory conditions and in the field respectively. Gastric emptying was best described by an exponential function, that was independent of meal size and the range of animal size when rapana were fed on fresh mussel. The fresh mussel (0.92-2.19 g) was fully digested by an average of 47 g rapana within the 6-8 hours. No change in feeding intensity was detected over 24 hours suggesting that rapana feed continioussly. Using gastric emptying rates from the laboratory studies, the data obtained from the field was converted to the food consumption estimates and concluded that an average of 50 g rapana in the eastern Black Sea marine ecossystem consume 0.17-0.30 g. mussel in a day, meaning that rapana in the eastern Black Sea marine ecosystem may cause an important predatory impact on the mussel beds.

[**Key words**: Food consumption, eastern Black Sea, *Rapana venosa*]

Rapana whelk, *Rapana venosa*, (Valenciennes, 1846) is a native mollusk to the Sea of Japan, Yellow Sea, Eastern China Sea and the Gulf of Bohai. It was first discovered in the Black Sea in 1947[1] and have subsequently spread throughout the Black Sea and into the Azov Sea as well as Agean Sea[2], Sea of Marmara and Adriatic[3]. As elswere it is thought that ship traffic is the probable source of introduction into the eastern Mediterranean and Black Sea[4]. *Rapana venosa* is a carnivore and feeds on many commercially valuable bivalves. The investigations on Rapana done over the past decade showed that it is capable of significantly affecting the local shellfish and benthic communities in a relatively short span[4,5]. Although a number of researchers have focused on studying the bio-ecology of the rapana whelk and its predatory impact on the benthic community, little information is available on feeding physiology, feeding periodicity and food consumption derived from a combinations of laboratory and field studies in the Black Sea. In this study, we investigate gastric emptying and feeding periodicity in the field, and estimate the food consumption in the south eastern part of the Black Sea since it is blieved that rapana whelks have become an important part of the Black Sea ecosystem.

All rapana whelks were collected either by scuba diving or dredging off Trabzon, on the eastern Black Sea of Turkey, (Fig. 1). Soon after collecting samples they were kept in a tank (300 liter) with flowing seawater. All the rapanas used in the experiments ranged from 40 to 120 mm in length. We used two types of experimental tanks. Six experimental tanks were of the size of $80 \times 35 \times 25$ cm and the other 9 tanks were $25 \times 40 \times 25$ cm. All tanks were connected with flowing seawater (500 ml/min). During the experimental studies the temperature (°C) was also recorded.

In order to determine the feeding periodicity, two samplings were made during April and May 1999. The sampling was conducted at every three hours starting at 15′00 hrs and stopped at 12′00 hrs next day. At each collection time, samples were kept in a deep freeze until analysis. In the laboratory all

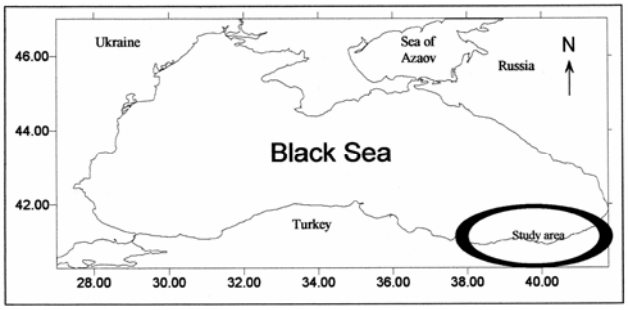

Fig. 1 — Study area.

animals were measured and weighted. The stomach contents were provided by means of serial slaughter. The stomach contents were weighted and identified to the lowest possible taxon and recorded. Stomach content data are presented in this study as the average weight (g), the number of samples ranged from 10 to 19 at each sampling occasions.

A number of experimens were conducted to examine the emptying process in the rapana fed natural diet of mussels. First we focused on the description of gastric emptying, then we examined two factors which could have an affect on gastric emptying rate, namely the animal size and the prey size. Prior to the experiments, only one rapana was placed in a tank and they were fed on fresh mussel until the experiments were started. This period lasted about 2 weeks. When all rapana were acclimated to the laboratory conditions, fed and behaved normally, feeding was stopped since a preliminary study had shown that it took approximately 2 days to clear the stomach and the intestine. Then each animal was fed on a known amount of fresh mussel. Two hours after the first feeding, sampling was initiated. At each sampling one or two rapana, depending on the availability of the animals in the experimental tanks, were removed. Their stomach content was removed, weighted and recorded. This continued until the stomach content was thought to be emptied.

Food consumption by an animal can only be estimated when gastric emptying rates and the stomach contents are desribed over a complete 24 hour period. Food consumption rate was estimated by using the model produced for fish which gastric emptying is best described by an exponential function[6]. Since gastric emptying was found to be exponential (see results) and stomach contents from field collected animals suggested feeding throughout 24 hours, food consumption was estimated using the formula:

$$F = [(St - So\exp(-bt)) \times bt]/1 - \exp(-bt)$$

where St is the stomach content (g) at time t, So is the initial stomach content (g), b is the gastric emptying rate.

A preliminary experiment was conducted to examine the emptying of a 1 g fresh mussel fed to rapana (50 ± 0.25g, $n = 45$). Gastric emptying of such natural diet in rapana whelk was best described by an exponential function (Fig. 2). The emptying started soon after food is digested and lasted about 8 hours. Statistical analysis also showed that the emptying of such fresh mussel was significantly faster in the first couple of hours than the rest of the time (Tukey test, $p < 0.01$).

Two more experiments were conducted to examine the factors affecting gastric emptying in rapana whelk. Figure 3 describes the effect of different sizes of meal, namely fresh mussel, on gastric emptying in rapana whelk. Gastric emptying starts soon after meal is digested and then emptying process slows down. The first empty stomach was observed 3 hours after first feeding. Rate of gastric emptying was not consistent for animals examined. Statistical anaysis (ANOVA) showed that meal size did not affect the gastric emptying time of the meal sizes used in these experiments ($p < 0.37$). Same result was also obtained when the effect of animal sizes (57.78 ± 7.53 mm, $n = 34$; 65.08 ± 7.6 mm, $n = 28$; 101.79 ± 14.78 mm, $n = 19$) fed on 1 g fresh mussel on gastric emptying in

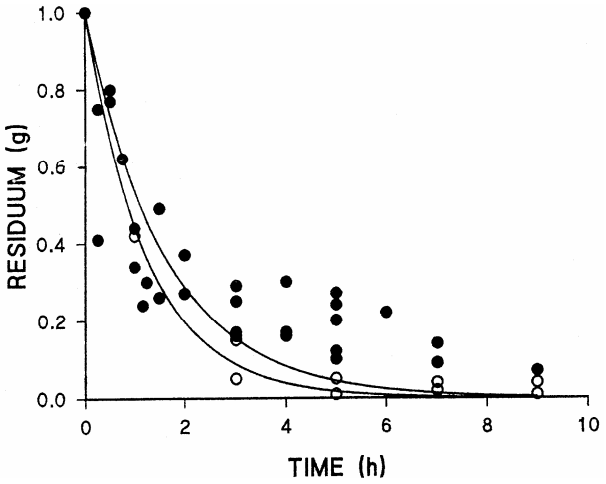

Fig. 2 — The emptying of 1g. fresh mussel fed to *Rapana venosa* at 20 °C and the effect of animal size on emptying.

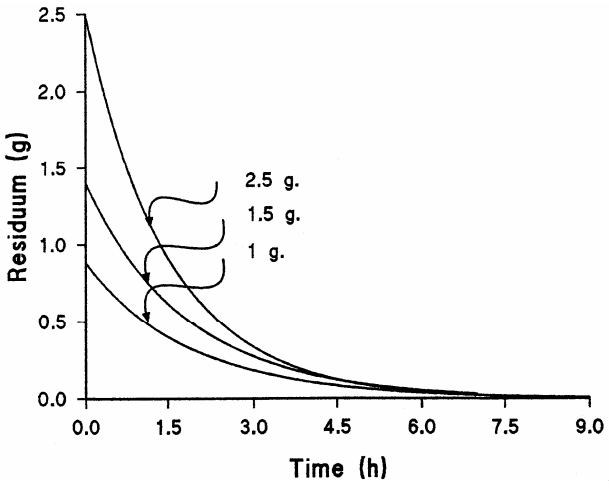

Fig. 3 — Effects of meal size on gastric emptying.

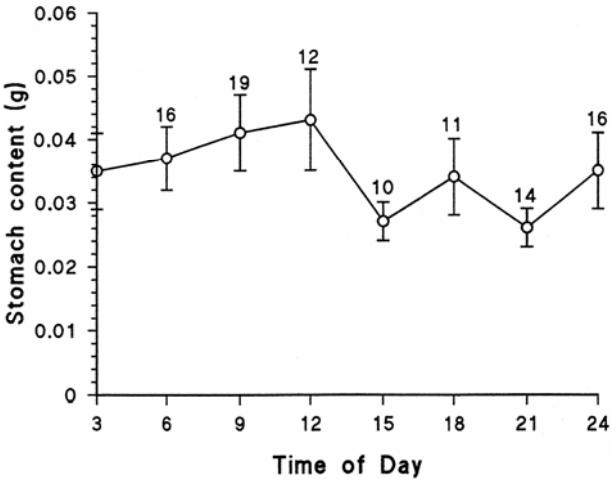

Fig. 4 — Feeding periodicity of the *Rapana venosa*.

rapana whelks of 3 different sizes was tested (Fig. 2) ($p < 0.63$).

Feeding periodicity of rapana whelks in the eastern Black Sea marine ecosystem (Fig. 4) shows that rapanas feed continuously and no significant peak in feeding was noticed (ANOVA, $p < 0.37$). Field observations and laboratory studies were combined to estimate food consumption of rapana in the field. We estimate that an average 50 g rapana consume 0.17-0.30 g/day natural diet namely mussel flesh.

Feeding behaviour of rapana have been studied previously. Rapana prefer hard sand bottom habitats[7] but will also invade hard substrate where food is abundant. For example local rapana abundance increased after artificial reef deployment in the Adriatic Sea. Reports on the feeding behaviour of *R.thomasiana* (now also recognised as *R.venosa*) shows that they either drill their prey[8] or use paralytic toxins during feeding[5]. They mainly feed on bivalve molluscs, but the preference of their prey depends on the diversity of the available prey items. For example prefered prey can vary from hard clam to oyster, soft clam and mussel (*Mytilus edilus*)[7]. The potential predators of the rapana in their native waters are octopus and other apex predators.

Based on laboratory studies and the field data it is concluded that on an average of 50 g rapana in the Eastern Black Sea marine ecossystem consume 0.17-0.30 g mussel in a day. Previous investigation on recruitment of rapana in the same area[9] has indicated that the eggs abundance was estimated to be ca. 6000 eggs/m^2. This results about 120 rapana/m^2. By a simple calculation, it can be concluded that a sum of 7-13 kg mass of mussels are eaten by these whelks on a daily basis in 1 km^2 in the Black Sea marine ecosystem. This is an important predatory impact on the mussel beds where they mainly feed in the area.

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