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RESEARCH ARTICLE

Some aspects of the biology and the present state of the population of *Protodrilus flavocapitatus* (Polychaeta: Protodrilidae) in the coastal zone of Crimea (the Black Sea)

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Abstract

The annual density fluctuations of the polychaete *Protodrilus flavocapitatus* (Uljanin, 1877) was investigated in the Crimean coastal zone. The maximum density of polychaete was recorded in December (472 ind.m^{-2}) and the minimum in July (13 ind.m^{-2}). In addition, an experiment regarding its asexual reproduction strategy was conducted. Females with eggs were recorded from April to June. It was found that this species can regenerate missed body fragments and the regeneration of the distal end began in the second day.

Key words: Polychaete worms, Protodrilidae, *Protodrilus flavocapitatus*, Black Sea.

Introduction

In the Black Sea, three species of *Protodrilus* were reported: *Protodrilus flavocapitatus* (Uljanin, 1877), *Protodrilus mirabilis* Czerniavsky, 1881 and *Protodrilus purpureus* (Schneider, 1868) (Kurt and Çınar 2012). *P. flavocapitatus* is widespread in the Mediterranean Sea and eastern Atlantic (Martin 1978; Davies 1998; Kiseleva 2004). In the Black Sea, this species occurs near the shores of Romania, Bulgaria and along the Crimean coastline (Yakubova 1930; Kiseleva 2004; Kiseleva and Gagolkina 2004; Kiseleva *et al.* 2009; Bondarenko 2010; Kurt and Çınar 2012).

Some characterisics on the biology and the ecology of *P. flavocapitatus* were discussed earlier (Vinogradov 1949; Bacescu 1963; Bondarenko 2010). It

usually inhabits coastal sandy sea beds (Vinogradov 1949; Losovskaya 1977; Marinov 1990; Surugiu 2005).

The aims of the present paper were to study the biology of *P. flavocapitatus* and to increase our knowledge on the present state of its population along the coast of Crimea.

Materials and Methods

Samples of macrobenthos were collected from different areas of the Crimean coastal zone (the Black Sea) in 2006-2011 (Figure 1).

Figure 1. The map of sampling locations along the Crimean coast

More than 800 benthos samples were collected from the pseudolittoral zone by using a hand bottom-sampler with the 0.04 m^2 capture area. Pseudolittoral zone is a narrow strip of beach, between the top edge of the splash and riprap beach. Samples were then fixed with 4% formaldehyde and transferred to the laboratory (Department of the Ecology of Benthos, IBSS). The material was washed with tap water on a sieve with 0.5 mm mesh size and then sorted according to taxonomic groups. Specimens of *P.flavocapitatus* were examined under a stereomicroscope. In the bays of Sevastopol, samples were collected monthly for 13 months. On other areas of the Crimean coastal zone, samples were taken once in summer. Living specimens of worms in samples, regardless of their size groups, were placed into a 2.5-l crystallizing dish for two months (10 April-12 June 2011). The water was aerated and changed twice a week. The worms were fed with microalgae (5 ml) twice a week. The species used as food were *Isochrysis galbana* Parke (Chrysophyta), *Tetraselmis suecica* Butch (Chlorophyta), *Phaeodactylum tricornutum* Bohlin (Heterokontophyta) and *Rhodomonas salina* Wislouch (Cryptophyta).

The length of the worms was measured using an ocular micrometer. The worms were weighed without tubes. Before weighing worms were dried on filter paper, then weighed to the nearest 0.0005 mg.

Results and Discussion

Body length cited in previous studies varied from 2-3 to 15 mm (Vinogradov 1949; Kiseleva 2004). Polychaetes measured during our investigation were 15-18 mm long and 0.15-0.20 mm wide, the length of antennae was 0.5 – 0.6 mm. Colour is pale yellow or orange. All worms found in the collected samples were yellowish, with a distinct pinkish probosis behind the prostomium. The genus *Protodrilus* is the only taxon of interstitial polychaetes possessing a pair of sensory organs generally thought to be statocysts. However, in contrast to the pattern common for polychaetes these sensory organs are situated in the prostomium (Purschke 1990). *P. flavocapitatus* has the body with a broadened anterior end. Prostomium has ventrally set eyes and two elongated tentaculiform antennae. Posterior end is equipped with two leaf-like plates or lobes bearing papillae or surculi on the ventral side. Skin covering is ciliated (Figure 2).

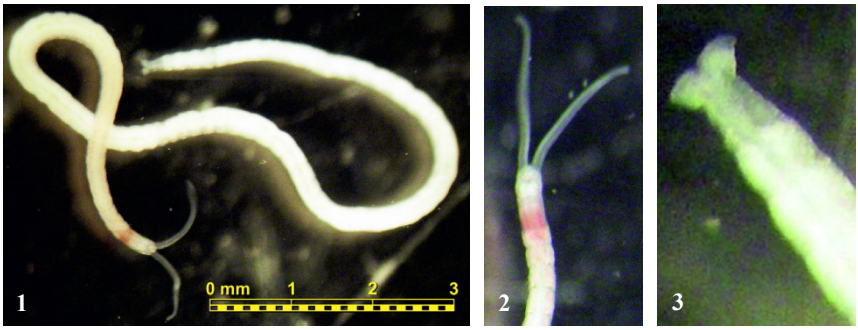

Figure 2. *Protodrilus flavocapitatus*: 1. general view of the body; 2. anterior end; 3. posterior end

Reproduction

P. flavocapitatus is gonochoristic. Female worms have lateral glandular bags of seminal receptacles, and males are equipped with spermatophores (Nordheim 1991). Sexually mature individuals, which are usually found during March - May (Kiseleva 2004), were found in samples collected in April. When exposed to mechanical impacts, female polychaetes were contracting the body and began to release eggs of 35-40 μm.

It was observed that only large individuals (15 mm long or larger) dwell in the pseudolittoral. Therefore, it was hypothesized that adult *P. flavocapitatus* breed at a depth onto which their larvae would settle to avoid seawater turbulence.

Larvae penetrate into interstices between sand grains, attach to the bottom substrate, grow to a certain size and migrate into splash zone. It was also observed that small worms [2.5-3.5 mm long, (Figure 3)] were abundantly present in samples taken from 1 m depth but absent in 1.5 m depth.

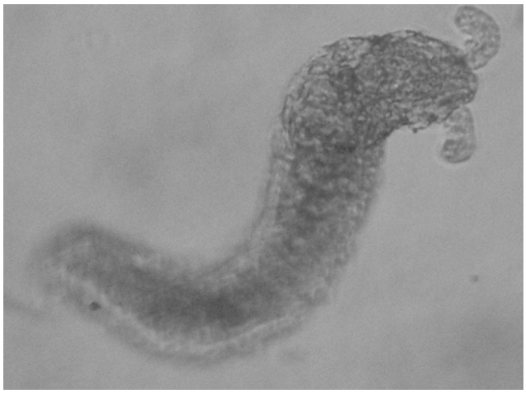

Figure 3. A juvenile specimen of *Protodrilus flavocapitatus*

Locomation

Worms invariably moved by undulating and constricting the body; the natural rate of movement of undisturbed individuals was estimated 0.149-0.2 mm/s.

Regeneration

The experiment showed that when worms were exposed to mechanical stimulations they can tear their bodies into two or more parts. They were capable of regenerating the missed fragment(s) afterwards. Pygidium started to regenerate on the second day, emerging as two small lamella-like structures. Worms progressively increased their lengths by adding new segments. Regardless of body size, all worms added six segments to posterior part on the sixth day. In 13 days, the numbers of newly generated segments were around 8-10. Antennae were also regenerated. The new antennae became visible on the 35th day as a tiny (0.025-0.035 mm) process, which progressively grew and, finally, replaced the missing organ.

Density

In Sevastopol Bay, *P. flavocapitatus* was found in all months. The density of *P. flavocapitatus* reached its maxima (472 ind.m^{-2}) in November and its minima (13 ind.m^{-2}) in June. Two density peaks were found in November (472 ind.m^{-2}) and December (422 ind·m^{-2}) (Figure 4).

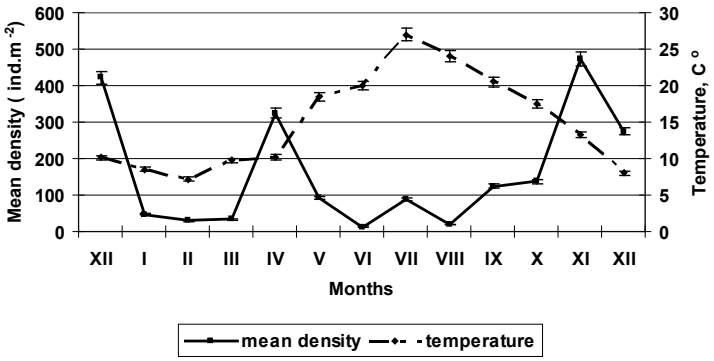

Figure 4. Seasonal changes of the mean density of *Protodrilus flavocapitatus* in relation with seawater temperature in Sevastopol Bay

The seasonal variation of the density of *P. flavocapitatus* directly depended on the seawater temperature. Within the temperature range from 8 to 18°C, *P. flavocapitatus* sustained high abundance which decreased in response to warming or cooling of the sea water.

Figure 5 shows the distribution of *P. flavocapitatus* in different seasons. Low numbers of specimens were found in supralittoral zone, whereas high numbers of specimens were encountered in upper infralittoral zone in summer and mediolittoral zone in other seasons.

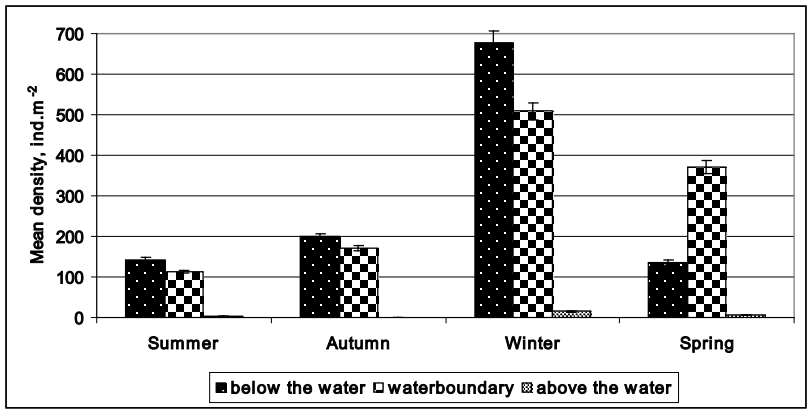

Figure 5. The mean density of *P. flavocapitatus* in different seasons in Kazachiya Bay

Supralittoral zone (also termed as splash zone) receives pollutants both from the sea and the land. This area is also under the pressure of high recreational usage,

strong wave exposure, and pronounced seasonal temperature variations, which make this specific habitat even more difficult for species (Zaitsev 1982).

Our investigation revealed that *P. flavacapitatus* can migrate from supralittoral zone to infralittoral in unfavorable conditions.

Conclusions

The present paper indicated that *P. flavocapitatus* inhabits littoral zones of only Sevastopol and Kazachiya Bays (Crimea, the Black Sea). Large worms (body length ≥ 15 mm) prevailed in the splash zone (supralittoral zone). Small specimens (length: 2.5-3.5 mm) dominated samples taken from 1m depth, accounting for 65.5 % of the total abundance.

P. flavocapitatus prefers upper infralittoral zone in all seasons and rarely occurred in supralittoral zone.

P. flavocapitatus can graze on phytoplankton and moves at the rate of 0.149-0.2 mm/s. This worm is capable of regenerating missed body fragments.

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