The population dynamics and reproduction of *Streblospio gynobranchiata* (Annelida, Spionidae), an alien polychaete worm, in the Sevastopol Bay (the Black Sea)

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Abstract
The macrozoobenthic investigation in the Sevastopol Bay was conducted from 2001 to 2013. In 2007, first individuals of *Streblospio gynobranchiata* Rice & Levin, 1998, exotic for the Black Sea, were found in samples of soft sediment from the bay. According to the records, by 2009, mean population density has increased to 703±43 ind.:m\(^2\) and decreased to 465±56 ind.:m\(^2\) by 2013. The spionid polychaetes *S. gynobranchiata* inhabit muddy seabed with vast admixture of pelitic silts (66±8%), at depths ranged from 2 to 17 m and seawater salinity from 14.3 to 17.7‰. As our experiments have shown, in warm (17–18°C) sea water *S. gynobranchiata* completed planktonic stage of development in 9–10 days; in the absence of adequate substrate this period lasted for about a month. Worms fully matured within 3.5 months since their appearance in plankton and started to reproduce in the fourth month. Such life strategy favours rapid spreading of *S. gynobranchiata* along the shoreline of the Black Sea.

Key words: *Streblospio gynobranchiata*, alien species, population dynamics, larval growth.

Introduction
The spionid polychaete *Streblospio gynobranchiata* Rice & Levin, 1998 was first described from the Gulf of Mexico (Rice & Levin 1998). Presently, this species is recognized as widespread along the Atlantic coast of North and South Americas (Mahon et al. 2009; Radashevsky & Selifonova 2013). In 2003, *S. gynobranchiata* was detected at the Turkish coast of the Aegean Sea (Cinar et al. 2005) and later in the Sea of Marmara (Cinar et al. 2009). In 2004, high-density population of this worm was found in the southern Caspian Sea (Taheri et al. 2008). Until recently, the species *S. shrubsolii* (Buchanan, 1890), reported from some brackish-water lakes on the Bulgarian coast, was the only representative of the genus *Streblospio* in the Black Sea (Marinov 1977; Kiseleva 2004). In 2001, in the mouth of the Tsemess, Novorossiysk Harbour, a dense population of *S. shrubsolii* was found (Melnik & Smolyar, 2002). Further investigation has showed that by a number of diagnostic characters these polychaete worms differ from *S. shrubsolii* (Murina et al. 2008). In 2007, polychaetes of the genus *Streblospio* were found in the macrozoobenthic samples from the Sevastopol Bay. After detailed examination of their morphological features these worms were identified as *Streblospio gynobranchiata* Rice & Levin, 1998 (Boltacheva 2008; Boltachova & Kolesnikova 2013). Later, similar polychaetes identified as *S. gynobranchiata* were reported from samples collected from Dry Lake Liman (Sukhoi Liman) near Odessa and from the Novorossiysk Harbour (Radashevsky & Selifonova 2013).
Presently, of three species of the genus *Streblospio* known worldwide (Rice & Levin 1998), two occur in the Black Sea (Mahon *et al.* 2009; Kurt Şahin & Cinar 2012). The biology of the widespread *S. benedicti* Webster, 1879 has been profoundly studied whereas many aspects of the ecology and biology of two other species (*S. shrubsolii* and *S. gynobranchiata*) remain obscure and need further research (Maccain 2008; Gibson *et al.* 2010).

The goal of our work was to investigate population dynamics of the spionid polychaete *S. gynobranchiata* in the Sevastopol Bay and to reveal features pertaining to their reproduction cycle in the Black Sea.

Material and Methods

Macrozoobenthic surveys in the Sevastopol Bay were conducted from 2001 to 2013. Samples were collected in conformity with a station grid which fully covered the area of the bay. Position of stations remained unchanged while their number varied in different years. In June 2001, the benthic survey included 32 sampling stations, in October 2006, 2007 and 2008 – 25, 12 and 23 stations, correspondingly; in November 2009 – 8 stations; in May and in October 2013 – 18 and 15 stations, respectively. Depths at which stations were located varied from 4 to 18 m.

Material collected from October 2006 to December 2007 as the design of year-round survey suggested, was also used to underpin this investigation. Samples were monthly taken from four stations situated in the innermost part of the Sevastopol Bay, within 0.5 – 2 m depth range; soft sediment was mainly muddy silt. In the near-bottom seawater layer temperature varied from 6 to 26°C and salinity – from 14.3 to 17.7‰, according to the season of the year.

At each station 1–2 samples were taken by a Petersen grab (0.04 m² capture area). Samples were thoroughly washed through a series of sieves with the smallest mesh size of 0.5 mm and fixed with 4% formaldehyde. In the laboratory worms were picked out, sorted and identified to species.

Worms for the study of larval development of *S. gynobranchiata* were collected from 5 to 15 m depths in the Sevastopol Bay in May and October 2013. For a year, from May 2013 to June 2014, the polychaetes were kept in laboratory tanks containing silt; the experimental design imitated the natural course of seasons by changing the temperature from 15 to 25°C. As the worms matured, they were removed and placed into special tanks; to stimulate hatching of larvae from the eggs, the sea water was gradually warmed up from 22 to 28.8°C. Hatched larvae were isolated into crystallizers filled with 50 ml of filtered sea water and fed on mixed microalgae – *Isochrysis galbana, Chaetoceros calcitrans, Dunaliella viridis, Phaeodactylum tricornutum*, and *Tetraselmis suecica*. As the larvae were growing, they were repeatedly measured and photographed alive.

Results and Discussion

Most probably, alien spionid worms *S. gynobranchiata* appeared near the Crimean coast during the recent decade; at least, this species was absent in the records of benthic surveys made in the Sevastopol Bay in 2001 and in 2006. First individuals of the species were observed in the samples collected in May 2007 to implement the year-round survey of 2006–2007. In May and in August 2007 only solitary polychaetes were observed; in October 2007 they increased in number and in December 2007 they reached an average abundance of 398 ind·m⁻² (Fig. 1). Results of the investigation suggest that in the Sevastopol Bay *S. gynobranchiata* emerged in spring 2007.

Since then these worms have been commonly seen in benthic samples. In October 2007, the benthic survey in the Sevastopol Bay has shown that polychaete worms *S. gynobranchiata* were present at 10 of 12 stations (83% frequency of occurrence); their average density was estimated to 301±58 ind·m⁻² with a maximum value of 1675 ind·m⁻². One year later, in October 2008, these worms were found at 22 of 23 stations (96% frequency); their average abundance has increased to 526±43 ind·m⁻² with a maximum value of 1287.5 ind·m⁻². In November 2009, the frequency decreased to 88% whereas the average and the maximum density increased to 703±43 ind·m⁻² and 1550 ind·m⁻², respectively. In October 2013, this species occurred in benthic samples taken at 12 of 15 stations (80% frequency); the average and maximal abundance were 465±56 ind·m⁻² and 2275 ind·m⁻², respectively (Fig. 2).
Figure 1. Seasonal dynamics of the average abundance of spionid polychaetes *S. gynobranchiata* in the innermost part of the Sevastopol Bay (2006–2007).

Figure 2. Multi-annual dynamics of the average abundance of *S. gynobranchiata* in the Sevastopol Bay (2007–2013).
As Fig. 3 shows, worms of *S. gynobranchiata* were unevenly distributed in the Sevastopol Bay, giving preference to muddy silts in the innermost part of the bay, i.e., in the estuarine zone where, during the observation period, the inflowing river decreased seawater salinity from 17.7 to 14.3‰ and the sediment was largely represented by pelitic silts (66±8%, on the average).

![Figure 3. Distribution of polychaete worms *S. gynobranchiata* (density in ind.·m⁻²) in the Sevastopol Bay: A – in 2007; B – in 2008; C – in 2013.](image)

Detritivorous polychaetes of the genus *Streblospio* live in upper layers of soft sediment, well tolerate organic enrichment and, like some other species of Spionidae, can be indicators of above-normal eutrophication of habitats (Cinar *et al.* 2009). Population density of this worm is especially high in areas in or around seaports (Cinar *et al.* 2005, 2009; Radashevsky & Selifonova 2013). In 2007, in the Sevastopol Bay, severely polluted by organic substances, estimates of *S. gynobranchiata* population density were highest in the sampling locations which had bottom sediment with largest nitrogen content.

By 2009, population density of the polychaetes *S. gynobranchiata* has increased to its maximum; after this peak, it slightly decreased by 2013. Such dynamics is typical of opportunistic species naturalizing new biotopes. Hypothetically, the abundance would stabilize with time.
Researchers studying the genus *Streblospio* suppose that this worm has lecitho- or planktotrophic larvae or can develop directly (Rice & Levin 1998; Radashevsky & Seliftonova 2013). Since 1998, when the species *S. gynobranchiata* was first described, little evidence has been acquired about details of the biology of this polychaete. Presently, it is known that larvae are planktotrophic, appearing in the plankton at 3–chaetiger stage; when the body attains 9–12 chaetigers, they settle onto the substrate (Rice & Levin 1998). All authors explain appearance of *S. gynobranchiata* in the Aegean and Caspian Seas by accidental introduction with ballast water (Cinar *et al.* 2005; Taheri *et al.* 2008). Probably, this explanation applies as well to the Black Sea. The study of features pertaining to reproduction cycle of *S. gynobranchiata* from the Sevastopol Bay acquires interest.

The adult females were 38–40 chaetigers, eggs are carried in the coelom of chaetigers from 8th to 23rd. The maximum size of the eggs was 100–112 µm. Having developed to 3-segmented stage, the larvae come into the sea water. Their length varies from 144 to 160 µm and width – from 80 to 88 µm. Prostomium is rounded, with the reddish edge and one pair of red eyes present. Simple chaetae on the 1st chaetiger exceed the whole body length. At this stage of development larvae actively swim in the surface layer. On the 2nd day, the swimming activity slowed and the larvae began to sink to the bottom. Their bodies have grown 168–210 µm long without getting broader; segmentation is feeble; another pair of red eyes has formed. Larvae of *S. gynobranchiata* are transparent, with distinctly visible deep-yellow intestine. On the 3rd–4th day, the length and width increased to 250–300 µm and to 96–100 µm, respectively and the number of segments increased to 5. Pygidium was equipped with four anal antennae. On the 5th–6th day, larvae drifted close to the bottom, periodically rising to the surface. Body length has increased to 550 µm, width to 96–100 µm, while the number of segments increased to 6–7. On the 7th–8th day, larvae were 700 µm long and 125 µm wide, with 8–9 chaetigers bodies and newly developed palps. On the 9th–10th day, they had 10–12 chaetigers bodies, 700–900 µm in length and 100–125 µm in width; settling onto the bottom of crystallizers began, as has been described earlier (Rice & Levin 1998). As soon as the body grew to 1050–1150 µm in length, 150–175 µm in width and reached 13–14 chaetigers, all settled larvae began to build slimy tubes of sand particles and mud (Fig. 4, 5). In the laboratory, juveniles of this generation reached maturity in 3.5 months (with eggs visible in female bodies) and started to reproduce in the fourth month.

![Figure 4](image1.png)

*Figure 4.* *S. gynobranchiata*: A, a body fragment of an egg-carrying female; B, a 3–chaetiger larva just hatched from egg capsule; C, a 3–chaetiger larva on the 2nd day; D, a 5–chaetiger larva equipped with anal cirri; E, a 9–chaetiger larva; F, a 13–chaetiger larva making a tube. Scale: A- F – 100 µm.

It is noteworthy to mention that in crystallizers which did not contained soft sediment some larvae did not settled but went on swimming free near the bottom for more than 20 days, without growing and without forming new segments.

Under the year-round incubation in the tanks worms *S. gynobranchiata* produced larvae the year through; only solitary larvae were seen in December–January whereas in spring and in autumn their number
conspicuously increased. These observations suggest an extended reproduction period with the intensity peaks in spring and in autumn (March–April and September–November, respectively) when the sea water has a temperature of 15 to 24.4°C.

![Figure 5](image)

**Figure 5.** Adult worm (♂). Scale: 1 mm.

In October 2013, the average number of spionid polychaetes *S. gynobranchiata* observed in benthic samples collected from the Sevastopol Bay was twice as large as in May (Fig. 6). Presumably, basic recruitment of the population goes during warm season of the year thereby attain largest abundance by the end of autumn.

![Figure 6](image)

**Figure 6.** Average abundance of *S. gynobranchiata* in Sevastopol Bay in May and in October 2013.

**Conclusions**

In 2007, first individuals of *S. gynobranchiata* were recorded in the Sevastopol Bay. Since then, this species has been constantly present in the bay; at first, density of the population steadily grew up, having increased to the maximum of 703±43 ind. m⁻² in 2009, and then reduced to 465±56 ind. m⁻² by 2013. The polychaetes inhabit muddy areas of the sea floor largely covered with pelitic silts (66±8 %) at 2–17 m depths and 14.3 – 17.7‰ salinity of the sea water.

It was experimentally proved that at seawater temperature of 17–18°C planktonic stage of this polychaete worm completed development in 9–10 days; in the absence of suitable substrate the period of
growth increased to a month. Worms fully matured within three and a half months since their appearance in plankton and started to reproduce half a month later, at four months. This reproduction strategy facilitates fast and potentially massive expansion of the invasive alien *S. gynobranchiata* along the Black Sea shoreline.

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