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ABOUT THE FINDING OF PELAGIC LARVAE OF HOLOTHUROIDS (ECHINODERMATA: HOLOTHUROIDEA) OFF THE SOUTHWESTERN COAST OF THE CRIMEA (THE BLACK SEA)

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Due to the low salinity of the Black Sea water, only a few species of echinoderms inhabit it. During the entire research period, seven species of sea cucumbers were found. Out of those, five can be considered true inhabitants; the rest were recorded only in the Bosporus outlet area. Two species of holothuroids, *Leptosynapta inhaerens* (O. F. Müller, 1776) and *Stereoderma kirchsbergii* (Heller, 1868), were relatively frequently encountered in zoobenthos off the coast of the Crimea. There is no data on the reproduction of sea cucumbers in the Black Sea. In the early 20th century, their larvae were rarely and mostly singly noted in plankton. After 1935, holothuroid larvae were not observed in plankton off the coast of the Crimea. During regular year-round meroplankton sampling in the Sevastopol Bay, holothuroid larvae, auriculariae, were found in the surface layer (0–10 m) in August 2023, for the first time within the past 20 years. Water temperature at the time of sampling was +25.3 °C, and salinity was 17.7‰. Larval density was 2 ind.·m^{-3} of water mass. Dimensions of auriculariae were as follows: length, 750–800 µm, and width, 400–425 µm. It is suggested that registered auriculariae belong to the species *S. kirchsbergii*. It is relatively abundant in the Black Sea benthos and occurs at depths of 30–125 m. The rarity of auricularia findings is probably due to the fact as follows: a holothuroid *S. kirchsbergii* inhabits biotopes with constant low water temperature, and all stages of its development are adapted to occur in water layers below the thermocline.

Keywords: macrozoobenthos, holothuroid, *Stereoderma kirchsbergii*, pelagic larvae, auricularia

There are seven species of holothuroids in the Black Sea; out of those, five can be considered true inhabitants, and the rest are recorded only in the Bosporus outlet area [Baranova, Savel'eva, 1972; Marinov, 1990; Öztoprak et al., 2014]. Among the five species, *Oestergrenia thomsonii* (Herapath, 1865) was found only once in the Bugazsky Estuary, while the validity of *Synapta hispida* Heller, 1868 and, consequently, reports on its finding in the Black Sea raise certain doubts [Baranova, Savel'eva, 1972; Bohn, 2004]. K. Vinogradov [1967] believed that *S. hispida* identification was a mistake, and that it was actually *Leptosynapta inhaerens* (O. F. Müller, 1776). In the middle of the 20th century, one holothuroid species, *L. inhaerens*, was registered in the northwestern Black Sea off the Soviet coast, and also *Oestergrenia digitata* (Montagu, 1815) was noted off the Romanian coast [Biologiya, 1967]. Later, in addition to *L. inhaerens*, which was fairly common, a holothuroid *Stereoderma kirchsbergii* (Heller, 1868) was occasionally found in the northwestern Black Sea [Samyshev, Zolotarev, 2018]. Only two holothuroid species, *L. inhaerens* and *S. kirchsbergii*, were often encountered in zoobenthos off the Crimean coast.

The first one was registered at a depth of 18–100 m, while the second one, at 50–125 m [Kiseleva, 1981; Revkov, 2003; Revkov et al., 2015; Samyshev, Zolotarev, 2018]. Single specimens of *O. digitata* were recorded only in 1904–1910 in one of Sevastopol bays [Zernov, 1913], and confirmation is required whether the species inhabits the Crimean shelf area.

In the first half of the 20th century, holothuroid larvae, auriculariae, were registered rarely and mainly as single specimens in plankton off Sevastopol and off the coast of Karadag [Dolgopol's'ka, 1940; Galadzhiev, 1948; Zernov, 1904, 1913], and were reported for the Karkinitsky Bay only once [Galadzhiev, 1948]. Within 1902–1912, auriculariae were recorded in the coastal area of Sevastopol in summer, during the period of maximum water warming [Zernov, 1913]. In 1929–1933, June to September, single auriculariae were noted in the Karadag Biological Station vicinity, primarily in a water layer of 10–15 m [Dolgopol's'ka, 1940]. After 1935, holothuroid larvae were not found in plankton off the Crimean coast. There is no data on holothuroid reproduction in the Black Sea, except for the fact that reproductive products in gonads of two species (*L. inhaerens* and *S. kirchsbergii*) inhabiting the Crimean coast were encountered in June and July [Kiseleva, 1981; Zernov, 1913].

In August 2023, we registered two holothuroid larvae (Fig. 1A) in plankton sampled in a water layer of 10–0 m on the outer roadstead of the Sevastopol Bay (44°37′13″N, 33°30′07″E). The larvae were 750–800 μm long and 400–425 μm wide. At the time of sampling, the water temperature was +25.3 °C, and salinity was 17.7 ‰. The material was sampled with a Juday plankton net (mill gas mesh of 135 μm, and inlet diameter of 36 cm). Pictures of the larvae and adult holothuroids were taken in live condition with a Sony Cyber-shot 16.2 camera. The material was preserved in a 4% formalin solution.

Notably, this is the first time holothuroid larvae were found in 20 years of regular year-round meroplankton sampling (since 2004) on the outer roadstead of the Sevastopol Bay. According to an oral report of Yu. Zagorodnyaya (IBSS), zooplankton she sampled on the Crimean shelf between 2010 and 2022 included auriculariae only once: in the Feodosia Gulf (June 2016; 45°0′48″N, 35°38′06″E). They were noted in a water layer of 18–0 m at a 22-m deep station, and the density was 2 ind.·m^{-3}.

Fig. 1. Holothuroids found in the coastal waters of the Crimea: A, auricularia (photo by E. Lisitskaya); B, C, *Stereoderma kirchsbergii* (photo by A. Nadolny). Scale bars are 100 μm (A) and 5 mm (B)

Considering how incidental and minor auricullariae findings in plankton are, one could make an assumption that holothuroids are a rare component of zoobenthos in the shelf area of the Crimean Peninsula. However, this is not the case. According to our data, two holothuroid species, *L. inhaerens* and *S. kirchsbergii*, are fairly common in macrozoobenthos of the Black Sea shelf area, including the coast of the Southwestern Crimea. *L. inhaerens* is common in coastal biotopes of the Southwestern Crimea at a depth of 0.5–30 m both in open areas and in bays. Its occurrence at certain sites reached 10–25%, and density was up to 200 ind.·m^{-2} [Boltachova et al., 2022]. Earlier, M. Galadzhiev [1948] suggested that holothuroid larvae registered in the Black Sea plankton belonged to the genus *Leptosynapta* Verrill, 1867. However, studies of reproductive biology of *L. inhaerens* off the coast of Great Britain revealed that it is characterized by direct development [Thomson, 1862]. Therefore, auricullariae found in plankton off the Crimea could not be *L. inhaerens*, with its adult form being a common and abundant species in zoobenthos of this area. We can only assume that the holothuroid larvae recorded in plankton are another species: *S. kirchsbergii* (Fig. 1B, C).

Most representatives of the family Cucumariidae Ludwig, 1894, to which *S. kirchsbergii* belongs, have a larval stage of development, but some arctic forms are characterized by direct development [Kohtsuka et al., 2021]. *S. kirchsbergii* is common in seas of the Mediterranean Basin and off the Atlantic coast of Morocco [Bohn, 2004]. There is no data on its reproduction, apart from the fact as follows: in June and July, the sex ratio in the Black Sea population was 1 : 1, and gonads of females with a length of 16–18 mm contained 1,130 eggs of 0.175 mm [Kiseleva, 1981]. We noted mature females with eggs in samples taken off the Crimean coast on 23.06.2022 at a depth of 64 m. This species is common in the Black Sea; it occurs at depths of 30 to 125 m where it can even form significant aggregations [Baranova, Savel'eva, 1972; Kiseleva, 1981]. Most often, *S. kirchsbergii* is found in biotic communities dominated by bivalves: *Mytilus galloprovincialis* Lamarck, 1819 (the silt form) and especially *Modiolula phaseolina* (R. A. Philippi, 1844) [Kiseleva, 1981; Zernov, 1913]. We registered *S. kirchsbergii* on the Crimean shelf primarily in *M. phaseolina* community deeper than at 70 m, with the species maximum density of 72 ind.·m^{-2} and wet weight of 7.53 g·m^{-2} [Revkov et al., 2015]. On the coast of Sevastopol (33°24′8″N, 44°32′45″E), *S. kirchsbergii* was recorded at a depth of 62 m, also in *M. phaseolina* community; its density reached 48 ind.·m^{-2}, and wet weight was of 2.59 g·m^{-2}. In the Black Sea, sustainable *M. phaseolina* communities, as well as its biocenosis, exist within a depth range of 40–50 to 125 m [Kiseleva, 1981; Mitilidy Chernogo morya, 1990]. Therefore, the depth distribution of adult holothuroids *S. kirchsbergii* in the Black Sea is quite similar to that of *M. phaseolina*. The latter one is known to have a pelagic stage of development; however, its planktonic larvae were not observed in water layers above the thermocline (35–50 m), even though adult *M. phaseolina* were occasionally recorded at a smaller depth [Mitilidy Chernogo morya, 1990]. Considering the boundaries of *S. kirchsbergii* vertical distribution (30–125 m), one could assume that all its development stages, similar to those of a bivalve *M. phaseolina*, are adapted to occur under constantly low water temperature, which is generally registered in the Black Sea at depths of 35 m and lower. It is also known as follows: during strong offshore winds, some larvae of benthic animals can be carried to a small depth, to the shore, from a near-bottom layer or a layer below the thermocline [Mitilidy Chernogo morya, 1990]. If our assumption is correct and auricullariae noted in plankton off the Crimean coast are indeed *S. kirchsbergii*, then, the rarity of such findings can be attributed to the vertical distribution of this species: its association with biotopes with constantly low water temperature.

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О НАХОЖДЕНИИ ПЕЛАГИЧЕСКИХ ЛИЧИНОК ГОЛОТУРИЙ (ECHINODERMATA: HOLOTHUROIDEA) У ЮГО-ЗАПАДНОГО ПОБЕРЕЖЬЯ КРЫМА (ЧЁРНОЕ МОРЕ)

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В Чёрном море обитает лишь несколько видов иглокожих, что связано с пониженной солёностью его вод. За весь период исследований было обнаружено семь видов голотурий, из которых истинными обитателями можно считать пять; остальные зарегистрированы только в прибосфорском районе. У берегов Крыма два вида голотурий — *Leptosynapta inhaerens* (O. F. Müller, 1776) и *Stereoderma kirchsbergii* (Heller, 1868) — относительно часто встречали в зообентосе. Данных о размножении голотурий в Чёрном море нет, а их личинок редко и в основном единично находили в планктоне в начале XX в. После 1935 г. личинки голотурий в планктоне у побережья Крыма отмечены не были. В ходе проведения регулярных круглогодичных сборов мероланктона в Севастопольской бухте в августе 2023 г. в поверхностном слое (0–10 м) впервые за последние 20 лет были обнаружены личинки голотурий — аурикулярии. Температура воды на момент

отбора проб составляла +25,3 °C, солёность — 17,7 ‰. Плотность личинок — 2 экз.·м$^{-3}$ водной массы. Размеры личинок: длина — 750–800 мкм, ширина — 400–425 мкм. Предполагается, что обнаруженные аурикулярии относятся к виду *S. kirchsbergii*. Он относительно многочислен в бентосе Чёрного моря и обычно встречается на глубине 30–125 м. Редкость находок личинок в поверхностных слоях воды, вероятно, обусловлена тем, что голотурия *S. kirchsbergii* обитает в биотопах с постоянной низкой температурой воды и все стадии её развития проходят ниже границы термоклина.

Ключевые слова: макрозообентос, голотурия, *Stereoderma kirchsbergii*, пелагические личинки, аурикулярия