ON THE REPRODUCTION OF THE CURLED PICAREL *CENTRACANTHUS CIRRUS* (SPARIDAE) IN THE BLACK SEA

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The article presents a description of the larva of the curled picarel *Centracanthus cirrus* Rafinesque, 1810, caught in the northern part of the Black Sea off the coast of the Crimean Peninsula in the waters of the Koktebel Bay near Cape Malchin (Karadag Nature Reserve). The occurrence of the curled picarel larva in the ichthyoplankton of this area indicates the reproduction of this species in the Black Sea and thus confirms its adaptation to new environmental conditions and the expansion of its range in the seas of the Mediterranean basin.

Keywords: curled picarel *Centracanthus cirrus*, reproduction, Black Sea, South-Eastern Crimea.

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INTRODUCTION

The curled picarel *Centracanthus cirrus* Rafinesque, 1810 (synonym *Smaris insidiator* Valenciennes, 1830) and three species of the genus *Spicara* (*S. maena* (Linnaeus, 1758), *S. smaris* (Linnaeus, 1758) and *S. flexuosum* Rafinesque, 1810) are representatives of the Sparidae family described for the Mediterranean Sea (until 2014, they were all classified as belonging to the family Centracanthidae) . The main distinguishing features of adult specimens of the curled picarel from the three mentioned species of the genus *Spicara* are a low, elongated and laterally compressed body, a large number of scales in the lateral line (up to 100), 13 hard spiny rays in the dorsal fin, separated by a deep notch from 10 soft rays. The curled picarel is a short-lived fast-growing species, with a maximum age of five years, inhabiting the sublittoral zone in areas with rocky and pebble substrates at depths of up to 500 m, feeding mainly on copepod crustaceans (Copepoda) (Salekhova, 1979; Ozaydin et al., 2000 ; Christiansen et al., 2009) .

All three aforementioned species of the genus *Spicara* are found in the Black Sea, while information about the presence of adult specimens of the curled picarel here is absent in the literature (Zei, 1951; Svetovidov, 1964; Rass, 1965; Dekhnik, 1973; Salekhova, 1979; Vasilyeva, 2007). Evidence of the probable migration of the curled picarel into the Black Sea is its successful reproduction in June 1982 - live developing eggs of the curled picarel were caught in the open part of the sea east of Varna (43°18′ N, 31°33′ E) (Tsokur, 1988). There is also information that in 2004, the curled picarel was registered in Romanian waters and until 2013, only 3 specimens were caught (Abaza et al., 2006; Radu, personal communication - cited from: Boltachev, Karpova, 2014). However, the authors do not specify whether these individuals were sexually mature or not.

The native range of the longfin centracanthid covers the Eastern Atlantic from the waters off Morocco in the south to Portugal in the north, including the Azores, Canary Islands, and Madeira, as well as the Mediterranean Sea (Kalinina, Podosinnikov, 1978; Haemstra, 1990). It was previously believed (Keskin et al., 1998; Kallianiotis et al., 2004) that the species' distribution in the Mediterranean Sea was limited to the northern part of the Aegean Sea, however, in 2012, a female with gonads at stage II of maturity was caught in the northwestern part of the Sea of Marmara (Artüz, Kubanç, 2015).

Data on the breeding periods of the centracanthid are contradictory. In the Mediterranean Sea, according to Sanzo (Sanzo, 1939), the longfin centracanthid reproduces in the autumn season, while according to Marinaro (Marinaro, 1971), – in summer. In the Central-Eastern Atlantic (Canary Current region), its eggs and larvae were found in the ichthyoplankton from March to November and were absent only in the winter season from December to February (Kalinina, 1981). In the Black Sea, centracanthid eggs were caught in July (Tsokur, 1988). It should be noted that the eggs of this species, unlike those of the genus *Spicara* , are pelagic and have a characteristic cone-shaped protuberance, which makes them easy to identify in the ichthyoplankton (Sanzo, 1939; Kalinina, 1981; Tsokur, 1988). One larva of the longfin centracanthid was caught in July 2010 in the 0-10 m layer off the southwestern part of the Crimean Peninsula (Klimova, Podrezova, 2018).

In our work, for the first time, we present a description of a longfin centracanthid larva caught in the Black Sea near the eastern part of the Crimean Peninsula in the waters of Koktebel Bay near Cape Malchin.

MATERIAL AND METHODS

The larva was caught on 07/21/2021 (44°56.309′ N, 35°15.277′ E) during an 8-minute horizontal surface catch with an IKS-80 ichthyoplankton net (inlet diameter 80 cm, mesh size 400 μm) at a distance of 100 meters from the shore over a depth of ~ 10 m. The seabed at the fishing site is rocky, with boulders covered with macroalgae. The ichthyoplankton sample was fixed with a 4% formaldehyde solution. Laboratory processing was performed using a Zeiss Stereo Discovery V.20 binocular microscope combined with an Axiocam 208 camera ("Carl Zeiss AG", Germany). Identification was carried out using literature sources (Sanzo, 1939; Salekhova, 1979). The specimen is stored in the laboratory of biochemistry and physiology of aquatic organisms at the Karadag Scientific Station - Nature Reserve of the Russian Academy of Sciences.

RESULTS

In addition to the larva of the whiskered centracanthus, the sample contained larvae of the European anchovy *Engraulis encrasicolus* (Linnaeus, 1758), the tentacled blenny *Parablennius tentacularis* (Brünnich, 1768), and the Mediterranean horse mackerel *Trachurus mediterraneus* (Steindachner, 1868). European anchovy larvae dominated numerically (83%).

The total body length (*TL*) of the centracanthus larva was 2.17 mm, weight 0.8 mg, ante-anal distance 0.60 mm (27.7% *TL*) (figure). The larva's body is elongated, spindle-shaped, with a height of approximately 1/6 of its length. The fin fold is well-developed, especially in the anterior-dorsal part, where it reaches its greatest height. It encompasses the entire body, extending to the upper part of the head, absent only on its anterior and ventral parts. There is a mouth slit and rudiments of pectoral fins. In the trunk section, there are eight myomeres, and in the caudal section – 20. The yolk sac is spherical with a diameter of 0.15 mm, transparent. As in the developing eggs described by Tsokur (1988), the yolk contains fatty inclusions in the form of droplets of various sizes. The presence of fatty inclusions gives the yolk a granular structure. One large opaque oil droplet is located in the posterior part of the yolk. Pigmentation of the trunk and ventral part of the caudal section behind the anus is weakly expressed. At the base of the caudal fin, a bright pigment spot is noticeable.

DISCUSSION

According to Salekhova (1979), *TL* of hatching larvae of the blotched picarel is 2.4-2.8 mm, their body is fusiform, elongated, its height is approximately 1/6 of its length, the anus is located in the anterior part of the body, the pre-anal distance is about 43% of *TL* , there is no pigment in the eyes, the head is tightly pressed to the yolk sac, and the oil droplet is located in its posterior part. There are eight myomeres in the trunk section and 20 in the caudal section. The pigmentation of prelarvae and larvae varies significantly. At the age of 2 days with *TL* of 3.4 mm, the yolk is partially resorbed, the mouth opening begins to form, and slight pigmentation appears around the eyes. At three days of age, the *TL* of larvae is 3.5 mm, remnants of the yolk sac persist, the pre-anal distance is reduced to 33% of *TL* , and the eyes are pigmented.

Thus, the larva caught in the waters of Koktebel Bay has typical systematic features of the blotched picarel: an elongated fusiform body, eight trunk and 20 caudal myomeres, anus location in the anterior part of the body, and the presence of a large oil droplet at the end of the yolk sac (figure, a). Judging by the developmental characteristics (yolk sac with a large oil droplet in its posterior part, the presence of a mouth slit, pre-anal distance of approximately 30% of *TL* , pigment just beginning to appear in the eyes), the age of the caught larva is approximately 2-3 days (figure, b, c).

The individual was 1.5 times smaller than larvae of the same species and age from the Mediterranean Sea, described by Salekhova (1979) using information from Sanzo (Sanzo, 1939). At least three factors could have affected the larva's size: the Black Sea temperature regime differing from the Mediterranean during the embryonic and post-embryonic development of the individual, lower salinity in the Black Sea, and the effects of formalin fixation. In September, the water temperature in the Mediterranean Sea is usually ~20°C, while in the Koktebel Bay area in the third decade of July 2021, the sea surface temperature was 27°C. According to experimental studies (Reproduction and ecology... 1970; Daufresne et al., 2009), increased water temperature leads to a reduction in the duration of embryonic and post-embryonic development of fish and to a decrease in the size characteristics of their larvae. In recent years, due to climate warming in the Black Sea, there has been a 1.5-2.0 times decrease in the size of fish larvae both at hatching and during post-embryonic development. Moreover, changes in the size composition of larvae were observed in both temperate-water fish (European sprat *Sprattus sprattus*) and warm-water (European anchovy and Black Sea horse mackerel) complexes (Klimova et al., 2021, 2022).

In the absence of data on catches of adult specimens suggesting the possibility of their spawning in the region, the question arises about the origin of eggs and larvae of the striped seabream in the Black Sea near the shores of the Crimean peninsula. Their presence in the northern half of the Black Sea excludes the possibility of their transfer here by cyclonic currents from the Sea of Marmara, since during the summer spawning season, the embryonic development of pelagic eggs of various fish species in the Black Sea at temperatures of 20-23°C usually varies from 1.5 to 5.0 days. Currents do not have sufficient speed to transport freshly fertilized eggs from the Sea of Marmara to the shores of Crimea within these timeframes. According to Boltachev and Karpova (2014, p. 16), findings of centracanthid specimens in the Black Sea may be a result of "isolated cases of independent penetration."

The expansion of the range of the curled picarel in the Mediterranean Sea to the Sea of Marmara (Artüz, Kubanç, 2015) increases the probability of species migration into the Black Sea through the Bosphorus Strait, which is confirmed by the discovery of live developing eggs near the coast of Bulgaria (Tsokur, 1988), a curled picarel larva near the southwestern coast of Crimea off Sevastopol (Klimova, Podrezova, 2018), and finally, the capture of a larva near the eastern coast of the peninsula (off Karadag). Probably, adults from the Sea of Marmara penetrate the Black Sea through the Bosphorus Strait, move northward along the coasts of Turkey, Bulgaria, and Romania, and then eastward along the Crimean Peninsula.

Unlike the Mediterranean Sea, which has an average salinity of 38‰, the salinity in the Sea of Marmara varies from 22.5‰ in winter to 23.5‰ in summer, which corresponds to the maximum salinity indicators of the bottom water layer in the Black Sea from the near-Bosphorus area to the northeast to the southern part of the Crimean Peninsula. Salinity in the surface horizons of the Black Sea waters increases toward the autumn hydrological season due to enhanced vertical mixing and the removal of salts from great depths to the surface (Fundamentals of Biological Productivity..., 1979). Climate change occurring in recent decades has led to an increase in the speed of the Main Black Sea Current during the summer hydrological season (Artamonov et al., 2019), which contributes to increased anticyclonic activity in the coastal shelf zone and vigorous water exchange between the latter and the deep-sea areas. Simultaneously, there is an export of nutrients from coastal waters to open shelf waters, which increases the biodiversity and abundance of planktonic organisms, promotes the survival of planktivorous fish species in the Black Sea, and attracts Mediterranean invaders here.

The question of the survival prospects of early development stages of the curled picarel in the Black Sea conditions requires further study. It is necessary to continue monitoring studies of coastal areas of the Black Sea shelf waters to analyze the biodiversity of ichthyofauna at all stages of ontogenesis - from the initial stages of development to mature individuals.

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COMPLIANCE WITH ETHICAL STANDARDS

All manipulations with the research object did not contradict international standards and were carried out in accordance with the guidelines for the maintenance and use of laboratory animals (http://oacu.od.nih.gov/regs/index.htm). The study was approved by the Bioethics Commission of FRC IBSS RAS, protocol No. 2(7)/24 dated March 28, 2024.

CONFLICT OF INTEREST

The authors of this work declare that they have no conflict of interest.

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FIGURE CAPTION

Larva of Centracanthus cirrus *Centracanthus cirrus TL* 2.17 mm: a - general view; b, c - head and trunk sections, lateral and ventral views, respectively. *an* - anus, *ey* - eye, *ff* - fin fold, *ld* - oil droplet, *pf* - pectoral fin, *yo* - yolk sac. Scale, μm: a - 500; b, c - 100.