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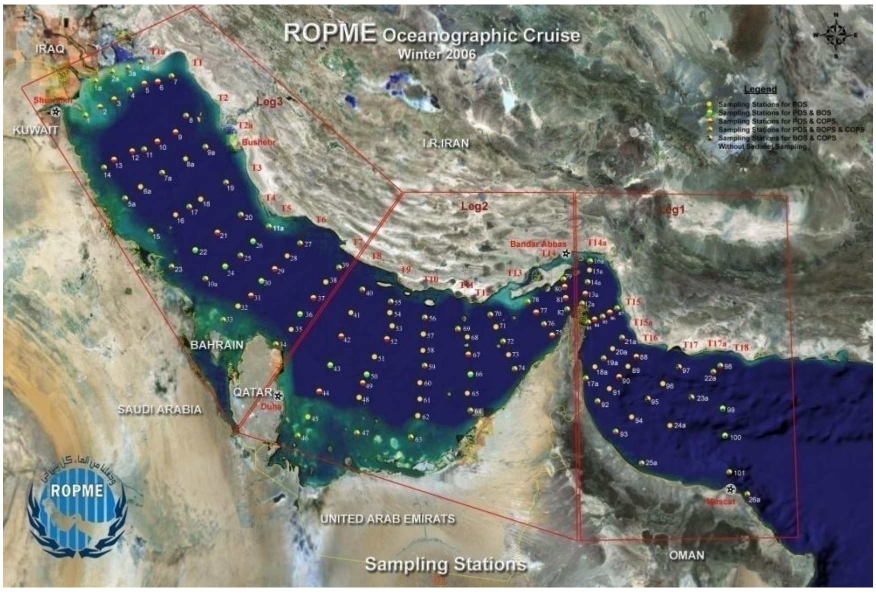
Regional Organization for the Protection of the Marine Environment

ROPME Oceanographic Cruise - Winter 2006



Technical Report Series

Technical Report : No. 8

Ichthyoplankton in the ROPME Sea Area

March 2012

ROPME Oceanographic Cruise - Winter 2006

Technical Report Series:

1. Physical Oceanography
2. Contaminants in Marine Sediments
3. Nutrients
4. Chlorophyll-*a*
5. Phytoplankton
6. Zooplankton
7. Decapod Larvae
8. Ichthyoplankton
9. Tintinnids
10. Meiobenthos
11. Macrobenthos

Disclaimer

This Report has been prepared by Kuwait Institute for Scientific Research, as the Principal Investigator on 'Ichthyoplankton' under a contract with ROPME. The Report is being separately subjected to peer review and linking with other relevant data and information, in order to develop an integrated understanding of the ROPME Sea Area. Meanwhile, in order to bestow the benefit of viewing the results in their preliminary form and promote a general level of understanding of the marine environment of the Region, notwithstanding the possible delay by peer review, this document is being brought out as part of a special Technical Report Series in the very form in which it was submitted by the Principal Investigator. Owing to this reason, ROPME shall not accept responsibility on the accuracy of data or interpretations contained in this Report. ROPME does not also subscribe to the inappropriate terms used to denote parts or full of the ROPME Sea Area inadvertently used by the Principal Investigator or provided in the published references and citations.

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Preface

In recognition of the importance of the oceanographic Cruises in the ROPME Sea Area to understand the state of the marine environment, ROPME Council has assigned high priority to the ROPME scientific Cruises. In pursuance of the Council Decision CM12/7, ROPME was mandated to coordinate a comprehensive oceanographic Cruise in Winter 2006. The Cruise was planned in such a way that the results and reports of the studies can find their way into the synthesis of ROPME State of the Marine Environment Report.

As a result of sustained efforts, cooperation of Member States, guidance of the designated scientific committee for the Cruise, encouragements from the Executive Committee of ROPME and the generous provisions made by the Council, the historic Winter Cruise was carried out successfully on board of M/V Ghods of I. R.Iran during 1st February and 11th March 2006.

Totally, 115 stations covering the RSA have been surveyed and 97 experts from ROPME Member States participated in the Cruise. The survey covered most of the main oceanographic disciplines.

The collected samples during the Cruise were distributed on a competitive basis to the competent laboratories in the Region and elsewhere for detailed analyses while sub-sample sets were kept in ROPME Marine Sample Bank to enable repetitive analyses in future, when required.

To enhance benefits from the reproduced results of the Cruise among Regional scientific community towards a better understanding of the marine environment in the RSA and to enable furtherance of marine researches, ROPME Secretariat decided on the publication of the results in a series of Technical Reports as follows:

1. Physical Oceanography
2. Contaminants in Marine Sediments
3. Nutrients
4. Chlorophyll-*a*
5. Phytoplankton
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The present Technical Report is devoted to the taxonomy and spatial occurrence and abundance of ichthyoplankton in the RSA. The analyses of ichthyoplankton samples and reporting have been conducted by a team of scientists led by Dr. Faiza Al-Yamani at Kuwait Institute for Scientific Research (KISR) under a contract with ROPME.

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Executive Summary

Samples of fish eggs and larvae were collected from the ROPME Sea Area (RSA) (Covers inner RSA and Sea of Oman) from 59 stations during the period from 3 February 2006 until 9 March 2006. In total, 46 taxa were identified and counted in the samples. Taxonomic descriptions of 35 families of fish larvae with microscopic photographs of larvae are given in this Report.

The maximum abundance of fish larvae in the Sea of Oman was mainly due to the presence of mesopelagic fish species *Diaphus* sp. Such high abundance may be explained by the location of the three sampling stations in areas of convergence, appearing as a result of conjunction of currents transporting larvae.

In the Sea of Oman, pronounced variety of larvae were encountered, which are representatives of the Sparidae family. In the inner RSA, ichthyoplankton abundance was generally lower than the rest of the sampled areas. Abundance of eggs in the inner RSA was higher than the Sea of Oman, especially at the northern end of the inner RSA. Maximum larval abundances were encountered in the inner RSA, nearly off the Strait of Hormuz. These high abundances were mainly associated with the high densities of the Engraulidae family, which were ubiquitous but with low abundances.

The values of Shannon Index were low during the Winter Cruise, and ranged from zero to 1.77. The ichthyoplankton community was diverse in the waters of Sea of Oman and inner RSA to the north-west off Bahrain. Most likely, this pattern reflects results of interactions between hydrodynamic properties, spawning, and behavior of fish, including migrations.

1. Introduction

The area of the survey – ROPME Sea Area (RSA), exactly inner RSA, together with Sea of Oman is situated in the subtropical climatic zone. The climate in this Region is arid, resulting in an excess of evaporation over precipitation plus river runoff (Swift and Bower, 2003).

The RSA receives freshwater influx from the Euphrates and Tigris rivers in Iraq, Karun and Mond Rivers in I.R. Iran as well as from numerous small seasonal streams draining the Zagros mountains in I.R. Iran, together with perennial Minab and Sarbaz Rivers draining the Strait of Hormuz and the Sea of Oman.

Much of the evaporation takes place along the shallow inner RSA shorelines, causing increasing salinity and density currents, which sink towards the northeast, eventually exiting the Strait of Hormuz in its deepest part (Hunter, 1986). Replacement water flows in through the Strait of Hormuz in surface levels, passing inwards along the Iranian coast before reaching the coasts of inner RSA in a broadly anti-clockwise flow (Sheppard *et al*., 1992). Abdelrahman and Ahmad (1995) analyzed the current meter data collected during the expedition on RV "Mt. Mitchell" and confirmed the existence of a surface anticlockwise flow in the months of March and April. This circulation pattern transformed into a northward surface flow in May and was attributed to the seasonal change of the wind fields (Azam *et al*., 2006).

The circulation in the inner RSA is primarily driven by the prevailing northwesterly winds, secondarily by thermohaline forcing, and thirdly by the tides (Thoppil and Hogan, 2010). The tidal influence on the circulation in the inner RSA is insignificant, except in the Strait of Hormuz and along the Iranian coast (Blain, 1998). A typical basin-scale circulation in the inner RSA is cyclonic and composed of a northwestward-flowing Iranian Coastal Current from the Strait of Hormuz along the northern side of the basin with speeds greater than 10 cm s^{-1} (Hunter, 1983) and a southeastward-flowing current in the southern portion of the RSA (Reynolds, 1993).

The surface current is strongest during the summer and weakest (5-10 cm s^{-1}) in the winter. The weaker winter circulation is a result of the reduced density gradient between the inner RSA and the Sea of Oman and because of weak stratification owing to winter cooling. Winter circulation consists of a wind-driven southeastward current (5 cm s^{-1}) downstream from north of Qatar and density-driven Iranian Coastal Current, which flows against the prevailing northwesterly winds and develops in February-March, reaching its maximum strength in June-July (Thoppil and Hogan, 2010).

Average winter surface water temperatures (SST) ranges from 22°C near the Strait of Hormuz to 16°C near the North-West part of the inner RSA (Brewer and Dyrssen, 1985). The lowest known reported SST was 11.5°C (Coles and Fadlallah, 1991). Salinity values up to 43 are common in winter toward the north-west head of the RSA (Reynolds, 1993) and salinity of >39 occurs in most waters of RSA (Sheppard *et al*., 2010).

The study of fish biology should include their early life stages and their ontogenesis – embryonic and postembryonic phases, i.e., components constituting ecological conglomeration defined as ichthyoplankton. Ichthyoplankton includes eggs, prelarvae and larvae of only bony pelagofilous fishes but postembryonic stages of fishes with demersal eggs.

The identification of larval stages of fish is a difficult task, and most reports include identification to the family level. Only in a very few cases did the identification go to the genus level or species level.

There are a few published studies of larval fishes (Houde *et al*., 1986; Grabe *et al*., 1992; Gjøsæter and Tilseth, 1988) from the whole inner RSA and Sea of Oman, and most studies are published as as internal reports. However, it was noted that in Kuwait Bay peak numbers and types of larvae occurred during late spring and early summer with the minimum during winter (Grabe *et al*., 1990). In October 2008, the first comprehensive guide of larval fishes from the inner RSA was published by Richards (2008).

The Regional Organization for the Protection of the Marine Environment (ROPME) organized its third oceanographic Cruise in Winter 2006. The goals of ROPME cruise was to study the ecosystems of the RSA and to expand the scope of biological, physical and chemical observation in the RSA. Ichtyoplankton was an important part of this cruise.

2. Materials and Methods

The ichthyofauna of the inner RSA and Sea of Oman comprises more than 500 species of bony fishes, not taking into account many species of the meso- and bathypelagic zones of the Sea of Oman. Fig. 1 displays the different phenotypes of larval fish belonging to different families.

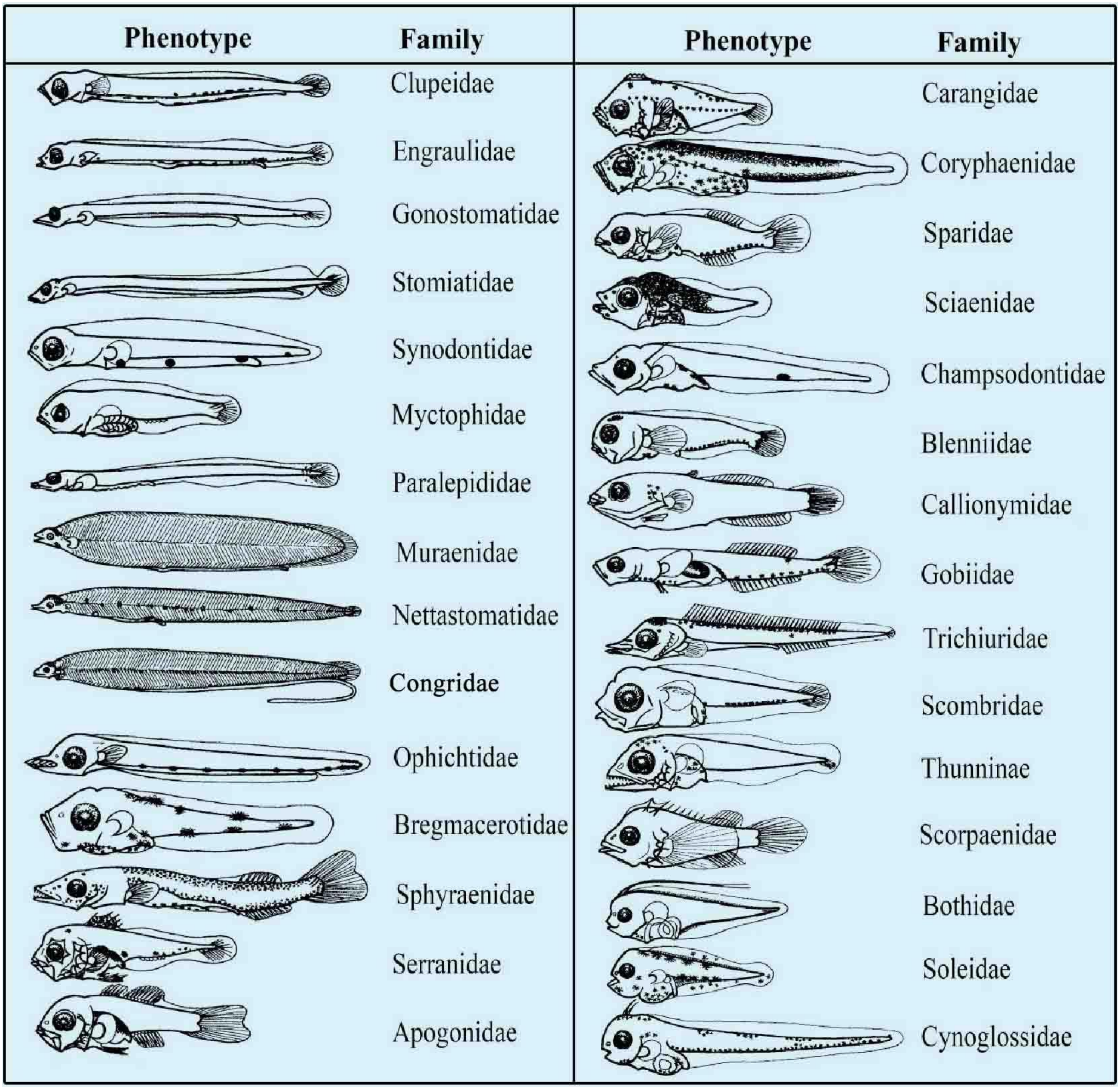


Fig. 1. Phenotypes of fish larvae of the different fish families.

2.1 Study Area and Sampling Methods

The sampled stations covered the inner RSA as well as the western waters of the Sea of Oman. Within the inner RSA, the sampled stations were located in the northeastern periphery in the sphere of activity of the surface southeastern current, and in the southwestern periphery – in the sphere of action of the northwestern surface current (Fig. 2).

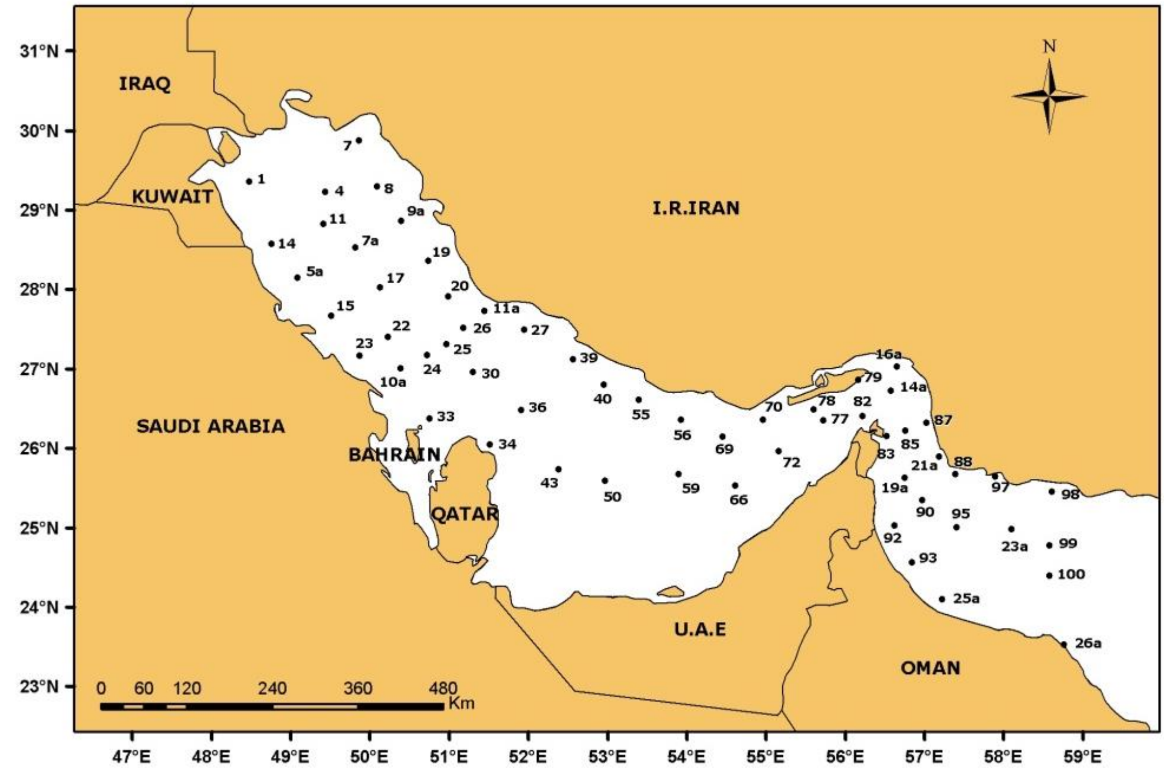


Fig. 2. Map showing the locations of the sampled stations in the RSA during Winter 2006.

Samples from 59 stations in the RSA were obtained by towing a plankton net with a mouth opening of 60 cm, which was equipped with a digital flowmeter (model GO 438 110). The towing duration at each of the different stations varied from 2 to 5 min, but most sampling operations lasted about 4 min. Towing depths varied, and were not kept stable and ranged from 8 to 14 m. The speed of the research vessel during the towing operations varied from 2 to 3 knots, but on average was about 2 knots (1 m/sec).

The sampling period in the RSA was from 3 February 2006 to 9 March 2006, i.e., during the winter pattern of the hydrometeorological condition (Table 1).

Table 1. Summary of Sampled Stations along Transects in the RSA

Tr. #	S. #	Date D/M/Y	Position		Tr. #	S. #	Date D/M/Y	Position	
			Lat (ºN)	Long (ºE)				Lat (ºN)	Long (ºE)
18	26a	3/2/06	23°31.000'	58°46.100'	9	55	22/2/06	26°36.057'	53°24.057'
T18	100	3/2/06	24°23.404'	58°35.244'	T8	40	23/2/06	26°47.800'	52°57.400'
T18	99	3/2/06	24°46.136'	58°35.100'	T8	43	23/2/06	25°43.513'	52°23.170'
T18	98	3/2/06	25°26.801'	58°36.914'	7	34	28/2/06	26°02.500'	51°31.200'
T17a	23a	4/2/06	24°58.210'	58°06.300'	7	36	28/2/06	26°28.190'	51°54.900'
T17a	25a	4/2/06	24°05.505'	57°13.813'	7	39	1/3/06	27°07.000'	52°34.100'
T17	93	5/2/06	24°33.147'	56°50.739'	6	27	1/3/06	27°29.200'	51°57.000'
T17	95	5/8/06	24°59.595'	57°24.758'	6	30	1/3/06	26°57.100'	51°18.500'
T17	97	5/2/06	25°38.200'	57°54.000'	6	33	2/3/06	26°21.800'	50°45.500'
T16	88	5/2/06	25°40.043'	57°24.048'	5	10a	2/3/06	26°59.800'	50°23.700'
T16	90	6/2/06	25°20.310'	56°58.530'	5	24	3/3/06	27°10.100'	50°43.500'
T16	92	6/8/06	25°01.340'	56°37.800'	5	25	3/3/06	27°18.290'	50°58.400'
T15a	19a	6/2/06	25°37.386'	56°45.487'	5	26	3/3/06	27°30.497'	51°11.060'
T15a	21a	6/2/06	25°53.400'	57°11.300'	5	11a	3/3/06	27°43.179'	51°27.088'
T15	87	7/2/06	26°18.900'	57°01.800'	4	20	3/3/06	27°54.410'	50°59.518'
T15	85	8/2/06	26°13.000'	56°46.000'	4	22	4/3/06	27°23.887'	50°13.952'
T15	83	8/2/06	26°08.763'	56°31.767'	4	23	4/3/06	27°09.561'	49°52.363'
T14a	14a	9/2/06	26°43.200'	56°34.590'	3	15	5/3/06	27°39.842'	49°30.928'
T14a	16a	9/2/06	27°01.400'	56°39.300'	3	17	5/3/06	28°01.115'	50°07.896'
14	79	13/2/06	26°51.046'	56°10.378'	3	19	5/3/06	28°21.033'	50°44.312'
14	82	13/2/06	26°23.771'	56°13.583'	02a	09a	6/3/06	28°51.200'	50°24.200'
13	77	14/2/06	26°20.671'	55°43.561'	02a	07a	6/3/06	28°31.145'	49°49.321'
13	78	14/2/06	26°28.769'	55°36.474'	02a	05a	6/3/06	28°08.501'	49°05.508'
12	70	14/2/06	26°32.104'	54°57.957'	2	14	7/3/06	28°33.885'	48°45.702'
T12	72	15/2/06	25°57.254'	55°10.080'	2	11	7/3/06	28°49.120'	49°25.120'
T11	66	15/2/06	25°31.090'	54°37.156'	2	8	8/3/06	29°17.580	50°05.490'
T11	69	16/2/06	26°08.382'	54°27.506'	1	7	8/3/06	29°52.106'	49°52.049'
10	56	21/2/06	26°20.905'	53°55.864'	1	4	9/3/06	29°13.245'	49°26.487'
T10	59	21/2/06	25°39.885'	53°53.944'	1	1	9/3/06	29°21.000'	48°29.000'
T9	50	22/2/06	25°35.092'	52°58.225'					

Tr - # = Transect number **S - # = Station number**

2.2 Early Stages of Fish Eggs and Larvae

Three descriptions of fish eggs and larvae were derived from the concept of availability of four phases of fish growth at the early stages of ontogenesis (Fig. 3).

- The egg phase covers the period of embryonic growth
- The prelarvae phase is the initial stage of postembryonic development immediately after hatching from an egg up to the complete resorption of yolk sac, i.e., this phase is characterized by yolk sac
- The larvae phase is more prolonged, lasting from the moment of yolk resorption until the completion of metamorphosis. This phase is characterized by the presence of embryonic fins as well as peculiar larval pigmentation. Larvae phase is subdivided into two groups: L1 – underformed; LII – formed larvae

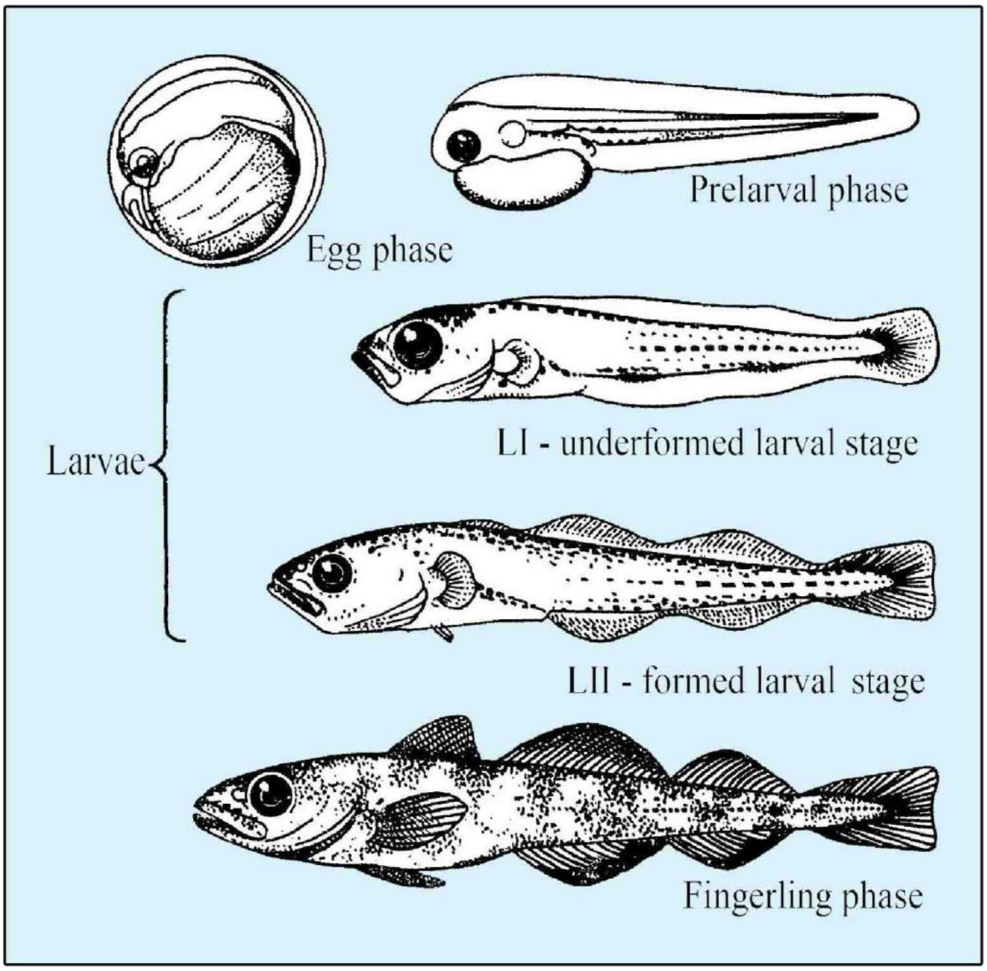
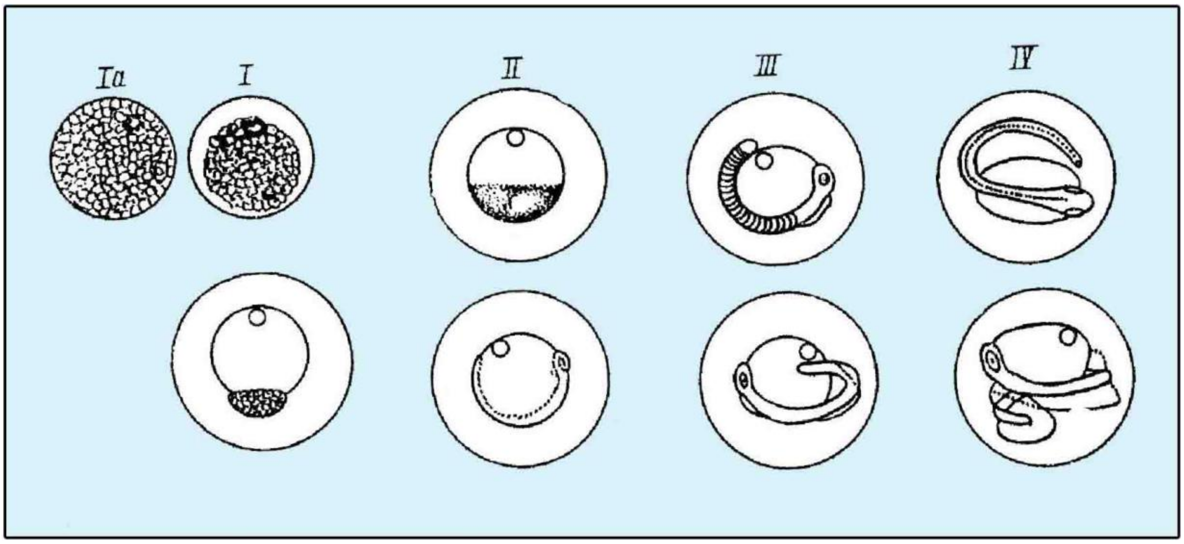


Fig. 3. The main phases of fish development.

- The fingerlings phase begins from the moment of the organism's period of growth. It is characterized by gradual growth with sharp transformation in the constitution of the formed fries

For the egg phase, several stages of development are distinguished (Fig. 4): zero stage or the stage of unfertilized underdeveloped eggs, without signs of division and the four stages of embryonic development. At the zero stage, there is the opalescent white spot in the area of animal pole on the eggs at the zero stage on the covering of eggs.

The first stage or the stage of division and growth lasts from the beginning of division until the beginnings of obliteration of embryonic band upwards the blast dermal ring (bolsters).



I – stage of division and growth; Ia – initial stage of division (from 2 till 8 blastometers); II – the stage of embryonic band formation; III – the stage of the under-formed embryo; IV – the stage of formed embryo.

Fig. 4. The stages of embryonic development of fishes.

The second stage or the stage of embryonic band lasts up to the appearance of the embryonic increment until the moment of tail's separation from the yolk (the appearance of the tail kidney).

The third stage or the stage of underformed embryo begins from the moment of tail isolation and lasts until the moment when the embryo covers (or may cover) along the periphery of the yolk.

The fourth stage or the underformed embryo stage lasts from the moment of coverage by embryo of all the yolk up to leaving the egg. At this last stage, the embryos of many fishes have pigmented eyes, and the locations of pigment cells on the body are special for every species.

2.3 Morphological Characters of the Fish Larvae

- Total length (TL) – the distance from the end of snout to the end of rays of the tail fin. This index was measured; tail part of the fin fold of forming rays may be damaged
- Standard length [body length] (BL) – the distance from the end of snout to the end of notochord tip, i.e. the real body length. This index was the most stable
- Preanal Length (PL) - distance from the end of snout to the anal opening along the strait parallel axis of the body
- Predorsal fin length I (PDL I) – the distance from the end of the snout to the first ray of the first dorsal fin along the strait parallel axis of the body
- Predorsal fin length II (PDL II) - the distance from the end of the snout to the second ray of the first dorsal fin along the strait parallel axis of the body
- Dorsal fin length (DFL) – the length of the base of the dorsal fin

  The last three indices were determined for the specimens at the stage of the formed larvae
- Head length (HL) – the distance from the end of the snout to the post-temporal thorn or to the rear edge of the head at the level of the beginning of the vertebrae
- Snout Length (SL) – the distance from the end of the snout to the front edge of the orbit
- Eye Diameter (ED) – horizontal diameter of the eyehole
- Body Depth (BD) – the distance from the symphysis of the shoulders (vertical) to the upper edge of the cranium

- Body depth near the anus (BDA) – the distance from the anus (vertical) to the upper edge of the body. The total diameter (D) and diameter of the yolk mass (d) were measured for eggs

Besides morphometric indices, other fixed characters were considered: the location of pigment series on the body, including those on the back (Dorsal Pigment Series, DPS) and in the ventral area (Ventral Pigment Series, VPS); development of soft rays (SR) and their bases (Soft Ray Base, SRB); the orientation of notochord tip (NT); and the degree of development of hypural plates as an indicator of the caudal fin development (Fig. 5).

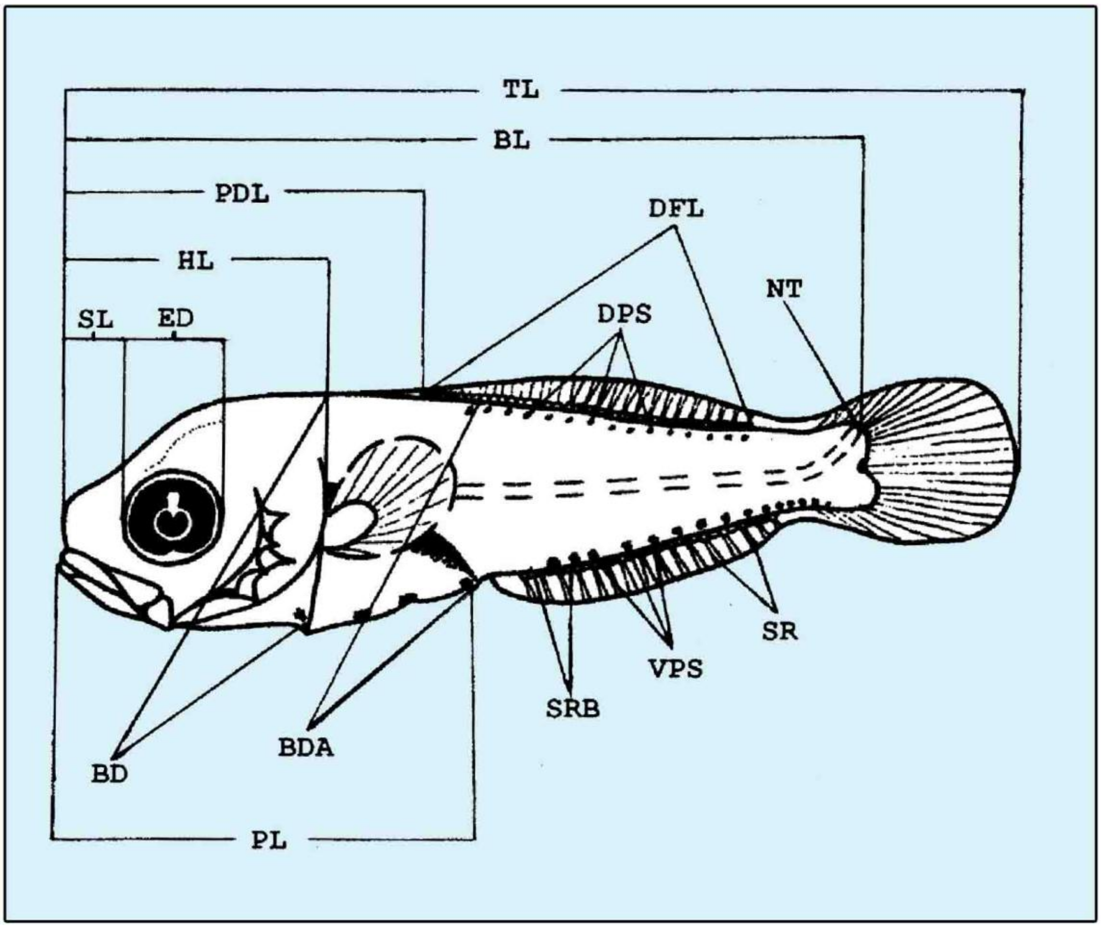


Fig. 5. A fish larva showing the major morphological characters.

3. Results and Discussion

3.1 Taxonomy of Fish Larvae

Family MYCTOPHIDAE

***Diaphus* sp.** (Plate 1)

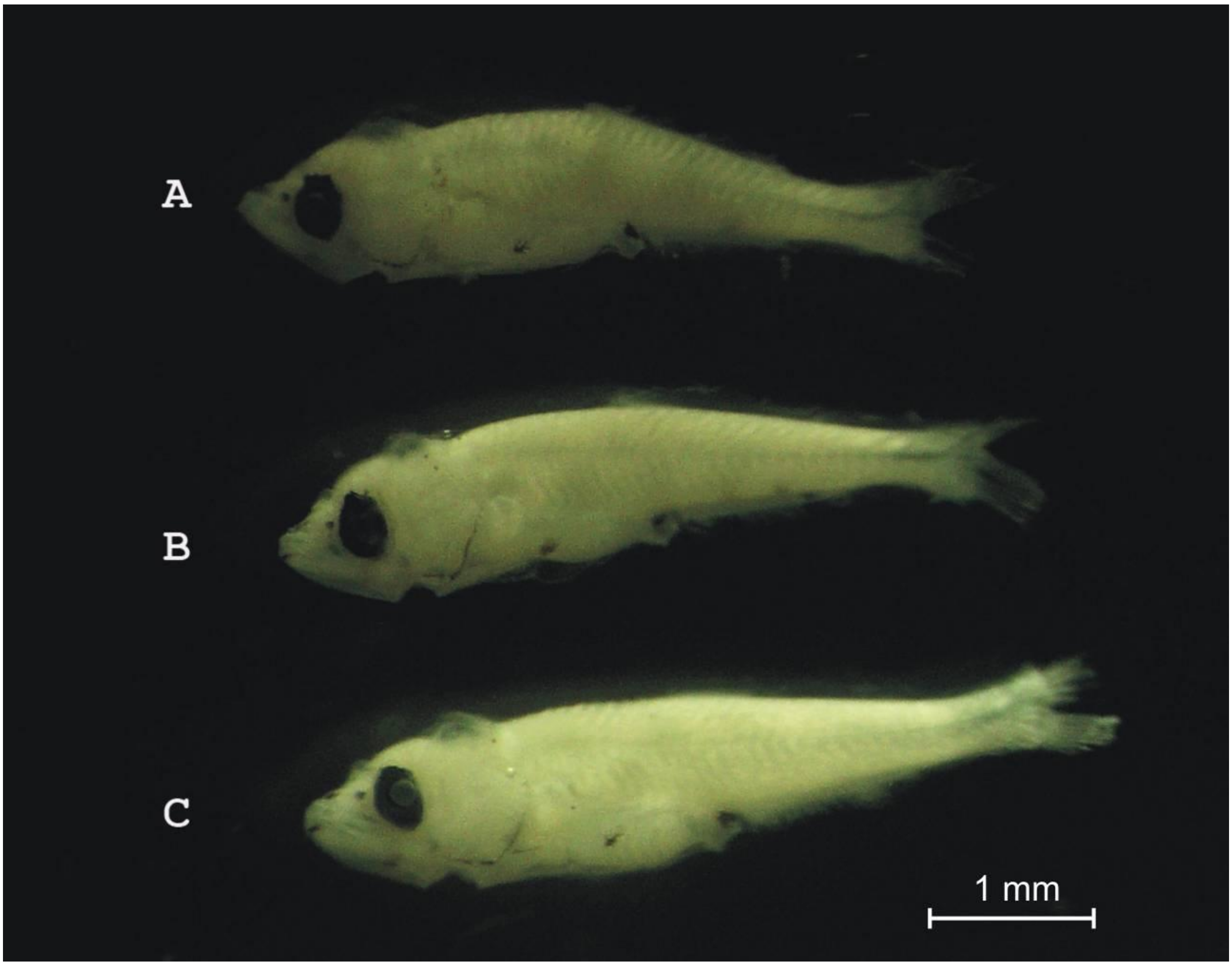


Plate 1. Larval stages of Myctophidae, *Diaphus* sp.

A. BL 4.00 mm; B. BL 4.25 mm; C. BL 4.35 mm.

Description: Larvae are of symmetric, fish-like shape. Mouth opening finishes behind the vertical line of the rear edge of the eye. Eyes are almond-shaped, well formed even for prelarvae. Up to BL of about 3.75 mm, the urostyle is straight; the process of formation of hypural plates takes place under the notochordum. With BL of 4.20 mm, urostyle is dented, hypural plates are quite formed. Formation of dorsal and adiposal fins begins with BL of about 3.70 mm, and with BL equal to 4.40 mm, the process of formation of rays in the dorsal and anal fins takes place.

Distribution of pigment cells are characterized by their presence as a band in the lower side of the gill cover; there are several separate cells at the abdomen side up to anal opening, large-sized melanophore near the anal opening and by one melanophore before each eye. Representatives of this family have developing Platephores (lumenophores) in the area of separate melanophores in the post-larval period. Presence of two platephores (Dn and Vn under the scheme of location of Platephores) locating on the nose before eyes is a specific sign for *Diaphus* genera. Among representatives of this genus in the northern part of the Indian Ocean *Diaphus splendidus* (Brauer, 1904) is the most abundant one. The *Diaphus* larvae in this study are most likely this species.

Measurements: Morphometric characteristics of these larvae are characterized by relative stability, and spread of indices is sure to be connected with specific features in the dynamics of their growth (Fig. 6).

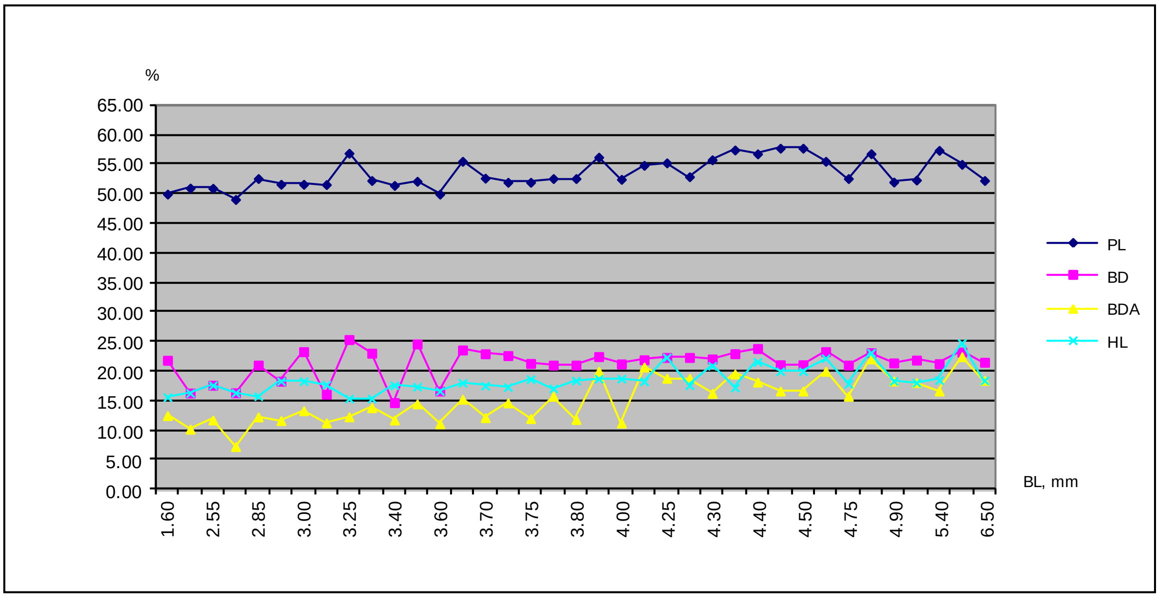


Fig. 6. Morphometric characteristics of *Diaphus* sp. larvae.

X axis – Body Length in millimeters (BL, mm); **Y** axis – percentage to Body Length (%).

BL - Standard length [Body Length] is the distance from the end of snout to the end of notochord tip, i.e. the real body length. Body length is most stable morphometric index;

PL - Preanal Length is the distance from the end of snout to the anal opening along the strait parallel axis of the body;

BD - Body Depth is the distance from the symphysis of the shoulders by vertical to the upper edge of the cranium;

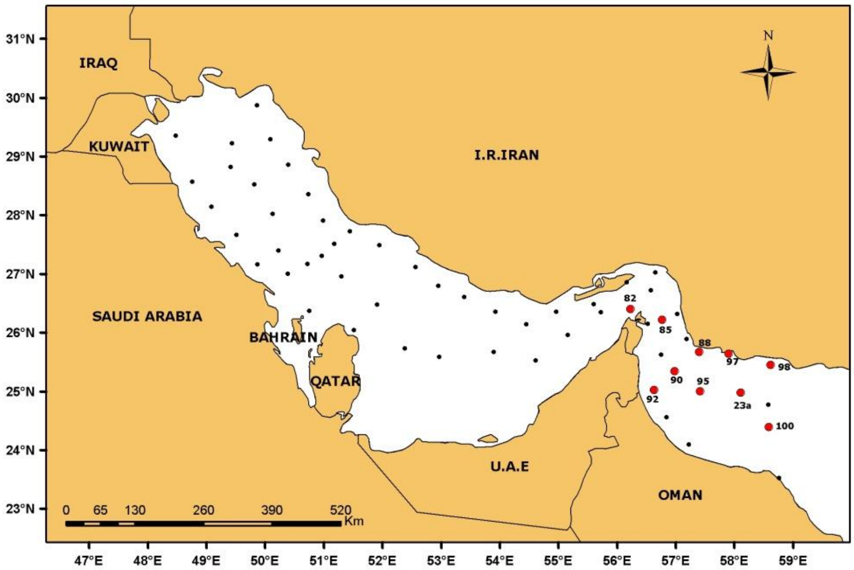
BDA - Body Depth near the Anus is the distance from the anus by vertical to the upper edge of the body;

HL - Head Length is the distance from the end of the snout to the post-temporal thorn or to the rear edge of the head at the level of the beginning of the vertebrae.

Sites of Occurrence in RSA:

Sea of Oman: Stations 98, 100, 23a, 95, 97, 88, 90, 92 and 85.

Inner RSA: Station 82.



Sites of occurrence of *Diaphus* sp. larvae in RSA

Family SYNODONTIDAE

Genus *Trachinocephalus*

***Trachinocephalus myops* (Forster, 1801)** (Plate 2)

Synonyms: *Goodella hypozona* Ogilby, 1897; *Trachinocephalus hypozona* (Ogilby, 1897); *Saurus brevirostris* Poey, 1860; *Synodus brevirostris* (Poey, 1860); *Trachinocephalus brevirostris* (Poey, 1860); *Saurus limbatus* Eydoux and Souleyet, 1850; *Trachinocephalus limbatus* (Eydoux and Souleyet, 1850); *Trachinocephalus trachinus* (Temminck and Schlegel, 1846); *Saurus trachinus* Temminck and Schlegel, 1846; *Saurus truncatus* Spix and Agassiz, 1829; *Osmerus lemniscatus* Lacepède, 1803; *Saurus lemniscatus* (Lacepède, 1803); *Salmo myops* Forster, 1801; *Saurus myops* (Forster, 1801); *Synodus myops* (Forster, 1801).

Plate 2. Larval stages of *Trachinochephalus myops*.

A. BL 4.40 mm; B. BL 4.90 mm; C. BL 5.50mm.

Description: The body is elongated, cylindrical, with a short nose, large mouth and eyes. The mouth opening extends up to the vertical of the middle of the eye. Eyes are oval-shaped.

Large melanophores are located from the ventral side in couples from both sides above the digestive tube. The first couple is located near the basis of the pectoral fin; there are 4 melanophores farther up to the anal opening, one locating near the basis of the anal tube and one in the area of the anal fin. In larger individuals, melanophores are appearing in the area of the caudal fin – on hypural plates.

With BL of about 5.50 mm, the process of forming of hypural plates and hardening in the fin fold in the places of forming of dorsal and anal fin takes place. With BL about 7.00 mm, the larvae have a dented urostyle, hypural plates are developed, and the process of forming rays in the dorsal and anal fin is under way. Pectoral fins are formed completely with BL of about 7.5 mm, formation of rays in them is observed with BL of about 3.65 mm.

Measurements: Morphometric characteristics during the process of growth are rather stable (Fig. 7)

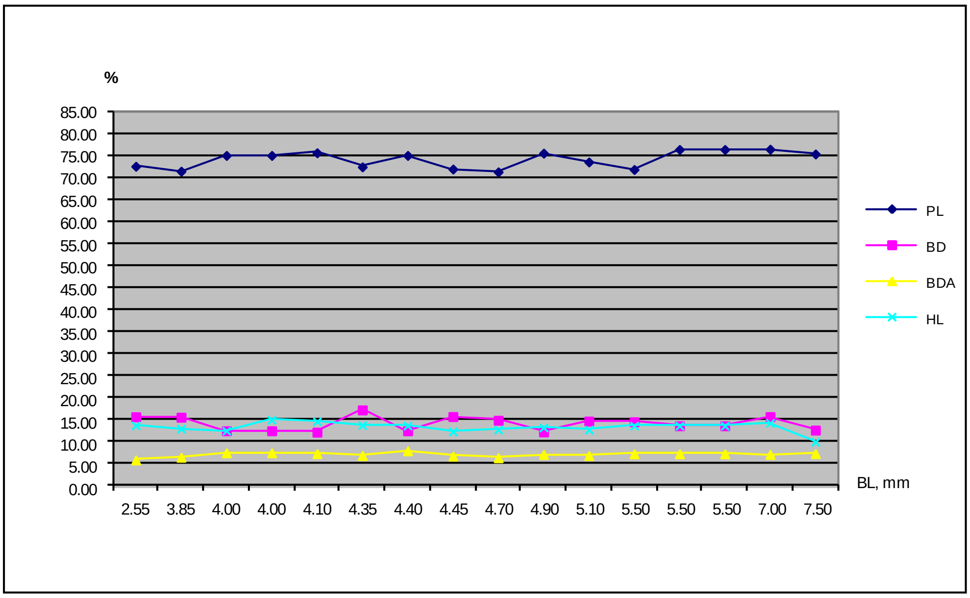


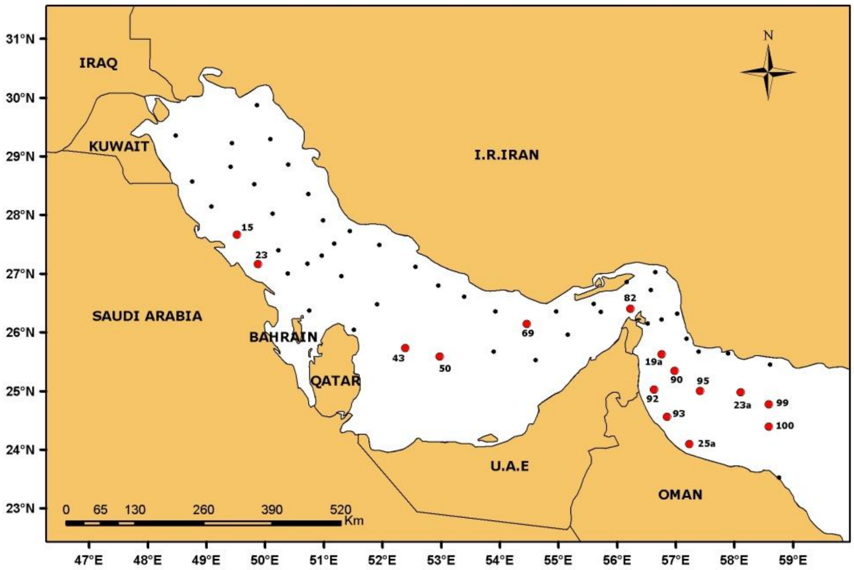
Fig. 7. Morphometric characteristics of *Trachinocephalus myops* larvae.
Symbols as in Fig. 6.

Geographical Distribution: Worldwide in tropical and warm temperate waters with the exception of the eastern Pacific and the northeast Atlantic north of Cape Blanc, Africa.

Sites of Occurrence in RSA:

Sea of Oman: Stations 99, 100, 23a, 25a, 93, 95, 90, 92 and 19a.

Inner RSA: Stations 82, 69, 50, 43, 23 and 15.



Sites of occurrence of *Trachinocephalus myops* larvae in RSA

Family PHOTICHTHYIDAE

Genus *Vinciguerria*

***Vinciguerria* sp.** (Plate 3)

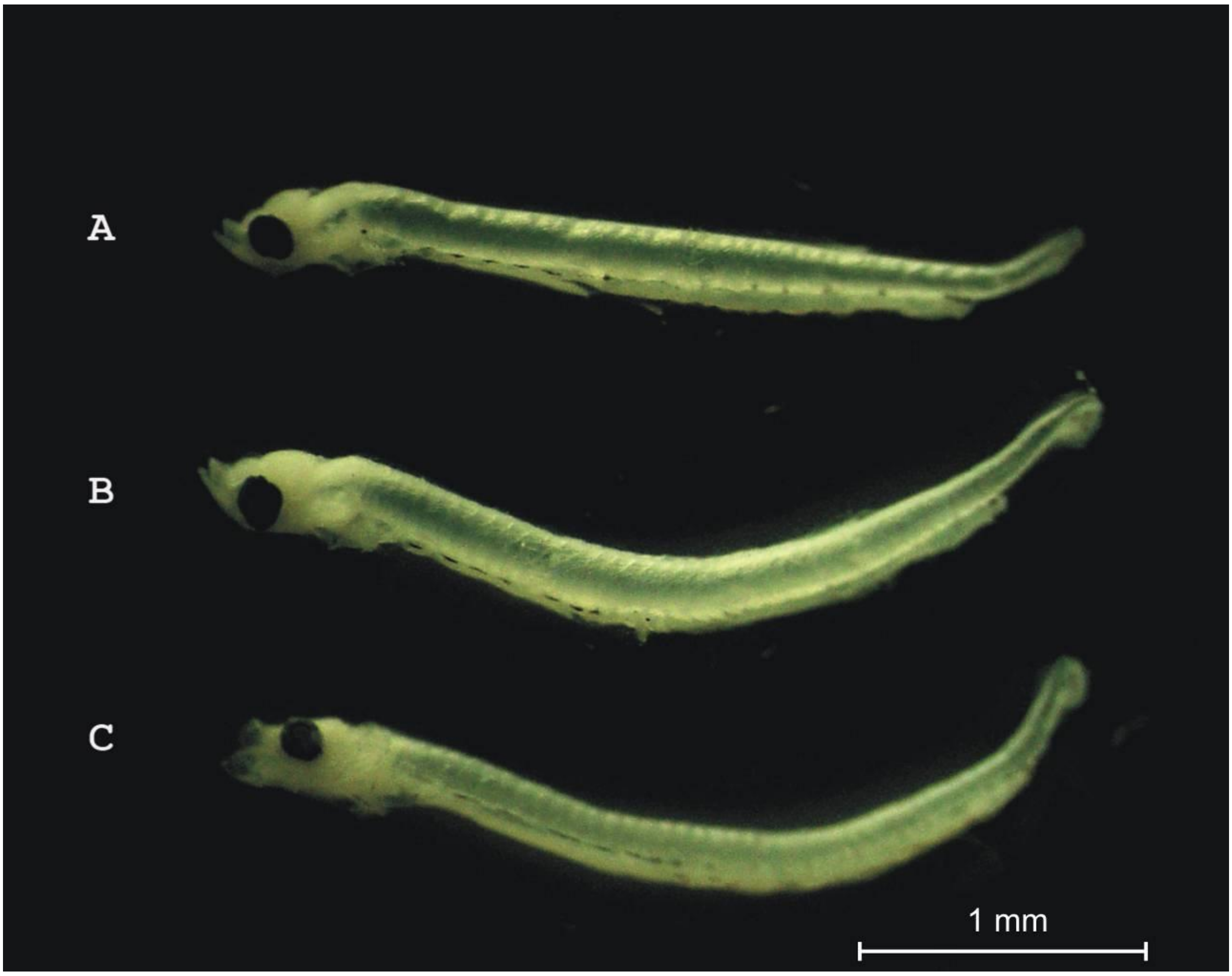


Plate 3. Larval stages of Photichthyidae, *Vinciguerria* sp.

A. BL 5.30 mm; B. BL 5.50 mm; C. BL 5.60 mm.

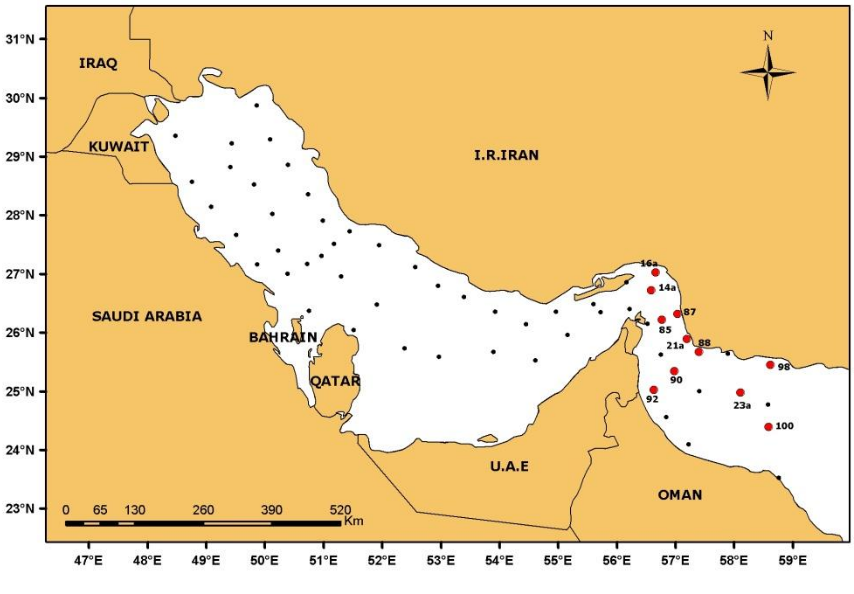
Description: Formed larvae have a prolonged body with well-developed digestive tube, where a spiral valve is visible. Eyecups are of ellipse shape. The surface of the nose is hardened, not rounded. Pigment cells are absent on the body. They are located in the chain above digestive tube from the isthmus to the anal opening and farther along the middle line of the caudal part to the basis of the caudal fin. In the caudal fin, formation of the rays begins with the straight urostyle, and in the dorsal and anal fins with BL of about 3.50 mm.

In the waters of the northern periphery of the Indian Ocean, individuals of species *V. nimbaria* (Jordan and Williams, 1896) present this mesopelagic genus with appreciable abundance. In this area, larvae of this species are observed all year round as well as in the area of the Gulf of Aden. Therefore, it may be stated with great certainty that larvae of this fish genus belong to the genus *V. nimbaria* even in the Sea of Oman. However, to be quite sure, it is required that information be obtained concerning the dynamics of the reproductive process of this fish species under the conditions of the Sea of Oman.

Measurements: The relative indices of plastic features for larvae of different size are stable and constitute: for PL – 82.45-82.95%, PDL I – 70.00-70.83%, BD – 7.50-7.95%, BDA – 5.26-5.83%, HL – 12.28-12.72%, SL – 25.00-28.57%, ED – 20.83-25-50%.

Sites of Occurrence in RSA:

Sea of Oman: Stations 98, 100, 23a, 88, 90, 92, 21a, 87, 85, 14a and 16a.



Sites of occurrence of *Vinciguerria* sp. larvae in RSA

Family ENGRAULIDAE

Engraulidae gen. sp. (Plate 4).

Plate 4. Larval stages of Engraulidae gen. sp.

A. BL 6.75 mm; B. BL 8.30 mm; C. BL 10.50mm.

Description: The specific feature of larvae of these fishes of this family is a long, thin, squeezed body from the sides; the anus is extended far rearwards. The intestine is long and straight, without loops, with a well-seen spiral formation. Small-sized prolonged melanophores are located along the ventral side of the body above the intestine, two of them, more intensive, being along the upper edge of the swimming bladder. Melanophores appear in more large-sized individuals in the post-anal part. Up to BL of about 6.30 mm, the urostyle is straight, hypural plates are forming as well as the caudal fin, being symmetrical to the end of the notochord. The fold of the dorsal and anal fin is formed with BL equal to 5.70 mm. The dorsal fin is forming by a vertical above the anus. In this fin, with BL of about 6.70 mm, rays are split. The swimming bladder is forming for individuals with BL of about 2.90 mm, and with BL 5.50 mm, it is filled with air.

This family embraces representatives of three genera – *Encrasicholina*, *Stolephorus* and *Thryssa*. For the area of the inner RSA, it is most likely that these larvae belong to second genus, most probably to the *Stolephorus* genus, as the anal opening is located below the dorsal fin, and for representatives of the other two genera – located behind it.

Measurements: Morphometric indices for these larvae remain rather stable in the process of growth (Fig. 8).

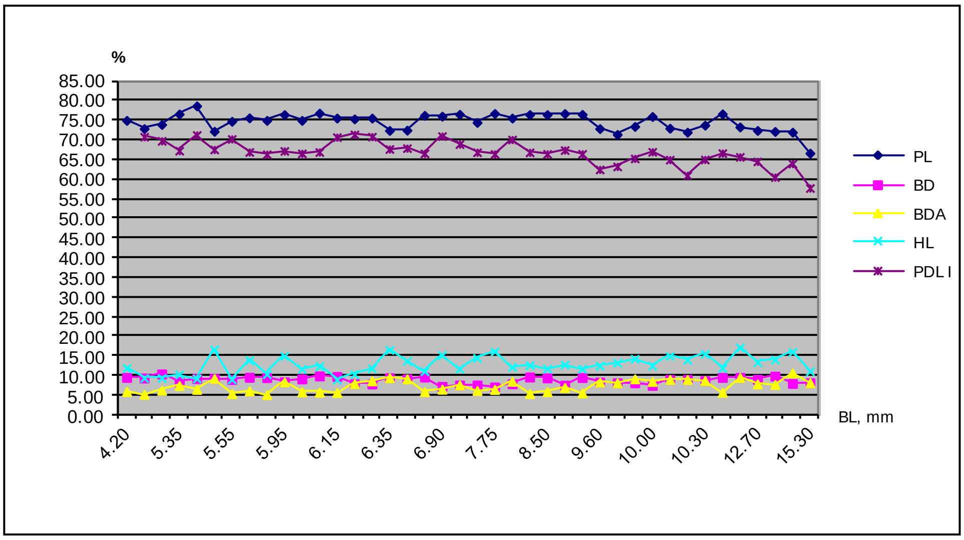


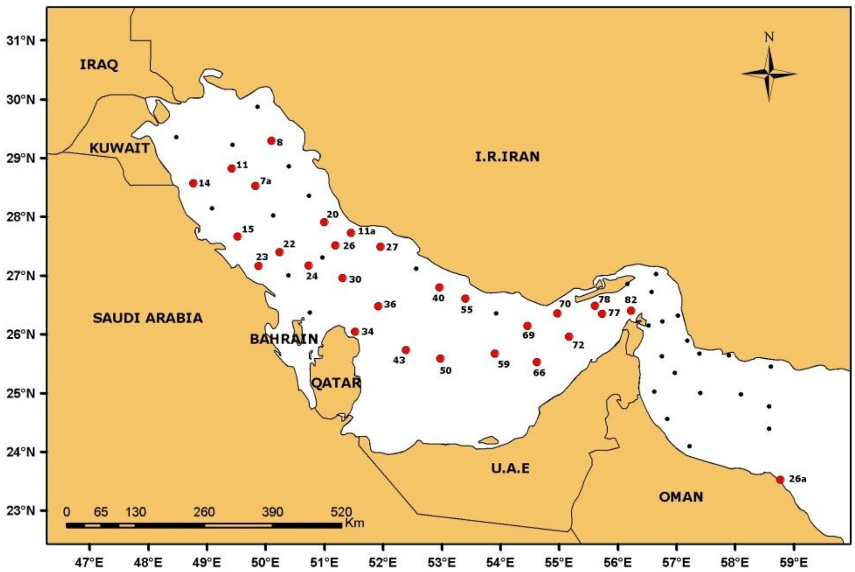
Fig. 8. Morphometric characteristics of Engraulidae gen.sp. larvae.

Symbols as in Fig. 6.

Sites of Occurrence in RSA:

Sea of Oman: Station 26a.

Inner RSA: Stations 82, 77, 78, 70, 66, 72, 69, 59, 50, 55, 40, 43, 34, 36, 27, 30, 24, 26, 11a, 20, 22, 23, 15, 07a, 14, 11 and 08.



Sites of occurrence of Engraulidae gen. sp. larvae in RSA

Family PARALEPIDIDAE

Paralepididae gen.sp. (Plate 5).

Plate 5. Larva of Paralepididae gen. sp.

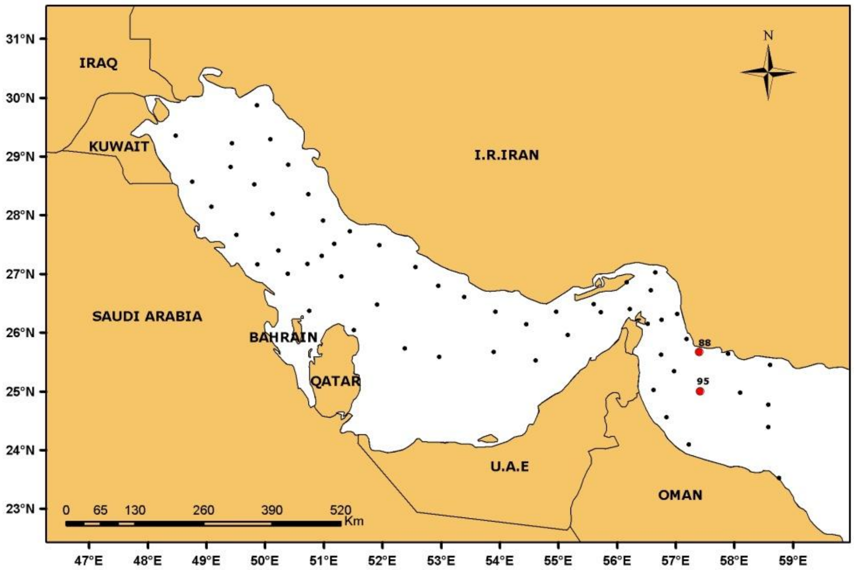
BL 11.00 mm.

Description: The bodies of these larvae are prolonged, PL makes up approximately 2/3 of BL, the noses are long and flat; teeth are observed on the edge of the upper jaw. The anal fin is formed immediately behind the anus; the dorsal fin ends above anus. In the dorsal fin with BL of about 10.00 mm, 9-10 soft rays are observed. Eyes are of oval shape. Pigment cells are located at the basis of the anal and caudal fins.

Measurements: Morphometric features for larvae with BL=2.25 mm are characterized by the following values: PL – 0.70 mm (31.11%), BD – 0.30 mm (13.33%), BDA – 0.10 mm (4.44%), HL – 0.30 mm (13.33%), SL – 0.10 mm (33.33%), ED – 0.15 mm (50.00%).

Sites of Occurrence in RSA:

Sea of Oman: Stations 95 and 88.



Sites of occurrence of Paralepididae gen. sp. larvae in RSA

Family BREGMACEROTIDAE

Bregmacerotidae gen. sp. (Plate 6)

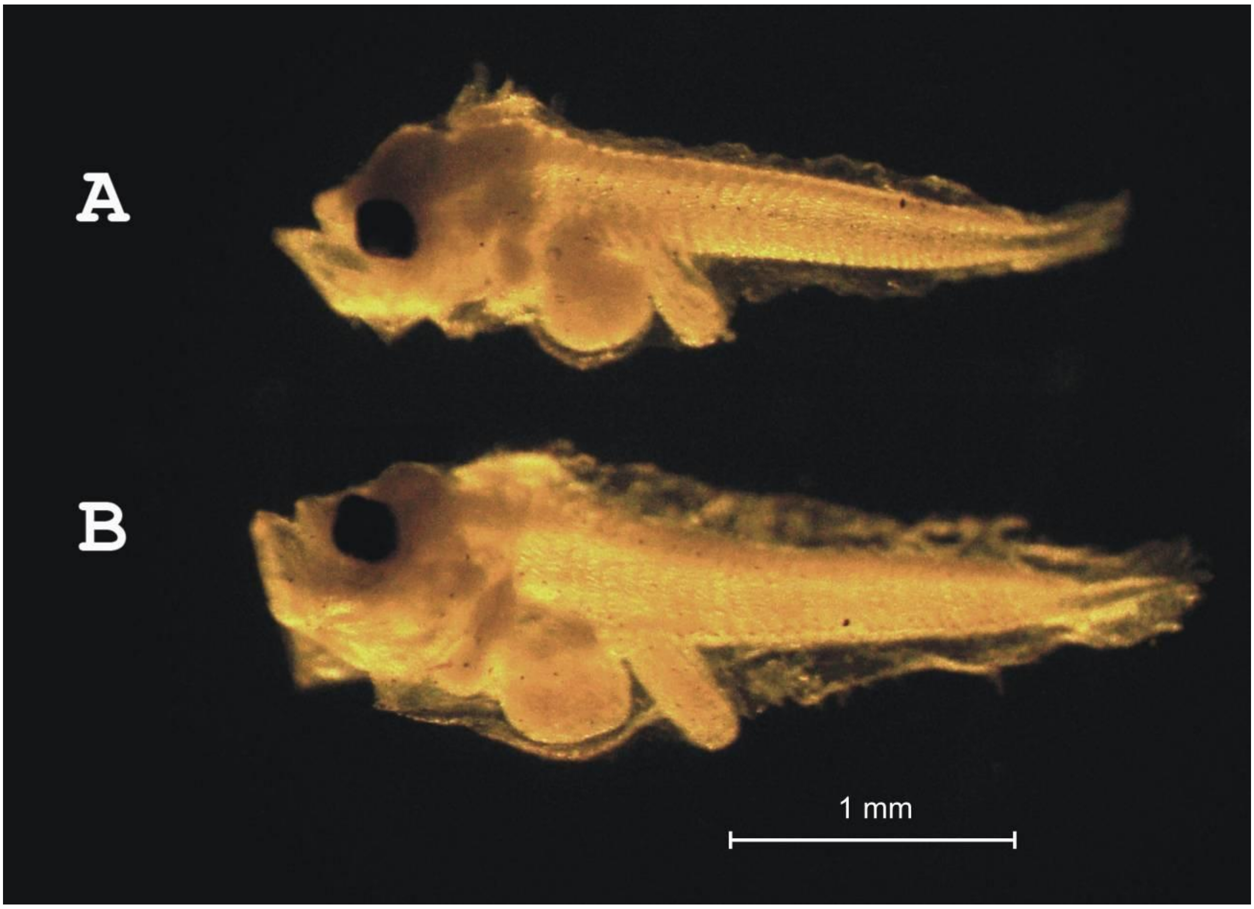


Plate 6. Larval stages of Bregmacerotidae gen. sp.

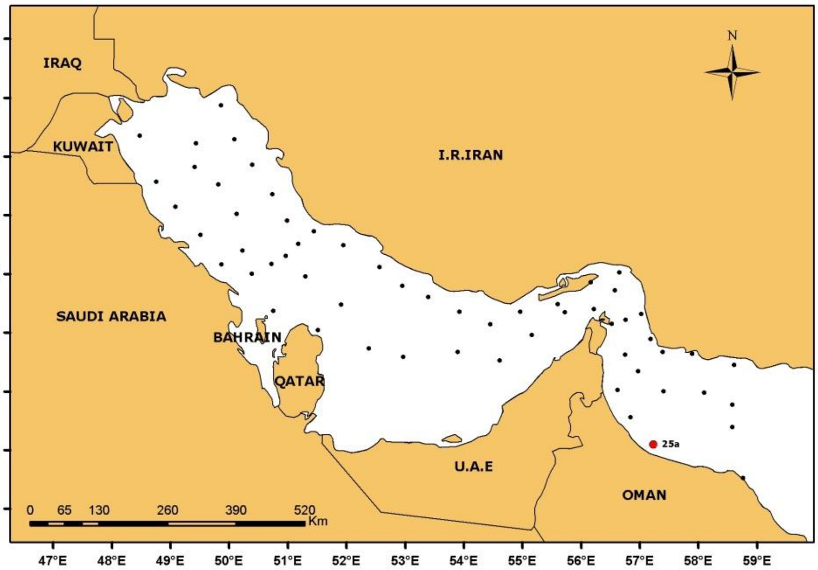
A. BL 2.70 mm; B. BL 3.10 mm.

Description: Small pigment cells are distributed diffusively on the bodies of the larvae. The anal opening is located at the tube detached from the body. In individuals with BL up to 3.10 mm, the fin fold is preserved around the body without places of formation of odd fins; however, pectoral fins are formed.

Measurements: Morphometric parameters and relative indices of plastic characteristics for larvae of 2.70-3.10 mm are as follows: PL – 1.40-1.60 mm (51.85-51.61%), BD – 0.60-0.65 mm (20.96-22.22%), BDA – 0.50-0.60 mm (19.37-20.37%), HL – 0.50-0.75 mm (18.51-20.19%), SL – 0.20-0.25 mm (33.33-35.10%), ED – 0.10-0.15 mm (20.00-20.80%).

Sites of Occurrence in RSA:

Sea of Oman: Station 25a.



Site of occurrence of Bregmacerotidae gen. sp. larvae in RSA

Family MUGILIDAE

Mugilidae gen. sp. (Plate 7).

Plate 7. Larval stages of Mugilidae gen. sp.

A. BL 8.0 mm; B. BL 8.0 mm.

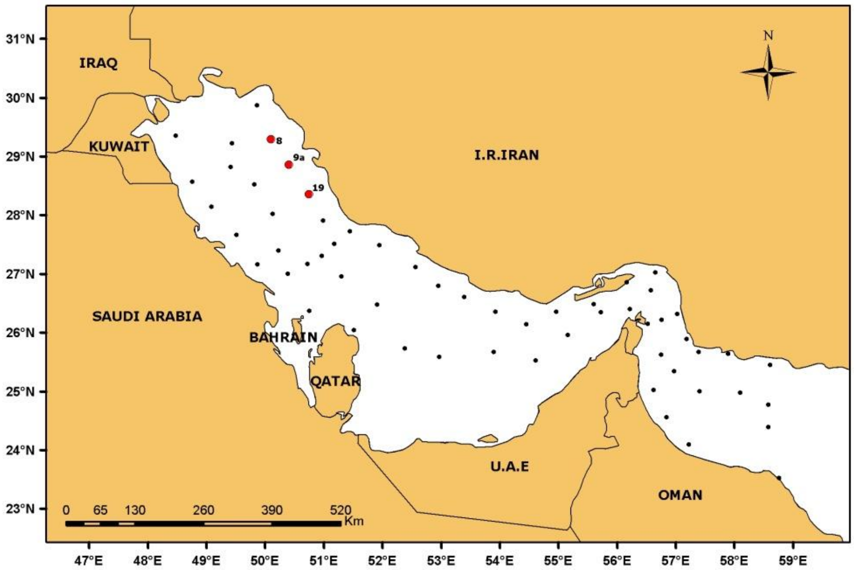
Description: Availability of representatives of three genera – *Liza*, *Mugil* and *Valamugil* – is reported for the waters of the inner RSA. Identification of the taxonomic status of the different species is difficult as many identifiable features are overlapping for the above species.

Larvae of fishes of this family have abundant pigmentation of the body; a whole band of melanophores is located along the vertebra; peritoneum is pigmented; there is a band of melanophores behind the anus to the basis of the caudal fin. Formation of bases of the odd fins takes place with BL of about 3.50 mm, and with BL of more than 5.00 mm in the first dorsal fin, four spiny rays are observed; in the second dorsal fin – 14-16 soft rays, in the anal one – 3 spiny and 9 soft rays. These parameters coincide with adult parameters.

Measurements: Morphometric indices and relative parameters of the dynamics of the plastic features for larvae of different sizes are rather stable and vary within the following ranges: BL 7.40-8.00 mm, PL – 4.70-5.00 mm (62.50-64.18 %), PDL I – 3.75-4.45 mm (50.67-51.25)%, PDL II – 5.25-6.05 mm (70.94-75.00%), BD – 1.75-2.00 mm (23.64-25.00%), BDA – 1.50-1.75 mm (20.27-21.87%), HL – 2.00-2.10 mm (26.25-27.02%), SL – 0.55 mm (27.50%), ED – 0.80-0.85 mm (40.00-40.47%).

Sites of Occurrence in RSA:

Inner RSA: Stations 19, 09a and 08.



Sites of occurrence of Mugilidae gen. sp. larvae in RSA

Family POLYNEMIDAE

Polynemidae gen.sp. (Plate 8).

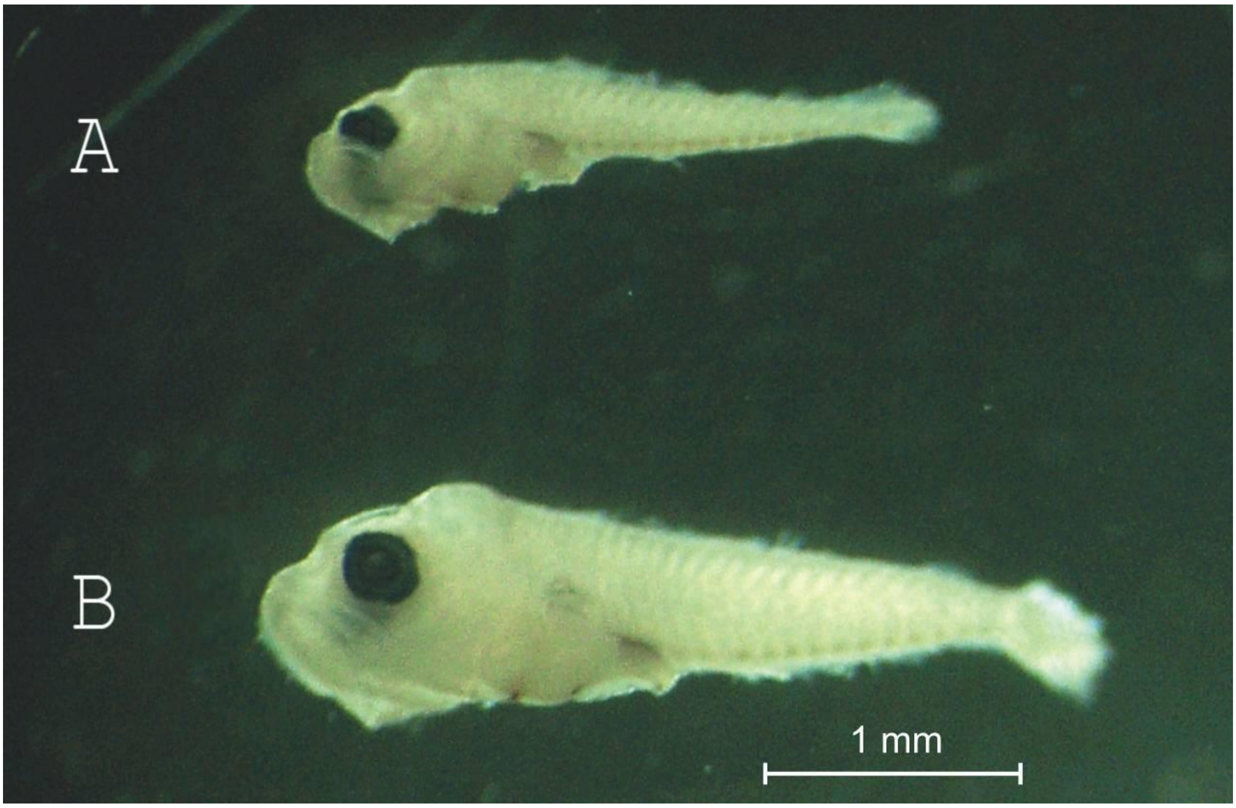


Plate 8. Larval stages of Polynemidae gen. sp.

A. BL 2.15 mm; B. BL 3.05 mm.

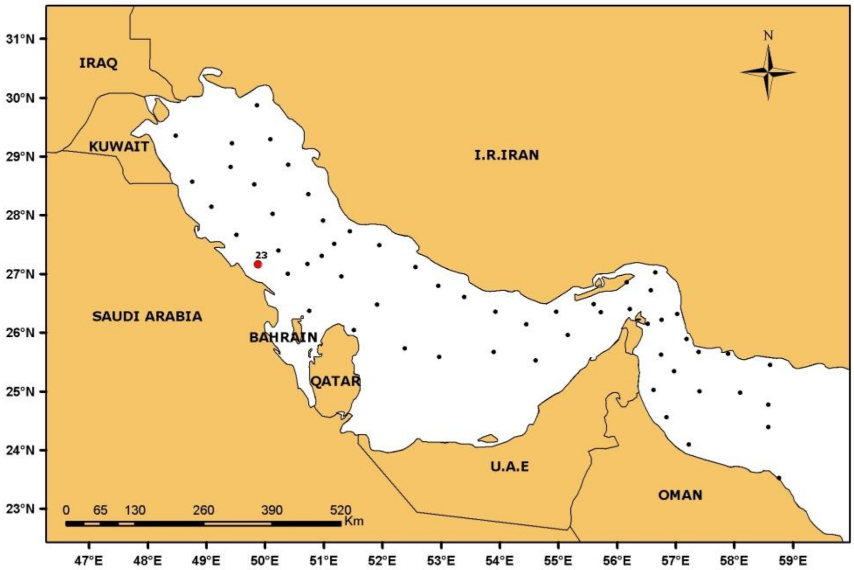
Description: Larvae are with well-formed eyes; a mouth opening is in lower position, and the end of the nose extends forward the mouth opening. A pigmented peritoneum with a large melanophore is good visible before the anus. There are 7-9 small-sized melanophores in VPS and pigmented cell on the isthmus. Small thorns are developing in large individuals on the pre-cover. For individuals with BL less than 4.00 mm, the urostyle is straight. Under the bases of the pectoral fins for individuals with BL of more than 4.00 mm, folds of free filaments are observed.

Measurements: Morphometrical indices and relative parameters of the plastic features for larvae of different size are as follows: BL 2.15-4.15 mm, PL – 0.95-1.90 mm (44.18-45.78%), BD – 0.54-1.00 mm (20.93-23.61%), BDA – 0.35-0.70 mm (14.06-16.86%), HL –

0.35-0.85 mm (19.44-20.48%), SL – 0.10-0.35 mm (28.57-30.76%), ED – 0.15-0.35 mm (41.17-42.85%).

Site of Occurrence in RSA:

Inner RSA: Station 23.



Site of occurrence of Polynemidae gen. sp. larvae in RSA

Family SERRANIDAE

Genus *Serranus*

***Serranus* sp.** (Plate 9).

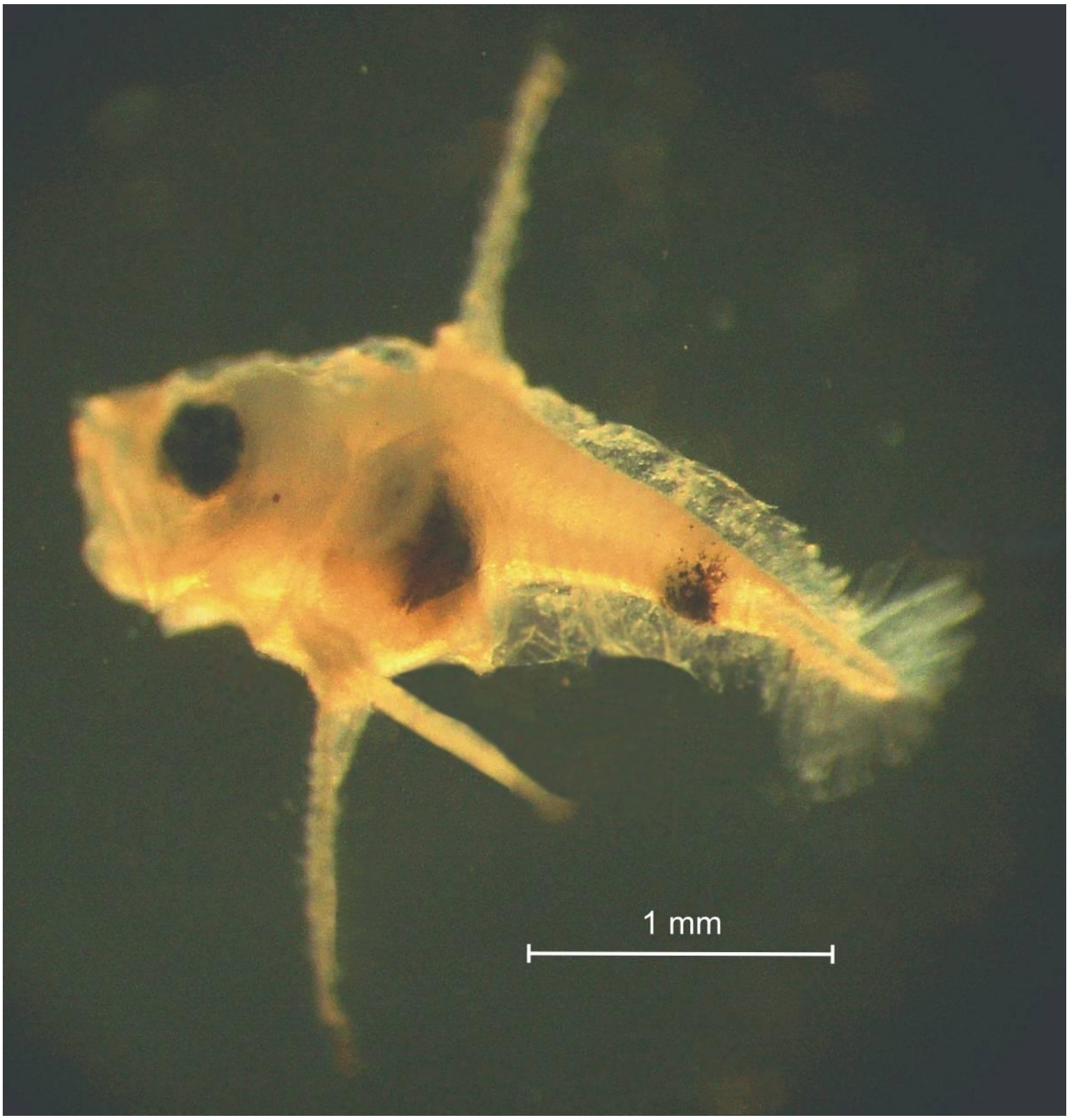


Plate 9. Larva of Serranidae, *Serranus* sp.

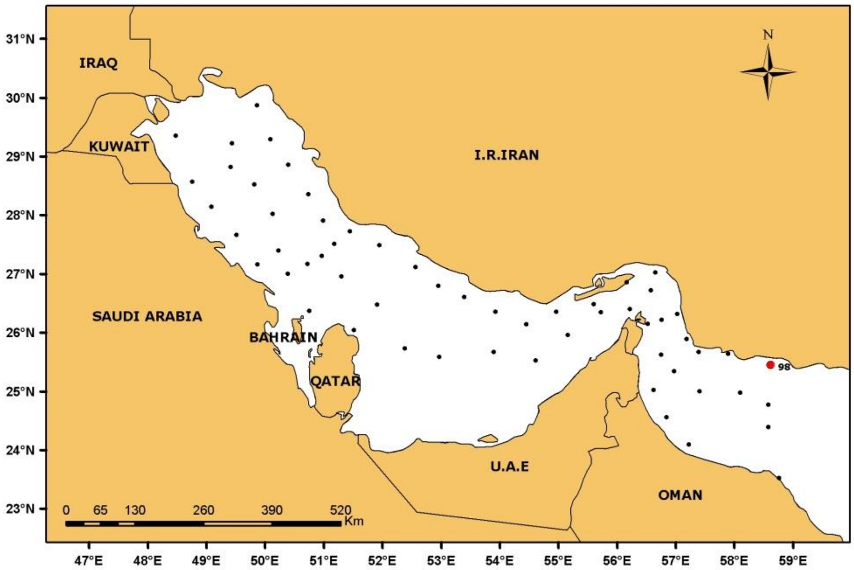
BL 2.75 mm.

Description: Formed larvae of this fish genus have the first ray as a detached thorn of 1.00 mm in the first dorsal fin. In the abdomen rays, the first rays are formed as thorns of 1.00 mm long. Larvae have a well-pigmented peritoneum. There is a large pigmented spot in the postanal part from the ventral side. The fin fold preserves for a long time even when rays are forming in the caudal ray, and the urostyle keeps being straight. The mouth of the larvae is slanting and keeps the upper position.

Measurements: Morphometric indices and relative parameters of plastic features are characterized by following values: BL 2.75 mm, PL – 1.60 mm (58.18%), BD – 1.05 mm (58.18%), BDA – 0.50 mm (18.18%), HL – 0.65 mm (23.63%), SL – 0.25 mm (38.46%), ED – 0.25 mm (38.46%).

Site of Occurrence in RSA:

Sea of Oman: Station 98.



Site of occurrence of *Serranus* sp. larva in RSA

Family SERRANIDAE

Genus *Epinephelus*

***Epinephelus* sp.** (Plate 10).

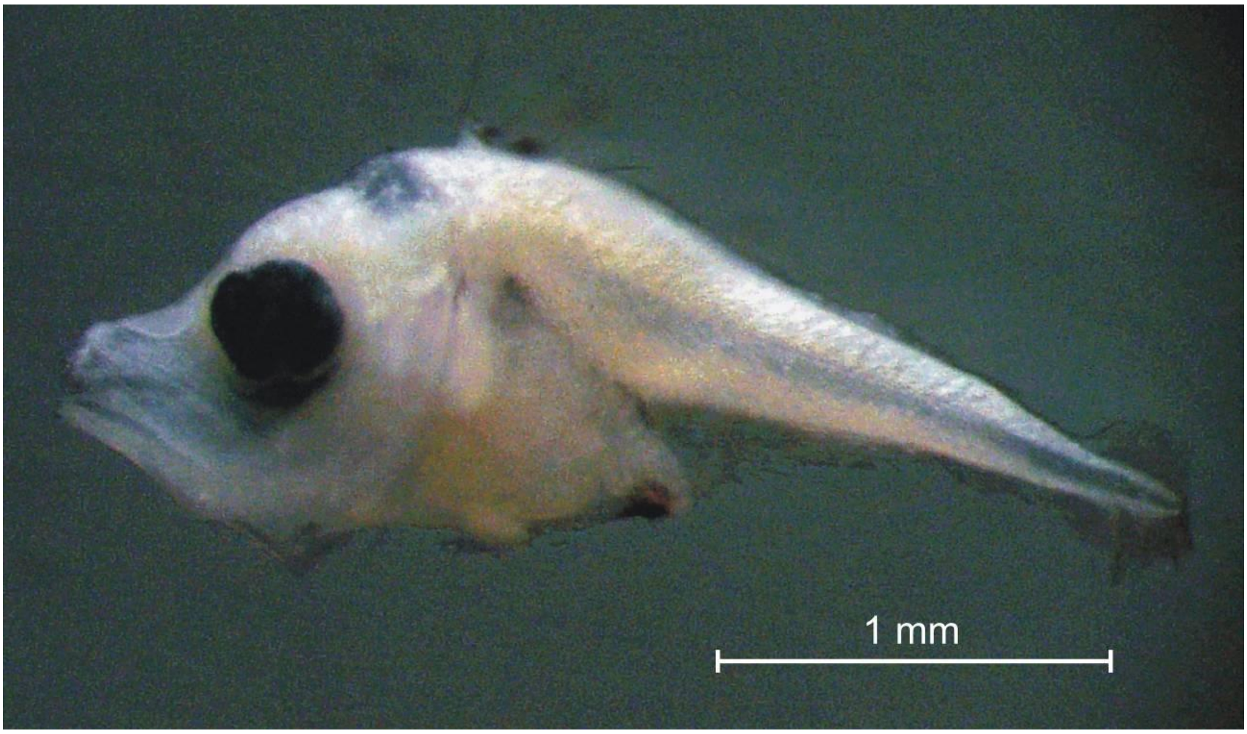


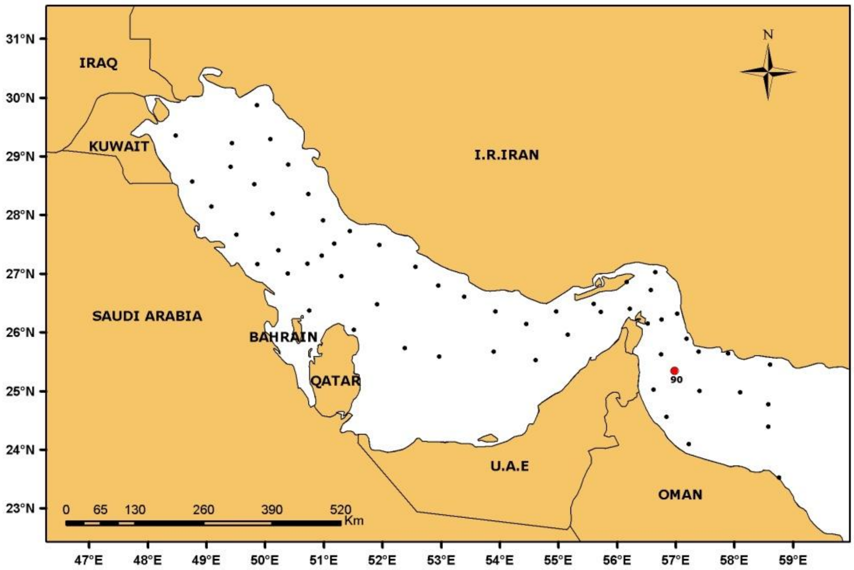
Plate 10. Larva of Serranidae, *Epinephelus* sp.
BL 2.85 mm.

Description: Larvae in the preanal part have a great height of the body. Melanophores are located near the anus, in the upper part of the peritoneum, on the isthmus and at the basis of the dorsal fin. With BL 2.85 mm in the upper part of the dorsal fin there are 4 well-formed thorny rays. The process of formation of the dorsal ray as a whole takes place. Small thorns are formed on the edge of the pre-cover. Small teeth are observed on the upper jaw.

Measurements: Morphometric indices and relative parameters of plastic features are characterized by following values: BL 2.85 mm, PL – 1.50 mm (52.63%), BD – 1.20 mm (42.10%), BDA – 0.80 mm (28.07%), HL – 1.00 mm (35.08%), SL – 0.35 mm (35.00%), ED – 0.25 mm (25%).

Site of Occurrence in RSA:

Sea of Oman: Station 90.



Site of occurrence of *Epinephelus* sp. larva in RSA

Family CARANGIDAE

Carangidae gen. sp. (Plate 11).

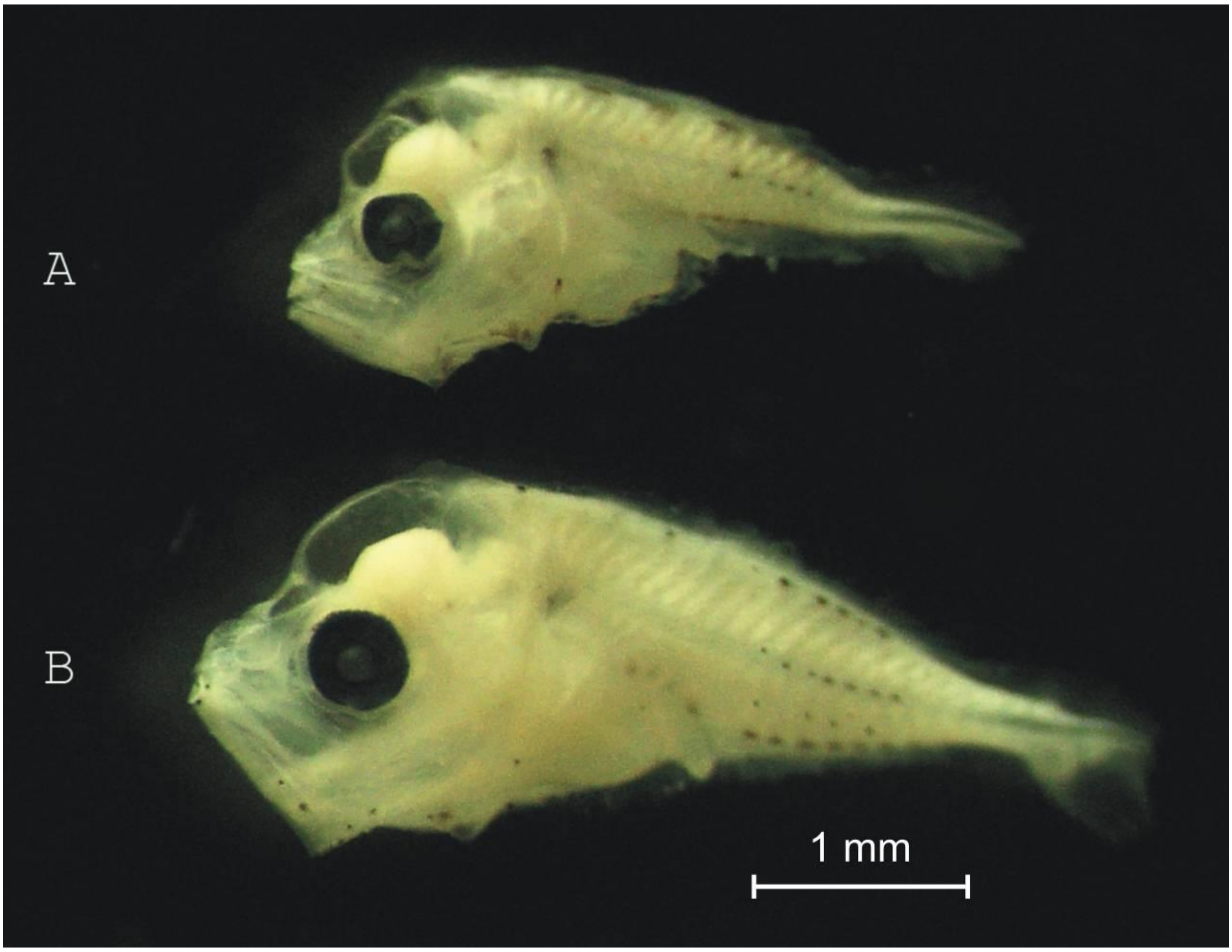


Plate 11. Larval stages of Carangidae gen. sp.

A. BL 3.50 mm; B. BL 4.50 mm.

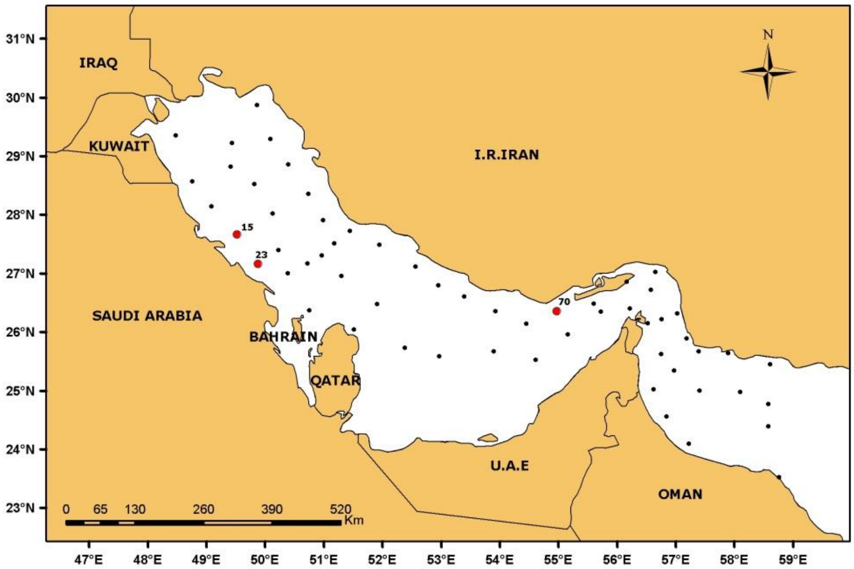
Description: Larvae are high in the body with sharp reduction of the body height in the post-anal part of the body. Pigment cells are located as a chain in VPS and DPS, laterally along the vertebra and on the head. Small thorns are developing on the edge of the pre-cover. Up to BL of about 4.05 mm, the urostyle is straight; hypural plates are formed; formation of rays begins in odd fins.

Measurements: The relative parameters of morphometric features are characterized by following values: BL 2.20 mm-6.75 mm, PL – 54.07-55.55%, PDLI – 43.70%, BD – 37.03-

40.00%, BDA – 24.69-29.62%, HL – 30.86-35.55%, SL – 31.25-36.00%, ED – 29.16-35.00%.

Sites of Occurrence in RSA:

Inner RSA: Stations 70, 23 and 15.



Sites of occurrence of Carangidae gen. sp. larvae in RSA

Family CARANGIDAE

Genus *Caranx*

***Caranx* sp.** (Plate 12).

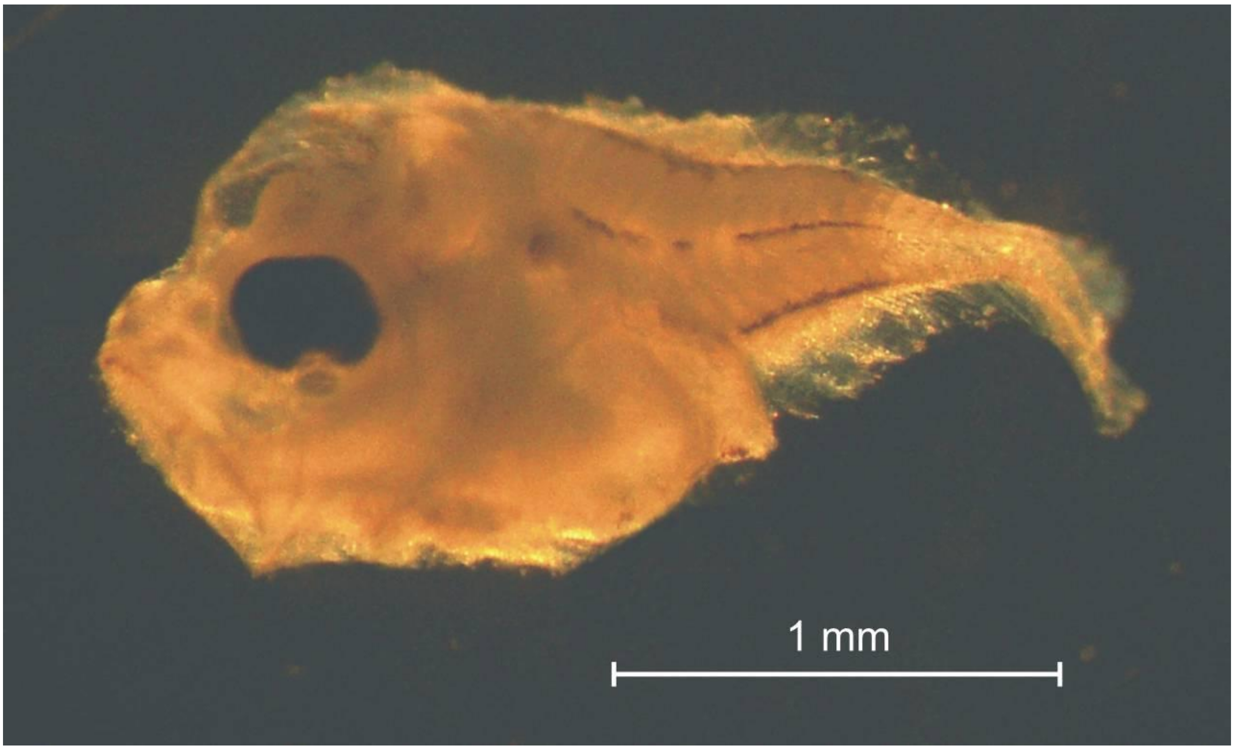


Plate 12. Larva of Carangidae, *Caranx* sp.

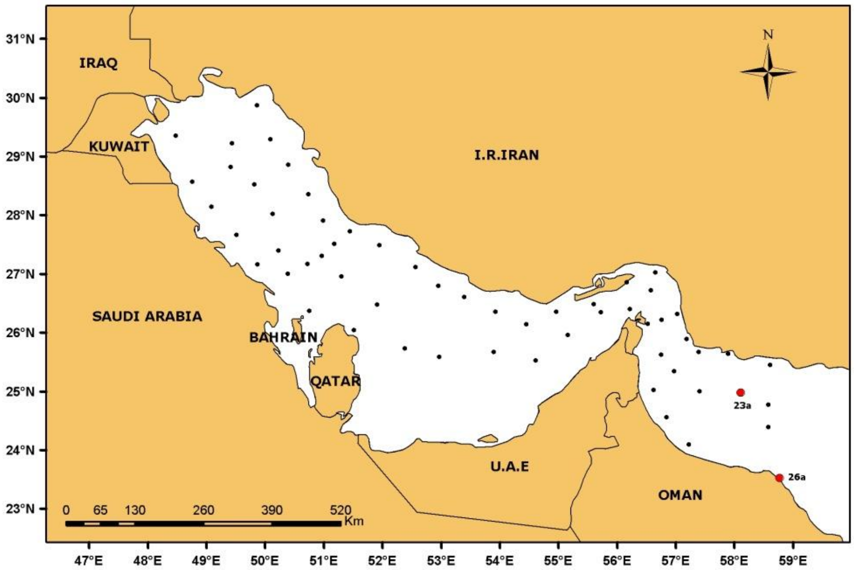
BL 2.30 mm.

Description: Larvae are high in the body. Individuals with BL of about 3.50 mm preserve a fin fold from the dorsal and ventral sides; up to this length the urostyle is straight. Hypural plates are not formed. There are 24 melanophores in the post-anal part. There are small thorns on the gill pre-cover. Pigment cells are located on the cranium, as a chain in VPS and DPS and along the middle line of the body.

Measurements: Morphometric indices and parameters of morphometric features are characterized by following values: BL 2.30 mm, PL – 1.55 mm (67.39%), BD – 1.00 mm (43.47%), BDA – 0.70 mm (30.43%), HL – 0.70 mm (30.43%), SL – 0.25 mm (35.71%), ED – 0.30 mm (42.85%).

Sites of Occurrence in RSA:

Sea of Oman: Stations 26a and 23a.



Sites of occurrence of *Caranx* sp. larvae in RSA

Family NEMIPTERIDAE

Nemipteridae gen. sp. (Plate 13).

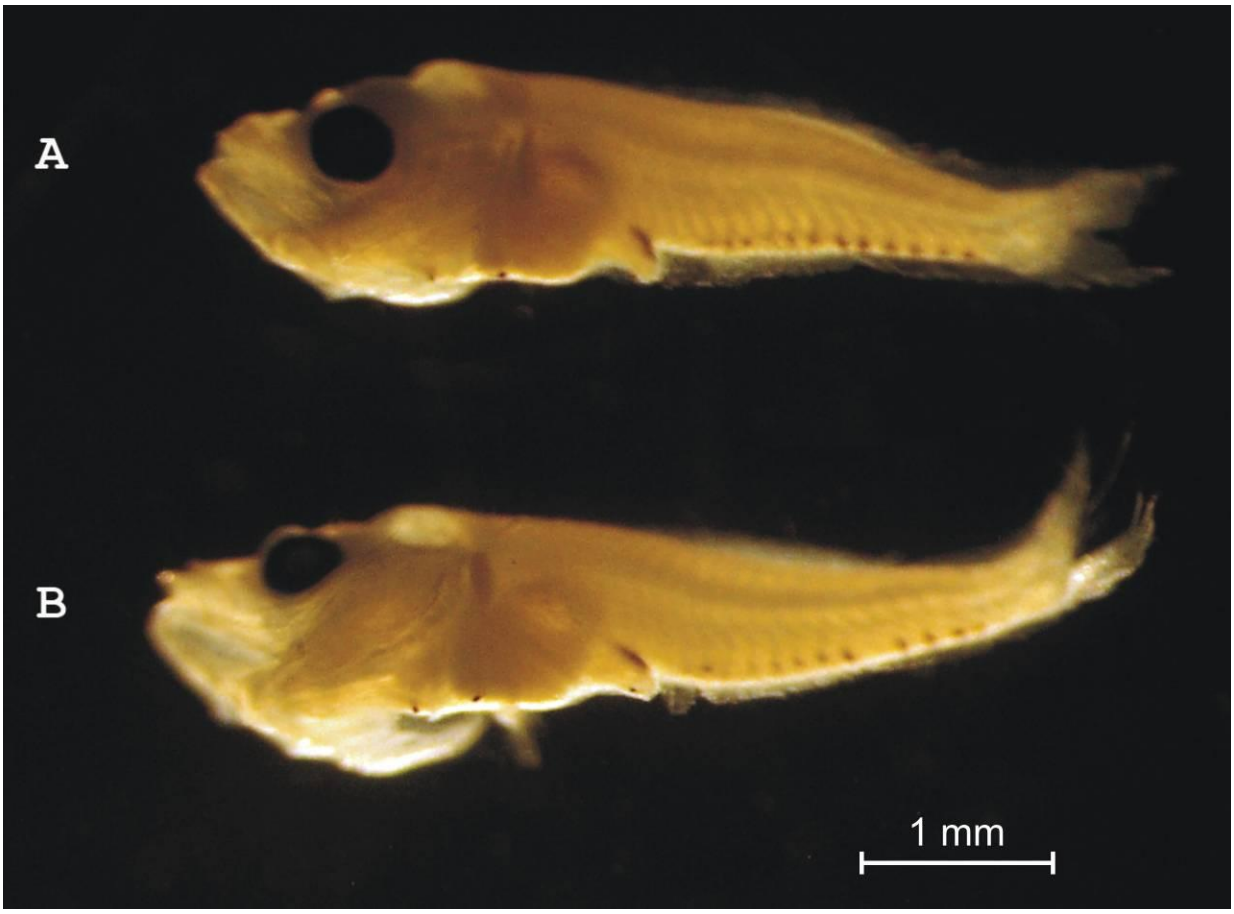


Plate 13. Larval stages of Nemipteridae gen. sp.

A. BL 4.50 mm; B. BL 4.65 mm.

Description: Larvae of the representatives of this species have no pigment cells on the head; however, the peritoneum is intensively pigmented. It is characteristic that there is a large melanophore on the end of the anal tube and before the anus on the abdomen – several small melanophores. In the post-anal part in VPS, 16-18 melanophores are located in chain. The swimming bladder and hollow formation on the border of the head and body are well observed in the larvae of all sizes. Edges of opecular bones have no thorns. With BL of about 3.30 mm, the urostyle is straight, in the area of the future caudal fin, the structure of the fin fold becomes denser; pectoral fins are developing. In the caudal fin, rays begin to form with BL of about 4.00 mm they form symmetrically to the straight end of the urostyle. With BL of about 5.50 mm, the urostyle is dented; hypural plates are forming; a fin fold becomes denser in the places of formation of the dorsal and anal fins.

Measurements: Relative parameters of dynamics of plastic features for larvae of different size are not quite stable, that can be connected with specific features in dynamics of larvae growth (Fig. 9).

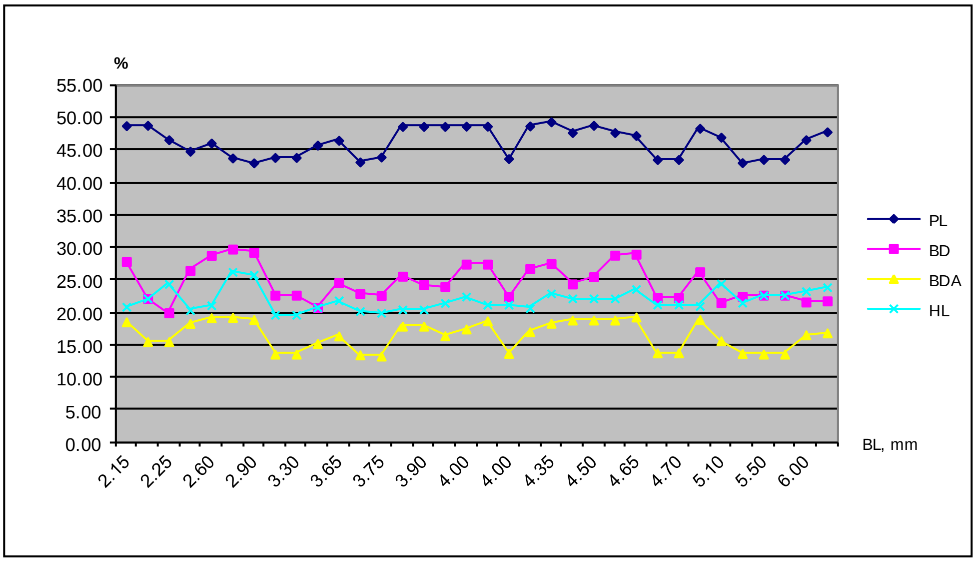
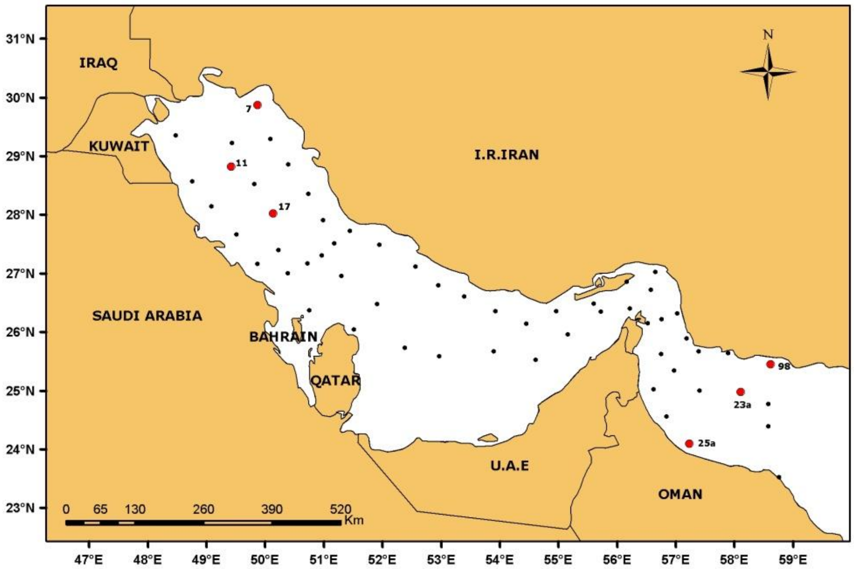


Fig. 9. Morphometric characteristics of larvae of Nemipteridae gen.sp. Symbols as in Fig. 6.

Sites of Occurrence in RSA:

Sea of Oman: Stations 98, 23a and 25a.

Inner RSA: Stations 17, 07 and 11.



Sites of occurrence of Nemipteridae gen. sp. larvae in RSA

Family SPARIDAE

In the area of the Sea of Oman, a relatively great variety of larvae belonging to the Family Sparidae was found. These larvae are characterized by similarity in the location of melanophores on the cranium and in the VPS, where there were found 16-18 cells. However, these larvae greatly varied by morphometric parameters. Therefore, they are conventionally identified as groups *Sparidae* gen. sp. II and *Sparidae* gen. sp. III, incorporating individuals with higher bodies. Sparidae gen. sp. I and Sparidae gen. sp. IV together incorporate individuals with bodies of smaller height. Among adult representatives of Family Sparidae, the representatives of genera *Acanthopagrus* and *Argyrops* have the greatest body height. Larvae of the first two groups are likely to be the representatives of following two groups.

Sparidae gen. sp.I (Plate 14).

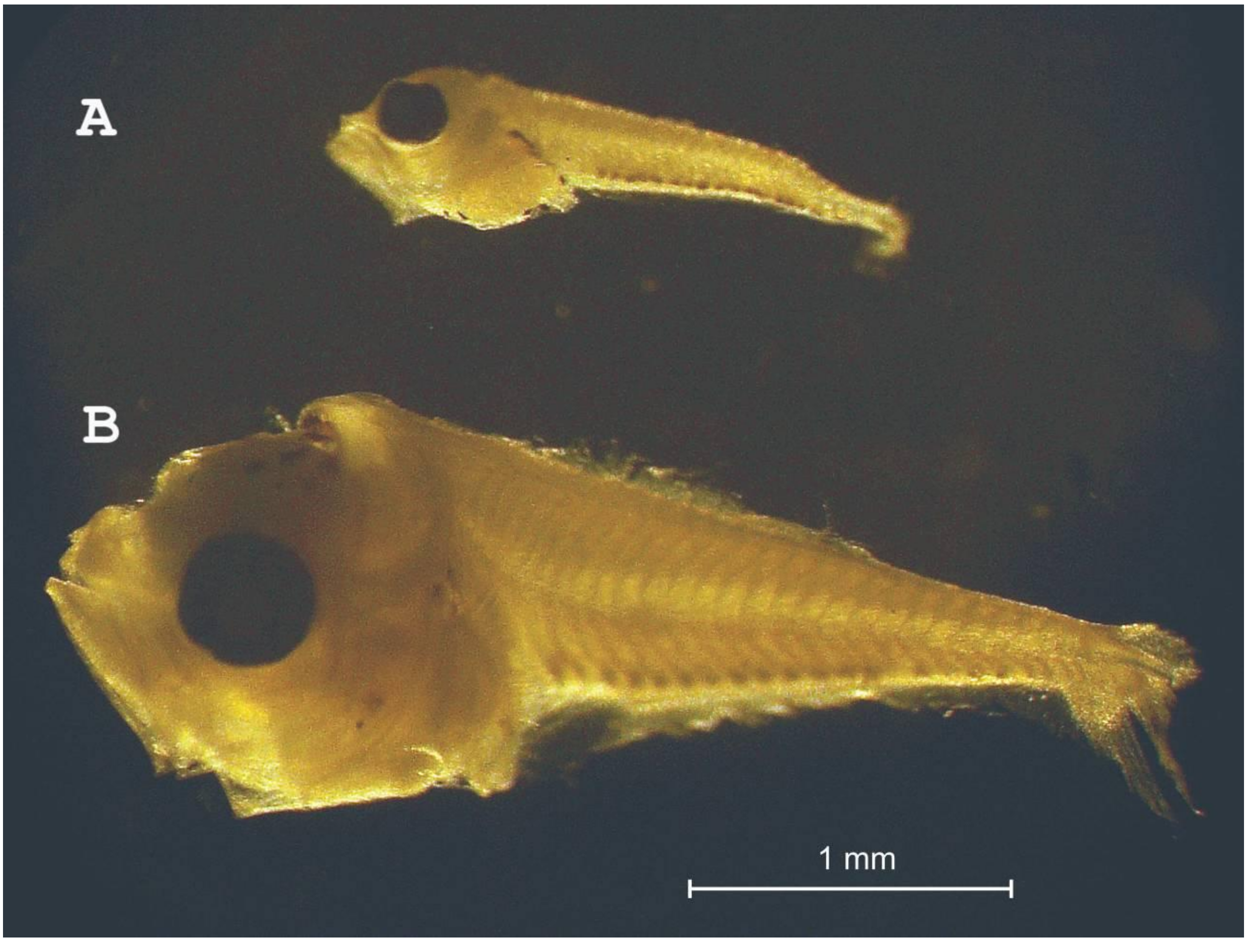


Plate 14. Larval stages of Sparidae gen. sp. I

A. BL 1.75 mm; B. BL 3.50 mm.

Description: Larvae of this type have separate large melanophores on the cranium, several small melanophores in the area of the peritoneum, a chain of melanophores in the VPS in the amount of 16-18 cells. With BL of about 2.00 mm, pectoral fins in the shape of a kidney have no differentiation of rays. This process is observed with BL of about 2.9 mm. With BL of about 3.50 mm, the urostyle is dented; hypural plates are formed; rays are forming in the lower blade of the caudal fin, and odd fins are not forming. This process is observed with BL of about 4.00 mm. With BL of about 4.55 mm the process of formation of rays in the odd rays and in the dorsal fin, up to 10 rays are counted, in the anal fin – up to 9 ones. Signs of abdomen fins are appearing.

Measurements: Some relative parameters of dynamics of plastic features for larvae of different size are rather unstable, that is likely to be connected with specific features of dynamics of larval growth (Fig. 10)

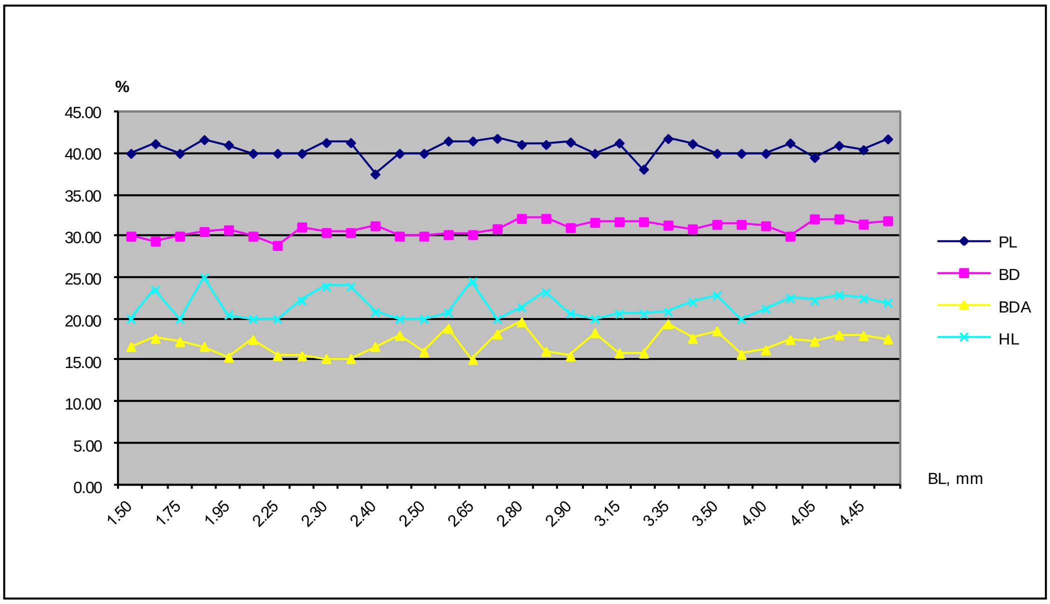
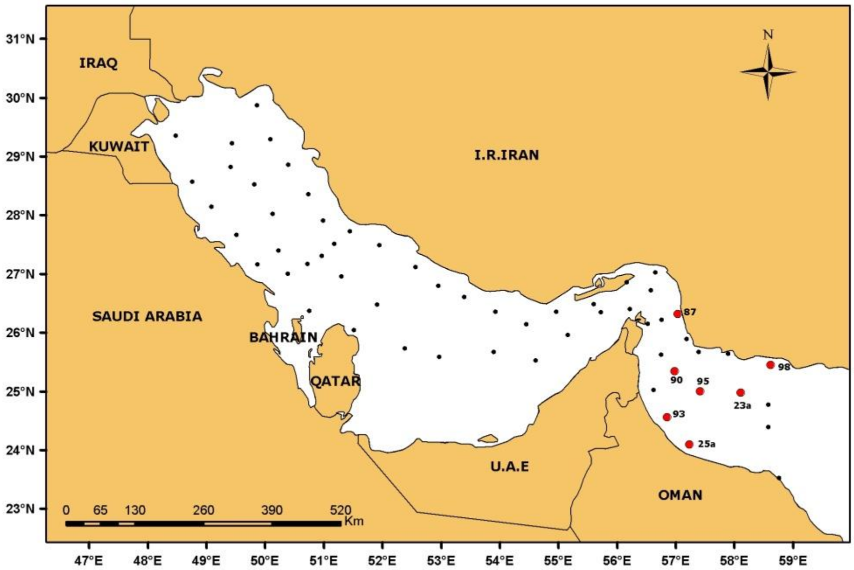


Fig. 10. Morphometric characteristics of Sparidae gen. sp. I larvae.
Symbols as in Fig. 6.

Sites of Occurrence in RSA:

Sea of Oman: Stations 98, 23a, 25a, 93, 95, 90 and 87.



Sites of occurrence of Sparidae gen. sp.I larvae in RSA

Sparidae gen. sp. II (Plate 15).

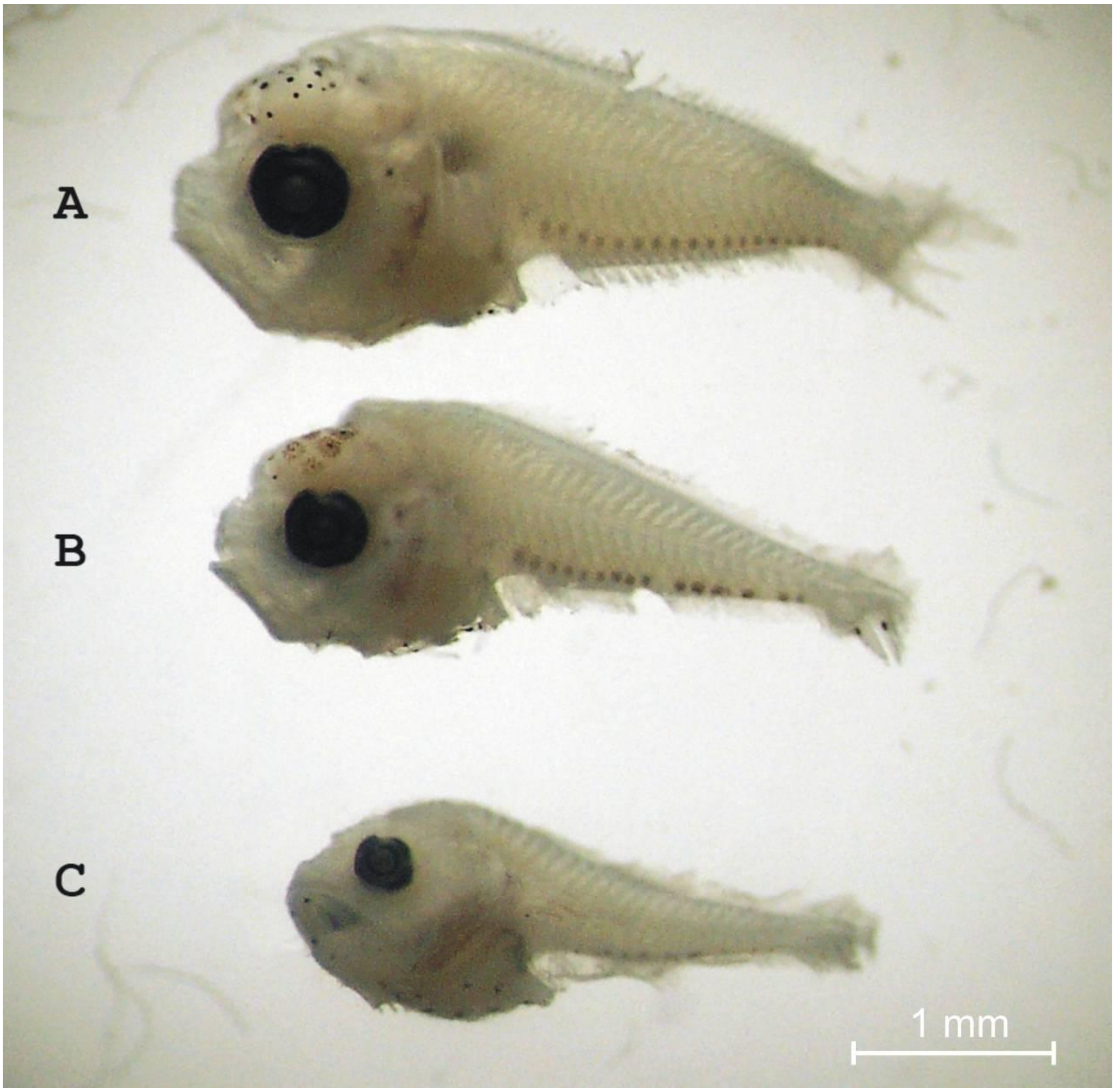


Plate 15. Larval stages of Sparidae gen. sp. II

A. BL 4.00 mm; B. BL 3.50 mm; C. BL 3.40mm.

Description: Larvae have large body height in the pre-anal area. There are separate melanophores on the cranium and a chain of 16-17 small melanophores in each miomere in the VPS. Gill covers have no thorns. Individuals of BL equal to 3.40 mm have a straight urostyle, and with BL of about 3.50 mm, it is denting. The process of formation of hypural plates takes place. A forming blade of the caudal fin is divided into the upper and lower parts. With BL equal to 3.60 mm, the process of formation of the dorsal and anal fins takes place.

Measurements: The relative parameters of the dynamics of plastic features for larvae of different size are rather stable (Fig. 11).

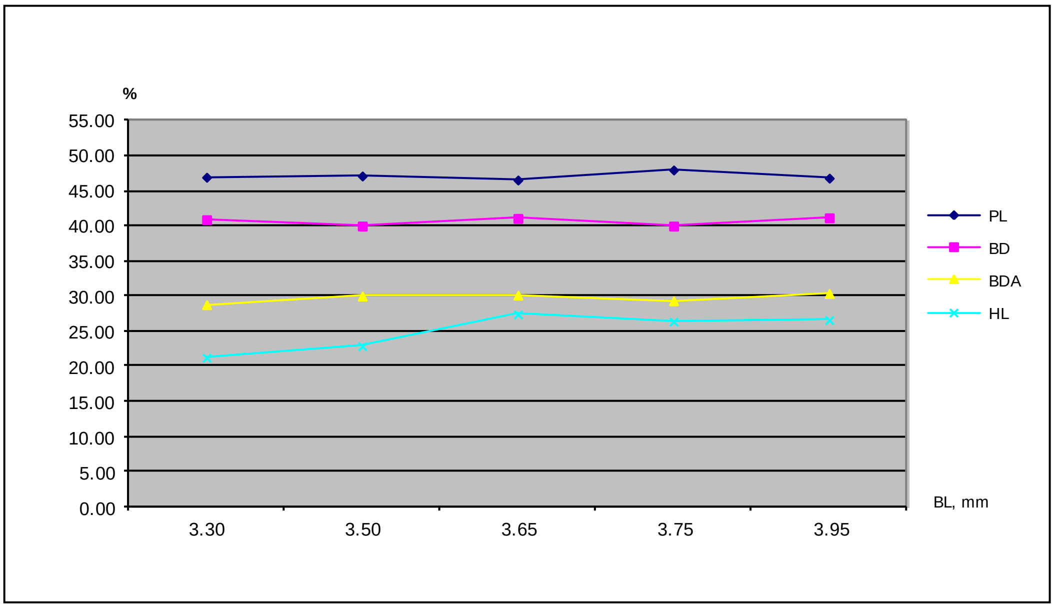
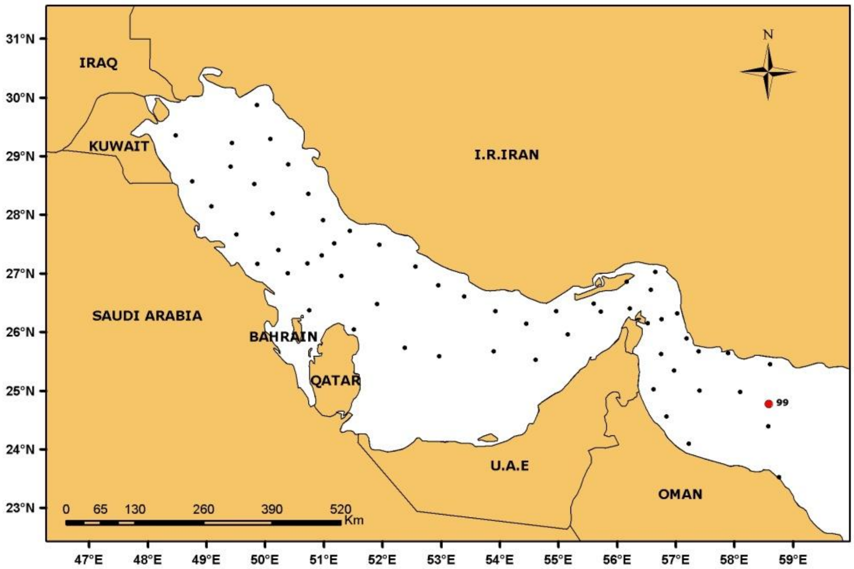


Fig. 11. Morphometric characteristics of Sparidae gen. sp. II larvae. Symbols as in Fig. 6.

Site of Occurrence in RSA:

Sea of Oman: Station 99.



Site of occurrence of Sparidae gen. sp.II larvae in RSA

Sparidae gen. sp. III (Plate 16).

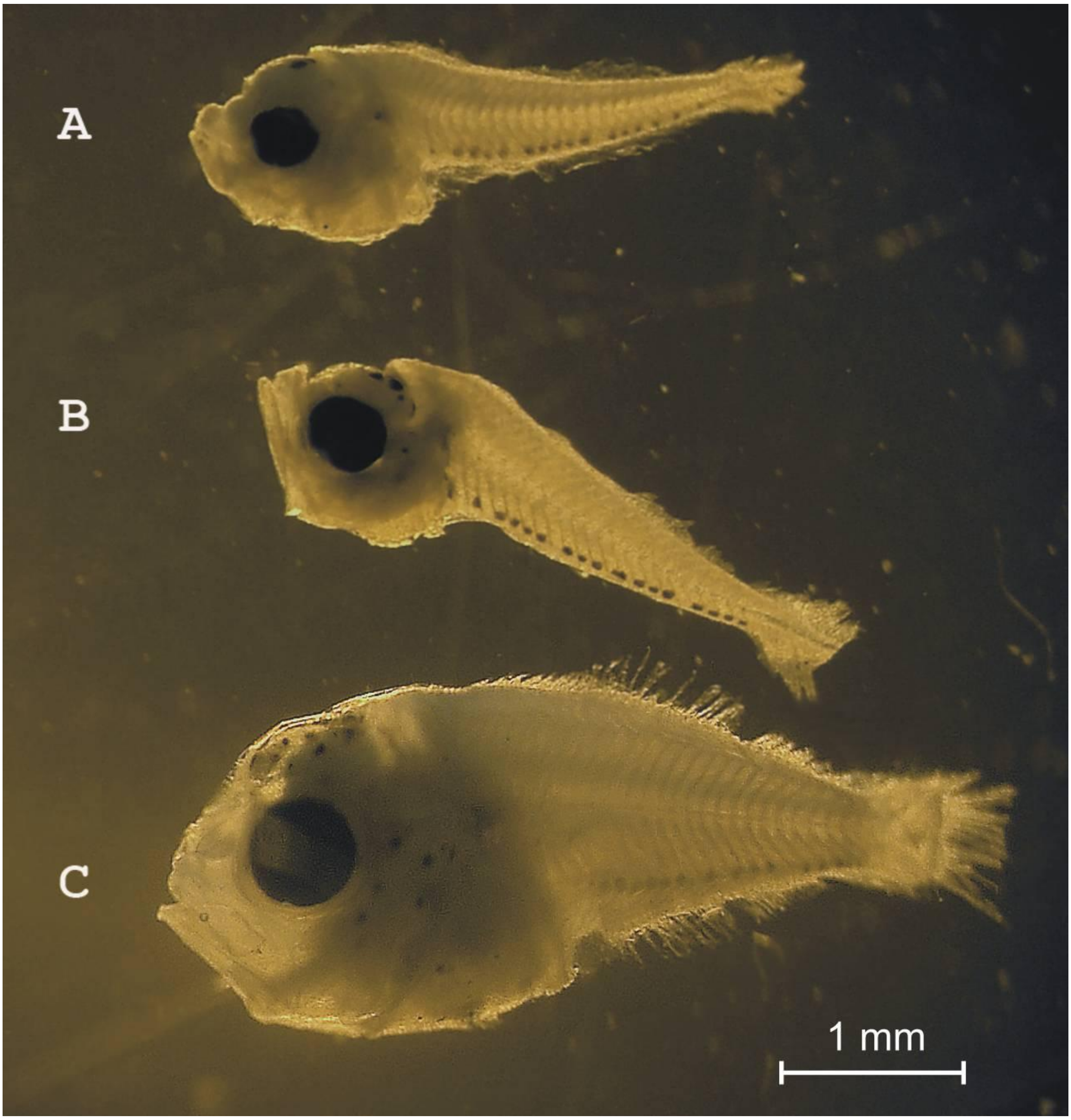


Plate 16. Larval stages of Sparidae gen. sp. III.
A. BL 3.00 mm; B. BL 3.10 mm; C. BL 4.30 mm.

Description: Larvae have large body height in the pre-anal section, and this feature is clearly expressed for larger individuals. Melanophores are located on the cranium, on the gill covers and in the VPS as a chain in the amount of 17-19 pieces. Edges of gill covers have no thorns. The urostyle is denting in individuals with BL of about 5.50 mm; the formation of rays in the odd fins is observed for individuals with BL of about 4.00 mm.

Measurements: The relative parameters of the dynamics of the plastic features for larvae of different sizes are rather stable (Fig. 12).

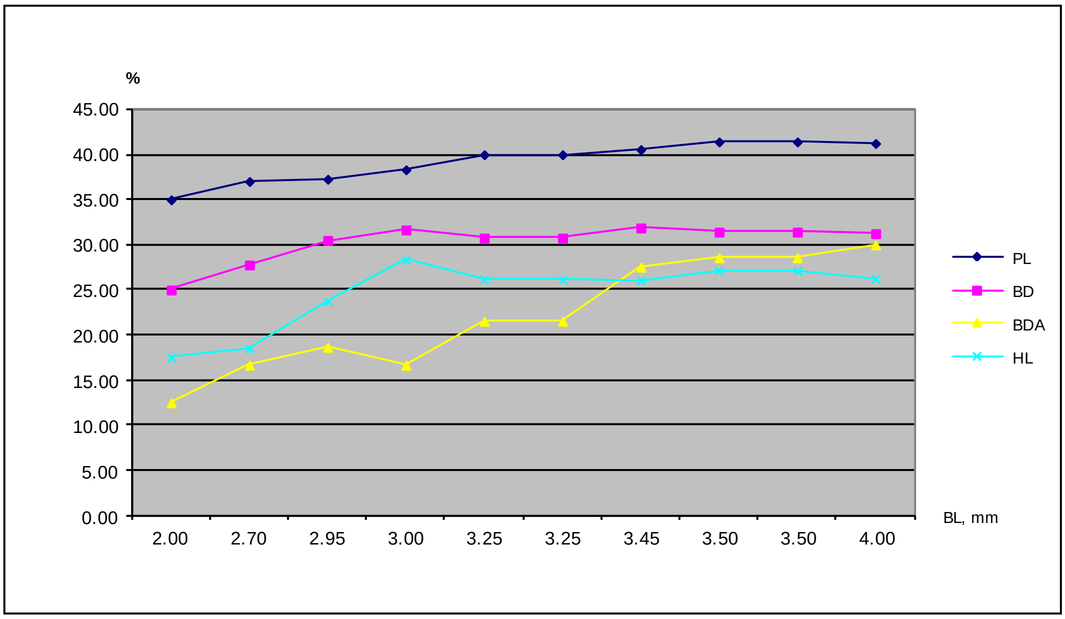
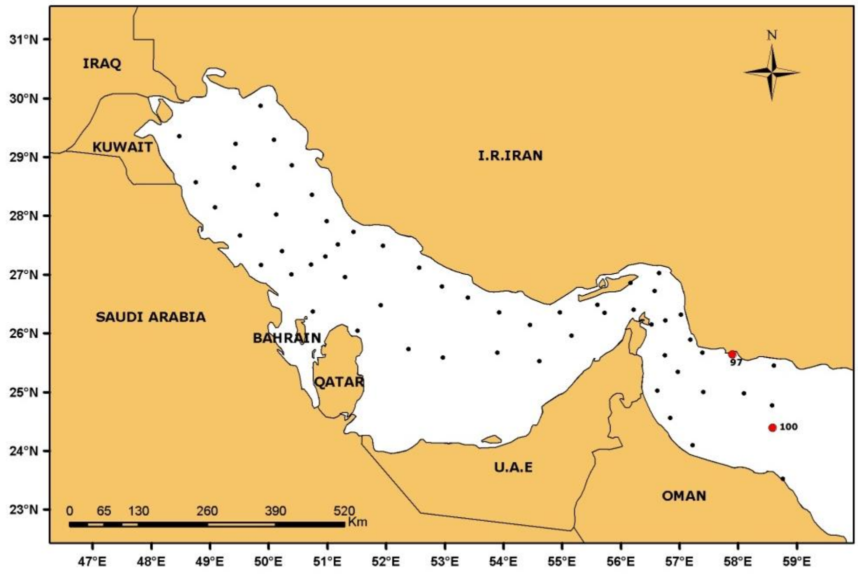


Fig. 12. Morphometric characteristics of Sparidae gen. sp. III larvae.
Symbols as in Fig. 6.

Sites of Occurrence in RSA:

Sea of Oman: Stations 100 and 97.



Sites of occurrence of Sparidae gen. sp.III larvae in RSA

Sparidae gen. sp. IV (Plate 17).

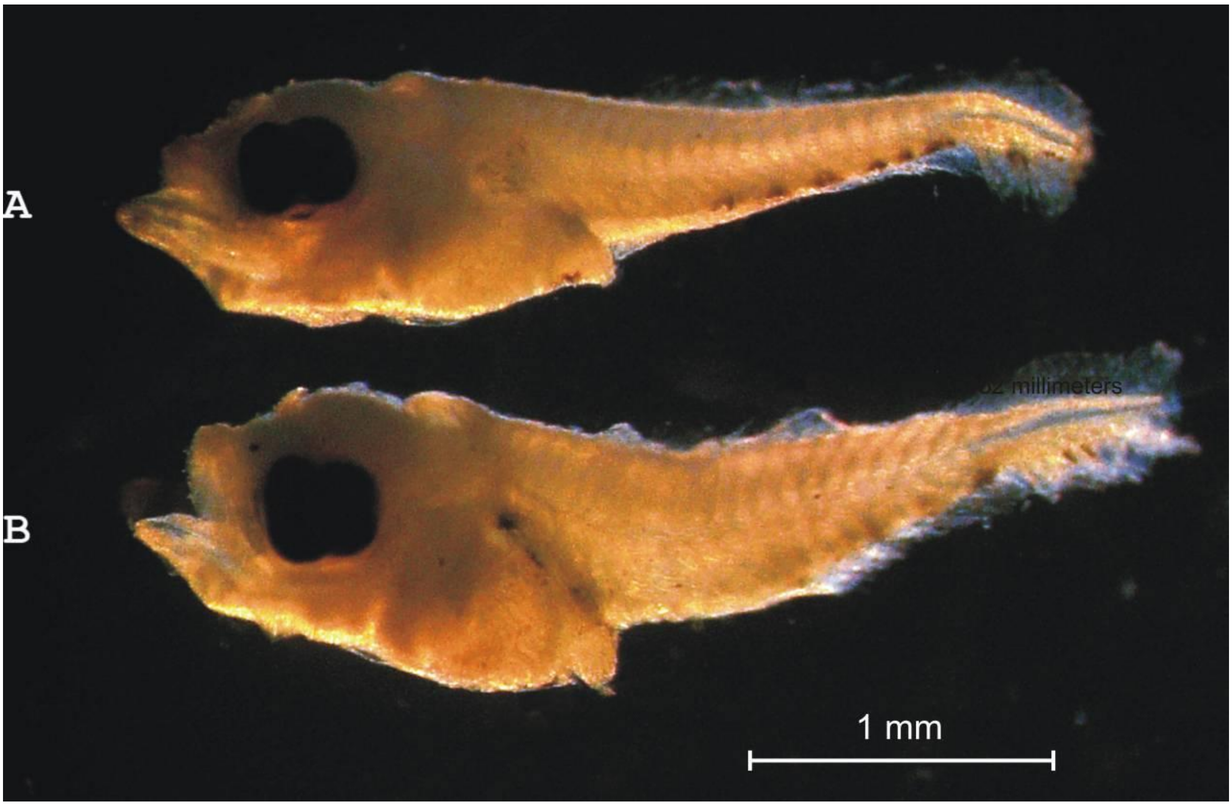


Plate 17. Larval stages of Sparidae gen. sp. IV.
A. BL 2.85 mm; B. BL 3.20 mm.

Description: Pigment cells are located on the cranium; separate ones are on the peritoneum, and the VPS has a chain of 6-7 melanophores. Individuals with BL of about 3.20 mm have the straight urostyle. The anal fin is forming.

Measurements: The relative parameters of the dynamics of the plastic features for larvae of different sizes are rather stable (Fig. 13).

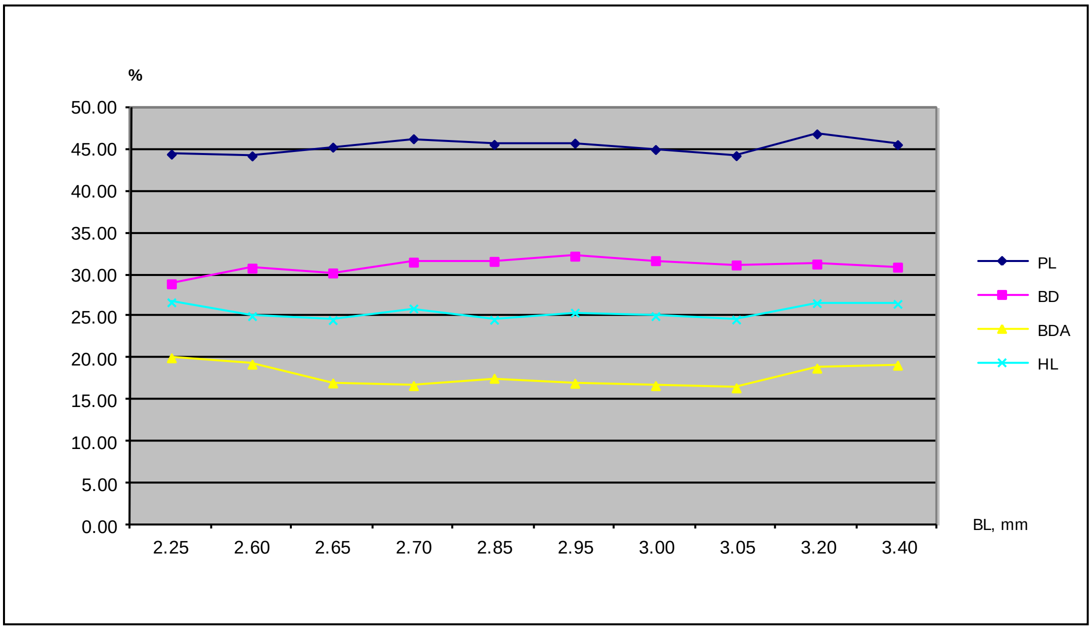
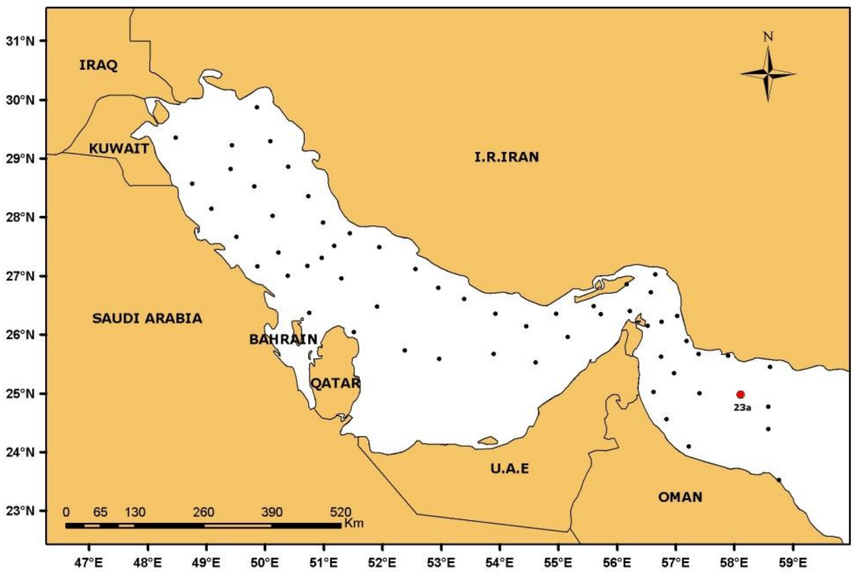


Fig. 13. Morphometric characteristics of Sparidae gen. sp. IV larvae. Symbols as in Fig. 6.

Site of Occurrence in RSA:

Sea of Oman: Station 23a.



Site of occurrence of Sparidae gen. sp. IV larvae in RSA

Sparidae gen. sp. V (Plate 18).

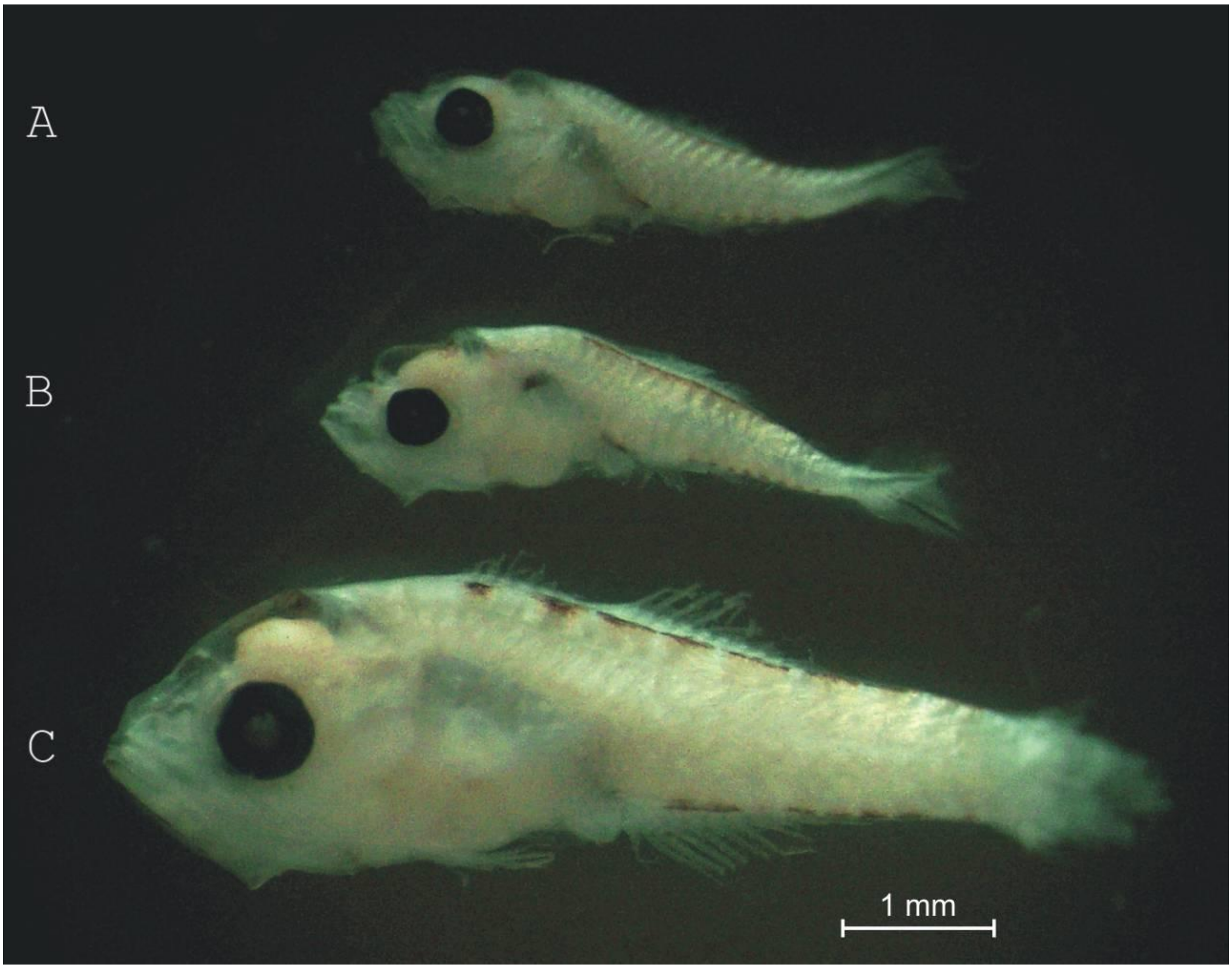


Plate 18. Larval stages of Sparidae gen. sp. V.

A. BL 3.55 mm; B. BL 3.80 mm; C. BL 6.30 mm.

Description: Starry pigment cells are located on the cranium, in the pace of formation of dorsal (DPS) and anal (VPS) fins. Edges of gill covers have no thorns. Individuals with BL of about 2.25 mm have pectoral fins forming. Rays are forming in the caudal fin symmetrically to the straight end of the urostyle. With increasing body length, pigmentation in DPS and VPS is increasing. Rays in the odd fins begin to form with BL of about 3.50 mm.

Measurements: The relative parameters of the dynamics of the plastic features for larvae of different sizes are rather stable (Fig. 14).

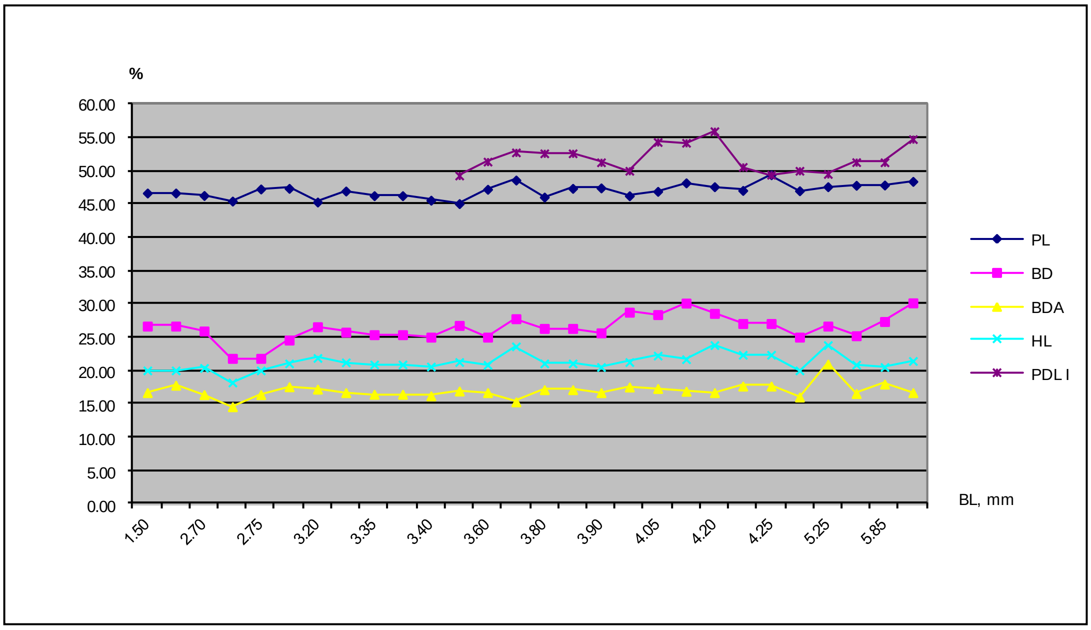
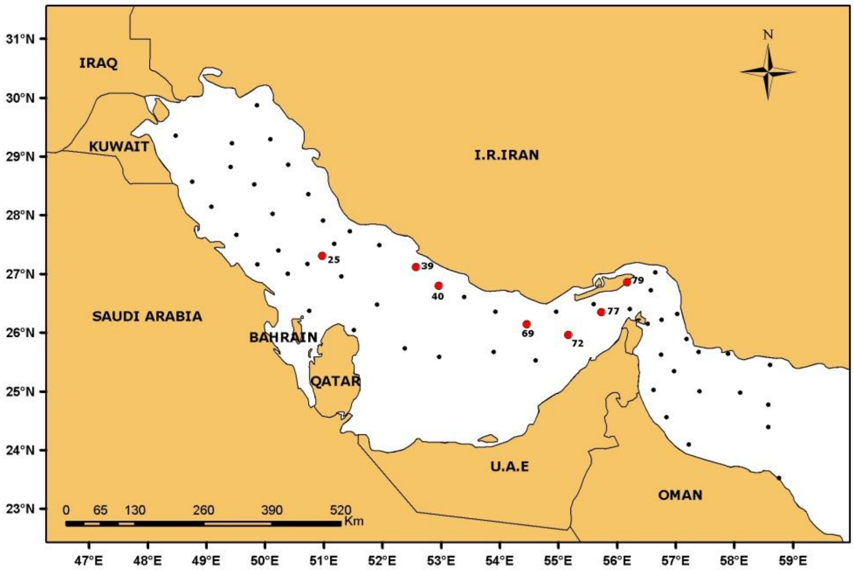


Fig. 14. Morphometric characteristics of Sparidae gen. sp.V larvae.

Symbols as in Fig. 6.

Sites of Occurrence in RSA:

Inner RSA: Stations 79, 77, 72, 69, 40, 39 and 25.



Sites of occurrence of Sparidae gen. sp.V larvae in RSA

Family URANOSCOPIDAE

Uranoscopidae gen. sp. (Plate 19).

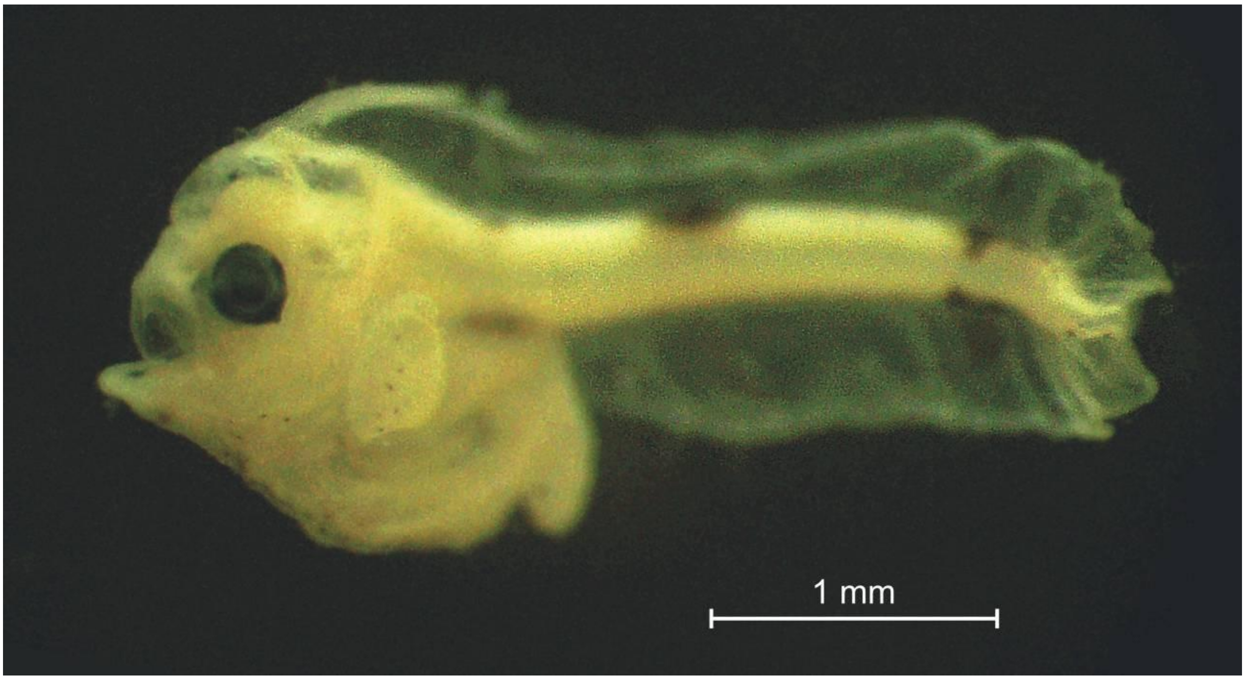


Plate 19. Larva of Uranoscopidae gen. sp.

BL 3.5 mm.

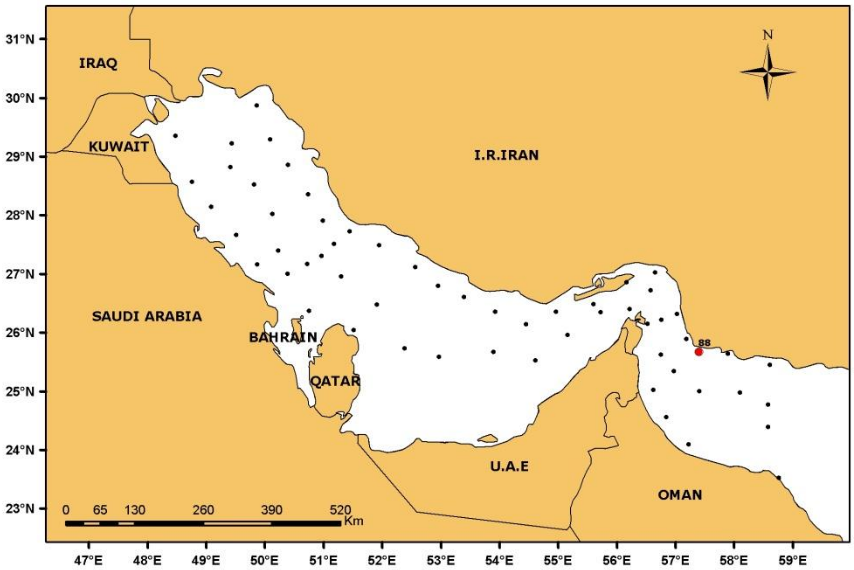
Description: Larvae have a very wide fin fold covering the body in the dorsal side from the head, and from the ventral side – from the anus. Large pigment spots are located on the dorsal side in the middle section of the body and near the caudal fin from the dorsal and ventral sides. The upper part of the peritoneum is pigmented. The mouth is wide. The pectoral fins are oval-shaped, wide with forming rays.

Measurements:

Body length – 3.50 mm.

Site of Occurrence in RSA:

Sea of Oman: Station 88.



Site of occurrence of Uranoscopidae gen. sp. larva in RSA

Family BLENNIIDAE

Blenniidae gen. sp. (Plate 20).

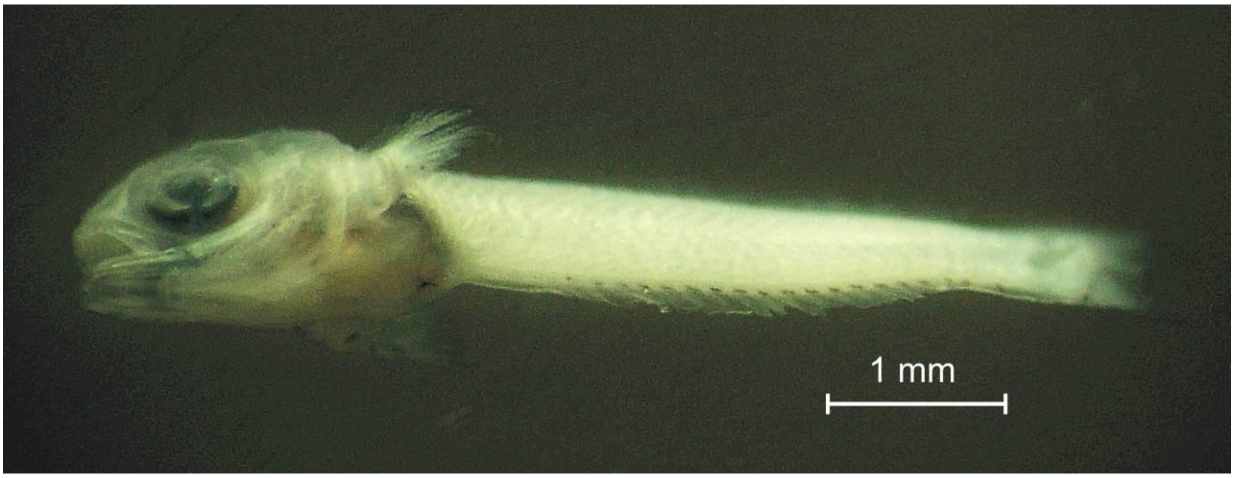


Plate 20. Larva of Blenniidae gen. sp.

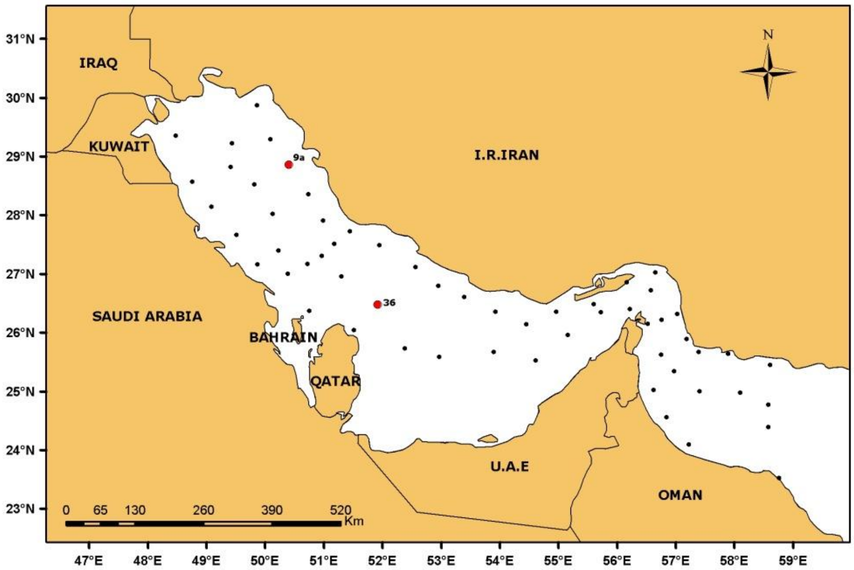
BL 5.75 mm.

Description: Larvae have prolonged bodies, slightly squeezed from the sides; the anus is located in the first third of the body. Larvae with BL of about 5.75 mm have large pectoral fins, and they reach the anal opening. There are teeth on the jaws. Ventral pigment series is clear (VPS). There are pigment cells based on the pigment fins and on the peritoneum. The urostyle is dented. Hypural plates and rays in the odd fins are forming.

Measurements: Morphometrical indices are as follows: TL – 6.50 mm, BL 5.75 mm, PL – 2.05 mm, BD – 1.50 mm, BDA – 1.15 mm, HL – 1.45 mm, SL – 0.50 mm, ED - 0.50 mm. The relative parameters of the morphometric characteristics for these larvae are as follows: PL – 35.65%, BD – 26.08%, BDA – 20.00%, HL – 25.21%, SL – 34.48%, ED – 34.48%.

Sites of Occurrence in RSA:

Inner RSA: Stations 36 and 09a.



Sites of occurrence of Blenniidae gen. sp. larvae in RSA

Family ACANTHURIDAE

Acanthuridae gen. sp. (Plate 21).

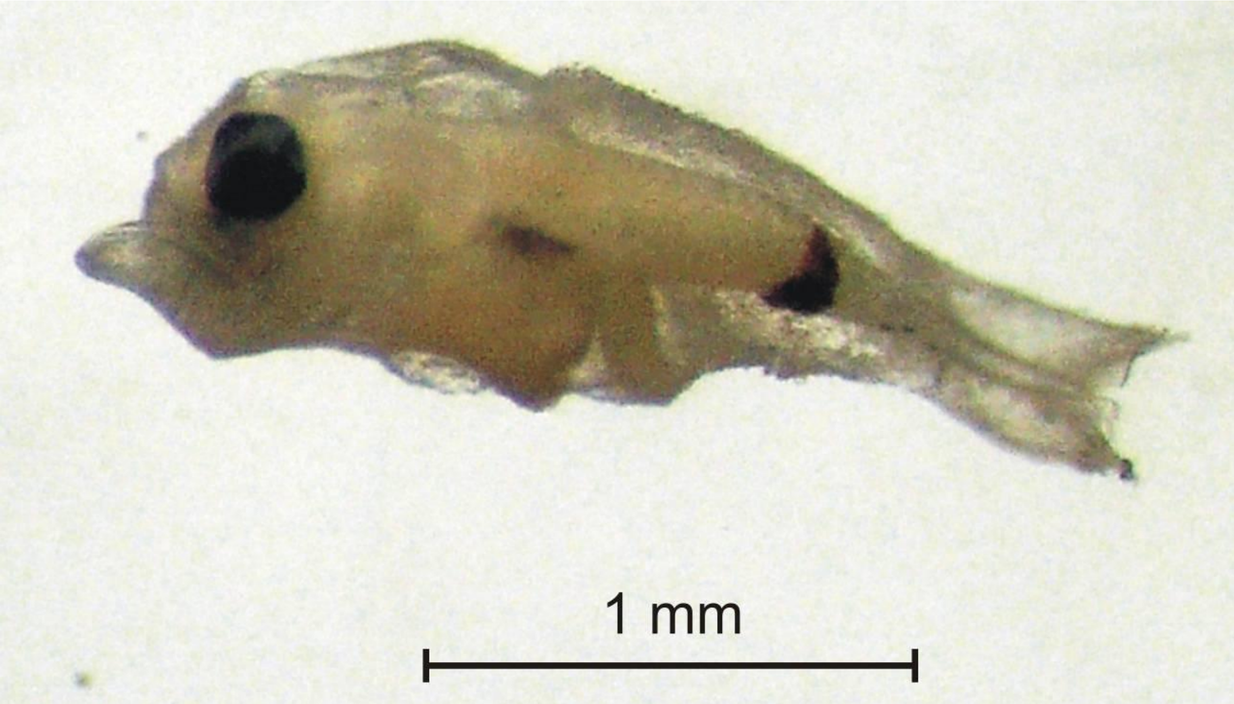


Plate 21. Larva of Acanthuridae gen. sp.

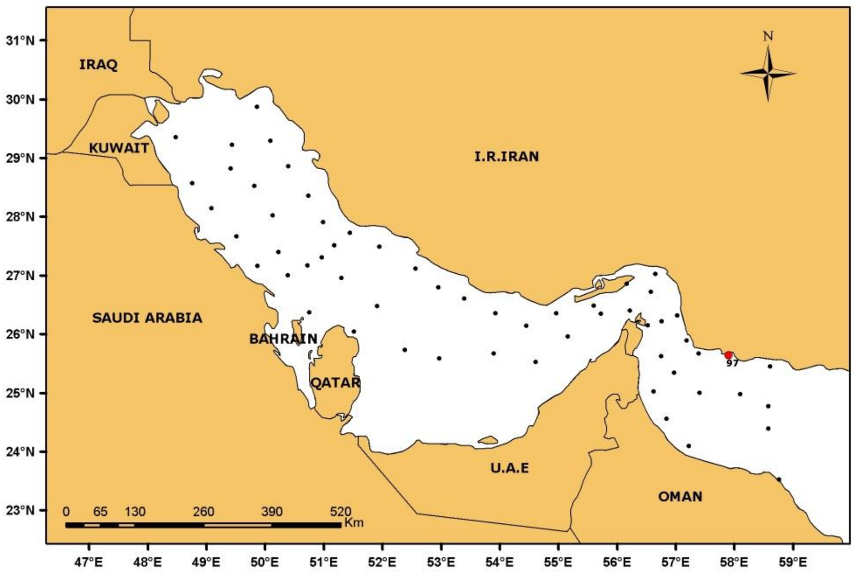
BL 1.70 mm.

Description: Larvae have a watered fin fold as a shell around the body. Pectoral fins are forming. The anal tube is detached from the body. The upper part of the peritoneum is pigmented. A large melanophore covers the body as a ring in the post-anal part. There are small thorns on the edge of the gill cover. Individuals with BL of 1.70 mm have the straight urostyle. The caudal fin is forming with detached upper and lower blades. Such a form of the caudal fin is characteristic for representatives of the *Acanthurus* genus.

Measurements: Morphometric indices of Acanthuridae gen. sp. are: TL – 1.75 mm, BL 1.70 mm, PL – 0.85 mm, BD – 1.00 mm, BDA – 0.45 mm, HL – 0.35 mm, SL – 0.10 mm, ED – 0.15 mm. The relative parameters of the morphometric characteristics for these larvae are as follows: PL – 50.00%, BD – 58.82%, BDA – 26.47%, HL – 20.58%, SL – 28.57%, ED – 42.85%.

Site of Occurrence in RSA:

Sea of Oman: Station 97.



Site of occurrence of Acanthuridae gen. sp. larva in RSA

Family TRICHIURIDAE

Trichiuridae gen. sp. (Plate 22).

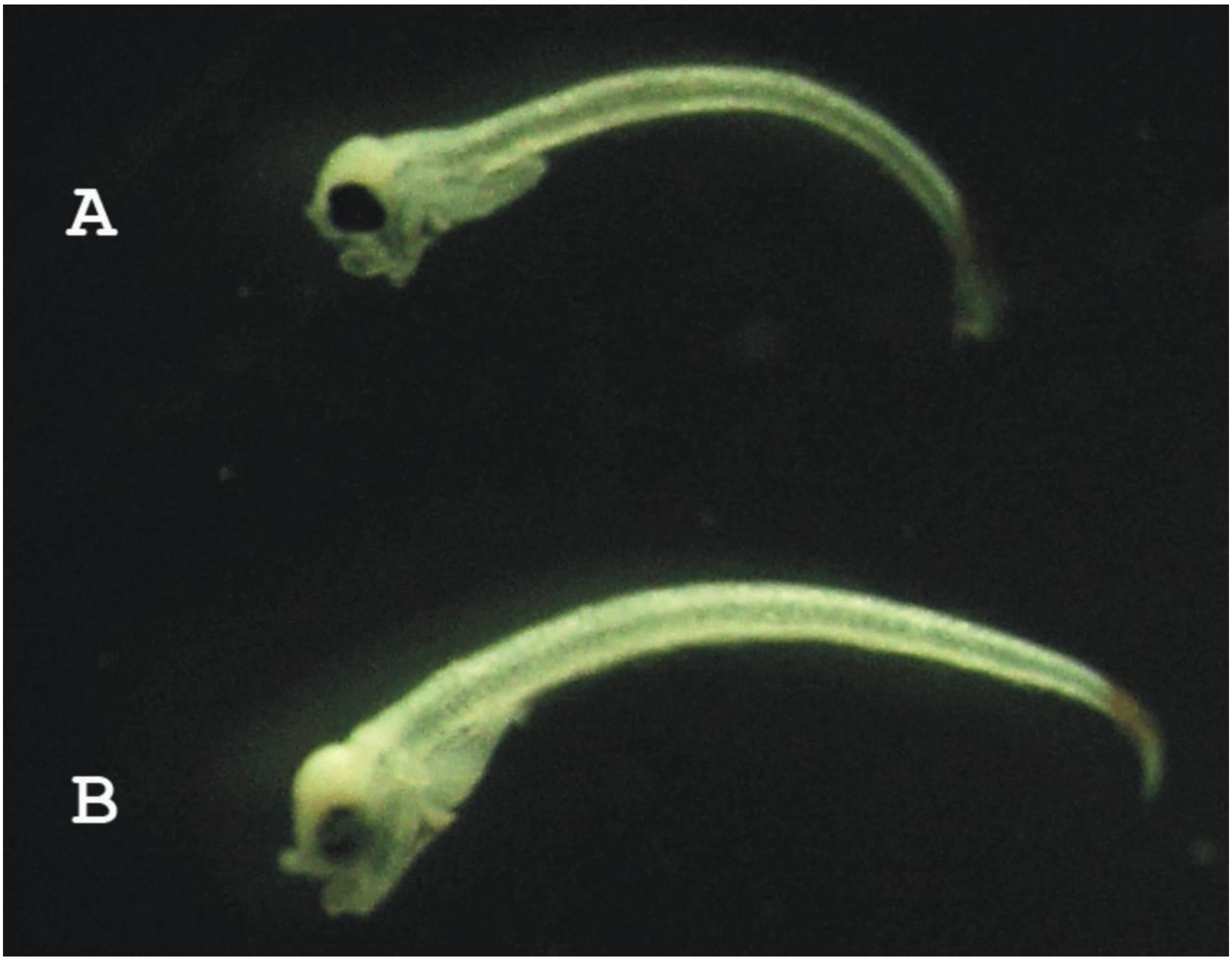


Plate 22. Larval stages of Trichiuridae gen. sp.

A. BL 3.00 mm; B. BL 3.50 mm.

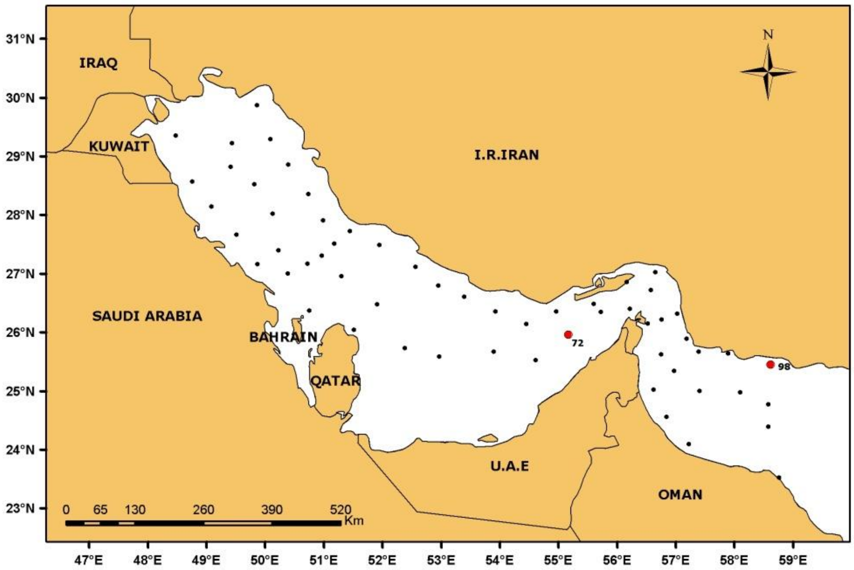
Description: Larvae have a small body height, with a short pre-anal length (PL). The urostyle is straight. The pigment spot covers the body as a ring before the basis of the caudal fin.

Measurements: The relative parameters of the morphometric characteristics for larvae with BL of 5.90 mm are as follows: PL – 26.27%, BD – 16.10%, BDA – 6.77 %, HL – 16.94%, SL – 25.00%, ED – 40.00%.

Sites of Occurrence in RSA:

Sea of Oman: Station 98.

Inner RSA: Station 72.



Site of occurrence of Trichiuridae gen. sp. larvae in RSA

Family CALLIONYMIDAE

Callionymidae gen. sp. (Plate 23).

Plate 23. Larva of Callionymidae gen. sp.

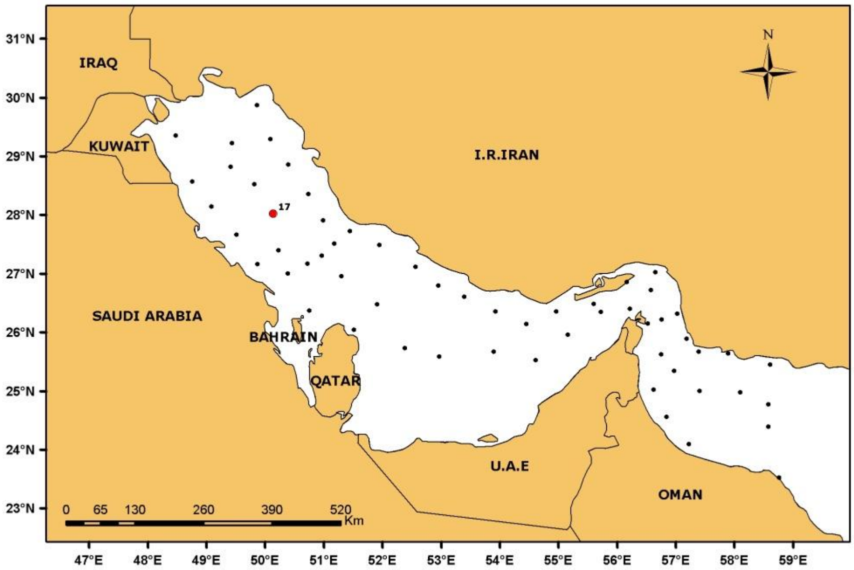
BL 4.90 mm.

Description: The body of the larvae is large, narrowing to the post-anal part. With BL of about 4.90 mm, the fin fold covers the body in the post-anal part in the dorsal and ventral side. Formation of odd fins is beginning. The pectoral fins are developed. Lateral and ventral sections of the body are intensively pigmented.

Measurements: Morphometric indices are as follows: TL – 5.45 mm, BL 4.90 mm, PL – 1.75 mm, BD – 1.15 mm, BDA – 1.10 mm, HL – 1.10 mm, SL – 0.30 mm, ED – 0.45 mm. The relative parameters of the morphometric characteristics are as follows: PL – 35.71%, BD – 23.46%, BDA – 22.44%, HL – 22.44%, SL – 27.27%, ED – 40.90%.

Site of Occurrence in RSA:

Inner RSA: Station 17.



Site of occurrence of Callionymidae gen. sp. larva in RSA

Family GOBIIDAE

Gobiidae gen. sp. (Plate 24).

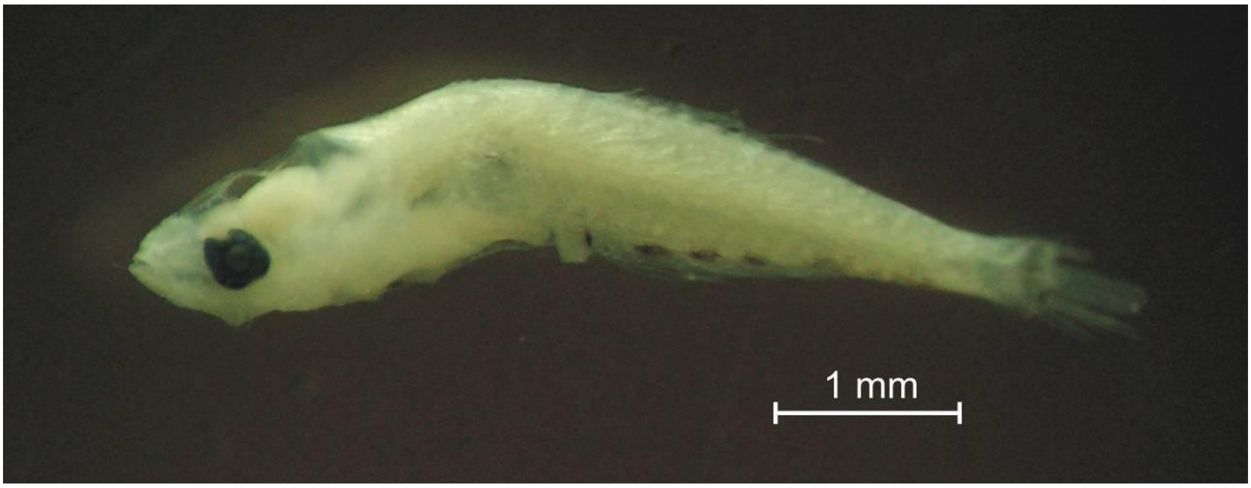


Plate 24. Larva of Gobiidae gen. sp.

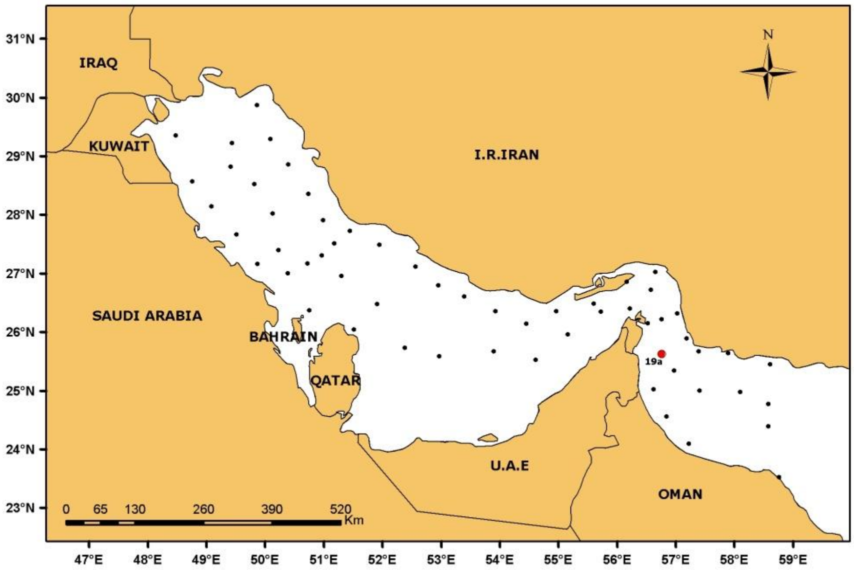
BL 5.00 mm.

Description: Larvae have a prolonged body, without pigments; however, there is a series of 5-6 melanophores as a chain in VPS. One melanophore is located on the anal tube. The swimming bladder is good visible. With BL of about 3.00 mm, there are forming dorsal and anal fins seen. With BL of about 5.00 mm, hypural plates and the caudal fin are formed in the larvae. Rays are forming in the odd fins.

Measurements: Body length is 5.00 mm.

Site of Occurrence in RSA:

Sea of Oman: Station 19a.



Site of occurrence of Gobiidae gen. sp. larva in RSA

Family SCOMBRIDAE

Genus *Auxis*

***Auxis thazard* (Lacepède, 1800)** (Plate 25).

Synonyms: *Auxis brachydorax* Collette & Aadland 1996; *Auxis rochei eudorax* Collette & Aadland 1996; *Auxis vulgaris* Bauchot & Blanc, 1961; *Auxis maru* Kishinouye 1915; *Auxis hira* Kishinouye, 1915; *Auxis ramsay*i Castelnau 1879; *Auxis thynnoides* Bleeker 1855; *Auxis tapeinosoma* Bleeker, 1854; *Auxis vulgaris* Cuvier, 1832; *Auxis taso* (Cuvier 1832); *Scomber taso* Cuvier, 1831; *Thunnus rocheanus* (Risso 1826); *Thynnus rocheanus* Risso, 1827; *Auxis rochei* (Risso, 1810); *Scomber rochei* Risso, 1810; *Auxis bisus* (Rafinesque, 1810); *Scomber bisus* Rafinesque, 1810; *Scomber alletteratus* Rafinesque, 1810; *Scomber thazard* Lacepède, 1800.

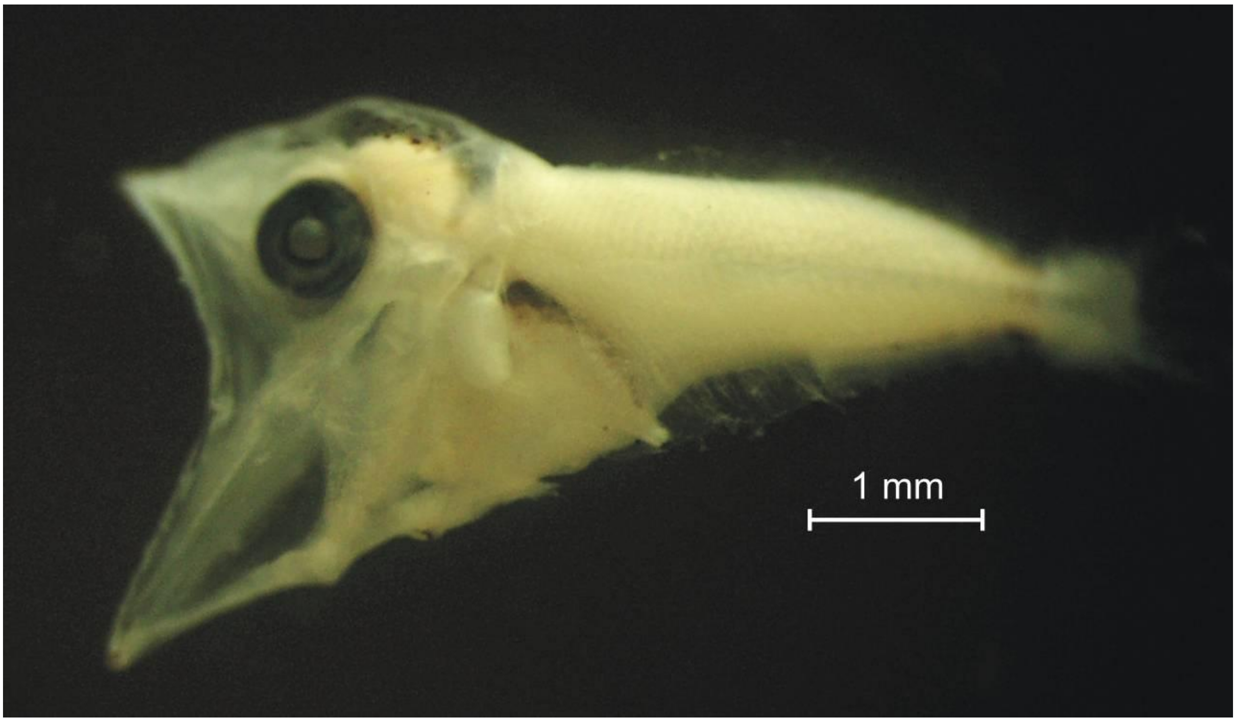


Plate 25. Larva of *Auxis thazard*.

BL 5.50 mm.

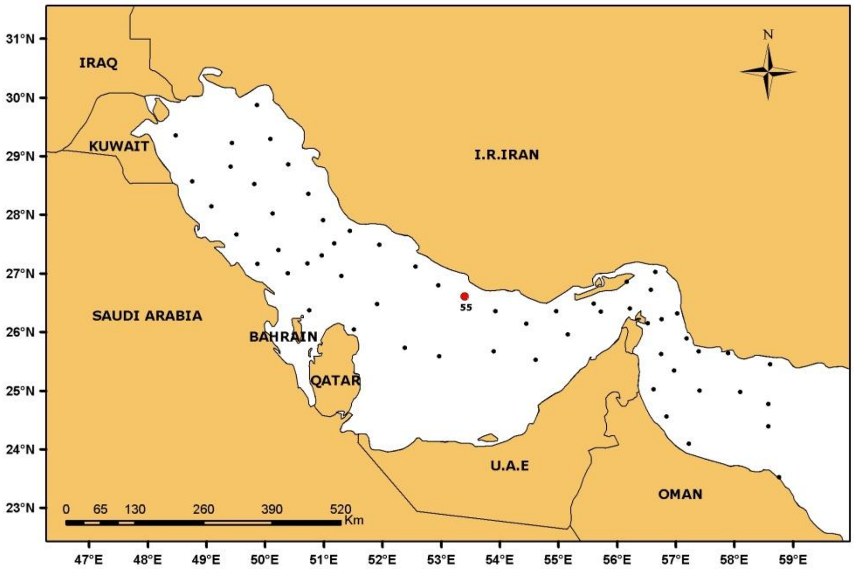
Description: Larvae have a large body height in the pre-anal section of the body. Small-sized teeth are located on the jaws. Pigment cells are located on the cranium, in the place of junction of lower jaws and in three rows (dorsal, lateral and ventral) before the caudal fin.

This feature is specific for *A. thazard* and *A. rochei*; however, the first species has the greater body height for larvae (by parameter BD).

Measurements: The relative parameters of the morphometric characteristics for these larvae for larvae with BL of 3.85 mm are as follows: PL – 41.55%, BD – 32.46%, BDA – 12.98%, HL – 25.97%, SL – 40.00%.

Geographical Distribution: Cosmopolitan in warm waters. Isolated records from the British Isles and coasts of Belgium and Scandinavia. Subspecies "thazard" occurs in the Atlantic and Indo-West Pacific and "brachydorax" in the eastern Pacific.

Site of Occurrence in RSA:
Inner RSA: Station 55.



Site of occurrence of *Auxis thazard* larva in RSA

Family NOMEIDAE

Genus *Psenes*

***Psenes cyanophrys* Valenciennes, 1833** (Plate 26).

Synonyms: *Psenes kamoharai* Abe, Kojima & Kosakai, 1963; *Psenes rotundus* Smith, 1949; *Psenes pacificus* Meek & Hildebrand, 1925; *Psenes chapmani* Fowler, 1906; *Cubiceps multiradiatus* Günther, 1872; *Psenes fuscus* Guichenot, 1866; *Psenes auratus* Valenciennes, 1833; *Psenes guamensis* Valenciennes, 1833; *Psenes javanicus* Valenciennes, 1833; *Psenes leucurus* Valenciennes, 1833.

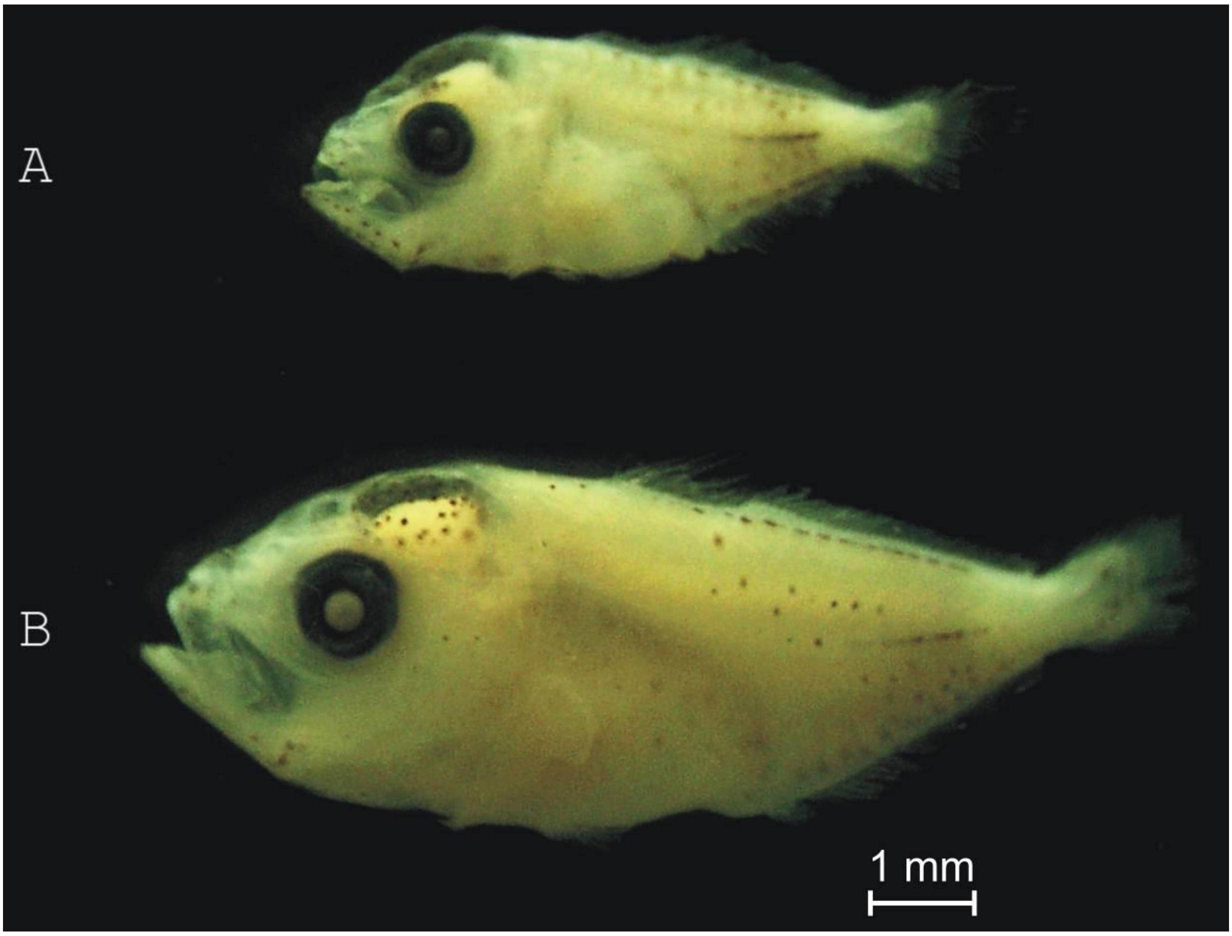


Plate 26. Larval stages of *Psenes cyanophrys*.

A. BL 6.00 mm; B. BL 9.20 mm.

Description: Larvae have a large body height with a relatively narrow caudal line. Pigment cells are located as a stripe from the anus to the beginning of formation of rays in the caudal fin; from the dorsal side, there is a pigment stripe along the whole caudal section; separate melanophores are located on the cranium and on the body sides. With increasing length of the larvae, pigmentation becomes more intensive and a stripe of pigment cells is forming in the caudal section sideward. Larvae with BL up to 3.40 mm, the urostyle is straight. Hypural plates begin to form. Below NT, rays in the caudal fin are forming. Pectoral fins have formed. With BL of about 5.00 mm rays in the dorsal and anal fins are at the stage of forming. Fold of abdomen rays is seen. Small thorns are located on the pre-cover. With BL of about 5.50 mm rays in the dorsal and anal fins are formed, the process of formation of abdomen fins takes place. These elements get formed with BL of about 7.90 mm. In larger larvae, these features are further developing and formulas of odd fins are as follows D IX-XI 23-28, A III 23-28.

Measurements: The relative parameters of the dynamics of the plastic features for larvae of different sizes are rather stable (Fig. 15).

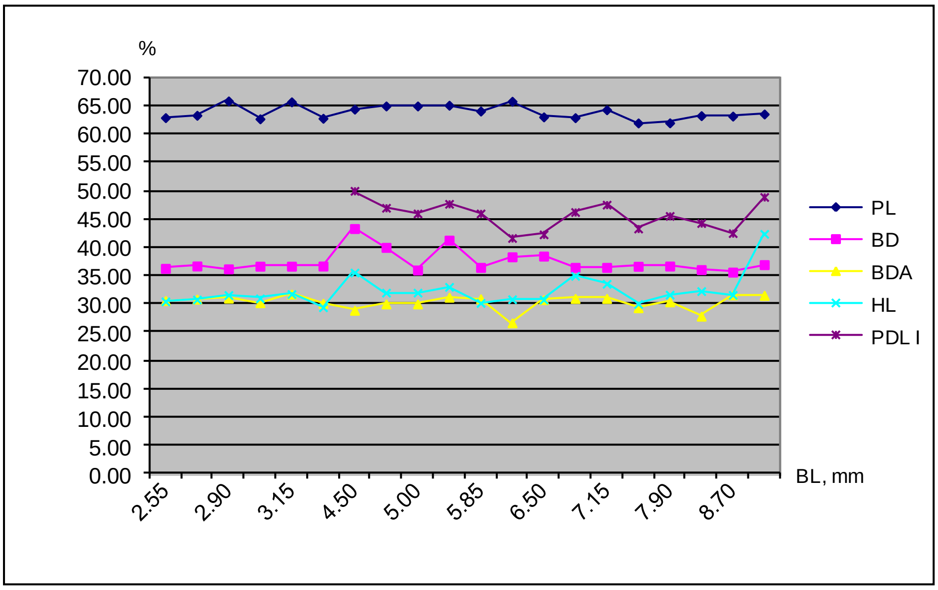


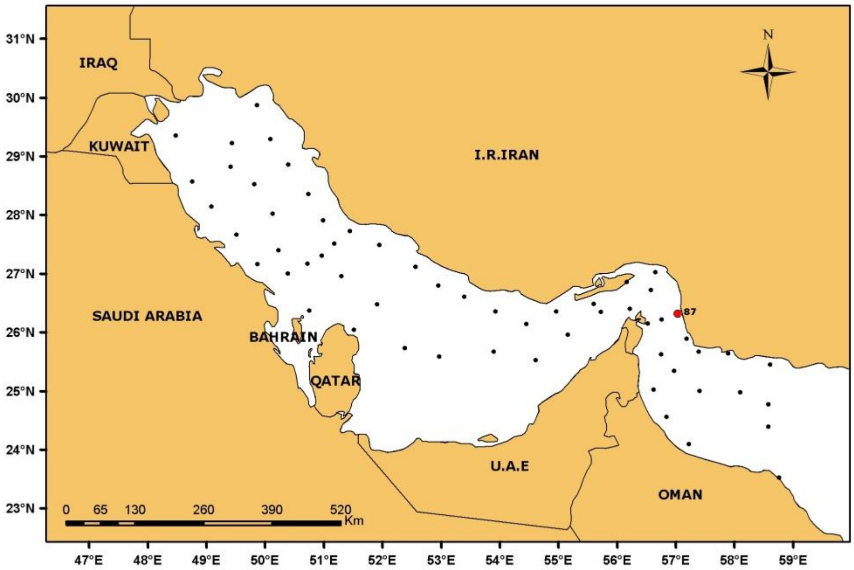
Fig. 15. Morphometric characteristics of *Psenes cyanophrys* larvae.
Symbols as in Fig. 6.

Geographical Distribution:

Circumglobal, cosmopolitan in warm waters. Bathypelagic, inhabits the open ocean. Lives in association with jellyfish.

Site of Occurrence in RSA:

Sea of Oman: Station 87.



Site of occurrence of *Psenes cyanophrys* larvae in RSA

Family SCORPAENIDAE

Scorpaenidae gen. sp. (Plate 27).

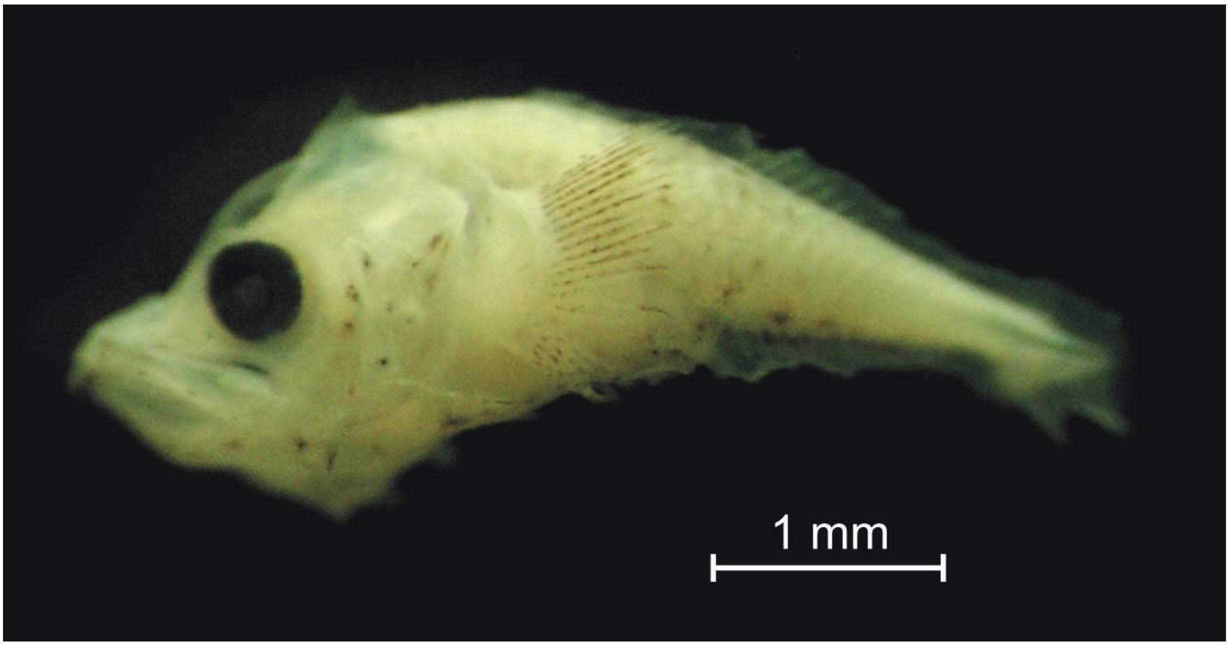


Plate 27. Larva of Scorpaenidae gen. sp.

BL 4.50 mm.

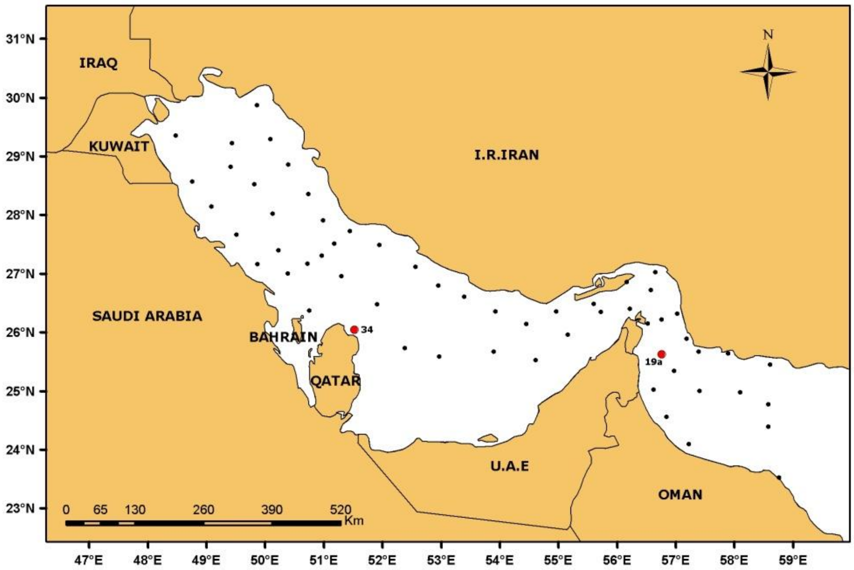
Description: Larvae have a great body height in the pre-anal part of the body. A low crest is developed on the head; small thorns are located on the gill cover. Pectoral fins are large, with well-developed rays. They reach the anal opening. Rays are forming in the dorsal and anal fins in larvae with BL 3.25 mm. The anal fin begins behind the anus, and the dorsal one – immediately after the head. Kidney-like increments are observed at the basis of the forming abdomen fins.

Measurements: Body length is 3.25-4.50 mm.

Sites of Occurrence in RSA:

Sea of Oman: Station 19a.

Inner RSA: Station 34.



Sites of occurrence of Scorpaenidae gen. sp. larva in RSA

Family TRIGLIDAE

Triglidae gen. sp. (Plate 28).

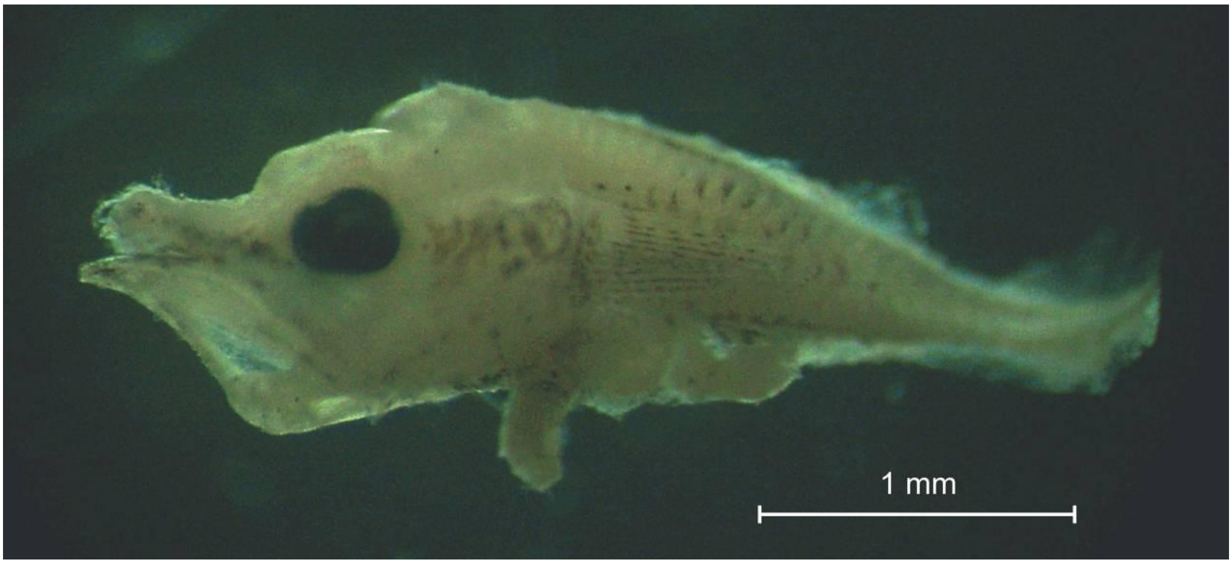


Plate 28. Larva of Triglidae gen. sp.

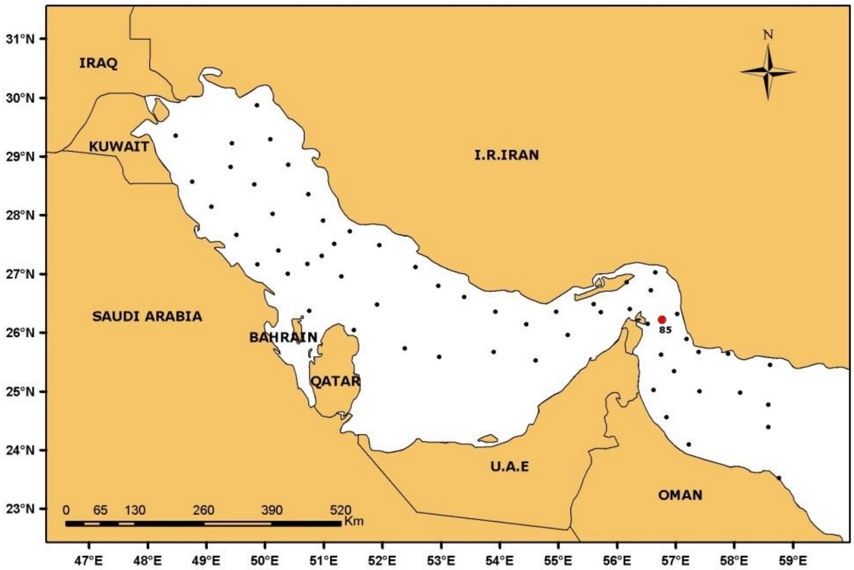
BL 3.40 mm.

Description: Larvae with BL=3.40 mm have a prolonged nose; there are small teeth on the jaws; pectoral fins are large, veer-like with pigmented rays. The body is diffusively pigmented. The urostyle is dented. Hypural plates are forming. Rays are forming in the caudal fin.

Measurements: Morphometric indices are as follows: TL – 3.50 mm, BL 3.40 mm, PL – 1.75 mm, HL – 1.05 mm, SL – 0.50 mm, ED – 0.30 mm. The relative parameters of the morphometric characteristics are as follows: PL – 51.47%, HL – 30.88%, SL – 47.61%, ED – 28.57%.

Site of Occurrence in RSA:

Sea of Oman: Station 85.



Site of occurrence of Triglidae gen. sp. larva in RSA

Family PSETTODIDAE

Genus *Psettodes*

***Psettodes erumei* (Bloch & Schneider, 1801)** (Plate 29).

Synonyms: *Hippoglossus orthorhynchus* Richardson, 1846; *Hippoglossus erumei* (Bloch & Schneider, 1801); *Pleuronectes erumei* Bloch & Schneider, 1801.

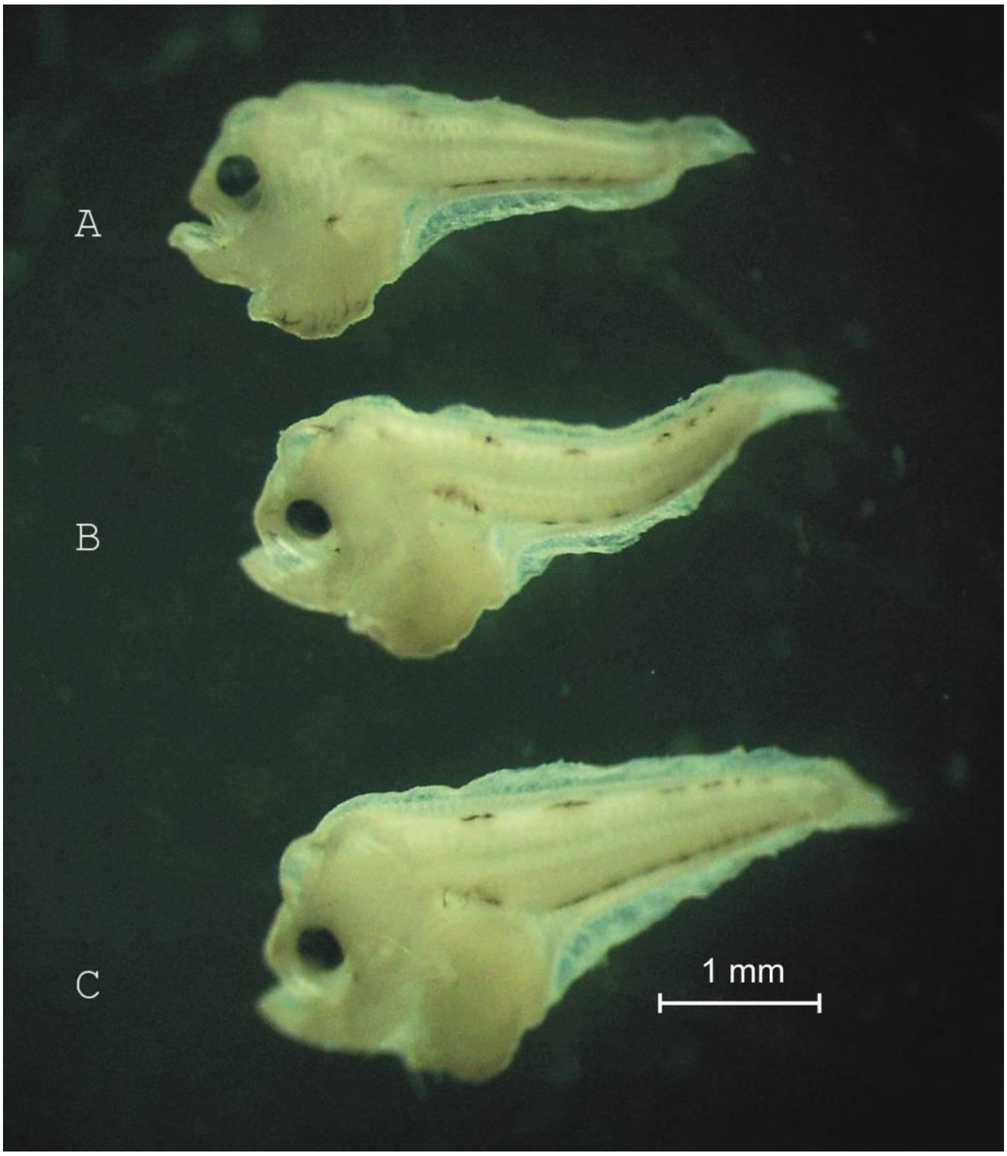


Plate 29. Larval stages of *Psettodes erumei*.

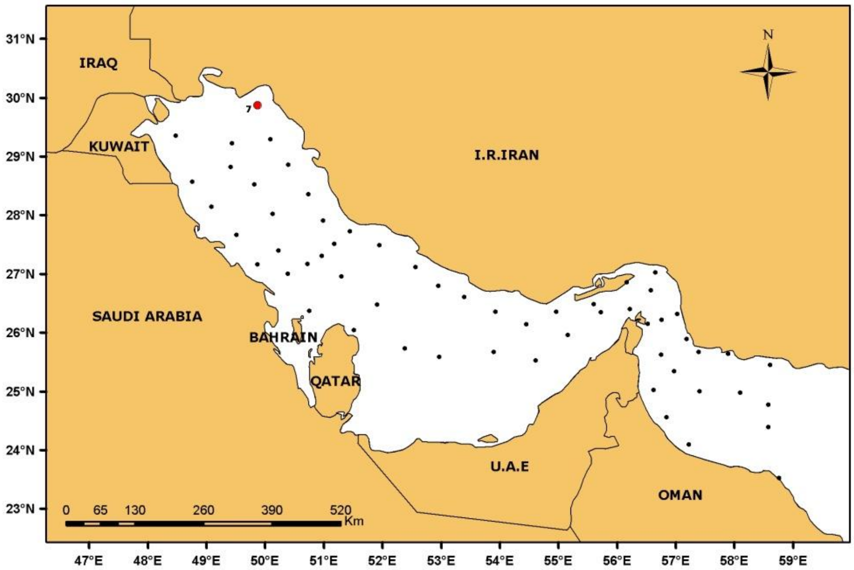
A. BL 3.20 mm; B. BL 3.50 mm; C. BL 3.70 mm.

Description: Larvae have turbot-like shape of the body. Eyes are located symmetrically. Dorsal fin begins behind the cervical section (a specific feature of the family) and forms along the dorsal side. Larvae with BL=4.5 mm have the dented urostyle. Hypural plates are forming. Pectoral fins are formed, there are separate pigment cells on the back and from the abdomen side; star-like melanophores are located on the isthmus.

Measurements: Morphometric indices are characterized by the following values: TL – 5.25 mm; BL 4.50 mm PL – 2.00 mm, PDL – 1.00 mm, BD – 2.00, BDA – 1.75 mm, HL – 0.25, ED – 0.25 mm. The relative parameters of the morphometric characteristics are as follows: Pl – 44.44%, PDL – 38.88%, BD – 44.44%, BDA – 38.88%, HL – 22.72%, ED – 22.72%, SL – 22.72%.

Geographical Distribution: Red Sea, Indo-West Pacific: East Africa, Madagascar and Mauritius (Mascarenes) east to Philippines and Papua New Guinea, north to southern Japan, south to Perth (Western Australia) and Queensland (Australia). Depth range: from 1 to 100 meters.

Site of Occurrence in RSA:
Inner RSA: Station 07.



Site of occurrence of *Psettodes erumei* larvae in RSA

Family BOTHIDAE

Bothidae gen.sp. (Plate 30).

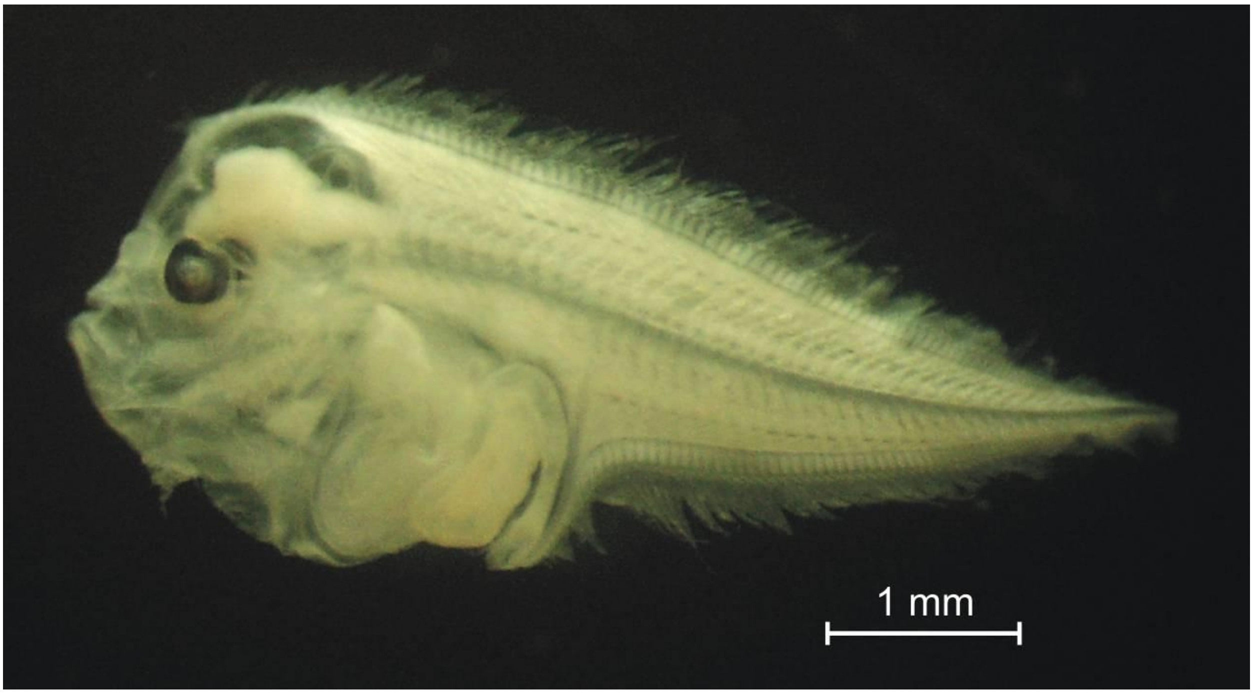


Plate 30. Larva of Bothidae gen. sp.

BL 5.70 mm.

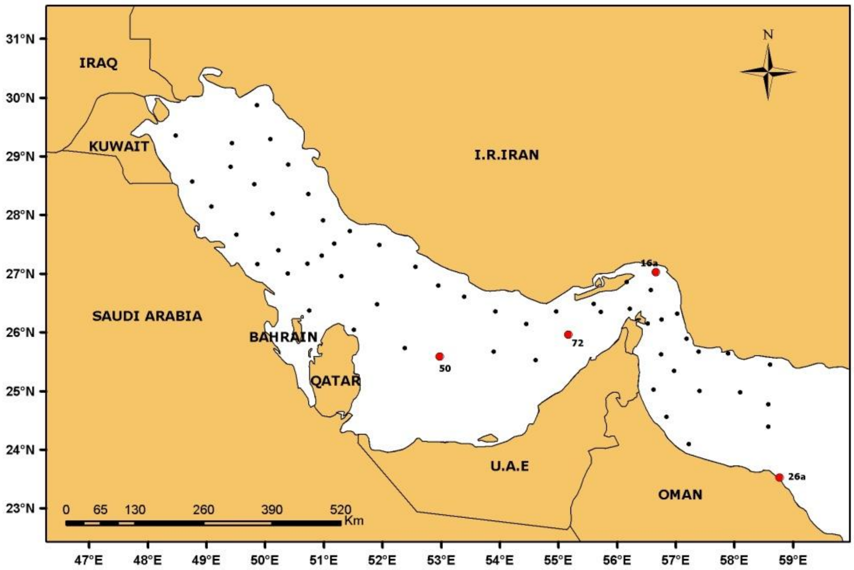
Description: Larvae have turbot-like shape of the body; the body is high, squeezed in the lateral direction; the nose is not sharp. The intestine forms loops. Dorsal and anal fins are not detached from the caudal one, which is slightly expressed. The body has no pigmentation. There is a filamentary increment before the beginning of the dorsal fin.

Measurements: Body length is 2.00-18.7 mm. Morphometric indices and relative parameters of the morphometric characteristics of specimen with BL 5.70 mm are as follows: PL – 2.65 mm (46.49%), BD – 2.35 mm (41.22%), BDA – 1.40 mm (24.56%), HL – 1.55 mm (38.70%), SL – 0.60 mm (47.61%), ED – 0.50 mm (28.57%).

Sites of Occurrence in RSA:

Sea of Oman: Stations 26a and 16a.

Inner RSA: Stations 72 and 50.



Sites of occurrence of Bothidae gen. sp. larvae in RSA

Family SOLEIDAE

Soleidae gen. sp. (Plate 31).

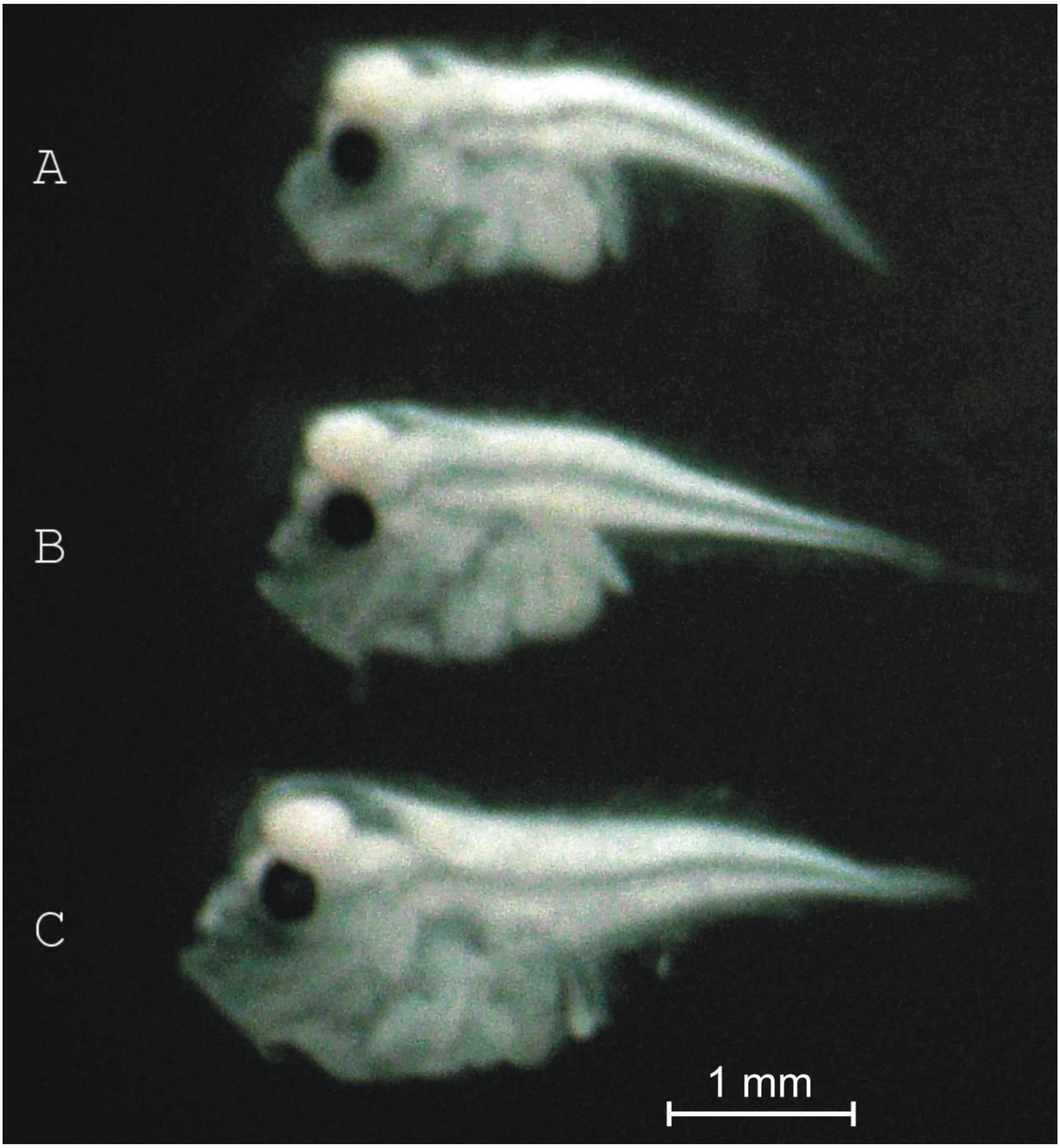


Plate 31. Larval stages of Soleidae gen. sp.

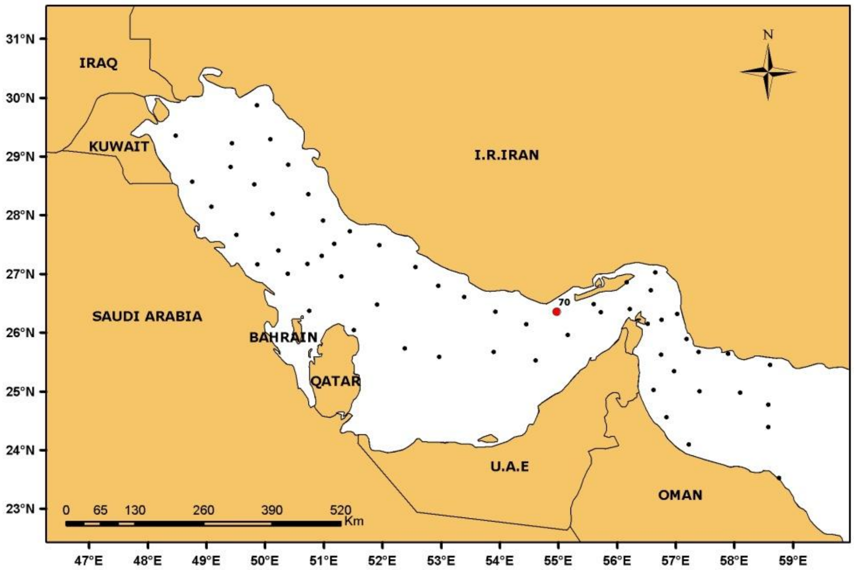
A. BL 3.00 mm; B. BL 3.20 mm; C. BL 4.00 mm.

Description: The body in the pre-anal part is high, symmetric, being sharply narrow in the caudal section. There are small melanophores on the abdomen side and a small thorn on the head. Fin fold becomes denser in the process of formation of the basal elements of the dorsal and anal fins when BL reaches about 3.90 mm. Formation of the beginning of the dorsal fin occurs before the eye line.

Measurements: Morphometric features for larvae of 3.2-12.5 mm are characterized by the following values: PL – 1.60-6.75 mm (50.00-54.00%), BD – 1.25-7.20 mm (38.46-47.60%), BDA – 0.55-3.60 mm (17.18-20.51%), HL – 0.65-2.20mm (17.60-20.31%), SL – 0.25-0.60 mm (30.80-38.46%), ED – 0.25-0.50 mm (31.25-38.46%).

Site of Occurrence in RSA:

Inner RSA: Station 70.



Site of occurrence of Soleidae gen. sp. larvae in RSA

Family CYNOGLOSSIDAE

Cynoglossidae gen. sp. (Plate 32).

Plate 32. Larva of Cynoglossidae gen. sp.

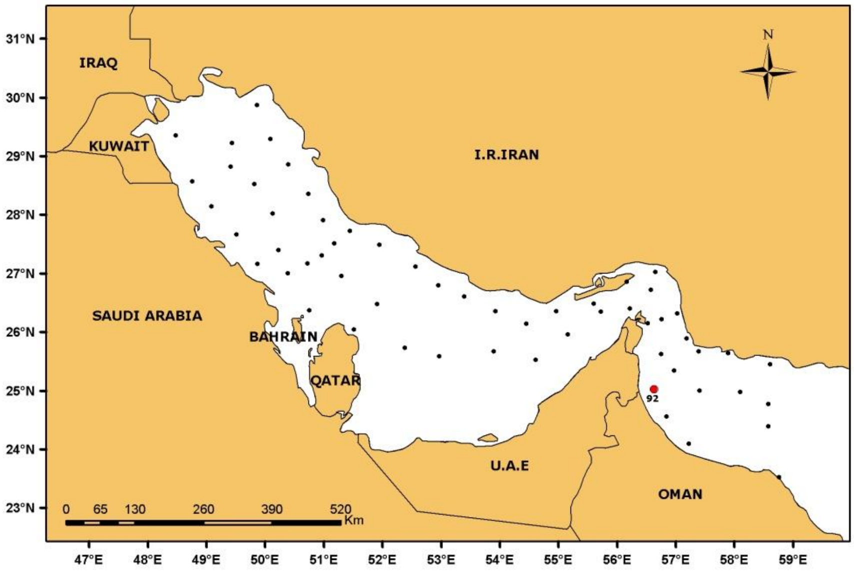
BL 3.00 mm.

Description: Larvae have a shape of a turbot, symmetric, squeezed in the lateral direction. The thorax section is short, as the anus is located in the first part of the body. On the border of the head and the body, filamentary increment is well developed.

Measurements: Body length is 3.00 mm.

Site of Occurrence in RSA:

Sea of Oman: Station 92.



Site of occurrence of Cynoglossidae gen. sp. larva in RSA

Family MONACANTHIDAE

Monacanthidae gen. sp. (Plates 33 and 34).

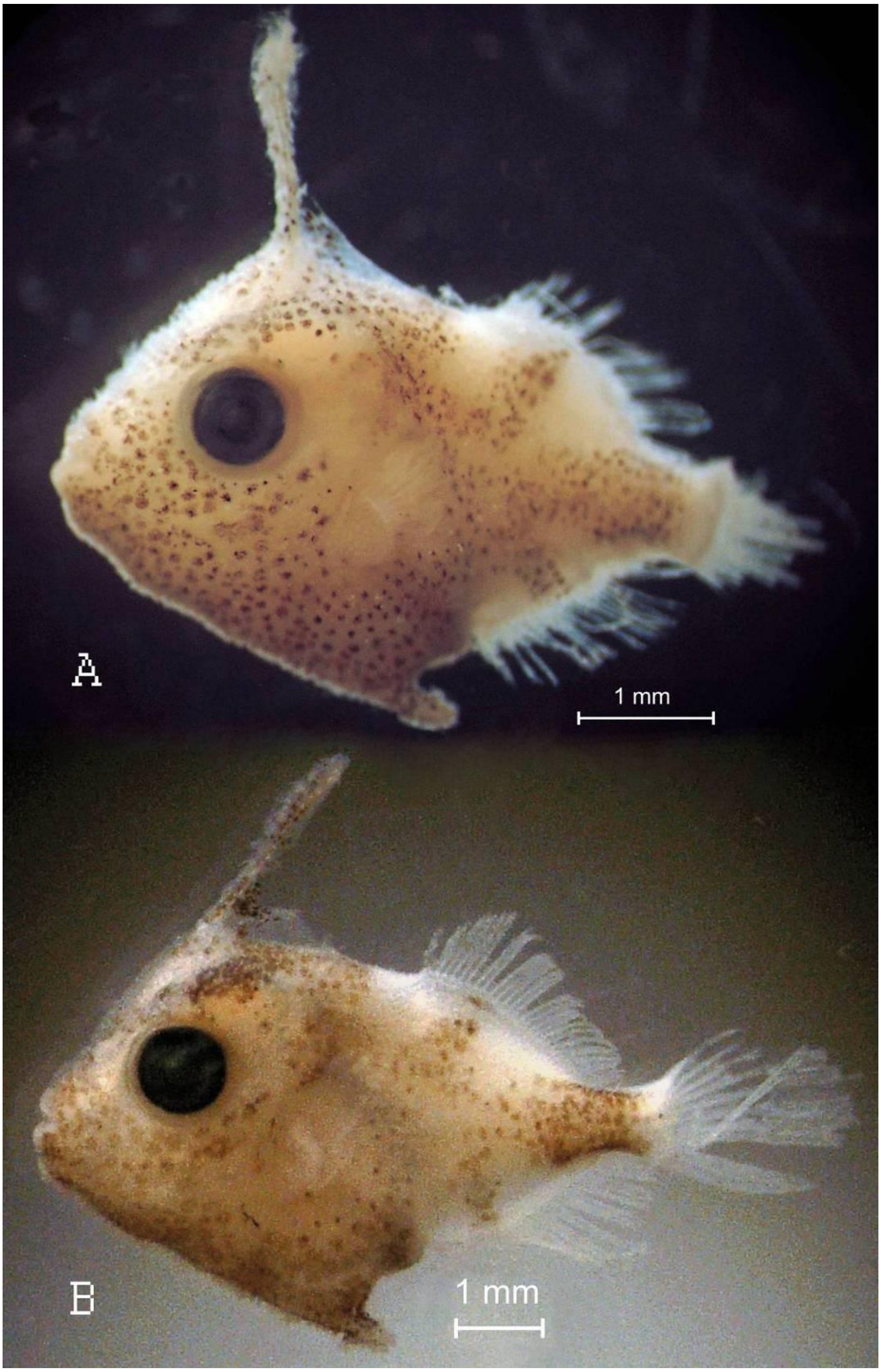


Plate 33. Larval stages of Monacanthidae gen. sp.

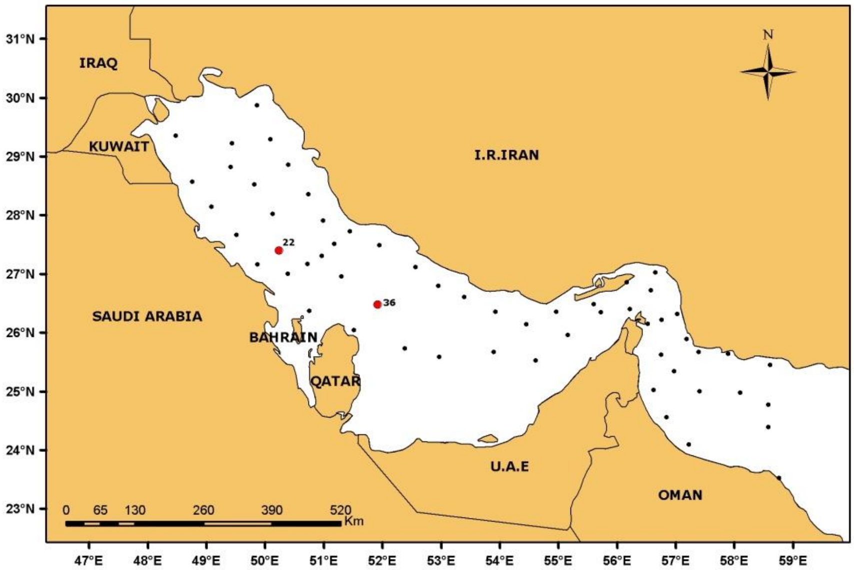
A. BL 5.00 mm; B. BL 7.30 mm.

Description: These individuals are practically fingerlings with formed features of adult forms. Rays in odd fins are well developed. The first ray locating vertically above the middle of the eye is well developed in the dorsal fin. This is characteristic of the representatives of Genus *Paramonacanthus*.

Measurements: Body length is 5.00-7.30 mm. Specimen with BL 5.20 mm has BD 3.50 mm.

Sites of Occurrence in RSA:

Inner RSA: Stations 36 and 22.



Sites of occurrence of Monocanthidae gen. sp. larvae in RSA

Family TETRAODONTIDAE

Tetraodontidae gen. sp. (Plate 34).

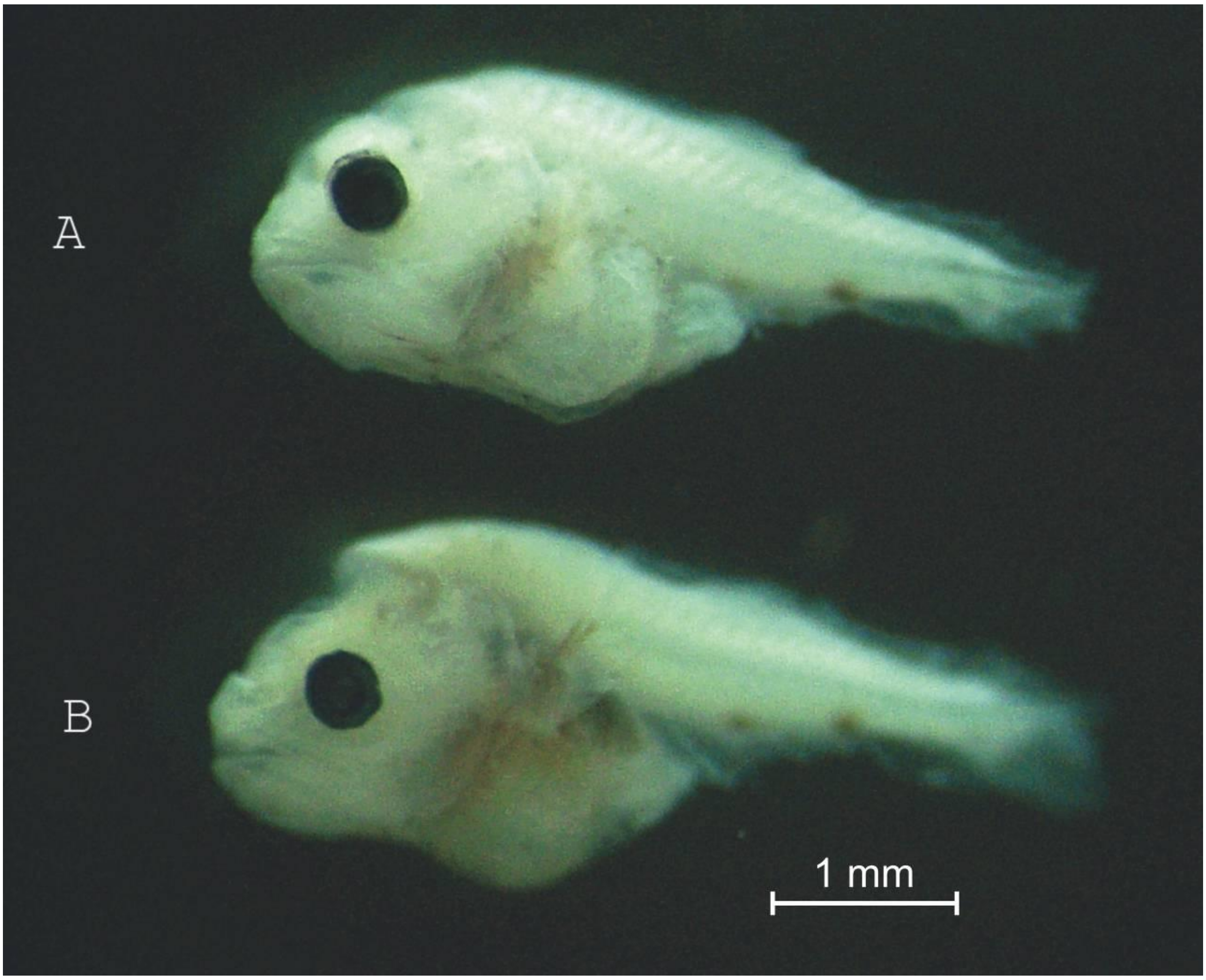


Plate 34. Larval stages of Tetraodontidae gen. sp.

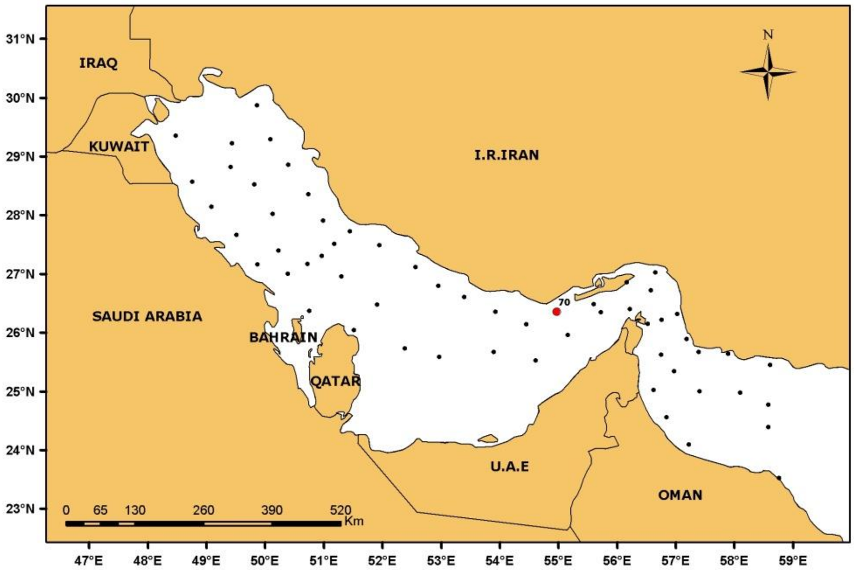
A. BL 4.50 mm; B. BL 4.70 mm.

Description: Larvae have a ball-like shape of the body in the pre-anal section of the body; the mouth is straight with well-developed jaws. Pectoral fins are developed. Pigment cells are located in two groups in the post-anal part from the ventral side. Gill covers have no thorns.

Measurements: Body length is 4.50-4.70 mm.

Site of Occurrence in RSA:

Inner RSA: Station 70.



Site of occurrence of Tetraodontidae gen. sp. larvae in RSA

Family DIODONTIDAE

Diodontidae gen. sp. (Plate 35).

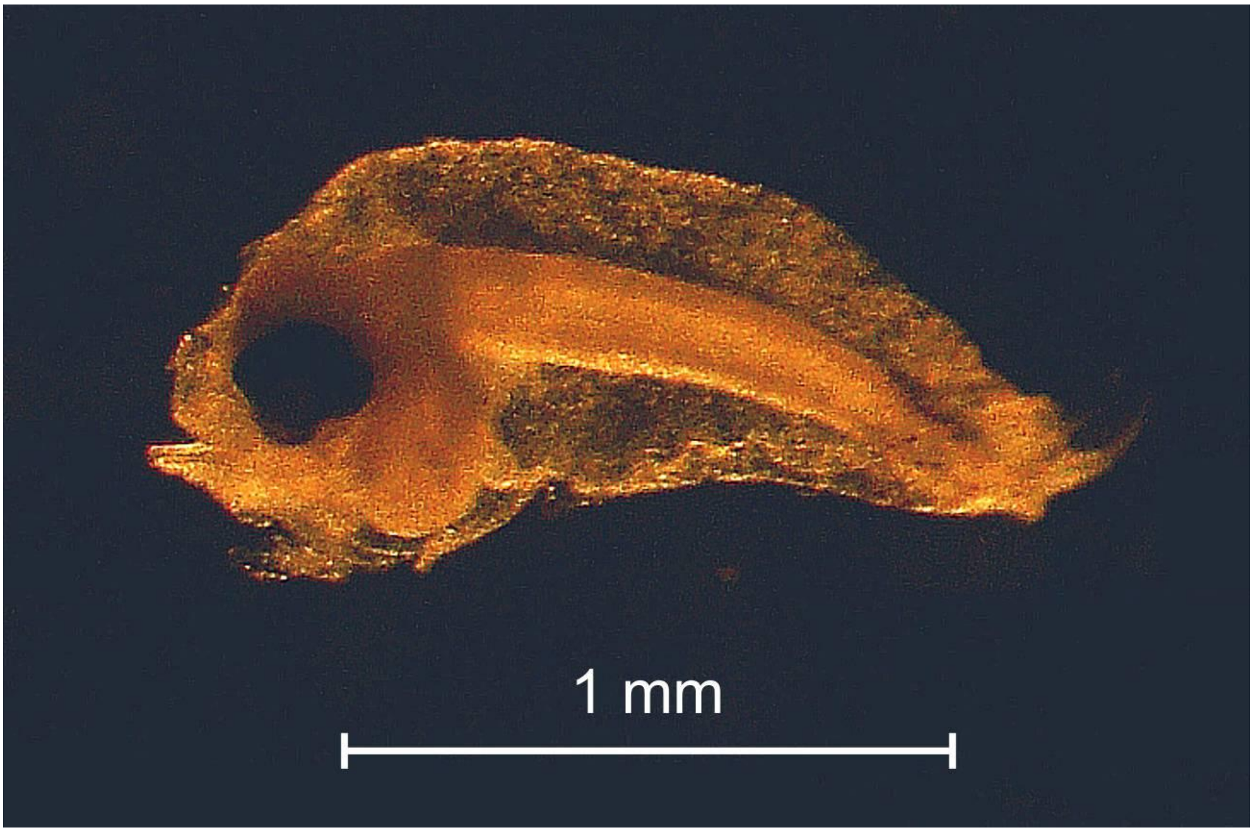


Plate 35. Larva of Diodontidae gen. sp.

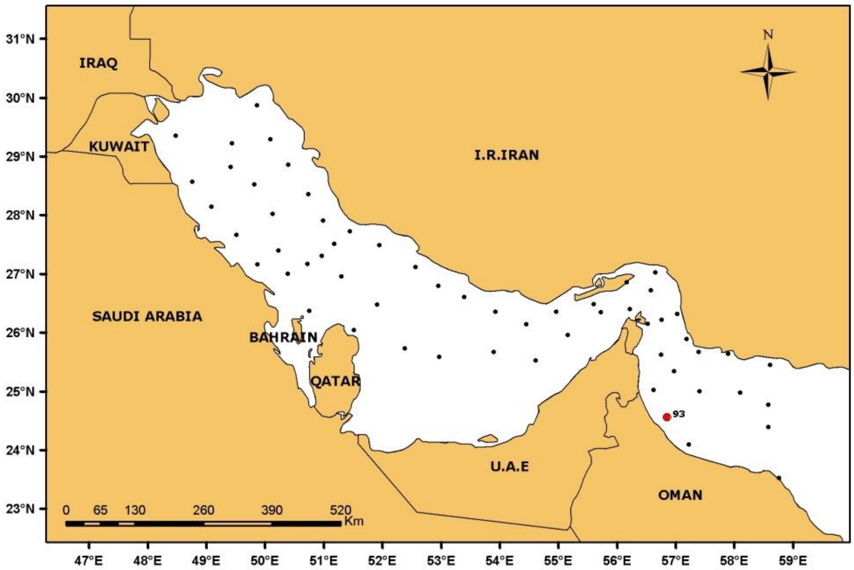
BL 1.45 mm.

Description: The body of the larvae is surrounded with the waterish shell; there is a large melanophore above the anus and one in the post-anal part of the body. Pectoral fins are formed.

Measurements: Parameters of the morphometric features for larvae with different body length are characterized by the following values: BL 1.45-1.65 mm, PL – 0.75-0.80 mm (48.48-51.72%), BD – 0.40-0.60 mm (35.50-36.36%), BDA – 0.20-0.30 mm (13.79-18.18%), HL – 0.35-0.40 mm (24.13-24.24%), SL – 0.10 mm (25.00-28.57%), ED – 0.20 mm (50.00-57.14%).

Site of Occurrence in RSA:

Sea of Oman: Station 93.



Site of occurrence of Diodontidae gen. sp. larva in RSA

3.2 Spatial Distribution and Abundance of Ichthyoplankton

In general, the physical, geographic and bioecological conditions of the inner RSA and Sea of Oman are continuation of the shelves of the Oman coasts and the north-western part of the Arabian Sea (Longhurst, 2007); and therefore their fauna, including ichthyofauna, are similar in many respects. However, oceanographic specific features of the inner RSA and Sea of Oman have a big influence on the composition of their ichthyofauna, mainly towards the reduction in their species variety and fish population abundance.

The ichthyofauna composition in the Sea of Oman is under the impact of the narrow shelf zone and deep-water trough connecting it with the Indian Ocean. Limiting factors in the inner RSA are as follows: its relative shallowness, intake of large amounts of freshwater especially in the north, high water temperatures in the surface layers, and restricted water exchange with the Indian Ocean.

The aforementioned factors and a series of other factors influence the physicochemical variables of the waters in the inner RSA and Sea of Oman, which in turn affect the distribution and abundance of fish eggs and larvae. Growing eggs of most of fish species are usually encountered in the surface layer. However, the larvae are widely dispersed vertically in the water column. The general trend is that the abundance of eggs decreases from the coastal areas toward offshore waters. Usually spawning areas are different from nursery and larval feeding areas. Thus, areas of high larval concentrations do not correspond to areas of high abundance of eggs. In general, there is dissociation between habitat areas of adult fishes and areas of high abundance of larval stages of fish. Planktivorous adult fishes (plankton feeders) are competitors with pelagic larvae, which feed on plankton. Dissociation of inhabiting areas of adult fishes and larval stages is an important adaptive feature influencing the survival of the early life stages of fish.

The distribution of ichthyoplankton is greatly affected by the dynamic processes occurring in their habitats – both in the vertical and horizontal scales. Sampling the surface layers at different times of day affects the abundance estimates of larvae due to their diurnal migration. Moreover, the ichthyoplankton samples were collected at each station by horizontal tows, but the sampling depth at each station varied from the other stations with a deviation that ranged between 3-5 m. Therefore, quantitative estimates of ichthyoplankton and the species distribution as well as the abundance distribution of the eggs and larval stages from this study cannot be considered as an accurate abundance assessment. However, it provides valuable information on the community composition of larval fish. The calculations of the volume of filtered water made by obtaining the difference of flowmeter readings multiplied by the coefficient 0.3 and by the area of the net opening (0.3 m^2). The fact that low abundance of fish eggs was encountered (in some samples they were absent at all) and embryos at stage III, and unformed embryo deserves interest. It is unknown how long the process of embryogenesis had taken place before this stage of development began, i.e., virtual time of drifting of eggs after spawning. The spatial distribution of pelagic eggs and larvae of fish are under the impact of currents and the location of zones of contacts of these currents. During this cruise, the south-eastern and northwestern systems of these currents were predominant in the Sea of Oman. The maximum concentration of ichthyoplankton (eggs and larvae) was encountered in the area of station No. 90, 300 m depth (Fig. 16). Fig. 17 displays the distribution of abundance of fish eggs. On average, there were more eggs (1-2 ind/m^3) at station 90 than at any other station. The maximum abundance of ichthyoplankton at station 90 was due mainly to the high abundance of fish larvae (Fig. 18) at that station.

The maximum abundance of fish larvae in the area of the Sea of Oman was mainly due to the presence of mesopelagic fish species *Diaphus* sp. (Fig. 19). At station No. 95 (depth of 1039 m), the abundance of larvae of this species in 1 m^3 of filtered water was indicated by 6.27 individuals, at station No. 92 (depth 183 m) the abundance was registered by 8.94 ind/m^3, and at station No. 90 (depth 300 m), 34.62 ind/m^3. Such high abundance may be explained by the location of the aforementioned stations in areas of convergence, appearing as a result of conjunction of currents transporting larvae.

Maximum abundance of larvae of other mesopelagic fish *Vinciguerria* sp. was registered at station 100 (depth 2700 m) (Fig. 20) where the abundance was 2.55 ind/m^3. Larvae of this species were encountered in the area of the Sea of Oman, where the currents carry the early life stages from the area of the northern periphery of the Indian Ocean where this fish spawns all the year round.

In the area of the Sea of Oman, pronounced variety of larvae were encountered, which are representatives of the Sparidae family. These larvae are characterized by similarity in the location of melanophores, but they vary greatly in the morphometric parameters. Therefore, they were classified as different groups under the family. Abundance of larvae of these types and their distribution in the area of the Sea of Oman were not large and even. Maximum abundance of larvae of the type group Sparidae gen. sp. I was registered at station 90 and at the coastal station 93 where their of abundance was 2.60 ind/m^3 (Fig. 21).

In the samples, *Trachinocephalus myops* larvae of different sizes and lower abundance were often encountered. Their maximum abundance was registered at station 90 (1.81 ind/m^3) (Fig. 22). Eggs of this fish species were absent at all sampled stations. In the area of the inner RSA, ichthyoplankton abundance was generally low (Fig. 23). Abundance of eggs in inner RSA area was a bit higher than in the Sea of Oman, especially at the northern end of the inner RSA (Fig. 24). Maximum larval abundances were encountered in the vicinity of the Strait of Hormuz area in the inner RSA (Fig. 25). These high abundances were mainly associated with the high densities of larvae (with different sizes) of the Engraulidae family, which were ubiquitous but with low abundances (Fig. 26). Maximum abundances of these larvae were registered at stations in the vicinity of the Strait of Hormuz area. Thus, the highest abundance (11.96 ind/m^3) was observed at station 78. The same sample contained eggs of fish of the Engraulidae family. Neither eggs nor larvae of other fish species were found in that sample. Slightly lower abundances for these larvae were registered at station 69 (8.11 ind/m^3), at station 70 (1.03 ind/m^3) and at station 72 (1.92 ind/m^3). The summarized quantitative abundance (ind/m^3) estimates for ichthyoplankton are given in the latter chapter.

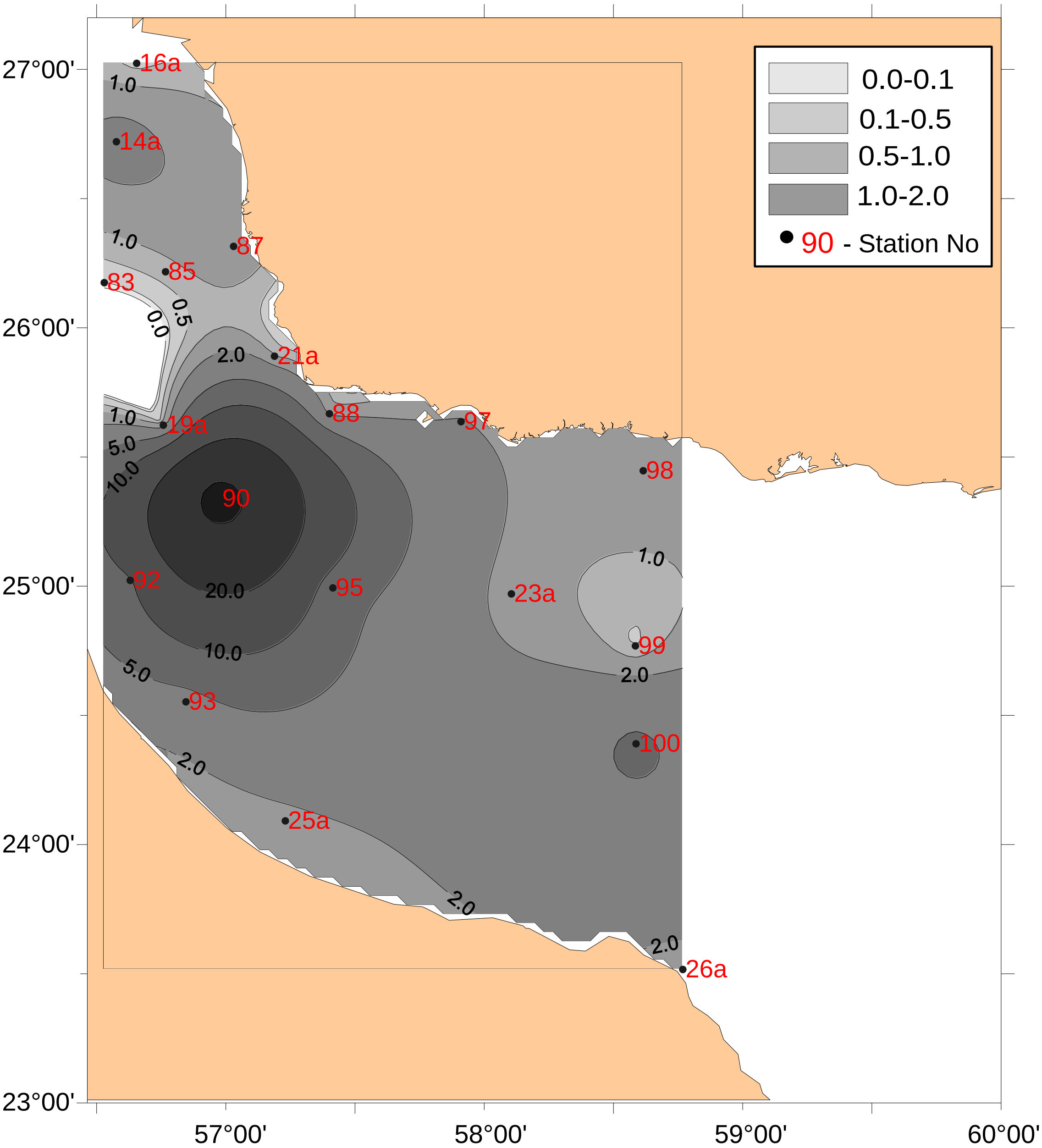


Fig. 16. Distribution of ichthyoplankton abundance (ind/m^3) in the Sea of Oman.

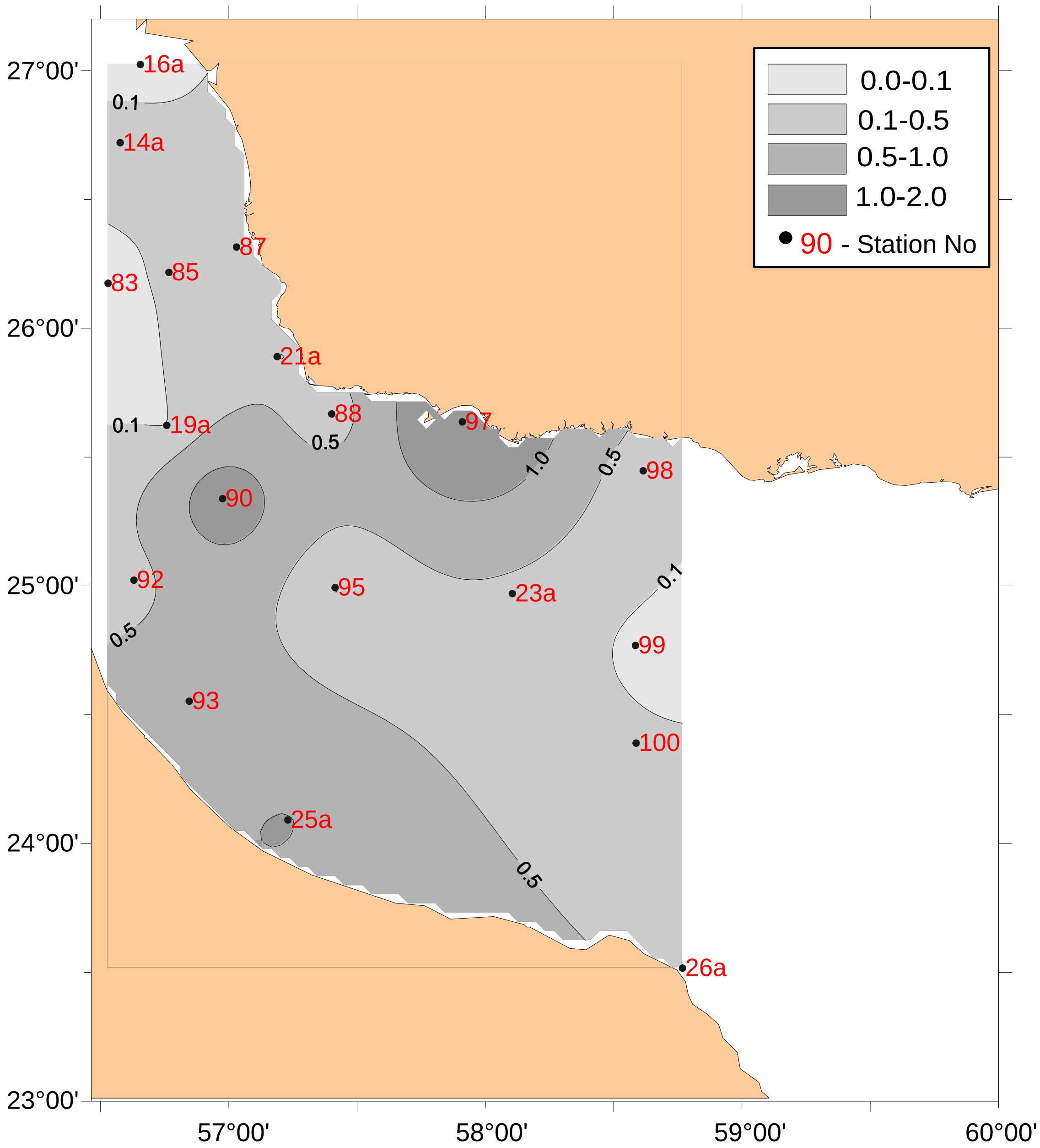


Fig. 17. Distribution of fish eggs abundance (ind/m^3) in the Sea of Oman.

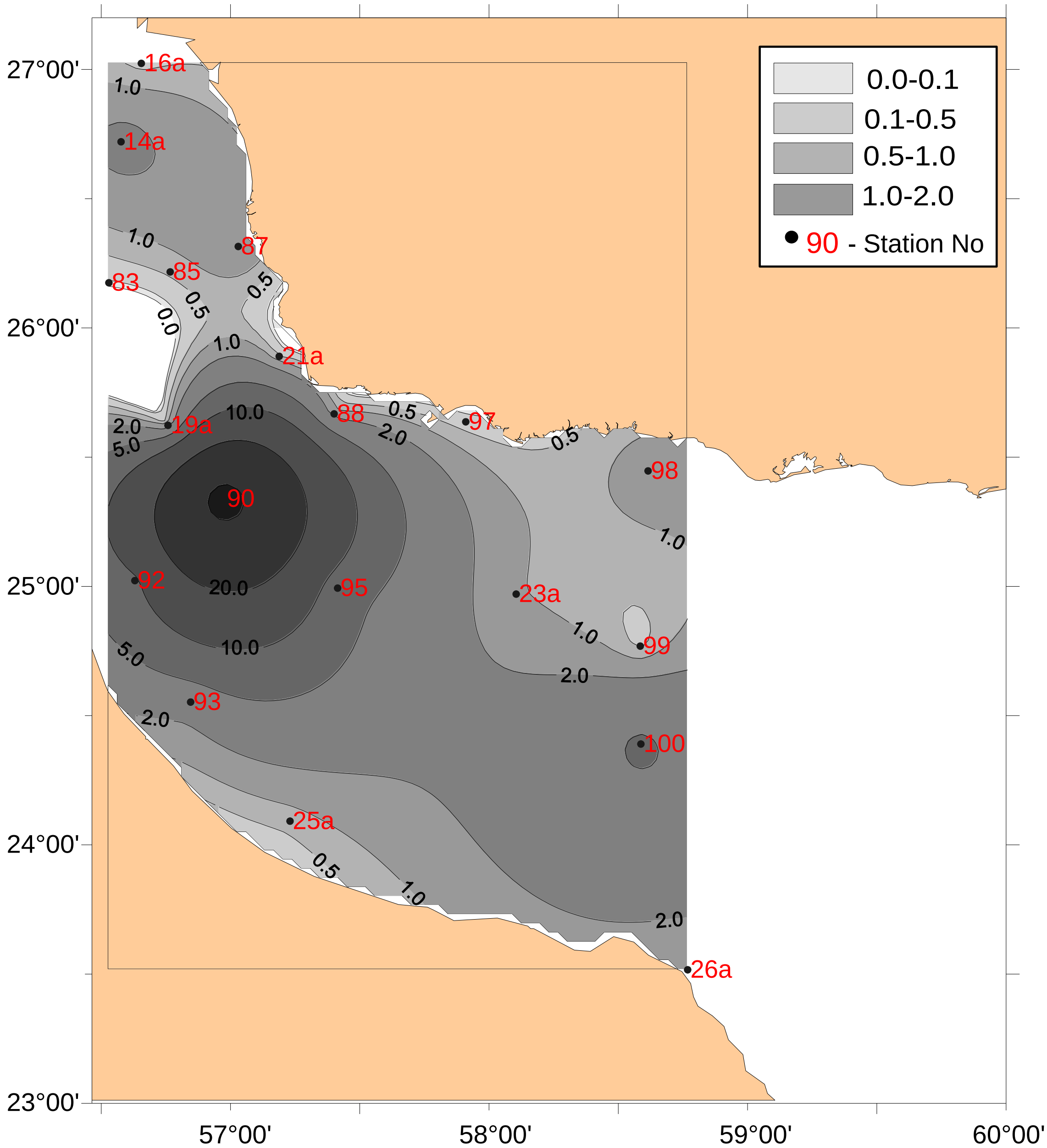


Fig. 18. Distribution of fish larvae abundance (ind/m^3) in the Sea of Oman.

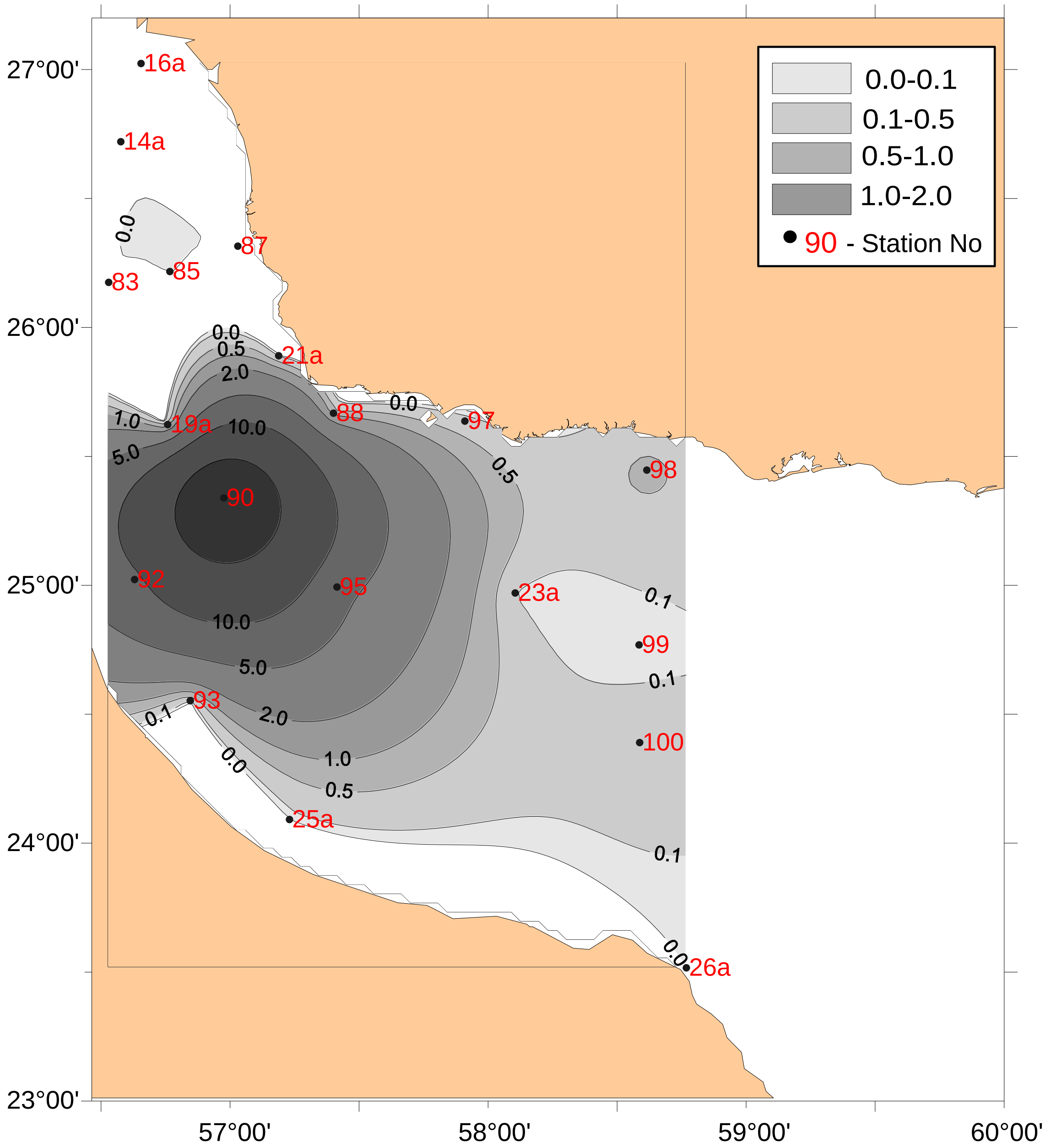


Fig. 19. Distribution of larval abundance (ind/m^3) of *Diaphus* sp. in the area of the Sea of Oman.

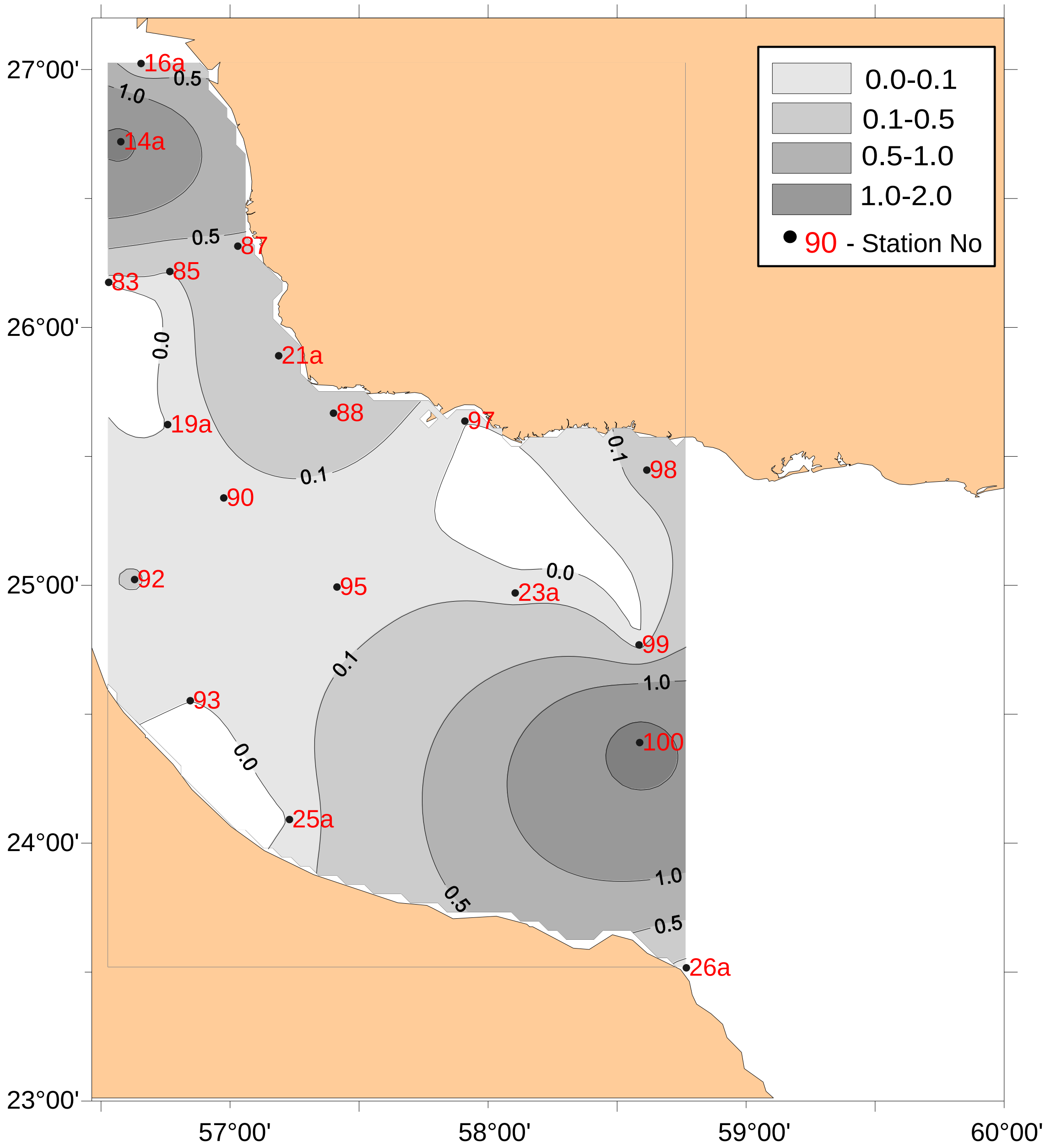


Fig. 20. Distribution of larval abundance (ind/m^3) of *Vinciguerria* sp. in the Sea of Oman.

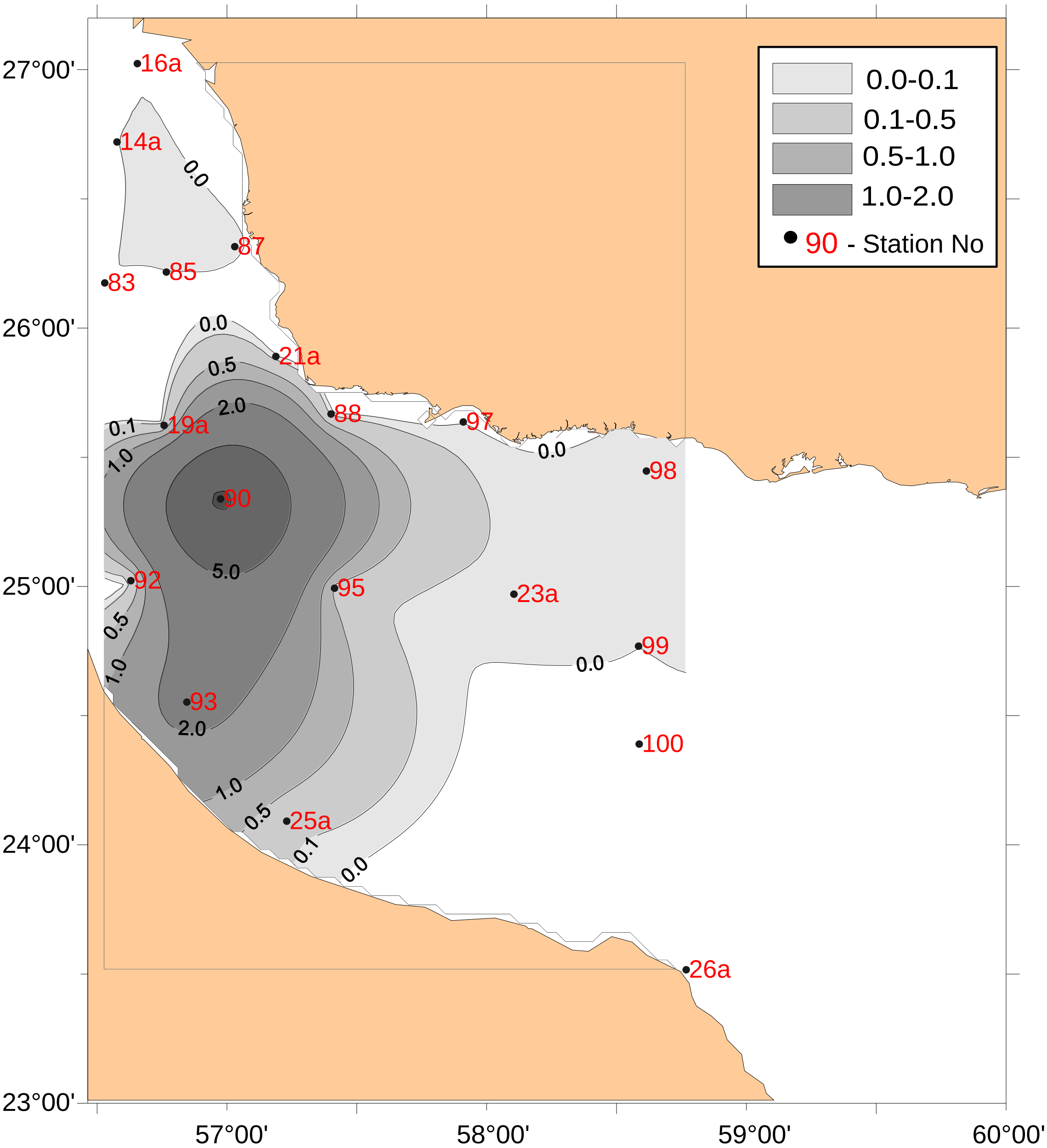


Fig. 21. Distribution of abundance (ind/m^3) of Sparidae gen. sp. I larvae in the Sea of Oman.

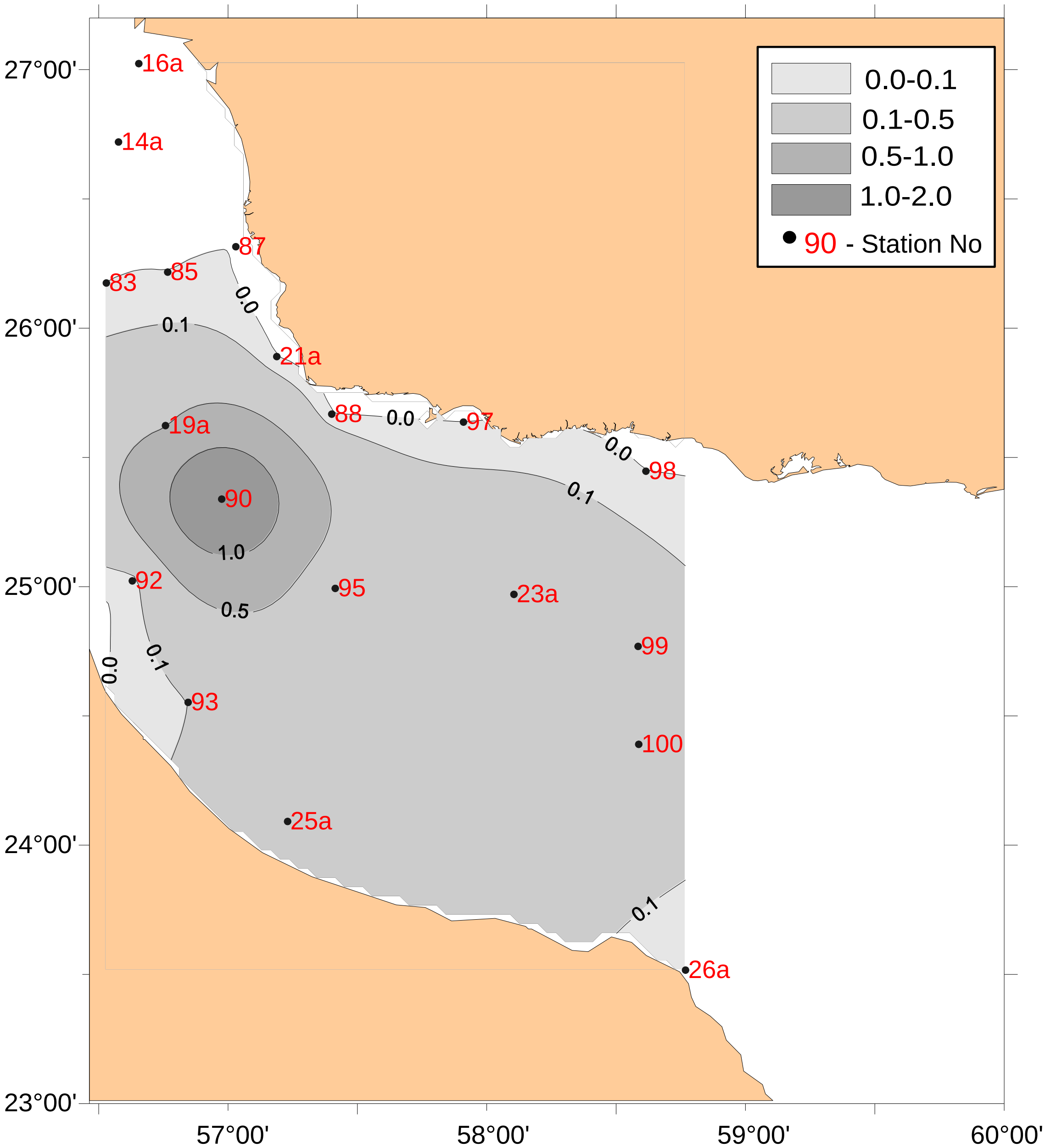


Fig. 22. Distribution of *Trachinocephalus myops* larval abundance in the Sea of Oman.

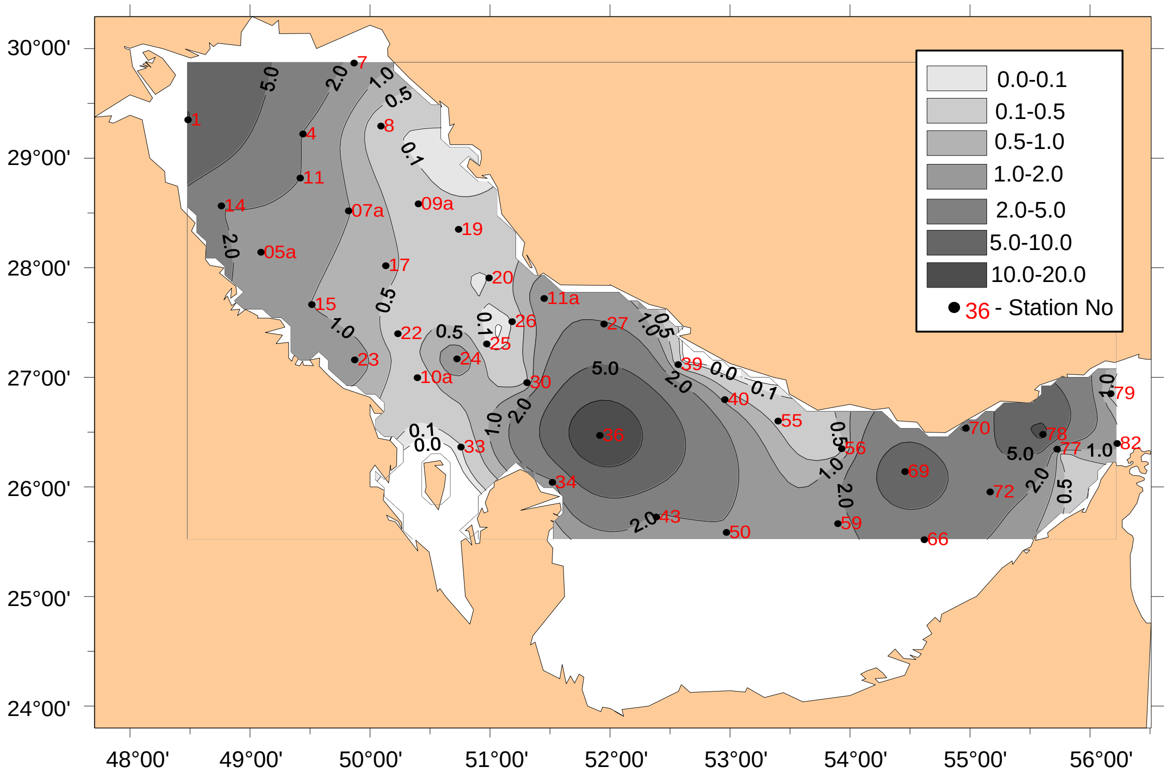


Fig. 23. Distribution of ichthyoplankton abundance (ind/m^3) in the inner RSA.

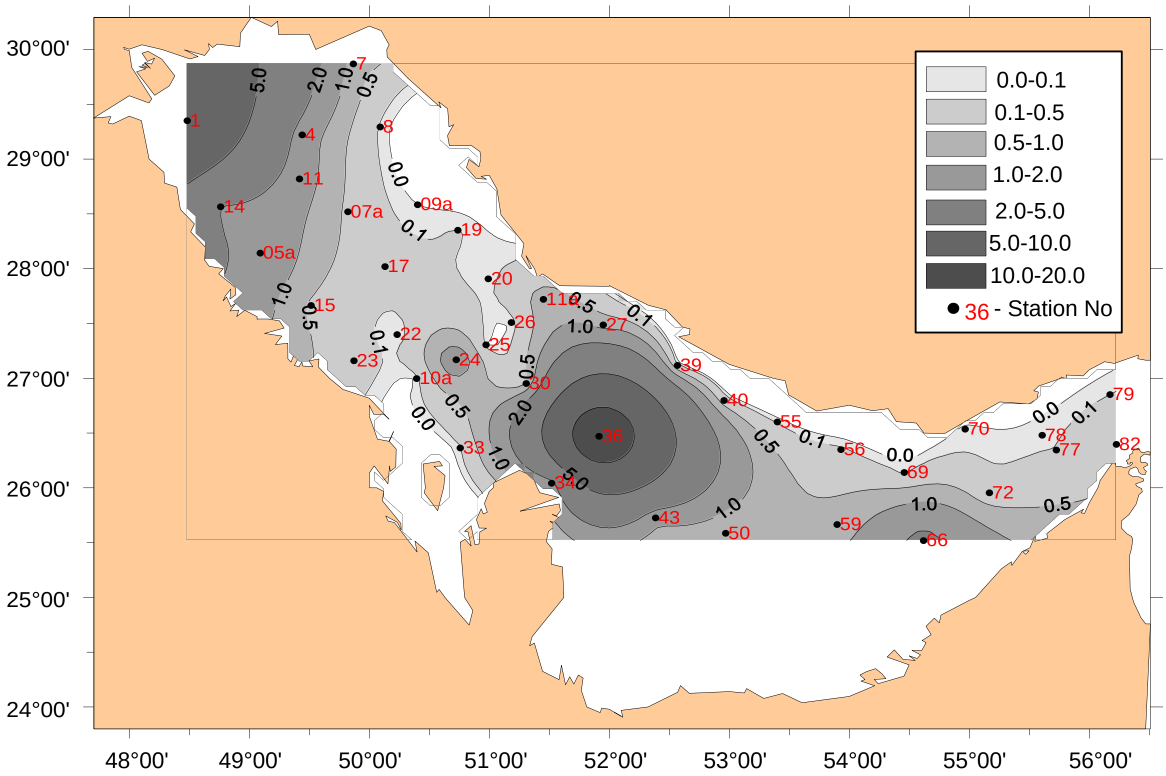


Fig. 24. Distribution of fish eggs abundance (ind/m^3) in the inner RSA.

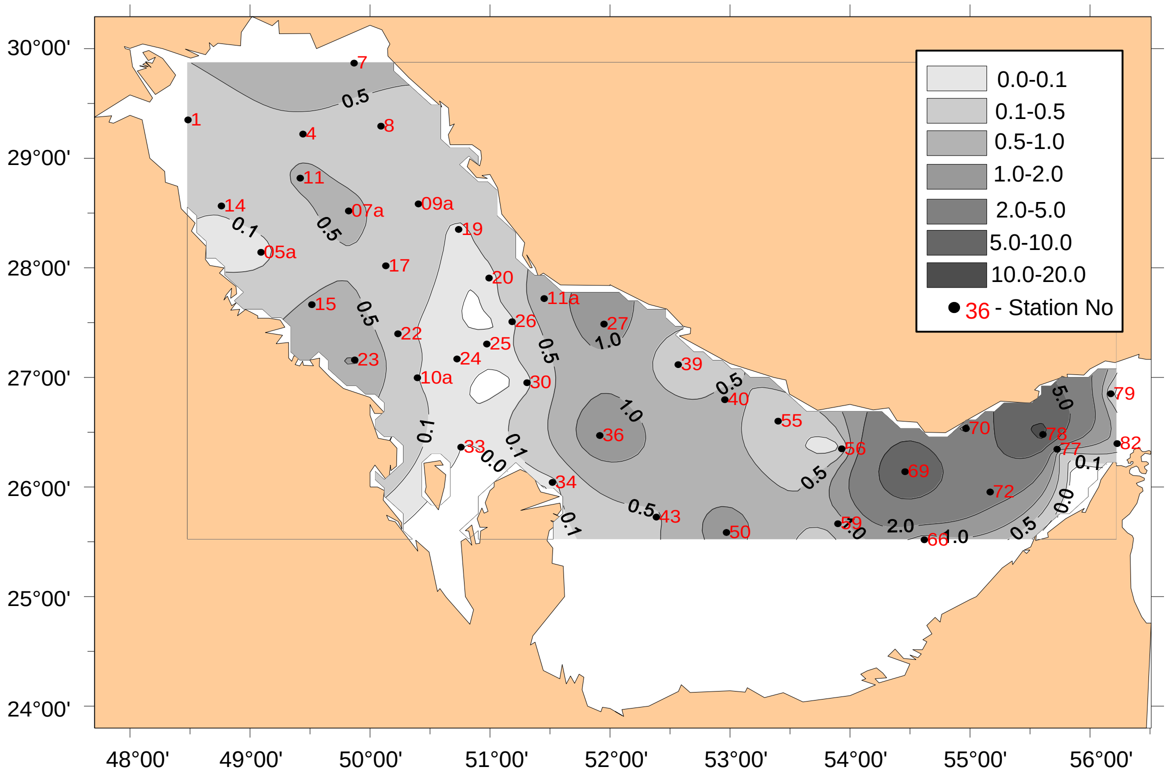


Fig. 25. Distribution of fish larval abundance (ind/m^3) in the inner RSA.

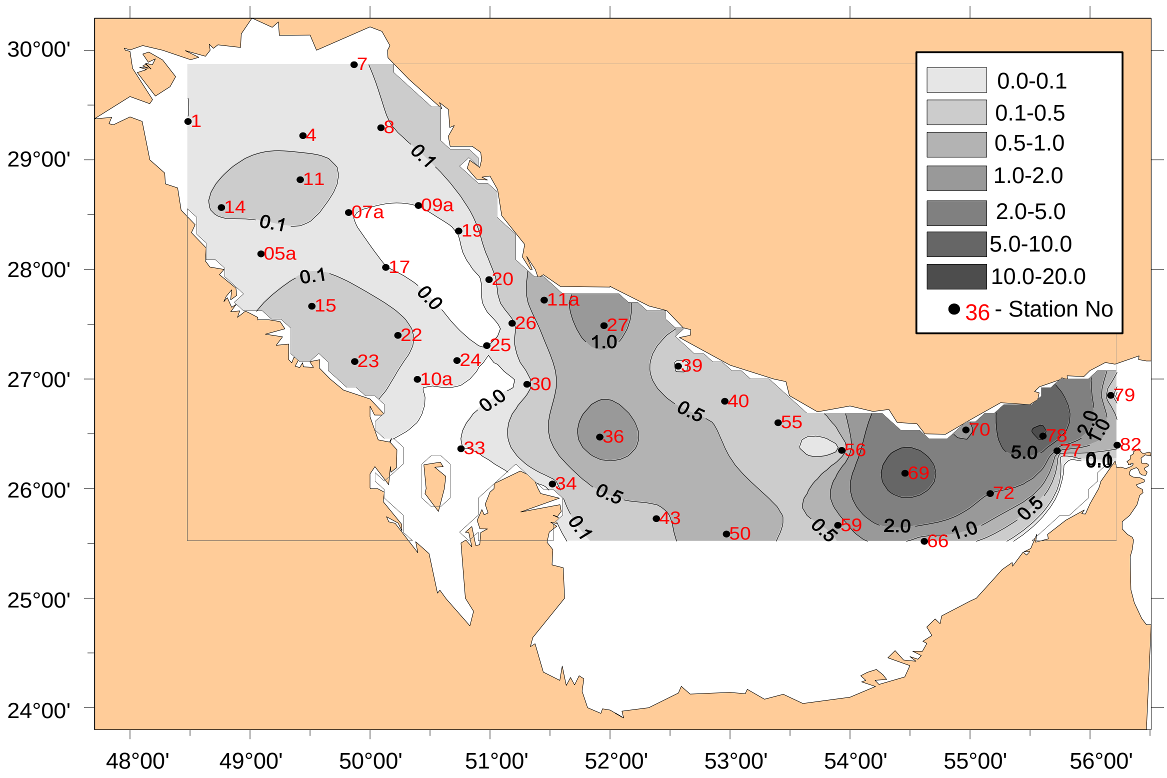


Fig. 26. Distribution of abundance (ind/m^3) of Engraulidae gen. sp. larvae in the inner RSA.

Analysis of the relations between distribution of the ichthyoplankton and hydrographical, chemical and biological properties of the studies basins, obtained during the cruise, shown absence of correlations between fish eggs and larvae abundance and other variables, and classification using cluster analysis was doubtful. It can be explained by two main reasons.

First, fish larvae and eggs typically well correlate with zooplankton, which abundance was not included in the present report due to data not presented by ROPME. Moreover, temporal variability of the ichthyoplankton more pronounced in comparison with spatial (for example, Rodriguez, 2008), and changes in temperature can be a key factor in changing of larval fish assemblages. However, these changes are seasonal, and not correspond to observed differenced in RSA scale, where samples were taken during winter cruise.

The variability in plankton distribution typically observed at frontal structures reflects interactions between hydrodynamic processes, spawning patterns, behavioural adaptations, and differential survival (Gray and Miskiewicz, 2000; Espinosa-Fuentes and Flores-Coto, 2004; Somarakis *et al*., 2002). Thus, this is combination of many factors, which is significantly related to the sprawning of fish. Dynamic of fish sprawning can be successfully studied during recurring surveys in the same area and it is difficult to interpret existing data for fish larvae and eggs in terms of sprawning efforts in the RSA.

Second reason is relate to sampling methodology. Sampling using only horizontal trawling, during different time of day and at different depths (varied for 3-5 meters at different sampling stations) can not be estimated as sufficient for collection of a representative samples of ichthyoplankton, enough for comprehensive ecological analysis. Using a oblique tows together with neuston nets can be recommended for collection of representative samples in future studies.

This is helpful in comparing the observed diversity with the diversity provided by the neutral model (Caswell, 1976). This model constructs an ecologically neutral community with the same number of species and individuals as the observed community assuming certain community assembly rules (random birth/deaths and random immigration/emigrations and no interactions between species). The deviation V-statistics is then determined which compares the observed diversity (H') with that predicted from the neutral model. While the V value of zero indicates neutrality, positive values indicate greater diversity than predicted and negative values lower diversity. Values > +2 or <-2 indicate significant departure from neutrality. However, in case of fish larvae data, only stations 36, 69, 90, 92, 93, 95 and 100 were acceptable for this analysis (and results shown lover diversity then predicted by neutral models). All other samples were characterized as contained too few individuals for number of species and was rejected from analysis.

The estimation of the Species-Area was also used for understanding the biodiversity properties of fish larvae in the RSA. This is easy approach, i.e. plotting the cumulative number of different species observed as each new sample is added (Clarke and Warwick, 2001) typically show that curve rises further and further with addition of sample is more diverse than the one which has attained the plateau. It is also used for deciding the number of samples to be collected in a particular habitat to get all the species. However, as it can be seen from Fig. 27, plateau was not reached for ichthyoplankton samples. This means what in spite of wide studied area in the cruise, only part of the species were catched by nets (as a result of sampling design).

However, collected data provides useful information on the biodiversity of larval fish assemblages in RSA during winter season. The Shannon index of diversity was used as measure of ichtyoplankton biodiversity. The value of Shannon diversity is usually found between 1.5 and 3.5. Shannon diversity is the very widely used index for comparing diversity between various habitats (Clarke and Warwick, 2001). As it shown in Table 2, values of the Shannon Index were low during the Winter Cruise, and ranged from zero (only one species per sample, registered for five stations) up to 1.77 (eight species, station # 23a).

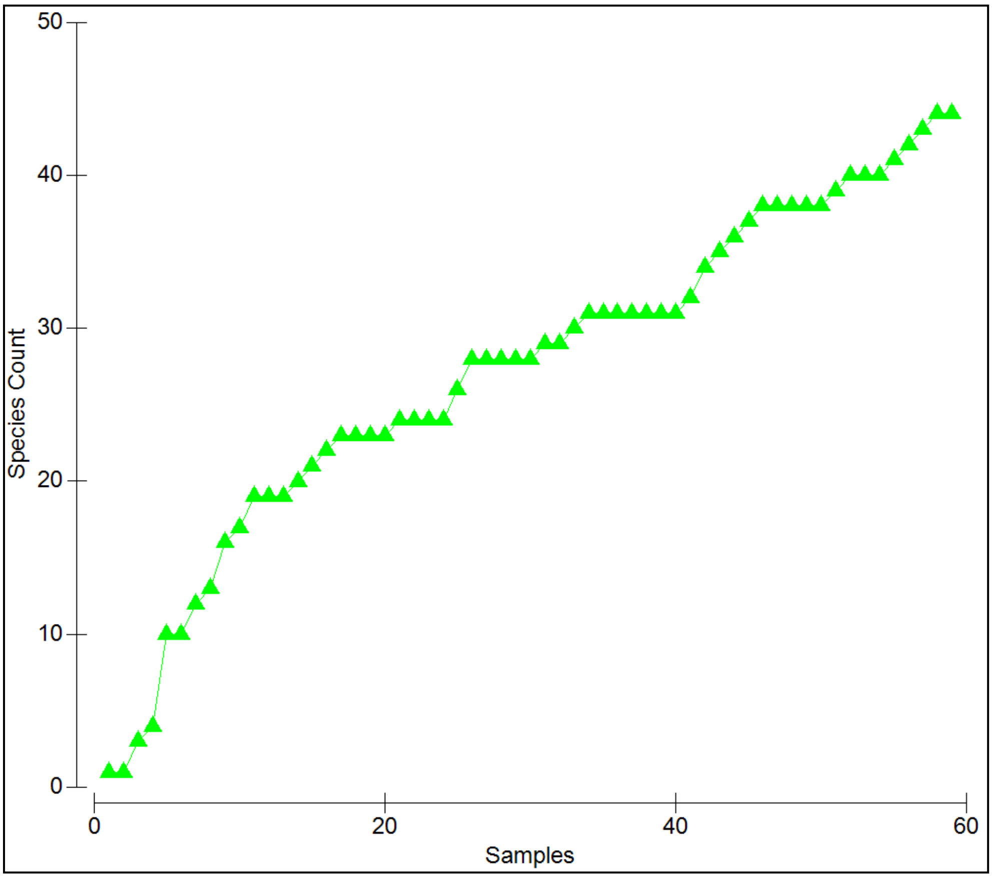


Fig. 27. Cumulative species-area plot (number of species versus number of samples) in the RSA.

Table 2. Number of Species Observed in the Sample, Abundance (no./m^3) and Values of the Shannon Index for the Different Sampling Stations in the RSA

Station No.	**S, Number of Species**	**N, Abundance (no./m^3)**	**Shannon Index, H'(log^e)**
1	2	10.26	0.15
4	2	1.9	0.53
7	3	1.03	1.08
8	3	0.17	0.87
11	4	2.01	0.88
14	2	2.02	0.23
15	5	0.98	1.23
17	4	0.63	1.20
19	2	0.19	0.66
20	2	0.09	0.53

Table 2 (Contd...)

Station No.	S, Number of Species	N, Abundance (no./m^3)	Shannon Index, H'(log^e)
22	2	0.17	0.22
23	7	1.41	1.69
24	2	1.69	0.13
25	1	0.03	0.00
26	2	0.04	0.56
27	3	2.07	0.92
30	3	0.3	0.29
33	1	0.07	0.00
34	3	1.52	0.08
36	4	17.29	0.31
39	3	0.1	1.05
40	3	0.83	0.94
43	3	1.67	0.67
50	5	1.91	1.08
55	4	0.4	0.93
56	1	0.14	0.00
59	2	1.3	0.69
66	2	2.89	0.46
69	5	8.7	0.33
70	4	1.4	0.79
72	5	2.86	0.92
77	3	0.44	1.07
78	2	12.03	0.04
79	2	0.15	0.64
82	4	1.26	1.07
83	2	0.09	0.64
85	5	0.72	1.07
87	5	1.99	1.32
88	6	1.54	1.40
90	7	49.25	0.84
92	5	9.45	0.26
93	4	3.62	0.77
95	5	7.14	0.52

Table 2 (Contd...)

Station No.	**S, Number of Species**	**N, Abundance (no./m^3)**	**Shannon Index, H'(log^e)**
97	4	2.11	0.47
98	7	1.67	1.64
99	3	0.39	0.94
100	5	5.68	1.12
05a	1	1.77	0.00
07a	4	1.68	1.14
09a	2	0.21	0.31
10a	1	0.09	0.00
11a	2	1.61	0.69
14a	3	2.76	0.51
16a	3	0.32	0.88
19a	5	0.66	0.93
21a	2	0.97	0.69
23a	8	1.49	1.77
25a	5	1.69	1.13
26a	5	1.53	1.12

Typically, high values of Shannon Index does not coincide with high density of the studied animals. So, the most abundand by ichthyoplankton sample from station 90 contained 49.25 no./m^3, but only 7 species – the same, as less abundant samples from stations 23, 98, and less than sample from station 23a.

General distribution of the Shannon Index values over the RSA shown at Fig. 28. Comparison with the Figs. 16-18 and 23-25 clearly shown differences between total abundance and diversity in the studied area. Most diverse for the ichtyoplankton are Sea of Oman and inner RSA waters to the north-west of Bahrain. Probably, this pattern reflects results of interactions between hydrodynamic properties, spawning, and behavior of the fish, including migrations.

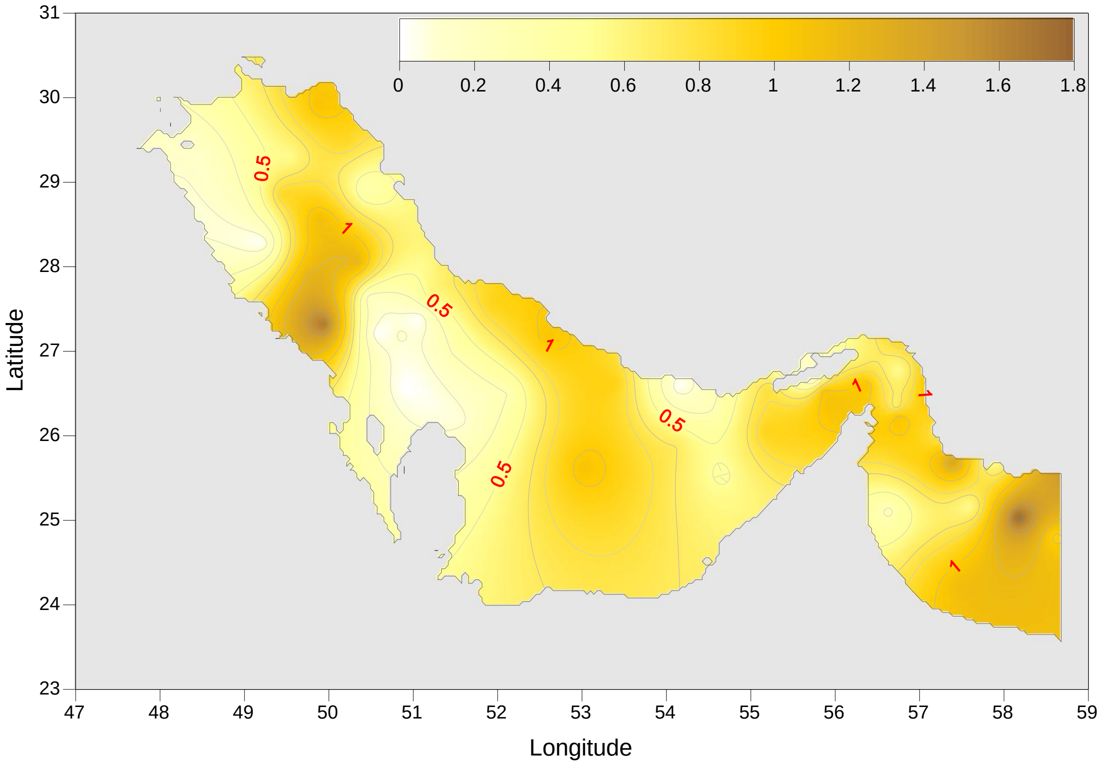


Fig. 28. Spatial Distribution of the Shannon Index Values in the RSA.

4. Conclusions

In general all planned tasks for study of the ichtyoplankton performed in this cruise. This was a first detailed study for the biodiversity of the early fish stages in the surface layer of the ROPME Sea Area, discovered and estimated abundance of 44 taxons of different species and life stages.

The main features of the spatial distribution, abundance, diversity, incuding species-specific, were analyzed. This information is valuable for any future investigation of the early fish stages in the ROPME Sea Area. Detailed identification guide will be a basis for the next stages of the ROPME activity for study of the biological resources of the sea.

Unfortunately, species classification of eggs and larvae of oceanic fish species is not sufficient yet. Information on duration of embryos and early post-embryonic development for certain stages is not available in the published literature. Therefore, it is advisable to undertake research and conduct experiments on incubation of eggs taken from breeders of identified species. One possible option may be the post-incubation of eggs gently collected just after fish spawning. In this case, a link between features of eggs of a definite type and the larvae produced may be of great help in reaching accurate identifications. If the process of egg incubation takes place under stable temperature conditions, information about duration of each stage of embryonic development can be possibly obtained.

5. References

Abdelrahman S. M., and Ahmad F. A. (1995). Note on the residual currents in the Arabian Gulf. *Cont. Shelf Res*. 15: 1015-1022.

Al-Yamani F.Y.; Bishop J.; Ramadhan E.; Al-Husaini M.; and Al-Ghadban A.N. (2004). *Oceanographic atlas of Kuwait's waters*. Kuwait: Kuwait Institute for Scientific Research. 203 p.

Azam M.H.; Elshorbagy W.; Ichikawa T.; Terasawa T.; and Taguchi K. (2006). 3D model application to study residual flow in the Arabian Gulf. *J. Waterw. Port Coastal Ocean Eng*. 132: 1-13.

Brewer P. G. and Dyrssen D. (1984). Chemical oceanography of the Persian Gulf. In: Essays on Oceanography: A Tribute to John Swallow. Edited by J. Crease, W. J. Gould, and P. M. Saunders. *Prog. Oceanogr*. 14: 41–55.

Carpenter K.E.; Krupp F.; Jones D.A.; and Zajonz U. (1997). The living marine resources of Kuwait Eastern Saudi Arabia, Bahrain, Qatar and the United Arab Emirates. Rome, FAO. 293 p.

Clarke K.R. and Warwick R.M. (2001). Changes in marine communities: an approach to statistical analysis and interpretation, 2nd edition, PRIMER-E: Plymouth.

Coles S.L. and Fadlallah Y.H. (1991). Reef coral survival and mortality at low temperatures in the Arabian Gulf: New species-specific lower temperature limits. *Coral Reefs* 9: 231-237.

Dehnik T.V. (1973). Ichthyoplankton of the Black Sea, Kiev, Naukova Dumka. 234 p. (In Russian).

Delsman H.C. (1931). Fish eggs and larvae from Java Sea. 17. The genus Stolephorus. *Treubia* 13: 217-243.

Espinosa-Fuentes M.L. and Flores-Coto C. (2004). Cross-shelf and vertical structure of ichthyoplankton assemblages in continental shelf waters off the Southern Gulf of Mexico. *Estuarine, Coastal and Shelf Science* 59:333-352.

Fursa T.I. (1981). Quantitative composition of the ichthyoplankton in the shelf waters of the western Hindustan (the Arabian Sea, Indian Ocean). Kerch, YugNIRO Library. 90 p. (In Russian).

Gjøsæter J. and Tilseth S. (1988). Spawning behaviour, egg and larval development of the myctophid fish *Benthosema pterotum*. *Marine Biology* 98(1): 1-6.

Grabe S.A.; Lees D.C. and Allaire H.P. (1992). Macrozooplankton studies in Kuwait Bay (Arabian Gulf). I: Distribution and composition of the ichthyoplankton. *Journal of Plankton Research* 14: 607-623.

Gray C.A. (1986). Small-scale temporal variability in assemblages of larval fishes: implications for sampling. *Journal of Plankton Research* 18:1643-1657.

Houde E.D.; Almatar S.; Leak J.C. and Dowd C.E. (1986). Ichthyoplankton abundance and diversity in the western Arabian Gulf. *Kuwait Bulletin of Marine Science* 8: 107-393.

Hunter J.R. (1983). Aspects of the dynamics of the residual circulation of the Arabian Gulf. In *Coastal Oceanography*, edited by H. G. Gade, A. Edwards, and H. Svendsen, Plenum, New York, pp. 31– 42.

Hunter J.R. (1986). The physical oceanography of the Arabian Gulf: A review and theoretical interpretation of previous observations. In *Marine Environment and Pollution*. Proceedings 1st Arabian Gulf Conference on Environmental Pollution. Kuwait University, Kuwait, pp. 1–23.

ICES Zooplankton Methodology Manual (2000). Edited by R. Harris, P. Wiebe, J. Lenz, H.R. Skjoldal and M. Huntley. New York, USA: Academic Press. 684 p.

Jones D.A. (1986). A field guide to the sea shores of Kuwait and the Inner Gulf. Kuwait: University of Kuwait, Blandford Press, 192 p.

Krakatitsa V.V. (1979). Embryonic and early post-embryonic growth of some fish species from the Aden Bay (the Indian Ocean). Moscow, VINITI, 105 p. (In Russian).

Krakatitsa V.V. (1980). Quantitative composition of the ichthyoplankton from the Arabian Sea (the Indian Ocean). Kerch, YugNIRO Library, 93 p. (In Russian).

Krakatitsa V.V. (1980). Morphology and growth of larvae of some fish species from the Aden Bay (the Indian Ocean). Moscow, VINITI, 96 p. (In Russian).

Leis J.M. and Trnski T. (1989). The larvae of Indo-Pacific shorefishes. Hawaii: University of Hawaii Press. 371 p.

Loghurst A.R. (2007). Ecological geography of the sea. Academic Press, 2nd Edition, pp. 542.

Reynolds R.M. (1993). Physical oceanography of the Gulf, Straits of Hormuz, and the Gulf of Oman: results from the Mt. Mitchell expedition. *Marine Pollution Bulletin* 27: 35–59.

Richards W.S. (2008). Identification Guide of the Early Life History Stages of Fishes from the Waters of Kuwait in the Arabian Gulf, Indian Ocean. Edited by F. Al-Yamani. Kuwait: Kuwait Institute for Scientific Research. 329 p.

Rodriguez J.M. (2008). Temporal and cross-shelf distribution of ichthyoplankton in the central Cantabrian Sea. *Estuarine, Coastal and Shelf Science* 79(3): 496-506.

Sheppard C.; Al-Husiani M.; Al-Jamali F.; Al-Yamani F.; Baldwin R.; Bishop J.; Benzoni F.; Dutrieux E.; Dulvy N.K.; Durvasula S.R.V.; Jones D.A.; Loughland R.; Medio D.; Nithyanandan M.; Pilling G.M.; Polikarpov I.; Price A.R.G.; Purkis S.; Riegl B.; Saburova M.; Namin K.S.; Taylor O.; Wilson S. and Zainal K. (2010). The Gulf: A young sea in decline. *Marine Pollution Bulletin* 60: 13-38.

Sheppard C.; Price A. and Roberts C. (1992). Marine Ecology of the Arabian Region: Patterns and Processes in Extreme Tropical Environments. Academic Press, London.

Smith M.M. and Heemstra P.C. (1986). Smith's Sea Fishes. New York: Springer – Verlag, 1047 p.

Somarakis S.; Drakopoulos P. and Filippou V. (2002). Distribution and abundance of larval fish in the northern Aegean Sea – eastern Mediterranean – in relation to early summer oceanographic conditions. *Journal of Plankton Research* 24:339-357.

Swift S.A. and Bower A.S. (2003). Formation and circulation of dense water in the Persian/Arabian Gulf. *J. Geophys. Res*. 108: 4-1 – 4-22.

Thoppil P.G. and Hogan P.J. (2010). A Modeling Study of Circulation and Eddies in the Persian Gulf. *J. Phys. Oceanogr*. 40: 2122-2134.

Yang H.J. (2005). Larval development of *Latreutes anoplonyx* (Decapoda: Hippolytidae) reared in the laboratory. *J. Crust. Biol.* 25(3): 462-479.

Yang H.J. (2007). Larval Development of *Latreutes acicularis* Ortmann (Crustacea: Decapoda: Hippolytidae) Reared in the Laboratory. *Integrative Biosciences* 11: 79-92.