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CONTRIBUTION TO THE STUDY OF THE ECOLOGY OF THE PLANCTONIC PHASE IN THE LIFE HISTORY OF THE ANCHOVY IN THE CENTRAL ADRIATIC

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INTRODUCTION

Due to its great economic importance the anchovy, *Engraulis encrasicolus* (Linnaeus, 1758), which lives in the Adriatic, Mediterranean, Eastern Atlantic, (from Dahomey to the English Channel), North Sea and the Baltic, has always been of greatest interest to many research workers. As the Mediterranean and the Adriatic abound in this fish it is only natural that exceptional attention has been paid to these regions.

Raffaele (1888) is the first author who has described the anchovy eggs. According to him, the egg is ellipsoidal in shape, the longer diameter being from 1.15 to 1.25 mm long. The structure of the yolk and the capsule is smooth, there are no pores or grooves, no oil drop in the yolk. The yolk has large vesiculae all over the mass. This author has found that in the Bay of Naples the anchovy spawns from April till September.

Graeffe (1888) has given the first data on the anchovy in the Adriatic stating that in the Northern Adriatic it spawns during the summer months. Gamulin (1940) cites that Stiasny (1910) and Steuer (1910) have stated that the anchovy in the Northern Adriatic spawns from April till October. Fage (1910) has found that the anchovy in the Mediterranean spawns from April till September.

Gamulin (1940) has investigated the area of the Central Adriatic to the isobath of about 100 meters and has found anchovy eggs everywhere, however, only in small quantities. In May 1940 he found the greatest number of eggs in the Splitska vrata (Split Gate). By basing it on the others' and his own data he has concluded that the anchovy spawns in the shallower regions, in the Northern Adriatic and in the whole eastern area of the Eastern coast of the Adriatic.

The investigations in the Lakes of Mljet on the island of Mljet (Vučetić, 1957) have shown that the anchovy spawns from May to September and that it deposits eggs from 7—9 p.m. The eggs can be found only in the surface layers and their development takes 1—2 days, depending upon temperature. When investigating into the spawning of the anchovy in the open Adriatic,

on the outer side of the island of Dugi otok Vučetić (1964) has found that in this region the anchovy spawns most intensively in June and that the spawning area shifts from the open sea coastwards.

According to Dehnik (1963) the anchovy eggs, larvae and postlarvae in the Mediterranean can be found in small quantities only in the vicinity of the shore, and in larger quantities only in the Northern Adriatic above the depth of 30 meters. He has found that the anchovy postlarvae occur in the greatest number at the depth of 10 meters.

Lugovaja (1963), when examining the shape and size of the anchovy egg in various regions of spawning, has stated that the longer diameter increases and the shorter diameter decreases in the regions with greater salinity. She has also stated that the eggs are somewhat shorter and wider in the Northern Adriatic than in the Central.

Varagnolo (1964) has found that the anchovy in the Northern Adriatic spawns from the first half of April till the end of October. He has found the relative maximum of eggs in May, and the absolute one by the end of August and the beginning of September. The same author (1964a) has found that the anchovy deposits eggs between 6 p.m. and 8 p.m. and that their development lasts from 1—4 days depending upon the water temperature. According to the data by the same author (1965) the greatest amount of anchovy eggs can be found about 1 m below the sea's surface, and the spawning area, according to him, is shifting from the open sea coastwards, moving counterclockwise.

Investigating into the anchovy's spawning in the coastal waters of Istra Zavodnik (1967) has found eggs from May to September, however, in small quantities and on this basis he has concluded that this is not the actual spawning region.

When examining the hyponenston in the Gulf of Trieste Specchi (1968) has found anchovy eggs in the microlayer 7 to 27 cm below the sea's surface. These eggs occur in the greatest number at midday hours, and less so during the day, and at night they are quite rarely found.

Ehrenbaum (1905—1909, p. 371) cites Wenckebach to be the first to describe the anchovy larva. According to Ehrenbaum (1905—1909) the larva in the North Sea is about 4 mm long. Fage (1920) gives a detailed description of the anchovy postlarvae 4 to 50 mm in length. According to his data, the anchovy spawns in the Mediterranean in the vicinity of the shore from April to September with its maximum in June and July, however, the larvae of this fish have been found by the end of February and in the first days of March in the Strait of Messina and in November in the vicinity of the African coast. By basing it on these data he has concluded that »the anchovy, as most of the pelagic fish of large distribution, has no distrinctly limited reproductive period«. He has also found that the larvae hatched only recently float at the very surface. According to his findings, the postlarvae in

the Mediterranean develop in the layers 15 to 30 m deep characterized by a high temperature (17.8°C), rather low salinity (37.5‰), high oxygen concentration and plankton abundance.

D'Ancona (1931) has given a detailed description of the anchovy larvae and postlarvae in the Bay of Naples. The larva has a prolonged yolk sac stretching backwards. The chord is relatively thick with two lines of cells, particularly apparent in its forepart. The colon is thin, stretching backwards ending at the ventral limit of the primordial fin. The larva has neither the oral opening nor the pharynx and therefore it is similar to an embryo. On its ventral side, along the colon itself, it has a series of pigmental cells. After Ehrenbaum (1905—1909) the larvae in the North Sea have not this pigment. D'Ancona points out that the larva passes into the postlarva at the length of 4 to 5 mm. The yolk has arleady been completely resorbed, the cartilage of the cranium visible, eyes pigmented and silvery otocysts very large, and the oral aperture was already formed by the end of the larval stage, while the yolk was not yet fully resorbed. With the postlarva the primordial fin has been reduced, and in the dorsal, anal and caudal fins the rays are already visible. The dorsal fin has been forming at the hight of the anal aperture. The pigment cells are along the colon, on the base of the caudal fin and on the edge of the underpart of the body, behind the anal aperture. Above the anal aperture itself the melanophore in the shape of a dot is being formed. The longest postlarva mentioned by D'Ancona vas 33 mm.

Karlovac J. (1963), when studying the material collected in 1948—1949 on the bio-fischeries expedition »HVAR« in the whole of the open Adriatic, has found that the anchovy larvae and postlarvae occur in this region from May to November and that their number increases with the depth and attains its maximum at 150—200 m above the bottom.

Duka (1963) has found that the anchovy postlarvae in the Adriatic feed on nauplii, copepodits, and the adult forms of certain copepoda, and that the plasticity in their nutrition habits is small. The larval forms of the anchovy, according to her data, feed most intensively in the morning and afternoon hours, while at night they do not feed at all.

Karlovac J. (1967) quotes that the anchovy larva and postlarva density in the Central Adriatic is higher in the open coastal waters and channels than in the enclosed bays and that the larvae and postlarvae of this species are complementary in their occurrence with regard to that of the sardine larvae and postlarvae.

With regard to the synonymity of this species Whitehead made a revision of the name of the species *Engraulis encrasicholus* L. in 1969. In his work he quotes:

»Fam. Engraulidae: *Clupea encrasicolus* = *Engraulis encrasicolus* (Linnaeus, 1758).

Clupea encrasicolus Linnaeus 1758, Syst.Nat., X ed: 318; Bloch, 1782, Oeconom. Naturg. Fische Deutsch., 1.212, pl. 30 (2).

Clupea encrasicholus: Schneider, 1801, Syst. Ichth. Bloch.: 423.

Variations in the spelling of the name of this species still exist. Linnaeus (1735) was the first to use *encrasicholus,* however, what is cited in X edition is the definite one«. (p. 273).

Demir (1965), in his synopsis on the anchovy, quotes as the correct spelling for this species: *Engraulis encrasicolus* (Linnaeus) 1758.

In this paper I use the name *Engraulis encrasicolus* (Linnaeus, 1758).

AREA UNDER INVESTIGATION

The investigations have been conducted on the profile stretching southwards from Split, and thus set, it has included the area in the immediate vicinity of the shore, the channel region between the islands, and the open sea beyond the islands. On this profile are situated the following stations: Kaštelanski zaljev (the Bay of Kaštela) (43°31'N 16°22' E), Pelegrin (43°12' N 16°19' E) and Stončica (43°00'N 16°20'E). These are reference sations at which the Institute of Oceanography and Fischeries from Split carry out investigations of the primary and secondary productivity. Another station Pakleni otoci (the Pakleni Islands) (43°10'N 16°22'E) has been added to these ones. It lies East of the station Pelegrin (Fig. 1).

The station Kaštelanski zaljev — 42 m deep — is characterized by extreme fluctuations of hydrographic factors, which is conditioned by the immediate vicinity of the mainland, shallow bottom of the Kaštelanski zaljev and fresh water influx from the mainland. After Buljan and Zore—Armanda (1963) the annual temperature fluctuations are great ranging from 11.00°C to 23.36°C on the surface, namely, from 12,02°C to 22.19°C for the water column 30 m deep. Salinity varies on the surface between 28.17‰ and 38.19‰.

Station Pelegrin is in the vicinity of the Pelegrin Point on the Island of Hvar. At this station the depth is 78 m. It is under the influence of both the mainland and the open sea, therfore the fluctuations in salinity and temperature are smaller than in the Kaštelanski zaljev, and higher than on the open sea. During the year the surface temperature ranges between 12.07°C and 22.80°C, and salinity from 35.52‰ to 38.39‰ (Buljan and Zore—Armanda, 1966).

Station Pakleni otoci lies in the Pakleni Channel, between the islands of Pakleni and the Island of Hvar, 3 NM off the station Pelegrin eastwards. The depth at this station is 68 m. Here the physicochemical characteristics of the water are similar to those at the Pelegrin station.

Station Stončica lies 4 NM southeasterly from the Stončica Point on the Island of Vis. The depth at this station is 107 m. The Stončica station is under the influence of the open sea so the fluctuations of the hydrographical factors are smaller here than at the above mentioned stations. Annual temperature values on the surface range from 13.52°C to 23.88°C and salinity from 37.39‰ to 38.35‰ (Buljan and Zore—Armanda, 1966).

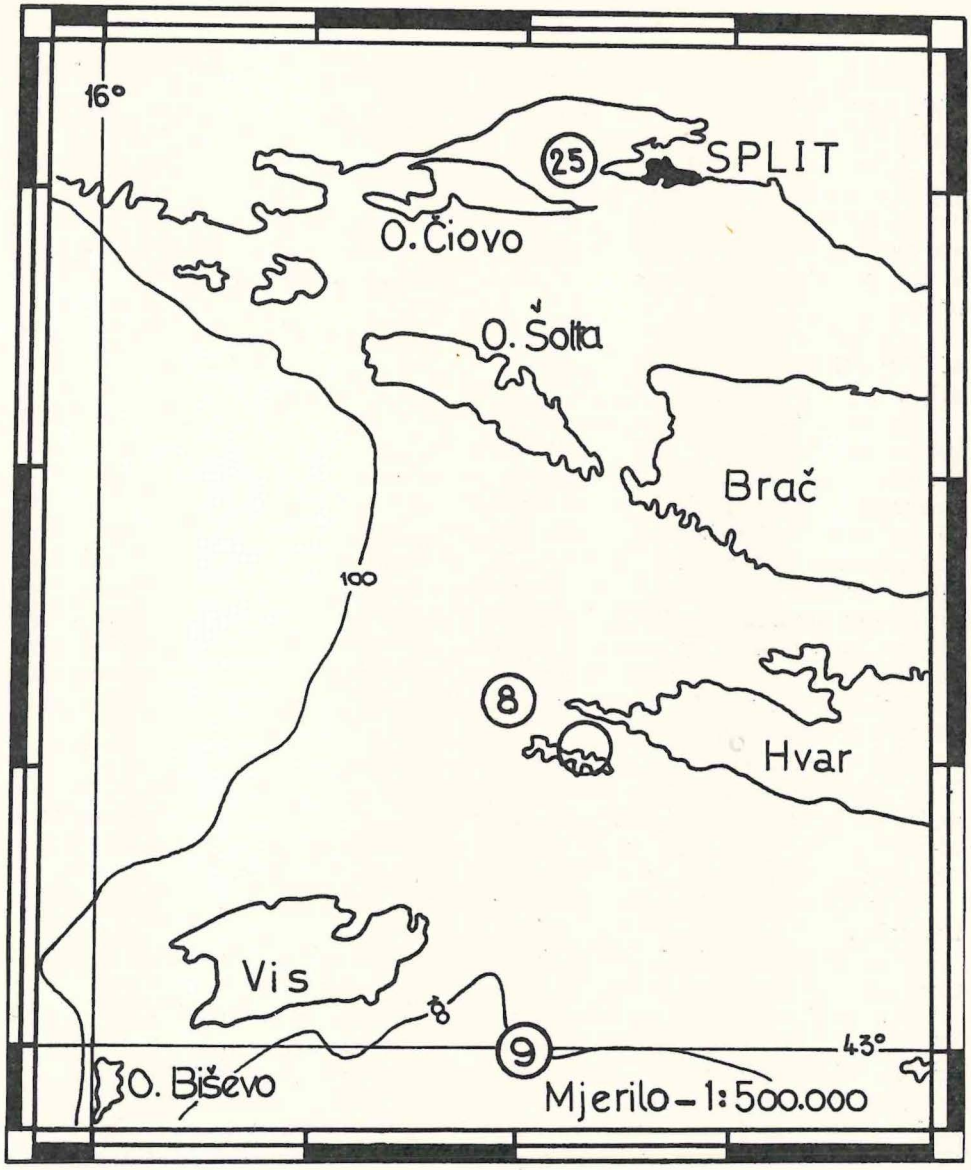


Fig. 1. Area of investigation
Stations:
No. 25 = Kaštelanski zaljev
No. 8 = Pelegrin
No. 9 = Stončica
Ring without No. = Pakleni otoci

METHOD AND MATERIAL

The investigations were carried out from January 1968 to December 1969 with the vessels m/b »Bios« and m/b »Predvodnik«. At all the stations sampling was done once a month during the 24 cruises lasting 3—4 days each.

At each station samples of zooplankton were taken with the plankton net type »Helgoland« (K ü n n e, 1933). The mean size of the anchovy eggs in the region under investigation was 1.36 × 0.57 mm. As the silk No. 6, out of which the net was made, has the mesh size 0.516 mm there is a probability, although a very slight one, that a portion of the eggs could have passed through the net.

At the stations Stončica and Pelegrin the net was hauled from the depth of 75 m, at the station Pakleni otoci from 60 m and at the station Kaštelanski zaljev from 30 m.

In order to investigate into the vertical distribution of the anchovy eggs, larvae and postlarvae, and to establish the probably day-night migration of the larvae and postlarvae, the closing net made of silk No. 3, mesh size 0.333 was used. The mouth diameter of this net was 57 cm. The front of the net was 69 cm long, cylindrical in shape and the mouth and the lower part were strengthened with a piece of canvas 10 cm wide. On the canvas strengthening the lower end of the front part rings were sawn up through which the rope that closes the net passed. The lower part of the net was narrowing into a cone 117 cm long. It shut by means of the Nansen closer of »Bergen—Nautik« production activated by means of a weight descending down the steel rope that was holding the net. This net was loaded with a 5 kg weight and hauled at the rate of 0.5 m/sec.

The catches with this net were taken at regular intervals during 24 hours from various layers at the station Stončica in the July and August of 1968 and 1969. In 1968 the catches were taken every three hours from the depths of 75—50 m, 50—25 m and from 25—0 m. The 1969 catches were taken every four hours at the depth of 30—20 m, 20—10 m and 10—0 m.

The material obtained by these nets was fixed in the neutralized 2% Formalin.

Concurrently with the trials data were taken at each station on temperature, salinity and water density at the depths of 0,10 and 20 m.

The anchovy eggs, larvae and postlarvae were determined after F a g e (1920) and D'A n c o n a (1931). The number of total ichthyoplankton and the number of anchovy eggs, larvae and postlarvae are given per catch.

The live and dead eggs and undamaged larvae and postlarvae of the anchovy were measured with the binocular lens magnifying 10 × 4 by means of an ocular-micrometer with the precision of one line of the ocular-micrometer, i.e. of 0.375 mm. We measured the longer and the shorter diameters (D_1 and D_2) of the eggs, the length from the top of the snout to the end of the notochord of the larvae, and the length from the top of the snout to the base of the caudal fin (as most often the caudal fin is likely to be damaged) of the postlarvae.

To classify the plankton stages of fish we used the method Karlovac J. (1967) applied when studying the ecology of the plankton stages of the sardine.

According to this classification three developmental stages exist:

1. The egg stage from the fertilization to hatching (Fig. 2).
2. The larval stage from hatching to the total resorption of the yolk sac. An odd number of fins. (Fig. 3).
3. The postlarval stage has no yolk sac, mouth and fins are being formed. The body loses transparency, pigmentation is intensified, becoming similar to that of the adult form. (Fig. 3).

As the base for the classification of the anchovy eggs, with regard to the embryonal development, the classification for the sardine eggs published in »GFCM Studies and Reviews No. 1« under the title »Standardization of biometric and observation methods for Clupeidae (especially *Sardina pilchardus Walb.)* used in fisheries biology« was applied in a shortened version in which 11 stages (I—XI) were reduced to five (A—E), (Fig. 2).

The measured larvae and postlarvae have been classified according to length into groups of 2, 4, 6 and 8 mm. Each of these length groups has been determined by the initial interval value, so that the length group of 2 mm includes the samples from 2.00 to 3.99 mm, the length group of 4 mm all the samples from 4.00 to 5.99 mm, the length group of 6 mm the samples 6.00 to 7.99 mm and the length group of 8 mm those from 8.00 to 9.99 mm.

In this way all the larvae and postlarvae from each catch were classified.

During the investigations in 1968 and 1969 24 samples of zooplankton were taken with the net »Helgoland«. The analysis has shown that 4.349 eggs and 2,087 larvae and postlarvae of fish were collected out of which 912 eggs, 411 larvae and 282 postlarvae belong to the anchovy. With the closing net 115 eggs and 162 larvae and postlarvae of fish were caught out of which 70 eggs, 40 larvae and 55 postlarvae belonged to the anchovy. A total of 982 eggs, 451 larvae and 337 postlarvae of the anchovy were collected.

RESULTS

1. *Distribution of anchovy eggs*

During the investigations conducted at the stations Stončica, Pelegrin, Pakleni otoci and Kaštelanski zaljev in 1968 and 1969 4,349 fish eggs were collected during the months positive for the anchovy eggs by means of vertical hauls with the »Helgoland« net out of which 912 eggs belonged to the anchovy.

Table 1 shows the distribution of the total number of the anchovy eggs.

Table 1. Total number of anchovy eggs per stations in 1968 and 1969

Station	1968	1969
Stončica	256	326
Pelegrin	39	85
Pakleni otoci	11	27
Kaštelanski zaljev	78	90
TOTAL:	384	528

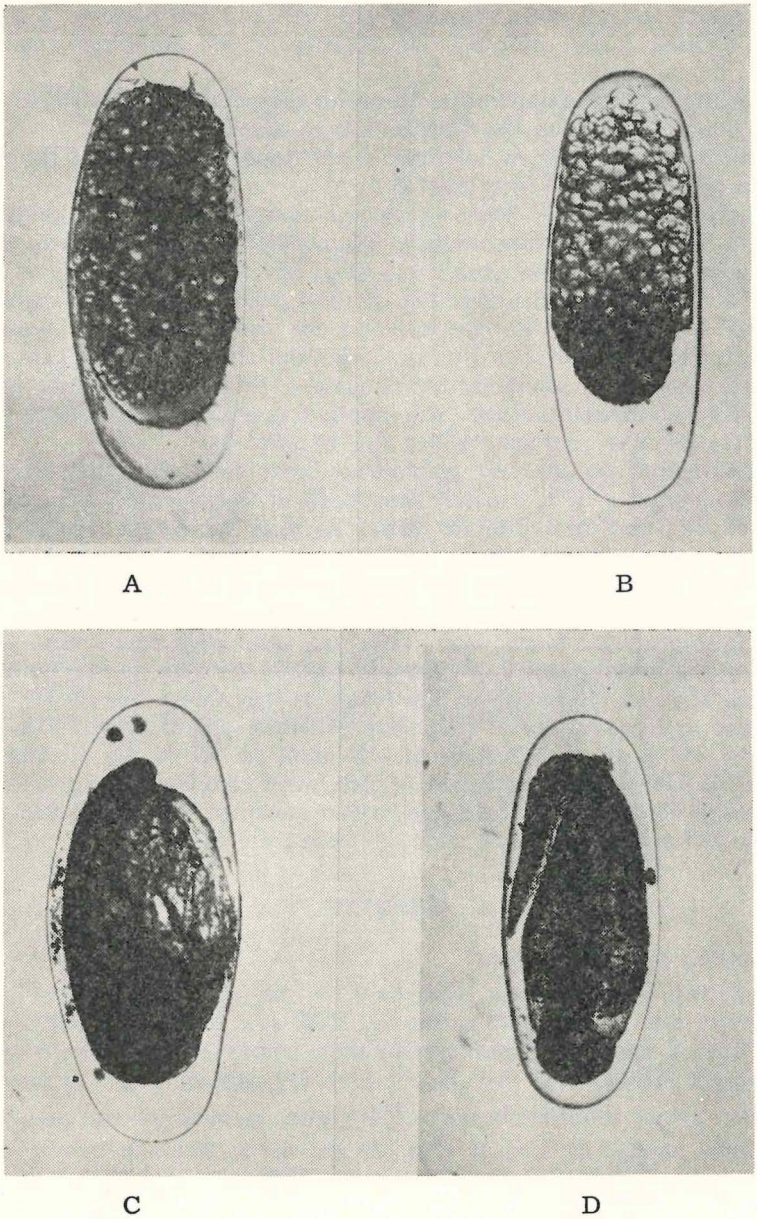
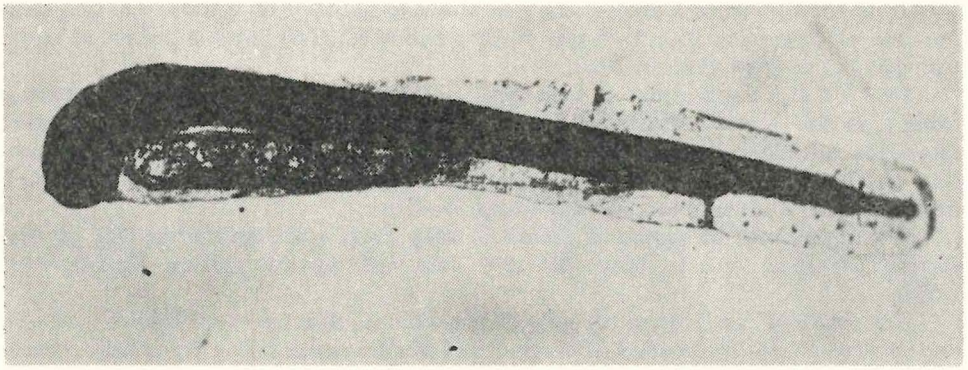
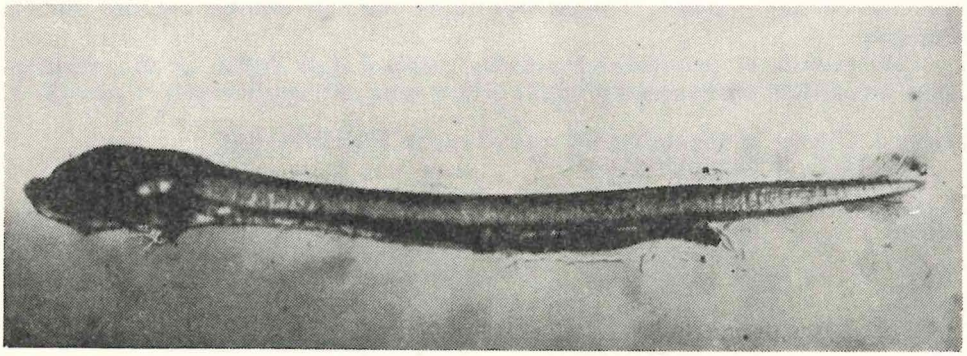


Fig. 2. Embryonal stages of the anchovy eggs (Magnification: ocular 10 x, objective 4 x). Original photography taken by M. Alajbeg



Larva



Postlarva

Fig. 3. Anchovy larva and postlarva (Magnification: ocular 5 x, Objective 4 x). Original photography taken by M. Alajbeg

It is visible from Table 1 that in the course of both years the greatest number of eggs was found at the station Stončica. The total number of eggs was greater in 1969 than in 1968.

In 1968 the occurrence of eggs was recorded in April at all the stations except at the station Kaštelanski zaljev where these were found a month later, i.e., in May. At the station Stončica the eggs were found for the last time in October, at the stations Pelegrin and Kaštelanski zaljev in September, at the station Pakleni otoci in May (App. I—IV).

The maximum of eggs was found in May (149) and September (75) at the station Stončica, and in May (26) and June (47) at the station Kaštelanski zaljev.

The earliest occurrence of eggs at the station Stončica in 1969 was recorded in March. At the stations Pelegrin and Kaštelanski zaljev their occurrence was recorded in April, and at the station Pakleni otoci in May. At the stations Stončica and Kaštelanski zaljev the anchovy eggs were present in the plankton as early as November. In October they were found for the last time at the station Pelegrin, and in September at the station Pakleni otoci. (App. I—IV).

That year the maximum of eggs was found in June (82) and July (175) at the station Stončica and in June (62) at the station Kaštelanski zaljev. An increase in the number of eggs was found also in October at the station Pelegrin.

The results of the research into the vertical distribution of the anchovy eggs, larvae and postlarvae by means of a closing net are shown in Tables 2—5,

Table 2. Catches by the closing net carried out on July 23/24, 1968, at the station Stončica

Depth of layer	75—50 m		50—25 m		25—0 m	
Time	eggs	larvae & postlarvae	eggs	larvae & postlarvae	eggs	larvae & postlarvae
2200	0	0	0	0	1	2
0600	0	0	0	0	2	1
0900	0	0	0	0	0	0
1200	0	0	0	0	2	5
1500	0	0	0	0	1	1

Table 3. Catches by the closing net carried out on August 15/16, 1968, at the station Stončica

Depth of layer	75—50 m		50—25 m		25—0 m	
Time	eggs	larvae & postlarvae	eggs	larvae & postlarvae	eggs	larvae & postlarvae
1100	0	0	0	0	3	0
1700	0	0	0	0	1	3
2000	0	0	0	0	6	16
2300	0	0	0	0	8	10
0200	0	0	1	0	3	2
0500	2	0	0	0	0	0
0800	0	0	0	0	11	2

Table 4. Catches by the closing net carried out on July 16/17, 1969, at the station Stončica

Depth of layer	30—20 m		20—10 m		10—0 m	
Time	eggs	larvae & postlarvae	eggs	larvae & postlarvae	eggs	larvae & postlarvae
2100	0	0	0	1	3	1
0100	0	1	6	9	6	6
0500	0	1	2	4	11	3
0900	0	0	0	6	0	5
1300	0	2	1	2	1	0
1700	0	5	0	1	4	0

Table 5. Catches by the closing net carried out on August 15, 1969, at the station Stončica

Depth of layer	30—20 m		20—10 m		10—0 m	
Time	eggs	larvae & postlarvae	eggs	larvae & postlarvae	eggs	larvae & postlarvae
0100	0	0	0	0	3	0
0500	0	0	0	0	2	4
0900	0	0	1	0	4	2
1700	0	0	0	1	5	0

The investigations conducted in 1968 with this net have shown that beyond the depth of 25 m no live anchovy eggs exist. (Tab. 2 & 3). Therefore the 1968 investigations were conducted in the layer 30 m deep. These investigations have shown that the greatest number of eggs can be found in the layer 0 to 10 m deep, while in the layers 10 to 20 m and 20 to 30 m the eggs occur in smaller quantities.

2. *Size of anchovy eggs during their occurrence in the plankton, number relation of live and dead eggs per stages*

Although the number of the examined eggs can satisfy us only to a minimum, an attempt has been made at the research into the causes of the occurrence of eggs of various dimensions in a season.

Due to the elipsoidal shape of the anchovy eggs the measurings were conducted in two diameters. The means have been calculated in order to see the eventual variations in their size during the two years of investigations. To calculate the mean lengths of the larger and smaller diameter 25 eggs were taken per each catch from the material collected at the stations Stončica and Pelegrin during Aprill, May and July 1968 and 1969, except from those taken in June when the amount of eggs was not satisfactory. From the same catches the mean lengths of larvae were calculated in order to compare them with the size of the eggs.

Table 6 shows the mean lengths of both diameters of the egg.

Table 6. Length variations of the longer (D_1) and the shorter (D_2) diameter of eggs during the season (dimensions are expressed in millimeters)

	D_1 month			D_2 month		
Year	IV	V	VII	IV	V	VII
1968	1.57	1.46	1.26	0.59	0.59	0.53
1969	1.56	1.53	1.32	0.60	0.58	0.55

It follows from the above Table that in 1969 the anchovy eggs were somewhat larger than those in 1968 and their decrease in size was better expressed in 1968.

The analysis of the embryonal stages of the eggs was conducted in order to notice the occurrence of the dead ones at individual stages. The obtained results are given in Tables 7—10.

The eggs of the stage A were rarely caught, and this always dead. The finding of only dead eggs in the daily catches might be explained, according to the data given by V u č e t i ć (1957), by the fact that the anchovy deposits eggs in the evening hours. Therefore in the daily catches only those eggs of the stage A were present which died and therefore did not develop any cleavage.

Table 7. No. of live and dead eggs at individual stages at the station Stončica during 1968 and 1969. No. of dead eggs is given in parentheses

	1968 stage				1969 stage			
Month	A	B	C	D	A	B	C	D
III	—	—	—	—	—	1	—	1
IV	—	—	2	1	(1)	1(1)	3	13
V	—	22(10)	70(6)	1	—	3(1)	2(1)	4(1)
VI	—	—	6(1)	1	—	15(8)	2	55(2)
VII	—	—	12(5)	—	—	80(80)	2	13
VIII	—	—	1(1)	—	—	(1)	14(1)	1
IX	—	14(5)	1	52(3)	—	—	9	—
X	—	—	—	2	—	—	2	—
XI	—	—	—	—	—	—	—	8

Table 8. No. of live and dead eggs at individual stages at the station Pelegrin during 1968 and 1969. No. of dead eggs is given in parentheses

	1968 stage				1969 stage			
Month	A	B	C	D	A	B	C	D
IV	—	1(1)	5(2)	1	—	(1)	2	—
V	—	(1)	3(1)	1	—	—	3(1)	1
VI	—	—	1	—	—	(1)	6(1)	11
VII	—	1(5)	2(6)	2	(1)	—	1	14
VIII	—	—	(1)	—	—	1	2	1
IX	—	(1)	1(2)	(1)	(1)	—	1	—
X	—	—	—	—	—	—	7(29)	—

Table 9. No. of live and dead eggs at individual stages at the station Pakleni otoci during 1968 and 1969. No. of dead eggs is given in parentheses

	1968 stage				1969 stage			
Month	A	B	C	D	A	B	C	D
IV	—	—	1	—	—	—	—	—
V	—	(2)	6(1)	1	—	—	—	—
VI	—	—	—	—	—	—	—	13
VII	—	—	—	—	—	—	—	—
VIII	—	—	—	—	—	—	6(2)	—
IX	—	—	—	—	—	1	3(2)	—

Table 10. No. of live and dead eggs at individual stages at the station Kaštelanski zaljev during 1968 and 1969. No. of dead eggs is given in parentheses

	1968 stage				1969 stage			
Month	A	B	C	D	A	B	C	D
IV	—	—	—	—	—	—	2	4
V	(1)	1(1)	18	5	—	(1)	—	1
VI	—	14(4)	22(1)	6	—	10(6)	—	42(4)
VII	—	(1)	—	1	—	7(1)	1	5
VIII	—	—	—	1	—	1	1	—
IX	—	(1)	—	1	—	—	—	—
X	—	—	—	—	—	(1)	—	1
XI	—	—	—	—	—	(1)	—	1

The above Tables show that the number of dead eggs is high at the stage B, while at the stages C and D it is much lower.

3. *Anchovy larvae and postlarvae distribution with regard to the quantity in space and time*

In 1968 and 1969 2,087 larval stages of fish were caught with the »Helgoland« net out of which 411 larvae and 282 postlarvae belonged to the anchovy.

There were more anchovy larvae in 1968 than in 1969, while the number of the postlarvae and eggs was grater in the second year of the investigation. The greatest number of larvae and postlarvae was found at the station Pelegrin, followed by Stončica, Kaštelanski zaljev and Pakleni otoci (Tab. 11).

Table 11. Total number of anchovy larvae and postlarvae at the profile under investigation in 1968 and 1969

	1968		1969	
Station	larvae	postlarvae	larvae	postlarvae
Stončica	86	41	50	48
Pelegrin	103	48	49	71
Pakleni otoci	14	7	11	19
Kaštelanski zaljev	46	25	52	23

The occurrence of larvae and postlarvae was recorded in Aprill 1968 at the station Pelegrin, while at the other stations both larvae and postlarvae occurred in May for the first time. At the station Pelegrin the larvae and postlarvae were found in the plankton as early as October. At the station

Stončica the larvae were found last in October and the postlarvae in September. At the stations Kaštelanski zaljev and Pakleni otoci the postlarvae were found as late as August and the larvae as late as September (App. I—IV).

The maximum of the larvae was found in July and August and of the postlarvae in July, August and October.

In 1969 the larvae and postlarvae in the plankton occurred from April to November. At the earliest they occurred at the station Kaštelanski zaljev in Aprill while at the station Pelegrin they occurred one month later and at Stončica and Pakleni otoci two months later. At Stončica and Kaštelanski zaljev they were still present in the plankton in November, and at the other two stations in October (App. I—IV).

The maximum of the larvae was found from June to August and in September and October and of the postlarvae in June, August and November.

The 1968 investigations with the closing net have shown that in the layers beyond 25 m no larval form of the anchovy was found and the larvae and postlarvae occur in the layer 0 to 25 m deep. (Tables 2 & 3). According to the results obtained from the catches carried out in 1969 the larvae and postlarvae of the anchovy occur in the greatest number in the layer 10 to 20 m deep. It has also been noticed that in the afternoon hours there are no larval stages of this fish in the layer from 0 to 10 m and during this period they are more numerous in the layer 20 to 30 m deep (Tab. 4 & 5).

4. *Anchovy larvae and postlarvae distribution with regard to the length groups*

During the investigations 411 larvae and 282 postlarvae of the anchovy were caught. Their length varied from 2.16 to 3.93 mm and that of the postlarvae from 2.81 to 9.37 mm.

The measured larvae and postlarvae are classified into length groups of 2, 4, 6 and 8 mm. The damaged samples are entered in a separate column (App. I—IV).

In 1968 287 samples were caught and these belonged to the length group of 2 mm, 48 to the group of 4 mm, 13 to the group of 6 mm and 2 to the one of 8 mm.

In 1969 244 samples were caught from the group of 2 mm, 41 from that of 4 mm, 18 from the group of 6 mm, and 5 from the group of 8 mm.

During both the seasons when the anchovy larval stages occurred in the plankton there were more samples from the first length group than from all the others taken together.

The distribution of larvae and postlarvae classified into length groups per individual months during both the seasons of their occurrence is shown in the Appendices I—IV. The samples from the older length groups (of 6 and 8 mm) were somewhat more numerous in 1969 than in 1968.

5. *The anchovy planktonic phase in relation to the abiotic factors*

The relation of the planktonic stage of the anchovy to temperature, salinity and water density has been analysed. The representative values relating to the depth of 0 m have been taken for these factors as it was established that the planktonic stages of the anchovy are found near the surface.

During both years the anchovy eggs occurred in the region under investigation at the temperature interval from 13.17 to 23.70°C. However, at all the stations, except at the station Pakleni otoci, in 1969 they started to appear at lower temperatures than in 1968. The maximum of eggs was found at all the stations at the temperature interval from 18.30 to 22.12°C.

The anchovy larvae were recorded at all the stations at the temperature interval from 13.17 to 23.70°C. The maxima were recorded at the interval from 20.93 to 23.70°C.

The occurrence of the postlarvae was recorded at the temperature interval from 15.59 to 23.70°C, the maxima were found within the same values as the maxima of the larvae were. (Tab. 12).

The occurrence of the anchovy eggs was recorded during both the years of the investigations at the salinity interval from 33.86 to 38.69‰. The maxima at the outer stations of the profile were found at the interval from 37.79 to 38.69‰ ,and at the station Kaštelanski zaljev from 34.52 to 35.71‰.

The larvae were found at the salinity interval from 32.70 to 38.69‰, and the maxima at the station Kaštelanski zaljev from 35.71 to 37.99‰, and at the other stations from 37.27 to 38.57‰.

The occurrence of the postlarvae was recorded within the same range of salinity as the occurrence of the larvae was, and the maxima at the station Kaštelanski zaljev were ranging from 35.71 to 35.95‰, and at the other stations from 37.54 to 38.62‰ (Tab. 13).

The anchovy eggs were found at the water density interval from 24.13 to 28.97 σt. The maxima at the station Kaštelanski zaljev were found at the density interval from 24.13 to 24.81 and at the other stations from 26.63 to 27.39 σt.

The larvae were found at the density interval from 22.42 to 28.34 σt. At the same interval the postlarvae were also found. The maxima of the larvae were found at the station Kaštelanski zaljev at the interval from 24.46 to 26.80 σt, and at the other stations from 24.85 to 26.98 σt. The maxima of the postlarvae were found at the station Kaštelanski zaljev at the interval from 24.46 to 24.81, and at the other stations from 25.90 to 26.78 σt. (Tab. 14).

The above values of temperature, salinity and water density, within which the maxima of the eggs, larvae and postlarvae were found, represent the optima of these factors in the region under investigation.

Table 12. Relation of anchovy eggs, larvae and postlarvae temperature (T°C, depth 0 m)

Station	Year	Eggs		Larvae		Postlarvae	
		Occurrence	Max.	Occurrence	Max.	Occurrence	Max.
Stončica	1968.	15,93—23,28	18,72—21,28	18,72—23,28	22,69—23,28	18,72—23,28	22,69—23,28
	1969.	14,22—23,60	20,19—20,93	20,19—23,60	20,93—21,62	20,19—23,60	20,93—23,60
Pelegrin	1968.	15,59—23,20	—	15,59—23,20	21,88—22,73	15,59—23,20	22,73
	1969.	14,08—23,40	22,12	17,50—23,40	21,45—23,40	17,50—23,40	21,45—23,01
Pakleni	1968.	15,59—18,48	—	18,48—23,16	22,60	18,48—23,16	22,60
otoci	1969.	20,24—23,45	—	20,24—23,25	—	20,24—23,25	22,90
Kaštelanski	1968.	18,30—22,90	18,30—21,89	18,30—22,90	21,89	21,74—22,90	21,89
zaljev	1969.	13,17—23,70	21,09	13,17—23,70	20,95—23,70	20,78—23,70	23,70

Table 13. Relation of anchovy eggs, larvae and postlarvae to salinity (S‰, detpth 0 m)

Station	Year	Eggs		Larvae		Postlarvae	
		Occurrence	Max.	Occurrence	Max.	Occurrence	Max.
Stončica	1968.	37,68—38,69	37,79—38,69	37,68—38,69	37,68—38,31	37,68—38,69	37,68—38,62
	1969.	37,07—38,69	37,81—38,10	37,81—38,69	37,81—38,48	37,81—38,69	37,81—38,33
Pelegrin	1968.	37,43—38,57	—	37,43—38,57	37,43—38,57	37,43—38,57	38,57
	1969.	36,74—38,24	38,24	36,74—38,24	37,27—38,24	36,74—38,24	38,01—38,04
Pakleni	1968.	37,83—38,21	—	37,27—38,55	38,22	37,27—38,22	38,22
otoci	1969.	36,85—38,02	—	36,85—38,55	—	36,85—38,55	37,54
Kaštelanski	1968.	34,31—37,30	34,91—35,71	34,31—37,30	35,71	35,71—37,30	35,71
zaljev	1969.	33,86—37,99	34,52	32,70—37,99	35,95—37,99	32,70—37,99	35,95

Table 14. Relation of anchovy eggs, larvae and postlarvae to vater density (σ t, depth 0 m)

Station	Year	Eggs		Larvae		Postlarvae	
		Occurrence	Max.	Occurrence	Max.	Occurrence	Max.
Stončica	1968.	24,85—28,28	27,25—27,39	24,85—27,46	24,85—25,90	24,85—27,39	25,90—26,78
	1969.	26,30—28,97	26,63—27,09	26,30—27,48	26,63—26,98	26,30—27,48	26,30—26,63
Pelegrin	1968.	25,97—28,34	—	25,97—28,34	26,11—26,73	25,97—28,34	26,73
	1969.	25,55—27,78	26,67	25,55—26,86	25,55—26,68	25,55—26,86	26,26—26,68
Pakleni	1968.	27,34—28,33	—	25,93—27,34	—	25,93—27,34	26,51
otoci	1969.	25,22—27,03	—	25,22—27,03	26,00	25,22—27,03	25,90
Kaštelanski	1968.	24,69—26,06	24,69—24,81	24,69—26,06	24,81	24,81—26,06	24,81
zaljev	1969.	24,13—26,80	24,13	22,42—26,80	24,46—26,80	22,42—26,80	24,46

DISCUSSION

The researches have shown that the anchovy eggs during both the years of investigation were the most numerous at the station Stončica which is, with regard to its hydrographic characteristics, under the influence of the open sea. In the channel region there were relatively few of them, whereas their number increased again in the coastal region. The total number of the eggs was greater in 1969 than in 1968. (Tab. 1).

Diferently from the anchovy eggs, its larvae and postlarvae were the most numerous in the channel region. The total number of the larvae was greater in 1968 and that of the postlarvae and eggs in 1969. (Tab. 11).

The anchovy eggs are predominant in the open sea area where they make 50% of the total number of fish eggs, while in the coastal area they do so only by 15%. The proportional distribution of the anchovy eggs in relation to the total number of fish eggs per individual stations is shown in Table 15.

Table 15. Percentage of anchovy eggs in relation to the total number of fish eggs during 1968 and 1969

Station	Anchovy eggs in % 1968	1969
Stončica	68.2	19.0
Pelegrin	10.8	23.5
Pakleni otoci	3.8	8.0
Kaštelanski zaljev	15.7	15.7

The table shows that the eggs in 1969 were represented by only 19% at the station Stončica. This percentage was obtained because that year at that station the anchovy eggs were found in a small number in March and November when the sardine, whose eggs occur in a large number, was spawning. If those two months are excepted the percentage of eggs at Stončica vas 68.1% that year.

The data by various authors on the duration of the occurrence of anchovy eggs and larvae in the Mediterranean and the Adriatic differ mutually (Graeffe, 1888; Fage, 1911, 1920; Gamulin, 1940; Vučetić, 1957, 1964; Dehnik, 1963; Karlovac J., 1963, 1967; Varagnolo, 1964; Zavodnik, 1967). By basing it on these data it can be concluded that the period of the occurrence of the eggs and larvae varies according to the area of the anchovy's spawning.

In the region under investigation the period of occurrence of the eggs was longer in 1969 (from March to November) than in 1968 (from April to October). When comparing the stations mutually we can see that the occurrence of the eggs at the station Stončica has begun earlier and lasted longer than at the other stations as it is under the influence of the open sea.

The occurrence of the anchovy larvae and postlarvae lasted also longer in 1969 (from April to November) than in 1968 (from April to October). As different from the occurrence of the eggs, the occurrence of the larvae and postlarvae at the station Pelegrin lasted the longest in 1968 and at the station Kaštelanski zaljev in 1969 (Fig. 4 and 5).

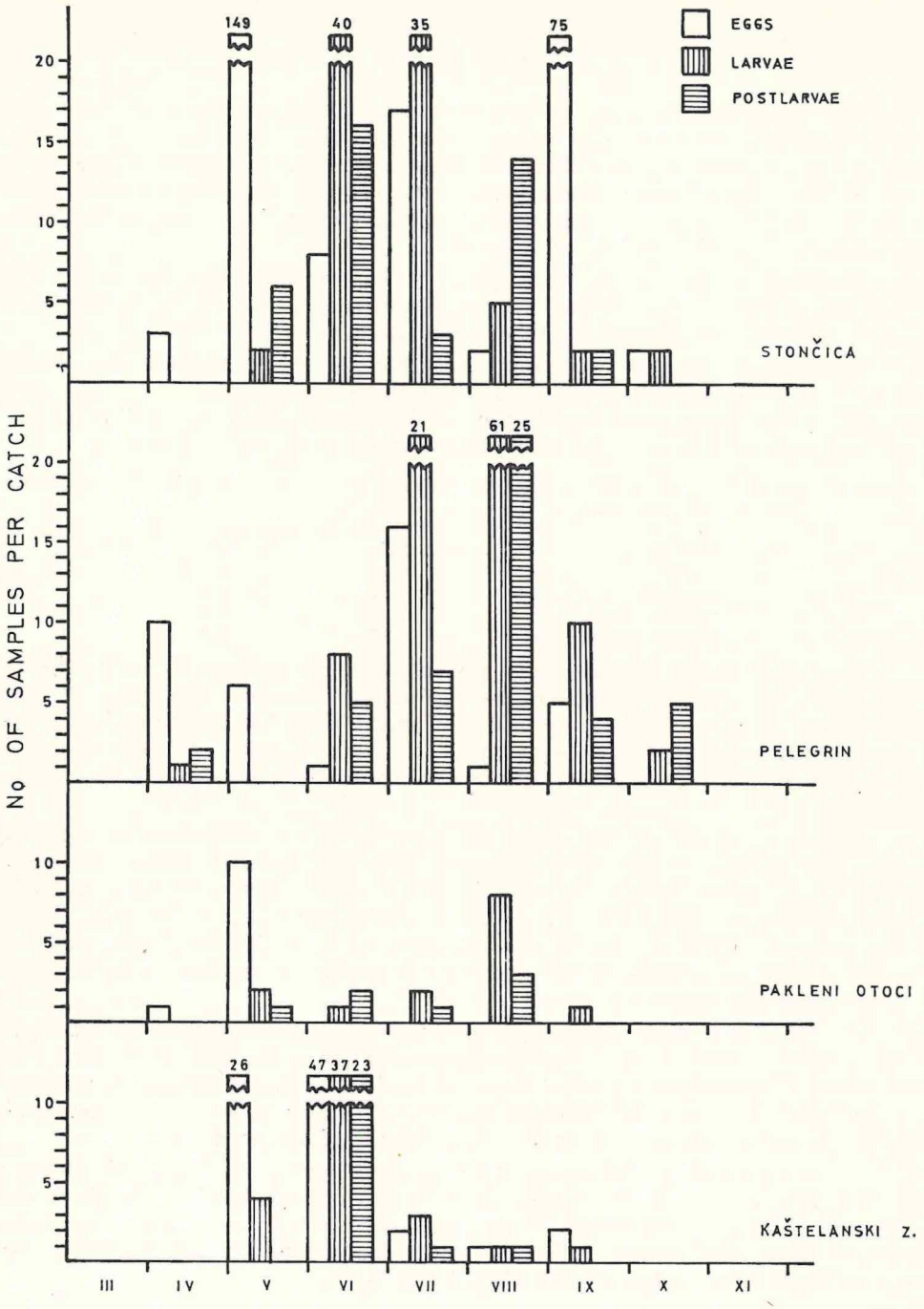


Fig. 4. Quantitative distribution of the anchovy eggs, larvae and postlarvae at the stations under investigation in 1968

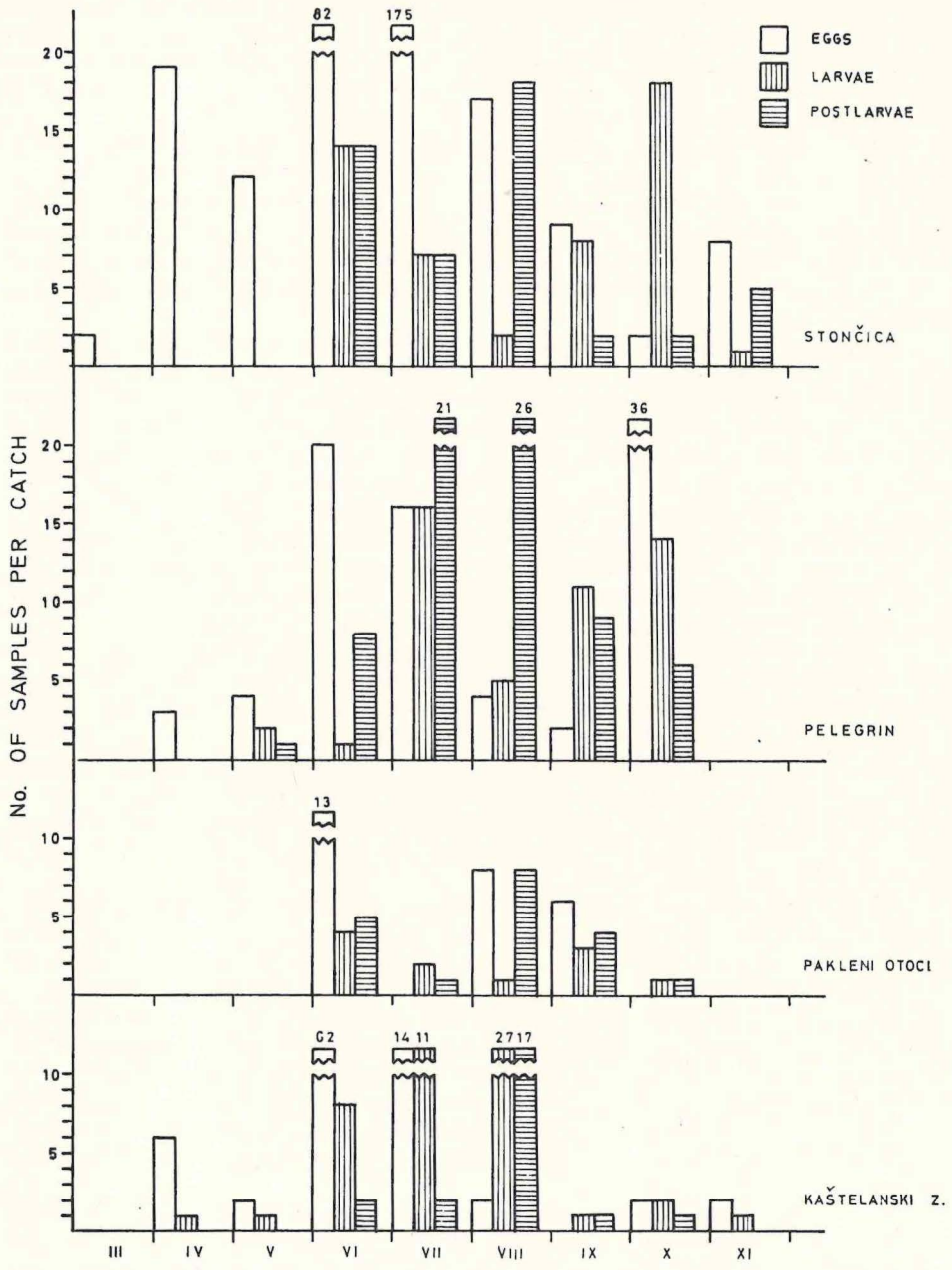


Fig. 5. Quantitative distrubution of the anchovy eggs, larvae and postlarvae at the stations under investigation in 1969

Judging by the fact that the anchovy eggs, larvae and postlarvae could be found for a longer period in the plankton all over the area under investigation, and also because the number of the larvae and postlarvae was greater in 1969, it can be concluded that that year was more favourable for the spawning of this fish than was the previouns year.

One of the reasons for a longer occurrence of the planktonic phase of the anchovy in 1969 was probably the sea temperatures which were higher in March, October, and November of that year than they had been the year before. In March the sea temperature at Stončica was 14.22°C in 1969 and 13.35°C in 1968. In the October and November od 1969 the temperatures on the profile, under investigation varied from 19.40 to 22.12°C and in 1968 from 15.90 to 20.63°C.

During both years the maximum of the eggs was found in the vicinity of the mainland, at the station Kaštelanski zaljev, in June. At the station Stončica in 1968 two maxima were registered: the absolute one in May and the relative one in September; and in 1969 one during the June—July period (Fig. 4 and 5). The phenomenon of separated maxima of the anchovy had been stated in the Golfo di Venezia by Varagnolo (1964 and 1965). The difference in the occurrence of the maxima in our region was, probably, caused by the seasonal variations of the abiotic factors, temperature and density in the first place. In the June, July and August of 1968 these were off the optimal limits and reached them again in September. This resulted, probably, in the occurrence of a greater number of eggs in September.

In 1968 the maximum of the larvae occurred in June and August and in 1969, in addition to these months, also in September and October. The maximum of the postlarvae was found in June, August and October 1968 and in June, August and November 1969. (Fig. 4 and 5).

The temperature and salinity limits, within which the anchovy eggs, larvae and postlarvae occured, as well as the optima of these factors for the mentioned stages (Chapter 4.5 and Tab. 12 and 13) coincide mainly with the data given by some earlier authors (Fage, 1920; Vučetić, 1957; Karlovac J., 1963; Dehnik, 1963).

Our results show that the anchovy eggs and postlarvae in the Kaštelanski zaljev reach their maximum within the water salinity and density limits, which are lower than those at the other stations (Tab. 13 and 14). This might suggest that the anchovy in the Kaštelanski zaljev, represents, probably, a separate group. The data which Mužinić (1956) obtained in her investigations speak in favour of this hypothesis, i.e., that the adult anchovy in the vicinity of the mainland is smaller than that of the open sea. Karlovac J. (1967) has found a similar phenomenon regarding the sardine. When investigating into the ecology of the planktonic stages of the sardine, she has set the hypothesis that in the channel region a separate population of this fish existed.

The anchovy eggs, larvae and postlarvae reached their maximum within a very narrow range of the sea water density, narrower than that of salinity and temperature. This phenomenon was especially well pronounced in eggs

where the range of the optimal temperature was 3.93°C and of salinity 1.40‰, at the station Kaštelanski zaljev, and 1.10‰ at the other stations. On the other hand the water density varied by only 0.68 σt at the station Kaštelanski zaljev and by 0.76 σt at the the other stations. It may be thus concluded that density is one of the major factors that is controlling the distribution and abundance of the anchovy eggs.

By basing it on the investigations with the closing net we have stated that beyond the depth of 25 m no live anchovy eggs exist. The highest concentration of live anchovy eggs was found in the layer 0 to 10 m deep. The obtained results coincide with those Vučetić (1957), Varagnolo (1965), and Specchi (1968) found for the Adriatic. The results of our investigations have shown that neither the larvae nor the postlarvae of the anchovy can be found beyond the depth of 25 m and that their greatest concentration lies in the layer 10 to 20 m deep. Similar results were obtained by Fage (1920), Dehnik and Sinjokova (1964) for the Mediterranean and by Specchi (1968) for the Bay of Trieste. According to our results, at night and in the morning hours the larvae and postlarvae are in the layer 0 to 10 m deep, and they can not be found there by day. On the other hand, during the day their number increases in the layer between 20 to 30 m deep, which points to the existence of the day-night migration of this species in the investigated region. (Tab. 2-5).

The mean values of the larger and smaller diameter of the anchovy eggs have been calculated from only a small number of samples from the catches collected during the April, May and July of both years, and they show that the eggs were smaller in May and July than in April (Tab. 6). According to Ehrenbaum (1905-1909) Dietz has already noticed this phenomenon in the anchovy. Nikolski (1963) has stated that the variety in the size of the fish eggs is due to the very early spawning of the older year classes which give the largest eggs, while the younger ones spawn later. Mužinić (1956) has found that in the adult anchovy in the Adriatic the gonads of the larger samples mature earlier than do those of the smaller ones. When comparing it with our findings, this might suggest that the older year classes spawn earlier. Our results have shown that also the increase in temperature could affect the size of the eggs in reverse sense (Fig. 6). According to Lugovaja (1963a) Fish (1928) has found that the higher the water temperature is, the smaller are the eggs of the pelagic fish.

The analysis of the dead eggs distribution per embryonal stages has shown that their number is the greatest in the earlier stages and that it decreases with the progress in the development of the embryo (Tab. 6-9). This finding coincides thoroughly with the findings of Dehnik (1963a) who has found a similar phenomenon in the Black Sea anchovy.

The results of measuring the lengths of the anchovy larvae and postlarvae show that at the length interval from 2.81 to 3.93 mm there are 77.11% of larvae and 22.89% of postlarvae, which points to the fact that at this lenght

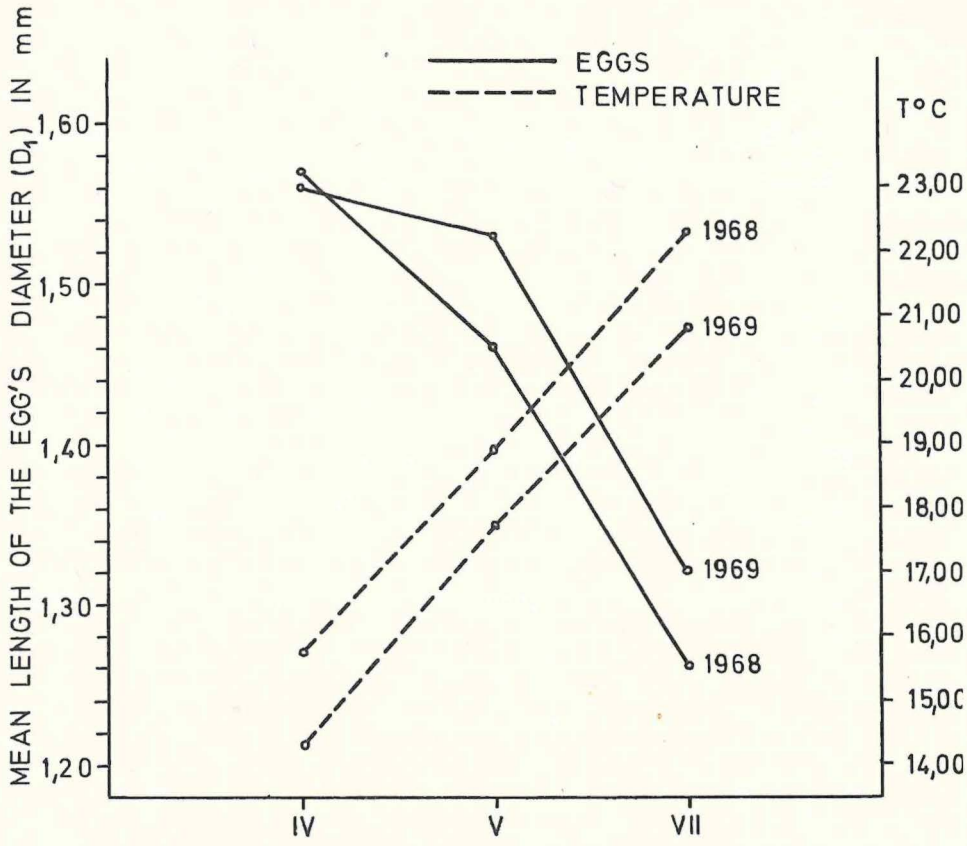


Fig. 6. Ratio between the anchovy egg's longer diameter (D_1) and the mean temperature values at the depth of Om at the stations Stončica and Pelegrin in April, May and July 1968 and 1969

interval the larva changes into the postlarval stage. Our results approach those found by D u k a (1963) who has established that, in the Adriatic, this transition occurs at the length from 3.1 to 3.5 mm.

The mean walues of the lengths of the larvae from the material collected from the April to July of 1968 and 1969 show that their size decreases from April towards July, i.e. from the beginning to the end of the spawning season (Tab. 16). These results point out that, probably, from the smaller eggs smaller larvae develop.

Table 16. Mean lengths of the anchovy larvae from April to July of 1968 and 1969. Lengths are in mm

	Months			
Year	IV	V	VI	VII
1968	3.86	3.60	2.97	2.93
1969	—	3.65	2.92	3.09

The results of the classification of the anchovy larvae and postlarvae into length groups of 2, 4, 6 and 8 mm have shown that the number of samples in the 4 mm group, in which are the postlarvae that feed only actively, decreases suddenly in relation to the number of samples from the 2 mm group, in which the larvae and postlarvae have passed over to active feeding only recently. The decrease in the number of the 4 mm group with regard to those of the 6 and 8 mm groups is not so abrupt any more. This phenomenon has been prominent at all the stations and during all the months of investigation. (Fig. 7 and 8). From the enclosed histograms it is visible that the sudden decrease in the number of samples of the 4 mm group in relation to the 2 mm group shows that the anchovy in the Central Adriatic has a well marked »critical period« during the transition from the larval into the postlarval stage, i. e. the transition from the passive into the active feeding.

Marr (1956) cites the hypothesis on the existence of the »critical period« in the early phases of the life history of fishes set by Hjort (1914). He says that Hjort considers that the »critical period« starts after the yolk sac has been resorbed, i.e. when passing over onto the active feeding, due to lack of food. In his critical review of Hjort's hypothesis Marr thinks that no categorical answer is possible as to the question of the existence of the »critical period«, because the small number of the existing evidence points more to the existence of a constant mortality rate than to the large-scale mortality in a short period of time.

However, the »critical period« of the sardine in the Adriatic is the turn from the larval into the postlarval stage (Karlovac J., 1967), and our data also point to its existence in the anchovy at the same stage of the ontogenetic development. On the other hand, Dehnik (1963a) has found that in the Black Sea anchovy the highest mortality rate occurs at the time when larva feeds on the yolk. This variety might be explained by the fact that the postlarvae in the Black Sea have larger quantities of food at their disposal. Namely, Duka (1963) has stated, that in the Adriatic there are 6,000 organisms to a postlarva to feed on; and in the Black Sea 11-19,000. Nakai et al. (1966) have found that the numerousnese of the anchovy postlarvae in the region of the Japanese waters depends more upon the number of the nauplii of the copepoda present, i.e. food, than on the number of the eggs spawned.

The greatest number of the postlarvae from the length groups of 4,6 and 8 mm has been found at the stations Stončica and Pelegrin between June and August, and by basing it on this fact it can be concluded that in those months the conditions for the development are, probably, more favourable. In 1969 the older length groups were represented in a greater number in September and October, which proves that the increased temperature is also one of the factors

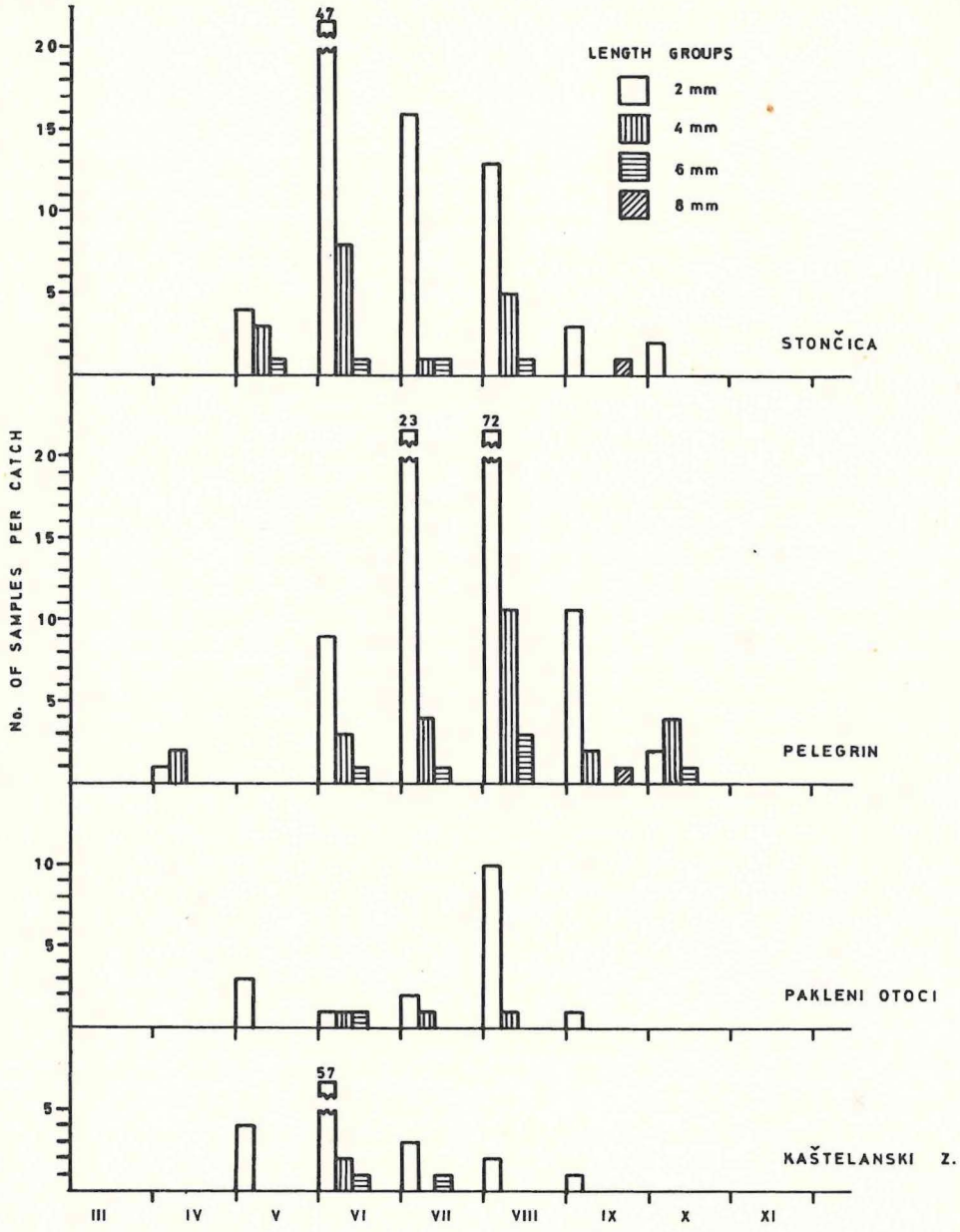


Fig. 7. Distribution of the length groups of the anchovy's larval stages at the stations under investigation in 1968

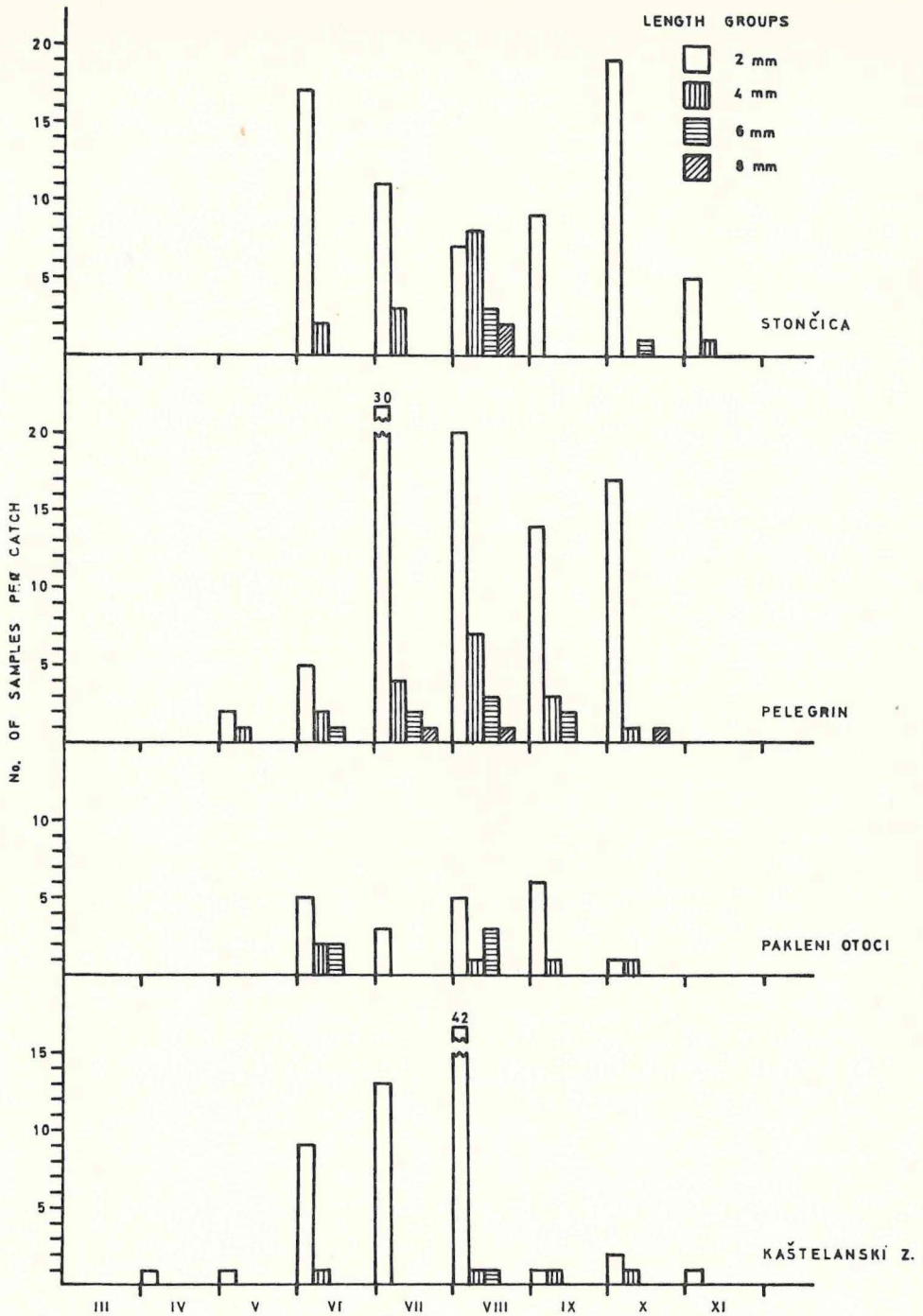


Fig. 8. Distribution of the length groups of the anchovy's larval stages at the stations under investigation in 1969

that affect favourably the development of the postlarvae. At the station Kaštelanski zaljev the 2 mm length group is well represented, however, the postlarvae from the older length groups are very few, and on this basis it can be concluded that the conditions for the development of the postlarvae in this area are less favourable. One of the causes is, probably, an abrupt change in the water salinity and density that has been recorded at this station.

A somewhat greater total number of samples from the 6 and 8 mm groups found in 1969 could yet be another proof that year was more favourable to the anchovy than the previous one.

CONCLUSIONS

1. It has been stated that the planktonic stages of the anchovy were found in the plankton in 1968. from April to October, and in 1969 from March to November.

2. The difference in the duration of the occurrence of the anchovy eggs has been established. In 1969 the occurrence of the eggs on the profile under investigation began one month earlier and it lasted one month longer than in 1968.

3. The anchovy eggs have attained their numerical maximum in the period June-July of both years, except in 1968 at the station Stončica when two maxima were registered, i.e. in May and September.

4. It has been stated that the anchovy eggs predominate at the station Stončica while at the other stations they constitute a stronger component.

5. It has been found that the concentration of the anchovy eggs is the densest near the surface, down to the depth of 10 m.

6. It has been stated that the size of the anchovy eggs decreases from the beginning towards the end of the season of their occurrence.

7. The greatest number of dead eggs was found in the first embryonal stages.

8. The occurrence of the anchovy larvae and postlarvae on the whole area under investigation has been stated from April to Nowember, however, they kept longer in the plankton in 1969 (from April to Nvember) than in 1968 (from April to October).

9. In 1968 the maximum in the occurrence of the anchovy larvae has beeen recorded in June and August, and in 1969 in June, August and October.

10. In 1968 the maximum in the occurrence of the anchovy postlarvae has been recorded in June, August, and October, and in 1969 in June, August and November.

11. The concentration of the anchovy larvae and postlarvae has been stated in the layer 10 to 20 m deep, while in the layer 0 to 10 m deep they occur only at night.

12. The transition of the anchovy from the larval into the postlarval stage, i.e. from the passive into the active feeding occurs at the lengths from 2.81 to 3.93 mm.

13. The mean length of the anchovy larvae decreases from April towards July, i.e.., from the beginning towards the end of the season of their occurrence.

14. It has been stated that the »critical period« occurs on the turn from the larval into the postlarval stage, namely, at the transition from the passive into the active feeding.

15. The occurrence of the anchovy eggs in the area under investigation was registered within the temperature limits from 13.17 to 23.70°C, however, the maximum of eggs was found at the narrower temperature interval from 18.30 to 22.12°C.

16. It has been stated that the anchovy larvae occurred in the plankton at the temperature from 13.17 to 23.70°C, and the postlarvae from 15.59 to 23.70°C. Both the larvae and postlarvae attained the maximum of occurrence at the temperature from 20.93 to 23.70°C.

17. It has been stated that the high temperature in 1969 was one of the causes of a longer duration of the occurrence of the anchovy's planktonic stages than in 1968.

18. It has been found that the size of the anchovy eggs is in reverse proportion to the height of the sea temperature.

19. It has been stated that the anchovy eggs occurred at the salinity from 33.86 to 38.69‰. The maximum of ccurrence of the eggs at the outer stations was found within the salinity limits from 37.79 to 38.69‰, and at the station Kaštelanski zaljev from 34.52. to 35.71‰.

20. The maximum of the anchovy larvae was found at the outer stations within the salinity limits from 37.27 to 38.57‰, and at the station Kaštelanski zaljev from 35.71 to 37.99‰, and of the postlarvae at the outer stations within the salinity limits from 37.54 to 38.62‰, and at the station Kaštelanski zaljev from 35.71 to 35.95‰.

21. The occurrence of the anchovy eggs was stated within the water density limits from 24.13 to 28.97 σt. The maximum of the egg occurrence was found at the outer stations within the density limits from 26.63 to 27.39 σt, and at the station Kaštelanski zaljev from 24.13 to 24.81 σt.

22. The maximum of the occurrence of the anchovy larvae was found at the outer stations within the water density limits from 24.85 to 26.98 σt, at the station Kaštelanski zaljev from 24.46 to 26.80 σt, of the postlarvae at the outer stations within the density limits from 25.90 to 26.78 σt, and at the station Kaštelanski zaljev from 24.46 to 24,81 σt.

23. It has been found that the limits of the water salinity and density within which the maximum of the planktonic stages of the anchovy occurs are lower at the station Kaštelanski zaljev than at the other stations, which might probaly suggest the hypothesis that the anchovy in this region represents a special group.

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PRILOG POZNAVANJU EKOLOGIJE PLANKTONSKE FAZE ŽIVOTA BRGLJUNA U SREDNJEM JADRANU

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KRATAK SADRŽAJ

Cilj ovoga rada je istraživanje horizontalne i vertikalne distribucije jaja, larava i postlarava brgljuna, *Engraulis encrasicolus* (Linnaeus 1758) u srednjem Jadranu, kao i istraživanje njihova odnosa prema abiotskim faktorima. Sakupljanje zooplanktonskog materijala vršeno je na profilu Kaštelanski zaljev — Pelegrin — Pakleni otoci — Stončica od siječnja 1968. do prosinca 1969. godine. Uzorci su uzimani na četiri postaje planktonskom mrežom tipa »Helgoland« jedan put mjesečno da bi se ispitala horizontalna distribucija jaja, larava i postlarava brgljuna u prostoru i vremenu. Mrežom na zapor uzimani su uzorci po slojevima u srpnju i kolovozu obje godine istraživanja na postaji »Stončica«, da bi se ispitala vertikalna raspodjela jaja, larava i postlarava brgljuna. Mrežom tipa »Helgoland« uzeto je ukupno 90, a mrežom na zapor 66 uzoraka.

Jaja brgljuna su se javljala na istraživanom profilu od ožujka do studenog, ali je njihova pojava u 1968. uslijedila mjesec dana kasnije (u travnju) i prestala mjesec dana ranije (u listopadu) nego u 1969. godini. Maksimum jaja je zabilježen u periodu lipanj — srpanj tokom obje godine istraživanja, ali su 1969. na postaji »Stončica« nađena dva maksimuma i to u svibnju i rujnu. Ustanovljeno je, također, da je broj jaja tokom obje godine najveći na postaji »Stončica« i da njihova pojava ranije počinje i duže traje na ovoj postaji nego na ostalim, koje su bliže kopnu. Postotak jaja brgljuna u odnosu na broj jaja ostalih riba opada od postaje »Stončica«, gdje iznosi preko 60%, prema postaji »Kaštelanski zaljev« što pokazuje da jaja brgljuna dominiraju na području izloženom utjecaju otvorenog mora za vrijeme njihove pojave u planktonu.

Larve brgljuna, kao i poslarve, javljaju se u planktonu od travnja do studenog. U 1968. godini njihova pojava je trajala mjesec dana kraće (do listopada) nego u 1969. Larve, kao i poslarve brgljuna, najbrojnije su na postaji »Pelegrin«, manje ih je na postajama »Stončica« i »Kaštelanski zaljev«, a veoma malo na postaji »Pakleni otoci«. Maksimum larava nađen je 1968. u lipnju i kolovozu, a 1969. u lipnju, kolovozu, rujnu i listopadu, dok je maksimum postlarava nađen u 1968. u lipnju, kolovozu i listopadu, a u 1969. u lipnju, kolovozu i studenom.

Istraživanja zapornom mrežom su pokazala da se jaja brgljuna nalaze u najvećem broju u sloju od 0 do 10 m, a larve i postlarve u sloju od 10 do 20 metara dubine. Larve se, kao i postlarve, javljaju u blizini površine samo noću, dok se njihov broj povećava u popodnevnim satima na dubini većoj od 20 m, što pokazuje da postoji dnevno-noćna migracija larvalnih stanja brgljuna.

Rezultati mjerenja većeg i manjeg promjera jaja, kao i dužine larava, na materijalu sakupljenom od travnja do srpnja tokom obje godine na postajama »Stončica« i »Pelegrin« pokazali su da se veličina jaja i larava smanjuje od travnja prema srpnju. Utvrđeno je da je veličina jaja obratno srazmjerna temperaturi morske vode. Usporedba između broja živih i mrtvih jaja u svaokm pojedinom stadiju pokazala je da je broj mrtvih jaja najveći u ranijim stadijima.

Utvrđeno je da se prijelaz sa stadija larve u stadij postlarve vrši u intervalu dužine od 2,81 do 3,93 mm. Analiza odnosa između broja larava i postlarava brgljuna svrstanih u dužinske skupine od 2, 4, 6 i 8 mm pokazala je da se broj primjeraka iz skupina od 4, 6 i 8 mm naglo smanjuje u odnosu na skupinu od 2 mm u kojoj se nalaze larve i postlarve koje su tek resorbirale žumančanu kesicu. Ta pojava pokazuje da postoji »kritičan period« pri prijelazu s pasivne na aktivnu ishranu.

U ovom radu izvršena su ispitivanja odnosa između planktonske faze brgljuna i abiotskih faktora. Granice temperature unutar kojih su utvrđena jaja i larve brgljuna kretale su se od 13, 17 do 23,70° C. Postlarve su nađene u granicama temperature od 15,93 do 23,70° C. Granica saliniteta unutar kojih su se pojavljivala jaja bile su od 33,86 do 38,69° C, a za larve i postlarve zabilježene su od 32,70 do 38,69° C. Gustoća vode je prilikom pojave jaja varirala od 24.13 do 28.89 σt, a za larve i postlarve od 22.42 do 28.34 σt.

Nađene su i optimalne granice temperature, saliniteta i gustoće vode unutar kojih se javlja maksimum jaja, larava i postlarava.

Utvrđeno je da sezonsko kretanje temperature utječe na dužinu trajanja pojave jaja, larava i postlarava brgljuna, kao i na vrijeme pojave njihova maksimuma. Više temperature u rujnu, listopadu i studenom 1969. godine su, izgleda, jedan od uzroka što su se planktonski stadiji brgljuna nalazili u većem broju u rujnu i listopadu, a i njihove pojave u studenom te godine.

Optimalne granice saliniteta za jaja, larve i postlarve brgljuna su niže na postaji »Kaštelanski zaljev« nego na ostalim postajama, a maksimum jaja je, također, nađen unutar nižih granica gustoće na toj postaji. Na osnovu toga bi se moglo zaključiti da brgljun koji se mrijesti na području Kaštelanskog zaljeva ima drugačiju ekološku valenciju od onoga koji se mrijesti na području ostalih postaja i da, vjerojatno, predstavlja posebnu grupu.

APPENDICES I - IV

Appendix I Stončica Station 1968

Date	Hour	Sediment in cm³	Total No. of fish eggs	Total No. of fish larvae & post-larvae	Anchovy — No.			Anchovy larvae & postlarvae, length gruops in mm				
					eggs	larvae	post-larvae	2	4	6	8	damaged
17. III	0855	60	71	100	0	0	0	0	0	0	0	0
18. IV	1235	75	29	7	3	0	0	0	0	0	0	0
17. V	1125	35	173	13	149	2	6	4	3	1	0	0
20. VI	1305	45	23	72	8	40	16	47	8	1	0	0
24. VII	1545	45	23	65	17	35	3	16	1	1	0	20
15. VIII	1829	30	27	25	2	5	14	13	5	1	0	0
26. IX	0935	30	86	7	75	2	2	3	0	0	1	0
16. X	0930	40	14	6	2	2	0	2	0	0	0	0
13. XI	1030	50	13	44	0	0	0	0	0	0	0	0

1969

Date	Hour	Sediment in cm³	Total No. of fish eggs	Total No. of fish larvae & post-larvae	Anchovy — No.			Anchovy larvae & postlarvae, length gruops in mm				
					eggs	larvae	post-larvae	2	4	6	8	damaged
21. III	1035	50	1133	58	2	0	0	0	0	0	0	0
10. IV	0930	33	72	30	19	0	0	0	0	0	0	0
13. V	0945	55	37	2	12	0	0	0	0	0	0	0
17. VI	0850	35	104	51	82	14	14	17	2	0	0	9
17. VII	1225	15	202	29	175	7	7	11	3	0	0	0
15. VIII	1140	40	26	37	17	2	18	7	8	3	2	0
9. IX	1000	45	11	13	9	8	2	9	0	0	0	1
8. X	1630	45	12	25	2	18	2	19	0	1	0	0
4. XI	1005	20	115	74	8	1	5	5	1	0	0	0

Appendix II Pelegrin Station 1968

Date	Hour	Sediment in cm³	Total No. of fish eggs	Total No. of fish larvae & post-larvae	Anchovy — No.			Anchovy larvae & postlarvae, length gruops in mm				
					eggs	larvae	post-larvae	2	4	6	8	damaged
15. III	1545	35	31	16	0	0	0	0	0	0	0	0
19. IV	1440	80	57	12	10	1	2	1	2	0	0	0
18. V	1450	25	62	10	6	0	0	0	0	0	0	0
21. VI	1220	30	63	29	1	8	5	9	3	1	0	0
25. VII	1355	35	73	67	16	21	7	23	4	1	0	0
16. VIII	1240	35	70	88	1	61	25	72	11	3	0	0
26. IX	1600	35	36	33	5	10	4	11	2	0	1	0
15. X	1230	45	51	35	0	2	5	2	4	1	0	0
12. XI	1215	45	15	37	0	0	0	0	0	0	0	0

1969

Date	Hour	Sediment in cm³	Total No. of fish eggs	Total No. of fish larvae & post-larvae	Anchovy — No.			Anchovy larvae & postlarvae, length gruops in mm				
					eggs	larvae	post-larvae	2	4	6	8	damaged
20. III	1420	45	25	47	0	0	0	0	0	0	0	0
8. IV	1340	40	51	7	3	0	0	0	0	0	0	0
12. V	1254	45	85	29	4	2	1	2	1	0	0	0
18. VI	1150	35	48	19	20	1	8	5	2	1	0	1
18. VII	1635	35	54	61	16	16	21	30	4	2	1	0
16. VIII	0925	65	44	80	4	5	26	20	7	3	1	0
10. IX	1230	45	22	53	2	11	9	14	3	2	0	1
7. X	1515	45	57	29	36	14	6	17	1	0	1	1
3. XI	1405	55	263	6	0	0	0	0	0	0	0	0

Appendix III Pakleni otoci Station 1968

Date	Hour	Sediment in cm³	Total No. of fish eggs	Total No. of fish larvae & post-larvae	Anchovy — No.			Anchovy larvae & postlarvae, length gruops in mm				
					eggs	larvae	post-larvae	2	4	6	8	damaged
19. IV	1635	18	34	4	1	0	0	0	0	0	0	0
18. V	1615	25	37	4	10	2	1	3	0	0	0	0
21. VI	1320	22	80	60	0	1	2	1	1	1	0	0
25. VII	1545	20	59	35	0	2	1	2	1	0	0	0
16. VIII	1420	15	51	23	0	8	3	10	1	0	0	0
26. IX	1510	15	23	5	0	1	0	1	0	0	0	0
15. X	1402	25	8	20	0	0	0	0	0	0	0	0
12. XI	1200	30	5	41	0	0	0	0	0	0	0	0

1969

Date	Hour	Sediment in cm³	Total No. of fish eggs	Total No. of fish larvae & post-larvae	Anchovy — No.			Anchovy larvae & postlarvae, length gruops in mm				
					eggs	larvae	post-larvae	2	4	6	8	damaged
8. IV	1515	27	32	23	0	0	0	0	0	0	0	0
12. V	1442	22	110	8	0	0	0	0	0	0	0	0
18. VI	1100	20	66	31	13	4	5	5	2	2	0	0
18. VII	1300	13	32	9	0	2	1	3	0	0	0	0
16. VIII	1105	32	41	46	8	1	8	5	1	3	0	0
10. IX	1150	17	34	14	6	3	4	6	1	0	0	0
7. X	1635	20	15	5	0	1	1	1	1	0	0	0
3. XI	1550	15	7	9	0	0	0	0	0	0	0	0

Appendix IV Kaštelanski zaljev Station 1968

Date	Hour	Sediment in cm³	Total No. of fish eggs	Total No. of fish larvae & post-larvae	Anchovy — No. eggs	larvae	post-larvae	Anchovy larvae & postlarvae, length gruops in mm 2	4	6	8	damaged
1. IV	1409	5	9	0	0	0	0	0	0	0	0	0
3. V	1249	25	86	23	26	4	0	4	0	0	0	0
6 VI	1042	70	270	535	47	37	23	57	2	1	0	0
27. VII	0721	20	54	42	2	3	1	3	0	1	0	0
18. VIII	0805	15	42	13	1	1	1	2	0	0	0	0
30. IX	0720	30	44	11	2	1	0	1	0	0	0	0
19. X	0805	20	6	12	0	0	0	0	0	0	0	0
16. XI	0820	15	10	6	0	0	0	0	0	0	0	0

1969

Date	Hour	Sediment in cm³	Total No. of fish eggs	Total No. of fish larvae & post-larvae	Anchovy — No. eggs	larvae	post-larvae	Anchovy larvae & postlarvae, length gruops in mm 2	4	6	8	damaged
14. IV	0815	15	52	8	6	1	0	1	0	0	0	0
15. V	0810	15	116	21	2	1	0	1	0	0	0	0
20. VI	0700	15	220	107	62	8	2	9	1	0	0	0
21. VII	0925	15	65	28	14	11	2	13	0	0	0	0
18. VIII	0813	15	28	57	2	27	17	42	1	1	0	0
12. IX	1050	15	26	20	0	1	1	1	1	0	0	0
6. X	1110	15	27	24	2	2	1	2	1	0	0	0
7. XI	0845	15	38	6	2	1	0	1	0	0	0	0