ON THE ECOLOGY OF ANCHOVY, *ENGRAULIS ENCRASICOLUS* (L.), IN THE CENTRAL ADRIATIC

O EKOLOGIJI BRGLJUNA, *ENGRAULIS ENCRASICOLUS* (L.) U SREDNJEM JADRANU

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INTRODUCTION

Anchovy, *Engraulis encrasicolus* (L.), are rather widely distributed in the Adriatic, but at lesser depths. They were recorded between 32 and 210 m (mean depth 98 m) in the area of HVAR Fishery Biological Expedition during 1948 and 1949 (Mužinić, 1973).

Anchovy play an important role in the Yugoslav commercial fisheries. Between 1947 and 1971 the average annual anchovy catch amounted to 2,250 tons. The catch also fluctuated considerably (coefficient of variation was about 80 per cent) and showed a rising trend (Mužinić, 1974).

Even though anchovy have a great commercial importance their ecology is not sufficiently known, especially their adult stage. Particular attention was, therefore, given to the anchovy length and sex distribution in the Mid-Adriatic commercial catches, their sexual cycle (on the basis of gonad state and gonosomatic ratio) and mesenteric fat fluctuations.

1. MATERIAL AND METHODS

Samples of anchovy catches were taken from the Kaštela Bay (the most inshore coastal waters) and from the region of Vis and Biševo Islands (open waters). In these areas anchovy are caught by purse seines, under artificial light, during darks of the moon. Majority of the fish analysed was obtained directly from fishermen and smaller proportion bought on the fish market.

Material was mainly collected during the 1974 fishing season and to a smaller extent during the 1975 one.

Representative samples were used for studies of length and sex distribution, state of gonads, quantity of mesenteric fat (approximately), and, partly, gonad weight and gonosomatic ratio.

Data on fish length in millimetres were placed in halfcentimetre groups. Lower class limits were used and means were corrected.

Data on the anchovy length refer to their total length. Standard length was used only when studying their length-weight relationship.

Sex was rather easily determined. The only exception were the smallest individuals belonging to the inactivity period of the sexual cycle whose sex was rather difficult to determine at the routine analysis.

The empiric scale applied by Mužinić (1954) in the analysis of sardine maturation was used for macroscopic estimation of gonad state. Fluctuations in gonad weight and gonosomatic ratio were also studied. Body weight is given in decigrams and gonad weight in centigrams.

Mesenteric fat amount was observed using the empiric scale applied earlier in sardine studies (Le Gall, 1930; Mužinić, 1954).

2. LENGTH DISTRIBUTION

Data on the length distribution of commercial catches from the coastal zone (Kaštela Bay) and the open Mid-Dalmatian waters (the region of Vis and Biševo Islands) were collected in 1974, mainly during the fishing season

2.1. *Results*

Kaštela Bay

Eight samples of catches with a total of 877 individuals were examined. Five of them were taken in the spring (April, May and June), the one in March and two in December 1974. Unfortunately, we were not able to work out the samples from July to November.

Catches were realized in the rather shallow north-western part of the Kaštela Bay.

Fish total length varied from 10.0 to 16.9 cm with means from 11.0 (1 April 1974) to 15.1 cm (14 March 1974) (Table 1). Length ranges were rather small in almost all the samples except for the sample realized on 24 April 1974.

Length distribution curves were for the most part unimodal and almost symmetric (Fig. 1). Dominant modal lengths varied from 10.5 (1 April 1974) to 15.5 cm (14 March 1974). Sample of catch realized on 24 April showed a secondary mode at 15.5 cm besides the dominant mode at 11.0 cm.

The largest fish were recorded about the middle of March and the smallest fish at the beginning of April. An increase in the length of fish took place between the beginning of April and the middle of June.

Vis and Biševo Islands

Six samples of catches with a total of 465 individuals were analysed between the latter half of May and the latter half of November 1974 These catches were taken around three submarine banks in the south-western part of the region.

Fish total length ranged from 12.8 to 18.7 cm, means varying from 14.9 (22 May 1974) to 16.8 cm (17 August 1974) (Table 2).

Length distribution curves were partly bimodal, one was even polymodal (Fig. 2). They were predominantly asymmetric.

Dominant modes ranged from 14.0 to 16.5 cm.

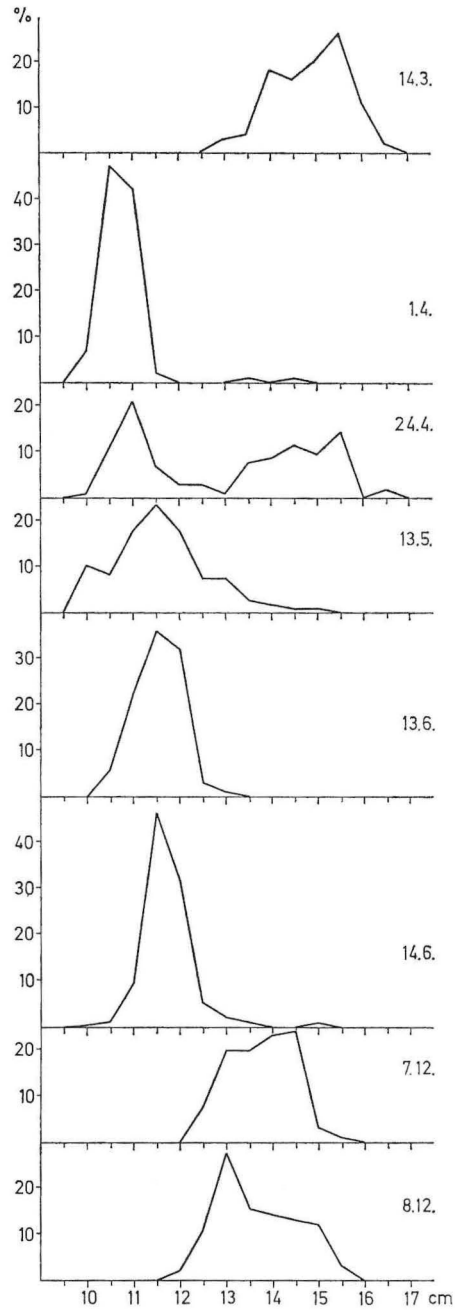

Fig. 1. Anchovy length distribution in the samples of catches from the Kaštela Bay 1974

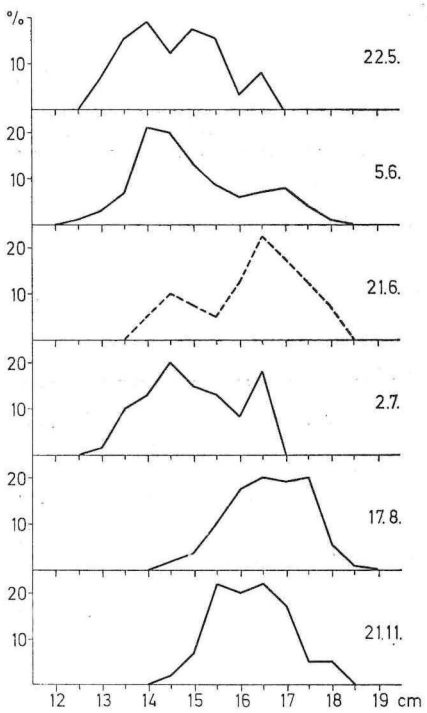

Fig. 2. Anchovy length distribution in the samples of catches from the Vis and Biševo Islands region (dashed line since 21 June sample included small number of individuals), 1974

2.2. *Discussion*

The data showed that the length of fish from the open Adriatic (12.8 — 18.7 cm) exceeded that of fish from the coastal waters (10.0 — 16.9 cm). The same was reported by Mužinić (1956) when analysing the anchovy length distribution of the trawl catches from the middle and southern Adriatic during the trawling season 1954—1955. Similar was recorded in the western Mediterranean anchovy over the period 1949—1951 (Bas and Morales, 1954).

Differences in the anchovy size are likely to be indicative of a certain relationship between the fish size and depth. During the trawling season 1954—1955 larger fish were recorded at depths greater than 70 m (Mužinić, 1956). Out of the data from the HVAR Expedition which in 1948 and 1949 carried out the observations mainly in the open waters (rarely in the shallow extreme northern Adriatic) it was shown that the smallest total length of anchovy from the bottom trawl catches reached 10.5 cm (Mužinić, 1972, according to unpublished data of O. Karlovac). Moreover,

anchovy length rarely exceeded 15.5 cm at depths up to 100 m and it amounted up to 16.5 cm at depths exceeding 130 m with a few exceptions.

Length distribution of samples of catches from the rather shallow north-western Adriatic (Fano) showed 6.0 — 14.8 cm fish, i. e. entirely smaller anchovy (Piccinetti, 1971). Small fish (5.2 — 11.0 cm) were reported to occur in the shallow waters of Israel as well (Ben — Tuvia, 1953). In the Bay of Catania, however, where depths range between 20 and 105 metres, anchovy length was 10.8 — 17.0 cm (Dulzetto, 1938).

In the area surveyed the length ranged from 10.0 to 18.7 cm. Some preliminary observations showed smaller anchovy. The smallest individuals recorded were 8.6 cm. Similar anchovy length range, i. e. of 8.2 — 18.2 cm was found by Mužinić (1972).

The length range in anchovy from the samples of the Kaštela Bay catches was sometimes very narrow (1.5 cm) but sometimes very wide (6.5 cm). In contrast, the length range was considerably narrower in the samples from the Vis and Biševo Islands region (3.5 — 5.5 cm).

2.3. *Conclusions*

Total length of anchovy from the Kaštela Bay and the Vis and Biševo region taken during the 1974 fishing season varied from 10.0 to 18.7 cm, with means 11.0 — 16.8 cm.

Mean lengths of anchovy from the Vis and Biševo region were greater (14.9 — 16.8 cm) than those of anchovy from the Kaštela Bay (11.0 — 15.1 cm).

Differences in the anchovy size between the two regions are probably indicative of a certain relationship between the fish size and depth.

Length range differred considerably between the individual samples of the Kaštela Bay catches, what was not the case with the catch samples from the region of Vis and Biševo Islands.

3. LENGTH DISTRIBUTION OF MALE AND FEMALE ANCHOVY

Differences between the male and female anchovy length distribution were studied on the samples of catches taken from the region of Vis and Biševo Islands in June, August and November 1974, as well as on the samples of May and the latter half of June although they comprised a smaller number of individuals. All the samples together counted a total of 465 individuals, 217 males and 248 females. We made no use of the samples from the Kaštela Bay catches since the sex of small fish is particularly difficult to determine at the routine analysis.

3.1. *Results and discussion*

The data covering male and female length distributions are presented in Table 3 and Figure 3. Mean lengths for both sexes are also given (Table 3).

Total male length ranged from 13.1 to 18.7 cm, and female length from 12.8 to 18.4 cm.

In some individual catches there were small differences between the male and female mean lengths (0.2, 0.3, and 0.4 cm) but in some this difference was greater (0.6 and 0.8 cm) in favour of females. Total difference was 0.3 cm.

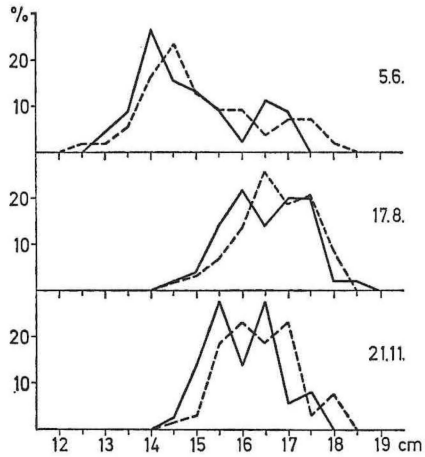

Fig. 3. Male and female anchovy length distribution in the samples of catches from the Vis and Biševo Islands region, 1974

Female modal lengths exceeded for 0.5 cm those of males.

Anchovy of the eastern Spanish coast showed on the whole similar difference (0.4 cm) in favour of females between June 1949 and August 1951 (B a s and M o r a l e s, 1954). However, differences in individual catches varied more, from 0.2 to 1.5 cm. In some of the samples of catches males were larger (the catch of August 1950 which also showed a bimodal length distribution).

3.2. *Conclusions*

There was not much dfiference between the male and female mean lengths in some of the samples of catches from the Vis and Biševo Islands region (0.2, 0.3, and 0.4 cm), but in some this difference was greater (0.6 and 0.8 cm). It was on the whole 0.3 cm in favour of females.

Female modal lengths exceeded for 0.5 cm those of males.

4. SEX RATIO

Sex ratio was studied on the samples from the region of Vis and Biševo taken between May and August, and in November 1974, i.e. mostly during the anchovy spawning period. Six samples of catches comprising a total of 465 individuals were analysed. The catches from the extreme coastal waters were not used since at routine sample analysis there occur some difficulties in determination of sex of the smallest individuals in an inactivity period of their sexual cycle.

4.1. *Results and discussion*

The numbers of each sex were about equal and varied from 36.0% males and 64.0% females (21 November 1974) to 58.3% males and 41.7% females (2 July 1974) (Table 4). Sex ratio was on the whole 46.7% males and 53.3% females.

Catches from the middle and southern Adriatic made during trawling season 1954—1955 comprised almost equal numbers of each sex, i. e. 52.3% (124) males, 47.3% (112) females and one hermaphrodite (Mužinić, 1956).

Between February and November 1960 Padoan (1963) recorded from the northern Adriatic anchovy the sex ratio 49.4% males to 50.6% females. Between February and October 1961 the same worker recorded 41.5% males and 58.5% females. This ratio given for both years was 45.9% males and 54.1% females.

Varagnolo (1968) examined 1,644 anchovy individuals from the northern Adriatic, during their spawning 1966, and found 48.6% males and 51.4% females. However, the sex ratio in individual samples varied to a considerable extent during the same period.

Varagnolo (1968) considered these variations due to anchovy behaviour during spawning and to capture conditions.

4.2. *Conclusions*

It was found that sex ratio differred between the individual samples from the Vis and Biševo Islands region. The most aberrant sex ratio was 36% males and 64% females.

In the material as a whole the numbers of each sex were about equal, 46.7% males and 53.3% females.

5. SEXUAL CYCLE

The sexual cycle of anchovy was analysed by a study of the state of gonads, as well as of gonad weight and gonosomatic ratio. Material was collected from the Bay of Kaštela and Vis and Biševo Islands region.

5.1. *State of gonads*

State of gonads was recorded from the samples collected during the fishing season 1974. Of a total of nine samples five were from the most inshore coastal waters (Kaštela Bay) and four from the open sea (Vis and Biševo Islands).

Maturity stages are given in accordance with the empiric scale used by Mužinić in sardine sexual cycle studies. Scale comprises seven maturity stages:

Stage I — Gonads occupy less than a half of the visceral cavity. This stage is encountered in fish which have not yet reached first maturity.

Stage II — Gonads occupy about the half of the visceral cavity. Eggs are not visible to the naked eye.

Stage III — Gonads occupy more than a half of the visceral cavity. Opaque eggs are visible to the naked eye.

Stage IV — Gonads occupy about two thirds of the visceral cavity. Eggs are opaque.

Stage V — Gonads are filling the visceral cavity. Almost all the eggs are opaque.

Stage VI — Gonads are fully ripe. Milt and eggs are readily extruded with a slight pressure on the abdomen. Eggs are hyaline.

Stage VII — Fish have already spawned. Gonads are slack and reddish.

5.1.1. *Results*

Kaštela Bay

It was illustrated that the majority of samples of anchovy catches from the end of the winter and from spring, except for the one of the latter half of April, consisted largerly of fish which belonged to stages I and II. The more advanced stages, particularly stage V, were also recorded from the sample of April although stages I and II predominated (Table 5, Fig. 4). Fish given under stage VI were not encountered. The appearance of more advanced gonad state is likely to be due to a partial presence of larger fish in the sample of catch of the latter half of April (Table 1, Fig. 1).

The maturing was noted even in the smaller fish. To our regret we were not in a position to analyse the gonad state of anchovy from the later summer 1974. But between June and August 1975 we recorded the advanced stages IV, V and, to a smaller extent even VI, from the smallest anchovy what indicated that they also were maturing.

Data from December indicated an inactive period within the sexual cycle.

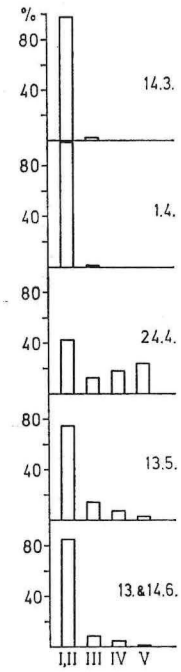

Fig. 4.

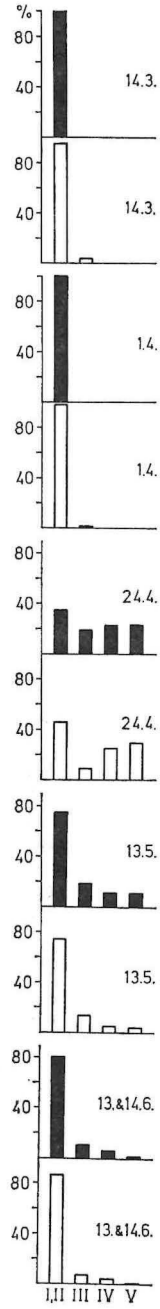

Fig. 5.

Fig. 4. Anchovy distribution as to the maturity stages in the samples of catches from the Kaštela Bay, 1974

Fig. 5. Male and female anchovy distribution as to the maturity stages in the samples of catches from the Kaštela Bay (black: males; white: females), 1974

Vis and Biševo Islands

Fish analysed for gonad state were caught in the region of Vis and Biševo Islands during the spring and summer (May-August) 1974. Table 6 and Figure 6 show that the advanced maturity stages were well represented in all the samples. But fish caught in July and August belonged to the more

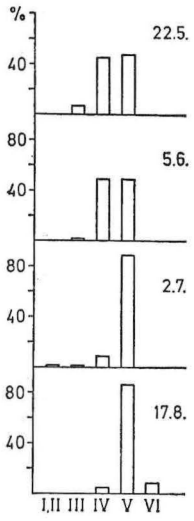

Fig. 6.

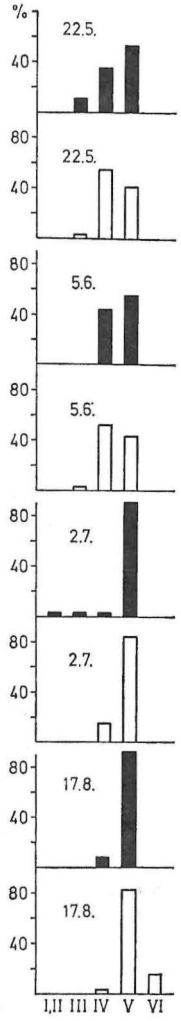

Fig. 7.

Fig. 6. Anchovy distribution as to the maturity stages in the samples of catches from the Vis and Biševo Islands region, 1974

Fig. 7. Male and female anchovy distribution as to the maturity stages in the samples of catches from the Vis and Biševo Islands region (black: males; white: females), 1974

advanced stages than fish captured in May and June. Thus, the spring is likely to be the period of an early maturation in anchovy at the given size, whereas the peak in their sexual activity occurs in the summer. During this early maturation males had more advanced state of gonads (Fig. 7).

Fish given under stage VI were rarely encountered. It is probable that we failed to identify this stage in some individuals at routine analysis, but it is in general rarely encountered.

5.1.2. *Conclusions*

From the data on gonad state it is apparent that the spring is the period of an early maturation and summer a peak in the sexual activity of anchovy at the given size.

During this early maturation gonads state was more advanced in males than it was in females from the Vis and Biševo region.

Data from December and March indicate winter to be the period of inactivity within the sexual cycle.

5.2. *Gonad weight and gonosomatic ratio*

Gonosomatic ratio is the percentage of gonad weight in body weight.

Data on gonad and body weight were collected on a monthly basis between March and December 1974. Unfortunately we were not able to analyse the samples of June and October.

5.2.1. *Results*

Means of gonad weight as well as of gonosomatic ratio are set out in Tables 7 and 8 and in Figure 8. They are given separately for males and females. Gonad weight and gonosomatic ratio rapidly increased from the middle of March to the latter half of April. This increase continued reaching a peak in August. Ovaries maximum weight was 1.81 g (17 August 1974). Maximum value of gonosomatic ratio 5.92% was also recorded in females (17 August 1974). Gonad weight and gonosomatic ratio were consistently greater in females.

From the middle of August to the middle of September gonad weight and gonosomatic ratio values rapidly decreased. This decrease probably continued through October since particularly low weights of gonads and values of gonosomatic ratio were recorded in November. They were even lower than those of March.

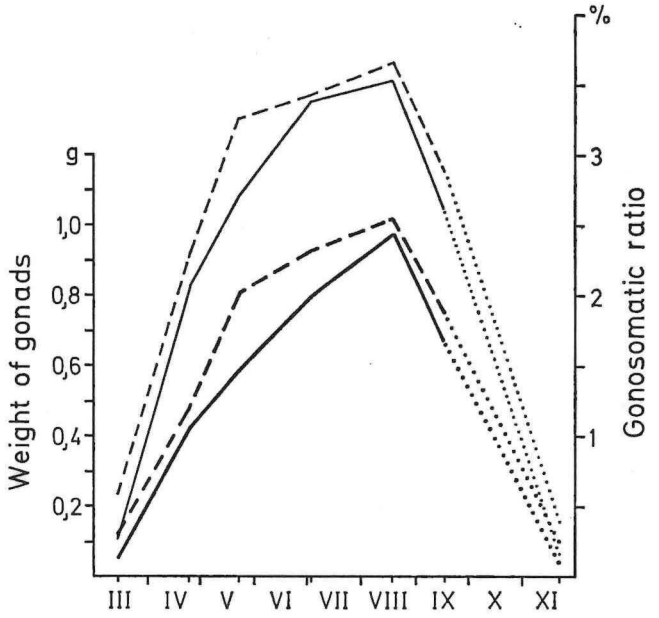

Fig. 8. Fluctuations in gonad weight (thick lines) and gonosomatic ratio (thin lines) of male (full lines) and female anchovy (dashed lines), 1974

5.2.2. *Conclusions*

A considerable increase in gonad weight and gonosomatic ratio was recorded from the middle of March to the latter half of May. Maximum gonad weight and gonosomatic ratio were encountered in August.

Low gonad weights and gonosomatic ratios recorded in November and March indicate the winter to be the period of inactivity within the anchovy sexual cycle.

Gonad weight and gonosomatic ratio were consistently greater in females.

5.3. *Discussion*

Maximum gonad weight and gonosomatic ratio as well as the more advanced state of gonads indicate that a peak in anchovy sexual activity takes place in the summer. This compares well with the majority of other workers' findings for the Adriatic anchovy spawning on the basis of the presence of their eggs, and eggs and larvae i the plankton.

The first records of eggs and larvae from the northern Adriatic plankton showed that anchovy spawned in the summer (Syrsky, 1876; Graeffe, 1888). According to Steuer (1910) northern Adriatic anchovy spawning took place from April to October. Stiasny (1910) established that they spawned in this area between June and September.

On the basis of eggs occurrence in the plankton Varagnolo (1964) concluded that northern Adriatic anchovy spawned from the first half of April until October 1961, with a relative peak in May and an absolute one in the last days of August and at the beginning of September.

Zavodnik (1969) found anchovy eggs in the plankton of the west Istrian coastal waters from May to September 1965.

Štirn (1969, 1970) recorded anchovy eggs from all the northern Adriatic between the beginning of May and the end of September 1965 with a peak in July and August.

The first reports on the anchovy spawning in the middle Adriatic on the basis of their eggs in the plankton were given by Gamulin (1940). Carrying out a more detailed surveys among the Mid-Dalmatian islands from June 1939 Gamulin found the anchovy eggs at all the stations although in very small numbers. At a fixed station in the Split Channel eggs were consistently present from April to the last days of August 1940. Maximum was recorded in May, July, and August.

On the basis of planktonic eggs records from the Mljet Lakes (sea water) Vučetić (1957) stated that anchovy spawned from May to September, hatching taking place between 7 and 9 p. m. Studying anchovy spawning close to Dugi otok in 1960 Vučetić (1964) found eggs maximum in June.

Over the period 1959—1969 Vučetić (1971) carried out the observations at three stations Kaštela Bay — Pelegrin (Hvar Islands western cape) — Stončica along the profile among the Mid-Dalmatian islands and found almost symmetric anchovy eggs distribution. Whereas eggs maximum recorded in June was prominent in samples from the coastal zone (Kaštela Bay) no marked maximum was recorded from the samples of catches from the channels and the open sea. However, the highest numbers of eggs were recorded between June and August at Pelegrin and between May and July at Stončica.

During 1968 and 1969 Regner (1972) found anchovy eggs and larvae in the plankton along the profile the Kaštela Bay — Pelegrin — Pakleni otoci — Stončica between April and October, and March and November respectively. Maximum for both years was recorded in June and July. The exception was the Station Stončica in 1968 with two maxima, i. e. in May and September. Regner (1972) also found the highest numbers of eggs at Stončica where they occurred earlier and later in the year than in waters closer to the mainland coast.

The larvae and postlarvae from the HVAR Fishery Biological Expedition collected in 1948 and 1949 from almost whole of the open Adriatic studied by Karlovac, J. (1963) indicate that anchovy spawned between May and November.

The Kaštela Bay and the region of Vis and Biševo Islands were probably the anchovy spawning grounds judging from the state of gonads as well as gonad weight and gonosomatic ratio in fish found there. On the basis of gonad state in the Kaštela Bay anchovy it seemed that only one part of the stock spawned. The data from the Kaštela Bay, however, referred to the samples of catches from the spring when entirely larger fish spawned. In contrast the samples from the summer 1975 used for the first maturity studies

showed that even the smallest fish had the advanced gonad condition and was to spawn in the Kaštela Bay.

Since considerable numbers of anchovy eggs (Vučetić, 1971; Regner, 1972), and of eggs and larvae (Karlovac, J., 1963) were found in the region of Vis and Biševo Islands it appears that anchovy did spawn there. Eggs (Vučetić, 1971; Regner, 1972) and larval phases (Karlovac, 1967) were more poorly represented in the Kaštela Bay.

Anchovy from the Vis and Biševo Islands region caught in May and June had a more advanced state of gonads than those from the Kaštela Bay. Since the samples of catches from the region of Vis and Biševo consisted mostly of larger fish (Tables 1 and 2, Figs. 1 and 2) such a difference indicates that sexual development started earlier in larger fish. This is in agreement with the data of Mužinić (1956) who noted that gonads of larger fish ripened earlier.

There is a close agreement between observations on an earlier development of gonads in the Adriatic anchovy and those for the other Mediterranean regions (Fage, 1911; Andreu and Rodríguez-Roda, 1951a; Bas and Morales, 1954). These data are also compatible with the observations of difference in size of eggs and larvae at the beginning and the end of spawning. As found by Regner (1972) eggs of Mid-Adriatic anchovy were smaller in May and July of both 1968 and 1969 than they were in April. He found the same for larvae in May, June and July of both years. Nikolsky (1963) considered this feature caused by differences in spawning time between various anchovy age groups.

Andreu (1950) observed that anchovy from Spanish waters rarely reached stage VI. The same was recorded during the present survey.

5.4. *Conclusions*

Anchovy showed intensive sexual activity in the late spring and summer, with a peak in August.

An early maturation was observed in spring.

November-March was the inactivity period within anchovy sexual cycle (data from December and March).

Gonad weight and gonosomatic ratio were consistently greater in females.

Sexual development started earlier in larger fish (from the region of Vis and Biševo Islands) than in smaller fish (from the Kaštela Bay).

6. FIRST SEXUAL MATURITY

To assess at which length anchovy mature for the first time the data on the gonad state in smaller fish collected from the Kaštela Bay in the spring-summer 1975 were used.

6.1. *Results and discussion*

All anchovy (64 males and 69 females) of the 12.0—12.9 cm length class had gonads in advanced state (stages IV, V, and to a smaller extent even VI) in May-August. During this time more advanced maturity stages were also noted in all the 11.0—11.9 cm length class fish (98 males and 77 females).

40 males and 19 females of the 10.0—10.9 cm class belonged to the advanced stages. However, it was not possible to detect any signs of sexual activity in two individuals (a male and a female) of this class captured in May and four (three males and a female) captured in June.

Having regard to that sexual development in smaller anchovy starts later during fishing season, it is possible that fish of May and June matured later, and even more so since all the 9.0—9.9 cm fish (five males and three females) of July and August had more advanced state of gonads. This was also recorded in two males of the 8.0—8.9 cm class.

The smallest male with signs of intensive sexual activity was 8.6 cm in length and the smallest female 9.7 cm. Thus, these investigations confirm that anchovy from the Kaštela Bay early reach first maturity, i. e. possibly at the end of the first year of age.

Mužinić (1956) found that Dalmatian anchovy showed at the beginning of the summer 1955 intensive sexual activity at a minimum total length, males at 10.3 and females at 10.9 cm.

Varagnolo (1968) observed fully ripe eggs in the majority of anchovy of 8.5 cm standard length captured from the northern Adriatic in May 1966. Fage (1920) concluded that Mediterranean anchovy reached first maturity at 12—13 cm in length. Vidalis (1949) recorded an intensive sexual activity in anchovy from Greek waters at 10.0 cm.

As found by Andreu and Rodríguez-Roda (1951) western Mediterranean anchovy were 11.1 cm (male) and 11.7 cm (female) in length at first maturity. The lengths of 11.8 (male) and 11.9 cm (female) were recorded from the same area by Bas and Morales (1954).

It is apparent from these data that male anchovy show intensive sexual activity at smaller length than females. This agrees with the data on the eastern Mid-Adriatic anchovy.

6.2. *Conclusions*

Mid-Adriatic anchovy early reach first sexual maturity, possibly at the end of their first year.

The smallest male showing intensive sexual activity was 8.6 cm in length and the smallest female 9.7 cm.

7. MESENTERIC FAT

Material studied at routine analysis for the mesenteric fat quantity was collected from the Kaštela Bay, and Vis and Biševo Islands region mainly during the spring-summer 1974.

Mesenteric fat quantity was estimated in accordance with the empiric scale used earlier by Le Gall (1930) and Mužinić (1954) in the studies of the Atlantic and Adriatic sardine respectively.

Scale comprises following five stages:

Stage 0 — Fish lean; no traces of mesenteric fat
Stage 1 — Fish very slightly fat; mesenteric fat quantity very low
Stage 2 — Fish slightly fat; mesenteric fat quantity still low
Stage 3 — Fish fat; mesenteric fat abundant
Stage 4 — Fish very fat; whole or almost whole of the alimentary tract covered by mesenteric fat

7.1. *Results*

Kaštela Bay

A total of 628 fish from five samples of the Kaštela Bay catches of March-June were analysed.

Fat quantity in anchovy caught about the middle of March was rather abundant, as stages 2 and 3 were predominant; later, i. e. in April, May, and June mesenteric fat quantity was lower (Fig. 9).

Even though the time between the analysis of fish from the middle of March and of fish from the beginning of April was not long, there was a significant difference between the former and the latter fish as to the mesenteric fat quantity. This difference was probably due to a difference in fish size (Fig. 1). Namely, fish caught about the middle of March were larger and had more mesenteric fat.

Vis and Biševo Islands

Six samples of catches with a total of 519 individuals collected between May and November were analysed.

It was shown that mesenteric fat quantity slightly decreased in July and particularly in August (Fig. 10). Mužinić (1954) reported that anchovy caught in the middle of August had no mesenteric fat at all.

Mesenteric fat quantity increased in September. Fish of November had the most abundant mesenteric fat with a highly predominant stage 4, such a predominance being not recorded in any other sample (in October sample was not obtained).

Fish caught from the Vis and Biševo Islands region in May had more mesenteric fat than fish caught from the Kaštela Bay the same month. This was also due to a difference in fish size, namely larger fish fat quantity was higher.

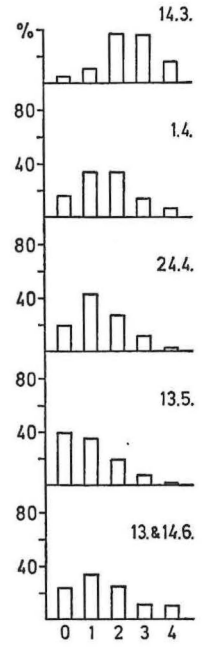

Fig. 9.

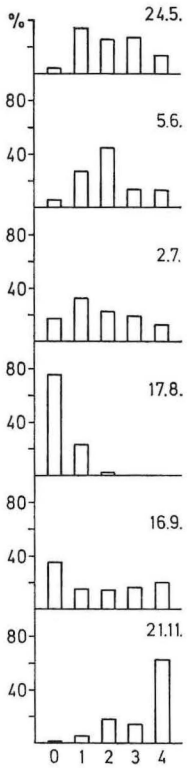

Fig. 10.

Fig. 9. Anchovy distribution as to the stages of mesenteric fat in the samples of catches from the Kaštela Bay, 1974

Fig. 10. Anchovy distribution as to the stages of mesenteric fat in the samples of catches from the Vis and Biševo Islands region, 1974

7.2. *Discussion*

Mesenteric fat fluctuations could not be compared well since the Kaštela Bay samples from the the second half of the year were missing. However, some differences were observed and they were likely due to a difference in fish size. Fish from Vis and Biševo Islands region were larger than fish from the Kaštela Bay and they had more mesenteric fat during the same months.

Data on mesenteric fat quantity in fish from the Vis and Biševo region as compared with those on gonad state as well as on gonad weight and gonosomatic ratio show that while mesenteric fat decreased in July and particularly in August fish were at maturity stage V (Fig. 6) and gonad weight and gonosomatic ratio means were at their highest (Fig. 8). Mesenteric fat quantity increased between September and November, i. e. during the period of decrease in gonad weight and gonosomatic ratio (the region of Jabuka Islet). The fluctuations in fat quantity in the warnem part of the year may therefore be

related to anchovy maturation. This presumption is supported by the fact that sardine from the same region which also feed on plankton, but, in contrast, spawn mainly in winter show quite different fluctuations in the mesenteric fat as comes out of the following comparison.

(i) Whereas in August anchovy from Vis and Biševo Islands had particularly low mesenteric fat quantity it was the highest in sardine from the same region (Krvarić and Mužinić, 1950);

(ii) While in May, fat in the Kaštela Bay anchovy began to decrease (Fig. 9) it started its increase from the lowest values in sardine (Krvarić and Mužinić, 1950);

(iii) September fat quantity increase in anchovy from the Vis and Biševo Islands region coincided with the beginning of decrease in sardine (Krvarić and Mužinić, 1950). This decrease in sardine mesenteric fat continued and finally disappeared in December and January, i. e. during the peak in sardine sexual activity (Mužinić, 1954). In contrast, fat quantity increased in anchovy in November (Fig. 10).

Fluctuations in sardine mesenteric fat were similar to the fluctuations in tissues fat content (Krvarić and Mužinić, 1950). Thus, we could presume that anchovy tissues fat content fluctuations might be similar to the fluctuations in mesenteric fat.

Antagonistic relation between gonad development and mesenteric fat accumulation was observed in anchovy, sardine, and gilt sardine from the eastern Spanish coast (Andreu and Rodríguez — Roda, 1951 b). Besides, minimum quantity of mesenteric fat in anchovy and gilt sardine coincided with its maximum in sardine. Both gilt sardine and anchovy spawn in the warmer part of the year whereas sardine mainly spawn in the winter. This agrees with the observations on Adriatic sardine and anchovy. Andreu and Rodríguez — Roda therefore concluded that fluctuations in fat quantity were related to the sexual cycle. This was confirmed later by Bas and Morales (1954) on the basis of data collected in July and August 1949, in June, July, and August 1950, and August 1951.

At the beginning of fishing season, i. e. in March-May larger anchovy contained higher quantity of mesenteric fat than smaller. There were no comparative data for later months.

7.3. *Conclusions*

Fluctuations in mesenteric fat quantity during the warmer part of the year indicate their dependence on sexual cycle. The highest amount of mesenteric fat was recorded during the inactivity period and the lowest during a peak in sexual activity.

In March-May larger fish had more abundant mesenteric fat than smaller.

8. LENGTH-WEIGHT RELATIONSHIP

The data obtained at the routine analysis of the samples of catches from the Kaštela Bay and Vis and Biševo Islands region were used in the length--weight relationship study. Material was collected in March-December except for October.

Formula $W = cL^n$ (where W = fish weight/g/, L = standard length /cm/ and c, n = constants) was applied in length-weight relationship description.

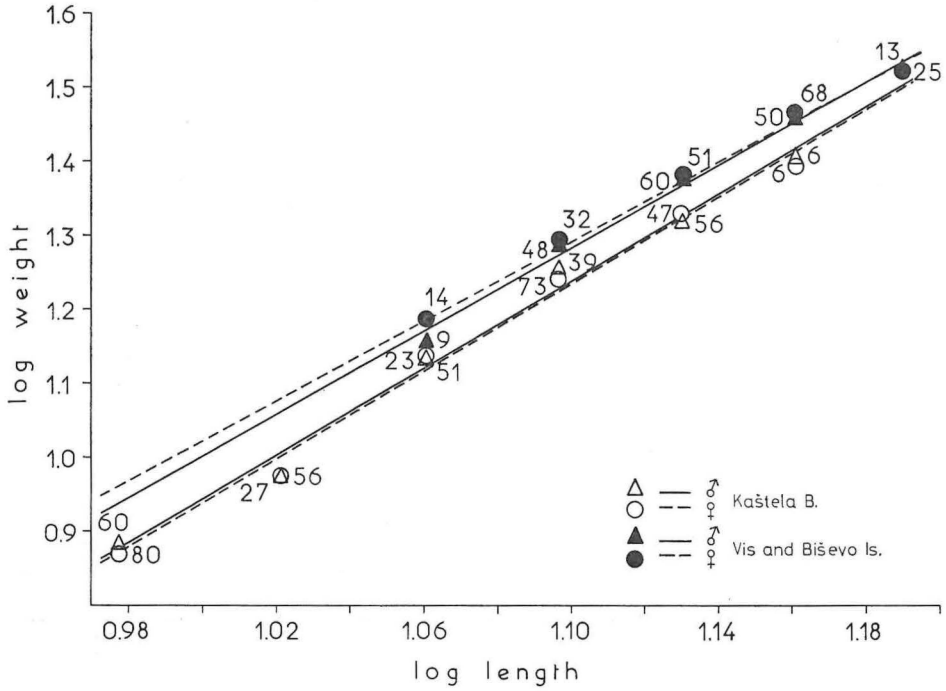

Fig. 11. Length-weight relationship of male and female anchovy from the Kaštela Bay, and Vis and Biševo Islands region (besides relationship values, numbers of individuals are also given, for males on the left, for females on the right) 1974

8.1. *Results and discussion*

The length-weight data were considered separately for anchovy from the Kaštela Bay and anchovy from the Vis and Biševo Islands region (Table 9, Figs. 11 and 12).

Length exponent values of anchovy from the Vis and Biševo Islands region were somewhat lower than those of anchovy from the Kaštela Bay (Table 9). Samples of the Kaštela Bay catches were taken in the spring, and in March and December. They consisted largerly of smaller fish (10.0 — 16.9 cm, mean length 12.8 cm) which were at the markedly predominant stages

I and II. In contrast, the samples from Vis and Biševo were taken in May--November, except for October, and consisted of larger fish (12.8 — 18.7 cm, mean length 15.9 cm). Fish from Vis and Biševo were at more advanced maturity stages than fish from the Kaštela Bay.

Differences in length exponent values between male and female anchovy from Vis and Biševo were small and there was no difference at all between males and females from the Kaštela Bay (Table 9).

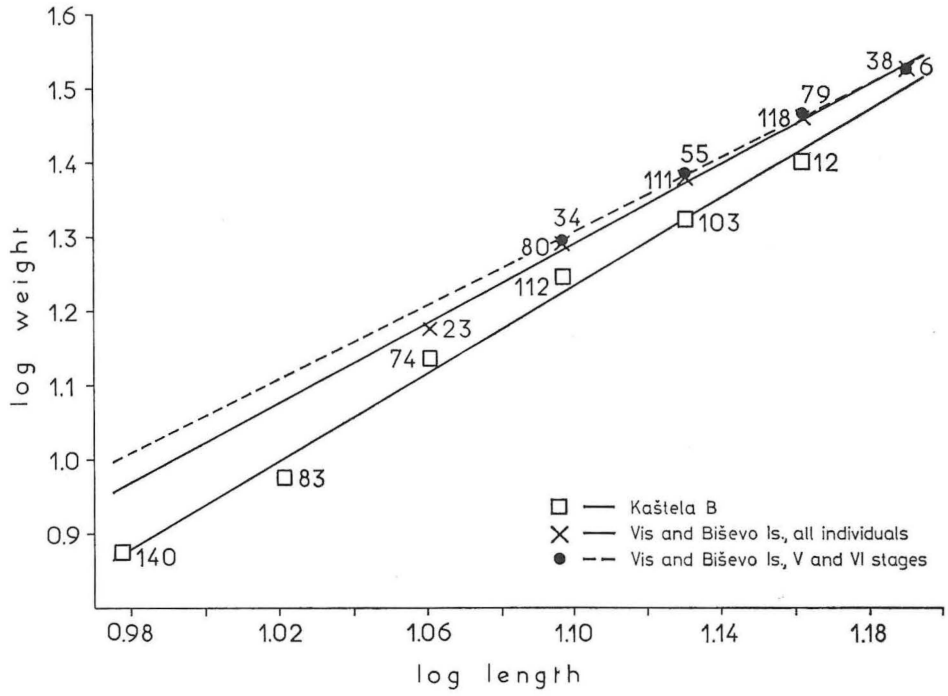

Fig. 12. Length-weight relationship of anchovy from the Kaštela Bay, and Vis and Biševo Islands region (separately for the material as a whole and for maturity stages V and VI) (besides relationship values, numbers of individuals are also given), 1974

Length-weight data for anchovy showing the most advanced maturity state (stages V and VI) from Vis and Biševo Islands region were also analysed. Their length exponent values were somewhat lower than those of the material from the region as a whole (Table 9).

Constant c varied from 0.0095 to 0.0353.

Regression lines for fish groups are given in Figures together with the empirical values.

SUMMARY

Total length of anchovy from the Kaštela Bay, and Vis and Biševo Islands region caught during fishing season 1974 varied from 10.0—18.7 cm.

Mean length of anchovy from the Vis and Biševo region (14.9—16.8 cm) exceeded that of anchovy from the Kaštela Bay (11.0—15.1 cm).

Mean and modal lengths were consistently greater in females but they did not differ much from those of males.

Sex ratio varied in the individual samples of catches from the Vis and Biševo region. The most aberrant sex ratio was that which showed 36% males and 64% females. In contrast, in the material as a whole the numbers of each sex were about equal, i. e. 46.7% males and 53.3% females.

The spring is the period of an early maturation in anchovy and summer the peak in their sexual activity.

During the period of the early maturation larger fish had more advanced state of gonads as well as higher values of gonad weight and gonosomatic ratio than smaller fish.

First sexual maturity was recorded in male anchovy at a minimum total length 8.6 cm and in female fish at a minimum length 9.7 cm.

Fluctuations in the anchovy mesenteric fat quantity were brought into connexion with the sexual cycle. The highest quantity of mesenteric fat was recorded during the inactivity period and the lowest during the peak in sexual activity. In March-May quantity of mesenteric fat was higher in larger fish than in smaller.

Length exponent values in anchovy from Vis and Biševo Islands region were somewhat lower than those in anchovy from the Kaštela Bay. However, differences between the fish from the two regions appeared as to the size, gonad state, and the time of the year.

Differences in length exponent values between male and female anchovy from Vis and Biševo Islands region were small whereas there was no difference at all between the ones from the Kaštela Bay.

In the region of Vis and Biševo Islands, fish with the most advanced maturity stages showed somewhat lower length exponent values than all fish taken together.

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O EKOLOGIJI BRGLJUNA, *ENGRAULIS ENCRASICOLUS* (L.), U SREDNJEM JADRANU

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KRATAK SADRŽAJ

Istraživanja ekologije brgljuna, *Engraulis encrasicolus* (L), u obalnim i otvorenim vodama srednjeg Jadrana, u sezoni lova 1974, a dijelom i u 1975, pokazala su slijedeće:

Totalna dužina brgljuna iz Kaštelanskog zaljeva i s područja otoka Visa i Biševa u sezoni lova 1974. kretala se od 10,0 do 18,7 cm.

Uzorci lovina brgljuna s područja otoka Visa i Biševa sadržavali su ribu veće srednje dužine (14,9 do 16,8 cm) od one u uzorcima lovina iz Kaštelanskog zaljeva (11,0 do 15,1 cm).

U uzorcima lovina ženke su pokazale nešto veće srednje i modalne vrijednosti dužine od onih kod mužjaka. Razlike su bile malene.

Brojčani odnos spolova je kolebao u pojedinim uzorcima lovina brgljuna s područja otoka Visa i Biševa. Najaberantniji odnos spolova bio je predstavljen s 36% mužjaka i 64% ženki. Naprotiv, u cjelokupnom materijalu spolovi su bili podjednako zastupljeni, tj. mužjaci s 46,7%, a ženke s 53,3%.

Proljetno razdoblje predstavljalo je fazu prematuracije brgljuna, a ljetno doba maksimalne spolne aktivnosti.

U fazi prematuracije veći primjerci brgljuna pokazali su naprednije stanje gonada od onog manje ribe. Kod većih primjeraka nađene su i više vrijednosti težine gonada i gonosomatičnog odnosa.

Prva spolna zrelost zabilježena je kod brgljuna iz Kaštelanskog zaljeva pri minimalnoj totalnoj dužini mužjaka od 8,6 cm i ženki od 9,7 cm.

Ustanovljeno je kolebanje količine mezenterične masti brgljuna u promatranom razdoblju, što se dovelo u vezu s njegovim spolnim ciklusom. Najveće količine mezenterične masti zabilježene su u vrijeme mirovanja u spolnom ciklusu brgljuna, a najmanje u vrijeme maksimalne spolne aktivnosti. U razdoblju od ožujka do svibnja veći primjerci sadržavali su više mezenterične masti od manjih.

Vrijednosti eksponenta dužine brgljuna s područja otoka Visa i Biševa nešto su niže od onih ribe iz Kaštelanskog zaljeva. Međutim, razlike postoje u odnosu na veličinu ribe, stanje gonada i doba godine.

Razlike u vrijednosti eksponenta dužine brgljuna između spolova malene su (područje otoka Visa i Biševa) ili ih nema (Kaštelanski zaljev).

Kod primjeraka s najnaprednijim stanjem zrelosti gonada s područja otoka Visa i Biševa nađene su nešto niže vrijednosti eksponenta dužine od onih za cjelokupni materijal iz tog područja.

TABLES

Table 1. ANCHOVY LENGTH DISTRIBUTION IN THE SAMPLES OF CATCHES TAKEN FROM THE KAŠTELA BAY DURING 1974 FISHING SEASON

Date	Number of individuals	Length, cm (%)														Mean length
		10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	cm
14. 3. 1974	100	—	—	—	—	—	—	3.0	4.0	18.0	16.0	20.0	26.0	11.0	2.0	15.1
1. 4. 1974	100	7.0	47.0	42.0	2.0	—	—	—	1.0	—	1.0	—	—	—	—	11.0
24. 4. 1974	105	1.0	11.4	21.0	6.7	2.9	2.9	1.0	7.6	8.6	11.4	9.5	14.3	—	1.9	13.3
13. 5. 1974	106	10.4	8.5	17.9	23.6	17.9	7.5	7.5	2.8	1.9	0.9	0.9	—	—	—	11.8
13. 6. 1974	100	—	6.0	22.0	36.0	32.0	3.0	1.0	—	—	—	—	—	—	—	11.8
14. 6. 1974	186	0.5	1.1	9.7	46.8	32.3	5.4	2.2	1.1	—	—	1.1	—	—	—	11.9
7. 12. 1974	90	—	—	—	—	—	7.8	20.0	20.0	23.3	24.4	3.3	1.1	—	—	13.9
8. 12. 1974	90	—	—	—	—	2.2	11.1	27.8	15.6	14.4	13.3	12.2	3.3	—	—	13.9

Table 2. ANCHOVY LENGTH DISTRIBUTION IN THE SAMPLES OF CATCHES TAKEN FROM VIS AND BIŠEVO ISLANDS REGION DURING 1974 FISHING SEASON

Date	Number of individuals	Length, cm (%)													Mean length
		12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	cm
22. 5. 1974	57	—	7.0	15.8	19.3	12.3	17.5	15.8	3.5	8.8	—	—	—	—	14.9
5. 6. 1974	100	1.0	3.0	7.0	21.0	20.0	13.0	9.0	6.0	7.0	8.0	4.0	1.0	—	15.2
21. 6. 1974	40	—	—	—	5.0	10.0	7.5	5.0	12.5	22.5	17.5	12.5	7.5	—	16.5
2. 7. 1974	60	—	1.7	10.0	13.3	20.0	15.0	13.3	8.3	18.3	—	—	—	—	15.3
17. 8. 1974	108	—	—	—	—	1.9	3.7	10.2	17.6	20.4	19.4	20.4	5.6	0.9	16.8
21. 11. 1974	100	—	—	—	—	2.0	7.0	22.0	20.0	22.0	17.0	5.0	5.0	—	16.4

Table 3. MALE AND FEMALE ANCHOVY LENGTH DISTRIBUTION IN THE SAMPLES OF CATCHES TAKEN FROM VIS AND BIŠEVO ISLANDS REGION DURING 1974 FISHING SEASON

Date	Sex	Number of individuals	Length, cm (%)													Mean length cm	Difference in favour of females cm
			12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5		
5. 6. 1974	♂	45	—	4.4	8.9	26.7	15.6	13.3	8.9	2.2	11.1	8.9	—	—	—	15.0	0.3
	♀	55	1.8	1.8	5.5	16.4	23.6	12.7	9.1	9.1	3.6	7.3	7.3	1.8	—	15.3	
17. 8. 1974	♂	50	—	—	—	—	2.0	4.0	14.0	22.0	14.0	20.0	20.0	2.0	2.0	16.7	0.2
	♀	58	—	—	—	—	1.7	3.4	6.9	13.8	25.9	19.0	20.7	8.6	—	16.9	
21.11. 1974	♂	36	—	—	—	—	2.8	13.9	27.8	13.9	27.8	5.6	8.3	—	—	16.2	0.4
	♀	64	—	—	—	—	1.6	3.1	18.8	23.4	18.8	23.4	3.1	7.8	—	16.6	
Total	♂	131	—	1.5	3.0	9.2	6.9	9.9	16.0	13.0	16.8	12.2	9.9	0.8	0.8	16.0	0.3
	♀	177	0.6	0.6	1.7	5.1	8.5	6.2	11.9	15.8	16.4	16.9	10.2	6.2	—	16.3	

Table 4. SEX RATIO IN THE SAMPLES OF CATCHES TAKEN FROM VIS AND BIŠEVO ISLANDS REGION DURING 1974 FISHING SEASON

Date	Number of individuals	Sex, % ♂	Sex, % ♀	Ratio ♂/♀
22. 5. 1974	57	49.1	50.9	1.0
5. 6. 1974	100	45.0	55.0	0.8
21. 6. 1974	40	57.5	42.5	1.4
2. 7. 1974	60	58.3	41.7	1.4
17. 8. 1974	108	46.3	53.7	0.9
21. 11. 1974	100	36.0	64.0	0.6
Total	465	46.7	53.3	0.9

Table 5. MATURITY STAGES DISTRIBUTION OF ANCHOVY FROM THE SAMPLES OF CATCHES TAKEN FROM THE KAŠTELA BAY DURING 1974 FISHING SEASON

Date	Sex	Number of individuals	Maturity stage, % I, II	III	IV	V	Mean length cm
14. 3. 1974	♂	54	100.0	—	—	—	
	♀	46	95.7	4.3	—	—	15.1
	♂+♀	100	98.0	2.0	—	—	
1. 4. 1974	♂	41	100.0	—	—	—	
	♀	59	98.3	1.7	—	—	11.0
	♂+♀	100	99.0	1.0	—	—	
24. 4. 1974	♂	55	38.2	18.2	21.8	21.8	
	♀	50	50.0	8.0	14.0	28.0	13.3
	♂+♀	105	43.8	13.3	18.1	24.8	
13. 5. 1974	♂	36	77.7	11.1	11.1	—	
	♀	70	74.3	15.7	5.7	4.3	11.8
	♂+♀	106	75.5	14.1	7.6	2.8	
13. and 14. 6. 1974	♂	116	81.0	11.2	6.0	1.7	
	♀	170	87.6	7.1	4.1	1.2	11.8
	♂+♀	286	85.0	8.7	4.9	1.4	

Table 6. MATURITY STAGES DISTRIBUTION OF ANCHOVY FROM THE SAMPLES OF CATCHES TAKEN FROM VIS AND BIŠEVO ISLANDS REGION DURING 1974 FISHING SEASON

Date	Sex	Number of individuals	Maturity stage, % I, II	III	IV	V	VI	Mean length cm
22. 5. 1974	♂	28	—	10.7	35.7	53.6	—	
	♀	29	—	3.5	55.2	41.4	—	14.9
	♂+♀	57	—	7.0	45.6	47.4	—	
5. 6. 1974	♂	45	—	—	44.4	55.6	—	
	♀	55	—	3.6	52.7	43.6	—	15.2
	♂+♀	100	—	2.0	49.0	49.0	—	
2. 7. 1974	♂	35	2.9	2.9	2.9	91.4	—	
	♀	25	—	—	16.0	84.0	—	15.3
	♂+♀	60	1.7	1.7	8.3	88.3	—	
17. 8. 1974	♂	50	—	—	8.0	92.0	—	
	♀	58	—	—	3.5	81.0	15.5	16.8
	♂+♀	108	—	—	5.6	86.1	8.3	

Table 7. GONADS WEIGHT AND GONOSOMATIC RATIO IN MALE ANCHOVY FROM 1974 FISHING SEASON

Date	Region	Number of individuals	Mean length of fish	Gonad weight, g			Gonosomatic ratio, %		
			cm	Min.	Max.	Mean	Min.	Max.	Mean
14. 3. 1974	Kaštela Bay	27	15.2	0.01	0.18	0.05	0.06	0.88	0.26
24. 4. 1974	Kaštela Bay	21	15.1	0.08	0.76	0.42	0.40	3.95	2.07
22. 5. 1974	Vis and Biševo Is.	24	15.0	0.21	1.13	0.59	1.30	4.59	2.71
2. 7. 1974	Vis and Biševo Is.	29	15.1	0.39	1.60	0.80	1.40	5.64	3.39
17. 8. 1974	Vis and Biševo Is.	28	16.1	0.50	1.80	0.98	1.90	6.56	3.54
16. 9. 1974	Vis and Biševo Is.	22	15.7	0.19	1.36	0.67	1.15	4.40	2.62
21. 11. 1974	Vis and Biševo Is.	19	16.0	0.02	0.09	0.04	0.07	0.33	0.16

Table 8. GONADS WEIGHT AND GONOSOMATIC RATIO IN FEMALE ANCHOVY FROM 1974 FISHING SEASON

Date	Region	Number of individuals	Mean length of fish	Gonad weight, g			Gonosomatic ratio, %		
			cm	Min.	Max.	Mean	Min.	Max.	Mean
14. 3. 1974	Kaštela Bay	24	15.2	0.03	0.28	0.12	0.14	0.92	0.58
24. 4. 1974	Kaštela Bay	21	15.0	0.13	1.11	0.48	0.77	5.24	2.31
22. 5. 1974	Vis and Biševo Is.	20	15.4	0.26	1.73	0.81	1.44	5.24	3.27
2. 7. 1974	Vis and Biševo Is.	24	15.8	0.30	1.55	0.93	1.43	5.35	3.43
17. 8. 1974	Vis and Biševo Is.	29	16.3	0.60	1.81	1.02	2.26	5.92	3.66
16. 9. 1974	Vis and Biševo Is.	15	16.0	0.40	1.30	0.75	1.42	4.71	2.88
21. 11. 1974	Vis and Biševo Is.	19	16.1	0.02	0.16	0.10	0.11	0.73	0.39

Table 9. LENGTH-WEIGHT RELATIONSHIP IN ANCHOVY FROM 1974 FISHING SEASON

Kaštela Bay	♂	$y = 0.0099\ X^{2,947}$
	♀	$y = 0.0095\ X^{2,959}$
	♂+♀	$y = 0.0096\ X^{2,958}$
Vis and Biševo Is.	♂	$y = 0.0150\ X^{2,826}$
	♀	$y = 0.0244\ X^{2,645}$
	♂+♀	$y = 0.0205\ X^{2,709}$
Vis and Biševo Is. V i VI stages	♂+♀	$y = 0.0353\ X^{2,508}$