Acta Adriat., 23 (1/2): 449—456 (1982) YU ISSN: 0001—5113
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PRELIMINARY DATA ON LARVAL AND POSTLARVAL MORTALITY OF ANCHOVY *ENGRAULIS ENCRASICOLUS* (L I N N A E U S, 1758) IN THE NORTHERN AND CENTRAL ADRIATIC

PRELIMINARNI PODACI O MORTALITETU LARVI I POSTLARVI BRGLJUNA, *ENGRAULIS ENCRASICOLUS* (L I N N A E U S, 1758), U SJEVERNOM I SREDNJEM JADRANU

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The results of calculation of the anchovy larvae and postlarvae mortality coefficients in the northern and central Adriatic are given. Mortality of both the larvae and postlarvae of anchovy in the northern Adriatic exceeds that in its central part.

INTRODUCTION

Even though the planktonic stages of anchovy have been intensively studied by a number of authors thorughout the whole area of their distribution, the little work has been done on their larval and postlarval mortality. After the available data, these problems seem to be dealt with only in the Black Sea and the Adriatic. The first data of this kind were given by D e h n i k (1963) for the Black Sea. This author observed the mortality of anchovy larval stages in function of time. He made use of the data on their growth rate at temperature range 22—24°C given by K o r n i l o v a (1955). Subsequently, some of the available data refer to a narrow part of the eastern central Adriatic (R e g n e r, 1972 and 1974). Since these data were obtained upon the observations of the reduction in the number of anchovy larvae and postlarvae by length groups they are not quite reliable. Finally, after the growth of larvae and postlarvae of anchovy was studied under experimental conditions at a larger number of different temperatures, the mortality coefficients of the anchovy larvae and postlarvae were calculated and their variations observed over a long period. However, all these data were also collected from the narrow area of the eastern central Adriatic (R e g n e r, 1979).

The knowlege of the mortality of anchovy larvae and postlarvae renders possible the elucidation of a large number of questions referring to the population dynamics and particulary to the short-term forecast of changes in their stocks. Therefore, we held it of use to publish the data embracing the wide area of almost two thirds of the Adriatic sea nevertheless they were collected over a rather short period.

MATERIAL AND METHODS

The investigations were carried out within the scope of the Italian-Yugoslav project »An assessment of the anchovy and sardine stocks on the basis of eggs and larvae« (Piccinetti, Regner and Specchi, 1979, 1979a, 1980). The planktonic material was collected during July 1978 from sixtyfour stations spaced along ten profiles from the Gulf of Venice to the line connecting Monte Gargano and Kotor. Samples were obtained by double oblique hauls with a Bongo — 20 net type (20 cm mouth diameter; 0.335 mm slik) down to the 50 m depth. At each of the stations the net was towed for about 15 minutes at a speed of 1.5—2 knots.

A total of 12.331 larvae and postlarvae were collected. The total length (LT) of all larvae and postlarvae was taken. Larvae were divided in two length groups and postlarvae in ten. Larvae and postlarvae up to 9.99 mm long were placed in 1 mm groups and postlarvae from 10 mm on in 2 mm groups. Lower class limits were used to mark the groups.

The investigations included the central and northern Adriatic. These two parts differ considerably in their ecological conditions. The northern part is shallower and owing to it and to the considerable inflow of rivers, particulary that of the river Po, the organic production there exceeds that in the deeper central Adriatic to a considerable extent (Buljan and Zore-Armanda, 1976). Since the aim of this work was to study whether there is any difference in the mortality between the larval stages of anchovy from the northern Adriatic and that of those from the central Adriatic. The connection line Ancona—Zadar was used to separate the study area in two parts. Thus, 22 stations covered the northern Adriatic and 42 stations its central part. Mean number of larvae and postlarvae was calculated for each length group under a square metre, separately for the northern and central Adriatic.

The time of duration (*dt*) was calculated for each length group of larvae and postlarvae, as well as the mean age of a group at a common mean temperature of the 0—20 m layer for each area separately.

Duration time of length groups was calculated in days according to the following equations:

$$dt = \frac{1}{c} \ln \frac{3.69 - l_{t_i}}{3.69 - l_{t_{i+1}}} \qquad (1)$$ for larvae and

$$dt = \frac{1}{c} \ln \frac{l_{t_{i+1}}}{l_{t_i}} \qquad (2)$$ for postlarvae,

where l_{t_i} and $l_{t_{i+1}}$ are larval and postlarval lengths at the beginning of the i-th length group, whereas the c values are in both of the equations the exponents of the growth curves which were found to be dependent on temperature. They may also be aclculated from the linear equations:

$$c = 0.26433\,T - 2.9767 \quad (3) \text{ for larvae and}$$

$$c = 0.004813\,T - 0.018522 \quad (4) \text{ for postlarvae,}$$

where T is temperature.

Mean age of the length group in days was calculated by the use of the following equations:

$$\bar{t} = \frac{1}{c} \ln \frac{1.96}{3.69 - l_{t_i}} + \frac{dt_i}{2} \quad (5) \text{ for larvae and}$$

$$\bar{t} = \frac{1}{c} \ln \frac{l_{t_i}}{3.34} + \frac{dt_i}{2} \quad (6) \text{ for postlarvae,}$$

where l_{t_i} are the initial lengths of the i-th length group of either larvae or postlarvae, and dt_i is the duration time of the i-th length group calculated according to the equations (1) and (2) (Regner, 1979). The *actual* age of larvae and postlarvae was simultaneously calculated, since their *specific* age was added the time needed for the entire embrionic development of eggs at a given environmental temperature.

The quantity of larvae and postlarvae under a square metre per day was calculated by the division of the number of larvae and postlarvae of each length group with the respective dt value.

Mortality coefficients were calculated from a general mortality equation:

$$N_t = N_o e^{-mt} \quad (7),$$

where N_t is the number of individuals at time t_i, N_o number of individuals at time $t = o$, while m is the mortality coefficient. Parameters of this equation were calculated by the method of linear regression from the natural logarithms of the number of larvae and postlarvae under a square metre per day and the mean time calculated by the use of the equations (5) and (6).

RESULTS AND DISCUSSION

Mean temperature of the 0—20 m water layer was found to be 21.5°C in the northern Adriatic and 22.5°C in its central part. On the basis of this and according to the equations (3) and (4), it may be concluded that the growth rate of larvae and postlarvae from the central Adriatic exceeded that of the larvae and postlarvae from the northern Adriatic. Subsequently, embrionic development of eggs was calculated to last 1.52 days in the northern

Adriatic and 1.40 days in its central part. This was calculated according to the equations of the relation between the anchovy egg develoment and temperature (R e g n e r, 1979).

Mean age of each length group of larvae and postlarvae as well as their absolute number (N/m²/day) were computed after the procedure described in Material and Methods. As it has been already mentioned, the age is taken to begin with the fertilization of eggs. The results obtained are given in Table 1.

Table 1. Mean number (under 1 m²/day) and age of the larvae and postlarvae of anchovy from the northern and central Adriatic.

	northern Adriatic		central Adriatic	
length groups	t (days)	N/m² day	t (days)	N/m² day
larvae				
2	1.72	134.56	1.58	96.71
3	3.12	27.97	2.85	35.85
postlarvae				
3	5.45	32.38	4.97	39.84
4	7.88	17.12	7.28	20.30
5	10.35	7.00	9.61	11.66
6	12.33	2.56	11.48	5.48
7	14.03	1.08	13.09	3.25
8	15.51	0.42	14.49	1.65
9	16.82	0.15	15.73	0.78
10	18.52	0.07	17.33	0.20
12	20.50	0.02	19.20	0.02
14	22.20	0.04	—	—

On the basis of the above data, the mortality coefficient of larvae is

$m = -1.1221$ for the northern Adriatic and

$m = -0.7814$ for the central Adriatic.

Accordingly, mortality of larvae from the northern Adriatic exceeds that of the larvae from the central Adriatic. On the basis of the known coefficients of mortality and temperature it was calculated that 4.32% of larvae survive the period from spawning to the transition to postlarva stage (completely resorbed yolk sac) in the northern Adriatic and 13.63% of larvae in the central Adriatic. Eggs mortality was not separately calculated during the investigations. However, since it was earlier established that anchovy eggs and larvae had the same coefficients of mortality (R e g n e r, 1979) the known coefficients would render possible the calculation of the mean number of spawned eggs per unit time and area. However, we held that the error in this computation would be too great, since we had only two age groups available and no statistical analysis of the assessment of the larval mortality coeficient was posible.

The following mortality coefficients were computed for the postlarvae from the northern Adriatic:

$$m = -0.4712; \quad r = -0.9842; \quad P < 0.001$$

and for the central Adriatic:

$$m = -0.4874; \quad r = -0.9532; \quad P < 0.001$$

Mortality coefficient for the central Adriatic somewhat exceeds that for the northern Adriatic. However, the calculations of standard errors of the mortality coefficients *(m)* showed that:

$s_m = 0.02993$ for the northern Adriatic and
$s_m = 0.0585$ for the central Adriatic.

The confidence limits of the assessment of mortality coefficients for the significance level of 99,9% were calculated on the basis of the above values. It was obtained that:

$$L_1 = m - (t_{.001\ (8)} \cdot s_m) = -0.3203$$
$$L_2 = m - (t_{.001\ (8)} \cdot s_m) = -0.6221 \text{ for the northern}$$

Adriatic and that:

$$L_1 = m - (t_{.001\ (7)} \cdot s_m) = -0.1741$$
$$L_2 = m - (t_{.001\ (7)} \cdot s_m) = -0.8034 \text{ for the central}$$

Adriatic. On the basis of the fact that the upper and lower confidence limits are overlapping, the differences between the mortality coefficients may be conculded not to be statistically significant.

Graphical representation of the data obtained (Fig. 1) show that two stages of specific mortality of larvae and postlarvae may be distinguished in anchovy for the wide area of the Adriatic. These two stages are the stage with the distinctly high rate of larval mortality and the stage with the considerably lower mortality rate of postlarvae. These results are in close agreement with the findings from the narrow zone of the central Adriatic (R e g n e r, 1979).

Further, Fig. 1 shows that the number of larvae which reached the complete resorption of yolk sac is lower than the number of the youngest postlarvae in both areas. This may be indicative of the fact that a part of larvae escapes a plankton net meshes of 0.335 mm. This is also proved by the negative deviation from the regression lines of the postlarvae from the first length group, which like the older larvae belong to a 3 mm length group.

It may also be observed that the postlarvae exceeding 8 mm as well show a negative deviation from the regression line. On this basis it may be concluded that, since these postlarvae are better swimmers that the smaller and younger ones, they are more able to avoid the plankton net of Bongo — 20 type. This is also supported by the fact that the deviation of the postlarvae from the central Adriatic is greater that that of the postlarvae from the northern Adriatic (Fig. 1). This may also be accounted for by that the transparency of

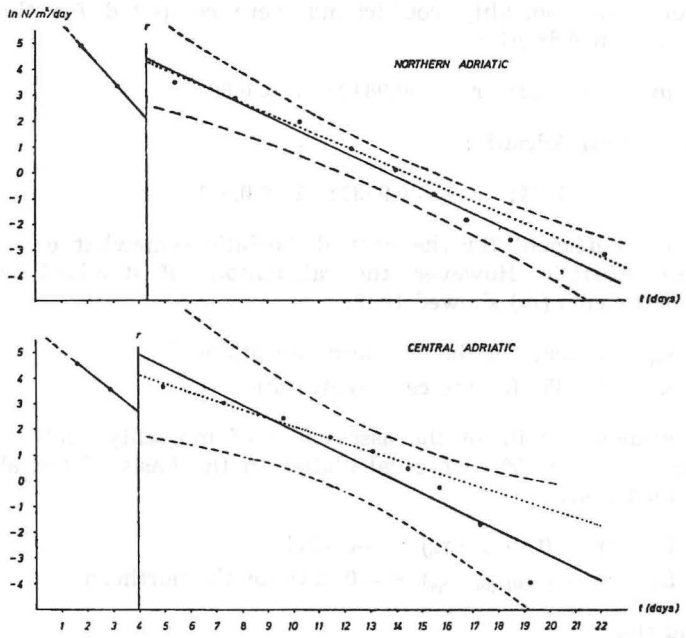

Fig. 1. Mortality curves of the anchovy's larvae and postlarvae (r = time of yolk sac resportion; ———— mortality curves for all length groups; - - - - - - confidence limits for 99.9% significance level for all length groups; ..... mortality curves for n = 6)

the central Adriatic water considerably exceeds that of the northern Adriatic water (Buljan and Zore-Armanda, 1976). Therefore, the approaching net is easier to be detected for the postlarvae from the central Adriatic. It should also be mentioned here that no negative deviations of the older postlarvae were observed during the course of earlier investigations when the net with the diameter of 143 cm of mouth aperture was used (Regner, 1979).

On the basis of the occurrence of the differential avoidance of net by younger and older postlarvae it may be concluded that, in case when all the length groups are taken into account, the mortality is probably overestimated. Therefore, the mortality coefficients were calculated only for the postlarvae of the first six length groups (from 3 to 8 mm). The following results were obtained:

$m = -0.4324$; $r = -0.989$; $P < 0.001$ for the northern Adriatic

$m = -0.3281$; $r = -0.994$; $P < 0.001$ for the central Adriatic.

The value of F — test for the significance level of 99.7% was found to be:

$F_s = 8.0151$, and the critical value is

$F_{.025\,(1,8)} = 7.57$

This means that the difference between the mortality coefficents is statistically significant for the ligh level of significance.

Accordingly, the postlarval mortality rate in the northern Adriatic seems to exceed that in the central Adriatic, like it does for the larvae. Since no parameters except temperature and salinity were observed this difference is difficult to be explained for the time being. The main cause of the larval mortality during the yolk sack feeding stage is the influence of predators. In case of postlarvae, the insufficient quantity of available food. which may cause the starvation due to the intensified intraspecific competition, (Ahlstrom, 1954; Hempel, 1965; Nikolsky, 1969) is the main cause of mortality in addition to predators. Biological production of the northern Adriatic exceeds that of the central Adriatic to a considerable extent (Buljan, 1964). Therefore, a larger concentration of predators as well as a larger concentration of food are to be expected in the northern Adriatic. Accordingly, while the influence of predation on larvae is assumed to prevail in the northern Adriatic, the intensive intraspecific competition may be assumed to affect the postlarvae from this area in addition to predators nevertheless the trophic base is larger here than in the central Adriatic.

CONCLUSION

Two stages of specific mortality of the anchovy larvae and postlarvae, i.e. the stage of relatively high mortality rate of larvae and presumably eggs and the stage of the lower mortality rate of postlarvae were found to be marked both in the northern and in the central Adriatic.

Mortality rate of larvae and postlarvae in the northern Adriatic exceeds that in the central Adriatic. This difference is statistically significant.

It seems that both the larvae and youngest postlarvae escape through the meshes in higher rate than older postlarvae and that the percentage of older postlarvae which avoid the net is larger than that of the younger ones. This suggests that the silk with smaller meshes should be used in future investigations, on the one hand, and that the diameter of the net opening and/or the towing speed should be increased, on the other.

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PRELIMINARNI PODACI O MORTALITETU LARVI I POSTLARVI BRGLJUNA, *ENGRAULIS ENCRASICOLUS* (LINNAEUS, 1758), U SJEVERNOM I SREDNJEM JADRANU

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KRATAK SADRŽAJ

Istraživanje mortaliteta larvi i postlarvi brgljuna vršena su na materijalu sakupljenom tokom jula 1978. godine na 64 postaje koje su obuhvatile područje sjevernog i srednjeg Jadrana. Dvostruko kosim potezima planktonske mreže tipa Bongo-20 sakupljena je ukupno 12 331 larva i postlarva brgljuna. Larve su svrstane u dužinske skupine od 2 i 3 mm totalne dužine (LT), a postlarve u deset dužinskih skupina, od 3 do 14 mm LT. Za svaku skupinu izračunat je srednji broj larvi ili postlarvi ispod 1 m^2 po danu, posebno za sjeverni i srednji Jadran.

Izračunati koeficijenti mortaliteta pokazali su da je stopa smrtnosti larvi i postlarvi veća u sjevernom nego u srednjem Jadranu. Statistička analiza rezultata je pokazala da je nađena razlika koeficijenata smrtnosti postlarvi značajna za visoku razinu vjerojatnosti.

Izračunate krivulje smrtnosti ukazuju da se jedan dio larvi gubi kroz okca upotrebljavane mreže, te da starije postlarve (duže od 9 mm) izbjegavaju mrežu u većem postotku od mlađih.