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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 7 (7): 1121-1126, 2004
ISSN 1028-8880

A Study on the Growth of the Anchovy *Engraulis encrasicolus*, Linnaeus (1758) in Turkish Seas

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Abstract: The present work aimed to determine the growth parameters of the anchovy, *Engraulis encrasicolus*, Linnaeus (1758), that is one of the most important commercial fish species in Turkish Seas. A total of 300 anchovy specimens were caught from different stations between November 2001 and January 2002. Standard length and total weight of the specimens ranged from 8.75 to 12.1 cm and from 6.65 to 16.75 g, respectively. Maximum age group determined was II, and sex ratio values of the specimens significantly differ from a 1:1 ratio (χ^2 test, $p>0.005$) except for those calculated in $_{KD1}$ (Trabzon). Weight increased allometrically for KD_3 (Istanbul), MD (Bandirma), ED_1 (Edremit), and ED_2 (Izmir) populations together with b=2.97, b=2.99, b=2.93, b=2.99, respectively. The values of condition factor shows that KD_1 (Trabzon), KD_2 (Sinop) and KD_3 (Istanbul) may be rich in nutrients.

Key words: *Engraulis encrasicolus*, anchovy, age, growth, sex ratio, condition factor

INTRODUCTION

Anchovy, *Engraulis encrasicolus,* Linnaeus (1758) is an endemic species of the Atlanto-Mediterranean region and the European only representative of the Engraulidae family[1]. It occurs in the Mediterranean, Black Sea, North Africa, Atlantic coasts northwards to southern North Sea and coasts of the British Isles; also Sea of Azov[2,3].

Anchovy is a pelagic species of a special economic value in Turkish coastal fishery. They play an important role in Turkish fishing industry. Namely, the mean annual catch value for the period from 1960 to 1980 was 500.000 tons because of improvements in fishery technology and increasing nutrients in northwestern coast of Turkey[4,5]. However, eutrophication in shallow waters of northwestern region, overfishing and invasion of the ctenophore, *Mnemiopsis leidyi* to the region cause to decrease the anchovy catch to 60.000 tons[5]. After the sudden decrease, the mean annual catch value reaches to 350.000 tons in 1999[6].

The biology and population dynamics of anchovy were investigated by numerous researchers in the Mediterranean Sea[7,8] in Adriatic Sea[1,9] in Black Sea[10,11] in various countries. There are some studies of the biology of the Turkish anchovy population[5,12-17]. Studying biology and population dynamics of anchovy which is subject to frequent and evident natural fluctations, is also important in population management. The present work was conducted to explore the knowledge on the growth of anchovy in Turkish Seas.

MATERIALS AND METHODS

Fifty anchovy specimens per sample were obtained from six different stations between November 2001 and January 2002 (Fig. 1). The samples of anchovy catches were obtained directly from fishermen. Unfortunately, no samples could be obtained from Mediterranean Sea.

Specimens were measured to the nearest 1 cm (standard length) and weighted to the nearest 0.1 g and their sagittal otoliths were removed immediately and stored dry properly labeled envelopes. All of 300 anchovy specimens were used for the age and growth analysis. Ages were determined, using the methods of[18]. Otoliths were viewed under a binocular microscope at 20 times magnification using reflected light and a dark background. The number of opaque zones (summer rings, appearing dark under reflected light) and the presence of marginal translucent zone (winter rings, appearing bright under reflected light) was checked by two readers. To avoid subjectivity effect on age estimations, as much as possible, there was an interval of 1 month between readings. Translucent bands that continued around the

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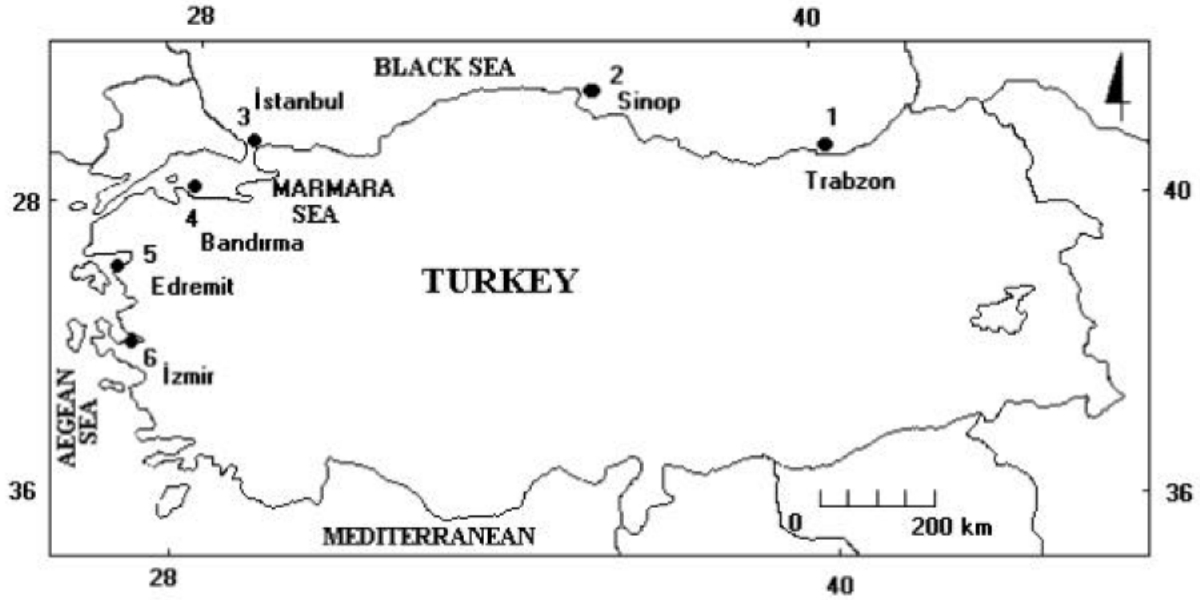

Fig. 1: Sampling stations of anchovy
1. Trabzon (KD_1); 2. Sinop (KD_2); 3. Istanbul (KD_3); 4. Bandirma Körfezi (MD); 5. Edremit Körfezi (ED_1);6. Izmir Körfezi (ED_2)

entire circumference of the otolith were considered to be annuli and the total number of these bands was recorded as the age. Age-classes were assigned based on the number of annuli and the month the fish was collected.

The commonly used length-weight relationship was applied[19,20]:

$$W = aL^b$$

Where, W = weight, L = standard length, a and b are constants.

The condition factor (CF) was calculated as $CF = Wx100\ L^{-3}$ to assess the maturity and condition of the specimens.

The gonads were examined macroscopically on fresh specimens to determine sex. Sex ratio was analysed regionally. Deviations from 1:1 null hypothesis was statistically tested by χ^2 analysis[21]. All statistical analyses and graphics were prepared with the programme of Quattro Pro for Windows and Microsoft Excel.

RESULTS

Length-weight frequency distribution: Length and weight measurements of anchovy include the distributions of standard length and weight of all specimens caught from different regions. Standard length of anchovies ranged from 8.75-12.1 cm. The most abundantly captured specimen ranged from 10.0-10.9 cm (76%) in KD_1; 9.0-10.4 cm (70%) in KD_2; 10.0-10.9 (70%) in KD_3; 11.0-11.9 cm (74%) in MD; 10.0-10.9 cm (82%) in ED_1; 9.5-10.4 cm (74%) in ED_2 in length groups (Fig. 2a), respectively. Weight of anchovies ranged from 6.65-16.75 g. The most abundantly captured specimen ranged from 9.5-13.9 g (88%) in KD_1; 8.0-12.4 g (78%) in KD_2; 9.5-13.9 g (84%) in KD_3; 11.0-15.4 g (84%) in MD; 8.0-10.9 g (86%) in ED_1; 8.0-10.9 g (90%) in ED_2 in weight groups (Fig. 2b), respectively.

Age and sex composition: According to the age determinations carried out on otoliths, the specimens were distributed among the age groups 0 to II. As age group I was mostly caught in total samples, the age groups 0 and II were the most abundant in KD_2 (Sinop) and MD (Bandirma) (Fig. 3), respectively.

The sex ratio of catches in KD_2 (Sinop), MD (Istanbul), ED_1 (Edremit) and ED_2 (Izmir) samples were skewed in favour of females which is significantly different from a 1:1 ratio (χ^2 test, $p>0.005$); however, sex ratio value of the specimens in Bandirma was skewed in favour of males which is significantly different from a 1:1 ratio (χ^2 test, $p>0.005$) (Fig. 4).

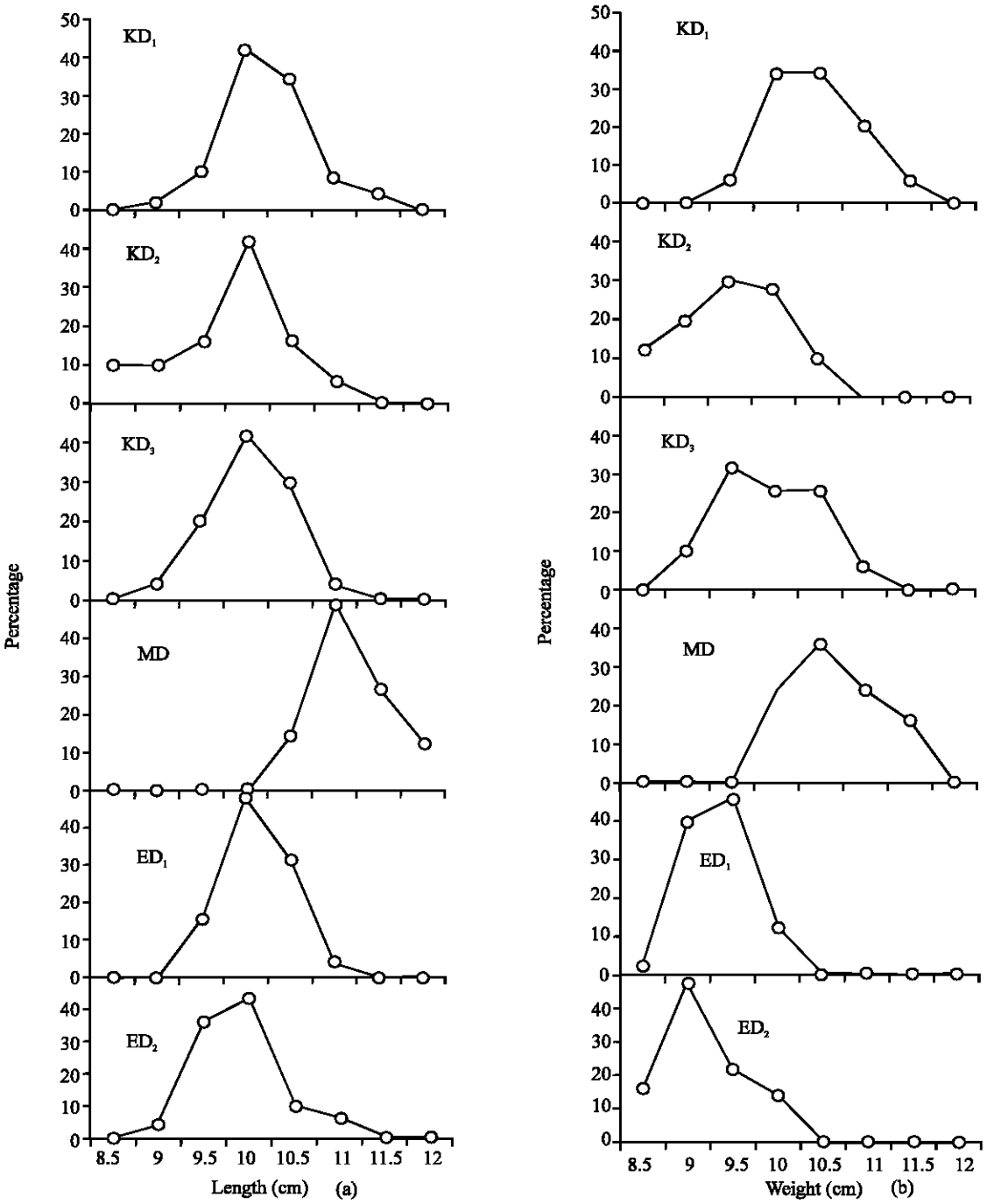

Fig. 2: Length-weight frequency distribution of anchovy

Length-weight relationship: The value of length-weight relationship is in KD_1 (Trabzon):

$$W = 0.032\ L^{2.5078}\ (R^2 = 0.8954),$$

and in KD_2 (Sinop):

$$W = 0.02414\ L^{2.6738}\ (R^2 = 0.9134)$$

Weight increased slower than the allometric rate of 3.0 since our slope values b=2.50, b=2.67 were significantly different from 3.0 ($p<0.005$) and in other populations:

$W = 0.0111\ L^{2.9796}$ ($R^2 = 0.8649$) in KD_3 (Istanbul),
$W = 0.0094\ L^{2.9995}$ ($R^2 = 0.9419$) in MD (Bandirma),
$W = 0.0102\ L^{2.937}$ ($R^2 = 0.8517$) in ED_1 (Edremit),
$W = 0.009\ L^{2.9914}$ ($R^2 = 0.8664$) in ED_2 (Izmir),

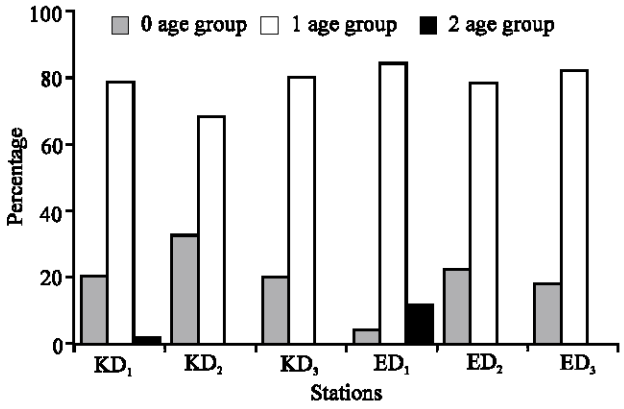

Fig. 3: Age groups of anchovy

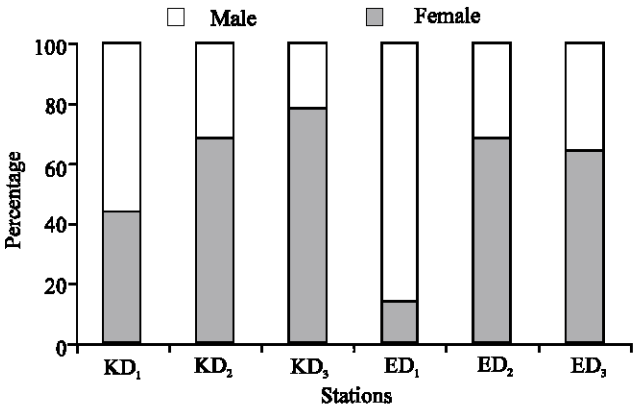

Fig. 4: Sexes of anchovy

The correlation coefficients computed for the length-weight relationship suggested that the growth in the population was harmonious and balanced (Fig. 5).

Condition factor: The average values of CF in KD_1 (Trabzon), KD_2 (Sinop) and KD_3 (Istanbul) showed significant differences (t-test, $p>0.005$) (Fig. 6).

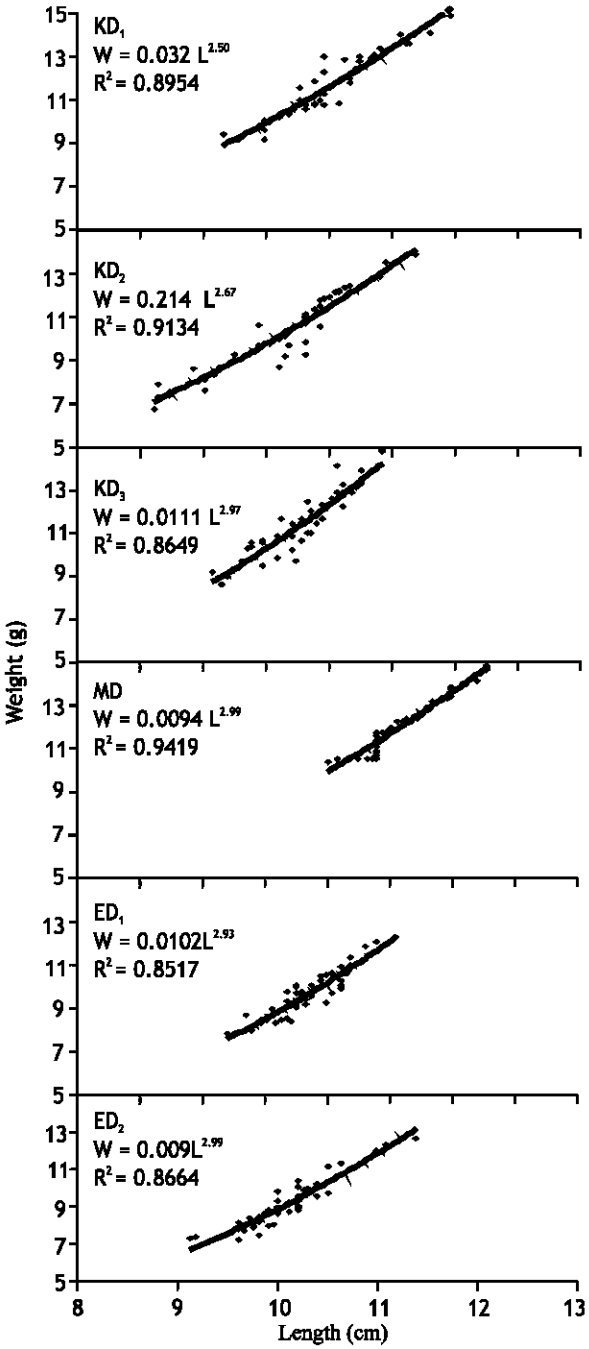

Fig. 5: Length-weight relationships of anchovy

DISCUSSION

The standard length of anchovy in the coastal waters of Turkey ranged from 8.75 to 12.1 cm. This range was compared with the results given[1] for the anchovy population of coastal waters of middle Adriatic (7.5-16.9 cm). The range values in our sample are highly contradict with these given above probably due to differences in ontogenetic development, condition, sex, maturity as well as variations in geographic location, seasonality and small sample size. Regarding Turkish seas[12,17,14,16], total length values for Black Sea (6.66-15.24, 6.0-15.3, 7.24-14.4 and 7.0-13.8 cm, respectively) are similar to those calculated by us in Black Sea. The standard length of anchovy specimens ranged between 7.5-12.1 cm, the dominant ones between 9.5-10.5 cm (Fig. 2a). The observations on anchovy length indicates the obeying of

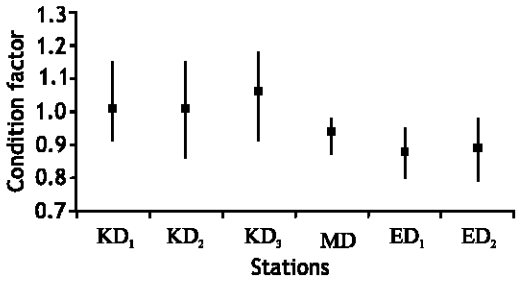

Fig. 6: Condition factors of anchovy

the fishery ban below 9.0 cm in recent years. Our values of b (2.5078, 2.6738, 2.9796, 2.9995, 2.937, 2.9914) differ from the ones estimated (Özdamar[17]; b= 3.1002), (Mutlu[14]; b=3.048), (Gözler and Çiloğlu[16]; b=3.015) for Black Sea coasts. The likely means for this are that we used standard length, a smaller sample, a narrow length range and a wider sampling period. Sinovčić[1] estimated b=3.1195, b=3.00 for the region of Kastella Bay and Dalmatia, respectively which are higher than the values we calculated. Changes in physiology, hydrological environmental conditions, different food availability during life and biological span growth increment or break in growth can all affect the growth exponent b[1,22]. Condition factor annual peaks observed in Black Sea coastal waters could be due to a greater food ability resulting from the winter and summer primer production peaks. Similar results have been observed by Giraldez and Abad[23] for western Mediterranean and mean values of CF indicated that anchovy in Black Sea coastal waters approach maturity at the end of first year and at the begining of the second year.

The regional fluctuation of sex ratio in anchovy may be shown according to their physiological state: in the spawning period on one side and in the inactivity period of sexual cycle on the other[1]. By comparing the proportion of sexes in various physiological stages, certain regularities have been noticed. Namely, males were predominant in spawning period (April-September). There were 7 females or 14% and 43 males or 86% in Bandirma population. Sex ratio value of those specimens was skewed in favour of males ($p>0.005$) that in the spawning period, males were predominant, whereas females dominated in the inactivity period of sexual cycle. Similar sex ratio was recorded by other authors. Mužinić[24] found a rather equal proportion of sexes in catches achieved by trawl in trawling season, Padoan[25] studied the sex ratio of anchovy from the northern Adriatic in the inactivity period of sexual scycle. Varganolo[26] found an almost equal proportion of sexes in 1644 anchovy specimens in northern Adriatic within spawning season similar to our samples from Trabzon. Sinovčić[1] found the proportion of sexes was almost equal in a whole population in Adriatic whereas in the spawning period males were predominant and females dominated in the inactivity period of sexual cycle. Gözler and Çiloğlu[16] found females dominated in catches carried out by trawl in trawling season of Rize-Hopa.

Presented mean lengths by age point out that anchovy life span in Turkish seas is three years, from age 0 to 2 (Fig. 3). There is considerable overlapping of lengths in anchovy of different ages, particularly in age classes 0 (Sinop population) and II (Bandirma population). The fastest growth in length and weight in anchovy occurs during the first three years of life. It was recorded by Düzgüneş and Karaçam[12], Özdamar[17] Mutlu[14], Gözler and Çiloğlu[16] based on the analysis of anchovy age composition of catches from Black Sea coasts, respectively that the life span of anchovy is three years. The fact that anchovy of 0 from coastal waters KD_2 (Sinop) is explainable with spawning area.

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