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Sex and Age Composition of Sprat (*Sprattus sprattus phalericus* (Risso, 1826)) Along the Turkish Black Sea Coast

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Abstract: Identification of sex and age composition of sprat (*Sprattus sprattus phalericus* Risso, 1826) collected from the Turkish waters of the Black Sea between April 1990 and January 1992 is performed. The range of the age groups was found to be between 0 and V, and dominant age group was the I age for each sex. Their occurrence in inshore waters decreased in winter and increased in autumn due to their spawning migration from inshore waters to offshore and vice versa. Juveniles were dominant in the warmer upper layer in winter, and adults were dominant before the intensive spawning season (autumn). Females were predominant in all seasons.

Key Words: Turkish Black Sea Coast, Sprat (Sprattus sprattus phalericus RISSO, 1826), Sex and Age composition.

Türkiye'nin Karadeniz Kıyılarındaki Çaça Balığı (*Sprattus sprattus phalericus* (Risso, 1826))'nın Cinsiyet ve Yaş Kompozisyonu

Özet: Nisan 1990 ile Ocak 1992 tarihleri arasında Türkiye'nin Karadeniz sularından toplanan çaçaların (Sprattus sprattus phalericus RISSO, 1826) cinsiyet ve yaş kompozisyonlarını belirlemek amacıyla bu çalışma yapıldı. Kıyı sularından açık sullara, ya da bunun tersi istikamette gerçekleştirdikleri yumurtlama göçüne bağlı olarak bu tür bireylerinin kıyı sularında kışın az, sonbaharda ise bol olarak bulundukları; gençlerin kiş döneminde, ergin bireylerin ise yoğun yumurtlama peryodundan önceki mevsimde (sonbahar) daha ılık olan yüzey tabakasında baskın bir şekilde bulundukları; dişilerin ise her mevsim için erkeklerden daha yoğun olarak bulundukları saptandı.

Anahtar Kelimeler: Türkiye'nin Karadeniz Kıyısı, Çaça (*Sprattus sprattus phalericus* Risso, 1826) Cinsiyet ve Yaş Kompozisyonu

Introduction

Sprat has a wide distribution in the Atlanto-Mediterranean system (1,2,3) where three sub species of this genus, namely the Atlantic Ocean form (*Sprattus sprattus sprattus*), the Baltic Sea form (*Sprattus sprattus balticus*), and the Black Sea form (*Sprattus sprattus phalericus*) have been distinguished. Black Sea sprat is the most abundant form along the northern Mediterranean (especially in the Adriatic) and in the Black Sea (4,5,6,7).

In the Black Sea, the sprat has become of increasing economic importance in recent years. The annual catch of sprat by the Commonwealth of Independent States, Romania and Bulgaria increased from 6,182 thousand tons in 1972 (8) to 105,306 thousand tons in 1989 (9). However, there is no study at the present time regarding statistics related to sprat landed in the Turkish Black Sea waters as this catch is not separated from sardines (10), anchovy, or Black Sea Shad (personnel observation) in the western Black Sea coast of Turkey.

While considerable information has been published on the growth (7,11), food and feeding (12), and condition of the Black Sea sprat (13,14), very little data are available on the sex composition and age distribution of this fish.

In this study, the poorly known sex composition and age distribution of Black Sea sprat have been ex-

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amined in different seasons from April 1990 to January 1992.

Material and Methods

Material collections were made from 57 sampling stations located along the Turkish Black Sea coast (Figure 1). Bottom trawl sampling was begun in April 1990 and continued in September 1990 and September 1991. Mid-water trawl samples were collected in December 1990 and January 1992. The hauling period was restricted to half an hour, but was sometimes changed due to the sea bed topography.

Fish were separated from the trawled material and sorted by species. In poor hauls, the number of the total catch was considered as the sample size for further analyses. Large catches were sub-sampled according to the procedure described by Holden & Raitt (15). Samples were preserved in solutions of 10 % Formalin buffered with borax (16).

The following examinations were carried out over a period of at least two months. Total length measurements were made to the nearest millimeter with each fish lying on its right side with mouth closed. Ranges of the total length measurements and number of specimens analyzed for each sex group in each sampling period are shown in Table 1.

In young individuals, sex differentiation was confirmed by means of stereo binocular microscope, and in older specimens, it was determined by direct examination of the gonads with the naked eye. The criteria for the identification of each sex are given in Table 2.

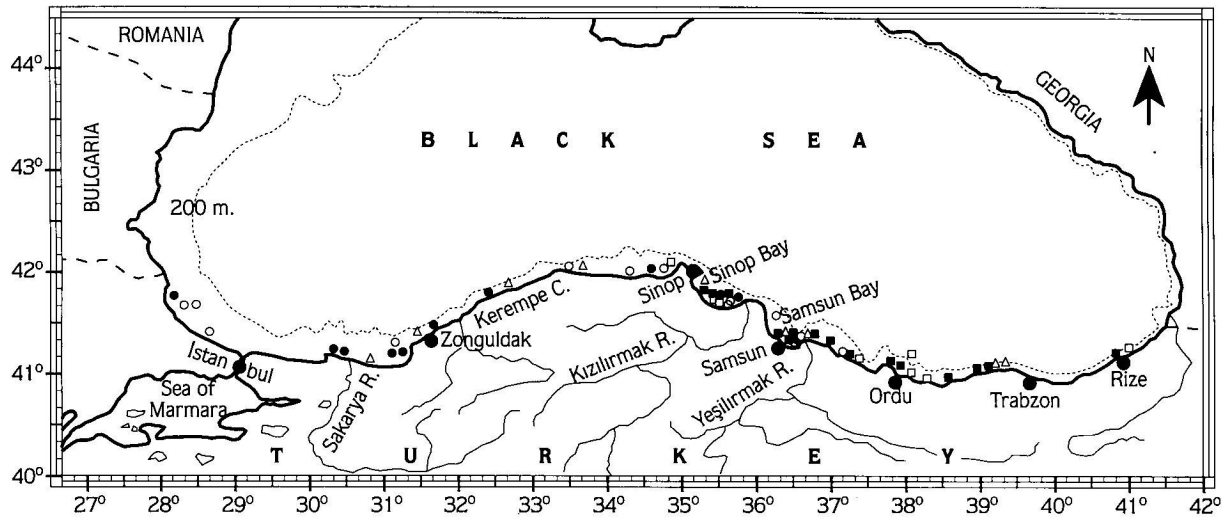

Figure 1. Location of the Sampling Stations Along the Turkish Black Sea Coast (Solid Circles: April 1990; Empty Circles: September 1990; Empty Squares: December 1990; Solid Rectangular Boxes: September 1991; and Triangles: January 1992).

Table 1 The Minimum and Maximum Total Length Measurements (mm) and Number of Specimens Analyzed (n) for Ageing in Each Sex and in each Sampling Period.

Sampling Period	Juveniles Min-max	(n)	Females Min-max	(n)	Males Min-max	(n)	Examined Fish
April 1990	- -	-	58-120	344	58-130	190	534
September 1990	34-46	17	52-125	427	51-119	159	603
December 1990	28-45	37	35-112	238	34-105	118	393
September 1991	- -	-	65-141	295	69-130	47	342
January 1992	- -	-	49-137	1427	48-119	887	2314
Overall	28-46	54	35-141	2731	34-130	1401	4186

Table 2. The Criteria for the Identification of Each Sex.

GONAD		
Characteristic	Color	Sex
Thin and transparent cord	pinkish	female
More or less symmetrical	whitish	male
Tubular and granular appearance	pinkish-yellow	female
Ventral edges with wave-like outline and with soft tissue	whitish to creamy	male
Full with large translucent ripe eggs	orange-pink	female
Full with soft tissue	whitish-creamy	male
Shrunken with opaque and ripe ova	darkened or translucent	female.
Shrunken with bloodshot and flabby	darkened	male

Both sagittal otoliths together with cleithra were used for age determination of a single fish. Ages were determined satisfactorily from the external surface of the whole left sagittal otolith, and the right one was used as a check. Cloudy or chalky surfaced otoliths were soaked by rapidly dipping in a 20% solution of HCL before placing it in water (17). The surface of otolith was then, examined under a stereo binocular microscope (magnification X 20) by immersing the otolith in glycerine in a petri dish under which there was a light source. Some otoliths proved difficult to read because of their transparency, intensive calcification, or indistinctive rings and these could not be aged. To solve such problems, the cleithra was also used for age determination. It was accepted that the pairs of growth bands observed in the otolith or cleithra as opaque and translucent are of an annual nature.

Results

Sex Composition

The results of the sex composition studies in each sampling period are given in Table 3. In the deep trawl catches, in April 1990 and September 1990, the female to male percentage and their ratios were found to be 64:36 = 1.8:1 and 70:26 = 2.7:1, respectively. The corresponding values were 61:30 = 2:1, 86:14 = 6.3:1, and 62:38 = 1.6:1 in December 1990 mid-water trawl survey, in September 1991 bottom trawling, and in January 1992 mid-water trawl survey, respectively. Juveniles were identified only in September and December 1990 samples. Their percentage ratio was found to be 4 and 9 in the respective two sampling periods.

Table 3. Percentage Distribution and Ratio of Sexes for Each Sampling Period.

Sampling Period	Percentage Distribution			
	Juveniles	Females	Males	Sex Ratios
April 1990	-	64	36	1.8 : 1
September 1990	4	70	26	2.7 : 1
December 1990	9	61	30	2.0 : 1
September 1991	-	86	14	6.3 : 1
January 1992	-	62	38	1.6 : 1
Overall	1	65	34	1.9 : 1

The overall female to male ratio was 1.9 (65%) : 1 (34%). Table 3 indicates that females predominated over the males in all sampling periods. In the samples taken in September 1990 and 1991, the number of females was relatively higher (70% and 86%, respectively) than in other sampling periods.

The percentage distribution and ratio of sexes in each age group are given in Table 4 which shows that the proportion of females was always high in all age groups. This ratio which is smaller in age groups "0" and "I" (1.5 : 1.6), abruptly increases until reaching age group IV, which seems to demonstrate that the female-to-male ratio increases with increasing age. The decrease in the sex ratio at age group V may be related to insufficient sample size (Table 4) due to the highest fishing pressure on this age group. Therefore, age group V may not be representative.

Table 4. Percent Sex Distributions and the Sex Ratios in Each age Group (Figures in Parantheses are the Number of Fish Examined).

Age Groups	Juveniles	(%)	Females	(%)	Males	(%)	Sex Ratios
0	(54)	10	(286)	55	(185)	35	1.5 : 1
I	-		(1023)	61	(651)	39	1.6 : 1
II	-		(608)	74	(210)	26	2.9 : 1
III	-		(218)	90	(25)	10	8.7 : 1
IV	-		(79)	91	(8)	9	9.9 : 1
V	-		(18)	78	(5)	22	3.6 : 1
Total	(54)	2	(2232)	66	(1084)	32	2.1 : 1

Age Composition

Percentage distribution of year-classes for each sex and for all (pooled) fishes caught in different sampling periods is shown in Figure 2. The percentage distribution of the ages shows a great similarity except for that of the December 1990 sample. In April 1990, a considerable part of the sample is composed of the age group I, while in both September 1990 and 1991 the age group II was predominant. April 1990, September 1990 and 1991, and January 1992 samples included a wide spread of age groups and representatives from all identified 5 year classes. Age group 0 was dominant only in December 1990, which may represent the approximate period of recruitment. However, to establish the recruitment period, separate special observations are needed (18).

Figure 2 illustrates that the sex and age groups of sprat vary with the time of year along the Black Sea coast of Turkey. Further, the age composition of the population is shown as pooled data in Figure 2, which shows that the percentage age distribution of the population is characterized by the increasing percentage from age group 0 to age group I and then gradually decreases until age group V.

There is also a considerable difference in the age composition data between the samples collected by mid-water trawl (December 1990 and January 1992) and by bottom trawl (April 1990, September 1990, and September 1991) (Figure 2). The yields of mid-water trawl were composed of relatively smaller age groups when compared to those of the bottom trawl. Feldman (19) reported that the young individuals of Atlantic sprat are found in the intermediate and sub-surface cold layers. This difference may be caused by the difference in vertical distribution of the young and adult Black Sea sprat.

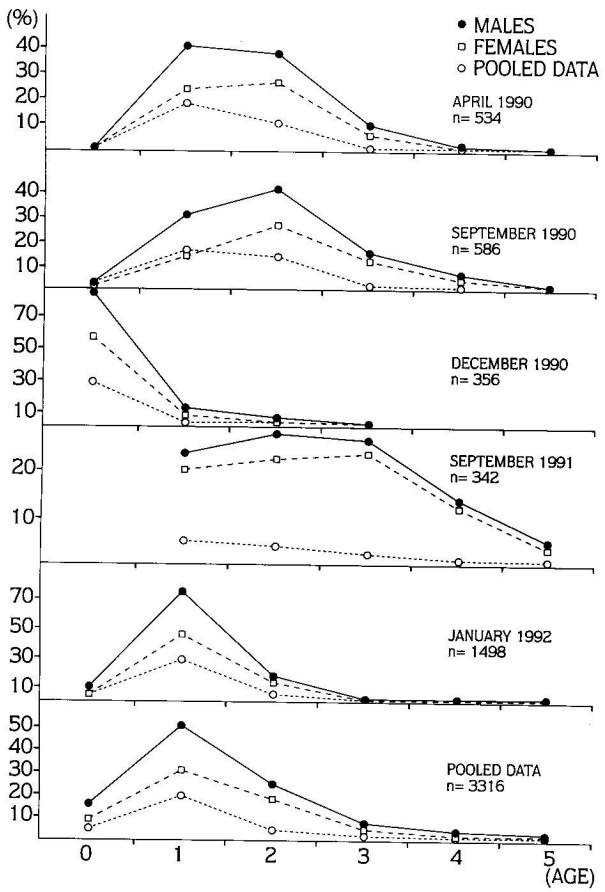

Figure 2. Percentage of age Composition of the Population Based on the Samples from Each Sampling Period and on Pooled Data (April 1990 to January 1992).

Discussion

Percentage sex ratios which were observed to be higher in September of both years than during the other sampling periods (Table 3) are in good agreement with the ratio of DBT-D.E.U (20) given for the region between Sinop and Ordu. They found that the female to male ratio was 84% in the same period (October).

Since the males of sprat tend to attain maturity earlier than females (21), a considerable portion of the males migrates to the spawning area earlier than the females. The emigration of mature males from inshore to the offshore waters, or to the northwestern shelf areas results in an initial increase in the percentage of females above the overall mean ratio in the inshore population pool during September.

Most of the samples collected in September 1990 were generally from the southwestern Black Sea coast (Figure 1). However, in September 1991 all of the samples were collected from the southeastern Black Sea basin and the female to male ratio was found to be at its maximum during this sampling period. This result may be related to the aggregation of the females in nutrient-rich areas such as Samsun and Sinop Bays before spawning.

The number of females in the inshore population decreased during their most intensive spawning periods, winter and early spring (Table 3) (7). The reduction in the number of females in December, January and April may be due to the fact that a large

portion of females migrated to the offshore waters of Turkey or to the northwestern basin of the Black Sea for spawning. However, repeated samples in consecutive years are necessary to confirm this.

The calculated female to male ratios in each age group (Table 4) are higher than those given by De Silva (22) for Atlantic sprat collected from inshore waters off the west coast of Scotland. He found that the sex ratio varied around 50% and there was no noticable relation in the sex-ratio at ages up to five. Disagreement between these results may relate directly to the selection of the nets used in both studies. It is clear that there is a positive correlation between the fraction retained in the cod-ends of nets and the fattest of fishes. According to Johnson (23) Atlantic sprat mature at the end of the first year of their life. It appeared obviously that after maturation, the body height of the females increases more due to the more material deposition in their ovaries when compared with the males. Therefore, the retained fraction of females and males in the cod-end has been more or less the same before maturation (Actually, the sex ratio has been found to be under the overall mean for age groups "0" and I). The fraction increases with increasing age, except for age V. The sex ratio for age group V is substantially lower than that of the previous two age groups (Table 4). The actual reason for this decrease is not known, but it may be purely a coincidental result due to their small sample size.

Because of the gear selection, the age group 0 may be represented in relatively smaller percentage in the catch compared to the age group I. At age groups greater than I, the percentages of occurrence of older ages were decreasing due to fishing pressure and also may be due to senescent stress.

The marked increase in the number of juvenile sprat (age group 0) in December and also the occurrence of just-matured individuals (age group I) in small quantities in January and April may represent the influx of the new generation of the year (Figure 2), which shows a parallelism with the findings of Van Den Broek (24) for the Atlantic sprat. This is also the period of the extensive spawning within the offshore waters. According to Uysal (25), inshore waters along the Turkish Black Sea coast are found to be more productive than offshore waters in terms of phytoplankton density in winter. In addition to other favourable conditions, it seems that juveniles prefer relatively productive water and are distributed in inshore waters during the winter, while adult stock is distributed relatively more in offshore waters.

Fish of age 0 were caught by means of bottom and mid water trawls during all sampling periods except in September 1991. The difference among the smallest age group of the stock in September 1991 and in the remaining sampling periods should certainly be related to the cod-end mesh size because only the September 1991 cruise was conducted by R/V SURAT1 equipped with a deep trawl which had a larger mesh size (14mm) than that of the R/V BİLİM (7mm). Unfortunately, catchability of smaller specimens belonging to age group 0 is much less with a larger mesh sized net. Therefore, no data on age group 0 are available for the September 1991 cruise.

According to Ivanov & Beverton (7), sprat spawns mainly in the northwestern shelves and river deltas located along the Black Sea coast. They found that mature sprats perform extensive spawning migrations towards the offshore of the large river deltas and northwestern shelf area. In the South, the offshore of Yeşilırmak and Kızılırmak deltas are the most important areas for sprat along the Turkish Black Sea coast. The September 1991 cruise was performed only in the southeastern part of the sea and was intensified in these two largest river deltas (Figure 1). The presence of one-year and older age groups in the September 1991 sample, suggests the aggregation of mature specimens possibly for feeding before spawning in these areas. This assumption is supported by the observation of Hoziosky et al. (26) whose findings imply that adult individuals of the Baltic sprat form relatively isolated feeding gatherings in the summer-autumn period of the year.

Conclusion

There is no comprehensive published study on the sex composition, and age distribution of Black Sea sprat. The present study was therefore carried out using the samples collected from the Turkish Black Sea coast during April 1990 and January 1992.

Females were more dominant than males in all sampling periods (Table 3), which was also observed by De Silva (22) in the Atlantic form (*S.sprattus sprattus*). The percentage of occurrences of female, males, and juveniles were estimated to be 65%, 34%, and 2%, respectively (Table 3). The decreasing percentage of the females in winter (December 1990 and January 1992) is most likely due to their spawning migration from inshore to offshore waters, and their increasing ratio in autumn (September 1990 and September 1991) is related to the aggregation in nutrient-rich inshore waters before spawning.

Age group (0) occurred almost in all sampling periods. However, due to the larger cod-end mesh size (=14mm) of the trawl net of R/V/SURAT1, samples collected in September 1991 are missing this age group. The highest percentage occurrence of the age group (0) in the December sample (Figure 2) which was sampled with a mid-water trawl net shows that the juveniles are distributed mainly in the upper layer during the cold season. The occurrence of relatively older individuals (age groups II and III) with the high dominancy in September of both years 1990 and 1991 supports the statement related to their aggregation in inshore waters before spawning. In all sampling periods, the small representation of individuals older than age group (III) can be explained by the fishing pressure and senescent stress.

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