Turkish Journal of Agriculture - Food Science and Technology

A Preliminary Study on The Determination of Reproductive Biology of European Pilchard, *Sardina pilchardus* (Walbaum, 1792) Distributed in The Aegean Sea

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A R T I C L E I N F O	A B S T R A C T
	Sardina pilchardus is a multiple spawning fish, i.e., the species that spawns periodically during the spawning period. In order to examine the reproduction biology of the species, the specimens were obtained in the known spawning period indicated by the current literature obtained from fishers who were commercially fishing in December 2018 and January-February 2019. After the fork length and total length together with their weight measurements, the specimens were dissected in the laboratory. The adult females' gonads were then fixed in 4% formalin solution for fecundity. A total of 170 individuals was examined and the values of their fork length, total length and weight were computed as 9.7-13.4 cm (mean: 11.16±0.81), 10.5-15 cm (mean: 12.3±0.89), 8.06-23.7 g (mean: 12.7±2.93), respectively. 44 of the supplied specimens were male (25.9%), 122 female (71.8%) and 4 (2.3%) uncertain, thus, the female: male ratio was determined as 2.77:1. According to χ^2 test results, a statistically significant difference was observed among individuals. For the specimens examined, the fork length-weight relationship was calculated as $W = 0.0098FL^{2.96}$, while total length-weight relationship was $W = 0.0071TL^{2.97}$. In order to calculate the fecundity, sub-samples were taken from the anterior, median and posterior parts of 15 ovaries in the ration of 2 - 5% of the ovary weight and the mature oocytes were counted. As a result, the species' fecundity was found to be between 4,600-9,800 (6,110±1,755). The relationship between total length and fecundity was computed as $W= 1,640.7$ TL$-13,907$ and a linear relationship was determined.

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Introduction

The European pilchard, *Sardina pilchardus* is a pelagic species (Whitehead, 1985), which forms schools and distributes in the northeastern Atlantic, Mediterranean, Marmara and Black Sea regions, and constitutes one of the most important fish species in Turkey. With a relatively short life cycle, sardine fish is a multi-spawning species having a high number of annual spawning (Hunter and Mackiewicz, 1985). According to 2017 TUIK data, the total amount of marine fish caught in Turkey is 269 676 tons. The total amount of sardines caught in Turkey is 23 426 tons, which constitutes 8.7% of overall fishing (TUIK, 2017).

Both in the world and in our country, the studies by Southward and Iron (1974), Yannopoulos (1977), Sinovcic (1983), Ferreiro and Labartau (1984), Rodrigez and Rubin (1990), Nejedli et al. (2004), Mustać and Sinovčić (2008), Pešić et al. (2010), Abderrazik et al. (2016), Tsikliras and Koutrakis (2013), Artüz (1960), Iron and Iron (1961), Private (1982), Kemahlı (1984), Torcu (1984), Cihangir

and Shavin (1990) and Cihangir (1993) are some of them that carried out about European pilchard's biological properties. Determining population size and catch rates of economically important fish species with short life cycles is highly important (Abderrazik et al., 2016). The aim of this study is to determine the reproductive biology of *S. pilchardus* having distribution of the Aegean Sea coasts of Turkey. Consequently, we have formed an opinion that this study, which is a preliminary study, may provide valuable insight into the studies to be conducted with yearly sampling.

Material and Method

In this study carried out to examine the reproductive biology of the species, the sardine specimens were obtained from commercial fishermen for a period of three months, December 2018, January and February 2019.

In the laboratory, for fork and total lengths of the specimens millimetric measurement board (cm) was used and they were weighted with 0.01 g precision balance. The specimens were dissected for sex determination. Total length-weight relationship the formula given by Ricker (1975) was used. The gonads of adult females were fixed in 4% formalin solution to determine fecundity. Holden and Raitt (1974) was used to determine the maturity stages of ovaries (Table 1).

In order to determine the fecundity, sub-samples at a rate of 2-5% of whole ovary weight were taken from the anterior, median and posterior parts of mature ovaries and thus the total ovary weight was tried to calculate by counting the mature oocytes. The determination of fecundite was made according the method given by Hunter et al., (1985). χ^2 (chi-square) test was used to determine whether there was a statistically significant difference between sexes (Sumbuloglu and Sumbuloglu, 1993).

Table 1 A five-point maturity scale for partial spawners*

Stage	State	Description
I	Immature	Ovary and testis about 1/3rd length of body cavity. Ovaries pinkish, translucent; testis whitish. Ova not visible to naked eye.
II	Maturing virgin and recovering spent	Ovary and testis about 1/2 length of body cavity. Ovary pinkish, translucent; testis whitish, more or less symmetrical. Ova not visible to naked eye.
III	Ripening	Ovary and testis is about 2/3rds length of body cavity. Ovary pinkish-yellow colour with granular appearance, testis whitish to creamy. No trans- parent or translucent ova visible.
IV	Ripe	Ovary and testis from 2/3rds to full length of body cavity. Ovary orange-pink in colour with conspicuous superficial blood vessels. Large transparent, ripe ova visible. Testis whitish- creamy, soft.
V	Spent	Ovary and testis shrunken to about 1/2 length of body cavity. Walls loose. Ovary may contain remnants of disintegrating opaque and ripe ova, darkened or translucent. Testis bloodshot and flabby.

*Holden and Raitt (1974)

Results

A total of 170 specimens were examined and 44 of them were male (25.9%), 122 female (71.8%) and 4 uncertain (2.3%). The female:male ratio was 2.77:1.00. According to the χ^2 test result ($\chi^2=16.11>\chi^2_{t0.05}=3.85$, P>0.05), a statistically significant difference was observed among the specimens. Fork length-weight relationship and total length-weight relationship were computed as $W=0.0098FL^{2.96}$ ($R^2=0.92$) and $W=0.0071TL^{2.97}$ ($R^2=0.92$), respectively (Figure 1 and 2).

For fecundity determination, mature oocytes in sub-samples (at a rate of 2-5 % of whole ovary weight) that were taken from the anterior, median and posterior parts of 15 ovaries were counted. Consequently, the fecundity of the species was determined between 4,600-9,800 (6,110 ± 1,755). The total length-fecundity relationship was computed as $W=1,640.7TL-13,907$ ($R^2=0.81$) and a linear relationship was determined (Figure 3).

Discussion

We here conducted a preliminary study to determine the reproductive biology of The European pilchard, *Sardina pilchardus* (Walbaum, 1792), collected from the Aegean Sea. In their study on sardines captured from Croatia, Mustać and Sinovčič (2010) gave total length and weight values of the specimens as 13.0-19.0 cm and 16.72 - 51.45, respectively, and determined male:female ratio as 1.0:1.2. The total length-weight relationship given by them was $W=0.026LT^{2.5538}$ (Mustać and Sinovčič, 2010). In our study, length and weight values were 10.50-15.00 cm and 8.06-23.70 g and it was found that the specimens we evaluated in this study were smaller than those evaluated by Mustać and Sinovčič (2010). While total length-weight relationship was $W=0.0071TL^{2.97}$ and female: male ratio was 2.77:1.00 in our

study, it was found that the females were outnumbered.

In their study on specimens from Boka Kotorska Gulf, while Pešić et al. (2010) gave the total length and weight values 8.7-14.7 cm and 4.67-22.61 g, they calculated while the total length-weight relationship as $W=0.0059LT^{3.0891}$ and female: male ratio as 1.49: 1.00, respectively. Length and weight values of the specimens they examined were similar to those in our study and likewise, it was found that females were outnumbered as in our study. Differences between length and weight values determined among studies are caused by sampling area and time, number of specimens, sampling number, type of fishing, sexes and annual changes of species feeding, gonad maturity and environmental conditions (Bagenal and Tesch, 1978; Froese, 2006).

In his study of the reproductive biology of sardines from Edremit Bay, Izmir Bay and Büyük Menderes Delta, Cihangir (1990) computed the female: male ratio as 1.00: 0.28, 1.00: 0.83 and 1.00: 0.82, respectively, and found that females are outnumbered as in our study. Cihangir (1990) found that fecundity was 2000-3000 among the specimens with a length of 12-13 cm, and 10000-15000 among the specimens with 16-17 cm lengt. In our study, we had the specimens between the lengths of 10.5-15.0 cm, fecundity was computed as 4600-9800. Consequently, we thought that the fecundity values calculated between the similar size groups of both studies were almost similar.

As indicated above, in this preliminary study the reproductive biology of an economic fish species, which is very important in Turkish fisheries, was examined. The results obtained here show that the reproduction biology of the species should be examined in more detail by a whole year sampling. In this way, more detailed information may be obtained about the control and continuity of the sardine stocks and sustainable sardine fishing.
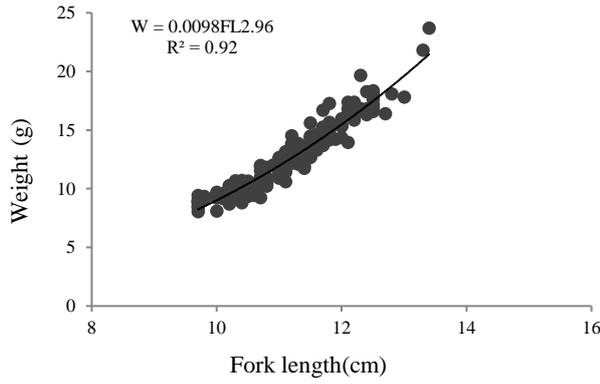
$W = 0.0098FL^{2.96}$
$R^2 = 0.92$

Figure 1 Fork length-weight relationship of 170 Sardina pichardus specimens examined.

$W = 0.0071TL^{2.97}$
$R^2 = 0.92$
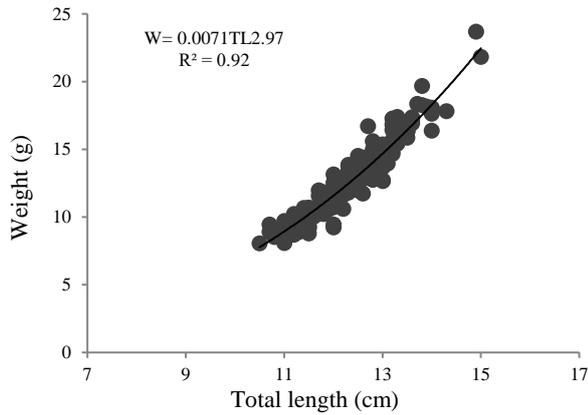
Figure 2 Total length-weight relationship of 170 Sardina pichardus specimens examined.
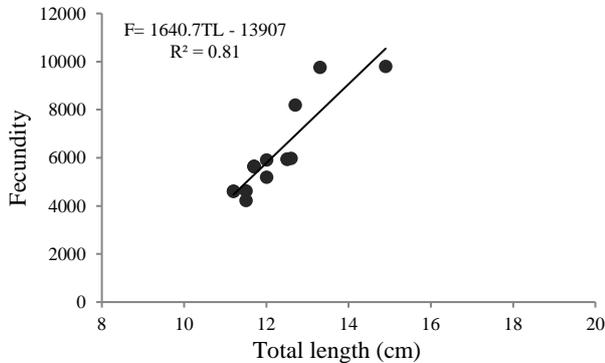

$F = 1640.7TL - 13907$
$R^2 = 0.81$

Figure 3 The total length-fecundity relationship

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