INTRODUCTION

The spawning period has long been a principal issue in fisheries biology, ecology, and management because of its importance for the recruitment (Beaugrand et al. 2003), survival (Garvey et al. 2002), and stock biomass, and thus the fishery yield (Kjesbu and Witheram 2007). Therefore the knowledge of fecundity is useful in investigating the population dynamics of a fish species and for fish culture purposes (Dulčić et al. 1998). Consequently, the reproductive studies may be used for quantification of the reproductive capacity of fish (Murua et al. 2003).

The spotted flounder, *Citharus linguatula* (Linnaeus, 1758), is a flatfish that is distributed in the Mediterranean Sea and eastern Atlantic (Nielsen 1986). It generally occurs at depths from 10 to 100 m (Sartor et al. 2002). This species is widely distributed in the Mediterranean, including the Aegean and Marmara seas and the territorial waters of Turkey (Bilecenoglu et al. 2002). It is often discarded from commercial trawl fisheries in Turkish waters (Bayhan et al. 2009).

A number of studies on *Citharus linguatula* is available as a reference. The age, growth, and reproduction of this fish from Greek waters were studied by Vassilopoulou and Papaconstantinou (1994), while the same aspects were investigated by García-Rodríguez and Esteban (2000) and Teixeira et al. (2010) from the Iberian Mediterranean and the Portuguese coast, respectively. The diets of spotted flounder from the eastern coast of Spain and the central Tyrrhenian Sea were studied by Redon et al. (1994) and Carpentieri et al. (2010), respectively. Sartor et al. 2002 provided data on the abundance and the distribution of *C. linguatula* in the Mediterranean Sea.

As for Turkish waters, the information on age, growth, and reproduction of the species come from Edremit Bay (Türker Çakırlar et al. 2005) and Izmir Bay (Bayhan et al. 2009, Kınacıgil et al. unpublished**, Ulutürk unpublished***).

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** Kınacıgil H.T., İlyaz A.T., Metin G., Ünal A., Soykan O., Akyol O., Gurber R. 2008. Balıkçılık Yönetimi Açısından Ege Denizinde Demersal Balık Stoklarının İlk Ürume Boyanı, Yavlalan ve Böyleme Parametrelerinin Tespiti. [Determination of the first maturity length/age and growth parameters of demersal fish stock in the Aegean Sea from the fishery management point of view.] The Scientific and Technological Research Council of Turkey (TUBITAK), Project number: 103Y132. Ege University Faculty of Fisheries, Bornova, Izmir. [In Turkish.]

*** Ulutürk E. 2007. Izmir Körfezi’nde dagılım gösteren kancacığzı pisi balığı (*Citharus linguatula* Linnaeus, 1758)’ın bazı biyolojik özellikleri. [Some biological features of spotted flounder *Citharus linguatula* (L., 1758) from Izmir Bay.] MSc Thesis, Ege University Faculty of Fisheries, Izmir. [In Turkish.]
Gürkan and Bayhan (2009) reported some morphometric features of the spotted flounder in Izmir Bay. While Cengiz et al. (2011) documented its presence in Saros Bay, Cengiz et al. (2012a) examined the relation between total length and otolith size of *C. linguatula* in same region.

No information concerning the reproduction of *C. linguatula* was so far available in from the Northern Aegean Sea. The objectives of this study were to estimate the gonadosomatic index (GSI), the length at maturity (*L*₅₀), and the relations between the absolute fecundity and total length, absolute fecundity and total weight, as well as absolute fecundity and age of *C. linguatula* from Saros Bay and to compare these results with those of the previous studies in other areas.

**MATERIALS AND METHODS**

The samples of the spotted flounder, *Citharus linguatula*, were collected monthly, between September 2006 and September 2008 using a commercial bottom trawl net of 44 mm codend stretched mesh size at depths ranging from 0 m to 500 m in Saros Bay, which had been closed to trawl fishing since 2000 (Fig. 1).

The specimens were measured to the nearest 1 mm (total length, TL), weighed to the nearest 0.01 g (total weight). The chi-square (*χ²*) test was used to detect the differences in the sex ratio. The Student’s *t*-test was used to analyze the differences in the mean length and weight of the sexes.

In flatfishes, the otoliths from blind side were used for age estimation, as the nucleus is more central (Fig. 2) and the zones were easier to be interpreted compared to otoliths from the ocular side (Cengiz et al. 2012a, 2012b).

Following removal, the blind side otoliths were first soaked in 5% HCL and 3% NaOH solutions, respectively, and washed in distilled water and subsequently dried. The otoliths, placed in watch glass filled with the water, were read using a stereoscopic zoom microscope under reflected light against a black background. Opaque and transparent zones were counted; one opaque zone plus one transparent zone was assumed to be one year (Cengiz et al. 2013).

Sex was determined by examining the gonads macroscopically. The maturity was assessed according to Gunderson’s (1993) scale: stage I (immature), stage II (resting), stage III (developing), stage IV (ripe), and stage V (spent). The spawning period was estimated by monthly analyses, the changes of the gonadosomatic index (GSI) using the equation:

\[
\text{GSI} = \left[ \frac{W_g}{W} \times (W - W_g)^{-1} \right] \times 100
\]

where *Wₕ* is the gonad weight [g] and *W* is the total weight [g] of fish (Ricker 1975).

Length at maturity (*L*₅₀), the size at which 50% of the individuals were mature, was estimated by means of

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**Fig. 1.** Saros Bay and the sampling stations (Author: Ali İşmen, Reprinted under licence of Creative Commons; Map previously published in the following papers Cengiz et al. 2011, 2012a, 2012b, 2013, Ismen et al. 2013, İşmen et al. 2013, Yıgın and Ismen 2010, Yıgın and Ismen 2012, 2013)
a logistic function that was fitted to the proportion of sexually mature individuals by size class using a nonlinear regression (King 1995).

Gravimetric method was used for fecundity estimates (Bagenal and Braum 1978). In order to calculate fecundity, the ovaries of mature females (prior to the reproductive period) were weighed the nearest 0.0001 g (total weight), three sub-samples were taken from the front, mid- and rear sections of each ovary, weighed and then immersed separately in Gilson’s fluid. These ovaries were frequently shaken to ensure the separation of oocytes from ovarian tissues. All oocytes were counted directly under stereoscopic zoom microscope. The total number of eggs in each ovary sub-sample was then estimated by using the equation provided by Yeldan and Āvşar (2000):

\[ F_1 = (W_g \times N) \times W_s^{-1} \]

where: \( F_1 \) is the total number of eggs in ovary sub-sample 1, \( W_g \) is the gonad weight, \( N \) is the number of eggs in the sub-sample, and \( W_s \) is sub-sample weight. Later, by taking the mean number of three sub-sample fecundities (\( F_1, F_2, \) and \( F_3 \)), the absolute fecundity (\( F_a \)) for each female fish was estimated as:

\[ F_a = (F_1 + F_2 + F_3)^{-3} \]

Hereby, the relations between absolute fecundity (\( F_a \)) and total length (TL), absolute fecundity (\( F_a \)) and total weight (TW), as well as absolute fecundity (\( F_a \)) and age (\( A \)) were estimated as (respectively):

\[ F_a = aTL^b \]
\[ F_a = a + bTW \]
\[ F_a = a + bA \]

where \( a \) and \( b \) are the parameters of the equation (Avşar 2005).

**RESULTS**

Of 659 examined specimens of *Citharus linguatula*, 464 (70.4%) were females, and 195 (29.6%) males. The sex ratio (F : M) was 1 : 0.42, which is significantly different from equal representation of sexes (\( \chi^2 \) test: \( P < 0.05 \)). The mean ± standard error (and range) of total length were: 18.2 ± 0.10 (9.9–23.5) cm TL for females, 16.6 ± 0.15 (9.4–22.2) cm TL for males (Fig. 3). The respective values for total weight were: 47.59 ± 0.80 (7.81–102.42) g for females and 35.64 ± 1.03 (5.08–91.92) g for males. The Student’s t-test showed significant differences between the mean lengths and between weights of the both sexes (all \( P < 0.05 \)).

The variations in GSI values throughout the study period did not show strong changes for males, but presented a pronounced peak for females in September. All year
around the GSI values for females were higher than the male values. GSI reached the highest values with 3.63 and 0.52 for females and males, respectively, in September 2007. The elevated GSI values suggested the spawning period was from September till the end of October. After spawning, the gonadosomatic index remained almost constant for most of the year (Fig. 4).

In presently reported study, the smallest mature female and male were found to be 9.9 and 9.4 cm TL, respectively. The length at maturity \((L_{50})\) was at 15.0 cm TL for females and 14.0 cm TL for males (Fig. 5).

The absolute fecundity \((F_a)\) was estimated for 81 ripe females (age 2 to 6) caught in June–September 2008. The maximum value of 6262 eggs was recorded in a 6 year-old fish weighing 95.80 g (23.5 cm TL) while the minimum value of 1071 eggs for a 2 year-old fish weighing 19.59 g (15.2 cm TL). The mean value ± standard error of absolute fecundity was 3205 ± 129. The relations between the absolute fecundity and total length, total weight and age of the spotted flounder females were estimated as

\[
F_a = 0.1878TL^{3.29}, \quad F_a = 58.515TW + 36.453, \quad F_a = 887.59A - 389.43
\]

respectively (Fig. 6).

**DISCUSSION**

The reproductive biology of *Citharus linguatula* has been investigated for the first time in the Saros Bay (northern Aegean Sea, Turkey). The reproductive cycles of female and male individuals are synchronized. In this study, the spawning period of the spotted flounder started in September and continued until end of October. Sabatés (1988) and Ulutürk (unpublished) reported that the reproductive period was between August and November for the Western Mediterranean and Izmir Bay. Another study conducted in Izmir Bay (Aegean Sea) by Kınacıgil et al. (unpublished) indicated that the reproductive period was from October to December (Table 1). The spawning period has a close relationship to the ecological characteristics of the water system in which the species live (İlkyaz et al. 2010) and are attributed to the factors such as stagnant or running water, temperature, and quality of food (Nikolsky 1963). According to Wootton (1990), temperature appears to be the most important factor among those that may influence the reproduction of fishes.

Our results showed that the length at maturity \((L_{50})\) was at 15.0 cm TL for females and 14.0 cm TL for males. Kınacıgil et al. (unpublished) determined the length at maturity \((L_{50})\) of females and males to be 15.0 cm and 14.0 cm, respectively. The fecundity is estimated as

\[
F_a = 0.1878TL^{3.29}, \quad F_a = 58.515TW + 36.453, \quad F_a = 887.59A - 389.43
\]

respectively (Fig. 6).

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* See footnote on page 123.
maturity ($L_{50}$) as 12.0 cm for females and 12.9 cm for males, whereas, Vassilopoulou and Papaconstantinou (1994) estimated the length at maturity ($L_{50}$) to be 15.1 cm for females and 12.4 cm for males (Table 2).

The $L_{50}$ for both female and male appears to increase with the latitude. This regularity is related to the pattern of overall body size in flatfish species being larger at higher latitudes (Pauly 1994a). Rijnsdorp (1989) and Sampson and Al-Jufaily (1999) stated that $L_{50}$ increased with the latitude, however, Walsh (1994) interpreted this relation as $L_{50}$ declining with the temperature increase.

For all flatfishes studied to date, females grow larger and faster than the males (Pauly 1994a, Vassilopoulou and Ondrias 1999). This phenomenon is a common feature in many pleuronectiforms (Lozán 1992, Landa and Pinerio 2000, Cengiz et al. 2013). This could be attributed to differences in metabolism between females and males, such as differences in oxygen consumption (Pauly 1994a, 1994b), differences in the level of surplus energy between reproduction and somatic growth (Rijnsdorp and Ibelings1989), and differential food ingestion (Lozán 1992). Vassilopoulou and Papaconstantinou (1994) and Ulutürk (unpublished*) also found out that the natural mortality was higher for males than for females for *C. linguatula*.

In addition, the difference in growth rates between males and females seems to occur at the onset of maturity (Vassilopoulou and Papaconstantinou 1994). Males spawn for the first time earlier than females, as was also reported by Vassilopoulou and Papaconstantinou (1994) and by the presently reported study. Similar findings on males have been made many other flatfishes such as lemon sole, *Microstomus kitt* (Walbaum, 1792) (see Rae 1965); American plaice, *Hippoglossoides platessoides* (Fabricius, 1780) (see Roff 1983); turbot, *Psetta maxima* (Linnaeus, 1758); common sole, *Solea vulgaris* (Linnaeus, 1758); common dab *Limanda limanda* (Linnaeus, 1758); Mediterranean scadfish, *Arnoglossus laterna* (Walbaum, 1792); and Thor’s scadfish, *Arnoglossus thori* Kyle, 1913 (see Deniel 1990). Roff (1982) insisted that male flatfish having reached the length at which they could successfully reproduce, decreased their growth, in part, as a response to the divergence of energy into reproduction and as a response to decreased foraging activity which reduced the risks of being preyed upon. Also Roff (1983) suggested that there was a clear association between the relative size of male fish and their reproductive behaviour—males that did not hold territories and did not care for their progeny were consistently smaller than females.

The fecundity results, provided by us, represent the first such data on *C. linguatula*. The marked differences in fecundity among species often reflect different reproductive strategies (Murua and Saborido-Rey 2003). Within a given species, fecundity may vary as a result of different adaptations to environmental habitats (Withthames et al. 1995). Even within a stock, fecundity is known to vary annually, undergo long-term changes (Rijndorp 1991) and has been shown to be proportional to fish size and condition. For a given size, females in better condition exhibit higher fecundity (Kjesbø et al. 1991). Fish size and condition are, thus, key parameters to properly assess fecundity at the population level. However, the fecundity–size relations has been used principally as a rapid means of predicting the fecundity of fish (Dulčić et al. 1998).

As a consequence, the data of this study will increase the life history data available for *C. linguatula* by providing the scientific support required so as to identify the cur-

### Table 1

| Area                  | Spawning period    | Reference             |
|-----------------------|--------------------|-----------------------|
| Western Mediterranean | August–November    | Sabatés 1988          |
| Izmir Bay, Turkey     | August–November    | Ulutürk unpublished*  |
| Izmir Bay, Turkey     | October–December   | Kınacıgil et al.       |
| Portuguese coast      | Autumn              | Teixeira et al. 2010   |
| Saros Bay, Turkey     | September–November | This study             |

### Table 2

| Area                        | Sex | Length at maturity | Reference                   |
|-----------------------------|-----|--------------------|-----------------------------|
| Northern Aegean Sea, Greece | ♀   | 15.1 cm            | Vassilopoulou and Papaconstantinou 1994 |
|                             | ♂   | 12.4 cm            |                             |
| Izmir Bay, Turkey           | ♀   | 12.0 cm            | Kınacıgil et al. unpublished* |
|                             | ♂   | 12.9 cm            |                             |
| Saros Bay, Turkey           | ♀   | 15.0 cm            | This study                  |
|                             | ♂   | 14.0 cm            |                             |

*See footnote on page 123.*
rent stock state and will help conservation and management of the species.

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REFERENCES

Ayar D. 2005. Balıkçılık Biyolojisi ve Populasyon Dinamigi. [Fisheries biology and population dynamics.] Nobel Kitabevi, Adana, Turkey. [In Turkish.]

Bagenal T.B., Braum E. 1978. Eggs and early life history. Pp. 106–201. In: Begenal T. (ed.) Methods for assessment of fish production in freshwaters. 3rd edn. Blackwell Scientific, Oxford, UK.

Bayhan B., Sever T.M., Taşkavak E. 2009. Age and feeding habits of Atlantic spotted flounder Citharus linguatula (Linnaeus, 1758) (Pisces: Pleuronectiformes) from central Aegean Sea of Turkey. North-Western Journal of Zoology 5 (2): 330–337.

Beaugrand G., Brander K.M., Lindley J.A., Souissi S., Reid P.C. 2003. Plankton effect on cod recruitment in the North Sea. Nature 426 (6967): 661–664. DOI: 10.1038/nature02164

Bilecenoglu M., Taskavak E., Mater S., Kaya M. 2000. Contribution to the knowledge of Citharus linguatula (Linnaeus, 1758) (Osteichthyes [sic]: Heterosomata) in the Iberian Mediterranean. Pp. 131–140. In: Bertrand J.A., Relini G. (eds.) Demersal resources in the Mediterranean: Proceedings of the symposium held in Pisa, 18–21 March 1998. IFREMER: Actes de colloques No. 26.

Garvey J.E., Herra T.P., Leggett W.C. 2002. Protracted reproduction in sunfish: the temporal dimension in fish recruitment revisited. Ecological Applications 12 (1): 194–205. DOI: 10.1890/1051-0761(2002)012[0194:PRISTT]2.0.CO;2

Gunderson D.R. 1993. Surveys of fisheries resources. John Wiley and Sons, New York, NY, USA.

Gürkan Ş., Bayhan B. 2009. İzmir Körfezi’nde kancaağız pisi Citharus linguatula (Linnaeus, 1758)’nün bazı morfometrik özellikleri. [Some morphometrics features of Atlantic spotted flounder Citharus linguatula (Linnaeus, 1758) in Izmir Bay ( Aegean Sea).] Tübat Bilim Dergisi 2 (4): 394–398. [In Turkish.]

Ismen A., Arslan M., Yigin C.C., Bozbay N.A. 2013. Age, growth, reproduction and feeding of John Dory, Zeus faber (Pisces: Zeidae), in the Saros Bay (North Aegean Sea). Journal of Applied Ichthyology 29 (1): 125–131. DOI: 10.1111/j.1439-0426.2009.01382.x

İlkyaz A.T., Metin G., Soykan O., Knaagil H.T. 2010. Age, growth and sexual development of solenette, Buglossidium luteum (Risso, 1810), in the central Aegean Sea. Journal of Applied Ichthyology 26 (3): 436–440. DOI: 10.1111/j.1439-0426.2009.01382.x

King M. 1995. Fisheries biology, assessment and management fishing. Fishing New Books, Oxford, UK.

Kjesbu O.S., Klungsøyr J., Kryvi H., Withthames P.R., Greer Walker M. 1991. Fecundity, atresia, and egg size of captive Atlantic cod ( Gadus morhua ) in relation to proximate body composition. Canadian Journal of Fisheries and Aquatic Sciences 48 (12): 2333–2343. DOI: 10.1139/f91-274

Kjesbu O.S., Withthames P.R. 2007. Evolutionary pressure on reproductive strategies in flatfish and groundfish: Relevant concepts and methodological advancements. Journal of Sea Research 58 (1): 23–34. DOI: 10.1016/j.seares.2007.02.001

Landa J., Pirene C. 2000. Megrim (Lepidorhombus whiffii-gonis ) growth in the north-eastern Atlantic based on back-calculation of otolith rings. ICES Journal of Marine Science 57 (4): 1077–1090. DOI: 10.1006/jmsc.2000.0702
Reproductive biology of Citharus linguatula

Lozán J.L. 1992. Sexual differences in food intake, digestive tract size, and growth performance of the dab, Limanda limanda L. Netherlands Journal of Sea Research 29 (1–3): 223–227. DOI: 10.1016/0077-7579(92)90022-7

Murua H., Kraus G., Saborido-Rey F., Thorson A., Junquera S. 2003. Procedures to estimate fecundity of marine fish species in relation to their reproductive strategy. Journal of Northwest Atlantic Fishery Science 33: 33–54.

Murua H., Saborido-Rey F. 2003. Female reproductive strategies of marine fish species in the North Atlantic. Journal of Northwest Atlantic Fishery Science 33: 23–31.

Nielsen J.G. 1986. Citharidae. P. 1286. In: Whitehead P.J.P., Bauchot M.-L., Hureau J.-C., Nielsen J., Tortonese E. (eds.) Fishes of the north-eastern Atlantic and Mediterranean. UNESCO, Paris, France.

Nikolsky G.V. 1963. The ecology of fishes. Academic Press, London and New York.

Pauly D. 2002. Distribution and abundance of Citharus linguatula, Lepidorhombus boscii, and Solea vulgaris (Osteichthyes: Pleuronectiformes) in the Mediterranean Sea. Scientia Marina 66 (Suppl. 2): 83–102. DOI: 10.3989/scimar.2002.66s283

Teixeira C.M., Batista M.I., Cabral H.N. 2010. Diet, growth and reproduction of four flatfishes on the Portuguese coast. Scientia Marina 74 (2): 223–233. DOI: 10.3989/scimar.2010.74n2223

Türker Çakır D., Bayhan B., Hoşsucu B., Ünlüoğlu A., Akalın S. 2005. Some parameters of the population biology of spotted flounder (Citharus linguatula Linnaeus, 1758) in Edremit Bay (north Aegean Sea). Turkish Journal of Veterinary and Animal Sciences 29 (4): 1013–1018.

Vassilopoulou V., Ondrias I. 1999. Age and growth of the four-spotted megrim (Lepidorhombus boscii) in eastern Mediterranean waters. Journal of the Marine Biological Association of the United Kingdom 79 (1): 171–178. DOI: 10.1017/S0025315498000198

Wass J.S. 1994. Life history traits and spawning characteristics in populations of long rough dab (American plaice) Hippoglossoides platessoides (Fabricius) in the North Atlantic. Netherlands Journal of Sea Research 32 (3–4): 241–254. DOI: 10.1016/0077-7579(94)90002-7

Withthams P.R., Greer Walker M., Dinis M.T., Whiting C.L. 1995. The geographical variation in the potential annual fecundity of Dover sole, Solea solea (L.) from European shelf waters during 1991. Netherlands Journal of Sea Research 34 (1–3): 45–58. DOI: 10.1016/0077-7579(95)90013-6

Wootten R.J. 1990. Ecology of teleost fishes. Chapman and Hall, Upper Saddle River, NJ, USA.

Yeldan H., Ayşar D. 2000. A preliminary study on the reproduction of the rabbitfish (Siganus rivulatus Forsskal, 1775) in northeastern Mediterranean. Turkish Journal of Zoology 24 (2): 173–182.

Yığın C., Ismen A. 2010. Age, growth, reproduction and feed of longnosed skate, Dipturus oxyrinchus (Linnaeus, 1758) in Saros Bay, the north Aegean Sea. Journal of Applied Ichthyology 26 (6): 913–919. DOI: 10.1111/j.1439-0426.2010.01510.x

Yığın C.C., Ismen A. 2012. Age, growth and reproduction of the common stingray, Dasyatis pastinaca from the North Aegean Sea. Marine Biology Research 8 (7): 644–653 DOI: 10.1080/17451000.2012.659667

Yığın C.C., Ismen A. 2013. Reproductive biology of spiny dogfish Squalus acanthias, in the north Aegean Sea. Turkish Journal of Fisheries and Aquatic Sciences 13 (1): 169–177. DOI: 10.4194/1303-2712-v13_1_20

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