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Maturity and Fecundity of Lizardfish (*Saurida undosquamis* Richardson, 1848) in İskenderun Bay (Eastern Mediterranean)

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Abstract: The spawning season, size and age at first sexual maturity, and fecundity of the commercially important lizardfish (*Saurida undosquamis*) were studied on the basis of 602 specimens from İskenderun Bay in the eastern Mediterranean. Lizardfishes had ripe gonads all around the year. The monthly gonadosomatic index values and the frequency of ripe gonads indicated that the spawning of this species occurred mainly in two seasons (May-July and September-November). Males attained first sexual maturity at a total length of about 16 cm and females at about 16.5 cm. Fecundity-length relationships estimated between 1999 and 2000 were log F = 0.422 + 3.293 log L (r = 0.76), log F = 0.132 + 3.490 log L (r = 0.86), respectively. In 1999 and 2000, fecundity-age relationships were estimated as log F = 4.379 +1.164 log A (r = 0.80), log F = 4.501 + 0.925 log A (r = 0.82), respectively. No annual variation in fecundity was apparent for the study period.

Key Words: İskenderun Bay, Lizardfish (Saurida undosquamis), First Sexual Maturity, Fecundity

İskenderun Körfezi (Doğu Akdeniz) Iskarmoz Balığının (*Saurida undosquamis* Richardson, 1848) Eşeysel Olgunluğu ve Yumurta Verimi

Özet: Doğu Akdeniz'de İskenderun Körfezi'nin ticari önemi yüksek balıklarından biri olan Iskarmoz balığının (*Saurida undosquamis*) yumurtlama mevsimi, ilk eşeysel olgunluk boyu, yaşı ve yumurta verimi (fekondite) örneklenen 602 bireyde çalışılmıştır. Iskarmozların tüm yıl boyunca olgun gonadlara sahip olduğu saptanmıştır. Aylık gonadosomatik indeks (GSI) değerleri ve olgun gonad frekansları, bu türün esas olarak iki dönemde (Mayıs-Temmuz ve Eylül-Kasım) yumurtladığını göstermiştir. Erkekler ilk eşeysel olgunluğa yaklaşık 16 cm; dişiler ise 16.5 cm toplam boyda ulaşmışlardır. 1999 ve 2000 yıllarında yumurta verimi-boy ilişkisi sırasıyla; log F = 0.422 + 3.293 log L (r = 0.76), log F = 0.132 + 3.490 log L (r = 0.86) olarak saptanmıştır. 1999 ve 2000 yılında yumurta verimi-yaş ilişkisi sırasıyla; log F = 4.379 +1.164 log A (r = 0.80), log F = 4.501 + 0.925 log A (r = 0.82) olarak hesaplanmıştır. Bu çalışma süresinde yumurta veriminde yıllara göre bir değişim görülmemiştir.

Anahtar Sözcükler: İskenderun Körfezi, Iskarmoz Balığı (*Saurida undosquamis*), İlk Eşeysel Olgunluk, Yumurta Verimi

Introduction

The lizardfish (*Saurida undosquamis*) is a Lessepsian migrant species that penetrated into the Mediterranean Sea from the Indo-West Pacific through the Suez Canal (Ben-Tuvia, 1966; Gücü et al., 1994; Mater et al., 1995). This species invaded the Levant Basin, and established a population of considerable commercial importance. The first report about lizardfish in Turkish seas was by Kosswig (1951). This is a demersal species, found over mostly sandy or muddy bottoms of coastal waters as deep as 200 m. It is reported that the maximum size of this fish is about 50 cm; however, in catches the common size range is between 20 and 30 cm (Bauchot, 1987). In the eastern Mediterranean (North Levantine Basin), *S. undosquamis* is among the most common species caught in the trawl fishery, accounting for 17-18% annually (Bingel et al., 1993).

Comprehensive studies on the biology and ecology of this species are scarce. In the eastern Mediterranean, except for a few studies on its reproduction (Bingel, 1988a) and food intake (Bingel and Avşar, 1988a,b; Bingel, 1988b), most of the work deals with its distribution (Ben-Yami and Glaser, 1974; Golani, 1993) and general biology (Golani, 1990; Torcu, 1995). Gücü and Bingel (1994) reported most Lessepsian species to be found on the continental shelf of the Northeastern Levantine Basin. Gücü et al. (1994) and Başusta (1997) studied the distribution of Red Sea species along the Turkish coast. Payza (1983) investigated the enzyme system in three species (*S. undosquamis, M. barbatus* and

U. moluccensis) of the eastern Mediterranean for use in a biochemical genetic method of stock differentiation. Avşar et al. (1990) studied the morphometric separation of lizardfish stocks in the Gulf of Mersin using the Mahalanobis distance function. Türeli and Erdem (1997), and Torcu (1995) reported observations on its age, growth, food and reproduction in İskenderun Bay.

This paper presents results from spawning time, length and age at first maturity and fecundity studies on lizardfish in İskenderun Bay and the eastern Mediterranean in relation to length and age, and compares the fecundity-length relationship in different years.

Materials and Methods

Six hundred two lizardfish specimens were collected by monthly sampling using the R/V Mustafa Kemal-1 from May 1999 to June 2000 in İskenderun Bay. The bottom trawling operations were carried out in the areas circled in Figure 1 only during the daytime at depths ranging from 10 to 50 m. The trawl was equipped with a 18-mm mesh size net at the cod-end. Hauling lasted about 2.5 h at a towing speed of 1.5 kn. Due to adverse weather conditions, it was not possible to collect specimens in March or April 2000.

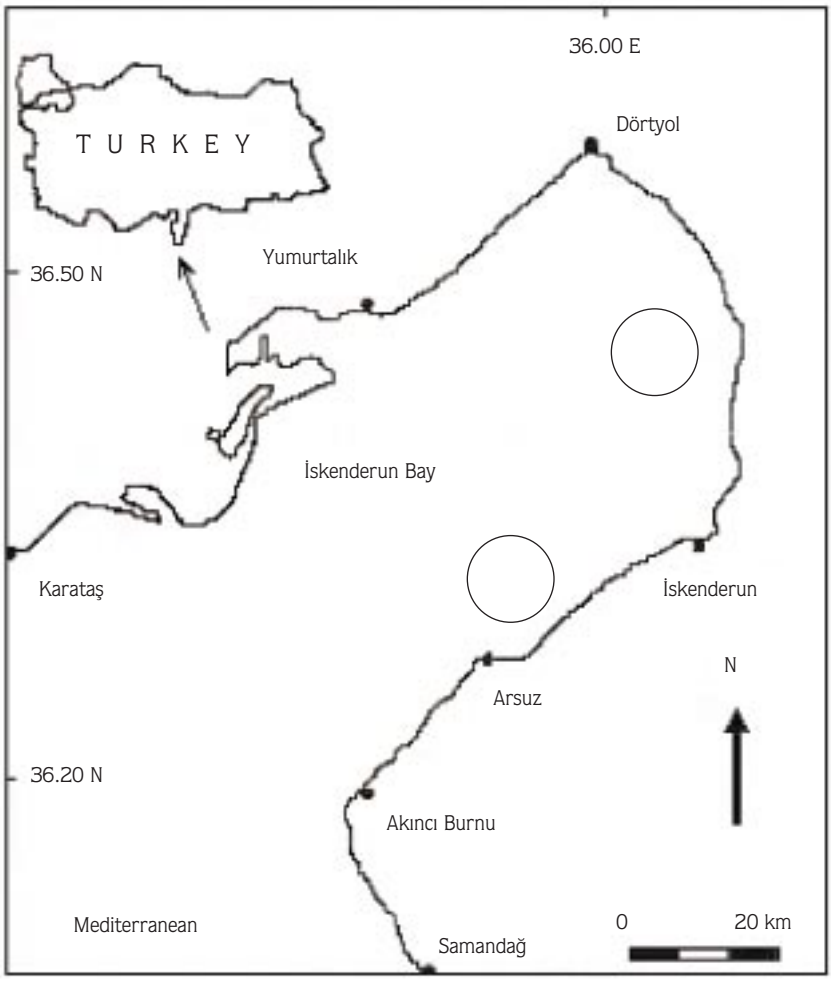

Figure 1. Location of the sampling stations in İskenderun Bay (O: sampling station).

Samples were kept in ice boxes until transfer from the boat to the laboratory. Total length was measured to the nearest millimeter and body and gonad weights to the nearest gram in the laboratory. Age was determined from rings in the sagittal otoliths. Otoliths removed from the fish were cleaned with water and alcohol, and then stored dry in paper envelopes. The otoliths were sectioned across the center of the nucleus, using a scalpel, and the section or surface of otoliths was polished in order to make it much easier to read. The otoliths (the number of opaque and hyaline zones) were examined in glycerin under a stereozoom microscope illuminated from above (Holden and Raitt, 1974). For the age determinations, 1 January was used as the date of birth (Holden and Raitt, 1974; Bingel, 2002). The length distributions of lizardfish and the back-calculation method in otolith readings were used to distinguish true annual zones from secondary or false zones.

The degree of sexual maturity of each specimen was determined by inspection of the gonads in fresh individuals. The stages of maturation were classified according to Holden and Raitt' s (1974) scale. The typical appearance of the gonad at each maturity stage is described below.

Stage I (immature): Gonads are very small. Ovaries are pinkish translucent. Testis is whitish.

Stage II (maturing and recovering spent): Gonads are small, dully transparent and pinkish-whitish.

Stage III (ripening): Gonads are enlarged. Ovary is pinkish-yellow with granular appearance. Testis is whitish to creamy. There are no transparent ova.

Stage IV (ripe): Gonads are considerably enlarged. Ovary is orange-pink with conspicuous superficial blood vessels and is large and transparent. Ripe ova are visible. Testis is whitish-creamy, soft.

Stage V (spent): Gonads are shortened, walls loose, flabby, empty, dark red with traces of sperm or ova.

The gonadosomatic index (GSI) was calculated by monthly period with the equation given below:

GSI = (gonad weight/fish weight without gonad)*100

The mean lengths (cm) at 50% maturity from the percentages of mature lizardfish were calculated with 1-cm length intervals.

Ovaries were cut longitudinally and stored in Gilson's fluid to dissolve the connective tissue. The egg numbers were estimated using the gravimetric method described by Bagenal (1978). The subsamples for counting were taken from anterior, middle and posterior parts of the ovary. All samples was counted three times under a stereozoom microscope and the mean value was calculated. The fecundity was estimated by multiplying the mean value with the factor *G/g*, where (*G)* is the gonad weight and (*g)* is the subsample weight. In all species the fecundity appears to be related to the length of the fish by an equation of the type $F = aL^b$. Therefore, the fecundity estimates were converted to a linear form using log-log (base 10) transformations, and the data were analyzed by least squares regression. Analysis of covariance (Rohlf, 1986) was used to test the significance of the differences between regression coefficients.

Results

The sex ratios of lizardfish for the study period in İskenderun Bay were 38.8% for males and 61.2% for females.

Changes in maturity and GSI

Gonads classified by their macroscopic appearance are given in Table 1. The ripe fish (stage IV) in samples taken at monthly intervals showed that the spawning season extends over 12 months of the year. The intensity of spawning in each month throughout the spawning period

Table 1. Number of fish in each maturity stage between May 1999 and June 2000.

Months	Maturity Stages					
	N	I	II	III	IV	V
May	69	50	8	8	3	-
June	30	17	2	8	3	-
July	78	14	23	25	14	2
August	44	3	31	8	2	-
September	78	17	48	6	2	5
October	45	18	12	15	-	-
November	42	14	16	2	9	1
December	52	15	22	14	1	-
January	29	1	11	16	1	-
February	21	-	7	13	1	-
March	-	-	-	-	-	-
April	-	-	-	-	-	-
May	91	-	3	36	52	-
June	23	3	-	15	3	2

showed that most fish spawn during two main seasons (May-July and September-November).

Monthly changes in the GSI revealed that gonad development was remarkably high between May and June (Figure 2). After June, the GSI showed a sharp decline and then increased slowly again between September and October. These periods coincide with the two main spawning periods.

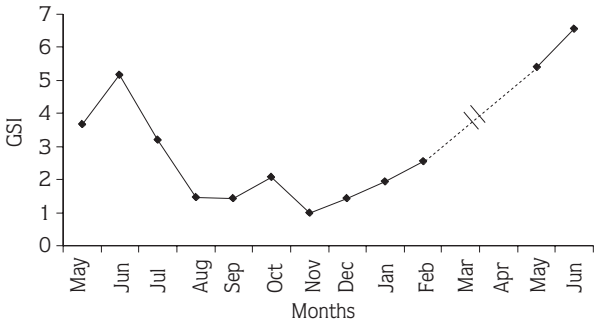

Figure 2. The monthly changes in the gonadosomatic index (GSI) of lizardfish.

Length and age at first sexual maturity

The transition from immaturity to maturity usually occurs over a range of lengths and is not abrupt, and this is reflected by the data presented in Table 2. Males attain sexual maturity at a total total length of about 16 cm and females at about 16.5 cm (Figure 3). These lengths at first sexual maturity coincide with age group I. Males have an average total length of 13.4 cm (10-16 cm) in age group I, and 17.7 cm (14-19 cm) in age group II. Females have an average total length of 14.6 cm (9-17 cm) in age group I, and 19.6 cm (16-22 cm) in age group II. Mature fish below 11 cm for males and 13 cm for females were not recorded. All males (100%) above 21 cm in total length and all females (100%) above 22 cm in total length were mature (Table 2).

Fecundity related to fish length

For İskenderun Bay, the analysis of data for 1999 and 2000 indicated that the fecundity of *S. undosquamis* is related to length by the relationships

Table 2. Percentage distribution of ripe gonads of lizardfish in relation to the length groups (F: females, M: males).

Length (cm)	N		Immature		Ripe (n)		Ripe (%)		Mean (Three Running Averages)	
	F	M	F	M	F	M	F	M	F	M
9	1	-	1	-	-	-	-	-	-	0
10	1	1	1	1	-	-	0	0	0	8.3
11	7	4	7	3	-	1	0	25.0	0	17.4
12	4	11	4	8	-	3	0	27.3	11.1	23.0
13	6	6	4	5	2	1	33.3	16.7	13.5	25.8
14	14	21	13	14	1	7	7.1	33.3	22.4	31.3
15	26	25	19	14	7	11	26.9	44.0	27.0	41.6
16	17	21	9	11	8	10	47.1	47.6	45.9	53.3
17	22	19	8	6	14	13	63.6	68.4	60.7	68.7
18	21	21	6	2	15	19	71.4	90.1	72.2	82.9
19	27	32	5	3	22	29	81.5	90.1	83.3	92.0
20	34	24	1	1	33	23	97.1	95.8	89.6	95.3
21	32	17	3	-	29	17	90.1	100	95.7	98.6
22	19	9	-	-	19	9	100	100	96.7	100
23	23	6	-	-	23	6	100	100	100	100
24	22	1	-	-	22	1	100	-	100	-
25	22	3	-	-	22	3	-	-	-	-
26	17	-	-	-	17	-	-	-	-	-
27	13	1	-	-	13	1	-	-	-	-
28	17	2	-	-	17	2	-	-	-	-
29	6	1	-	-	6	1	-	-	-	-
30	7	-	-	-	7	-	-	-	-	-

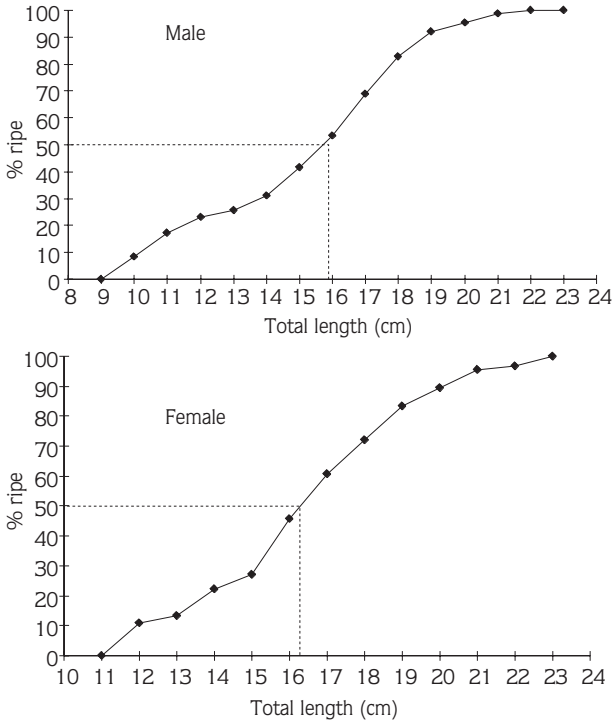

Figure 3. The mean lengths at 50% maturity of lizardfish in each sex.

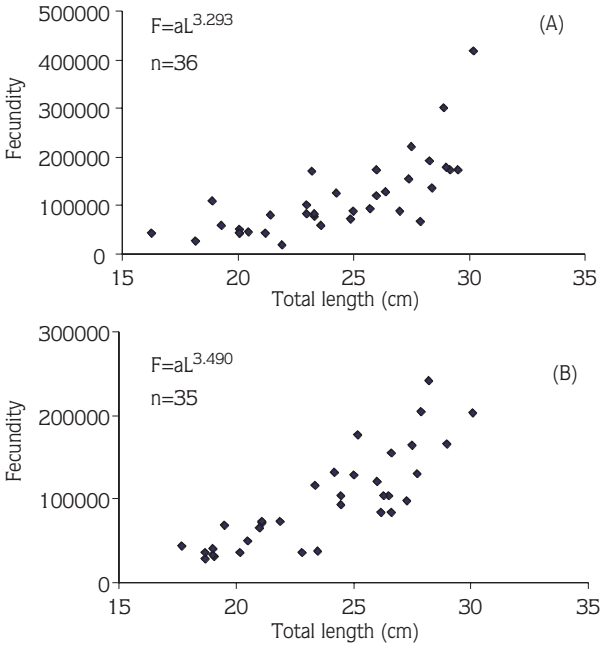

Figure 4. Relationships between fecundity and total length of lizardfish from İskenderun Bay for 1999 (A) and 2000 (B).

$$log\ F = 0.422 + 3.293\ log\ L \quad (1999)$$

$$log\ F = 0.132 + 3.490\ log\ L \quad (2000)$$

where (*F*) is fecundity (number of eggs) and (*L*) is fish length (cm). Plots of fecundity-length data and an arithmetic representation of the relationship are shown in Figure 4. In all cases the correlation coefficients (for 1999 r = 0.76, and for 2000 r = 0.86) are significantly different from zero ($P < 0.01$) (Table 3).

Analysis of covariance of the fecundity-length data for İskenderun Bay between 1999 and 2000 indicated that there are no significances between the regression coefficients (rate of egg production) ($P > 0.01$).

Fecundity related to fish age

The fecundity-age relationship for İskenderun Bay in 1999 and 2000 is indicated by the expressions

$$log\ F = 4.379 + 1.164\ log\ A \quad (1999)$$

$$log\ F = 4.501 + 0.925\ log\ A \quad (2000)$$

where (A) is fish age (years). Plots of the data and the arithmetic representation of the equations are shown in Figure 5. The correlation coefficients (for 1999 r = 0.80, and for 2000 r = 0.82) for all relationships are significantly different from zero ($P < 0.01$) (Table 3).

Analysis of covariance of the 1999 and 2000 fecundity-age data for İskenderun Bay indicated that there are no significant differences between the regression coefficients ($P > 0.01$).

Discussion

The ripe fish (stage IV) in samples taken at monthly intervals in İskenderun Bay showed that the spawning season extends over 12 months of the year. The intensity of spawning in each month (Table 1) and the GSI results revealed that most fish spawn during two main seasons (May-July and September-November). These results are similar to those determined in other studies on lizardfish in this area (Ben-Tuvia, 1966; Bingel, 1988a; Ben-Yami and Glaser, 1974; Torcu, 1995; Arakawa, 1993; TÜGM, 1993). Ben-Tuvia (1966) reported that Red Sea species in the eastern Mediterranenan reproduce in late spring and summer. It is likely that the same species in the southern Red Sea reproduce throughout the year. Ben-Yami and Glaser (1974) stated that ripe, nearly ripe, and partly spent females occur in catches almost all year around, although the former author indicated that the greater proportion of nearly ripe females occurs in the

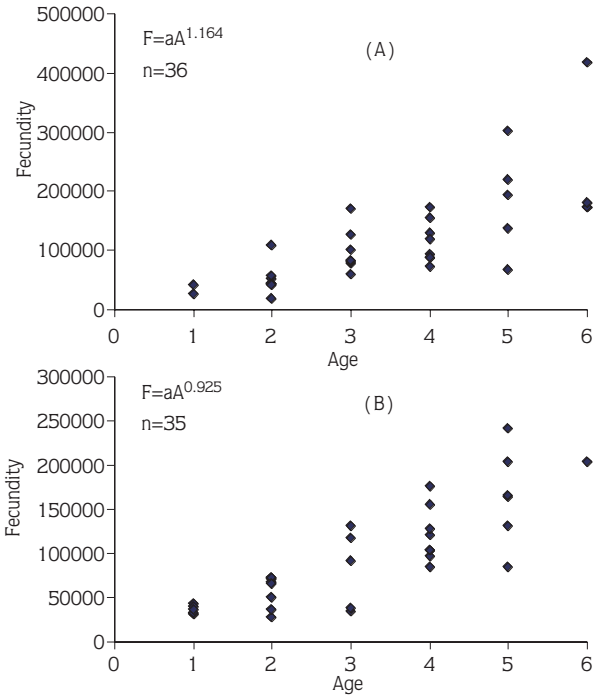

Figure 5. Relationships between fecundity and age of lizardfish from İskenderun Bay for 1999 (A) and 2000 (B)

early summer. They stated that lizardfish may spawn over a prolonged season, while the survival of its fry may be confined to a much shorter period controlled by favorable seasonal conditions. Bingel (1988a) studied the spawning of *S. undosquamis* in the Tırtar and Göksu regions along the Turkish eastern Mediterranean coast, and noted that the measured ovary weights show two clear and distinct spawning seasons (June-July and September-October). He also stated that there are probably early, intermediate and late spawners of the two main spawning periods and based on eventually unfavorable conditions. Arakawa (1993) and the TÜGM (1993) studied the resources of demersal fishes by seasonal sampling off the Turkish Mediterranean coast and stated that lizardfish may spawn throughout the year, with maxima in spring (April-July) and fall (September-November). Torcu (1995) reported that GSI results revealed that reproduction in the eastern Mediterranean Sea occurred after August when the GSI reached its highest level.

The spawning season and fecundity of the same species have been reported to vary from one geographical area to another. This may result from differences in growth rates, and seasonal, geographical and ecological conditions. Bauchot (1987) stated that lizardfish spawn from April to May off Japan; and in addition to this, Sanders and Morgan (1989) reported that in the Suez Canal, lizardfish reproduce partly in April, May and June, being fully active in other months.

The sex ratios for the study period were 38.8% for males and 61.2% for females in İskenderun Bay. This result agrees with the results of other studies performed in the eastern Mediterranean. Based on the data given by Torcu (1995), the sex ratios of lizardfish can be calculated as 0.39% for males and 0.61% for females at Fethiye and Mersin on the Mediterranean coast of Turkey. Bingel (1988a) noted that the sex ratios were 37.95% for males and 62.05% for females at Göksu and 34.83% for males and 65.17% for females at Tırtar. The TÜGM (1993) stated that females predominate over males in all seasons and the sex ratio was 1.67 in fall and 2.20-2.75 in other seasons.

The total length and age at 50% maturity (first maturity) for males and females in this study were 16 cm

Table 3. Regression constants and significance tests in correlations of fecundity with length and age for lizardfish from İskenderun Bay in 1999 and 2000.

Years	No. of fish	Slope (b)	Intercept (log a)	r
Fecundity-length				
1999	36	3.293	0.422	0.76**
2000	35	3.490	0.132	0.86**
Fecundity-age				
1999	36	1.164	4.379	0.80**
2000	35	0.925	4.501	0.82**

** Significant, $P < 0.01$

(age group I) and 16.5 cm (age group I), respectively. This result agrees with other studies; e.g., Arakawa (1993) and the TÜGM (1993) reported that lizardfish along the Turkish eastern Mediterranenan coast attained sexual maturity at age I. No data are available for the length at first sexual maturity. However, the TÜGM (1993) stated that the mean fork lengths in age group I for males and females are 20.6 cm and 23.4 cm in spring, 16.7 cm and 17.2 cm in summer, 16.8 cm and 17.3 cm in fall, and 15.1 and 20.5 cm in winter, respectively.

Fecundity-length relationships estimated between 1999 and 2000 were $\log F = 0.422 + 3.293 \log L$ (r = 0.76) and $\log F = 0.132 + 3.490 \log L$ (r = 0.86), respectively. In 1999 and 2000, fecundity-age relationships were estimated as $\log F = 4.379 + 1.164 \log A$ (r = 0.80) and $\log F = 4.501 + 0.925 \log A$ (r = 0.82), respectively. Since no data are available on the fecundity-length and fecundity-age relationships, the results could not be compared with them. There is only one observation on the number of eggs produced in the eastern Mediterranean Sea. Torcu (1995) found that the fecundity of lizardfish, which were 84.1-300.1 g in weight, is 14,226-65,833 in Mersin Bay.

Annual fluctuations in the fecundity of lizardfish were not apparent in this study. Oosthuizen and Daan (1974), Buzeta and Waiwood (1982), Bowering (1980) and İşmen (1995) compared the fecundity of some teleost fishes like cod and whiting in relation to years and they were also unable to detect any significant change. However, such variation has been reported in many studies. Bagenal (1963) attributed annual fluctuations in the fecundity of witch flounder (*Glyptocephalus cynoglossus*) to changes in fishing intensity, which in turn affected fecundity through variations in the food supply. He also concluded that the variation in fecundity was not related to changes in hydrographic conditions. Pinhorn (1984) found some annual variations in the fecundity of Newfoundland cod. He attributed the observed variation to less feeding and a slower digestion rate because of changing water temperature.

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