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Reproductive biology of lesser spotted dogfish *Scyliorhinus canicula* (L., 1758) in the Cantabrian Sea*

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SUMMARY: This paper examines sexual maturity of the female lesser spotted dogfish *Scyliorhinus canicula* (L., 1758) in the Cantabrian Sea (north of Spain). Analyses made using data collected from commercial trawlers during 1994 and 1995 showed that females reach sexual maturity at a length of 54.2 cm, and the mean egg-laying size is 56.4 ± 0.94 cm. At least one in six adult female dogfish carried egg-capsules during the study period. Sex-ratio by depth strata indicates a larger proportion of females in deeper waters. Mature and spawning females were found at depths ranging from 100 m to more than 400 m, with their proportion being larger in the deeper strata.

Key words: dogfish, sexual maturity, sex-ratio, egg-capsules, Cantabrian sea.

INTRODUCTION

Length or age at maturity, fecundity and sex-ratio are some of the most important parameters in studying the reproductive dynamics of elasmobranch populations.

The lesser spotted dogfish is a quite abundant shark in the Cantabrian Sea, particularly over sandy, gravelly and muddy bottoms, at depths ranging from 50-500 m, although mainly from 150-300 m (Sánchez, 1993). Some recent studies have shown that this species plays an important role in the trophic scheme of the demersal fish community (Kaiser, *et al*., 1995; Olaso *et al*., in press).

There is a great deal of literature concerning lesser spotted dogfish sexual biology and reproduction. Most of these studies are rather descriptive, with data from the first half of this century (Lo Bianco, 1899; Ford, 1921; Fauré-Fremiet, 1942; Leloup *et al*., 1951). However, no studies have previously been conducted in the Cantabrian Sea regarding the sexual maturity of this species.

The present paper focuses on defining the length at first sexual maturity of female lesser spotted dogfish, and examines the question of seasonal or depth changes regarding egg-laying and sex-ratio in the Cantabrian Sea.

MATERIAL AND METHODS

Data were collected monthly in 1994 and in autumn 1995 (in order to complete the sampling of the previous year in this season) on board commercial trawlers. The sampling area comprised the continental shelf along the Cantabrian coast, over depths rang-

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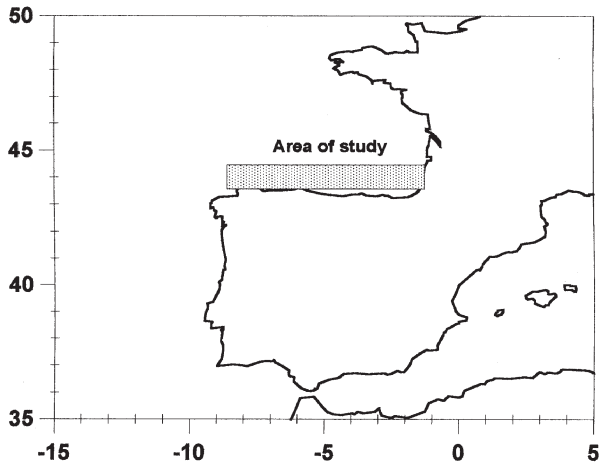

FIG. 1. – Map of the study area.

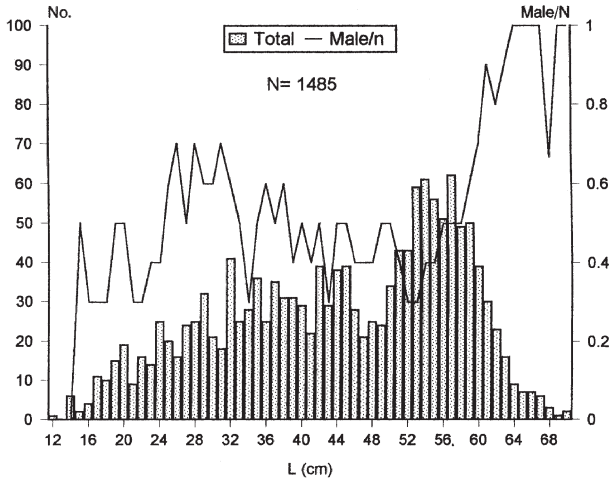

FIG. 2. – Length distribution and sex-ratio of lesser spotted dogfish sampled during 1994 and 1995.

ing from 41 m to 495 m on soft substrata (Figure 1). Ten individuals were selected from every haul, covering almost the whole length- range of the catch, and for each of these specimens, total length was measured to the centimeter below, and sex was noted together with maturity in the case of females which were the focus of this study. Three different maturity stages were defined, as follows: I) Ovaries small, pale grey colour, no oocytes differentiated. II) Ovaries enlarged, oocytes differentiated in various sizes. Granular appearance, brownish colour. III) Egg-capsules in the oviducts. Shell glands well-developed. The second and third stages were grouped together in a single stage to obtain the maturity ogive.

The sex-ratio analysis was performed using a t-test (Lamotte, 1984). A logistic model (O'Brien *et al.*, 1993) was used to estimate the maturity ogive:

$$p = \frac{1}{1 + e^{-(A+Bx)}}$$

where, p is the proportion mature by length-class; x is the length-class (length + 0.5); and A and B are model parameters to be estimated. A non-linear regression was fitted using the statistical program SPSS (3.0) which gives the estimated values of the parameters, their standard errors and the 95% confidence intervals as well as the correlation coefficient.

RESULTS AND DISCUSSION

Sex-ratio

The sex-ratio by length-class shows that the longest specimens were always males (Figure 2), in keeping with previous reports by other authors (Capapé, 1991; De la Gándara *et al.*, 1994). This suggests either that the sexes have different growth patterns, or that larger females are less accessible because they move to specific reproductive areas. The first hypothesis could be supported by reports that the growth rate of this species slows down after sexual maturity is reached (Leloup *et al.*, 1951; Zupanovic, 1961; Capapé *et al.*, 1991).

The sex-ratio of S. canicula by month during 1994 and 1995 is close to 1:1 (Table 1); only March, July and September deviate significantly from this proportion. However, this species frequently shows sexual aggregations in some specific geographic areas (De la Gándara *et al.*, 1994).

Analysis of the sex-ratio by depth strata (Figure 3) reveals a larger proportion of females at lower depths. These results are statistically significant (P25= 45,51 p< 0.01). In order to check whether this result could be affected by sexual aggregation data from annual trawl surveys carried out in the

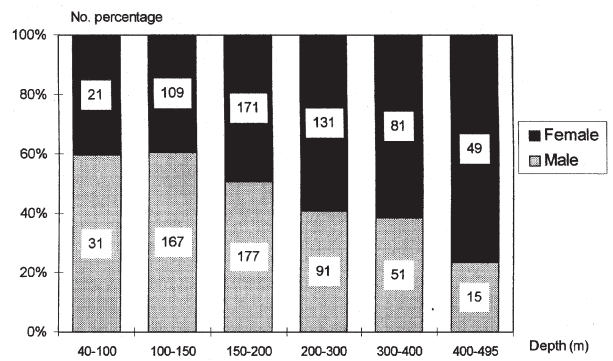

FIG. 3. – Percentage by sex per depth ranges. Number in boxes = totals for each sex.

TABLE 1.– Sex-ratio by month during 1994 and 1995.

1994	Male	Female	n	♂/n	t Student 95%	99%
January	0	0	0			
February	20	28	48	0.42		
March	102	132	234	0.44	♀	
April	54	55	109	0.50		
May	44	56	100	0.44		
June	44	44	88	0.50		
July	12	30	42	0.29	♀	♀♀
August	2	1	3	0.67		
September	231	190	421	0.55	♂	
October	3	7	10	0.30		
November	5	5	10	0.50		
December	15	14	29	0.52		
Total	532	562	1094	0.51		

1995	Male	Female	n	♂/n	t Student 95 %	99%
September	156	99	255	0.61	♂	♂♂
November	57	79	136	0.42	♀	
Total	213	178	391	0.54		

TABLE 2. – Parameter values A and B from the logistic equation.

1994+1995 Parameter	Estimate	Std. Error	Confidence interval 95 % Lower	Upper
A	-15.8791	0.3533	-16.5727	-15.1854
B	0.2930	0.0065	0.2802	0.3058
R^2	0.9389			
n	739			

Cantabrian sea were examined. Apparently there is not a significant relationship between depth and sexual aggregation.

Length at maturity

Our results indicate that the length at sexual maturity of females is between 49.7 - 59.1 cm, when all data are combined (Table 2 and Figure 4). This length is shorter than that found in the North Atlantic, and longer than that found in the Mediterranean Sea, in accordance with the hypothesis that the first- maturity length is determined by latitude (Lam, 1983 ; Leloup *et al*., 1951; Capapé *et al*., 1991). Although no data were collected on male sexual maturity, several studies conducted in different areas seem to agree that the length of first sexual maturity is the same for males and females (Table 3).

Egg-laying

The maximum proportions of egg-carrying females in 1994 were found in April, May and June (Figure 5). Nevertheless, the low number of specimens sampled in autumn does not allow us to determine whether differences exist with regard to spawning intensity throughout the year. Data collected in 1995 suggest that egg-laying must have an extended period, as other authors have already described: Lo Bianco (1899) pointed out that egg-laying may take place in any season (south of Britain); Ford (1921) reported a peak in August and

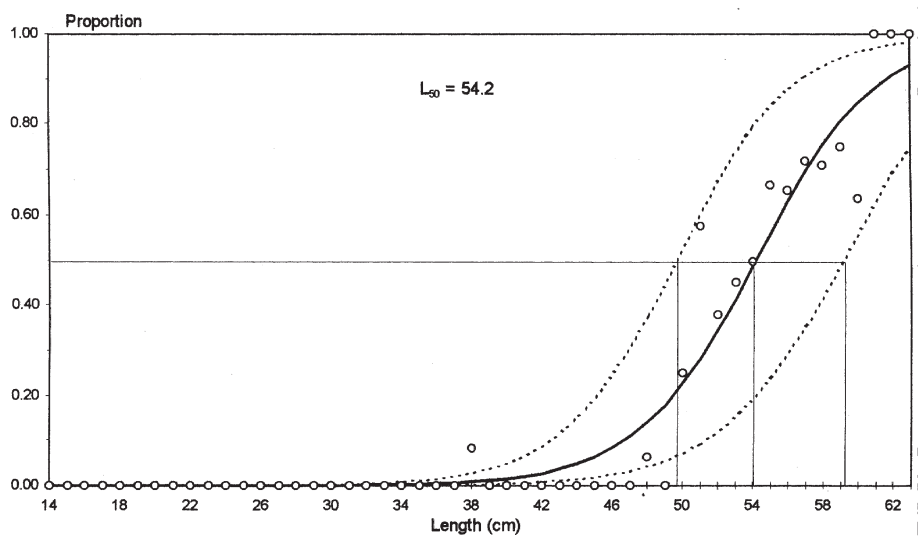

FIG. 4. – Maturity ogive of female lesser spotted dogfish. Data from 1994 and 1995.

TABLE 3. – Summary of first-maturity size data of lesser spotted dogfish from different authors.

Author	Area	Male	Female
Ford (1921)	English Channel	57-60	57-60
Fauré-Frémiet (1942)	Atlantic	52-60	52-60
Leloup and Olivereau (1951)	Atlantic	52-60	52-60
Leloup and Olivereau (1951)	Mediterranean	37-44	37-44
Zupanovic (1961)	Adriatic Sea	34	34
Collenot (1966)	English Channel	60-68	60-68
Capapé *et al.* (1991)	Mediterranean	44	41-47

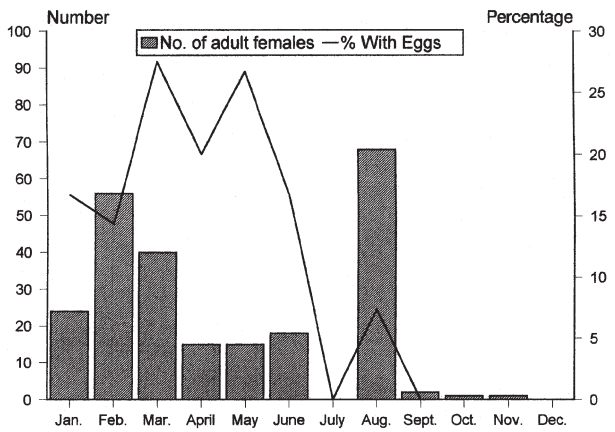

FIG. 5. – Number of mature females (Stages II and III) and proportion of those carrying eggs per month in 1994.

a minimum in September-October (Plymouth); Fauré-Fremiet (1942) found egg-laying females from June to January (Concarneau); and finally, Leloup and Olivereau (1951) and Capapé *et al.* (1991) suggested that egg-laying takes place without interruption throughout the year.

A study carried out to the north of Wales by Sumpter *et al.* (1979) concerning endocrine control of the reproductive cycle supports the idea that even if it is true that lesser spotted dogfish have an extended egg-laying period, there must be a maximum in spring and winter.

The length at which lesser spotted dogfish began laying eggs during the years of the present study was 51 cm, while the mean length was 56.3±1.08 cm in 1994 and 56.9±1.75 cm in 1995. The small difference between these figures suggests that once maturity has been reached, spawning can take place almost immediately; at least, this is what.

Regarding the proportion of females carrying egg-capsules, we found that, during 1994 and 1995, approximately one in every six lesser spotted dogfish had eggs in their oviducts (Figure 6).

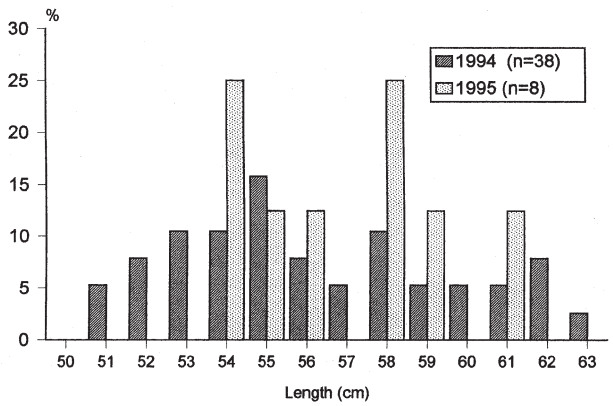

FIG. 6.– Percentage of mature females (>48 cm) carrying eggs in 1994 and 1995.

Occasionally, we found immature adult females longer than 60 cm in stage I. Although delayed sexual maturity is possible for certain individuals, it could also be attributable to a sterility disorder or simply to natural variation. Abnormalities that have been reported for S.canicula include hermaphroditism (Arthur, 1950; King, 1966) and other abnormal states. The causes of such abnormal states are not known although Vivien (1941) and Oliverau (1949) pointed out that both somatic and gonadal growth, as well as sexual activity, have a close relationship with the hypophysis and the thyroid, and any disturbance in the activity of these glands has a direct impact on gonadal development.

The relationship of maturity stage with depth shows a significant increase in egg-carrying adult females with increased depth (Figure 7), ($P26= 21.183$, $p< 0.01$). This species spawns not only in shallow waters with hard substrates near the shore (Wheeler, 1969; Múñoz-Chapuli, 1984; Capapé *et al.*, 1991) therefore , but also in deeper waters with soft bottoms, as also proved by the egg-capsules

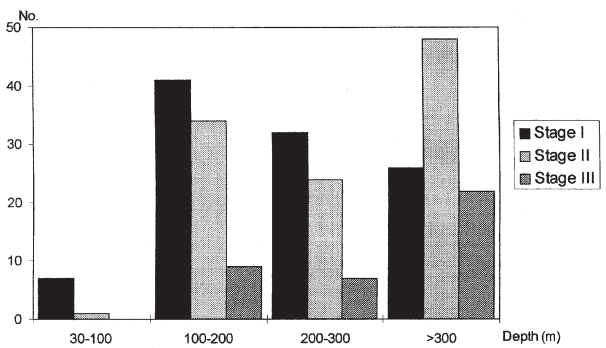

FIG. 7.– Maturity stage distribution per depth strata in mature females (>48 cm). Data from 1994.

found occasionally fixed to the bryozoa *Litocarpium myriophillum,* during annual trawl surveys carried out in the Cantabrian Sea. This spawning in deep waters has also been reported by Harris (1952) and D'Onghia *et al*. (1995), who, in the Aegean Sea, found young individuals together with adults of both sexes at depths greater than 200 m, suggesting that spawning could take place on the slope.

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