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Population biology of the roudi escolar *Promethichthys prometheus* (Gempylidae) off the Canary Islands*

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SUMMARY: The biology of the roudi escolar, *Promethichthys prometheus*, from the Canary Islands was studied. Specimens 38.3-78.9 cm in total length were captured from August 1992 to December 1993 around the islands. Male:female sex-ratio was 1:1.96. The spawning season extended from April to September with most gonadal activity in June-July. Size at first maturity was 51.9 cm for males and 52.9 cm for females. Weight grew allometrically with size. Fish from age 3 to 10 years were found. The von Bertalanffy growth parameters were L_∞=90.1 cm and k=0.17 yr^{-1}. The food consisted primarily of bony fishes, followed by cephalopods and crustaceans.

Key words: Roudi escolar, *Promethichthys prometheus*, population biology, Canary Islands.

RESUMEN: BIOLOGÍA DEL ESCOLAR PROMETEO *PROMETHICHTHYS PROMETHEUS* (GEMPYLIDAE) EN LAS ISLAS CANARIAS. – Se estudió la biología del escolar prometeo *Promethichthys prometheus* de las Islas Canarias. Los ejemplares, de tallas comprendidas entre los 38,3 y 78.9 cm, fueron capturados alrededor de las islas entre Agosto de 1992 y Diciembre de 1993. La proporción entre machos y hembras es 1:1.96. La puesta ocurre entre abril y septiembre, con un máximo en junio-julio. La talla de primera madurez se alcanza a los 51.9 cm de longitud total en los machos y a los 52.9 en las hembras. El peso crece alométricamente con la talla. Los ejemplares estudiados pertenecen a las clases de edad de 3 a 10 años. Los parámetros de la ecuación de crecimiento en longitud de von Bertalanffy son: L_∞=90.1 cm y k=0.17 $año^{-1}$. La dieta está basada, principalmente, en peces y, en menor medida, en cefalópodos y crustáceos.

Palabras clave: Escolar prometeo, *Promethichthys prometheus*, biología, Islas Canarias.

INTRODUCTION

The roudi escolar *Promethichthys prometheus* (CUVIER, 1832) is a benthopelagic gemfish found on continental slopes, around oceanic islands and submarine rises at 100 to 800 m. It is a cosmopolitan species, inhabiting the tropical and warm temperate waters of all oceans, but absent from the east Pacific Ocean except at Sala y Gomez Ridge (NAKAMURA, 1981; PARIN, 1986; NAKAMURA and PARIN, 1993).

In the waters of the Canary Islands, the roudi escolar is abundant (BRITO, 1991). Despite this, there is no fishery for it at present, although the species frequently appears as bycatch in the hook-and-line and longline demersal artisanal fishery.

No data are known about the roudi escolar off the Canary Islands and published information on the species is very scarce anywhere in the world. The few studies that exist mainly describe its distribution. Literature on this species has been recorded by NAKAMURA and PARIN (1993).

The biology and life history of this species should be studied for the exploitation of this potential resource. The objective of this paper is to provide information on the sexuality, reproduction, length-weight relationship, age and growth, and

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food habits of the Canary Islands roudi escolar population. This data will be useful for the management of the species resources.

MATERIALS AND METHODS

Samples of roudi escolar were collected monthly between August 1992 and December 1993. In total, 308 specimens, were obtained from commercial catches at different fishing ports of the Canary Islands (Fig. 1). Fish appeared as bycatch in the hake hook-and-line and longline fishery. The depth range of the captures was 375 to 870 m.

The sex-ratio of the sampled population was analysed by size intervals and by month. The spawning season was determined following the monthly changes in the percent frequency of the maturity stages and the monthly values of the gonadosomatic index, GSI (ANDERSON and GUTREUTER, 1983). For the estimation of the length at first maturity (L_{50}) a logistic function was fitted to the proportion of mature individuals using a non-linear regression. The relationship between total length and total weight was established by linear regression.

Whole otoliths were placed in a blackened-bottom watch glass containing water and were viewed under the reflected light of a stereoscope at a magnification of 18 x. Two independent readings were carried out for each otolith and only the coincidents were accepted. Age was assessed from counts of the opaque rings. The validation of ageing was verified by the examination of monthly changes in the appearence of the edges of the otoliths (MORALES-NIN, 1987). The age-length relationship data obtained from ring interpretation was employed to calculate the von Bertalanffy growth parameters. The growth equation was fitted to the age-length relationship data using a non-linear regres-

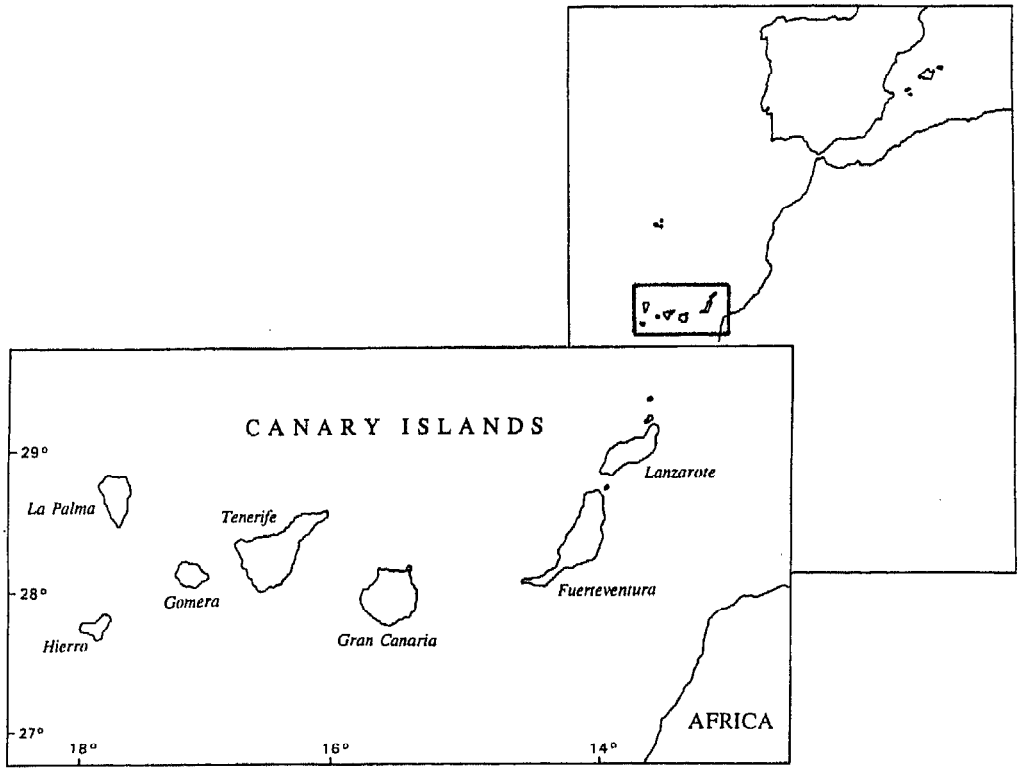

FIG. 1. – Map of the Canary Islands.

The analysis of the samples was always done inmediately after landing. Each fish was weighed to the nearest 0.1 g and its total length measured to the nearest cm. The sex and the maturity stage were then determined macroscopically and the weight of the gonads was recorded to the nearest 0.01 g. Maturity for each fish was assessed according to the scale of HOLDEN and RAITT (1974). The sagittal otoliths were extracted, cleaned and stored dry in plastic vials. The stomachs were removed and preserved in 70% ethanol.

sion computer program available in FISHPARM (SAILA *et al.*, 1988).

The stomach contents were examined. All food items from the stomachs were placed on filter paper to remove excess moisture and weighed. Prey items were identified only to class level. The relative percentage of each group was calculated on a mass basis.

RESULTS

Length and weight composition

Fish collected during the sampling period ranged from 38.3 to 78.9 cm in total length and from 217.5 to 1919.8 g in total weight. The length range of males was comprised between 38.3 and 77.0 cm and their weight between 223.5 and 1750.4 g. Females ranged in size from 38.4 to 78.9 cm, corresponding to weights from 217.5 to 1919.8 g.

Sexuality

Of the 308 specimens examined, 33.8% (104) were males and 66.2% (204) females. The overall ratio of males to females was 1:1.96. Statistical analysis by chi-square was significant ($P<0.05$). Females predominated in all size intervals (Table 1). Sex-ratios for males and females grouped into 5-cm length intervals had significant ($P<0.05$) departures from the expected 1:1 ratio for most size categories, except for the smallest and the largest. The nonsignificant values for the smallest and largest size intervals were probably unrealistic since the samples were very small. The sex-ratio was not constant throughout the period of study (Table 2). Females exceeded significantly ($P<0.05$) the number of males during the autumn and winter months.

TABLE 1. – Number and percentage of males and females of *P. prometheus* off the Canary Islands grouped into 5-cm size intervals, and the sex-ratio of each size group tested by chi-square analysis.

Length (cm)	Males		Females		Sex-ratio
	Number	%	Number	%	
35.1-40.0	2	40.0	3	60.0	1:1.50
40.1-45.0	4	25.0	12	75.0	1:3.00*
45.1-50.0	9	30.0	21	70.0	1:2.33*
50.1-55.0	13	32.5	27	67.5	1:2.07*
55.1-60.0	27	37.5	45	62.5	1:1.66*
60.1-65.0	25	35.7	45	64.3	1:1.80*
65.1-70.0	16	34.0	31	66.0	1:1.94*
70.1-75.0	6	27.2	16	72.8	1:2.66*
75.1-80.0	2	33.3	4	66.7	1:2.00
Totals	104	33.8	204	66.2	1:1.96*

*($\chi^2_{1,0.05} > \chi_t{}^2_{1,0.05} = 3.84$).

TABLE 2. – Number and percentage of males and females of *P. prometheus* off the Canary Islands collected by quarter, and the sex-ratio of each group tested by chi-square analysis.

Month	Males		Females		Sex-ratio
	Number	%	Number	%	
3/92	16	41.0	23	59.0	1:1.44
4/92	13	27.1	35	72.9	1:2.69*
1/93	13	26.0	37	74.0	1:2.85*
2/93	24	39.3	37	60.7	1:1.54
3/93	24	41.4	34	58.6	1:1.42
4/93	14	26.9	38	73.1	1:2.71*
Totals	104	33.8	204	66.2	1:1.96*

*($\chi^2_{1,0.05} > \chi_t{}^2_{1,0.05} = 3.84$).

Spawning period

Testes and ovaries of the roudi escolar were resting (stage II) during the period from November to March. Individuals with mature gonads (stage III) appeared in April, increased in May and became dominant in June-July. Spawning males and females (stage IV) were dominant in June and July. The first sign of spent condition (stage V) was noted in July and was also recorded between August and November (Fig. 2).

The gonadosomatic index (GSI) of males was usually lower than that of females (Fig. 3). However, very similar patterns were recorded for both sexes. In April the indexes tended to increase. From June to August, they were very high and variable, gradually decreasing in September and October to very low levels from November to March.

Sexual maturity

All the individuals sampled had differenciated gonads. The sexual maturity curves for males and females are shown in Fig. 4. Fifty per cent of maturity was reached by the males at 51.9 cm total length and by the females at 52.9 cm. No significant difference in length at first maturity (t-test, $P>0.05$) was found between both sexes.

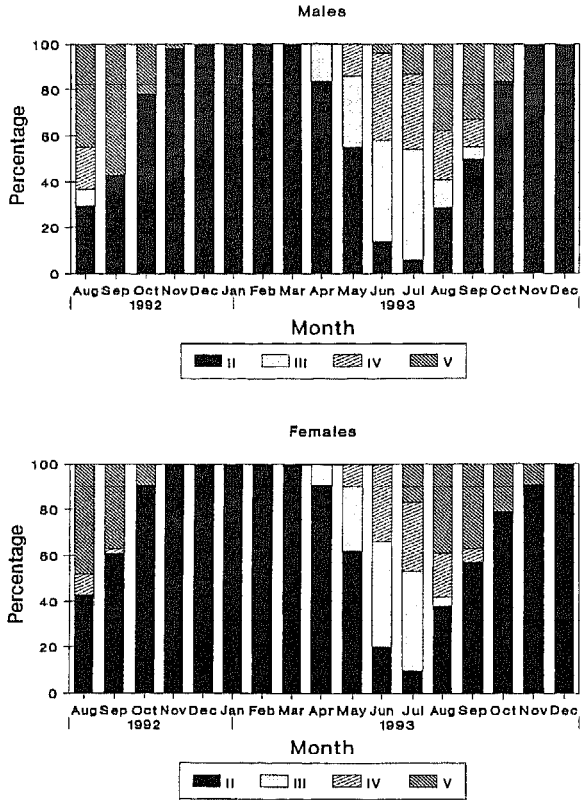

FIG. 2. – Monthly changes in the percent frequency of the maturity stages for males and females of *P. prometheus* off the Canary Islands.

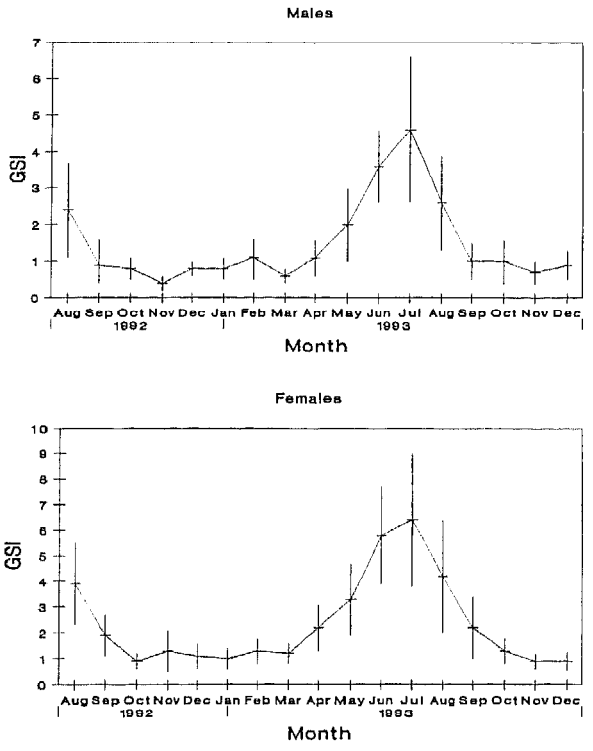

FIG. 3. – Monthly evolution of the gonadosomatic index (GSI) for males and females of *P. prometheus* off the Canary Islands.

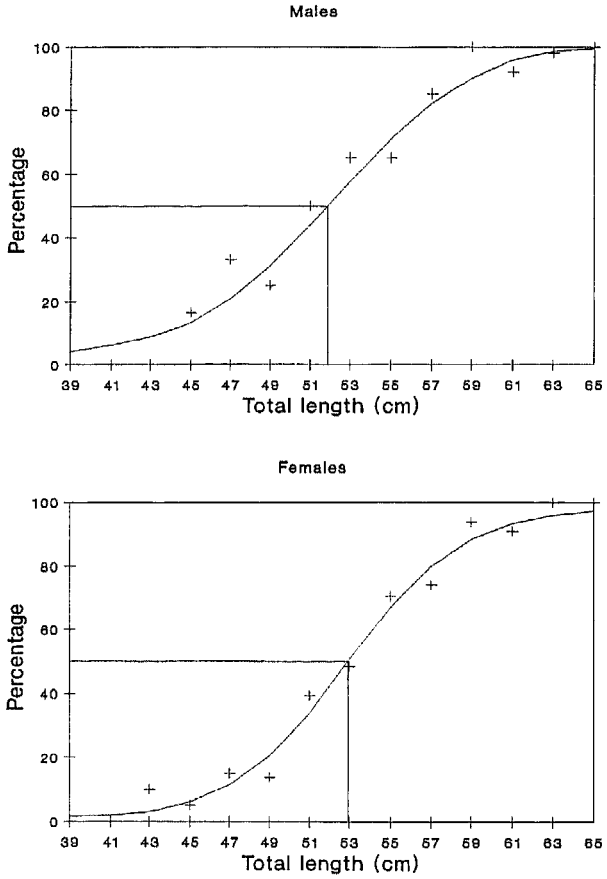

FIG. 4. – Sexual maturity curves for males and females of *P. prometheus* off the Canary Islands.

Length-weight relationship

The results of the length-weight regressions for males, females and both sexes combined are summarized in Table 3. The slopes of the length-weight regressions did not differ significantly between sexes (ANCOVA, P>0.05).

TABLE 3. – Lenght-weigth parameters of males, females and all the individuals of *P. prometheus* caughtt off the Canary Islands.

	a	b	sd(b)	r	n
Males	0.004481	2.96313	±0.0301	0.981	104
Females	0.005583	2.93371	±0.0292	0.989	204
All fish	0.004747	2.95980	±0.0239	0.991	308

Age and Growth

Roudi escolar otoliths are thin and show clear annual growth rings. Eighty-three percent (257) of the otoliths were readable and used for the study of

age and growth. Annual marks were concentric to the outer edge of the otolith and were more clearly visible in the region posterior to the otolith centre. A false hyaline ring was identified within the fourth annual opaque zone and in the subsequent opaque zones.

The examination of the monthly changes in appearence of the edges of the otoliths indicated that one annulus was formed per year (Fig. 5). The percentage of otoliths with an opaque edge was high in the months April-October, mainly in July and August. The percentage of otoliths with a hyaline edge peaked in December-January.

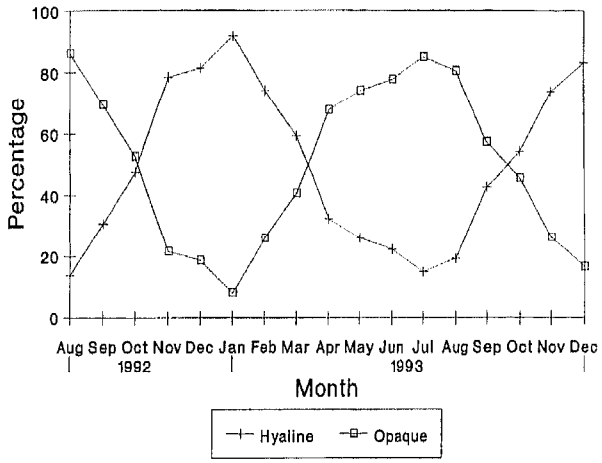

FIG. 5. – Mean monthly percentage of otoliths of the *P.prometheus* off the Canary Islands with opaque and hyaline edges.

Fish from age 3 to 10 years were found (Table 4). The application of t-tests revealed that there were no significant differences between the sexes for the mean length at each age (P>0.05). Average lengths were 42.2, 49.9, 56.0, 60.9, 65.3, 69.0 cm, 72.5 and 75.1 cm for ages 3 through 10, respectively.

The age-length matrix obtained from ring interpretation was employed to calculate the von Bertalanffy's growth parameters. The growth parameters obtained were: L_∞=90.1 cm; k=0.17 yr^{-1}; t_0=-1.03.

Food composition

Of the total stomachs examined, 61.3% (189) were empty. Stomach contents included bony fishes, cephalopods and crustaceans. On a mass basis, bony fishes constituted a large proportion of the diet contributing 79.6%, compared to the 12.2% and, 8.2% for cephalopods and crustaceans respectively.

TABLE 4. – Age-length key for all *P. prometheus* caught off the Canary Islands.

Length	Age group (yr)							
(cm)	III	IV	V	VI	VII	VIII	IX	X
38	1							
39	1							
40	2							
41	1							
42	3							
43	3	1						
44	2							
45	1	1						
46		2						
47	1	3						
48		3						
49		5	1					
50		8	2					
51		7	2					
52		5						
53		3	3					
54			3					
55		1	7	2				
56		1	12	2				
57			9	4				
58			5	4				
59			5	5				
60			3	8	2			
61				15	2			
62			1	10	3			
63				4	4			
64				3	6			
65				2	9	1		
66				1	8	1		
67					6	2		
68					3	5		
69					2	6		
70					1	5	1	
71						2	2	
72							4	
73						1	3	1
74							2	2
75							1	
76							1	2
77								1
x	42.2	49.9	56.0	60.9	65.3	69.0	72.5	75.1
sd	2.4	2.7	2.6	2.4	2.3	1.7	1.6	1.4
n	15	40	53	60	46	23	14	6

DISCUSSION

The roudi escolar off the Canary Islands is heterosexual with no evidence of sexual dimorphism. The sex-ratio for this species was unbalanced with many more females. This predominance may be attributed to schooling aggregated by sex more than to gear selectivity. The lowest deviations from the theoretical 1:1 sex-ratio during the reproductive period seem to confirm this conclusion.

The roudi escolar off the Canary Islands has a definite reproductive period which extends from

April to September, with a peak in spawning activity in June-July. It is in good agreement with the information reported by PARIN (1986) and NAKAMURA and PARIN (1993) for this species in the waters of Madeira near the Canary Islands. These authors pointed out that its reproduction is seasonal, occurring from August to September. NISHIKAWA (1987) found that the peak spawning season of gempylid fishes takes place during summer in the Pacific waters of Japan.

In the Canary Islands, the spawning of this species is probably associated with the temperature of the sea, because the gonads begin developing as the temperature increases and the spawning occurs when it reaches the highest values. In this way, STACEY (1984) demonstrated the importance of the temperature of the sea to gonad maturation and spawning in other species.

The mean length at first maturity does not differ between sexes. Fifty per cent of maturity is reached by males and females by the fourth year of life.

The results on the length-weight relationship revealed that males are as heavy as females for a given length. Data also indicated that weight increases allometrically with size for both sexes and for all the individuals.

The alternative pattern of opaque and hyaline zones was easily distinguishable on the otoliths of the roudi escolar off the Canary Islands. These zones are deposited due to alterning periods of rapid and slow growth (WILLIAMS and BEDFORD, 1974). The false hyaline zones observed within the fourth opaque ring and in the subsequent opaque rings are probably spawning bands, because this species spawns in the summer months, when the opaque zone is formed in the otoliths (MORALES-NIN, 1987).

Data indicated that the growth rings, consisting of one opaque zone and one hyaline zone, are formed annually. The opaque zone is formed during the spring and summer months, when the temperature of the sea is higher, and the hyaline one is formed during the remaining months of the year. This demonstrated the validity of using otoliths for estimating the age and growth of roudi escolar.

The roudi escolar is a moderately long-lived species. The oldest fish was found to be 10 years old. The mean lengths at age are equal for males and females, indicating that growth is equal for both sexes. Annual growth average increments decrease with age. The growth parameters obtained are reasonable because the theoretical maximal length value is higher than the size of the largest fish sampled and the growth coefficient value indicates relatively rapid attainment of maximal size.

Analysis of stomach contents of the roudi escolar from the waters around the Canary Islands revealed the primary food to be bony fishes, followed by cephalopods and crustaceans. The qualitative composition of the diet coincides with that recorded by NAKAMURA and PARIN (1993). These authors pointed out that this species feeds on fish, cephalopods and crustaceans.

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