Diet overlap of immigrant narrow–barred Spanish mackerel *Scomberomorus commerson* (Lac., 1802) and the largehead hairtail ribbonfish *Trichiurus lepturus* (L., 1758) in the Egyptian Mediterranean coast

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Abstract

Diet overlap of immigrant narrow–barred Spanish mackerel Scomberomorus commerson *(Lac., 1802) and the largehead hairtail ribbonfish* Trichiurus lepturus *(L., 1758) in the Egyptian Mediterranean coast*.— The immigrant *S. commerson* (Lac., 1802) represents more than 2% of the total Egyptian catch and its distribution stretches from East to West along the Egyptian Mediterranean coast. The feeding habits of *T. lepturus* and *S. commerson* were investigated through stomach content analysis of specimens collected from Abu Qir Bay (Egypt) on a seasonal basis from November 1999 to January 2001 using daytime purse seines. The food content range of *T. lepturus* was wide, including *Engraulis encrasicolus*, *Gobius* spp., *Sardinella aurita*, *Sardina pilchardus*, fish eggs, amphipods, copepods and shrimps. The main diet constituents of *S. commerson* included *Engraulis encrasicolus*, *Sardinella aurita*, *Sardina pilchardus* and shrimps. Seasonal variations of feeding activity indicated that food consumption was highest in spring to autumn for *T. lepturus* and in summer and autumn for *S. commerson*. The diet overlap in terms of number and weight between the two species was high. Food composition was related to fish size in both examined fishes. Small *T. lepturus* (less than 30 cm) fed mainly on crustaceans, while larger samples (more than 59 cm) fed only on fishes. Teleosts were the most important food item for *S. commerson* of all sizes, while this species became piscivorous when larger than 40 cm in length.

Key words: Diet and trophic level, *Trichiurus lepturus*, *Scomberomorus commerson*, Egyptian coast.

Resumen

El solapamiento de la dieta del carite estriado Indo–Pacífico Scomberomorus commerson *(Lac., 1802) y del pez sable* Trichiurus lepturus *(L., 1758) en la costa mediterránea egipcia*.— La especie inmigrante *S. commerson* (Lac., 1802) constituye más del 2% de las capturas egipcias totales y su área de distribución se extiende de este a oeste a lo largo de la costa mediterránea egipcia. Se investigaron los hábitos alimentarios de *T. lepturus* y *S. commerson* a través del análisis de los contenidos estomacales de los ejemplares recogidos en la bahía de Abu Qir (Egipto) siguiendo una pauta estacional desde noviembre de 1999 a enero del 2001, utilizando jábegas diurnas. La variedad del contenido estomacal de *T. lepturus* era amplia, incluyendo a *Engraulis encrasicolus*, *Gobius* spp., *Sardinella aurita*, *Sardina pilchardus*, huevas de pez, anfípodos, copépodos y decápodos. La dieta principal de *S. commerson* incluía *Engraulis encrasicolus*, *Sardinella aurita*, *Sardina pilchardus* y decápodos. Las variaciones estacionales de la actividad alimentaria indicaban que el mayor grado de consumo de alimentos se daba de primavera a otoño en *T. lepturus*, y de verano a otoño en *S. commerson*. El solapamiento de la dieta de las dos especies, en términos de número y peso, era grande. En ambas especies examinadas se detectaron cambios en la composición del alimento, en función de la talla de los peces. Los *T. lepturus* de tallas pequeñas (menos de 30 cm) se alimentaban principalmente de crustáceos, mientras que los de tallas grandes (de más de 59 cm) se alimentaban sólo de peces. En todos los grupos de tallas de *S. commerson*, las presas principales eran los teleósteos, aunque esta especie se vuelve totalmente piscívora al superar el tamaño de 40 cm.

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Palabras clave: Dieta y nivel trófico, *Trichiurus lepturus*, *Scomberomorus commerson*, Costa egipcia.

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Introduction

The exotic fish species of the Mediterranean Sea were reviewed in depth; Golani et al. (2002) described all alien fish species, including 59 Lessepsian migrants, which migrated from the Indo–Pacific through the Suez Canal. These included the narrow–barred Spanish mackerel *Scomberomorus commerson* (Lac., 1802), recorded for the first time in Palestine (Hornell, 1935). Ben–Tuvia (1985) recorded that *S. commerson* had reached the eastern part of the Mediterranean Sea (Israel, Lebanon, Syria, Turkey and south eastern Greece) and it was later reported that this Lessepsian migrant has expanded its distribution up to the Aegean Sea (Golani et al., 2002).

The relative abundance of *S. commerson* in the Egyptian Mediterranean landings has since increased from 224 to 1,301 tons, and it is now considered an important economic species. It constitutes 2.08% of the total catch off the Egyptian Mediterranean coast (fig. 1).

Although *S. commerson* was first recorded in 1935, its first representation in a commercial catch off the Egyptian Mediterranean coast was reported in the eastern area in 1991 (Port Said & Izbet El Borg). It has since expanded its distribution up to Alexandria in the western part of the Egyptian Mediterranean coast (GAFRD, 2004) (fig. 2). This indicates that *S. commerson* is now apparently well established in the eastern Mediterranean and has become an economically important species in the Egyptian Mediterranean fisheries.

The largehead hairtail ribbonfish (*T. lepturus*) (L., 1758) has a worldwide distribution along the shores of tropical and subtropical seas. It is a benthopelagic species found at depths not exceeding 350 m. The narrow–barred Spanish mackerel *S. commerson* is a migratory fish, found in small schools. It is epipelagic in coastal waters at depths between 15 and 200 m (Whitehead et al., 1986).

The coastal lagoons are important zones for the nourishment, nursing and reproduction of many fish species (Ribeiro et al., 1997). Abu Qir Bay is a main region of nourishment for the endemic ribbonfish and immigrant *S. commerson*, which have the same feeding habits as small size fish. The ribbonfish is generally found along muddy bottoms of shallow coastal waters, and often enters estuaries (Nakamura, 1995). *S. commerson* also exists in drop–offs and shallow or gently sloping reefs and lagoon waters that are often of low salinity and high turbidity (Myers, 1991). These environmental conditions are characteristic of Abu Qir Bay, which has a well–developed shallow thermocline (Gerges, 1976). This leads to the aggregation of small fish of these species in the same area, and the competition between them for food and feeding space determines their population size. This greatly helps to understand not only the feeding habit of fish species but also the inter–specific interactions.

The study of diets and feeding habits of fish and other marine vertebrates through the examination of stomach contents has become standard practice (Hyslop, 1980). It plays an important role in our understanding of the dynamics of the ecological relations between coexisting species, and consequently provides information that contributes to the management of fishing resources (Caragitsou & Papaconstantinou, 1993).

The purpose of this study was to evaluate the successful propagation and economical importance of *S. commerson* in the fisheries of Egyptian Mediterranean water, elucidate the interrelationship of *T. lepturus* and *S. commerson* in feeding habits and investigate their food variations according to seasons and fish size.

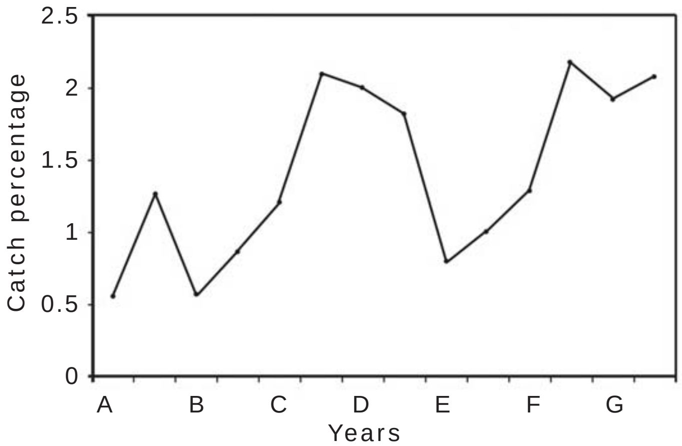

Fig. 1. Catch percentage of immigrant *S. commerson* in the Egyptian Mediterranean fisheries: A. 1991; B. 1993; C. 1995; D. 1997; E. 1999; F. 2001; G. 2003.

Fig. 1. Porcentaje de S. commerson *inmigrantes capturados en las pesquerías egipcias mediterráneas. (Para las abreviaturas de los años, ver arriba.)*

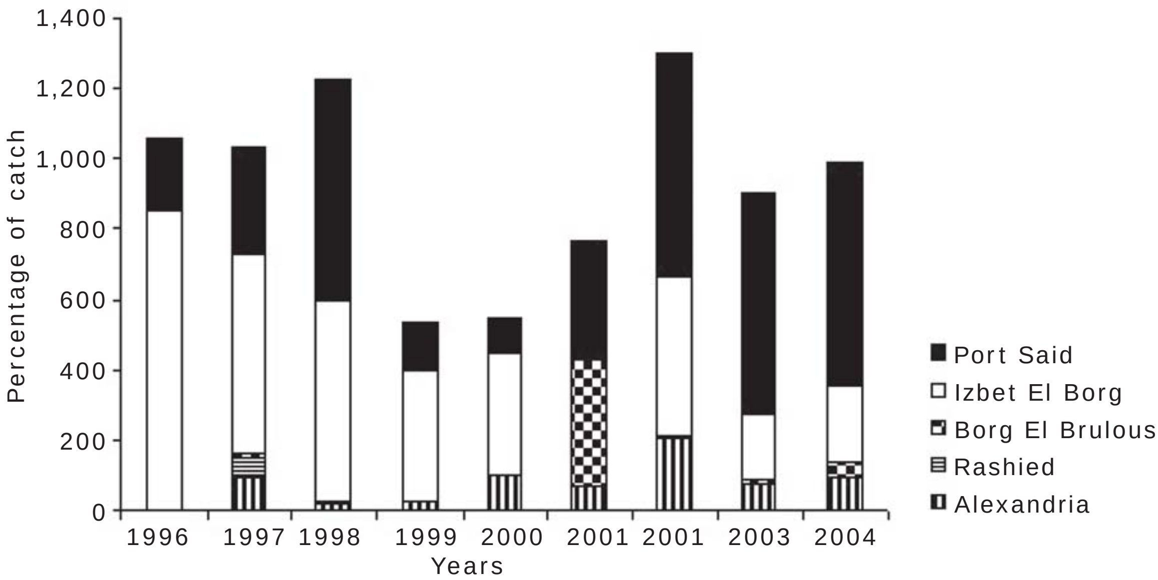

Fig. 2. The rate of expansion of *S. commerson* in the Egyptian Mediterranean coast.

Fig. 2. Tasa de expansión de S. commerson *en la costa mediterránea egipcia.*

Material and methods

Fish samples were collected seasonally from November 1999 to January 2001 from Abu Qir Bay in the Egyptian Mediterranean coast, east off Alexandria (latitude from 30° 5' to 30° 20' N and longitude from 31° 15' to 31° 25' E) (fig. 3).

Daytime purse seine fishing gear was used in the present study, in accordance with the description of El–Haweet (2001). This system/net consists of a long curtain with a bunt in the middle. Its upper edge is about 160 m long with a buoy every 50 cm and a lead line in the net bottom about 140 m with weights every 30 cm. A number of copper rings are attached along the lead line and the purse rope passes through these rings. The mesh size varies between 16 and 18 mm. About 12–17 persons operate the net.

A total of 297 *T. lepturus* and 178 *S. commerson* (Lac., 1802) specimens were collected. Total length (TL, cm), total (TW, g) and gutted weights (GW, g) were recorded for each specimen. Stomachs were preserved in 10% formalin solution. Weights of food content (g) were determined and analyzed to the lowest possible taxon, depending on the digestion stage of each item. Number and weight of the different prey in each stomach were also recorded.

Fullness index (FI) was calculated according to Berhaut (1973), $FI = 100W^{/} / W$, where $W^{/}$ is the weight of stomach contents and W is the gutted weight of the fish. Empty coefficient was computed as the percentage of the empty stomachs from among the total number of examined stomachs. The contribution of each type of food to the diet was expressed as percentage frequency of occurrence (%O), numerical percentage (%N) and weight percentage (%W). The percentage index of relative importance (%IRI) was estimated following King (1984) and Cortes et al. (1996). This index combines prey number, weight and occurrence (Hyslop, 1980).

Trophic levels were estimated from individual food items according to Pauly et al. (2000).

The interspecies dietary overlap was assessed with the Morisita–Horn Index (Horn, 1966; Smith & Zaret, 1982). The trophic overlap was classified according to the scale proposed by Langton (1982). Values between 0.0 and 0.29 indicate low overlap, values between 0.30 and 0.65 indicate middle overlap, and values from 0.66 to 1 indicate high overlap.

Seasonal variations in fullness index were analyzed using the Kruskal–Wallis test. If a significant difference was found, comparison was performed using the Mann–Whitney U–test (Siegel, 1981). The differences in number of fish prey per stomach between species were tested by covariance analysis. Contingency table analysis was applied to determine the seasonal variations in the empty coefficient and also to test the difference in prey composition by number between predators (Crow, 1982).

Data and statistics on fish production in Egypt were taken from the General Authority for Fish Resources Development (GAFRD, 2004).

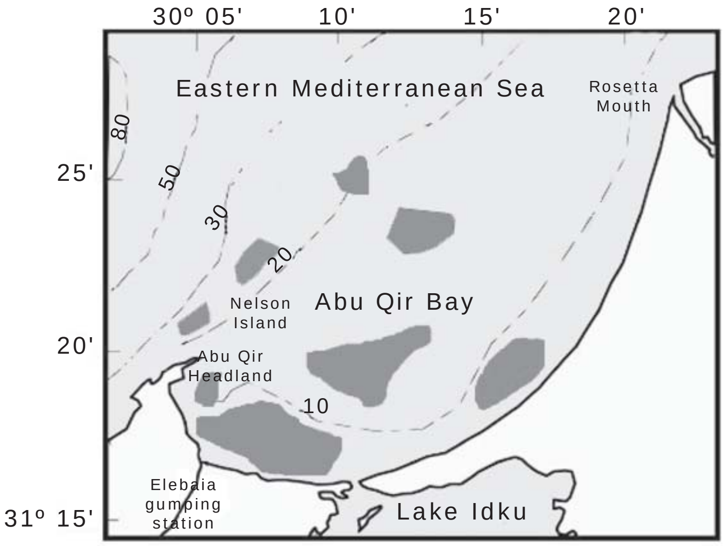

Fig. 3. Studing area with the fishing ground of daytime purse seine.

Fig. 3. Área de estudio incluyendo las zonas de pesca de la jábega diurna.

Results

The length of *T. lepturus* caught in the sampled area ranged from 22 to 60 cm TL, while the length of *S. commerson* ranged from 4 to 60 cm TL. These specimens were immature fishes that entered Abu Qir Bay for feeding.

Feeding intensity

The lowest values of empty stomachs for *T. lepturus* (8.33%) and *S. commerson* (12.12%) were observed in summer, while the highest proportions of empty stomachs for both species were observed in winter (44.74% and 34.15%, respectively). Fullness index reached the maximum values (2.01) for *T. lepturus* and (2.39) for *S. commerson* in spring and summer, and the lowest values in winter (0.84 and 0.33, respectively) (table 1).

Contingency table analysis was applied for testing the seasonal differences in the proportion of empty stomachs for the two mentioned species. The grand total χ^2 and G values indicated that there was no significant difference (G = 3.244, df = 3, $p > 0.05$). Kruskal–Wallis test showed significant seasonal differences in fullness index of *T. lepturus* (H = 24.759, df = 3, $p < 0.001$). This was attributed to the difference between spring and

Table 1. Seasonal variations of empty coefficient and fullness index of *T. lepturus* and *S. commerson* in Abu Qir Bay off Alexandria.

Tabla 1. Variaciones estacionales del coeficiente de estómagos vacíos y el índice de llenado del estómago de T. lepturus *y* S. commerson *en la bahía de Abu Qir, frente a la costa de Alejandría.*

	T. lepturus			*S. commerson*		
Season	N	Empty coefficient	Fullness index	N	Empty coefficient	Fullness index
Spring	36	22.2	2.0	44	29.6	0.5
Summer	32	8.3	1.6	33	12.1	2.4
Autumn	115	14.8	1.1	60	13.3	1.3
Winter	114	44.7	0.8	41	34.2	0.3

autumn (Mann–Whitney U–test, $p < 0.05$), spring and winter (Mann–Whitney U–test, $p < 0.001$) and summer and winter (Mann–Whitney U–test, $p < 0.001$). Significant seasonal differences in stomach fullness were also found for S. *commerson* (H = 27.938, df = 3, $p < 0.001$), and were observed between summer and both spring and winter (Mann–Whitney U–test, $p < 0.001$), between autumn and spring (U–test, $p < 0.05$) and between autumn & winter (U–test, $p < 0.001$). The comparison between seasonal differences in fullness index for *T. lepturus* and *S. commerson*, using the Kruskal–Wallis test, indicated that differences were not significant (H = 0.769, $p > 0.05$).

Food patterns

The diet of *T. lepturus* included *Engraulis encrasicolus*, *Gobius* spp., *Sardinella aurita*, *Sardina pilchardus*, fish eggs, amphipods (*Hyperia latissima* and *Gammarus latissima*), copepods (*Oithona* spp. and *Paracalanus parvus*) and shrimps (*Crangon crangon*). Results also revealed that *S. commerson* preyed upon the same food items as *T. lepturus* except for *Gobius* spp., fish eggs, amphipods and copepods.

Frequency of occurrence

The most frequent food item found in the *T. lepturus* diet was *E. encrasicolus*, while shrimps and unidentified fish remain ranked second and third. The most frequent species found in the stomachs of *S. commerson* were also *E. encrasicolus,* followed by unidentified fish remains (table 2).

Prey composition by number and weight

E. encrasicolus was the most important prey for *T. lepturus* comprising about 37.83% of the total food by number and 70.05% by weight. Amphipods were the second most important food item by number followed by copepods and shrimps. Other prey such as fish eggs, *Sardinella aurita, Sardina pilchardus* and *Gobius* spp. were rarely found in the diet of *T. lepturus*. The second most important prey in the diet of *T. lepturus* in terms of weight was unidentified fish remains, followed by digested food, *S. pilchardus*, *Gobius* spp., *S. aurita*, and shrimps, while amphipods, copepods and fish eggs were represented by less than 1% of the total food weight.

The diet of *S. commerson* by number consisted mainly of *E. encrasicolus* and shrimps, while *S. aurita* and, *S. pilchardus* contributed about 11%. The most important food item in terms of weight was also E*. encrasicolus*, followed by *S. aurita* and *S. pilchardus* (table 2).

Comparing the abundance by number for both species revealed that the eight food categories of *T. lepturus* included all four–food items of *S. commerson.* Contingency table analysis was applied to test the differences in prey composition by number between species. This test showed significant difference between species (G = 207.47, df = 7, $p > 0.01$) and was attributed to the difference between *S. commerson* and *T. lepturus* in the following prey, *S. aurita* (G = 15.74, $p < 0.05$), amphipods (G = 105.29, $p < 0.01$), copepods (G = 39.57, $p < 0.01$) and shrimps (G = 38.69, $p < 0.01$).

Percentage index of relative importance (%IRI)

This index revealed that teleosts were the most important food item, contributing 92.62% and 95.80% to the diet of *T. lepturus* and *S. commerson,* respectively. Amphipods and shrimps represented the second and third most important food items for *T. lepturus*, whereas shrimps were the second and *S. aurita* the third preferential food item for *S. commerson* (table 2).

Trophic levels of fishes

Trophic levels estimated from individual food items for *T. lepturus* and *S. commerson* were 4.10 and 4.30, respectively. This index revealed that the trophic level for *T. lepturus* clearly increased with fish length and that for *S. commerson* increased initially and then remained stable (table 3).

Seasonal variations of food patterns

Seasonal variation in diet of *T. lepturus* showed that fish was the main prey item throughout the year. Fish mostly occurred in the examined stomachs in summer and reached the maximum value in autumn. Their numerical abundance was low in spring and higher in autumn. The weight abundance of fish prey did not vary much between seasons, ranging from 83.75% to 98.82% of the total weight of food bulk throughout the year. Crustaceans were the second most important prey throughout the year. They were found in the stomachs in maximum numbers in summer and winter and were least frequent in autumn. Their numerical abundance was rare in autumn (table 4).

The preferred item in the diet of *S. commerson* in all seasons was *E. encrasicolus.* It occurred mostly in summer, and was fairly common in autumn and spring. Numerical abundance of this food item comprised lowest values in spring and autumn, with an increasing trend during successive seasons, reaching the maximum value in summer. Moreover, representation of *E. encrasicolus* in the food bulk weight ranged from 42% in winter to 88% in spring. Seasonal variations in the percent index of relative importance (%IRI) ranged from 85% in autumn to 96% in summer, indicating it was consumed in high quantities throughout the year. *S. aurita* was not observed as a food item in summer, but it became the second most important prey item in autumn. *S. pilchardus* was absent as prey in spring and summer but it represented the second and third most important prey in winter and autumn. Shrimps were rarely recorded in winter and autumn and reached maximum values in spring and summer (table 5).

Table 2. Diet composition of *T. lepturus* and *S. commerson* in Abu Qir Bay off Alexandria expressed as frequency of occurrence (%O), percent by number (%N), percent by weight (%W) and percentage index of relative importance (%IRI).

Tabla 2. Composición de la dieta de T. lepturus *y* S. commerson *en la bahía de Abu Qir, frente a la costa de Alejandría, expresada como la frecuencia de ocurrencia (%O), el porcentaje numérico (%N), el porcentaje según el peso (%W), y el porcentaje según el índice de importancia relativa (%IRI).*

Species	*T. lepturus*				*S. commerson*			
Food items	%O	%N	%W	%IRI	%O	%N	%W	%IRI
A–Teleosts	65.66	41.63	91.96	92.62	81.11	65.44	95.77	95.80
Engraulis encrasicolus	48.49	37.83	70.05	92.09	51.67	54.84	56.27	90.92
Gobius spp.	1.68	0.95	3.33	0.13	0.00	0.00	0.00	0.00
Sardinella aurita	2.36	1.33	2.59	0.16	8.33	7.37	20.23	3.64
Sardina pilchardus	2.02	1.14	5.20	0.23	3.89	3.23	16.95	1.24
Fish eggs	0.67	0.38	0.05	0.01	0.00	0.00	0.00	0.00
Unidentified fish remains	10.44		10.74		17.22		2.32	
B–Crustaceans	20.88	58.37	2.13	7.38	7.22	34.56	2.20	4.20
Amphipods	7.41	29.28	0.27	3.85	0.00	0.00	0.00	0.00
Copepods	2.36	16.35	0.03	0.68	0.00	0.00	0.00	0.00
Shrimps	11.11	12.74	1.83	2.85	7.22	34.56	2.20	4.20
C–Digested food	6.37		5.91		8.33		2.03	

Food overlap between species

A highly significant overlap, 0.75 by number and 0.95 by weight, was found in the diet of the two species. The overlap of food categories according to seasons revealed that there were no important seasonal changes according to weight, but wide variation according to number (table 6).

Feeding variations with fish length

Variation in abundance of food species in relation to fish size indicated that the diet of small *T. lepturus* mainly contained crustaceans (95%), while fish prey (*E. encrasicolus*) was of minor importance (5%). In contrast, teleosts were the most abundant food items (62%) followed by crustaceans (38%) in the diet of *S. commerson* of the same size range (less than 30 cm). The percentage of fish prey clearly increased in the diet of both species with increasing fish length. *T. lepturus* consumed crustaceans and fish prey until 59 cm in length, and fishes only at over 59 cm. Larger *S. commerson* (> 40 cm), however, fed only on fish prey (figs. 4–5).

The mean values of fish prey number per stomach for *T. lepturus* (1.352) was significantly lower

Table 3. Trophic levels of *T. lepturus* and *S. commerson* in Abu Qir Bay off Alexandria: Sg. Size groups (in cm); T. Trophic level; SE. Standard error.

Tabla 3. Niveles tróficos de T. lepturus *y* S. commerson *en la bahía de Abu Qir, frente a la costa de Alejandría: Sg. Tamaño de los grupos (en cm); T. Nivel trófico; SE. Error estándar.*

	Species			
	T. lepturus		*S. commersons*	
Sg	T	SE	T	SE
< 30	3.60	0.53	4.20	0.74
30–39	4.10	0.69	4.30	0.76
40–49	4.00	0.69	4.50	0.80
50–59	4.30	0.77	4.50	0.80
> 60	4.50	0.80	4.50	0.80
Total T	4.10	0.69	4.30	0.76

Table 4. Seasonal variations in the diet of *T. lepturus* in Abu Qir Bay off Alexandria expressed as frequency of occurrence (%O), percent by number (%N), percent by weight (%W) and percentage index of relative importance (%IRI).

Tabla 4. Variaciones estacionales en la dieta de T. lepturus en la bahía de Abu Qir, frente a la costa de Alejandría, expresada como la frecuencia de ocurrencia (%O), el porcentaje numérico (%N), el porcentaje según el peso (%W), y el porcentaje según el índice de importancia relativa (%IRI).

	Season															
	Spring				Summer				Autumn				Winter			
Food items	%O	%N	%W	%IRI	%O	%N	%W	%IRI	%O	%N	%W	%IRI	%O	%N	%W	%IRI
A–Teleosts	61.11	13.50	90.69	86.02	75.01	56.36	83.75	66.17	88.70	83.97	98.82	99.79	41.22	29.09	89.91	80.29
Engraulis encrasicolus	44.44	12.27	62.39	55.81	43.75	29.08	62.06	63.01	67.83	78.21	65.42	98.73	30.70	22.42	69.35	79.44
Gobius spp.	0.00	0.00	0.00	29.08	6.25	3.64	16.22	1.96	0.87	0.64	4.77	0.05	1.75	1.21	8.70	0.49
Sardinella aurita	5.56	1.23	21.9	0.00	0.00	0.00	0.00	0.00	3.48	2.56	5.58	0.29	0.88	0.61	2.08	0.07
Sardina pilchardus	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00	3.48	2.56	17.76	0.72	1.75	1.21	2.87	0.20
Fish eggs	0.00	0.00	0.00	0.00	3.13	23.64	0.62	1.20	0.00	0.00	0.00	0.00	0.88	3.64	0.03	0.09
Unidentified fish remains	11.11		6.40		21.88		4.85		13.04		5.29		5.26		6.88	
B–Crustaceans	49.99	86.5	7.26	13.98	37.50	43.64	13.45	33.83	4.35	16.03	0.50	0.21	23.68	70.91	7.88	19.71
Amphipods	19.44	51.53	3.23	9.33	0.00	0.00	0.00	0.00	1.74	5.13	0.11	0.09	10.53	37.58	1.42	11.58
Copepods	11.11	26.99	0.40	2.67	0.00	0.00	0.00	0.00	0.87	8.98	0.03	0.08	1.75	16.97	0.13	0.84
Shrimps	19.44	7.98	3.63	1.98	37.50	43.64	13.45	33.83	1.74	1.92	0.36	0.04	11.40	16.36	6.33	7.29
C–Digested food	5.56		2.05		18.75		2.80		5.22		0.68		5.26		2.21	

than those for *S. commerson* (1.727) (F = 87.649, $p < 0.01$) (fig. 6).

To determine the effect of the increasing catch percentage of the *S. commerson* on the relative abundance of *T. lepturus* as the result of food competition on fish prey, analysis of covariance showed no significant difference (F = 0.221, $p > 0.05$).

These results indicated that there is no effect of food competition on the catch of *T. lepturus*. Moreover, the results revealed increasing abundance of anchovy in the commercial catch (fig. 7).

Discussion

Human interventions has caused a global impact on the marine environment and has led to great changes in the distribution of native and non–native fishes. The Suez Canal, an artificial waterway connecting the tropical Red Sea and the sub–tropical Easthern Mediterranean Sea, presents an example of human intervention leading to changes in the distribution of native and non–native fishes in Mediterranean waters.

Table 5. Seasonal variations in the diet of *S. commerson* in Abu Qir Bay expressed as frequency of occurrence (%O), percent by number (% N), percent by weight (%W) and percentage index of relative importance (%IRI).

Tabla 5. Variaciones estacionales en la dieta de S. commerson *en la bahía de Abu Qir, frente a la costa de Alejandría, expresada como la frecuencia de ocurrencia (%O), el porcentaje numérico (%N), el porcentaje según el peso (%W), y el porcentaje según el índice de importancia relativa (%IRI).*

	Season															
	Spring				Summer				Autumn				Winter			
Food items	%O	%N	%W	%IRI	%O	%N	%W	%IRI	%O	%N	%W	%IRI	%O	%N	%W	IRI
A–Teleosts	70.46	55.56	97.48	95.71	87.88	81.48	80.79	96.46	88.34	92.00	97.77	99.08	65.86	94.74	96.51	99.67
Engraulis encrasicolus	50.01	53.34	87.72	95.48	66.67	81.48	77.42	96.46	53.33	64.00	49.39	85.39	36.59	78.95	42.13	93.83
Sardinella aurita	2.27	2.22	5.39	0.23	0.00	0.00	0.00	0.00	16.67	20.00	26.82	11.02	2.44	5.26	12.13	0.90
Sardina pilchardus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67	8.00	20.31	2.67	4.88	10.53	37.31	4.94
Unidentified fish remains	18.18		4.37		21.21		3.37		11.67		1.25		21.95		4.94	
B–Crustaceans (shrimps)	6.82	44.44	1.98	4.29	15.15	18.52	7.15	3.54	6.67	8.00	1.72	0.92	2.44	5.26	1.03	0.33
C–Digested food	2.72		0.54		18.18		12.06		6.67		0.52		9.76		2.46	

This Canal is 162 km long. It stretches from Port–Said to Port–Taufic, crossing marine lagoons and many shallow saline lakes. Since its opening in 1869 until the building of the Aswan High Dam in the 1960s, the fish species inhabiting the Red Sea faced two main barriers to migration. The first of these was the high salinity of the Bitter Lakes, 50–52‰ at the surface and 80‰ at the bottom (Thorson, 1971). The second was the difference in salinity between the entrance to the Red Sea (41–44‰) (Bogdanova, 1970) and the Egyptian Mediterranean waters (27–39‰) (Beltagy et al., 1985). Other barriers hindering migration include a rapid current that changes direction twice daily, in relation to tides (Miller & Münnus, 1974), and another strong current in the northern part of the Canal. Despite such barriers, however, 22 Red Sea fish species are known to have migrated. Two factors seem to have played a significant role in the last decades. The first of these is the construction of the High Dam. This led to cessation of Nile flooding (34 milliard m^3) as of 1966, resulting in a 39‰ decrease in salinity in front of Port–Said (Thorson, 1971). The second is that the volume of water flowing through the Canal has increased as a result of extensive dredging and deepening. The Canal is now 345 m wide and 17.7 m deep.

S. commerson is one of 16 of these exotic species that have extended their distribution as far

Table 6. Morisita–Horn overlap index between *T. lepturus* and *S. commerson* at different seasons.

Tabla 6. Índice de solapamiento de Morisita–Horn entre T. lepturus *y* S. commerson *en distintas estaciones.*

Season	By number	By weight
Spring	0.24	0.92
Summer	0.62	0.94
Autumn	0.94	0.94
Winter	0.42	0.74

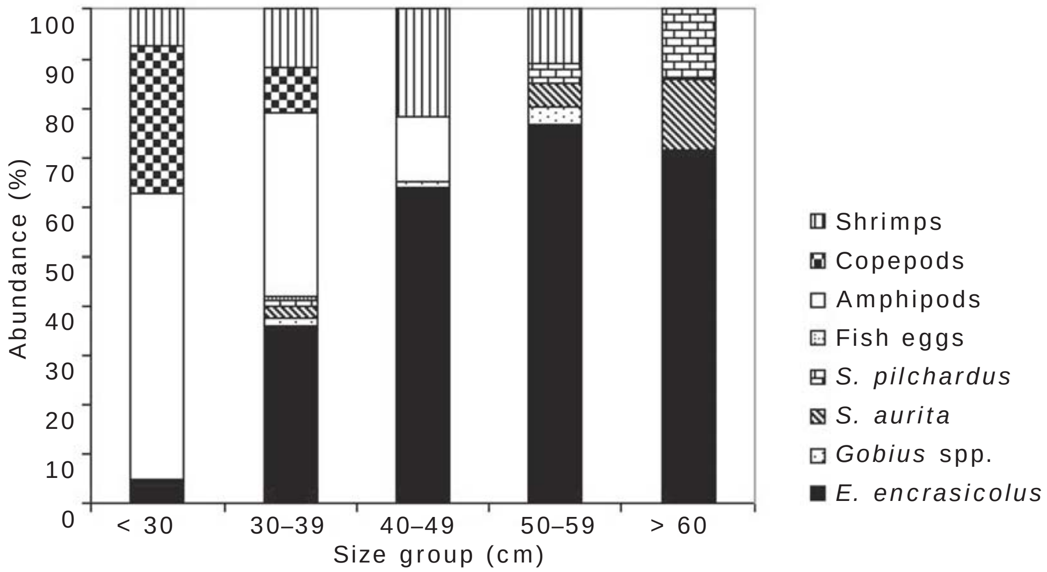

Fig. 4. Prey composition by number for *T. lepturus* at different size grups.

Fig. 4. Composición de las presas de T. lepturus *según el número, en los distintos grupos de tamaño.*

as the Aegean Sea (Golani et al., 2002). This may indicate that the environmental conditions in the East and the North of the Mediterranean Sea satisfy the requirements for successful propagation of *S. commerson*.

The ribbonfish (*T. lepturus*) in Abu Qir Bay consumed a wide range of food items (*E. encrasicolus*, *Gobius* spp., *S. aurita*, *S. pilchardus*, fish eggs amphipods, copepods and shrimps). This is in agreement with general information provided by

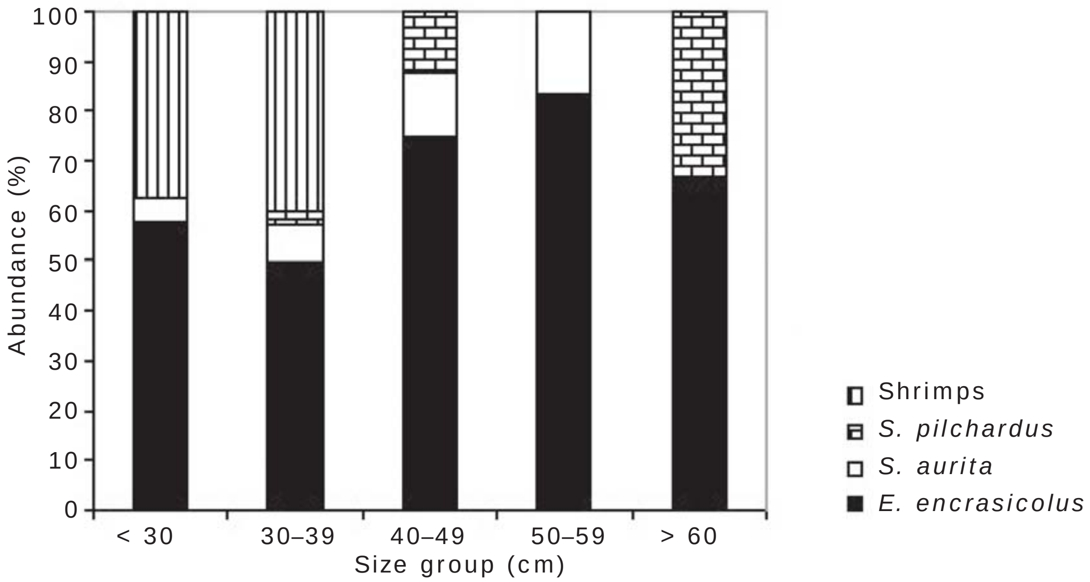

Fig. 5. Prey composition by numbers for *S. commerson* at different size groups.

Fig. 5. Composición de las presas de S. commerson *según el número, en los distintos grupos de tamaño.*

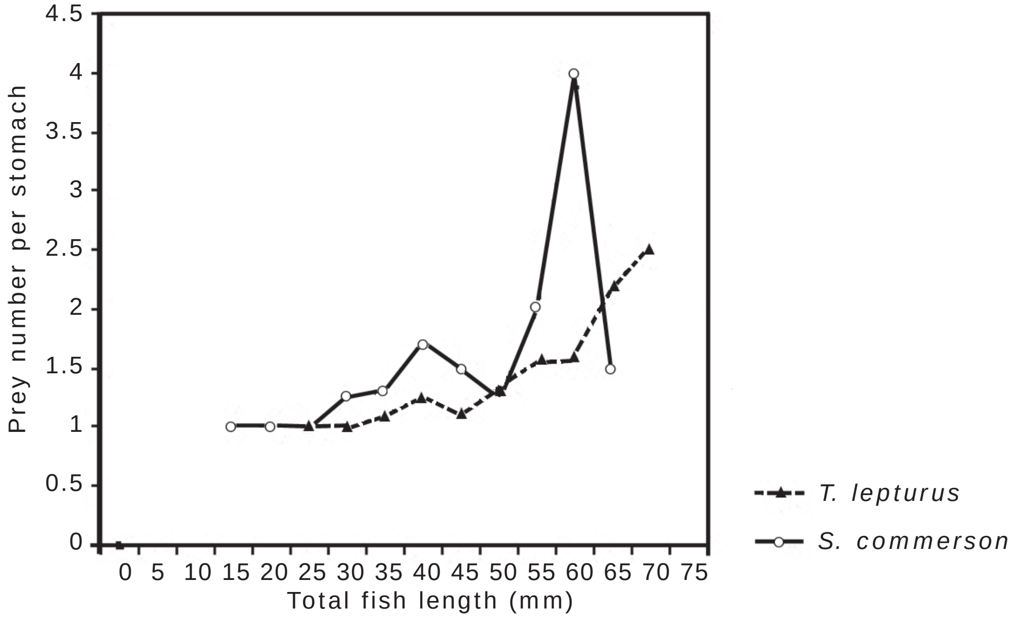

Fig. 6. Relation between fish prey number per stomach and fish length for *T. lepturus* and *S. commerson*.

Fig. 6. Relación entre el número de peces ingeridos por estómago y las longitudes para T. lepturus *y* S. commerson.

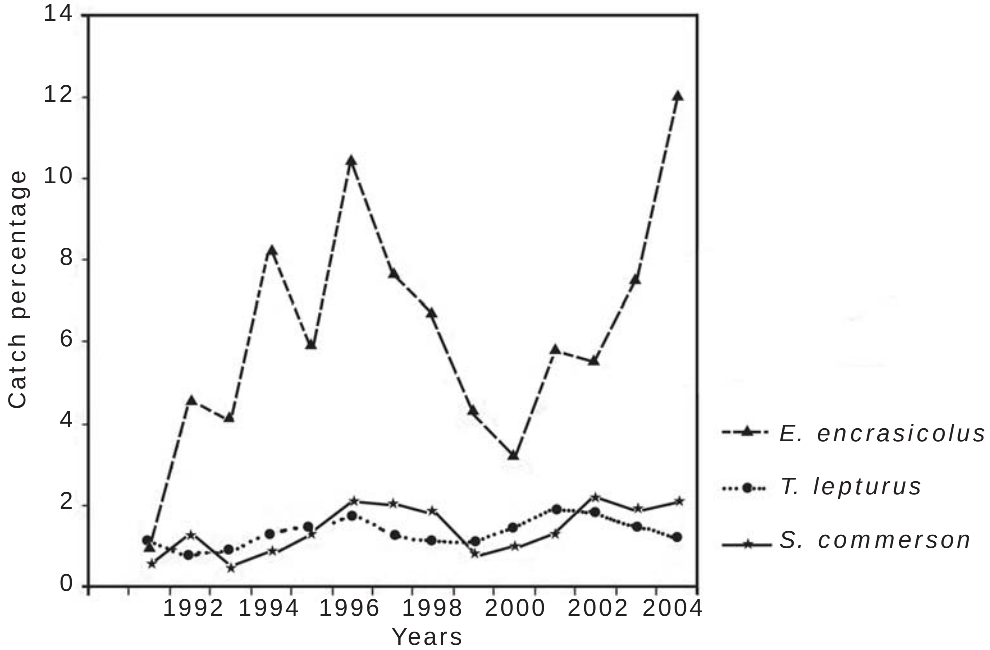

Fig. 7. Relation between catch percentages of fish prey (*E. encrasicolus*) and predators (*T. lepturus* and *S. commerson*) in the Egyptian Mediterranean coast.

*Fig. 7. Relación entre los porcentajes de capturas de peces (*E. encrasicolus*) y los depredadores (*T. lepturus y S. commerson*) en la costa mediterránea egipcia.*

Whitehead et al. (1986). In his study of food and feeding habits of ribbonfish in Taiwan, Sin (1978) mentions that *T. lepturus* fed mainly on fish prey and the other food categories such as shrimps, squids, mantis shrimp, euphausiaceans and isopods. As regards *S. commerson*, the main constituent of the diet is finfish (anchovies, *S. aurita* and *S. pilchardus*) and shrimps. This result confirms that given by Blaber et al. (1990) regarding the diet of this species in the Solomon Islands.

Feeding activity changes with seasons corresponding to variations in the abundance of fish, and seasonal changes in water temperature and food organisms (Sakamoto, 1982). In the present study, seasonal variation in feeding activity indicated that the highest amounts of food for both species were consumed from spring to autumn and from summer to autumn for *T. lepturus* and *S. commerson* , respectively. The percentage of empty stomachs reached a maximum value of 45% for *T. lepturus* and of 34% for *S. commerson* in winter. This finding suggests that the high percentage of empty stomachs is characteristic of piscivorous fishes as reported by Faltas (1993) and Juanes & Conover (1994). There were no seasonal differences between *T. lepturus* and *S. commerson* in the diet composition. This may be attributed to the abundance of anchovy, the preferred prey item for these species in all seasons in the Egyptian Mediterranean waters (Al–Kholy & El–Wakeel, 1975; Faltas, 1997).

Trophic levels are important for defining the position of different species within the food web. Quantification of the trophic overlap of coexistent species is important to establish the structure of the trophic chain in the coastal ecosystems and the availability of food resources in the coastal lagoon assemblages (Caragitsou & Papaconstantinou, 1993).

In the present study, the trophic level (4.10) for *T. lepturus* was close to its estimation (4.08) for the same species in the northwest Atlantic (Bowiman et al., 2000). According to Collette & Nauen (1983), the trophic level of *S. commerson* was 2.8 and higher, and Blaber et al. (1990) found it reached to 4.07, findings that are in keeping with those of the present study (4.30).

The overlap index value is sensitive to the taxonomic level at which food items are identified (Stergiou, 1988). Moreover, it serves to compare the use of food resources between species that coexist in a given community, demonstrating that such measures can help to define distribution patterns between community components (Farnsworth & Ellison, 1996). The high degree of overlap between these species in terms of number and weight indicated that they fed mainly on the same kind of food.. The trophic niche of *T. lepturus* was wider than that of *S. commerson.* Sin (1978) pointed out that intraspecific cannibalisms of the ribbonfish may be an ecological adaptation to ease the possible competition for space and food.

In the present study the diet of both species differed for different size groups. The diet of small–sized *T. lepturus* mainly consisted of crustaceans, while larger fish (> 59 cm) consumed only other fishes. In contrast, teleosts were the most important food item for all size groups of *S. commerson*, and this species became piscivorous at a smaller size (> 40 cm) than *T. lepturus*. According to Sin (1978), *T. lepturus* of less than 200 mm in length feed mainly on shrimps, mantis shrimp and squids, larger fish feed on anchovies and juvenile ribbon fishes, and the largest fish of this species feed on other bigger fishes. Hanabuchi (1973) pointed out that the young and immature *T. lepturus* , less than 230 mm in size, have pointed teeth and are plankton feeders, whereas the adults have a tendency towards an increased number of hooked canine teeth and are mostly piscivorous. The increase in the length range also revealed an increase in the percentage of fish prey in the diet of *S. commerson*. This coincides well with the findings of Jenkins (1984) for larvae of this species in the Great Barrier Reef (Australia) and Blaber et al. (1990) for the diet of this species in the Solomon Islands. It seems that *T. lepturus* and *S. commerson* which feed mainly on anchovy have the same seasons for feeding activity and there is a high value of overlap in terms of weight of diet. *S. commerson* also showed a high degree of consuming fish prey, and the prey numbers per stomach eaten by this species were significantly higher than for *T. lepturus*. In spite of the above, our results revealed that increases of *S. commerson* in the catch have no effect on the abundance of *T. lepturus*, possibly because anchovy have increased in abundance in the Egyptian Mediterranean waters. However, we consider that *T. lepturus* will likely be in serious trophic competition with the newly immigrant predator *S. commerson,* from the Red Sea to the Levant Basin of the Mediterranean Sea. Moreover, this trophic competition may also include the following species: *Trachurus mediterraneus*, *Merluccius merluccius*, *Sarda sarda*, *Tetrapturus belone* and *Scomber japonicus*, which feed mainly on anchovies (Whitehead et al., 1986).

The diet and feeding habits of immigrant predator *S. commerson* to the Levant Basin of the Mediterranean Sea are similar to *T. lepturus*. Competition for fish prey is not a major determinant of propagation of *S. commerson* due to the increasing numbers of anchovy in the Egyptian Mediterranean waters.

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