www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 17: 51-60 (2017) DOI: 10.4194/1303-2712-v17_1_07

PROOF

RESEARCH PAPER

Assessment of Some of the Feeding Aspects and Reproduction of *S. undosquamis* Distributed in the İskenderun Bay

Caner Enver Ozyurt[1, *], Hasan Ozgur Yesilcimen[2], Sinan Mavruk[1], Volkan Barış Kiyaga[1], Muzaffer Perker[1]

[1] Cukurova University Fisheries Faculty 01330 Sarıcam, Adana, Turkey.
[2] Republic of Turkey Ministry of Food, Agriculture and Livestock Eskişehir, Turkey.

* Corresponding Author: +90.322 3386084 - 2961; Fax: +90.322 3386439
E-mail: cozyurt@cu.edu.tr

Received 21 May 2016
Accepted 28 July 2016

Abstract

This study was performed with the purpose of determining the main feeding aspects and the reproductive period of *Saurida undosquamis* from January to December 2010. The samples were obtained by trawl operations conducted in monthly intervals. The result regarding the feeding reveals that the most important feeding group is the teleost. The IRI values (20621,06) for the teleost are much higher than those determined for crustaceans and cephalopods (31,66 and 0,02, respectively). The relative importance of the clupeiforms among the teleosts was the highest (Clupeidae:1890.13; Engraulidae: 910.06). In addition, while the sex and length were not significant predictors of the feeding groups, their variation, depending upon the month, was important. In general, the pelagic and native species were dominant in feeding preference. However, feeding with the demersal and indopacific species was more common in October and November. Moreover, the prey length increased with the predator length. The reproductive activities of this species increased during the warm months, and there was a negative correlation between the spawning activities and the feeding intensity.

Key words: *Saurida undosquamis*, feeding, spawning period, prey-predator length relationship.

İskenderun Körfezi'nde Dağılım Gösteren *S. undosquamis*'lerin Beslenme Özelliklerinin İncelenmesi ve Beslenmenin Üreme Dönemi ile İlişkisi

Özet

Bu çalışma, Ocak 2010 ile Aralık 2010 tarihleri arasında, *S.undosquamis*'in beslenme özellikleri ve üreme döneminin belirlenmesi amacıyla gerçekleştrilmiştir. Örnekler, aylık olarak yapılan trol operasyonları ile elde edilmiştir. Elde edilen sonuçlar, en önemli besin grubunun teleost olduğunu göstermiştir. Teleostların IRI değeri (20621,06), crustacean ve cephalopodların IRI değerlerinden (sırasıyla 31.66 and 0.02) oldukça yüksek bulunmuştur. Teleostlar içerisinde en yüksek IRI değerleri ise clupeiformes grubunda gözlenmiştir (Clupeidae:1890.13; Engraulidae: 910.06). Ayrıca, ana besin grubu tercihinde boy ve eşeyin etkili olmadığı, ancak zamana bağlı olarak bir değişim olduğu saptanmıştır. Besin tercihinde yılın genelinde zoocoğrafik orjin olarak yerli, habitat olarak ise pelajik türlerle beslenme söz konusuyken, Ekim ve Kasım aylarında demersal ve indopasik türlerle beslenmenin ağırlık kazandığı saptanmıştır. Ayrıca pradatör boyu büyüdükçe prey boyunda artış olduğu saptanmıştır. Bu türün üremesinin, yılın sıcak döneminde yoğunlaştığı ve üreme dönemi ile beslenme yoğunluğu arasında ters bir ilişki olduğu tespit edilmiştir.

Anahtar Kelimeler: *Saurida undosquamis*, beslenme, üreme periyodu, prey-predator boy ilişkisi.

Introduction

Iskenderun Bay is the area in which the continental shelf is considerably enlarged compared to the other areas of the Mediterranean Sea. Hence, it forms a suitable topography for many fishing methods, with bottom trawl being first (Gücü and Bingel, 1994). Furthermore, since the 1940s, this bay is known to have much richer fishery resources compared to the other areas of the East Mediterranean (Kosswig, 1953). In addition, this area is a biotope in which indopacific species reaching the coast of Turkey are first established (Avşar, 1999). Thus, it has a dynamic structure with respect to species diversity and dominance. For instance, recent studies point out that the occurrence and weight of teleosts was 35% and 75%, respectively (Perker *et al.*, 2015).

S. undosquamis is a species that is distributed from Japan to the Pacific and from South Africa to the Indian Ocean and the Eastern Mediterranean (Sulak, 1984). The first record of *S. undosquamis* was from Israel in 1953 (Golani, 1998). *S. undosquamis* began to meet 11% of total fishery production in the marine area and 20% of the total trawl fishery in 1956. The records showed that the Israel trawl fleet was fishing during the years 1955-1960 between Turkey and Cyprus, and an important part of this product was *S. undosquamis* (Ben Yami and Glaser, 1974). The importance of this species increased over time, and it was determined that *S. undosquamis* was among the four species that formed the main catch in the Mersin and İskenderun Bay in the 1980s (Gücü and Bingel, 1994). *S. undosquamis* is still a significant species for trawl fishery performed in the Eastern Mediterranean coasts, especially in İskenderun Bay. For instance, Perker *et al*. (2015) determined that, it was the fourth ranked species with respect to its occurrence among all teleosts in the demersal stocks.

S. undosquamis is an invasive species and one of the rare piscivor fish in this biotope. Fish that feed in this way are at the top of the aquatic tropic chain (Juanes *et al*., 2002), and they play an important role in the mortality rate as a result of the predation in the biotope in which they inhabit. Therefore, this species can strongly influence native fauna by way of the predation pressure. Hence, knowledge concerning the feeding of these species is very important with respect to the understanding of potential impact of this lessepsian immigrant on the native food web. Recently, multispecies approaches are widely used in order to understand the ecological interactions of fish stocks. These models are also quite important tools in fisheries management applications. The data obtained with this study such as food preference and feeding intensity are among the most crucial information to conduct these models. But, knowledge regarding the feeding of *S. undosquamis*, which inhabit Eastern Mediterranean ecosystems and became an important part of fishing production in the beginning of the 1950's, is very limited. Some of these studies were performed on the coasts of Israel (Chervinsky, 1959; Bograd Zismann, 1965; Golani, 1993), and others were conducted in the western parts of the Mediterranean coasts of Turkey (Bingel and Avşar, 1988a; Bingel and Avşar, 1988b). However, there is no study concerning this subject in Iskenderun Bay.

Little is known about the reproductive biology of *Saurida undosquamis* in Iskenderun Bay (İşmen, 2003; Mavruk, 2015). The both study show that this species spawns throughout year, however the spawning activity increases towards spring and summer.

The main purpose of this study is to develop an understanding of some feeding aspects of Saurida undosquamis distributed in Iskendeurn Bay. To reach this aim, we investigated the main feeding groups and their variations depending on the sampling time, predator length and sex. Additionally, we also evaluated the relationship between the prey and predator length. Furthermore, the connections between the feeding concentration and spawning activities were also studied.

Materials and Methods

Sampling Area and Collecting the Samples

To collect the samples required in the study, experimental trawl operations among the 10-70 m depth contours were conducted in Iskenderun Bay between January and December 2010 (Figure 1). The Iskenderun Bay which is located in northeast Mediterranean is of 65-km length, 35-km width and 2275 km^2 surface area, and its maximum depth is 70 m. This bay has a wide continental shelf compared with other areas of the eastern Mediterranean. For the samplings, a traditional Mediterranean Type trawl net was used. To prevent the escape of small individuals

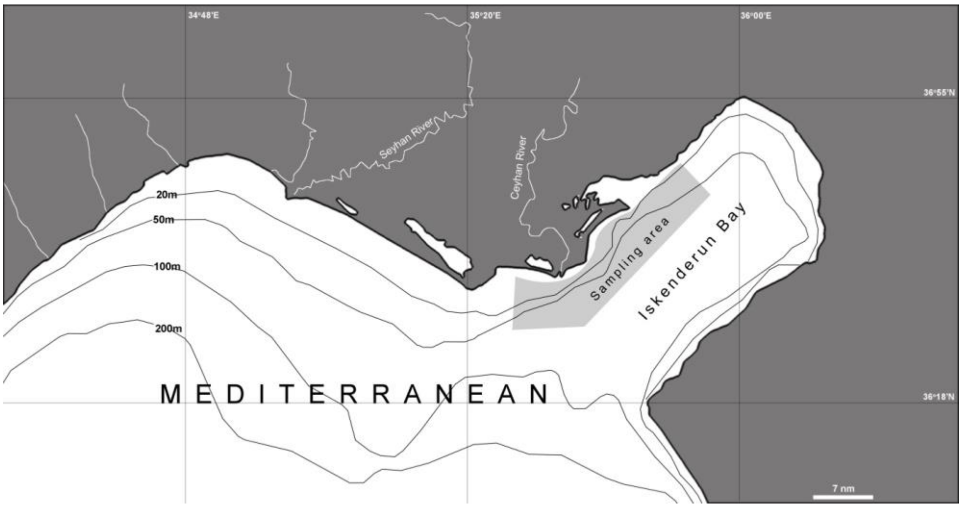

Figure 1. Iskenderun Bay and the sampling area

from the mesh of the trawl net, a secondary nonselective net was used at the cod end. Thus, all of the length groups in the population were represented. Four-percent formaldehyde buffered with borax was injected into the stomachs of all of the individuals caught. These samples were placed in cans containing 4% formaldehyde buffered with borax. The same process was applied to the *S. undosquamis* samples obtained at all depths of the contours. These materials were brought to the Fisheries Faculty of the Cukurova University to perform the required determinations and measurements.

In laboratory studies, the total length, fork length and standard length of each individual were measured on a mm scale and the total weight was measured as gr. Then, the individuals were dissected and sex determination was realized macroscopically from the measured gonad and gonadal weights. After these processes, the feeding groups, to the lowest possible systematic group, were determined. Then, the total weight of each feeding item in the stomach and the total length, if not digested, were measured.

Statistical Analyses

To explain the importance of the different groups, the Index of Relative Importance (IRI) was used (Hacunda, 1981). To determine the IRI values, the following equation was used:

$$IRI = (\%N + \%W) * \%FO$$

In this equation, %FO (Occurrence frequency) was the percentage of stomachs in which a dietary group was found relative to the total number of non-empty stomachs, %N (% occurrence in number) was the relative number of each dietary group as the percentage of the total number of all prey individuals obtained in all of the stomach contents investigated, and %W (% occurrence in weight) was the proportional wet weight of each dietary group as the percentage of all of the dietary groups.

Logit linear Models were used to test whether the feed is present in the stomachs of *S. undosquamis*. We determined whether the feed was a species distributed in the pelagic or demersal habitats and whether it was native or indopacific. Different models were formed for the zoological origin (indio pacific/local) and for the habitat (demersal/pelagic). The null model containing all of the variations of the relevant models is as follows:

$$Logit\left(P(Y_{ijk} = 1)\right) = \mu + m_i + s_j + (m \times s)_{ij} + TL_{ijk} + e_{ijk}$$

In this equation:

$P(Y_{ijk}=1)$: The possibility that it is foreign in the model that was generated for the zoogeographical and pelagic of the habitat.

μ: intercept

m_i: The effect of the i. month

s_j: The effect of the j. sex

TL_{ijk}: Total length (cm) of k. fish belonging to j. sex, sampled in the i. month whose stomach was full.

e_{ijk}: Random error; $e \sim N(0, ϐ^2)$

Only the fish with full stomachs were studied in the models formed for testing the hypothesis directed at the characteristics of feeding. Moreover, feeding was determined in taxons, which were not descriptive at the level of species, and thus, fish in which there was the possibility of belonging to both categories were not analysed. Every feeding group was assessed several times when more than one feeding group was dissected in the stomach.

The LSD (Least Significant Difference) method was utilized as a post Hoc tests in the assessment of the differentiation factors that are statistically important.

Four length groups were formed while the prey-predator length relationship was studied. While these length groups were being formed, the age-length distributions in the previous studies were examined. To determine the prey-predator relationship, only the preys whose total lengths could be measured were used. For this aim, the minimum, maximum and mean lengths of the prey were calculated for each predator length group. ANOVA was used to assess whether a statistical differentiation was present among the prey lengths corresponding to each predator length group. To determine which groups were distinct for this aspect, a Turkey HSD was utilized.

To determine the spawning period, the GSI values were determined monthly. The months in which the spawning occurred was determined by observing the monthly variation of this value. In the calculation of the GSI, the following equation suggested by Gibson and Ezzi (1978) was utilized:

$$GSI = \frac{GW}{BW - GW} * 100$$

In this equation:

GW: Gonad weight (gr)

BW: Body weight (gr)

Results and Discussion

Feeding Groups

During the study, a total of 1058 individuals were investigated. The total lengths varied from 11 to 35 cm. Of the individuals caught, 755 were female, 269 were male and 34 of were juveniles. We found 673 with full stomachs and 385 with empty stomachs. The general stomach fullness was 64%.

Thirty-five different species belonging to 18 families were found (Table 1). This notes that the feeding options of *S. undosquamis* are very wide. However, 15 of the 18 families and 31 of the 35 species were teleosts. For this reason, the main feeding group was the teleosts. The IRI values given in Table 1 clearly support this determination. The IRI values (20621,06) for the teleosts are much higher than those determined for crustaceans and cephalopods (31,66 and 0,02, respectively).

When the feeding activity was determined, the *Clupeidae*, *Engraulidae*, *Gobiidae*, *Leiognathidae*, and *Carangidae* families were the most highly ranked. The IRI values of the *Clupeidae* and *Engraulidae* families were especially high. *Engraulis encrasicolus*, *Sardinella aurita*, *Equuilites klunzingeri*, *Trachurus trachurus* and *Etrumeus teres* were the most highly ranked at the species level. However, the IRI values of *Engraulis encrasicolus* and *Sardinella aurita* were much higher than those of the other species (Table 1). This situation notes that clupeid constitutes the most important feeding group for *S. undosquamis* among the teleosts.

The IRI values, according to the months determined for the feeding groups, are given in Table 2. These data show that the *Clupeidae* family is found in the stomach during 12 months and *Engraulidae* during 9 months (except for September, October, and November). In addition, the IRI values of the *Clupeidae* family were the highest compared to those of the other families among all of the feeding group levels in February, April, May, July, September, October, and November, and those of *Engraulidae* were at the highest level in March, June, August, and December. In January, the IRI values of the *Gobiidae* family were higher than those of the other families. Therefore, when the feeding groups were assessed according to months, the families of *Clupeidae* and *Engraulidae* constituted the most important feeding groups in almost all months. *Atherinidae, Callionymidae, Centracanthidae, Nemipteridae, and Sphyraenidae* were detected in the stomach content during only one month, and species that belong to the families of *Bregmacerotridae* and *Synodontidae* were found in the stomach content during only three months (Table 2).

In most studies on the feeding of *S. undosquamis*, teleosts were the main feeding group (Chervinsky, 1959; Bograd-Zismann, 1965; Bingel and Avşar, 1988a; Golani, 1993; Torcu, 1994; Rao, 1981; Euzen, 1989; Yamashita *et al*., 1991; Rajkumar *et al*., 2003; Hadzley *et al*., 2005; Thangavelu *et al*., 2012; Kadharsha *et al*., 2013). Among the teleosts, *Clupeiformes* was dominant. Therefore, Chervinsky (1959) *Engraulidae*, Bograd-Zismann (1965) *Engraulidae and Clupeidae*, Rao (1981) *Clupeidae*, Golani (1993) and *Engraulidae*, Torcu (1994) noted that the *Clupeidae* groups were the most dominant feeding groups among the teleosts. Additionally, in this study, the *Clupeida*e and *Engraulidae* groups were the most dominant among the teleosts. Hence, it can be stated that the results obtained are consistent with those from previous studies.

Additionally, there are few studies in which the feeding groups, except for *Clupeids*, were determined to be the main feeding groups. For instance, Hadzley (2005) determined that *Leiognathidae* was dominant. According to Scharf *et al*. (2000), the predator species were fed by selecting from an abundance of prey indiscriminately or from certain individuals. It is not known whether *S. undosquamis* prefers an accidental or a deliberate feeding strategy. However, when the feeding strategy encountered in the stomach content is considered (35 different species have been identified), the idea that *S. undosquamis* uses a nonselective strategy strengthens over time. İbrahim *et al*. (2003) put forward a similar determination. Regarding the feeding of eight demersal species, they encountered the widest prey diversity in the stomach contents of *S. undosquamis*. Therefore, it follows a nonselective feeding strategy. Hence, it can be said that the species composition and occurrence in the environment play a determining role in the main feeding groups. Additionally, the species compositions and occurrence in the environment in which the study was conducted could determine the most dominant feeding groups naturally. Gücü *et al*. (2011) determined that *S. aurita* and *E. encrasicolus* were the most frequent (concentrated) species in the unit area (mile^2). In their study, they researched the abundance of small pelagic with an acoustic method in the Mersin and İskenderun Bay in the same period as the study mentioned above. In addition, in midwater trawl samplings, it has been reported that the occurrence of these two species in number is approximately 60% of all of the small pelagic. It is expected that *S. aurita* and *E. encrasicolus,* which exist abundantly in the environment during the feeding activity of *S. undosquamis*, are distributed in İskenderun Bay.

Contrarily, Bingel and Avşar (1988a) reported that the dominant feeding group consists of demersal teleosts such as *Mullidae, Sparidae* and *Leiognathidae*, respectively in Mersin Bay. This contradiction cannot be explained by the local differences alone. Eastern Mediterranean ichthyofaunal reveals a highly dynamic structure due to the external pressures such as lessepsian intrusions, fisheries and coastal eutrophication. After the study conducted by Bingel and Avşar (1988a) the demersal fish stocks of the area have more suffered from the overfishing (Bingel *et al*., 1993; Gücü, 1995) and small pelagics have remarkably increased (Gücü, 2000). This circumstance supports that *Saurida undosquamis* follows an opportunistic feeding strategy and food selection is related with the presence of prey items.

Saurida undosquamis may also affect the native fishes by way of the competition. For example, the importance of hake increased towards the middle of 1980’s and this situation remained during about 10 years. Then, hake stocks remarkably decreased towards 1998. This decrement was hypothesised to be attributed to several factors such as hydrographic shifts in Levant Basin, overfishing and as well as food competition with *Saurida undosquamis* (Gücü and Bingel, 2011). Accordingly, previous studies show that hake also feed on small pelagics (Bozzano *et al.*

Table 1. Food groups and the importance levels identified in the stomach contents

Feeding Groups	N	W	F	%N	%W	%F	IRI
Teleost	850	3040.83	715	94.87	99.23	106.24	20621.06
Atherinidae	4.00	14.30	4.00	0.45	0.47	0.59	0.54
Atherina sp.	4.00	14.30	4.00	0.45	0.47	0.59	0.54
Bregmacerotidae	9.00	4.36	8.00	1.00	0.14	1.19	1.36
*Bregmaceros atlanticus**	9.00	4.36	8.00	1.00	0.14	1.19	1.36
Callionymidae	1.00	0.97	1.00	0.11	0.03	0.15	0.02
*Callionymus filamentosus**	1.00	0.97	1.00	0.11	0.03	0.15	0.02
Carangidae	27.00	157.35	26.00	3.01	5.13	3.86	31.48
Caranx rhonchus	3.00	4.54	3.00	0.33	0.15	0.45	0.22
Trachurus trachurus	10.00	88.51	10.00	1.12	2.89	1.49	5.95
Trachurus mediterraneus	2.00	11.14	2.00	0.22	0.36	0.30	0.17
Trachurus sp.	2.00	4.59	2.00	0.22	0.15	0.30	0.11
Carangidae sp.	10.00	48.57	9.00	1.12	1.58	1.34	3.61
Centracanthidae	1.00	0.88	1.00	0.11	0.03	0.15	0.02
Spicara sp.	1.00	0.88	1.00	0.11	0.03	0.15	0.02
Clupeidae	191.00	1465.28	184.00	21.32	47.82	27.34	1890.13
*Dussumieria elopsoides**	2.00	9.97	2.00	0.22	0.33	0.30	0.16
*Etrumeus teres**	8.00	85.23	8.00	0.89	2.78	1.19	4.37
*Herklotsichthys punctatus**	4.00	42.13	4.00	0.45	1.37	0.59	1.08
Sardinella aurita	118.00	1137.98	112.00	13.17	37.14	16.64	837.18
Sardinella maderensis	1.00	3.92	1.00	0.11	0.13	0.15	0.04
Sardina pilchardus	1.00	14.78	1.00	0.11	0.48	0.15	0.09
Clupeidae sp.	57.00	171.27	56.00	6.36	5.59	8.32	99.44
Engraulidae	250.00	439.35	145.00	27.90	14.34	21.55	910.06
Engraulis encrasicolus	250.00	439.35	145.00	27.90	14.34	21.55	910.06
Gobiidae	42.00	86.04	38.00	4.69	2.81	5.65	42.32
Aphia minuta	15.00	3.05	13.00	1.67	0.10	1.93	3.43
Gobius niger	6.00	21.99	5.00	0.67	0.72	0.74	1.03
*Oxyurichthys papuensis**	7.00	41.99	7.00	0.78	1.37	1.04	2.24
Gobiidae sp.	14.00	19.01	13.00	1.56	0.62	1.93	4.22
Leiognathidae	40.00	95.98	35.00	4.46	3.13	5.20	39.51
*Equulites klunzingeri**	40.00	95.98	35.00	4.46	3.13	5.20	39.51
Mullidae	19.00	106.80	19.00	2.12	3.49	2.82	15.83
Mullus barbatus	2.00	8.34	2.00	0.22	0.27	0.30	0.15
Mullus surmuletus	1.00	29.38	1.00	0.11	0.96	0.15	0.16
*Upeneus molluccensis**	6.00	23.30	6.00	0.67	0.76	0.89	1.27
*Upeneus pori**	3.00	39.78	3.00	0.33	1.30	0.45	0.73
Mullidae sp.	7.00	6.00	7.00	0.78	0.20	1.04	1.02
Nemipteridae	1.00	31.97	1.00	0.11	1.04	0.15	0.17
*Nemipterus randalli**	1.00	31.97	1.00	0.11	1.04	0.15	0.17
Scombridae	13.00	32.30	12.00	1.45	1.05	1.78	4.47
Scomber colias	4.00	23.67	4.00	0.45	0.77	0.59	0.72
Scomber japonicus	5.00	5.66	4.00	0.56	0.18	0.59	0.44
Scombridae sp.	4.00	2.97	4.00	0.45	0.10	0.59	0.32
Sparidae	12.00	244.95	12.00	1.34	7.99	1.78	16.64
Diplodus annularis	1.00	12.92	1.00	0.11	0.42	0.15	0.08
Pagellus acarne	2.00	31.60	2.00	0.22	1.03	0.30	0.37
Pagellus erythrinus	5.00	108.35	5.00	0.56	3.54	0.74	3.04
Sparus aurata	1.00	45.47	1.00	0.11	1.48	0.15	0.24
Sparidae sp.	3.00	46.61	3.00	0.33	1.52	0.45	0.83
Synodontidae	3.00	24.59	3.00	0.33	0.80	0.45	0.51
*Saurida undosquamis**	3.00	24.59	3.00	0.33	0.80	0.45	0.51
Sphyraenidae	1.00	6.99	1.00	0.11	0.23	0.15	0.05
Sphyraena sp.	1.00	6.99	1.00	0.11	0.23	0.15	0.05
Other Teleosts	236.00	328.72	225.00	26.34	10.73	33.43	1239.22
Crustacean	42.00	15.63	41.00	4.69	0.51	6.09	31.66
Penaeidae	42.00	15.63	41.00	4.69	0.51	6.09	31.66
Penaeus kerathurus	2.00	3.17	2.00	0.22	0.10	0.30	0.10
Penaeidae sp.	40.00	12.46	39.00	4.46	0.41	5.79	28.23
Cephalopoda	1.00	1.58	1.00	0.11	0.05	0.15	0.02
Sepiidae	1.00	1.58	1.00	0.11	0.05	0.15	0.02
Sepia officinalis	1.00	1.58	1.00	0.11	0.05	0.15	0.02
Anthozoa	1.00	3.90	1.00	0.11	0.13	0.15	0.04
Pennatulidae	1.00	3.90	1.00	0.11	0.13	0.15	0.04
Pennatula phospherea	1.00	3.90	1.00	0.11	0.13	0.15	0.04
Algea	2.00	2.44	2.00	0.22	0.08	0.30	0.09

(*: Indopacific species)

Table 2. IRI value by months identified for the food groups

Feeding Groups	Months											
Teleost	1	2	3	4	5	6	7	8	9	10	11	12
Atherinidae				49.7								
Atherina sp.				49.7								
Bregmacerotidae							470.1	5.9				0.9
*Bregmaceros atlanticus**							470.1	5.9				0.9
Callionymidae	5.9											
*Callionymus filamentosus**	5.9											
Carangidae	802.2	34.6	14.9	21.3	80.7		21.8	21.6		42.9		
Caranx rhonchus	29.5			1.7								
Trachurus trachurus	301.3	15.7	2.3	10.9								
Trachurus mediterraneus							21.8	21.6				
Trachurus sp.	8.7		1.4									
Carangidae sp.	6.6	1.6	1.3		80.7					42.9		
Centracanthidae				1.9								
Spicara sp.				1.9								
Clupeidae	378.3	5003.4	986.1	3735.1	3125.6	847.5	337.0	1199.5	5740.3	1278.4	1906.5	453.4
*Dussumieria elopsoides**		1.9								7.1		
*Etrumeus teres**										25.9	296.6	19.1
*Herklotsichthys punctatus**	10.9							40.7				19.1
Sardinella aurita	251.3	2948.9	557.7	1141.9	2076.3	667.1	154.8	139.7	3900.9	316.7	306.6	53.8
Sardinella maderensis			1.9									
Sardina pilchardus												5.91
Clupeidae sp.		203.5	35.8	709.8	101.4	7.8	34.9	229.8	168.2	99.9	67.5	5.6
Engraulidae	5.5	23.1	1523.3	909.0	39.5	3655.1	15.1	1777.7				12091.2
Engraulis encrasicolus	5.5	23.1	1523.3	909.0	39.5	3655.1	15.1	1777.7				12091.2
Gobiidae	1152.5	7.9	48.4	9.5	38.4			6.6		2.5	143.4	82.1
Aphia minuta	179.2			9.5	5.9						42.4	0.8
Gobius niger	286.5											
*Oxyurichthys papuensis**	8.9	2.1	7.6		13.8					2.4	9.9	
Gobiidae sp.		1.9	13.6					6.6			4.7	66.5
Leiognathidae	20.1		7.0					47.9	953.6	1230.3	162.3	
*Equulites klunzingeri**	20.1		7.0					47.9	953.6	1230.3	162.3	
Mullidae			4.9	17.1			202.9	62.3	32.7	388.9	9.2	
Mullus barbatus								62.3				
Mullus surmuletus							87.4					
*Upeneus molluccensis**										122.2	9.2	
*Upeneus pori**			4.9						32.7	11.6		
Mullidae sp.				17.1			14.0			21.5		
Nemipteridae					14.8							
*Nemipterus randalli**					14.8							
Scombridae			1.3	39.5	67.8		33.2					4.5
Scomber colias					21.6		33.2					1.2
Scomber japonicus				39.5								
Scombridae sp.			1.3		12.3							1.0
Sparidae	65.7		35.6		28.8			106.3	36.1	14.8	260.1	
Diplodus annularis											18.9	
Pagellus acarne					5.2						32.6	
Pagellus erythrinus			12.7					106.3		14.8	35.2	
Sparus aurata	65.7											
Sparidae sp.			5.1		9.2				36.1			
Synodontidae				2.7		116.5		7.3				
*Saurida undosquamis**				2.7		116.5		7.3				
Sphyraenidae				4.7								
Sphyraena sp.				4.7								
Other Teleost	1223.8	2480.9	1513.1	1237.4	2797.3	2898.2	5897.3	1102.1	707.1	1076.9	822.1	
Decapoda												
Penaeidae	4.7	29.6	183.6	1.5	3.3			61.9	14.9	49.6	525.1	0.8
Penaeus kerathurus		1.4						10.0				
Penaeidae sp.	4.7	18.3	183.6	1.5	3.3			21.3	14.9	49.6	525.1	0.8
Cephalopoda												
Sepiidae					3.5							
Sepia officinalis					3.5							
Anthozoa												
Pennatulidae												2.1
Pennatula phospherea												2.1
Algea		1.2		2.3								

(*:Indopacific species)

1997; Carpentieri *et al*. 2005). Therefore, this argument can be considered providing further support to the hypothesis which connects the decrement of hake to the food competition with *Saurida undosquamis*.

The variations that *S. undosquamis* show according to the period, its sex and its length were studied, and it was determined that its feeding varies only according the period (P<0,01). The classification of the sex and length were not meaningful. The results obtained show that the indopacific and demersal species are frequent found only in October and November over twelve months, and the probability of the existence of other species in the stomach content never fell to 50% (P<0,05). In fact, the issue attracting attention in this subject is that *E. encrasicolus* was never found in September, October and November. When the whole year is considered, the most important species in the feeding of *S. undosquamis* is absent in the stomach content in the months mentioned, increasing the importance of the different species in these months. For instance, the relative significance of *E. klunzingeri* is higher compared to in the other months of the time course, and we found that the feeding option geographically differs native species to indopacific species and from the pelagic to the demersal in the habitat preference.

However, the main question is why the *Encrasicolus* individuals were not found in the stomach content during these three months. The fact that this species was not encountered in the subsequent three months and that *E. encrasicolus* was the most frequent species found in December, which follows those months, suggests that this species was not present in the environment from September through November. The situation may have changed depending on the migration of these species. However, clear knowledge regarding the migration of *E. encrasicolus* in this area of the Eastern Mediterranean does not exist.

Prey-Predator Length Relationship

The minimum, maximum and medium lengths of the prey are determined in the stomach content according to the length groups and are given in Table 3. The predator length increases as the prey length increases. Additionally, the mean prey length variation corresponding to the predator length group is statistically significant (P<0,01). When the difference among the predator length groups was investigated, it was determined that the first and second length groups were similar to each other, the third length group was different from the first two groups and the fourth one was distinct from all of the other groups (P<0,05). In fact, the increase of prey length with the predator length is an expected situation, and it has been assessed in many species (Keast and Webb, 1966; Popova, 1967; Nielsen, 1980; Persson, 1990; Juanes, 1994). Moreover, in other studies in which the stomach content of *S. undosquamis* was studied, the prey length increases with the predator length (Rao, 1981; Bingel, 1988).

The prey-predator length interval is enlarged with the increased predator length, as shown in Table 3. This case notes that there is an asymmetric distribution in the prey-predator length relationship. In other words, while the predator size increases, the upper bound of the prey size also increases and the lower bound of the prey size increases very little. The minimum prey lengths of the lengths groups were very close to each other. In spite of this, a constant increase in the maximum prey length of each length group is observed (Table 3). Correspondingly, Scharf *et al*. (2000) reported that the prey length interval increased with the predator length in 18 predator marine species. This case can be considered to be a feeding strategy. The prey-length interval that the small groups remained as part of the subgroup of the large predators was studied. This provides an advantage for large predators in the feeding competition.

Spawning Period

The variations of the GSI values of the *S. undosquamis* individuals, according to months, are shown in Figure 2, and those of the marine waters temperatures are shown in same figure. According to Figure 2, the GSI values increase from March and reach the highest level in June. There was a decrease in those values until November that was steep in the early periods. *S. undosquamis* has a very wide range of reproduction capacity considering this variation. Concerning the reproduction of *Saurida undosquamis* in Iskenderun Bay, Işmen (2003) states that *S. undosquamis* may have two main spawning periods in summer and autumn. In addition, mature eggs were observed in the gonads of the individuals throughout the year by İşmen (2003) Similarly, Özyurt (2003)

Table 3. The mean, maximum and minimum prey sizes and weights specified in the predator size group

Length Group (cm)	Med. Length Group (cm)	N	Prey Length (cm) Min.	Max.	Mean	Prey Weight (cm) Min.	Max.	Mean
13-18	15.5	32	3	9.7	6.43	0.25	6.02	2.07
18-23	20.5	80	3.2	14.3	7.86	0.31	20.57	4.40
23-28	25.5	31	4.4	17.7	10.35	0.49	31.51	10.37
28-33	30.5	9	8	21.2	14.20	1.28	65.45	26.77

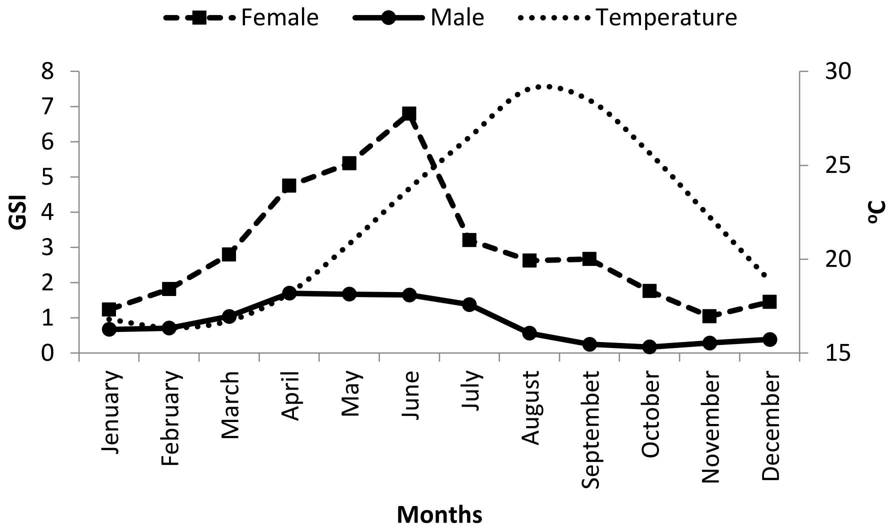

Figure 2. Changes in the GSI values and mean water temperature according to month.

studied the GSI variations of *S. undosquamis* and found that there are two main reproductive periods; one in the summer months and the other in the spring months. Mavruk (2015) observed that *S. undosquamis* larvae are present in the area throughout year however their abundance started to increase in April and reached the maximum levels between June and September. It is considered that, the monthly variation of the GSI values given in Figure 2 supports the Mavruk (2015)'s results.

When the term variation given in Figure 2 is taken into consideration, it is recognized that the level of reproductive activity differs according to the temperature. In the spring months, when the temperature increases, it inclines. The highest reproduction activity is observed in the period in which the term is the highest. These findings suggest that the reproductive activity changes depend upon the term rather than more than on one reproduction period.

The Relationship Between the Reproduction Period and the Feeding Concentration

Monthly variations of the GSI values, depending on the stomach fullness, are shown in Figure 3. This figure demonstrates that the stomach fullness rate constantly increases from January and reaches its highest value in April, declines in May and November and inclines steeply in December. In fact, the feeding concentration is related to the reproduction period. In many studies, the feeding concentration increases before and after the reproduction period (Sirotenko and Istomin, 1978; Argillier *et al.*, 2003; Jardas *et al.*, 2004) and decreases shortly before the spawning period (Jardas and Pallaoro, 1991; Dulcic, 1996; Fordham and Trippel, 1999; Jardas *et al.*, 2004). This situation is related to the fact that the gonads press the stomach as they enlarge and thus take up more space in the body (Golikatte and Bhat, 2011) and to the fact that physical variations occur in the fish during the reproductive period (Jardas *et al.*, 2004). The data obtained in this study note that the feeding concentration increases before the reproduction period, declines before spawning and increases again after that period. Therefore, a relationship between the feeding consideration and the reproduction period was detected in *S. undosquamis*.

Conclusion

The data obtained from the stomach content in this study reveal that the main feeding group of the *S. undosquamis* in İskenderun Bay are the teleost fishes. Among them Clupeiforms make the maximum contribution to the diet. Concerning the prey-predator relationship, the prey-length interval and the mean prey length increase as the predator length increases. The GSI variations show that the most concentrated reproduction activity occurs in the hottest period of the year. Furthermore, a negative correlation between the feeding concentration and the reproductive activity was determined.

Acknowledgments

This study was supported by United Nations Development Programme (UNDP MDGF) and Cukurova University Research Fund (BAP:SUF2012D3).

References

Argillier, C., Barral, M. and Irz, P. 2003. Growth and diet of the pikeperch *Sander lucioperca* (L.) in two French reservoirs. Archives of Polish Fisheries, 11: 99-114. doi: 10.2478/v10086-012-0024-0

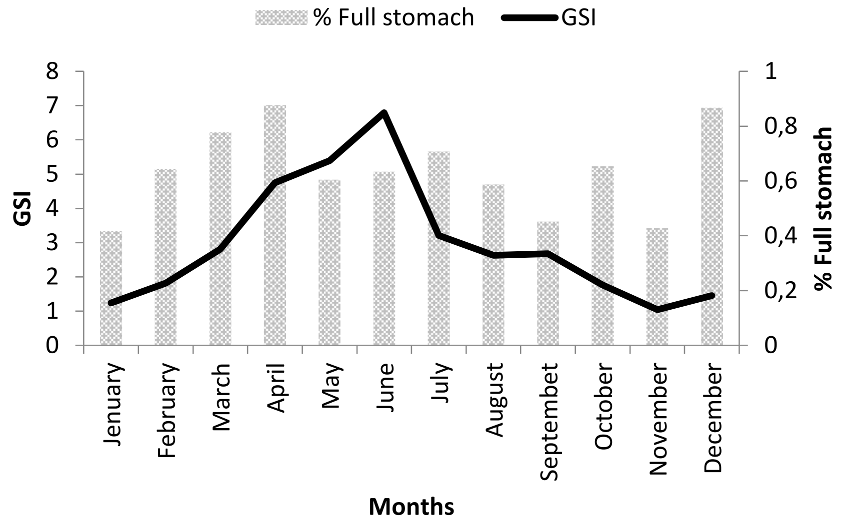

Figure 3. Stomach occupancy rates and changes in the GSI values.

Avşar, D. 1999. Yeni bir skifomedüz (*Rhopilema nomadica*)'ün dağılımı ile ilgili olarak Doğu Akdeniz'in fiziko-kimyasal özellikleri. Turkish Journal of Zoology, 23: 605–616.

Ben-Yami, M. and Glaser, T. 1974. The Invasion of *Saurida undosquamis* (Richardson) into the Levant Basin- An example of biological effect of interoceanic canals. Fishery Bulletin, 72: 359-373.

Bingel, F. 1988. Prey Size of *Saurida undosquamis* in the Northern Cilician Basin (Eastern Mediterranean). In: Rapports Et Proces – Verbaux Des Reunions. Condenses Des Travaux Presentes Lors Du XXXI Congres-Assemblee Pleniere 31 (2) V-II11, Athenes, CIESM, Monaco.

Bingel, F. and Avşar, D. 1988a. Food Items of *Saurida undosquamis* In: Rapports Et Proces – Verbaux Des Reunions. Condenses Des Travaux Presentes Lors Du XXXI Congres-Assemblee Pleniere 31 (2) V-II9, Athenes, CIESM, Monaco.

Bingel, F. and Avşar, D. 1988b. Time Series of the Stomach Fillings of *Saurida undosquamis* in the Northern Cilician Basin (Eastern Mediterranean). In: Rapports Et Proces – Verbaux Des Reunions. Condenses Des Travaux Presentes Lors Du XXXI Congres-Assemblee Pleniere 31 (2) V-II10, Athenes, CIESM, Monaco.

Bingel, F., Ozsoy, E. and Unluata, U. 1993. A review of the state of the fisheries and the environment of the Northeastern Mediterranean (Northern Levantine Basin). Studies and Reviews, GeneralFisheries Council for the Mediterranean. 65, Rome, FAO, 74 pp.

Bograd-Zismann, L. 1965. The food of *Saurida undosquamis* in the eastern Mediterranean in comparison with that in Japanese waters. Rapports Et Proces-Verbaux Reunions de la Commissions Internationnale pour Exploration de la Mer Mediterranee, 18: 251-252.

Bozzano, A., Recasens, L. and Sartor, P. 1997. Diet of the European hake *Merluccius merluccius* (Pisces: Merluciidae) in Western Mediterranean (Gulf of Lions). Scientia Marina, 61: 1-8.

Carpentieri, P., Colloca, F., Cardinale, M., Belluscio, A. and Ardizzone, G. D. 2005. Feeding habits of European hake (*Merluccius merluccius*) in the central Mediterranean Sea. Fishery Bulletin, 103: 411-416.

Chervinsky, J. 1959. A systematic and biological comparison between the lizardfish (*Saurida grandisquamis*) from the Mediterranean and the Red Sea. Fishermen's Bulletin, 19: 10-14.

Dulcic, J. 1996. Food and feeding habits of the damselfish, *Chromis chromis* (Teleostei: Pomacentidae) in the Eastern Adriatic. Annales for Istriani and Mediterranean Studies, 96: 31-38.

Euzen, O. 1989. Food habits and diet composition of some fishes of Kuwait. The Eight Shrimp and Fin Fisheries Management Workshop. Kuwait Bulletin of Marine Science, 10: 65-85.

Fordham, S.E. and Trippel, E.A. 1999. Feeding behaviour of cod (*Godus moruha*) in relation to spawning. Journal of Applied Ichthyology, 15: 1-9. doi: 10.1046/j.1439-0426.1999.00098.x

Gibson, R. N. and Ezzi, I. A. 1978. The biology of Scottish population of Fries' goby (*Lesueurigobius friesii)*. Journal of Fish Biology, 17: 371-389. doi: 10.1111/j.1095-8649.1978.tb04181.x

Golani, D. 1993. The biology of the Red Sea migrant, *Saurida undosquamis* in the Mediterranean and comparison with the indigenous confamilial *Synodus saurus* (Teleostei: Synodontidae). Hydrobiologia, 271: 109-117. doi: 10.1007/BF00007547

Golani D. 1998. Impact of Red Sea fish migrants through the Suez Canal on the aquatic environment of the eastern Mediterranean. Yale School of Forestry and Environmental Studies, 103: 375-387.

Golikatte, R.G. and Bhat, U.G. 2011. Food and feeding habits of the whipfin silver biddy *Gerres filamentotus* from Sharavati estuary, Central West Coast of India. World Journal of Science and Technology, 1: 29-33.

Gücü, A. C. 1995. A Box Model for the basic elements of northeastern Levant Sea (Mediterranean) trawl fisheries. Israel Journal of Zoology, 41, 551–568.

Gücü, A. C. 2000. Kuzeydoğu Akdeniz Balık Stokları -20 Yıllık Zaman Serisi-. I. Ulusal Deniz Bilimleri Konferansı. 30 Mayıs-2 Haziran 2000, 160-164.

Gücü, A. C. and Bingel, F. 1994. Trawlable species assemblages on the continental shelf of the

Northeastern Levant Sea (Mediterranean) with an emphasis on Lessepsian migration. Acta Adriatica, 35 (1/2): 83-100.

Gücü, A., Sakınan, S., Karakaş, E., Ok, M., Tüer, M., Yalçın, E., Örek, Y. and Bingel, F. 2011. Kuzeydoğu Akdeniz Küçük Pelajik Balık Stoklarındaki Değişimlerin Araştırılması. TÜBİTAK No.108O566, 166s.

Gücü, A. C. and Bingel, F. 2011. Hake, *Merluccius merluccius* L., in the northeastern Mediterranean Sea: a case of disappearance. Journal of Applied Ichthyology. 27: 1001–1012. doi: 10.1111/j.1439-0426.2011.01765.x

Hacunda, J. S. 1981. Trophic relationships demersal fishes in coastal area of the Gulf of Maine. Fisheries Bulletin, 79: 775-788.

Hadzley, H., Ibrahim, J. and Sallehudin, J. 2005. Feeding habits of five selected demersal fish species in coastal waters off east Johore. Malaysian Fisheries Journal, 4 (1): 1-12.

İbrahim, S., Muhammad, M., Ambak, M. A., Zakaria, M.Z., Mamat, A.S., İsa, M.M. and Hajisamae, S. 2003. Stomach contents of six commercially ımportant demersal fishes ın the south China Sea. Turkish Journal of Fisheries and Aquatic Sciences, 3: 11-15.

İşmen, A. 2003. Maturity and fecundity of Lizardfish (*Saurida undosquamis* Richardson, 1848) in İskenderun Bay (Eastern Mediterranean). Turkish Journal of Zoology, 27: 231-238.

Jardas, I. and Pallaoro, A. 1991. Food and feeding habits of black scorpionfish (*Scopaena porcus* L. 1758) (Pisces: Scorpaenidae) along the Adriatic coast. Acta Adriatica, 32: 885-888.

Jardas, I., Šantić, M. and Pallaoro, A. 2004. Diet composition and feeding intensity of horse mackerel, *Trachurus trachurus* (Osteichthyes: Carangidae) in the eastern Adriatic. Marine Biology, 144: 1051-1056. doi: 10.1007/s00227-003-1281-7

Juanes, F. 1994. What determines prey size selectivity in piscivorous fishes? In: D.J. Stouder, K.L. Fresh, R.J. Feller (Ed.). Theory and application in fish feeding ecology. Carolina University Press, Columbia: 79–100.

Juanes, F., Buckel, J.A. and Scharf, F.S. 2002. Feeding ecology of piscivorous fishes. In: P. Hart, J. Reynolds (Ed.). Handbook of Fish Biology and Fisheries. Vol. 1. Blackwell Publishing, Oxford: 267–284.

Kadharsha, K., Mohanchander, P., Lyla P.S. and Khan, S.A. 2013. Feding and reproduction biology of *Saurida undosquamis* (Richardson, 1848) from Parangipettai Coast, Southeast Coast of India. Pakistan Journal of Biological Sciences, 16 (22): 1479-1487.

Keast, A. and Webb, D. 1966. Mouth and body form relative to feeding ecology in the fish fauna of a small lake, Lake Opinicon, Ontario. Journal of the Fisheries Research Board of Canada, 23: 1845–1874.

Kosswig, C. 1953. Türkiye'de Balıkçılığın Bazı Biyolojik Veçheleri. Hidrobiologi Mecmuası Seri A, 1 (4): 145-153.

Mavruk, S. 2015. İskenderun Körfezi İhtiyoplanktonunun Zamansal ve Alansal Değişimi. PhD Thesis. Adana: University of Cukurova.

Nielsen, L. A. 1980. Effect of walleye (*Stizostedion vitreum vitreum*) predation on juvenile mortality and recruitment of yellow perch (*Perca flavescens*) in Oneida Lake, Canadian Journal of Fisheries Aquatic Sciences, 37: 11–19.

Özyurt, C.E. 2003. Babadıllimanı Koyunda (Silifke Mersin) Dip Trolü ile Avlanan Ekonomik Öneme Sahip Bazı Demersal Balık Türleri İçin Uygun Ağ Göz Genişliğinin Belirlenmesi. PhD Thesis. Adana: University of Cukurova.

Perker, M., Özyurt, C.E., Kiyağa, V.B. and Mavruk, S. 2015. İskenderun Körfezi trol balıkçılığında lesepsiyen türlerin durumu. Ulusal Tarım Kongresi, 29-31 Ekim Afyonkarahisar.

Persson, L. 1990. Predicting ontogenetic niche shifts in the field: what can be gained by foraging theory? In: R.N. Hughes (Ed.). Behavioural mechanisms of food selection, Springer-Verlag, Berlin: 303–321.

Popova, O. A. 1967. The 'predator-prey' relationship among fish. In: S.D. Gerking (Ed.). The biological basis of freshwater fish production, Blackwell Scientific Publications, Oxford: 359–376.

Rajkumar, U., Sıvakami, S., Rao, K.N. and Kingsly, H.J. 2003. Lizardfish fishery, biology and population dynamics of *Saurida undosquamis* (Richardson) off Visakhapatnam. Indian Journal of Fisheries, 50 (2): 149-156.

Rao, K.V.S. 1981. Food and feeding of lizard fishes, *Saurida* spp. from north western part of Bay of Bengal. Indian Journal of Fisheries, 28: 47-64.

Scharf, F.S., Juanes, F. and Rountree, R.A. 2000. Predator size - prey size relationships of marine fish predators: interspecific variation and effects of ontogeny and body size on trophic-niche breadth. Marine Ecology Progress Series, 208: 229–248.

Sirotenko, M. and Istomin, A. 1978. Seasonal variotions in the feeding of the Black Sea *Trachurus mediterraneus ponticus* Aleev. Journal of Ichthyology, 18: 424-431.

Sulak, K.J. 1984. Synodontidae. In: P.J.P. Whitehead, M.L. Bauchot, J.C. Hureau, J. Nielsen, and E. Tortonese (Ed.). Fishes of The North-Eastern Atlantic and the Mediterranean, Vol. 1., UNESCO, Bungay, United Kingdom: 405-420.

Thangavelu, R., Anbarasu, M., Zala, M.S., Mohamed Koya, K., Sreenath, K.R., Suresh, K.M. and Shiju, P. 2012. Food and feeding habits of commercially ımportant demersal finfishes off Veraval coast. Indian Journal of Fisheries, 59 (4): 77-87.

Torcu, H. 1994. Akdeniz ve Güney Ege sahillerinde yayılış gösteren ındo-pasifik kökenli balık türleri ve *Upeneus mollucensis* (Bleeker, 1855) paşa barbunyası ile *Saurida undosquamis* (Richardson, 1848) ıskarmoz balığının biyolojisi ve ekolojisi üzerine araştırmalar . PhD Thesis. Konya: University of Selcuk.

Yamashita, Y., Mochizuki, K. and Piamthipmanus, M. 1991. Gut contents analysis of fishes sampled from the gulf of Thailand. Bullettin of the Japanese Society of Fish Oceanogrphy, 55 (3): 197-207.