



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

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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.undusquamis*'in beslenme özellikleri ve üreme döneminin belirlenmesi amacıyla gerçekleştirilmiştir. 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 konusuysa, Ekim ve Kasım aylarında demersal ve indopasifik 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

İskenderun 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 (Aşar, 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 piscivore fish in this biotope. Fish that feed in this way are at the top of the aquatic trophic 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 İskenderun Bay.

Little is known about the reproductive biology of *Saurida undosquamis* in İskenderun 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 İskenderun 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 İskenderun Bay between January and December 2010 (Figure 1). The İskenderun Bay which is located in northeast Mediterranean is of 65-km length, 35-km width and 2275 km² 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

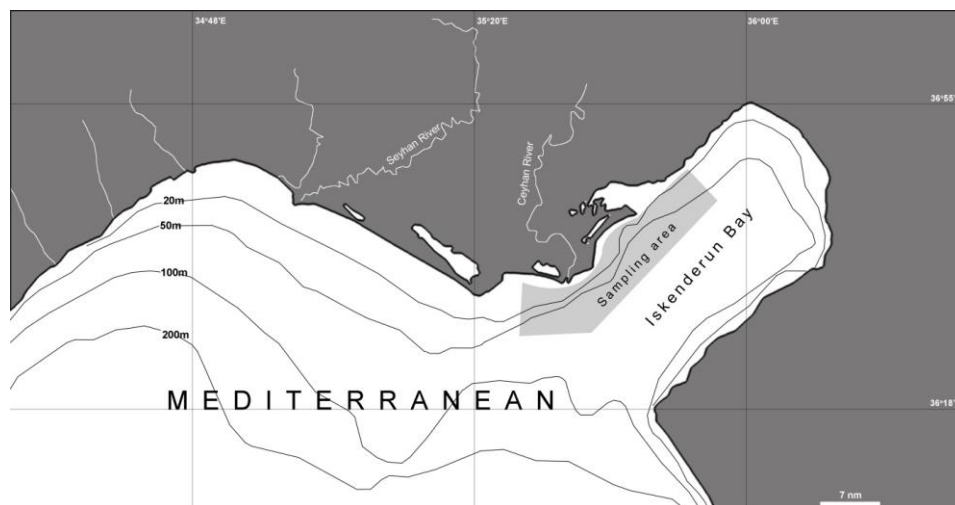


Figure 1. İskenderun Bay and the sampling area

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:

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

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; $e \sim N(0, \sigma^2)$

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*, *Equulites 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 *Bregmacerostridae* 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 *Clupeidae* 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 (mile²). 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
<i>Atherina sp.</i>	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
<i>Bregmaceros atlanticus*</i>	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
<i>Callionymus filamentosus*</i>	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
<i>Caranx rhonchus</i>	3.00	4.54	3.00	0.33	0.15	0.45	0.22
<i>Trachurus trachurus</i>	10.00	88.51	10.00	1.12	2.89	1.49	5.95
<i>Trachurus mediterraneus</i>	2.00	11.14	2.00	0.22	0.36	0.30	0.17
<i>Trachurus sp.</i>	2.00	4.59	2.00	0.22	0.15	0.30	0.11
<i>Carangidae sp.</i>	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
<i>Spicara sp.</i>	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
<i>Dussumieria elopsoides*</i>	2.00	9.97	2.00	0.22	0.33	0.30	0.16
<i>Etrumeus teres*</i>	8.00	85.23	8.00	0.89	2.78	1.19	4.37
<i>Herklotsichthys punctatus*</i>	4.00	42.13	4.00	0.45	1.37	0.59	1.08
<i>Sardinella aurita</i>	118.00	1137.98	112.00	13.17	37.14	16.64	837.18
<i>Sardinella maderensis</i>	1.00	3.92	1.00	0.11	0.13	0.15	0.04
<i>Sardina pilchardus</i>	1.00	14.78	1.00	0.11	0.48	0.15	0.09
<i>Clupeidae sp.</i>	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
<i>Engraulis encrasicolus</i>	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
<i>Aphia minuta</i>	15.00	3.05	13.00	1.67	0.10	1.93	3.43
<i>Gobius niger</i>	6.00	21.99	5.00	0.67	0.72	0.74	1.03
<i>Oxyurichthys papuensis*</i>	7.00	41.99	7.00	0.78	1.37	1.04	2.24
<i>Gobiidae sp.</i>	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
<i>Equulites klunzingeri*</i>	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
<i>Mullus barbatus</i>	2.00	8.34	2.00	0.22	0.27	0.30	0.15
<i>Mullus surmuletus</i>	1.00	29.38	1.00	0.11	0.96	0.15	0.16
<i>Upeneus molluccensis*</i>	6.00	23.30	6.00	0.67	0.76	0.89	1.27
<i>Upeneus pori*</i>	3.00	39.78	3.00	0.33	1.30	0.45	0.73
<i>Mullidae sp.</i>	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
<i>Nemipterus randalli*</i>	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
<i>Scomber colias</i>	4.00	23.67	4.00	0.45	0.77	0.59	0.72
<i>Scomber japonicus</i>	5.00	5.66	4.00	0.56	0.18	0.59	0.44
<i>Scombridae sp.</i>	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
<i>Diplodus annularis</i>	1.00	12.92	1.00	0.11	0.42	0.15	0.08
<i>Pagellus acarne</i>	2.00	31.60	2.00	0.22	1.03	0.30	0.37
<i>Pagellus erythrinus</i>	5.00	108.35	5.00	0.56	3.54	0.74	3.04
<i>Sparus aurata</i>	1.00	45.47	1.00	0.11	1.48	0.15	0.24
<i>Sparidae sp.</i>	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
<i>Saurida undosquamis*</i>	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
<i>Sphyraena sp.</i>	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
<i>Penaeus kerathurus</i>	2.00	3.17	2.00	0.22	0.10	0.30	0.10
<i>Penaeidae sp.</i>	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
<i>Sepia officinalis</i>	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
<i>Pennatula phosphorea</i>	1.00	3.90	1.00	0.11	0.13	0.15	0.04
Algae	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											
	1	2	3	4	5	6	7	8	9	10	11	12
Teleost												
Atherinidae				49.7								
<i>Atherina sp.</i>				49.7								
Bregmacerotidae							470.1	5.9				0.9
<i>Bregmaceros atlanticus*</i>							470.1	5.9				0.9
Callionymidae	5.9											
<i>Callionymus filamentosus*</i>	5.9											
Carangidae	802.2	34.6	14.9	21.3	80.7		21.8	21.6		42.9		
<i>Caranx rhonchus</i>	29.5			1.7								
<i>Trachurus trachurus</i>	301.3	15.7	2.3	10.9								
<i>Trachurus mediterraneus</i>							21.8	21.6				
<i>Trachurus sp.</i>	8.7		1.4									
<i>Carangidae sp.</i>	6.6	1.6	1.3		80.7					42.9		
Centracanthidae				1.9								
<i>Spicara sp.</i>				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
<i>Dussumieria elopsoides*</i>		1.9								7.1		
<i>Etrumeus teres*</i>										25.9	296.6	19.1
<i>Herklotsichthys punctatus*</i>	10.9							40.7				19.1
<i>Sardinella aurita</i>	251.3	2948.9	557.7	1141.9	2076.3	667.1	154.8	139.7	3900.9	316.7	306.6	53.8
<i>Sardinella maderensis</i>			1.9									
<i>Sardina pilchardus</i>												5.91
<i>Clupeidae sp.</i>		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
<i>Engraulis encrasicolus</i>	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
<i>Aphia minuta</i>	179.2			9.5	5.9						42.4	0.8
<i>Gobius niger</i>	286.5											
<i>Oxyurichthys papuensis*</i>	8.9	2.1	7.6		13.8					2.4	9.9	
<i>Gobiidae sp.</i>		1.9	13.6					6.6			4.7	66.5
Leiognathidae	20.1		7.0					47.9	953.6	1230.3	162.3	
<i>Equulites klunzingeri*</i>	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	
<i>Mullus barbatus</i>								62.3				
<i>Mullus surmuletus</i>							87.4					
<i>Upeneus molluccensis*</i>										122.2	9.2	
<i>Upeneus pori*</i>			4.9						32.7	11.6		
<i>Mullidae sp.</i>				17.1			14.0			21.5		
Nemipteridae					14.8							
<i>Nemipterus randalli*</i>					14.8							
Scombridae			1.3	39.5	67.8		33.2					4.5
<i>Scomber colias</i>					21.6		33.2					1.2
<i>Scomber japonicus</i>				39.5								
<i>Scombridae sp.</i>												1.0
Sparidae	65.7		35.6		28.8			106.3	36.1	14.8	260.1	
<i>Diplodus annularis</i>											18.9	
<i>Pagellus acarne</i>					5.2						32.6	
<i>Pagellus erythrinus</i>			12.7					106.3		14.8	35.2	
<i>Sparus aurata</i>	65.7											
<i>Sparidae sp.</i>			5.1		9.2				36.1			
Synodontidae				2.7		116.5		7.3				
<i>Saurida undosquamis*</i>				2.7		116.5		7.3				
Sphyraenidae				4.7								
<i>Sphyraena sp.</i>				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
<i>Penaeus kerathurus</i>		1.4						10.0				
<i>Penaeidae sp.</i>	4.7	18.3	183.6	1.5	3.3			21.3	14.9	49.6	525.1	0.8
Cephalopoda												
Sepiidae					3.5							
<i>Sepia officinalis</i>					3.5							
Anthozoa												
Pennatulidae												2.1
<i>Pennatula phosphorea</i>												2.1
Algae		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 to 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, İşmen (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)			Prey Weight (cm)		
			Min.	Max.	Mean	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

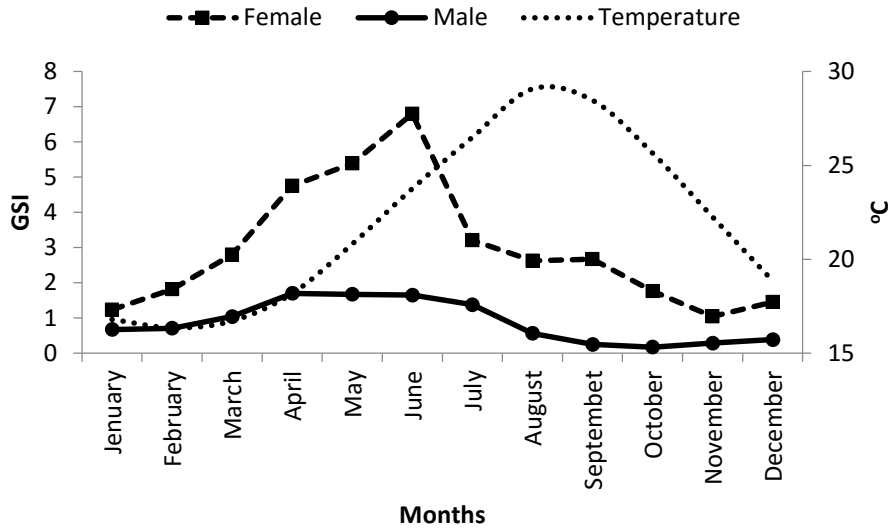


Figure 2. Changes in the GSI values and mean water temperature according to month.

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.

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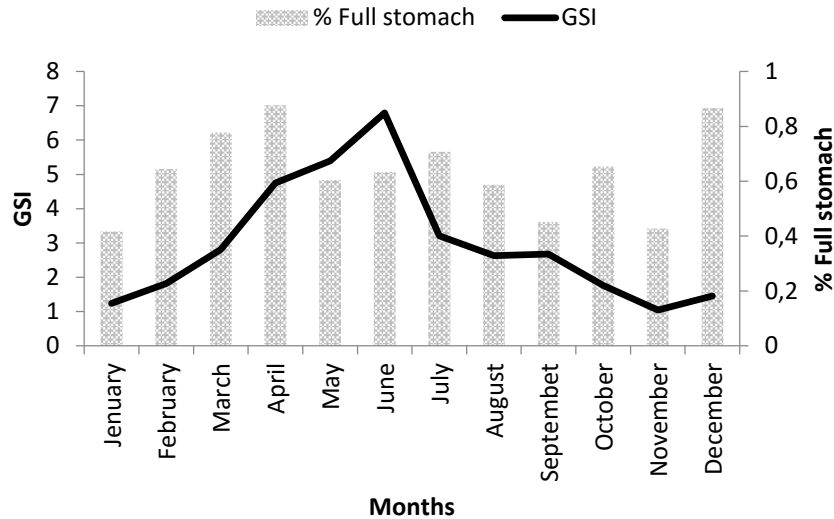


Figure 3. Stomach occupancy rates and changes in the GSI values.

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