International Journal of Fauna and Biological Studies
Available online at www.faunajournal.com

IJFBS International Journal of Fauna And Biological Studies

ISSN 2347-2677
IJFBS 2015; 2 (4): 38-42
Received: 21-05-2015
Accepted: 19-06-2015

Bahar Bayhan
Ege University, Faculty of Fisheries, Department of Hydrobiology, 35100 Bornova-Izmir/Turkey

Tuncay Murat Sever
Ege University, Faculty of Fisheries, Department of Hydrobiology, 35100 Bornova-Izmir/Turkey

Correspondence:
Bahar Bayhan
Ege University, Faculty of Fisheries, Department of Hydrobiology, 35100 Bornova-Izmir/Turkey

Feeding of the round sardinella *Sardinella aurita* Valenciennes, 1847 (Osteichthyes: Clupeidae) in the Turkish Aegean Sea

Bahar Bayhan, Tuncay Murat Sever

Abstract
The feeding of round sardinella, *Sardinella aurita*, was investigated in the Izmir Bay, central Aegean Sea of Turkey, during October 2010 - September 2011. Examined of the 434 stomach contents, 39 (9.0%) had emty. Most empty stomach were encountered during autumn (19.1%), followed by (8.0%) summer, winter (2.2%) and spring (2.0%). A total number of 14266 prey items and forty eight species were identified, belonging to six major groups: Polychaeta, Crustacea, Mollusca, Chaetognatha, Tunicate and Teleostei.
Finally crustaceans (particularly copepods) were the most important food item in terms of index of relative importance. At least 31 copepod species were identified, where Calanoida, *Oithona nana, Oncaea media* and *Oithona plumifera* appeared all year round with %IRI ≥ 10.

Keywords: *Sardinella aurita*, round sardinella, feeding habits, Izmir Bay, Aegean Sea

1. Introduction
Sardinella aurita, a round sardinella from Clupeidae family, is a pelagic fish found in tropical and temperate seas, just like other members of its family. Throughout the world, it is found in Mediterranean, rarely Black Sea, Atlantic and Western Pacific coasts from Japan to Philippines [1]. The species has a wide distribution and its contribution to Mediterranean and international fisheries production potential is high. Major fisheries off West Africa, in Mediterran and off Venezuela and Brazil, although catches not always distinguished from those of other *Sardinella* species (especially of *S. brasiliensis* western Atlantic). According to fisheries statistics from FAO, the annual production quantity of the species is usually about 400,000t, although it varies slightly [2].
In Turkey, this species has a wide distribution in the Mediterranean Sea and the Aegean Sea, on the other hand, it is rarely seen in the Black Sea and Marmara Sea. The Aegean Sea is the richest sea in Turkey that hosts approximately 449 fish species, in other words, 88% percent of Turkey's sea fish [3]. The Izmir Bay, which is located at the Aegean coast and has a length of 629 km, is one of the most fertile bay of Turkey in terms of fishing activities. It is the feeding and growth area of many fish species and also the main breeding area of this species [4, 5]. Round sardinella is generally caught in Turkish seas and usually marketed with other clupeid species, especially *Alosa* spp. Apart from its economic contribution to the world fisheries industry, the species has an important role in the food chain in regions it is found as it takes part in diet composition of its predators such as *Seriola dumerili* [6], *Coryphaena hippurus* [7] and *Merluccius merluccius* [8]. Therefore, the species is quite important in determination, conservation and management of feeding areas of fish species. Today, trophic levels are used in order to develop ecosystem based fisheries management strategies. Depending on the trophic controls forming upwards from the lowest level and downwards from the highest level of the food chain, long-term changes in fish stocks and leaps between low and high stock regimes can be identified [9]. The core of the ecosystem based fisheries management strategy is the knowledge that each living being has a function and a reason to exist in a specific environment. That is to say, species that could be considered as insignificant are in a tight relationship with each other in the food chain and keep the ecosystem, which we are a part of as well, healthy. In short, changes in the number, size or composition of species that make up a ring of the food chain due to any reason will affect all of the marine life and also the biosphere which it interacts with. Therefore, it is necessary to adopt rational and scientific approaches for sustainable use of marine resources. For this purpose, the feeding regime of the species outside our waters was studied by several researchers [10, 11, 12, 13, 14, 15, 16, 17, 18, 19]. Although food composition of the species has been comprehensively studied in various regions of the world

Seas, there is not a study conducted in the Aegean Sea of Turkey.

It is the purpose of our study to identify the most important food groups of the round sardinella and their seasonal variation. With this study, the feeding regime of round sardinella, which has an economic importance, was identified in detail for the Aegean Sea of Turkey for the first time. We hope that findings obtained as a result of this study will contribute to development of ecosystem based fisheries management strategies in Aegean Sea.

2. Material and Methods

Samples were obtained from commercial fishermen, who generally use purse seine and gill nets in Izmir Bay (coordinates between 38º22' N 26º40' E - 38º28' N 26º40' E and 38º28' N 26º46' E - 38º26' N 26º50' E), Turkish Aegean Sea, which consist of significant fishing grounds in central part of the Aegaen Sea concerned during October 2010 - September 2011.

A total of 434 *S. aurita* were collected all year round, with total lengths ranging 12.1 to 27.1 cm (110 in Autumn; 134 in Winter; 98 in Spring; 92 in Summer respectively). Fish were dissected immediately after capture, stomachs removed and stored in formalin (10%) until the contents were analysed. Stomach contents were homogenized in petri dishes, which were then examined using a SZX7 Olympus stereo microscope at 0.8-5.6x (zoom) and 10x resolution. Prey items were identified to the lowest possible taxon, except for Copepoda, where identification was made at the species or generic level. In case of digested copepods, identification was made from body parts following [20] and [21]. Once counted, the individuals of the same species were weighed together (wet weight to the nearest ±0.0001 g), after excess moisture was removed by blotting prey items on tissue paper. Following indices have been used to quantify the importance of different prey items in the diets of *S. aurita*:

(i) percentage frequency of occurrence (F%) for each prey groups computed separetly = the number of stomachs in which a food item was found is divided by the total number of non-empty stomachs, multipled by 100.

(ii) percentage numerical abundance (N%) = number of each prey item in all non-empty stomachs, divided by the total number of food items in all stomachs, multipled by 100.

(iii) percentage gravimetric composition (W%) = wet weight of each prey item, divided by the total weight of stomach contents, multiplied by 100 [22]. 0

The main food items were identified using the index of relative importance (IRI) of Pinkas *et al.* (1971): IRI = F% * (N% + W%); the index was expressed as: IRI% = (IRI / ∑ IRI) * 100. The percentage of empty stomachs to the total number of examined stomachs was expressed as the vacuity index (VI) by seasons. Vacuity index, VI% = 100 x (number of empty stomachs / number of examined stomachs) [23]. Also differences in the diet composition of the round sardinella were determined by the Bray–Curtis similarity index, using percentage IRI.

3. Results and Discussion

Of the 434 specimens of *S. aurita* examined, 39 (9.0%) had emty stomachs. Most empty stomach were encountered during autumn (19.1%), followed by (8.0%) summer, winter (2.2%) and spring (2.0%). Similarly, according to a study conducted by [14] in Greece's Northern Aegean Sea, the stomach fullness rate of the species was 72.5%, while the season with the highest rate of empty stomach was autumn (36.6%). As a result of a stomach content analysis of 400 *Sardinella aurita* individuals conducted in Port Sait coast located at Mediterranean shores of Egypt, [17] found that 27.3% of the examined stomachs were empty. Empty stomachs were more commonly found in the summer period, while no empty stomachs were found in spring period. Similarly, the lowest empty stomach rate was found in spring period in our study with 2.0%. However round sardinella displayed high vacuity index values, ranging from 64.3% in summer to 80.0% in autumn in the North Aegean Sea [18]. The stomachs of round sardinella only in March more than half contained food [19].

A total of 14266 prey items were determined. Summary statistics of examined stomachs of *Sardinella aurita* is shown Table 1. Frequency of occurrence, numerical abundance, gravimetric composition and index of relative importance values obtained in the study, in which six food groups were found including Polychaeta, Crustacea, Mollusca, Chaetognatha, Tunicate and Teleostei are as given in Table 2.

Table 1: Summary statistics of examined stomachs of *Sardinella aurita*

	Fish mean TL (cm)	Std. error (SE)	∑ number of prey items	∑ weight of prey items (g)	∑ number of stomachs examined	∑ number of empty stomachs
Autumn	19.64	0.214	654	7.2	110	26
Winter	17.28	0.110	4684	31.92	134	3
Spring	18.30	0.140	5670	43.68	98	2
Summer	17.75	0.194	3258	24.36	92	8
∑			14266	107.16	434	39

Table 2: Percentage numerical composition (N%), frequency of occurrence (F%), percentage gravimetric composition (W%) and percentage index of relative importance (%IRI) of main prey groups by seasons for *Sardinella aurita*

	Autumn, 2010				Winter, 2011				Spring, 2011				Summer, 2011			
Mean TL (cm)	**19.64**				**17.28**				**18.30**				**17.75**			
Std. Error (SE)	**0.214**				**0.110**				**0.140**				**0.194**			
Prey groups	**N%**	**F%**	**W%**	**IRI%**	**N%**	**F%**	**W%**	**IRI%**	**N%**	**F%**	**W%**	**IRI%**	**N%**	**F%**	**W%**	**IRI%**
Polychaeta	-	-	-	-	-	-	-	-	2.85	53.33	0.15	0.81	4.97	84.62	1.66	2.97
Crustacea	76.14	41.67	39.21	71.86	99.23	100.00	97.54	99.61	95.98	100.00	99.68	99.05	92.63	100.00	82.97	92.83
Mollusca	14.68	25.00	56.98	26.78	0.09	4.17	0.63	0.02	0.32	20.00	0.04	0.04	2.21	46.15	14.92	4.18
Chaetognatha	-	-	-	-	0.68	29.17	1.82	0.37	0.32	13.33	0.12	0.03	-	-	-	-
Tunicate	1.84	12.50	2.57	0.82	-	-	-	-	-	-	-	-	0.19	7.69	0.45	0.03
Teleostei	7.34	4.17	1.24	0.53	-	-	-	-	0.53	26.67	0.01	0.07	-	-	-	-

By means of numerical occurrence, there was a clear dominance of crustaceans all season. Similarly according to the %IRI, crustaceans were the most important prey group while other taxa, i.e. chaetognaths and teleost fishes, had less importance in the diet. Mollusca was present in the diet throughout the year, but the most remarkable quantity was only during autumn.

Among the crustaceans, copepods especially calanoids made the most important contribution to diet (IRI%=42.160), followed by polycheats (IRI%=3.778), cladoceran *Podon intermedius* (IRI%=1.171). Copepods were the primary food item in the diet, varying quantities between 0.001 and 42.160 of IRI% (Table 3).

Table 3: Feeding of round sardinella *Sardinella aurita* (N%:percentage numerical composition, F%: frequency of occurrence, W%: percentage gravimetric composition, IRI: index of relative importance, IRI%: percentage index of relative importance)

Prey groups	N%	F%	W%	IRI	IRI%
Polychaeta	1.927	35.185	9.853	414.457	3.783
Crustacea					
Copepoda					
Acartia clausi	4.031	46.296	3.597	353.185	3.224
Calanoida	24.866	98.148	22.189	4792.684	42.160
Candacia armata	0.428	11.111	0.382	9.002	0.082
Candacia simplex	0.107	3.704	0.096	0.750	0.007
Candacia spp.	0.178	9.259	0.159	3.126	0.029
Centropages kröyeri	0.214	5.556	0.191	2.250	0.021
Clausocalanus spp.	0.499	11.111	0.446	10.502	0.096
Clytemnestra rostrata	0.071	3.704	0.064	0.500	0.005
Copepoda nauplius	3.603	38.889	3.215	265.170	2.421
Corycaeus brehmi	0.428	9.259	0.382	7.501	0.068
Corycaeus typicus	2.854	20.370	2.547	110.019	1.004
Corycaeus sp.	0.036	1.852	0.032	0.125	0.001
Cyclopoida	0.036	1.852	0.032	0.125	0.001
Cymbulia sp.	0.036	1.852	0.032	0.125	0.001
Euterpina acutifrons	2.176	44,444	1.942	183.031	1.671
Farranula rostrata	6.993	33.333	6.240	441.074	4.026
Isias clavipes	0.071	3.704	0.064	0.500	0.005
Lucicutia flavicornis	0.036	1.852	0.032	0.125	0.001
Oithona helgolandica	0.071	3.704	0.064	0.500	0.001
Oithona nana	15.519	55.556	13.848	1631.525	14.894
Oithona plumifera	10.061	55.556	8.978	1057.678	9.655
Oncaea media	12.522	50.000	11.174	1184.825	10.816
Oncaea mediterranea	0.428	9.259	0.382	7.501	0.068
Oncaea spp.	0.036	1.852	0.032	0.125	0.001
Harpacticoida	0.999	29.630	0.891	56.009	0.511
Microsetella norvegica	0.428	18.519	0.382	15.003	0.137
Microsetella rosea	0.071	1.852	0.064	0.250	0.002
Nannocalanus minor	0.036	1.852	0.032	0.125	0.001
Paracalanus parvus	1.213	20.370	1.082	46.758	0.427
Pleuromamma abdominalis	0.143	7.407	0.127	2.000	0.018
Temora stylifera	4.852	31.481	4.330	289.049	2.639
Cladocera					
Podon intermedius	1.570	29.630	2.760	128.280	1.171
Podon polyphemoides	0.107	5.556	0.188	1.640	0.015
Podon sp.	0.178	3.704	0.314	1.822	0.017
Isopoda	0.036	1.852	0.023	0.109	0.001
Decapoda uniden.	0.535	25.926	1.205	45.102	0.412
Brachyura	0.036	1.852	0.030	0.122	0.001
Cirripedia nauplius	0.143	5.556	0.122	1.469	0.013
Cypris larvae	0.107	5.556	0.001	0.603	0.006
Amphipoda	0.071	3.704	0.047	0.437	0.004
Mollusca					
Bivalvia	1.106	27.778	0.560	46.269	0.422
Pteropoda	0.107	1.852	0.720	1.531	0.014
Chaetognatha					
Sagitta spp.	0.285	12.963	0.110	5.129	0.047
Tunicate					
Salpa sp.	0.392	5.556	0.951	7.465	0.068
Appendicularia	0.107	3.704	0.016	0.454	0.004
Ascidiacea					
Ciona intestinalis	0.036	1.852	0.012	0.088	0.001
Teleostei					
Fish eggs and larvae	0.214	9.259	0.063	2.563	0.023

The Bray–Curtis similarity index (based on IRI% values) revealed that stomach content of the round sardinella was 99% similar between winter and spring, 93% similar between winter and summer and 72% similar between winter and autumn. The single-linkage dendrogram indicated a grouping between summer, spring and winter, whereas the autumn stands as a single second group (Fig. 1).

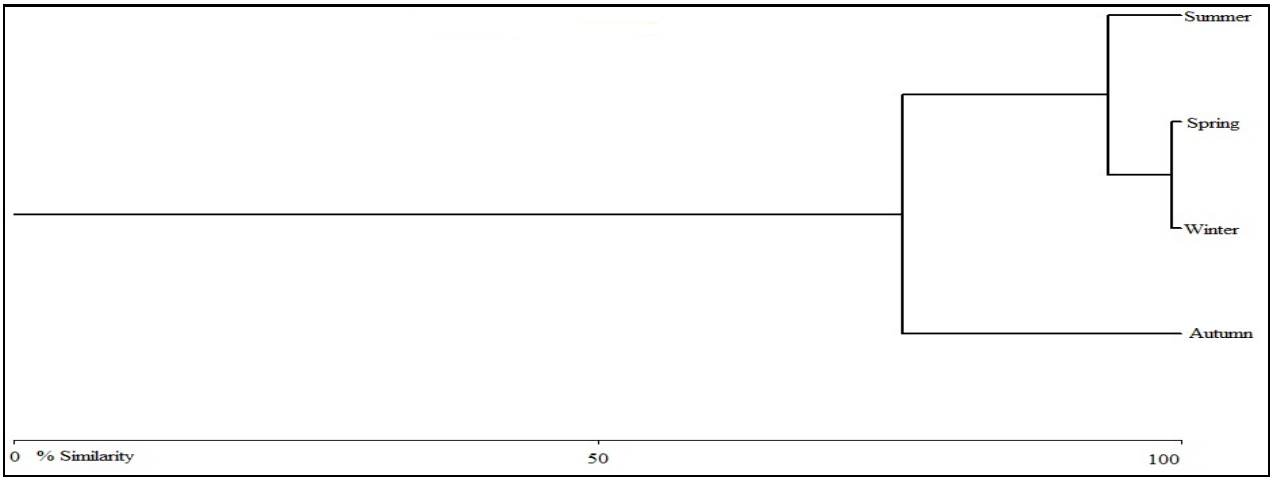

Fig 1: Dendrogram showing seasonal similarities in stomach contents of *Sardinella aurita* based on the Bray–Curtis index

The species found in Venezuela especially feeds on zooplankton (Planktonic copepods, mysid, cladocera, fish eggs and larvae), zoobenthos (ostracods and amphipods), phytoplankton (diatomeae, dinoflagellate) and other planktonic crustacea (*Lucifer* sp.) [10]. Similarly round sardinella feeds mainly on Copepoda and Appendicularia in the Canary Islands [11]. On a study conducted in Cape Hatteras region of the USA, it was found that the species fed on zooplankton. Especially planktonic copepods (calonioda) was preferred as the main food [12]. In their study in Columbia (La Guajira) [13] reported that the species mostly fed on zooplankton. Stomach contents of *Sardinella aurita* individuals examined in the Greece's Northern Aegean Sea [14]. While crustacea (copepods, amphipods, mysids, decapod larvae and others) made up the main food group; siphonophores, phytoplankton and fish larvae followed respectively. Copepods were the most abundant prey group in winter and spring, while decapod larvae and amphipods replaced copepods in summer and autumn. [15] studied the digestive system content of the species in the Sicily coast located at middle Mediterranean. Stomach content analyses showed that the species mainly fed on crustacea, especially copepods. In a study in which 63 prey groups were identified, copepods was in the first place in terms of quantitative abundance. First study of the larval feeding regime of the species found in the North-Western Mediterranean [16]**.** In this study, the selectivity was tried to identified by sampling plankton in the environment together with the diet composition of the species. According to study results, individuals usually fed throughout the day and the food was mainly copepods (nauplii and postnauplii) and cladocera (*Evadne* spp.). Zooplankton makes up 50.1%, phytoplankton makes up 34% and detritus makes up 15.9% of the preys that the species found in Port Sait coast located at Mediterranean shores of Egypt fed on [17]. The analysis of the stomach contents revealed 31 different food items, and Copepoda had the highest prey of round sardinella distrubuting in the North Aegean Sea [18].

Both in our study and other studies in which the digestive system content of *S. aurita* species was identified, it was seen that the species mainly fed on crustacean, especially copepods. It was found that our findings were similar to studies conducted in Venezuela [10]; Canary Islands [11], USA [12], Columbia (La Guajira) [13], Greece's Northern Aegean coast [14, 18], Sicily coast of the Mediterranean [15] and the NW Mediterranean [16]. However, the species found in Egypt coasts of the Mediterranean and in waters of Mauritania showed a difference in that its digestive system contained 15.9% detritus [17] and detritus–algal units compose [19] respectively.

4. Conclusion

Data on feeding habits in aquatic ecosystems are of great importance in determining the role that a certain fish species plays in its habitat and in related ecosystems. Nowadays, trophic levels are used in order to develop ecosystem based fisheries management strategies. Depending on the trophic controls forming upwards from the lowest level and downwards from the highest level of the food chain, long-term changes in fish stocks and leaps between low and high stock regimes can be identified [9]. There are no studies on the diet composition of the *Sardinella aurita* from the Aegean Sea coast. In this study, feding habits of the round sardinella were observed. We hope that this findings of study will contribute to development of management strategies of this species, which has economic value for the Aegean Sea coast of Turkey.

5. Acknowledgements

This study was supported by Ege University Scientific Research project (BAP Number: 2010-SUF-020), Izmir, Turkey.

6. References

1. Whitehead PJP, Bauchot ML, Hureau JC, Nielsen J, Tortonese E *et al*. Fishes of the North-eastern Atlantic and the Mediterranean. Clupeidae (eds. Whitehead PJP) Unesco, Paris 1984; I:268-281.
2. Fao. The State of World Fisheries and Aquaculture. - Rome, Italy, 2012; 230.
3. Bilecenoğlu M, Kaya M, Cihangir B, Çiçek E. An updated checklist of the marine fishes of Turkey. - Turkish Journal of Zoology 2014; 38:901-929.

4. Hoşsucu B, Mater S. Researches on bio-ecology of eggs and larvae of gilt (*Sardinella aurita* V., 1847) in Izmir Bay (Aegean Sea, Turkey). - Ege Journal of Fisheries and Aquatic Sciences 1995; 12:109-115.
5. Mater S, Bayhan B, Sever TM. Investigations on the growth and condition factor of the round sardinella (*Sardinella aurita* Valenciennes, 1847) distributed in the Bay of Izmir (Aegean Sea). - Ege Journal of Fisheries and Aquatic Sciences 2003; 20(1-2):111-119.
6. Pipitone C, Andaloro F. Food and feeding habits of juvenile greater amberjack, *Seriola dumerili* (Osteichthyes, Carangidae) in inshore waters of the central Mediterranean Sea. - Cybium 1995; 19(3):305-310.
7. Palko BJ, Beardsley GL, Richards WJ. Synopsis of the biological data on dolphin-fishes, *Coryphaena hippurus* Linnaeus and *Coryphaena equiselis* Linnaeus. FAO Fish. Synop. (130); - NOAA Technical Report. NMFS Circ. (443), 1982.
8. Cartes JE, Rey J, Lloris D, Sola G. Influence of environmental variables on the feeding and diet of European hake (*Merluccius merluccius*) on the Mediterranean Iberian coasts. - Journal of the Marine Biological Association of the UK 2004; 84(4):831-835.
9. Daskalov GM. Overfishing drives a trophic cascade in the Black Sea. - Marine Ecology Progress Series 2002; 225:53-63.
10. Rincon MC, Huq MF, Ramirez-Arredondo I. Aspectos alimenticios de la sardina, *Sardinella aurita* Valenciennes, 1847 (Pisces: Clupeidae) de los alrededores de la region noroccidental de la Peninsula de Araya y alrededores de las Islas de Coche y Cubagua, Venezuela. - Bol. Inst. Oceanogr. Venezuela, Univ. Oriente 1988; 27(1-2):129-143.
11. Moreno T, Castro JJ. Community structure of the juvenile of coastal pelagic fish species in the Canary Islands waters. - Scientia Marina 1995; 59:405-413.
12. Bowman RE, Stillwell CE, Michaels WL, Grosslein MD. Food of Northwest Atlantic Fishes and Two Common Species of Squid. - NOAA Technical Memoranda NMFS-NE 2000; 155:138.
13. Gómez-Canchong PL, Manjarrés M, Duarte LO, Altamar J. Atlas Pesquero del Area Norte del Mar Caribe de Colombia. - Universidad del Magadalena. Santa Marta 2004; 230.
14. Tsikliras CA, Torre M, Stergiou KI. Feeding Habits and Trophic Level of Round Sardinella (*Sardinella aurita*) in The Northeastern Mediterranean (Aegean Sea, Greece). - Journal of Biological Research 2005; 3:67-75.
15. Lomiri S, Scacco U, Mostarda E, Andaloro F. Size-related and Temporal Variation in The Diet of The Round Sardinella, *Sardinella aurita* (Valenciennes, 1847), in the Central Mediterranean Sea. - Journal of Applied Ichthyology 2008; 24(5):539-545.
16. Morote E, Olivar MP, Villate F, Uriarte I. Diet of round sardinella, *Sardinella aurita*, larvae in relation to plankton availability in the NW Mediterranean. - Journal of Plankton Research 2008; 30(7):807-816.
17. Madkour FF. Feeding ecology of The Round Sardinella, *Sardinella aurita* (Family: Clupeidae) in the Egyptian Mediterranean waters. - International Journal of Enviromental Science and Engineering 2011; 2:83-92.
18. Karachle PK, Stergiou KI. Feeding and ecomorphology of three clupeoids in the North Aegean Sea. - Mediterranean Marine Science 2014; 15(1):9-26.
19. Gushchin AV, Corten A. Feeding of pelagic fish in waters of Mauritania: 1. European anchovy *Engraulis encrasicolus*, European sardine *Sardina pilchardus*, round sardinella *Sardinella aurita*, and flat sardinella *S. maderensis*. - Journal of Ichthyology 2015; 55(1):77-85.
20. Rose M. Faune de France. - Copépods Pélagiques 1933; 26:374.
21. Brodskii KA. Calanoida of the Far Eastern Seas and Polar Basin of the USSR. Keys to the Fauna of the USSR. - Zoological Institute of the Academy of Sciences of the USSR 1967; 35:440.
22. Hyslop EJ. Stomach contents analysis - a review of methods and their application.- Journal of Fish Biology 1980; 17:411-429.
23. Berg J. Discussion of methods of investigating the food of fishes, with reference to a preliminary study of the food of *Gobiusculus flavescens* (Gobiidae). – Marine Biology 1979; 50:263-273.