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Feeding Regime of Whiting (*Gadus merlangus euxinus* Nordmann, 1840) In Turkish Middle Black Sea Coast

Serap Samsun[1,*], Yakup Erdem[2], Ferhat Kalayci[3]

[1] Ordu University, Fatsa Fisheries Faculty, Fatsa, Ordu, Turkey.
[2] Sinop University, Fisheries Faculty, Sinop, Turkey.
[3] Rize University, Fisheries Faculty, Rize, Turkey.

* Corresponding Author: Tel.: +90.452 4235053; Fax: +90.452 4239953;
E-mail: serapsamsun@hotmail.com

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Abstract

In this study, stomach contents of 716 whiting were examined caught from the Turkey Middle Black Sea Coast between December 2001 and April 2003. The analyses of feeding regime of whiting were made according to the seasons and age groups. The Frequency of Occurrence, The Numerical Occurrence Windell and Bowen (1978) and Geometric Index of Importance (GII) Assis (1996) methods were used.

Analysis of stomach contents showed that whiting feed on mainly the fishes and crustacean, mostly anchovy (*Engraulis encrasicolus*) with yearly find frequency as (%F) 23.04. The occurrence of the quantity and type of food items in the stomach was related to their seasonal abundance. It was observed that whiting consumed intensively during spring and summer. Anchovy as primarily prey; whiting, horse mackerel and shrimps as secondary prey; sprats and gobies as thirdly prey; pipefish and isopoda sp. as occasional prey were determined according to geometric index of importance (GII).

Keywords: *Gadus merlangus euxinus*, Whiting, Feeding Regime, Middle Black Sea.

Türkiye'nin Orta Karadeniz Kıyılarındaki Mezgit Balığının (*Gadus merlangus euxinus* Nordmann, 1840) Beslenme Rejimi

Özet

Bu çalışmada Aralık 2001- Nisan 2003 tarihleri arasında Türkiye'nin Orta Karadeniz kıyılarından avlanan 716 adet mezgit balığının mide içeriği incelenmiştir. Mezgit balığının beslenme rejimi incelemeleri yaşlara ve mevsimlere göre yapılmıştır. Bu incelemelerde Geometrik Önem İndeksi (GII) Assis (1996), Sayısal Varlık ve Bulunuş Frekansı Yöntemleri (Windell ve Bowen, 1978) kullanılmıştır.

Mide içeriği analizleri, mezgitin çoğunlukla balık ve kabuklularla, daha çokta yıllık bulunuş frekansı (%F) 23,04 olan hamsi (*Engraulis encrasicolus*) ile beslendiğini göstermiş, alınan besinlerin miktar ve çeşidinin, besin organizmalarının mevsimsel bolluğu ile ilişkili olduğu belirlenmiştir. Mezgitin yoğun olarak ilkbahar ve yaz aylarında beslendiği gözlenmiştir. Geometrik önem indeksi (GII)'ne göre hamsi birincil; mezgit, istavrit ve karides ikincil; kaya ve çaça üçüncül; deniz iğnesi ve isopoda türleri ise arasıra alınan diğer besin grupları şeklinde saptanmıştır.

Anahtar Kelimeler: *Gadus merlangus euxinus*, mezgit, beslenme rejimi, orta karadeniz.

Introduction

Whiting is semipelagic species that is preferred for consume cause of its white and tasty meat. According to 2009 year's statistics the total fish production of Turkey is 380.865 tonnes. In this production, after anchovy, horse mackerel and sardine, the whiting takes place in 5th rank with amount of 11,446 tonnes. The whiting is dominant species of Black Sea trawling. 80.6% of whiting is catched from Black Sea (TÜİK, 2010).

Beside commercial importance of fishes, ignored importance of the fishes is the importance of the food chain in ecosystem. As other living organisms, fishes need sufficient feeding for living, growing and reproducing. As other ecosystems, in aquatic ecosystem there are living groups which are responsible from primer, seconder and tertiary productivity. In this habitat, fish is important because of forming group of tertitary productivity. Many fishes are human nutrient on the other hand they are nutrient for other fishes and living organisms which are at the upper level (Bayhan *et al*., 2005).

Every fish species is a piece of ecosystem as all other living beings. In the food pyramid, that begins with phytoplanktons, ends with carnivores, the

whiting takes place at upper level as being carnivores. Adult individuals mostly eat other fishes and arthropods. In the other side, many predators as rough ray, starry sturgeon, other huge gadoids, piked dogfish, dolphin and seal feed with whiting fish.

Many researches show that whiting fish consumes many other fishes and species as food. Whiting incorporates its own species to its nutrition. Cannibalism is the general property of this fish family and it is determined that they completely feed with fishes (Bromley *et al*., 1993).

Researches from other countries' seas show that many fish which are not present in Black Sea, are took place in whiting's diet. But at our country's coasts there is not detailed information about fish species that whiting consumes. It is important determination of changes in nutrient composition that based on time, fish age, fish size and its sex and its effects on meat yield and fecundity of fish.

By this study, it is aimed to determine the nutrient composition of whiting. Thereby, this study has got an importance of being one of the first studies about this species which has important role in our country's and especially in Black Sea fishery.

Materials and Methods

Whiting fish samples which is the subject of the study are obtained from Middle Black Sea coasts (42°18′ N, 34°55′ E – 41°78′ N, 35°21 E) on the dates between December 2001- April 2003. The samples obtained by bottom trawl nets in free periods of trawling and in the inhibited times of trawling the samples are obtained by hook and deep net which intensely used for whiting catching.

The samples were taken to laboratory. Their total length (LT) is measured by milimetric divisioned fish measure block and the individual weight is measured by electronic weighing machine with 0.01 sensitivity. Digestive system of 716 fish was removed by scissor scissor (from oesophagus to anus) and kept in container with 5% formol.

The nutrient groups, that obtained from stomach, are classified as classis, ordo and family levels and the researches depended on ages and sesasons. The genus level numaration results of the livings that are received from stomach, are evaluated by the means in Lagler's formulas (1956),

The avarage numbers of organism found per individual fish = Total number of one genus org./Examined fish number

The percentage of availability frequency = (Number of fish of the one genus organism which found / Examined fish number) x 100

Numerical percentage = (Total number of one genus organism /Total number of all organisms) x 100

Geometric Index of Importance (GII) is used to in calculate whiting fish's nutrient types (Assis, 1996). The results obtained from stomach content analyses. The numerical percentage, percentage frequency of presence and stomach content's weigh results that obtained from stomach content analyses are used in this method. These results are evaluated individually for all groups and fish nutrient types are determined as order of importance.

For determining P value, which is using as a measure of nutrient importance for all prey, the used formulas are showed below (Assis, 1996).

$$|P_j| = \left[\sqrt{\sum_{i=1}^{n}(V_i)^2}\right]_j \quad \text{if formula generalized}$$

$$|P| = \sqrt{(V_i)^2 + (V_j)^2 + (V_k)^2}$$

which
|P| = Importance of nutrient
V_i = Numerical percentage of nutrient variety
V_j = The of availability frequency of nutrient variety
V_k = Stomach content weight

The formulas at below are used for obtaining GII value (Assis, 1996)

$$GII_j = \frac{\left[\sum_{i=1}^{n} V_i\right]_j}{\sqrt{n}} \quad \rangle \text{ if formula generalized}$$

$$GII = \frac{V_i + V_j + V_k}{\sqrt{n}} \text{ Formula obtained.}$$

which,
GII = Geomteric Index of Importance
V_i = Numerical percentage of nutrient variety
V_j = The percentage of availability frequency of nutrient variety
V_k = Stomach content weight
n = Number of category used

GII values, that obtained from results of stomach content analyse, assure showing of the nutrient types as modal on the graphics in order of importance. As the result, on this graph, it is possible to clasiffy the nutrient categories as preferred nutrient, secondary nutrient and occasionally consumed nutrient (Assis, 1996). Also the relation between fishes' length and feeding organisms' length-weight is investigated (Du Buit, 1996).

Results

General Nutrient Composition

For determination of organisms, that composes the nutrient composition of whiting, 716 fish is exampled and their stomach content is analyzed at

macroscobic base. The empty stomach content percentage is found as 57% (N: 408). The determined nutrient organisms of stomach is given in Table 1. 8 nutrient group determined at species and family level. Bony fishes (osteichthyes) contitute the large percentage of nutrient goups in number (Cn%) 82.97% and in weigh (Cw%) 93.64%. Crustaceans constitute the nutrient groups in number 10.22% and in weigh 3.07%. The percentage distribution of bony fishes are: anchovy (*Engraulis encrasicolus*) is 61.57%, horse mackerel (*Trachurus mediterraneus*) is 15.67%, whiting (*Gadus merlangus euxinus*) is 13.81%, goby (*Gobius spp*.) is 6.34%, sprat (*Spratus spratus*) is 1.87% and pipefish (*Syngnathus acus*) is 0.75%. The undefined nutrient groups take place in the nutrient groups as the percentage in number 6.81% and in weight 3.29%. The anchovy is the dominant species in all nutrient groups. The highest percentage frequency od presence is 23.04% for anchovy and the lowest is 0.42% for isopods.

Seasonal Changes of Nutrient Groups

Seasonal nutrient composition for whiting is given at Table 2 and Figure 1. In respect to frequency of occurance (F%), in numerical (Cn%) and in weight (Cw%) proportions, the anvhovy is the dominant species for all nutrient groups of stomach. The lowest and highest proportions are respectively determined as (F%) 12.78-32.26 (Cn%) 27.38-79.37 and (Cw%) 31.63-90.90. The horse mackerel and the whiting respectively follow anchovy, they also observed for all seasons. By means of weight (Cw) the whiting's values is higher than anchovy. Goby was observed in spring and summer, sprat in winter and pipefish in autumn. From Crustaceans, while shrimp was observed in all seasons, isopods were observed in spring and in summer.

Table 1. The number (Cn), weiğht (Cw) and percentage of availability frequency of the organisms encountered in stomach content of whitings indivuduals

Food Groups	Cn		Cw		%F
	N	N%	W	W%	
Bony fish (Osteichthyes)					
Anchovy (*Engraulis encrasicolus*)	165	51.08	388,218	55.01	23.04
Horse Mackerel (*Trachurus trachurus)*	42	13.00	95,789	13.57	5.87
Whiting (G. *merlangus euxinus)*					
Goby (*Gobius* sp.)	37	11.46	131,668	18.66	5.17
Sprat (*Sprattus sprattus)*	17	5.26	36,964	5.24	2.37
Pipe Fish (*Syngnathus acus)*	5	1.55	7,234	1.03	0.7
Crustaceans (Crustaceae)	2	0.62	0,905	0.13	0.28
Decapoda					
Shrimp (*Crancon crangon*)	30	9.29	17,464	2.47	4.19
İsopoda sp.	3	0.93	4,183	0.59	0.42
Food material can not be identified	22	6.81	23,266	3.30	3.07
Total	323	100	705,691		

Table 2. Seasonal Distribution of availability frequency (F%), numerical (Cn%) and weight (Cw%) proportions for the nutrient groups that were observed in whiting's stomach

Food Groups	Spring			Summer			Autumn			Winter		
	F	Cn	Cw	F	Cn	Cw	F	Cn	Cw	F	Cn	Cw
Bony Fish												
Anchovy	12.78	27.38	31.63	17.29	33.33	35.28	32.26	79.37	90.90	27.82	64.49	72.93
Horse Mackerel	11.11	25.00	28.15	1.50	2.90	2.71	0.65	1.59	1.02	6.85	16.82	17.12
Whiting Goby Sprat						40.79	0.64	1.59	3.73	0.40	0.93	2.07
Pipe Fish	8.33	17.86	24.78	15.04	28.99	13.07	1.29					
Crustaceans	3.33	7.14	6.76	8.27	15.94					2.02	4.67	3.73
(Crustaceae)							1.29	3.17	0.69			
Decapoda												
Shrimp												
İsopoda	4.44	11.9	3.09	2.26	5.80	1.79	5.81	14.29	3.67	2.42	6.54	1.66
Food material can not	0.56	1.19	0.62	1.50	2.90	1.64						
be identified	4.44	9.52	4.98	5.26	10.14	4.72				2.82	6.57	2.49
The number of stomach		180			133			155			248	
The number of emty stomach		96			64			92			141	

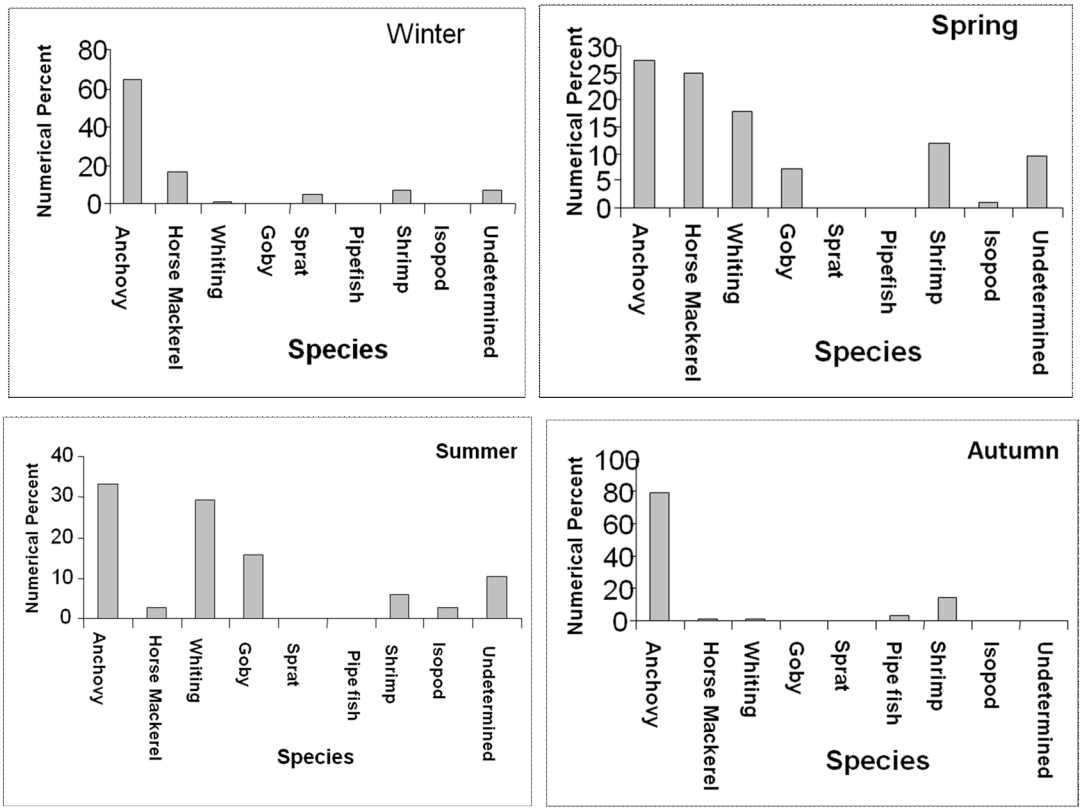

Figure 1. Stomach content of whiting according to seasons.

The Changement of Nutrient Groups According to Size

In distribution of organisms that presence in stomach content, the anchovy is the dominant species for all length groups, the horse mackerel follows this species. As anchovy, also horse mackerel is consumed by all size of whiting. The most consuming length group for anchovy and horse mackerel is 14-16 cm. Whiting and goby were mostly consumed by whitings that presence in length group between 16-18 cm. Sprat and pipefish were observed in fishes which are in small class. Beside the group larger than 22 cm, from crustaceans, the shrimp was observed in all length groups and mostly the 14-16 cm and 16-18 cm length groups' predators consumes shrimps (Table 3).

Relation Between Predator Length and Nutrient Length-Weight

Average prey length that calculated according to whiting's length group is given in Table 4 and Figure 2, 3. The stomach content analysis show that consumed smallest nutrient length is 2.5 cm and weight is 0.16 g, this nutrient was consumed by 16-18 cm length group. There is not linear correlation between length of fish and prey's length-weight. The minimum and maximum lengths of nutrient, that consumed by whitings in 12-14 cm, 14-16 cm, 16-18 cm, 18-20 cm, 20-22 cm and 22>cm length groups, are respectively expressed as 5.3-11.2 cm, 3.5-10 cm, 2.5-10 cm, 4.2-9 cm, 9-9.5 cm and 8-11.5 cm. As well as according to whitings' length group, there is not observed regular increase in prey lengths, generally the greater preys constitute the whitings'prey that are longer than 20 cm.

Evaluation of Nutrient Organisms according to Fish Ages

The anchovy constitutes the main nutrient of whiting. The age ratio of whiting, that consumes anchovy, are observed 48.48% 2 years-old, 27.88% 3 years old, 13.33% 4 years-old. The consumption percentage of other preys according to whiting age groups are determined as: horse mackerel 41.46% by 2 years-old, 29.27% by 3 years-old, 14.63% by 5 years-old whitings. Whiting was consumed with ratio 41.67% by 2 and 3 years-old whiting. Shrimp was consumed with ratio 40% by 3 years old, 30% by 2 years old, 20% by 4 years-old whitings. Goby consumed by 1–3 years old, sprat consumed by 2 and 3 years old whitings. 3 years-old whitings consumed isopods and 1-2 years old whitings consumed pipefishes.

Seasonal Geometric Index Averages of Nutrient Organisms

The seasonal GII values for spring, summer,

Table 3. The numerical (%Cn) and weight (%Cw) values of stomach content organisms according to length groups of whiting

Size (cm)	12-14		14-16		16-18		18-20		20-22		22>	
Food	Cn	Cw	Cn	Cw	Cn	Cw	Cn	Cw	Cn	Cw	Cn	Cw
Bony Fish												
Anchovy	76.9	87.59	54.55	59.91	38.38	33.56	62.86	71.57	33.33	35.4	37.5	62.46
Horse Mack.	7.69	7.56	14.69	15.54	9.09	11.02	2.86	7.43	25.00	11.37	62.5	37.54
Whiting			9.09	13.07	17.17	32.85	11.43	13.78	25.00	48.7		
Goby	3.85	1.57	2.1	3.19	13.15	13.29						
Sprat	3.85		2.8	1.99	1.01	0.35						
Pipe Fish		1.26	0.7	0.08								
Crustaceans												
Decapoda												
Shrimp	7.69	2.02	8.39	1.93	13.13	4.45	5.71	1.44	8.33	3.28		
İsopoda			0.7	0.53	1.01	0.61	2.86	1.66				
Can't be diag			6.99	3.75	7.07	3.87	11.43	4.11	8.33	1.25		

Table 4. The distribution of prey length and weight that measured during sampling period according to size groups of whiting

Size Groups	The average length of predator (cm)		The average length of prey (cm)		The average weight of prey (g)	
	L	N	PL	N	PW	N
12-14	13.53	26	8.08 (5.3-11.2)	11	2.76 (0.64-4.87)	11
14-16	14.12	143	7.31 (3.5-10)	63	3.02 (0.27-6.39)	63
16-18	15.85	99	6.73 (2.5-10)	35	2.85 (0.16-5.80)	35
18-20	16.64	35	6.63 (4.2-9.0)	7	3.00 (0.66-5.20)	7
20-22	19.28	12	9.25 (9.0-9.5)	2	5.44 (4.81-6.07)	2
22>	24.21	8	9.90 (8.0-11.5)	3	7.34 (5.03-9.80)	3

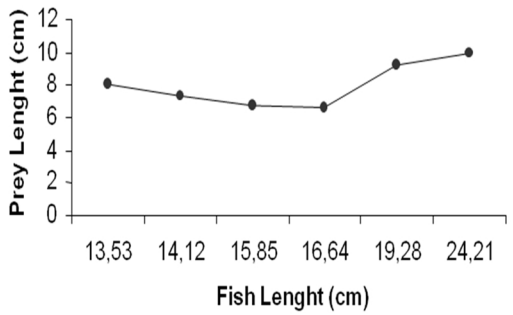

Figure 2. Fish length-prey length relationship.

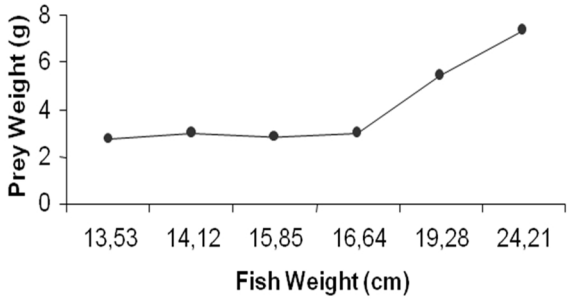

Figure 3. Fish weight-prey weigth relationship.

Table 5. Nutrient composition of whiting according to age

Age	Food Type							
	Anchovy Pieces-%	Horse Mackerel Pieces -%	Shrimp Pieces -%	Whiting Pieces -%	Goby Pieces -%	Sprat Pieces -%	Isopod Pieces -%	Pipe Fish Pieces -%
1	10-6.06	2-4.88	2 -6.67		1-5.88			1-50
2	80-48.48	17 -41.46	9 -30	15-41.67	5-29.41	2-40		1-50
3	46-27.88	12 -29.27	12 -40	15-41.67	11-64.71	3-60	2-66.67	
4	22-13.33	2 -4.88	6 -20	4-11.11			1-33.33	
5	6-3.64	6 -14.63	1 -3.33	2-5.56				
6	1-0.61	1 -2.44						
9		1 -2.44						

autumn and winter seasons are calculated and respectively expressed as: anchovy 15.16, 18.86, 40.29, 33.84, horse mackerel 13.71, 2.41, 1.27, 9.02, whiting 10.42, 16.85, 2.53, 1.89 (Table 6). GII values of goby in spring and summer are 4.49, 9.31, sprat in winter 2.88, pipefish in autumn 1.73. In crustaceans, GII values of shrimp for seasons spring, summer, autumn and winter are calculated and respectively expressed as 5.99, 3.13, 7.29 and 3.34. Isopods has GII values as 1.06 in spring, 2.07 in summer (Figure 4). The annual GII values of anchovy, horse mackerel, whiting, shrimp, goby sprat, isopods and pipefish are calculated and respectively exprssed as: 27.02, 7.47, 7.13, 4.97, 3.46, 1.31, 0.97 and 0.48. According to these datas, from the species those constitute whitings' prey, anchovy is classified as primer nutrient, horse mackerel, whiting and shrimp as seconder nutrient, goby, sprat as tertiary nutrient and isopods and pipefish as other groups (Figure 5).

Discussion

In stomach content researches, indicating the feeding situation of species doesn't have much mean. Instead of this, it is needed to determine the stomach content of species during the year (based on months and seasons). Thereby, in this study determination of seasonal feeding regime is preferred. Thus the study goes parallel with other studies, and ensures convenience for comparisons.

In research, the whiting's stomach content, that distributed in Middle Black Sea coast was analysed

Table 6. The annual and seasonal GII values of foods observed from whiting

Foods	Seasons				Annual average
	Spring	Summer	Autumn	Winter	
Anchovy	15.16	18.86	40.29	33.34	27.02
Horse Mackerel	13.71	2.41	1.27	9.02	7.47
Whiting	10.42	16.85	2.53	1.89	7.13
Shrimp	5.99	3.13	7.29	3.34	4.97
Goby	4.49	9.31	-	-	3.46
Sprat	-	-	-	2.88	1.31
İsopoda	1.06	2.07	-	-	0.97
Pipe Fish	-	-	1.73	-	0.48

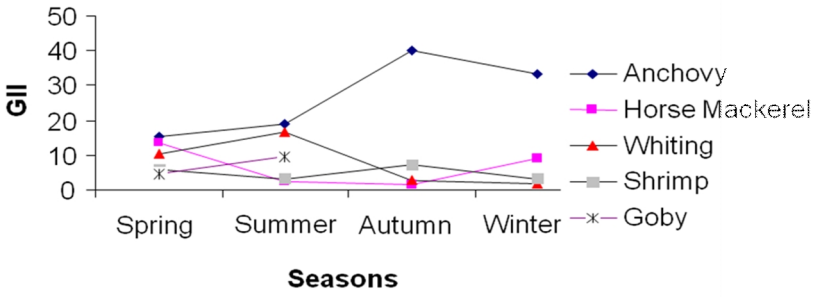

Figure 4. Seasonal GII values of whiting's nutrient.

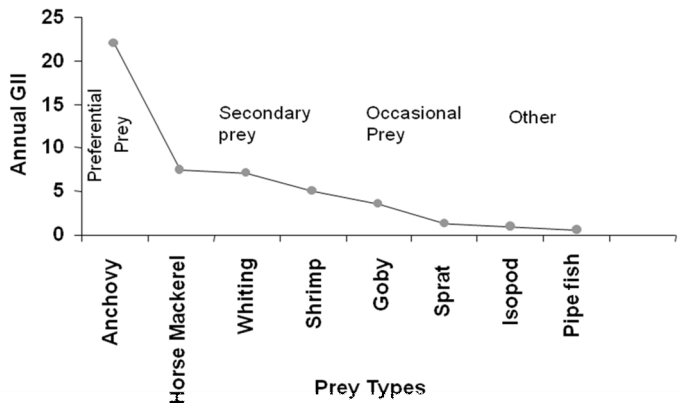

Figure 5. Annual GII values of whiting's nutrient.

by numerical and weight analyses and at the same time the type of feeding organisms and their consumption quantity were determined. According to stomach content analysis, the anchovy is the dominant feeding organism of whiting. In all feeding groups, anchovy constitutes numerical and in weight respectively 51.08% and 55.01% Crustaceans constitute 10.22% numerically and 3.07% in weight of nutrient groups. The distribution of bony fishes expressed as: anchovy 61.57%, horse mackerel 15.67%, whiting 13.81%, goby 6.34%, sprat 1.87% and pipefish 0.57%. İşmen (1995) expressed that in Turkish coasts of Black Sea the fishes and crustaceans are the main nutrients of whiting diet. While whiting size increases, the fish percentage of diet is also increases. Also İşmen (1995) expressed that whiting takes prey to stomach directly, this fish mainly prefers sprat and anchovy. These species generates shoal, also whiting and goby are the important preys that take part in diet. Hislop *et al*. (1983) expressed that in North Sea, fishes and crustaceans have got big ratio in whiting's nutrients, and with increment of predators' length in the fish ratio increases.

Whiting consumes preys from their own species, cannibalism is common in general of family. They nearly feed from fish, the whiting has multistage ovulation period during the year, the fry that comes towards the ovulation, are the nutrition sources for older fry (Bromley *et al*., 1997). Gordon (1977) expressed that in the diet of whiting the dominant crustacean species are Euphasid, Crangonidae; other from these species Copepod, Mysid and Amphipod are also determined. In this study, the shrimp that is the dominant crustacea species of whiting diet was observed for all seasons and also isopod was with less quantity.

Considering the seasonal distribution of nutrient species of whiting's stomach content, the feeding in spring and summer are numerically higher than the feeding in autumn and winter. Özdemir (1985), expressed that factors as seasonal changes, time, sunlight intensity, water temperature and metabolic acts are effective on feeding of fish species. Seyhan and Grove (1998) expressed that in Ireland Sea at August season when temperature raised to 18 °C the nutrition consumption of whiting is 60-80% higher than the nutrient consumption in February at temperature 7-8°C.

In this study further feeding amount in spring and summer seasons show that after reproduction period at the increase times of water temperature, feeding intensifies. Özdemir (1983), explained that fishes need less nutrient in winter, because in this season the water temperature decreases and for this reason the facilities of enzymes, that provide nutrient digestion, decrease. Larger *et al*. (1988) declerated that in higher water temperature times, fishes consume more nutrient, this arised from increment of digestion enzyme facility.

The anchovy is dominant in the seasonal nutrient composition in number and weight base. Its numerical ratios in spring, summer, autumn and winter seasons were respectively determined as 27.38%, 17.29%, 32.26% and 27.82%. The abundance of anchovy in sampling times and presence of it in summer is the reason of these results. The average water temperatures in spring and summer for years 1999, 2000, 2001 and 2002 are respectively expressed as 16.98±3.093°C, 16.02±2.911°C, 16.93±2.825°C and 15.75±2.740°C (Anemon, 2005). As seen from there, in year 2002, spring and summer seasons water temperatures were lower than the other years. For this reason, in Sinop coasts, the distributed anchovy shoals were observed by fishers. Arntz and Finger (1981) expressed that the seasonal changes in feeding intensity are related with feeding situations as water temperature, prey abundance, environmental factors. In summer, as numerical with 28.99% ratio whiting takes place after anchovy. As Patterson (1985), Bromley *et al*. (1997) and Singh-Renton and Bromley (1999) expressed, this shows whiting is opportunist predator and prefers its own species as nutrient.

In this study, the smallest length group, whose stomach content was searched, is 12-14 cm length group. For 14-16 cm and 16-18 cm length groups of predator nearly all nutrient groups were observed in their stomach content. In the groups bigger than 22 cm, from bonny fishes only anchovy and horse mackerel were determined. As being the nutrient of the whiting, the determined intense consumption percentages according to whiting ages are: anchovy 48.48% by 2-years-old, horse mackerel 41.16% by 2-years-old, whiting 41.67% by 2 and 3 –years-old, shrimp 40% by 3-years-old. For the other nutrients comsumption, goby by 3-years-old, sprat by 2 and 3-years-old, isopods by 3-years-old, pipefish by 1 and 2 years-old whitings. 2 and 3 –years-old whitings consume all the prey groups as nutrient.

Singh-Renton and Bromley (1999) expressed that crustacean is the main nutrient of little whiting, the percentages are 43–95% in number and 17-98% in weight. The percentages of fishes, which are seconder important prey, are 0.41% in number and 0.74% in weight. İşmen (1995) expressed percentage of whitings' nutrient kinds are: fishes 78%, crustacean 15.7% and polychaeta 3.8% in weight, the crustacean importance decreases with fish largeness.

In this study, pipefish and isopods are very less in number, and they were consumed respectively by whitings 1-2 years-old and 2-3 years-old. Shrimp was consumed by 1-5 age groups as well it was intensily consumed by whitings 2-3 years-old and 4- years-old. Anchovy, horse mackerel and whiting nearly consumed by all age groups. According to these datas, it is possible to think that according to age and size, the whiting (small than 22 cm) doesn't make choice between crustacean and fish preys. According to GII, it is determined that from nutrient groups, whiting

consumes anchovy as primer, horse mackerel, whiting and shrimp as seconder, goby and sprat tertiary and occasionally consumes other nutrient groups.

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