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Seasonal Food Composition and Prey-Length Relationship of Pipefish *Nerophis ophidion* (Linnaeus, 1758) Inhabiting the Aegean Sea

Sule GURKAN, Tuncay Murat SEVER and Ertan TASKAVAK*

Ege University, Faculty of Fisheries, Department of Hydrobiology, 35100 Izmir, Turkey

****Corresponding author, e-mail: ertan.taskavak @ege.edu.tr***

This study examined the gut content of 43 Nerophis ophidion *individuals obtained from Izmir Bay, Eastern Aegean Sea. A four season sampling process provided 7 groups of prey: Ostracoda, Amphipoda, Gastropoda, Cirripedia, Decapod crustacea, bentic Cinideria and Copepoda (Calanoid, Harpacticoid, Cyclopoid-Sapphirina sp.,* E. acutifrons *and Monstrilloid) Harpacticoid copepod, Cyclopoid copepod Cypris larvae and Ostracoda. Only 4 stomachs were empty. Gastropoda (9.47%), Amphipoda (37.22%) and Harpacticoid copepod (1.77%) are considered as dominant prey in the food composition of* N.ophidion*. On the other hand, Harpacticoid and Cyclopoid copepods are found in almost all sampling periods, and thus they are considered as major prey. Amphipoda was the most predominant prey in both spring (24.39%) and summer (12.82%), and Gastropoda (6.32%) in autumn. The presence of Harpacticoid copepods consumed by almost all lengths of fish indicates that their intake by pipefish derives from bentic vegetation rather than the water column. The ability to consume larger prey may be correlated with fish size. In our study, while larger* Nerophis ophidion *had an intake of relatively larger prey, they continued to catch smaller prey items as well. This result may imply that the bigger the fish in size, the more prey groups they could catch.*

Key words: food composition, *Nerophis ophidion,* pipefish, Aegean Sea

INTRODUCTION

Coastal waters are the most productive and biodiverse areas of the sea and it is believed that 90% of the global fish catch comes from coastal waters. Estuaries, lagoons and wetlands along coastal waters serve as nurseries for juvenile fish, crustaceans and molluscs, and are critical feeding areas and refuges for wildlife, fish and invertebrates. Members of the family Syngnathidae such as seahorses, seadragons and pipefish are important components of such habitats and inhabit sheltered areas, sea grass beds (HOWARD & KOEHN, 1985), sandy lagoons and brackish or freshwater habitats (LOURIE *et al.,* 1999; KUITER, 2000). These are also feeding and wintering zones for the family members (FRANZOI *et al.,* 1993).

Pipefish in coastal waters for their life cycle seem to have a specifid predator strategy known as “sit and wait” (HOWARD & KOEHN, 1985; STEFFE *et al.*, 1989) or “diurnal feeding process” (RYER & BOEHLERT, 1983). Wherever they inhabit, they can rapidly vacuum their prey (BRANCH, 1966; HOWARD & KOEHN, 1985; RYER & ORTH, 1987; RYER, 1988; GERKING, 1994) with their tiny mouths on the tubular snouts (NELSON, 1979; HYATT, 1979). The length of the tubular snout, which is supposed to function in catching prey, is highly diverse even among the Syngnathid species (KENDRICK & HYDNES, 2005; FLYNN & RITZ, 1999).

Studies on the feeding ecology of pipefish are limited to a few publications and these studies reported the groups of Amphipoda, Isopoda, Copepoda and small crustacea species (MERCER, 1973; HOWARD & KOEHN, 1985; RYER & ORTH, 1987; FRANZOI *et al.,* 1993) as foods for the family members. Studies on the feeding of the genus Nerophis reported that they feed on major prey groups such as Copepoda, Isopoda, Amphipoda and Gastropoda (*Hydrobia sp.*) (MARGONSKI, 1990; LYONS & DUNNE, 2004; GURKAN, 2004). However, studies on prey - fish length relationships and comprehensive feeding composition of this species in Mediterranean and Aegean coasts are quite scarce. In this study, we examined the feeding composition of 43 *Nerophis ophidion* specimens and determined the predominant prey groups in their diet, establishing the potential presence of a relationship between fish length and prey size.

MATERIAL AND METHODS

The 43 *Nerophis ophidion* specimens were caught by beach seine with 1 mm mesh size (120X1200 cm) in and round Camalti lagoon in Izmir Bay (Fig. 1). They were obtained from sand grounds covered with seagrass (mostly with *Cymadocae ulavecea*) at depths of not less than 1-1.5 m during four seasons. They were collected in the morning and evening, when sun light is most available, and preserved in solutions of 10% formaline. No anesthetic material was used, consequently both sampling size and duration were kept limited. The potential effect of the mesh size on fish length was ignored.

The total length (TL) of each *N. ophidion* was measured to the nearest millimeter and each individual was weighed to the nearest 0.01 g. Those fish caught to establish the relationship between fish length and prey groups were divided into 3 major length groups (75–134;

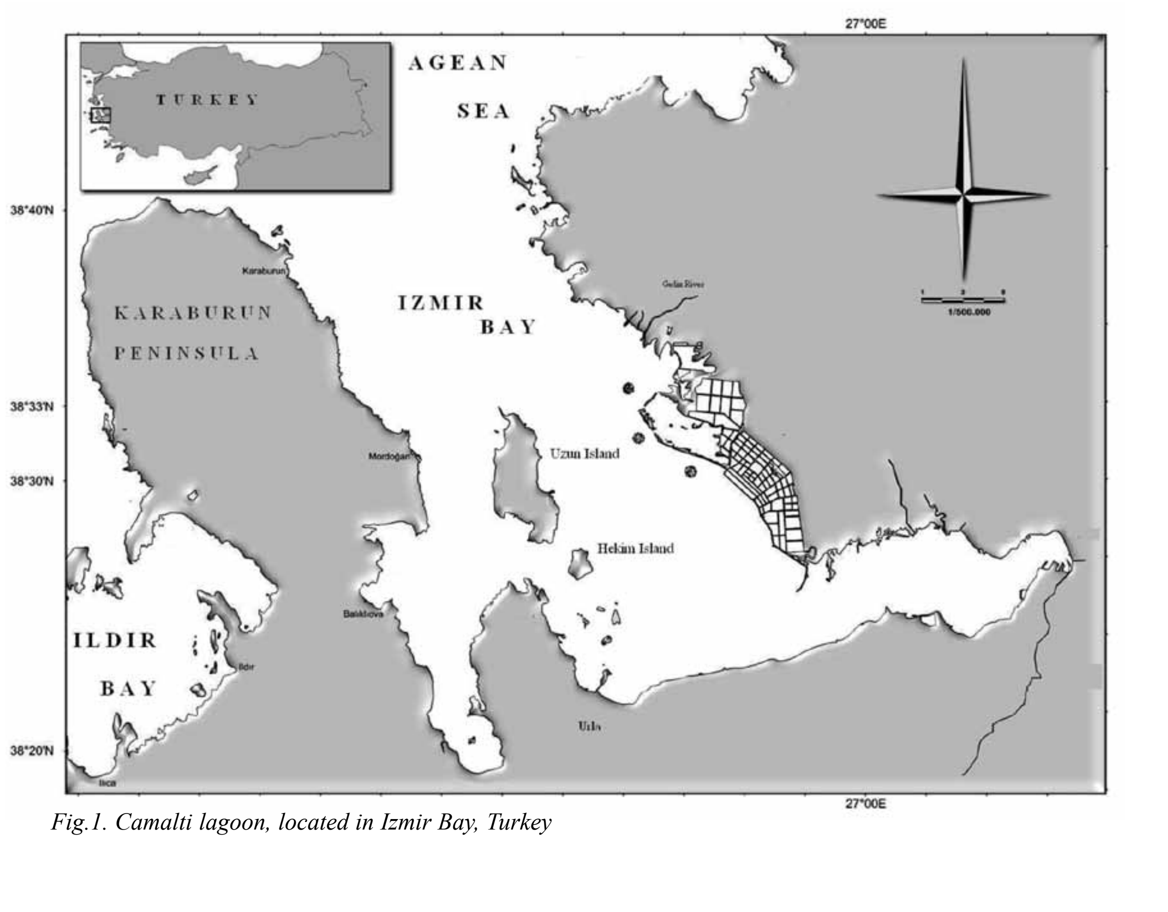


Fig.1. Camalti lagoon, located in Izmir Bay, Turkey

135–194; 195–254 mm). We did not take the sexes into consideration.

N. ophidion possesses a relatively undifferentiated gastrointestinal tract, and in order to avoid examination of digested food items, the anterior half of the gastrointestinal tract was defined as the gut. Consequently, the gut was dissected and examined under a microscope. The digestion system was excised using a dissection scissors. The excised stomachs were preserved in a solution of 4% formaline and examined in petri dishes under binocular microscope. Empty and full stomachs of the specimens were determined. Prey items in the stomach gut contents were tried to be identified to species level. Prey which could not be identified to species level were defined to genera and/or group level. The food items were counted and weighed to the nearest 0.0001g. Predominant preys in the gut contents were established. Relative weight of total gut content (W %) was evaluated by fish length groups and by the seasons concerned (PINKAS *et al.,* 1971; HYSLOP, 1980).

Lengths of Harpacticoid copepods, Cyclopoid copepods and other major food groups in *N. ophidion* diet were measured under the ocular micrometer of an Olympus SZ 60 binocular. A total of 41 Cyclopoid copepods were recovered from 13 stomachs and only 35 could be measured in length. A total of 143 Harpacticoid copepods were found in 26 of 43 stomachs, and a mere 110 were measured in length. Only 4 stomachs were observed to be empty. Prey pieces were ignored if they were too damaged to measure.

The lengths of predominant prey items (Cyclopoid and Harpacticoid copepods) were natural log transformed to achieve homogeneity of variance (SOKAL & ROHLF, 1969) and regression values of fish length (including predominant prey) were also determined. The results obtained were assessed by *t-test* (SOKAL & ROHLF, 1969).

RESULTS

In order to determine the feeding strategy of the species *N. ophidion,* the gut contents of 43 individuals captured were studied for four seasons, since no specimen was caught in August and September and only one individual, which had an empty stomach, was captured in December. Table 1 presents the gut contents of the samples and the related prey groups for four seasons. With length groups and seasons taken into consideration, the percentage distribution of dominant prey items within the food compositions of *N. ophidion* are given in Table 1 and Fig. 2. In lenght group I Gastropoda (9.47%), Amphipoda (37.22%) in length group II and Harpacticoid copepod (1.77%) in length group III were predominant prey items for the overall year (Fig. 2 and Table 1).

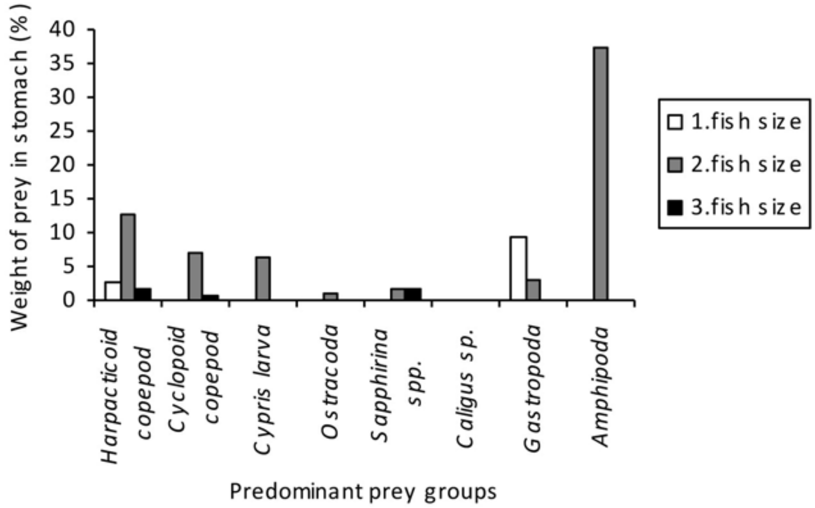


Fig. 2. Percentage weight distribution (%W) of predominant prey groups for fish sizes and four seasons

Table 1. Relative weight (%W) of prey groups in the stomach by season and by fish length group. (—: No fish samples in fish length. Fish length groups: I=75-134mm; II=135-194mm; III=195-254mm; T=Total)

	FOOD ITEMS	SEASONS				TOTAL
		WINTER	SPRING	SUMMER	AUTUMN	
LENGTH GROUP 1	Harpacticoid	0	0,0000544496	2,831377	0,000106177	2,831537256
	Cyclopoid	0	0	0,000229	0,000304917	0,000533606
	Ostracoda	0	0	0	0,0000680619	0,0000680619
	Cypris larva	0	0	0	0,0000462821	0,0000462821
	Dec.crus.yum	0	0,000171516	0	0	0,000171516
	Amphipoda	0	0	0	0	0
	Mostrilloid cop	0	0	0	0	0
	Parasitik cop	0	0	0,00043	0	0,000430151
	Caligus sp	0	0	0	0	0
	E.acutifrons	0	0	3,784244	0	3,784243765
	Sapphirina	0	0	0	0,0000490046	0,0000490046
	Gastropoda	0	0	3,158074	6,316147866	9,4742218
	Bentik cnideria	0	0	3,893143	0	3,893142866
	TOTAL	0	0,000225966	13,6675	6,316722309	19,98444431
		WINTER	SPRING	SUMMER	AUTUMN	
LENGTH GROUP 2	Harpacticoid	0,001026374	2,477454551	7,105666	3,185298708	12,76841961
	Cyclopoid	0,0000762294	5,336055956	0,000275	1,524587416	6,860918342
	Ostracoda	0	0,136123876	0,081674	0,680619382	0,898417584
	Cypris larva	0	0,92564236	0	5,553854158	6,479496518
	Amphipoda	0	24,39339866	12,82287	0	37,21626782
	Mostrilloid cop	0	2,749702304	0	0	2,749702304
	Parasitik cop	0	0	0	0	0
	Caligus sp	0	0	0	0,000563553	0,000563553
	E.acutifrons	0	0	3,784244	0	3,784243765
	Sapphirina	0	0	0	1,715160843	1,715160843
	Gastropoda	0	0	3,158074	0	3,158073933
	Bentik cnideria	0	0	0	0	0
	TOTAL	0,001102603	36,0183777	26,9528	12,66008406	75,63236687
		WINTER	SPRING	SUMMER	AUTUMN	
LENGTH GROUP 3	Harpacticoid	0	0	0,353922	1,415688315	1,769610394
	Cyclopoid	0	0	0,762294	0	0,762293708
	Ostracoda	0	0	0	0,136123876	0,136123876
	Cypris larva	0	0	0	0	0
	Amphipoda	0	0	0	0	0
	Mostrilloid cop	0	0	0	0	0
	Parasitik cop	0	0	0	0	0
	Caligus sp	0	0	0	0	0
	E.acutifrons	0	0	0	0	0
	Sapphirina	0	0	0	1,715160843	1,715160843
	Gastropoda	0	0	0	0	0
	Bentik cnideria	0	0	0	0	0
	TOTAL	0	0	1,116216	3,266973034	4,383188821

When we consider the food consumption for four seasons, the predominant prey group was Amphipoda in both spring (24.39%) and summer (12.82%). Cyclopoid copepod (5.34%) and Monstrilloid copepod (2.75%) followed Amphipoda in Spring, while Harpacticoid copepod (10.29%) and Gastropoda (6.32%) were second and third ranked prey items in summer, respectively (Table 1 and Fig. 3). In autumn, Gastropoda (6.32%) were the most dominant prey items, followed by Cypris larvae (5.55 %) and Harpacticoid copepod (4.60%), respectively (Table 1 and Fig.3). In winter, almost no food item was encountered in the dissected guts of *N. ophidion* except for only a few Harpacticoid and Cyclopoid copepods.

Regarding fish size Gastropoda (9.47%) were the dominant prey in length group I, followed by benthic Cinideria (3.89%) and *E. acutifrons* (3.78%) (Table 1 and Fig. 4a). Amphipoda (37.22%) were the most dominant prey items in length group II, while harpacti-

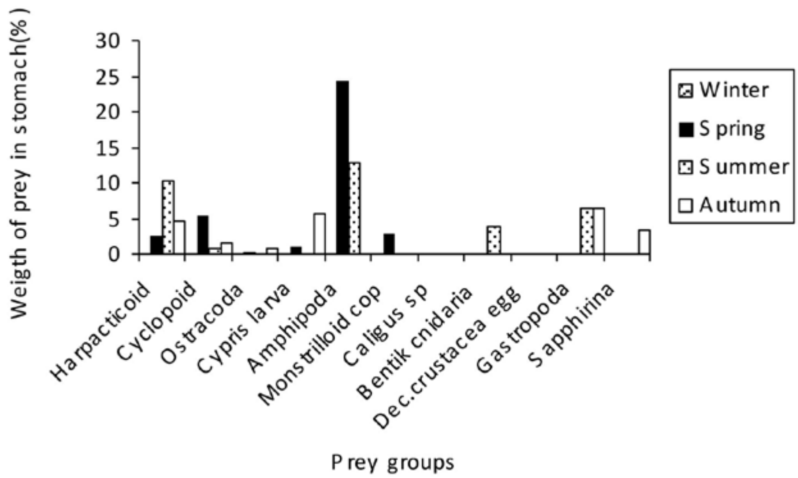


Fig. 3. Percentage weight distribution (%W) of predominant prey groups for seasonal consumptions

coid copepod (12.77%) and cyclopoid copepod (6.86%) were the second and third food items in gut contents (Table 1 and Fig. 4b). Harpacticoid copepod (1.77%), *Sapphirina* spp. (1.72%) and Cyclopoid copepod (0.76 %) were the first, second and third prey items in length group III (Table 1 and Fig 4c).

The ability to intake larger prey may be related to fish length. It was ontogenetically found that large-sized fish may intake *Sapphirina* spp which is larger and longer than Cyclopoid copepod. Regression results of two major prey groups, Harpacticoid copepod and Cyclopoid copepod, consumed by all length groups

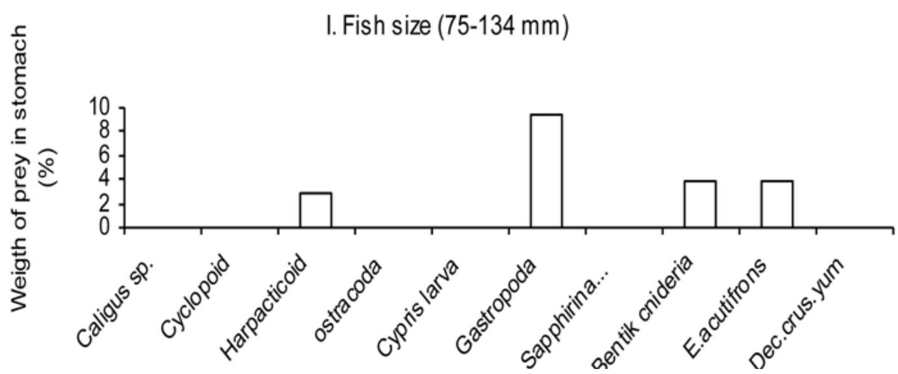


Fig. 4a. Percentage weight values vs. prey groups consumed by the 1st fish length group

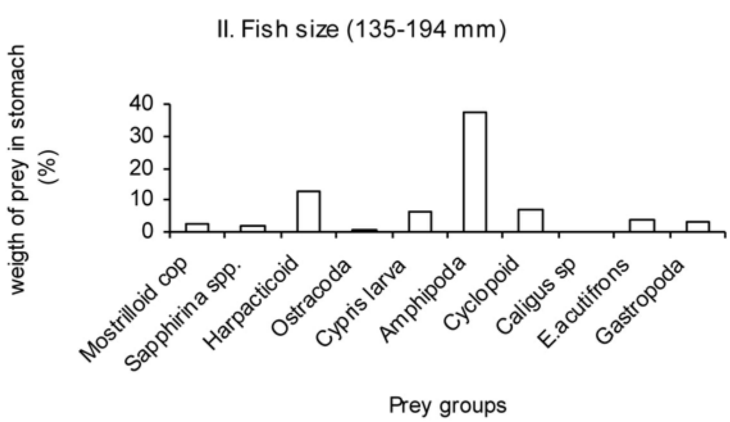


Fig.4b. Percentage weight values vs. prey groups consumed by the 2nd fish length group

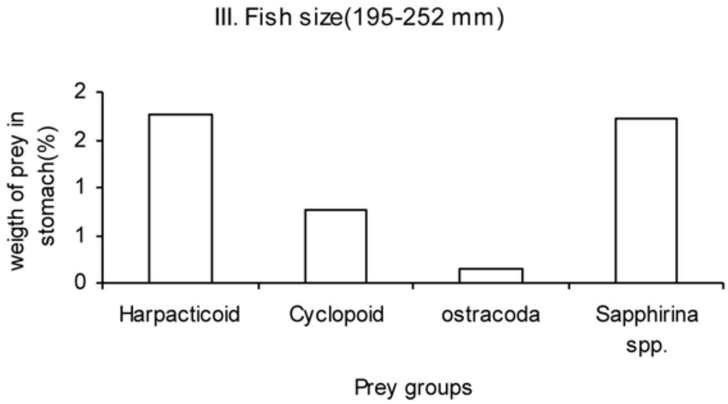
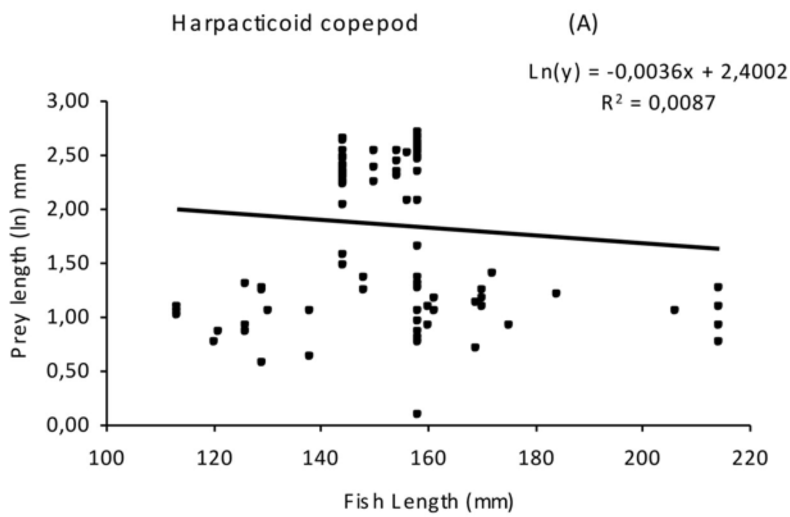


Fig. 4c. Percentage weight values prey groups consumed by the 3rd fish length group



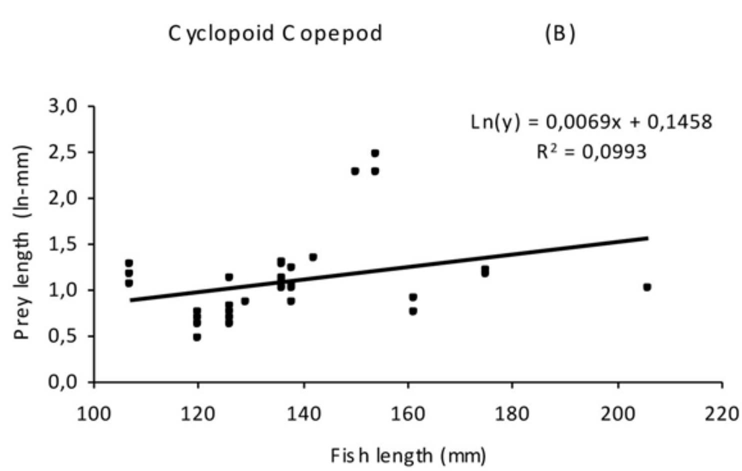


Fig. 5. Regression values of fish length vs. pray length for major prey (A and B)

are given in Fig. 5. Regression values found based on fish length for two major prey items were low (Harpacticoid copepod, r^2= 0.0087; Cyclopoid copepod, r^2=0.099, $p<0.05$), with a poor relationship between fish length and size of prey consumed.

DISCUSSION AND CONCLUSIONS

The comparison of the members of the family Syngnathidae with other demersal fish species indicates that a high degree of trophic specialization exists in snout morphology and feeding behaviors (PLATTELL & POTTER, 1999; KENDRICK & HYDNES, 2005). Development of snout length in pipefish gains an advantage in decreasing the time span for approaching prey (DE LUSSENET & MULLER, 2007). Syngnathids are species which catch their prey with the ability to see (HOWARD & KOEHN, 1985). Their prey are mostly composed of tiny crustacean groups (MERCER, 1973; HOWARD & KOEHN, 1985; TRIPTON & BELL, 1988; STEFEE *et al.,* 1989; MOREIRA *et al.,* 1992; FRANZOI *et al.*, 1993; TEIXZEIRA & MUSICK, 1995; LYONS & DUNNE, 2004).

The food composition of *N. ophidian* includes such species as Amphipods, Gastopods, Isopods (MARGONSKI, 1990) as well as benthic and planktonic ones (RAUSCHENPLAT, 1901; MUSS & NIELSEN, 1999). The results of our study are consistent with those given by the authors above. Benthic forms of Harpacticoid copepods were one of major prey items captured by almost all lengths of fish. This finding indicates that pipefish intake them from benthic vegetation rather than the water column (LYONS & DUNNE, 2004). The food composition of *Nerophis lumbriciformis,* the worm pipefish, consists mainly of benthic prey, and it proves that this species spends little time in the water column actively seeking prey (HOWARD & KOEHN, 1985; LYONS & DUNNE, 2004).

Cyclopoid copepods, the second major prey group, are typical planktonic prey for pipefish which have no caudal fin and feed mostly on vegetative areas (KENDRICK & HYDNES, 2005). This can also be clearly proven by the presence of pelagic Ostracods in the food composition (RAUSCHENPLAT, 1901; LYONS & DUNNE, 2004).

Our results obtained from three fish length groups indicate that small sized prey items are consumed mostly by small sized fish. Pipefish have short snouts and mouths specific for catching small sized prey groups (HOWARD & KOEHN, 1985; RYER & ORTH, 1987; FRANZOI *et al.*, 1993; GERKING, 1994; DE LUSSENET & MULLER, 2007) and which shows that they have relatively limited mouth gapes for larger segmented prey (RYER & ORTH, 1987). The ability to consume larger prey may be correlated with fish size (NELSON, 1979). In addition, the preference for Amphipods in gut contents of length group II suggested that their mouth gapes were also suitable for catching them (RYER & ORTH, 1987). The results obtained in our study are consistent with those of the authors above.

The seasonal gut contents of pipefish can also be explained by ontogenetic models (KENDRICK & HYDNES, 2005) in which regression analyses suggest that small length groups with small mouth gapes are likely to orient to relatively small prey groups (Cyclopoid copepod). Therefore, while larger fish intake relatively larger prey, they continue to catch smaller prey items as well, which implies that the bigger the fish in size, the more prey groups they could catch (KENDRICK & HYDNES, 2005).

Harpacticoid and cyclopoid copepod species in the food content of pipefish were found to be major prey and are invertebrate species seasonally abundant in seagrass (HECK & ORTH, 1980; HOWARD & KOEHN, 1985; HUH & KITTING, 1985). The abundance distribution of Harpacticoid copepods (LYONS & DUNNE, 2004), essentially benthic forms in fish stomachs, is understood to vary from the highest in summer to the lowest in winter (Table 1). Copepods species present in the Aegean Sea can fluctuate seasonally depending on the mobility of water masses (SEVER, 1997).

The abundance of harpacticoid copepods is thought to be associated with predation as well as with nocturnal and diurnal migrations in the water column, which can explain the lowest abundance level of harpacticoid copepods in winter and the highest in summer (Table 1). Similarly, the second major prey, Cyclopoid copepods, were the highest in abundance in spring and the lowest in winter (Table 1). A study carried out in Izmir Bay established that copepod forms were highest in late summer (98.99%) and lowest in winter (28.23%) (TASKAVAK *et al.,* 2006), which is also consistent with our findings. *N. lumbriformis,* a west Atlantic form, was reported to increase ingestion in the spawning period (LYONS & DUNNE, 2004). The spawning period of *N. ophidion* in Izmir Bay is between October and June (GURKAN, 2004), suggesting that such prey groups are mostly ingested by adult pipefish.

Finally, feeding of *N. ophidion* is established by food composition based on seasonal abundance rather than by consumption of given prey groups in the habitat. Pipefish are reported to be able to intake larger prey as well as smaller ones by constricting their mouth structures, specifically their snouts, to do so. In addition, while *N. ophidion* is hardly able to catch prey groups in the water column because of the lack of a caudal fin, their short snout provides them an advantage in efficiently catching existent prey groups in the surroundings when available.

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Sezonski sastav hrane i odnos plijen-dužina kod šila *Nerophis ophidion* iz Egejskog mora

Sule GURKAN, Tuncay Murat SEVER i Ertan TASKAVAK*

Ege University, Faculty of Fisheries, Department of Hydrobiology, 35100 Izmir, Turkey

**Kontakt adresa, e-mail: ertan.taskavak @ege.edu.tr*

U ovoj studiji su pregledana 43 želudca jedinki vrste Nerophis ophidion ulovljenih u Izmirskom zaljevu, istočni dio Egejskog mora. Nakon razdoblja jedne godine uzorkovanja (sve četiri sezone) utvrđeno je sedam grupa plijena: Ostracoda, Amphipoda, Gastropoda, Cirripedia, Decapoda, bentoski oblici Cnidaria i Copepoda (veslonošci) (Calanoid, Harpaticoid, Cyclopoid-Sapphirina sp., E. acutifrons i Monstrilloid), harpatikoidni kopepodi, cyclopodni veslonožac Cypris ličinke i Ostracoda. Samo su četiri želudca bila prazna. Gastropoda (9.47%), Amphipoda (37.22%) i harpatikoidni kopepodi (1.77%) su prevladavajući plijen vrste N. ophidion. S druge strane, Harpatikoidi i ciklopodini kopepodi su utvrđeni u gotovo svim razdobljima uzorkovanja i stoga se ubrajaju u glavni plijen. Amphipoda su najdominantniji piljen tijekom proljeća (24.39%) i ljeta (12.82%), a Gastropda (6.32%) tijekom jeseni. Nazočnost harpatikodinih kopepoda u svim dužinskim klasama ukazuje da njihova konzumacija vjerojatnije potiče sa bentoske vegetacije u odnosu na vodeni stupac. Mogućnost konzumacije većeg plijena je u korelaciji sa duljinom ribe. U ovoj studiji, veće jedinke uglavnom konzumiraju krupniji plijen no ne prestaju konzumirati i znatno sitniji plijen. Ovo može ukazivati i na to da što je veći grabežljivac to je njegova mogućnost ulova i konzumacije većeg broja različitih grupa plijena veća.

Ključne riječi: sastav hrane, Nerophis ophidion, šilo, Egejsko more