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THE NUTRITIONAL SPECTRUM OF SOME GOBIID SPECIES FROM THE ROMANIAN BLACK SEA COAST

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Abstract

The main aim of this study is to analyse the trophic spectrum of four goby species (Apollonia melanostomus, Neogobius cephalarges, Mesogobius batrachocephalus, and Gobius niger) from the Romanian coast of the Black Sea, examining their dietary diversity, sex ratios, distribution by area, and seasonal variation. Before analysing gastrointestinal contents and identifying ingested organisms, the gobies were measured to determine their length classes and weighed to establish their weight categories. The food components identified from the stomach contents mainly consist of molluscs, which have significant trophic importance. The gobies' diet is dominated by Dreissena polymorpha (27%), followed by Mytilaster lineatus (12%) and Mytilus galloprovincialis (11%). The digestive tract filling index across different seasons and sexes was also reported. For females of Apollonia melanostomus, the index was 48%, while for males it was 52%. Females of N. cephalarges had a filling index of 56%, compared to 44% in males. Females of Mesogobius batrachocephalus showed an index of 44%, with males at 56%. Females of Gobius niger had an index of 33%, whereas males reached 67%. Overall, the average digestive tract filling index is substantially higher in males (103.97) than in females (80.64).

Keywords: trophic spectrum, goby species, gastrointestinal tracts, index

Introduction

Gobies are found worldwide, inhabiting both salt and freshwater habitats, mainly in tropical, subtropical, and marine environments. Species of the Gobiidae family are present throughout the Black Sea, the Sea of Azov, the Caspian Sea, the Sea of Marmara, the Baltic Sea, and extend into the freshwater regions of North America. Research on the feeding behaviour of Gobiidae species initially concentrated on those in estuarine and marine settings, with recent focus shifting to freshwater species (Miller, 2003). Generally, gobies are recognised as benthic feeders, primarily consuming crustaceans and molluscs. It is also well known that some species feed indiscriminately, ingesting sediments alongside the organisms within them (Carle et al. 1982).

Studying feeding habits and feeding ecology is essential to understanding the functions of fish in their ecosystems. This research highlights relationships based on food resources. It

provides clues about how energy circulates within the community, which helps to identify the influences that competition and predation have on these structures (Hajisamaea et al 2003).

From a trophic level perspective, gobies form the foundation of the food chain for other fish species of significant economic value. They occupy the tertiary trophic level as second-order consumers. There is limited information in the specialised literature regarding the nutrition of gobies. Gobies demonstrate a high degree of adaptability to various environmental conditions: they are euryhaline and eurythermal species.

Materials and methods

The biological samples were collected from the Black Sea shore through sport fishing, volta, paragat, and inline fishhooks.

The fish were captured from May 2013 to December 2014 at five stations located in different habitats along the Romanian coast: Sulina, Constanta, 23 August, Mangalia, and Vama Veche. In total, 20 samples comprising 1490 specimens were analysed. At least 100 specimens from each sample were examined in the laboratory. The study utilised samples preserved in 4% formaldehyde to prevent digestion by fish enzymes even after death (Surugiu et al., 2004). After collecting, the digestive tracts were immersed in water. Gastric content analysis was performed using a binocular microscope (ocular 10x, objective 1.6x) to study the gastrointestinal content and identify ingested organisms.

The entire stomach content was weighed with an electronic scale for quantitative analysis and to determine the composition of different species. The contents of the digestive tracts were extracted, weighed, and identified under a binocular microscope. Finally, the empty gastrointestinal tracts were weighed to calculate their filling index. The filling index was estimated by calculating the feeding coefficient (CH) as follows:

$$C_H = \frac{G_S}{G_P} * 10000, \text{ where:}$$

C_H = feeding coefficient

C_S = gastrointestinal content's weight

G_P = fish's weight (Surugiu et al, 2004)

Total length measurement was taken using the ichthyometer to establish the length classes, and the fish were weighed to determine the weight classes. The stomach contents were analysed in terms of quality and quantity, followed by classification of each food type. From this, the most important food type for the goby was identified. Data were recorded regarding the food consumed. The number and size of the digested organisms were estimated based on the structure of certain elements (mandibles, legs, shellfish claws, shells) (Skora et al., 2001).

Results and discussion

The diet composition of gobies varies with the size of the fish and is typical of their habitat. Gobies generally feed on epibenthic and opportunistic organisms, depending on the benthos in the respective season.

The gobies use their pharyngeal teeth to open mollusk shells and extract the mollusk from the oral cavity before swallowing it (Ghedotti et al., 1995). Intact mollusc shells were mostly found in the gastrointestinal tracts. The gobies feed on spawn and seedling fish, including those of the same species.

Among the foods of gobies from the Romanian Black Sea coast, 14 species were identified: Mytilus galloprovincialis, Mytilaster lineatus, Cerastoderma edule, Mya arenaria, Dreissena polymarhina, Cyclope neritea, Scapharca cornea, Nassa reticulata, Gammarus sp., Balanus improvisus, Idotea baltica, Spisula subtruncata, Decapoda, and fish. The most significant were molluscs, especially bivalves.

In the goby diet, fine-sand species such as Idotea baltica, Balanus improvisus, Cyclope neritea, and Dreissena polymorpha were also found, along with representatives living on hard substrates, such as the stone mussel Mytilus galloprovincialis and Mytilaster lineatus, which exploit the trophic resources of both biocenoses.

The large number of nutritional components indicates a low degree of selectivity and suggests that food choice is occasional. No eggs of other fish were found in the digestive tubes of the gobies, probably because they are easily digestible and could not be detected.

For the Apollonia melanostomus (Pallas, 1814) samples (round goby), 1079 patterns were analysed over the two years the study lasted, with lengths between 59–201 mm. The dominant length classes range from 90–170 mm, and the dominant mass classes range from 20–130 g.

For the A. melanostomus females, the filling index of the digestive tract was 48%, while for the males it was 52%. Regarding the quantified food component, it was established that A. melanostomus males consumed a high proportion of 81% Dreissena, and females 94%. This shell was found only in the Sulina area. In Constanta, males predominantly consumed Mytilaster at 26%, and females at 31% Mytilus. In the 23 August area, Mytilaster was especially consumed at 29% by males and 37% by females, while in Mangalia, the male round goby preferred Mytilaster at 44%, and the females Mytilus at 57%. In Vama Veche, only Mytilus was consumed, with males at 45% and females at 61% (Table 1).

Table 1. The frequency of different elements inside the gastrointestinal tract of the round goby (%)

Location	Trophic resources	Frequency (%)	
		Male	Female
Sulina	*Cerastoderma edule*	17	4
	Dreissena polymorpha	81	94
	Neidentificat	2	2
Constanta	*Balanus improvisus*	6	0
	Mytilus galloprovincialis	19	31
	Mytilaster lineatus	26	29
	Cerastoderma edule	24	25
	Mya arenaria	14	10
	Gammarus sp.	3	2
	Decapode	6	3
	Neidentificat	2	0
23 August	*Cerastoderma edule*	7	8
	Balanus improvisus	2	3
	Mytilus galloprovincialis	21	17

	Mytilaster lineatus	29	37
	Scapharca cornea	2	8
	Mya arenaria	2	0
	Gammarus sp.	3	0
	Decapode	1	6
	Nassa reticulata	3	0
	Spisula subtruncata	18	21
	Pesti	12	0
Mangalia	*Mytilus galloprovincialis*	26	57
	Mytilaster lineatus	44	20
	Cerastoderma edule	7	12
	Gammarus sp.	4	0
	Decapode	16	10
	Nassa reticulata	2	0
	Neidentificat	1	1
Vama Veche	*Mytilus galloprovincialis*	45	61
	Mytilaster lineatus	20	25
	Cerastoderma edule	1	2
	Decapode	17	3
	Idothea baltica	17	9

Samples of Neogobius cephalarges (Pallas, 1814), commonly known as the ginger goby, collected between 2003 and 2004, were analysed for a total of 188 patterns. The lengths ranged from 66 to 202 mm, with the most common length classes between 70 and 200 mm, and the most common mass classes from 30 to 140 g for both sexes. In female N. cephalarges, the digestive tract was 56% full, compared with 44% in males. In the Sulina area, Dreissena was the dominant food, comprising 80% for males. In the Constanta area, the main food for males was Gammarus sp. (31%), while females predominantly ate Mytilaster (42%). In Mangalia, males fed mainly on decapods (67%), while females consumed Mytilus (56%). The main food of males from Vama Veche was Cerastoderma, at 5% (Table 2).

Table 2. The frequency of different elements inside gastrointestinal tract of ginger goby (%)

Location	Trophic resources	Frequency (%)	
		Male	Female
Sulina	*Dreissena polymorpha*	80	0
	Neidentificat	20	0
Constanta	*Mytilus galloprovincialis*	7	11
	Mytilaster lineatus	16	42
	Cerastoderma edule	11	0
	Decapode	18	8
	Scapharca cornea	12	0
	Gammarus sp.	31	39
	Neidentificat	5	0
Mangalia	*Mytilus galloprovincialis*	29	56
	Decapode	67	44

	Neidentificat	4	0
Vama Veche	*Mytilus galloprovincialis*	45	0
	Cerastoderma edule	55	0

Samples of Mesogobius batrachocephalus (Pallas, 1814), known as knout goby, were analysed over two years. There were 193 patterns with a dominant length class of 170–280 mm and a mass range of 70-220 g. The gastrointestinal tract filling index for females is 44%, while for males it is 56%. In the 23 August area, males consumed 42% and females 50% of Mytilaster. In the Mangalia area, the primary food source was Mytilus, accounting for 83% among males and 63% among females. At Vama Veche, males mainly consumed Mytilaster at 47% (Table 3).

Table 3. The frequency of diferents elements inside gastrointestinal tract of knout goby (%)

		Frequency (%)	
Location	Trophic resources	Male	Female
23 August	*Mytilus galloprovincialis*	20	2
	Mytilaster lineatus	42	50
	Decapode	2	1
	Peste	36	47
Mangalia	*Mytilus galloprovincialis*	83	63
	Cyclope neritea	17	17
	neidentificat	0	20
Vama Veche	*Mytilus galloprovincialis*	37	0
	Mtilaster lineatus	47	0
	Peste	13	0
	Nassa reticulata	3	0

For Gobius niger (Linnaeus, 1758) samples, 30 patterns were analysed in 2003, with lengths ranging from 90 to 138 mm and dominant classes spanning 10 to 30 g. The female filling index was 33% and the male filling index was 67%. The main nutrient was Mytilaster at 59% for females and Mytilus at 43% for males (Table 4).

Table 4. The frequency of different elements inside the gastrointestinal tract of Gobius *niger* (%)

Location	Trophic resources	Frequency (%)	
		Male	Female
Constanta	*Mytilaster lineatus*	57	0
	Cerastoderma edule	43	0
23 August	*Mytilaster lineatus*	36	59
	Mytilus galloprovincialis	43	19
	Cerastoderma edule	21	22

Along the Romanian coast, the intensity of food varies between regions and between different species.

Regarding the trophic spectrum for both sexes, it is observed that there are no significant differences caused by more components. The nutrition spectrum for both sexes does not show major differences, being composed of many different components.

For the male round goby's food, 12 components were found: Dreissena, Mytilus, Mytilaster, Cerastoderma, Mya, Gammarus, Decapode, Scapharca, Nassa, Balanus, Spisula and fish, as well as unidentified organisms (13 components) (Figure). While in the female, there were 10 components: Dreissena, Mytilus, Mytilaster, Cerastoderma, Mya, Gammarus, Decapode Scapharca, Balanus, Spisula (figure 2).

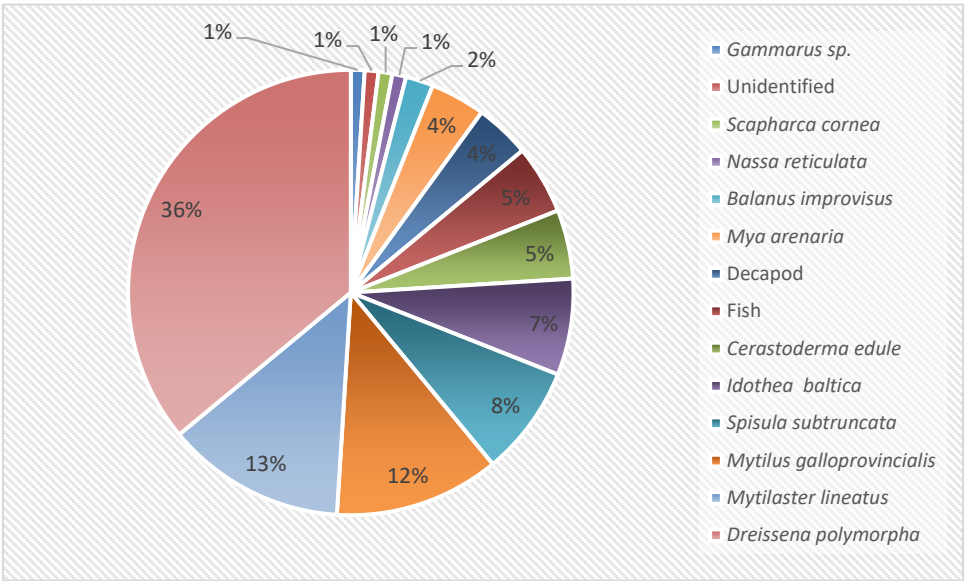

Figure 1. Trophic spectrum of males *A. melanostomus*

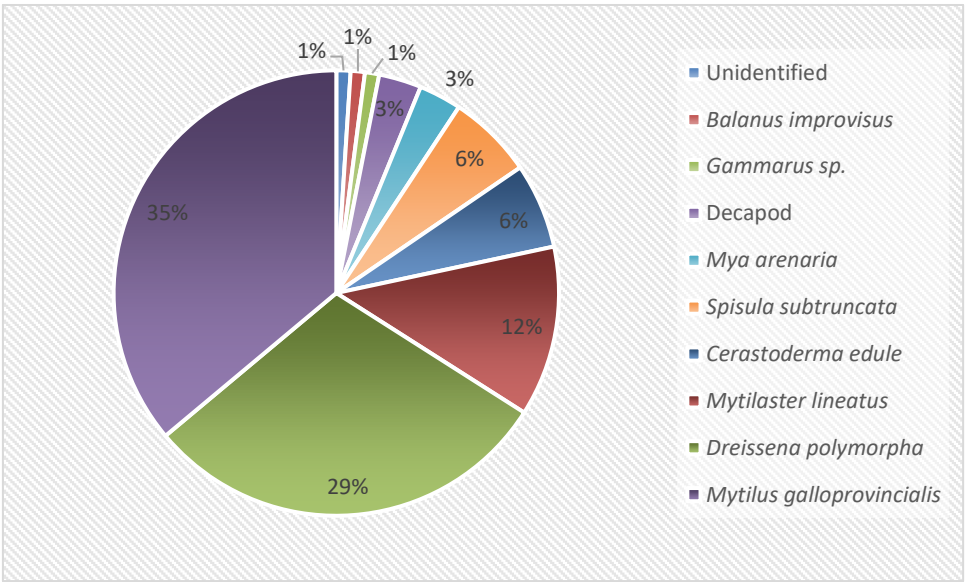

Figure 2. Trophic spectrum of females *A. melanostomus*

For the ginger goby, the current components found in the males' gastrointestinal tracts are: Dreissena, Cerastoderma, Scapharca, Gammarus, Mytilus, Mytilaster, Mya, Decapode (figure 3), while in the females, four nutritional components were identified: Gammarus, Mytilus, Mytilaster, Decapode (figure 4).

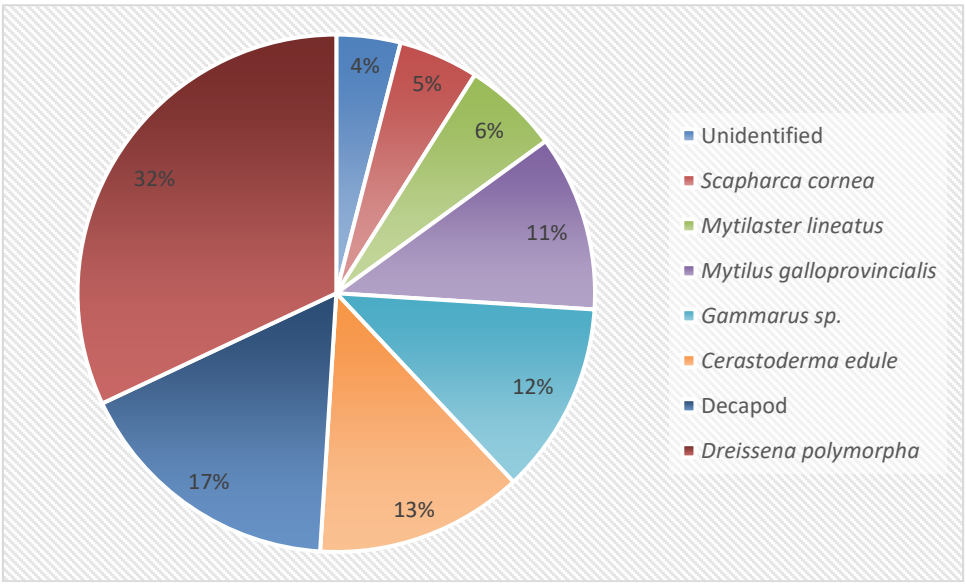

Figure 3. Trophic spectrum of males *N.cephalarges*

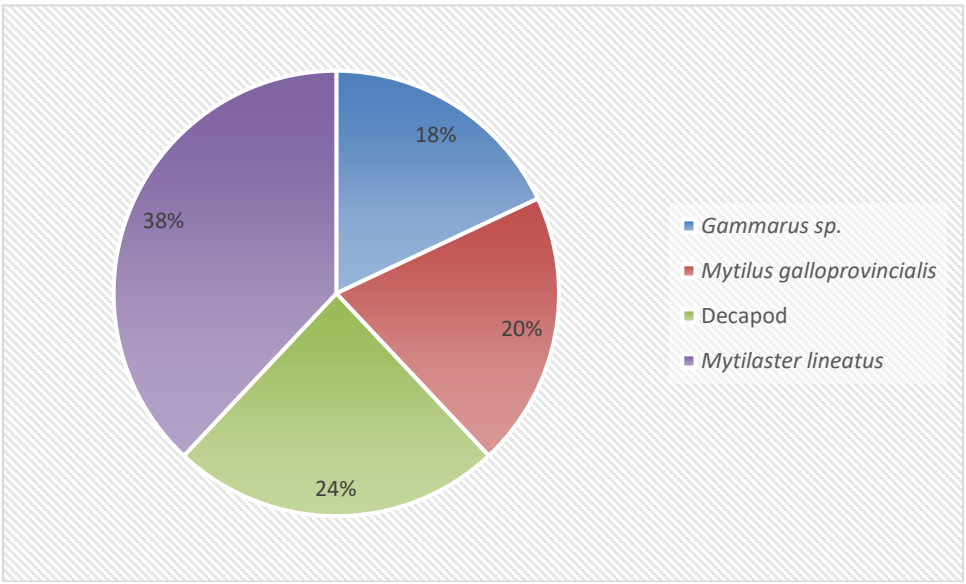

Figure 4. Trophic spectrum of females *N.cephalarges*

For the male knout goby, the food components included: Mytilus, Mytilaster, decapods, fish, Cyclope, and Nassa (6 components), as shown in figure 5. For the females, the food components consisted of: Mytilus, Mytilaster, decapods, fish, and Cyclope (5 components), as shown in figure 6.

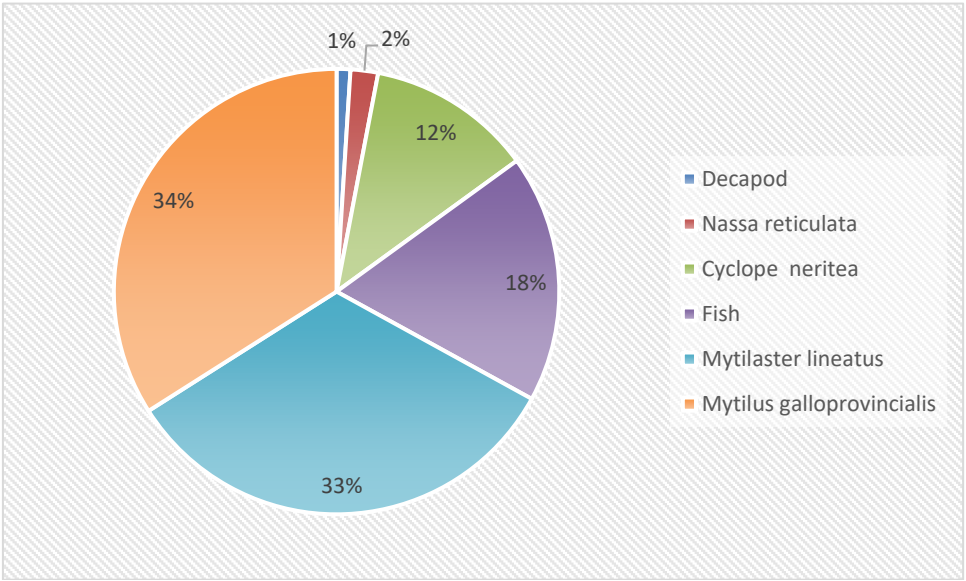

Figure 5. Trophic spectrum of males *M. batrachocephalus*

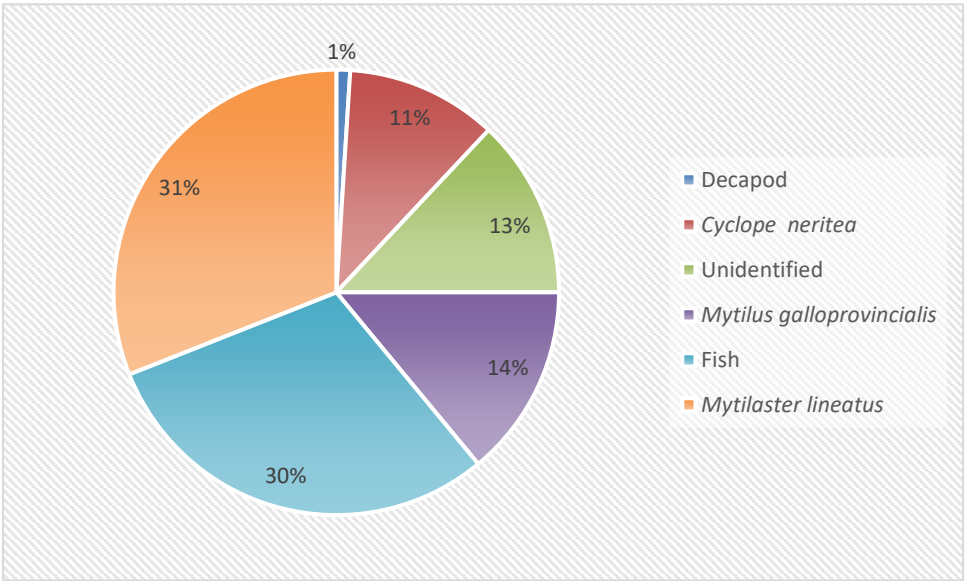

Figure 6. Trophic spectrum of females *M. batrachocephalus*

For *Gobius niger,* Linnaeus, 1758 the food component is: *Cerastoderma, Mytilaster, Mytilus* (3 components) for the females and the males (figures 7 and 8).

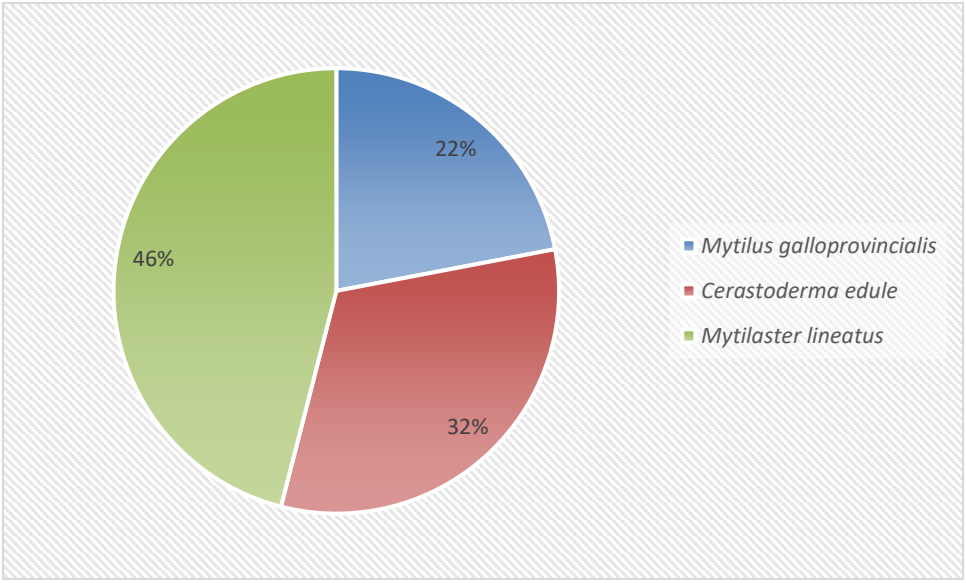

Figure 7. Trophic spectrum of males *Gobius niger*

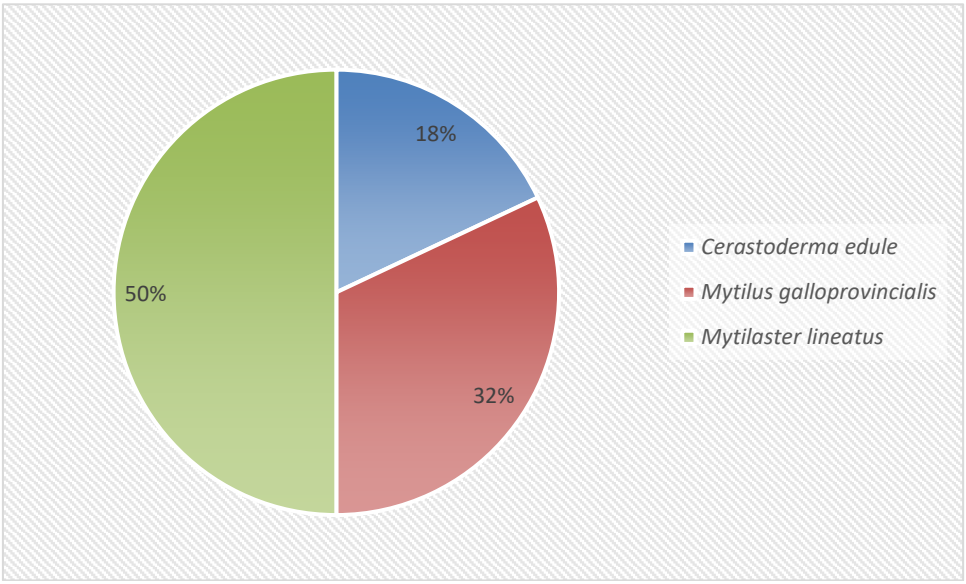

Figure 8. Trophic spectrum of females *Gobius niger*

Regarding the intensity of feeding habits, we can draw some conclusions by considering the digestive tract filling index (Table 5). The values show significant seasonal differences, due to intensive feeding during spring and summer.

Table 5. Digestive tract filling index by season

Species	Author	Winter	Spring	Summer	Autumn	Average
Round goby	Porumb	-	92.65	113.62	155.60	120.62
	Calculating	-	119.73	174.52	140.46	144.90

Ginger goby	Porumb	53.09	108.38	183.90	127.94	118.33
	Calculating	-	108.39	60.43	67.89	78.90
Knout Goby	Porumb	22.17	-	-	106.89	64.53
	Calculating	-	90.44	73.98	71.88	78.77
Average	Porumb	37.63	100.51	148.76	130.14	
	Calculating	-	106.18	102.97	93.41	

The average filling index of the digestive tract is considerably higher in males (103.97) compared to females (80.64). Males eat more and have a higher energetic expenditure over time, which leads to increased aggressiveness, territorial fights to control mating areas, and the energy required to produce sexual elements. These males, known as "wandering males," fertilise many nests. The feeding intensity varies between different species.

The average feeding index for Apollonia melanostomus is 144.90, which feeds intensively during summer at 40%, with a medium filling index of 174.52. This can be explained by the significant biological activity during this period. Porumb obtained lower data, at 120.62, while the round goby feeds intensively during autumn, with an average feeding index of 155.60 (Porumb, 1961).

Neogobius cephalarges feeds during spring at 45%, with a medium filling index of 108.39 in the digestive tract, which is identical to the figure obtained by Porumb in spring, 108.38. The knout goby, Mesogobius batrachocephalus, feeds intensively during spring at 39%, with a digestive tract medium filling index of 90.44. According to Porumb, the feeding intensity is higher towards autumn with 106.89; as autumn approaches, the feeding intensity decreases due to the chilling of the water (Porumb, 1961).

Table 6. Digestive tract filling index by gender

Species	Males	Female
Round goby	162.61	126.89
Ginger goby	68.80	40.84
Knout Goby	80.51	74.19
Average	103.97	80.64

The digestive tract filling index is higher among males (103.97) than females (80.64), as males consume more food than females due to their higher energetic needs (Table 6).

Conclusions

The study shows that the composition and the trophic spectrum vary significantly from one species to another, by season, region, and sex, in line with the trophic base composition. The gobies effectively utilise the fine sands biocenosis as well as the stone mussels biocenosis. They actively feed throughout the year, with their diet mainly consisting of psamobionte mollusks, which are common in the Black Sea's benthos. Fourteen food components have been observed: Mytilus galloprovincialis, Mytilaster lineatus, Cerastoderma edule, Mya arenaria, Dreissena polymorpha, Cyclope neritea, Scapharca cornea, Nassa reticulata, Gammarus sp., Balanus improvisus, Idotea baltica, Spisula subtruncata, Decapodes, and fish—gobies.

In the northern part of the Romanian coast, gobies preferentially consumed Dreissena polymorpha, compared to the southern section of the shoreline, where they mainly consumed Mytilaster lineatus and Mytilus galloprovincialis. Males were numerically dominant at 66%, compared to 34% for females, across any year, season, or area. The length varied significantly, ranging from 59 to 300 mm in males and 59 to 307 mm in females, with weights between 4.71 and 292.53 g for males and 5.05 to 252.28 g for females. The most common length classes for all examined gobies were 70-290 mm for males and 90-250 mm for females; the dominant mass classes ranged from 10-220 g for males and 20-220 g for females.

The dominant gastrointestinal content species were Dreissena polymorpha, Mytilaster lineatus, and Mytilus galloprovincialis; other nutritional components were consumed in smaller proportions. Regarding nutritional intensity—as indicated by the filling index—gobies feed more intensively during the spring and summer seasons. Males consumed more food than females. This can also be explained by the fact that males grow faster than females because, while guarding the brood, they do not feed, which could lead to their premature death after a single breeding season. Therefore, after breeding, their feeding activity becomes more vigorous.

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