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FOOD AND FEEDING HABITS OF THE DAMSELFISH *CHROMIS CHROMIS* (TELEOSTEI: POMACENTRIDAE) IN THE EASTERN ADRIATIC

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ABSTRACT

The stomach contents of 964 damselfish Chromis chromis *collected in the eastern central Adriatic in 1992 and 1993 were examined to assess the diet, as influenced by season and fish size. Damselfish is carnivorous from the juvenile stage onward, feeding on a narrow range of plankton and benthic prey items. Higher intensity of feeding activity in spring could be related to temperature and/or gonadal maturation. During all seasons copepods constituted the most important food resource by weight, number and frequency of occurrence. Appendicularia and cladocerans were the second most important food category. Dietary overlap was relatively high, indicating that the feeding spectrum of damselfish changed little across seasons, but for size groups was small, indicating greater changes in feeding spectrum.*

Ključne besede: črnik, *Chromis chromis*, prehrana, prehranjevalne navade, ceponožci, vzhodni Jadran

Key words: damselfish, *Chromis chromis*, food, feeding habits, copepods, Eastern Adriatic

INTRODUCTION

The damselfish, *Chromis chromis* (Linnaeus, 1758) is a small fish found in shoals in mid-water above or near rocky reefs or above sea grass *(Posidonia)* meadows at depths ranging from 3 to 35 m. It occurs in the Mediterranean and from Portugal southwards to Angola (Quignard & Pras, 1986).

In the Eastern Adriatic, the damselfish is abundant (Grubišić, 1982; Milišić, 1994), but it is of no commercial value along the eastern coast (except on the central Adriatic islands of Šolta, Hvar, Korčula and Lastovo, where it is much appreciated). In coastal fishery of Dalmatia, damselfish form a small but significant component of the coastal beach seine and gill net catch that is used as delicious food and as bait for lobsters. We have no new data on catch, but Grubišić (1982) reported that it is around 30 tons per year.

There are some data about the biology and ecology of this species from the eastern Adriatic. Dulčić *et al.* (1994a) presented data on the length-weight relationship in damselfish during spawning in the Eastern Adriatic. Dulčić *et al.* (1994b) analysed the vertebral number of damselfish. Age, growth and mortality of damselfish were presented by Dulčić & Kraljević (1995).

Despite its abundance, very little is known about the trophic ecology of damselfish in the Mediterranean Sea. The present study deals with food and feeding habits of the damselfish off the Eastern Adriatic. The purpose was to examine the feeding habits and intraspecific resource partitioning across seasons and during developmental life stages of damselfish in the Eastern Adriatic.

MATERIAL AND METHODS

A total of 964 specimens of damselfish were obtained during four seasonal beach seine survey cruises, from summer 1992 to spring 1993. Samples were taken near the island of Trstenik in the central Adriatic (Fig. 1). Damselfish were fixed in 4% formalin immediately after capture. The fish were processed promptly after collection. Processing included measurements and weighing to nearest 0.1 cm and 0.01 g respectively and gut removal prior to which both ends of the stomach were tied off. The contents of the dietary material were identified to the specific level where possible, but most items were identifiable only to the generic level. Presence of inorganic matter and detritus in the stomachs was recorded, but excluded from the analysis. After identification, preys were weighed to the nearest 0.01 g.

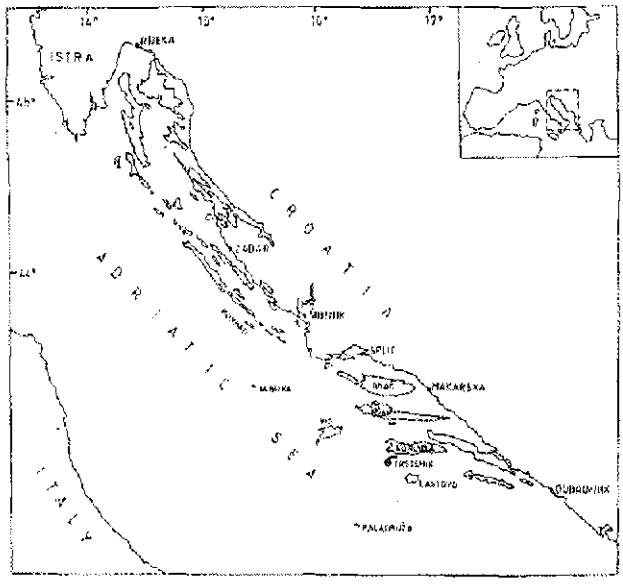

Fig. 1: Location of sampling station in the eastern central Adriatic, where damselfish** (Chromis chromis) **were collected (Trstenik Island).
***Slika 1: Zemljevid obravnavanega območja z označeno vzorčevalno postajo (otok Trstenik), kjer so bili ulovljeni črniki** (Chromis chromis).*

The contribution of the prey categories to the diet of damselfish was calculated as (1) the percentage of wet weight (C_w) of a prey category (pooled) to the weight of the total stomach contents, (2) the percentage abundance (C_n) of individuals of a prey category to the total number of prey individuals in the stomachs, (3) the frequency of occurrence (f) of stomachs in which a prey category occurred to the total number of stomachs examined (Hyslop, 1980). George & Hadley (1979) employed the "relative importance index" (RI) which is based on the "absolute importance index" (AI) as follows: AI = % frequency occurrence + % total numbers + % total weight; RI = 100 AI / $n_i\sum$ AI, where n is the number of i different food types.

Seasonal variations were analyzed using Fischer's least significant difference (LSD) test (Zar, 1984). The analysis of changes in feeding habits in different seasons and in different length classes was performed by the use of the fullness index (Hureau, 1970): %Ir = fullness index: weight of digested food/fish weight x 100.

Proportional food overlap between size classes and seasons for the species was calculated using the overlap index of Schoener (1970): Cih = 1 - 0.5 ($\sum$j Pij - Phj), where Pij and Phj are the proportions of prey j found in the diets of groups i and h respectively. This index has a minimum of 0 (no overlap of prey) and a maximum of 1 (all items in equal proportions). Schoener's index values above 0.60 are usually considered to be "biologically significant" (Zaret & Rand, 1971; Wallace, 1981), indicating a high dietary overlap (Langton, 1982).

RESULTS AND DISCUSSION

Fish lengths in the sample ranged from 8 to 134 mm caught (Fig. 2). Data sampled in 3 areas were aggregated for the analysis since there was no significant difference between them (ANCOVA). The specimens were divided into two size groups, to examine feeding habits of the fish developmental stages. Group 1 comprised fishes smaller than 65 mm (juvenile stage) and Group 2 fishes longer than 65 mm (adult stage). The proportion of empty stomachs among fish up to 65 mm long is 6.9%, while this proportion in longer fish is 5.0%. Feeding intensity expressed by the fullness index (Ir) was higher in smaller (Ir=6.83) than in larger fish (Ir=3.80).

In Group 1, polychaetes, ostracods, copepods and mysids constitued the bulk of the diet, while copepods, appendicularins and cladocerans were dominant in Group 2 (Table 1). Stomachs of larger individuals contained all mentioned prey taxa ingested by smaller fish, but in different proportions. Copepods were the dominant prey of damselfish in both size-classes, *Clausocalanus pergens* being the dominant species. As fish grew older there was a difference in the "relative index" (RI) of polychaetes, copepods, ostracods and mysids. Polychaetes exhibited a greater presence in the stomachs of smaller fish, corroborating the view that small damselfish select prey of low mobility.

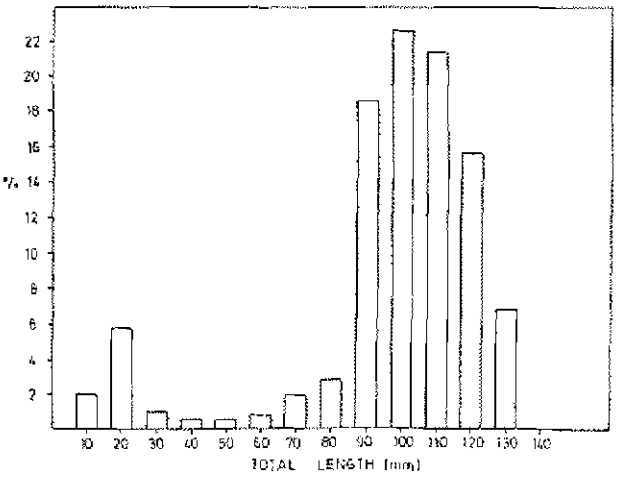

Fig. 2: Length frequency distribution of damselfish** (Chromis chromis) **collected in the eastern central Adriatic for dietary studies in 1992 and 1993 (n = 964).
Slika 2: Velikostna porazdelitev dolžine črnikov** (Chromis chromis), **ulovljenih v vzhodnem srednjem Jadranu v obdobju 1992-1993 (n = 964).

Size groups	8-65 mm					> 65 mm				
Contribution of the prey categories	f	C_n	C_w	AI	RI	f	C_n	C_w	AI	RI
Polychaeta	34.3	7.7	30.5	72.5	13.05	2.4	0.1	0.5	3	0.25
Appendicularia						76.2	27	13.8	117	9.93
Ostracoda	38.9	27.4	10.5	85.8	15.42	10.8	0.9	3.2	14.9	1.27
Copepoda	94.7	55.6	12.7	163	29.30	93.1	37.7	25.7	156.5	13.29
Paracalanus parvus						76.2	7.6	5.4	89.2	7.57
Clausocalanus pergens	36.8	23	5.3	65.1	11.70	51.7	10.1	6.1	67.9	5.77
C. furcatus	21.1	15	3.4	39.5	7.10	37.1	6.2	4.3	47.6	4.04
C.helgolandicus						11.6	1.1	1.1	13.8	1.17
C.paropergens						15.6	5.2	2.9	23.7	2.01
C.tenuicornis	19	10.5	2.4	31.9	5.73	3.3	0.1	0.1	3.5	0.30
Eucalanus elongatus	10.5	5	1.2	16.7	3	2.3	0.1	0.1	2.5	0.21
Euterpina acutiformis						4.6	0.1	0.1	4.8	0.41
Centropages typicus						62.5	6.8	5	74.3	6.31
Acartia clausi	7.4	2.1	0.5	10	1.80	14.2	0.6	0.8	15.6	1.33
Cirripedia (nauplii)						3.1	0.6	1.5	5.2	0.44
Decapoda (larvae)						26.3	6.1	7.1	39.5	3.35
Mysidacea	25.3	9.4	37.2	11.9	12.92	11.2	0.6	4.6	16.4	1.39
Cladocera						86.1	22.5	12.3	120.9	10.27
Penilia avirostris						12.8	1.8	1	15.6	1.32
Podon intermedius						40.2	12.7	6.8	59.7	5.07
Evadne spinifera						38.4	8.5	4.6	51.5	4.37
Gastropoda (larvae)						10.9	0.7	12.2	23.8	2.02
Bivalvia (larvae)						8.8	1.5	12.2	22.5	1.91
Pisces										
Eggs						30.5	1.7	3.8	36	3.07
Chromis chromis						6.7	0.2	0.4	7.3	0.62
Serranus hepatus						6.6	0.2	0.4	7.2	0.61
Cepola rubescens						9.2	0.4	0.8	10.4	0.88
Engraulis encrasicolus						9.8	0.5	1.1	11.4	0.97
Sardina pilchardus						8.1	0.5	1.2	9.8	0.83
Larvae						44.8	1	3.4	49.2	4.18
Chromis chromis						13.4	0.2	0.5	14.1	1.20
Serranus hepatus						*1.9*	*0.1*	*0.1*	*2.1*	*0.18*
Cepola rubescens						7.3	0.1	0.4	7.8	0.66
Gobius sp.						10	0.2	0.7	10.9	0.93
Oblada melanura						7.2	0.2	0.8	8.2	0.70
Diplodus vulgaris						0.3	0.01	0.1	0.41	0.04
Atherina hepsetus						12.2	0.3	1	13.5	1.15
Digested food	5.2		1.8			5.5		2.4		
No of stomachs		102					862			
No of empty stomachs		7					43			
% of empty stomachs		6.9					5.0			

Table 1: Contribution of the prey categories for damselfish stomach contents according to size groups.
Tabela 1: Delež posameznih kategorij plena v želodcih črnika glede na velikost.

Season	Winter					Summer				
Contribution of the prey categories	f	C_n	C_w	AI	RI	f	C_n	C_w	AI	RI
Polychaeta						14.1	0.2	1.3	15.6	2.49
Appendicularia	53.8	22.1	27.5	103.4	19.72	89.6	32.1	16.7	138.4	22.13
Ostracoda						11.5	0.8	3.2	15.5	2.48
Copepoda	100	58.2	33.8	192	36.61	75.6	34.2	24.6	134.4	21.50
Cirripedia (nauplii)						3.7	0.7	2	6.4	1.02
Decapoda (larvae)						25.2	5.6	7.4	38.2	6.10
Mysidacea						6.2	0.3	2.1	8.5	1.36
Cladocera	100	12.7	26.8	139.5	26.60	84.1	22.4	12	118.5	18.93
Gastropoda (larvae)						11.8	0.9	17	29.7	4.74
Bivalvia (larvae)						5.9	0.9	7.3	14.1	2.25
Pisces										
Eggs	47.3	6.4	8.7	62.4	11.90	33.6	1.6	4.1	39.3	6.28
Larvae	23.1	0.8	3.2	27.1	5.17	61.6	1.6	4.2	67.4	10.77
Digested food	8.8		4.3			10.4		9.8		
	Spring					Autumn				
Polychaeta	3.1	0.2	2.1	5.4	0.80					
Appendicularia	78.2	26.8	22.8	127.8	18.87	78.7	30.5	23.3	132.5	24.85
Ostracoda	34.5	1.4	3.1	39	5.76					
Copepoda	95.8	43	33.8	172.6	25.48	100	44.4	27.8	172.2	32.30
Cirripedia (nauplii)	17.2	0.2	2.6	20	2.95					
Decapoda (larvae)	32.7	2.3	2.3	37.3	5.51					
Mysidacea	19.2	0.2	2.1	21.5	3.97					
Cladocera	75.9	23.3	18.8	118	17.42	85.1	21.9	34.2	141.2	26.48
Gastropoda (larvae)	24.9	0.3	2.9	28.1	4.15					
Bivalvia (larvae)	28.7	0.4	3.2	32.3	4.77					
Pisces										
Eggs	36.4	0.3	2.3	39	5.76	47.9	3.2	12.9	64	12
Larvae	30.7	1.6	4.1	36.4	5.37	21.3	0.2	1.8	23.3	4.37
Digested food	19.6		3.7							

Table 2: Contribution of the prey categories for damselfish stomach contents according to season.
Tabela 2: Delež posameznih kategorij plena v želodcih črnikov v različnih letnih časih.

Seasons	Winter	Spring	Summer	Autumn
% Ir	1.91	5.67	3.69	2.10
Group	8 - 65 mm		> 65 mm	
% Ir	6.83		3.80	

Table 3: Fullness index (Ir) in specimens analyzed by seasons.
Tabela 3: Hureaujev indeks (Ir) primerkov, raziskanih v različnih letnih časih.

Season	Winter	Spring	Summer	Autumn
Winter		0.70	0.67	0.93
Spring			0.80	0.71
Summer				0.69
Autumn				

Size group	8 - 65 mm	> 65 mm
8 - 65 mm		0.58
> 65 mm		

Table 4: Proportional food overlap coefficients (Schoener index) of damselfish between seasons.
Tabela 4: Količnik prekrivanja v prehrani (Schoenerjev indeks) črnika v posameznih letnih časih.

Feeding intensity was lowest in winter, indicated by the higher frequency of empty stomachs in each group (14% for Group 1 and 11% for Group 2).

Copepods constited the bulk of diet throughout the year (Table 2), exhibiting their highest values by number during spring and summer. Cladocerans and Appendicularia were the second important food categories. They were eaten regularly during all seasons.

Seasonal changes in RI were examined to detect which prey accounted for the differences in the diet. This analysis indicated a great importance of copepods in all seasons.

Food quantity in analyzed guts, expressed as the fullness index (Ir), was highest in spring (Ir = 5.67) and a significant drop was recorded for winter (Ir = 1.91) (Table 3).

Fischer's LSD test indicated that the mean fullness index was significantly higher in spring and summer. The application of ANOVA and multiple range tests to the seasonal data indicated significantly higher values in spring (ANOVA: $F = 12.424$, $P < 0.001$).

Values of Schoener's (1970) index of dietary overlap were obtained from a comparison (by weight) between the different size groups (0.58) and seasons (Table 4). Almost all the values were > 0.60, indicating high dietary overlap. Thus, the feeding spectrum of damselfish depends little across season of capture. The small variations of the principal prey items between the different seasons contributed to the high level of inter-season proportional overlap.

Damselfish in the eastern Adriatic fed primarily on crustaceans, mostly copepods (such as *Paracalanus parvus, Clausocalanus pergens* and *Centropages typicus)* and cladocerans *(Podon intermedius),* but also consumed Appendicularia, Gastropoda (larvae) and Bivalvia (larvae), fish eggs and fish larvae, mainly at larger lengths. Polychaetes, Cirripedia (nauplii), Mysidacea and Decapoda (larvae) were also occasionally found in the stomachs. These results are generally in accordance with the observation of Duka & Shevchenko (1980) off the Mediterranean coast of island Lampedusa and for damselfish from the Black Sea. Same authors mentioned that copepoda (Calanoida, Cyclopoida - 15 species) were the most abundant food items, that Appendicularia *(Oikopleura dioica)* ranked second in the Mediterranean, and that damselfish eggs and Appendicularia *(Oikopleura dioica)* were the most abundant food items in the Black Sea. Although no quantitative data on prey consumption of damselfish were given, it is not possible to compare the data on that basis. Mapstone & Wood (1975) revealed that damselfish feeds both on planktonic and benthic organisms; eight out of 11 individuals contained predominantly planktonic and three predominantly benthic organisms in the Azores.

The stomachs of both size groups were significantly fuller in spring and summer, while the lowest feeding intensity coincided with winter. Many factors could result in the reduction of feeding activity in fish (Nikolsky, 1976). Many of the demersal fishes show a decrease in the feeding rate as the temperature drops (Tyler, 1971). In the study area, the lower temperature of the water occurs during winter (February) and beginning of spring (Zore-Armanda *et al.,* 1991). Because of the reduced abundance of prey and the lowered metabolism of the fish, predation on plankton and benthos was probably at a minimum during winter. Regner (1985) presented, for the central Adriatic, that copepods showed larger number of annual maxima predominantly during the warmer part of the year: in spring, summer and autumn. This occurrence of a larger number of maxima may be due either to natural fluctuations or to the enrichment of coastal area by nutrients (eutrophication) as well as to the sufficient food available over a larger part of the year. Favourable environmental conditions during the warmer months and abundant food supply support the expanded fish community without competitive interactions. However, the effect of temperature may be confounded with the effects on other abiotic factors and/or in change in food availability (Worobec, 1984). Warren & Davis (1967) discussed the profound effects of temperature and seasons on food consumption rates. More food is consumed in summer than in winter, this was demonstrated (Davis & Warren, 1965) from the experiments with *Coltus perplexus.*

Reproduction, which takes place at the end of spring and during summer (Dulčić & Kraljević, 1995), seems to have effect on feeding intensity (gonadal maturation). Feeding behaviour of most of fish species considerably oscillates during the year as a consequence of a physiological changes during reproduction. Jardas & Pallaoro (1991) found that feeding intensity of *Scorpaena porcus* expressed by the index of gut fullness showed markedly lower values during spawning, whereas it was at almost the same level during the rest of the year, with slight intensity increase in the postspawning period. Similarly to damselfish, high degrees of stomach fullness were reported for other demersal fish in the same area, such as

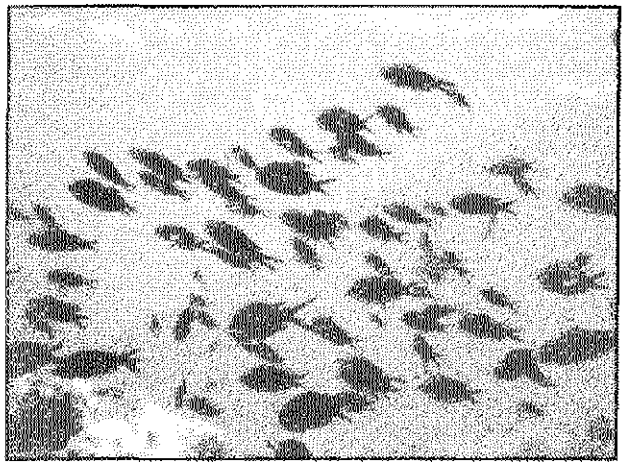

*Fig. 3: **School of Damselfish** (Chromis chromis) **(Photo: M. Richter).***
*Slika 3: **Jata črnikov** (Chromis chromis) **(Foto: M. Richter).***

Scorpaena porcus (Jardas & Pallaoro, 1991), indicating an abundance of food in this region even though this region contributes to oligotrophic area according to Buljan & Zore-Armanda (1976). The abundance of food in this region is connected with the upwelling in the area of Palagruža sill which is in vicinity of the studied area (Regner *et al.*, 1987). This occurs certainly more strongly during years with increased Mediterranean inflow at the time of strong advection of the intermediary water and also during the upwelling periods in spring and summer (Buljan, 1965). In the open central Adriatic the zooplankton (dry weight) shows a distinct spring maximum in March and April (Vučetić, 1973). Upwelling may be caused later in the spring-summer period by dominant coastward wind direction (the maestral). The spring maximum of the zooplankton is characterized by the presence of typical deep sea species; the maximal population densities at the beginning and by the end of summer are attained by the typical neritic species (Vučetić, 1973). The maximal quantities of zooplankton occurs firstly in the open sea and then farther towards the coast.

Dietary overlap is lower between summer and winter, when the metabolic demands are higher than for the rest of the year. This fact indicates that intraspecific competition for food between fish of the two groups is small, probably because of the different bathymetrical distribution of damselfishes at different size. The study of the bathymetrical distribution of the two groups revealed that younger specimens tended to inhabit smaller depths (Dulčić, unpublished data).

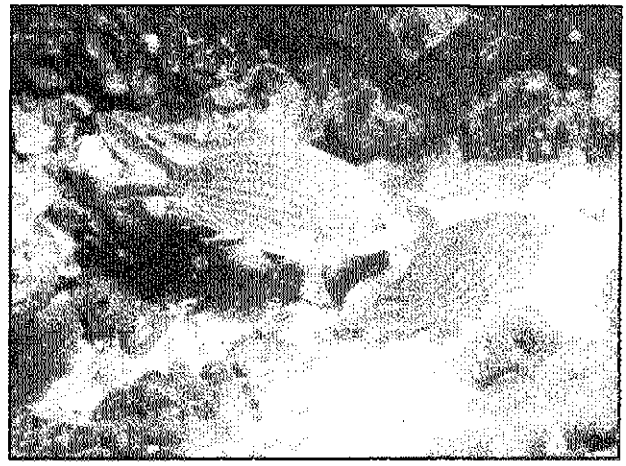

Fig. 4: Male and female damselfish. The male is waiting for the proper moment to fecundate the eggs (Photo: M. Richter).
Slika 4: Samec in samica črnika. Samec čaka, da se samica umakne, da lahko oplodi izmetana jaca (Foto: M. Richter).

POVZETEK

Črnik Chromis chromis *(Linnaeus 1758) je majhna riba, ki jo najdemo v plitvih vodah nad ali v bližini čeri ali pa nad travniki morske trave pozejdonke* (Posidonia oceanica), *in sicer v globini od 3 do 35 metrov. Živi v Sredozemskem morju in v vodah južno od Portugalske do Angole (Quignard & Pras 1986). V vzhodnem Jadranu je črnik številčen (Grubišić, 1982; Milišić 1994), vendar tam komercialno ni zanimiv (razen na otokih Šolti, Hvaru, Korčuli in Lastovem v srednjem Jadranu, kjer je zelo cenjen). V dalmatinskem obalnem ribištvu so črniki majhen, a pomemben sestavni del ulova z mrežami, uporabni predvsem kot slastna jed in vaba za jastoge.*

Da bi ocenili, s čim se črniki prehranjujejo glede na različne letne čase in velikost, je bila raziskana vsebina želodcev 964 osebkov, ujetih v vzhodnem srednjem Jadranu v letih 1992 in 1993. Črnik je mesojeda riba že od svojega mladostnega stadija naprej, hrani pa se le z določenimi planktonskimi in bentoškimi organizmi. Večjo prehranjevalno intenzivnost v spomladanskem času bi lahko pripisali temperaturnim spremembam in dozorelosti

spolnih žlez. Po biomasi, številu in pogostosti pojavljanja v celoletnem obdobju so bili ceponožci najpomembnejši vir hrane. Drugi najpomembnejši prehranjevalni vir so bili repati plaščarji in morske bolhe. Prehransko prekrivanje je bilo razmeroma izrazito, kar pomeni, da so razlike v prehranjevalnem spektru črnikov prek vseh štirih letnih časov majhne, medtem ko je bilo za velikostne skupine neznatno, kar kaže na večje spremembe v prehranjevalnem spektru.

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