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**COMPARATIVE STUDIES ON HERRING AND SPRAT FEEDING
IN THE SOUTHERN BALTIC WITHIN 1978–1982**

**PORÓWNANIE ODŻYWIANIA SIĘ ŚLEDZI I SZPROTÓW
W POŁUDNIOWYM BAŁTYKU W LATACH 1978–1982**

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The author compares herring and sprat feeding in the Southern Baltic within 1978–1982. Food composition, feeding intensity as well as diet overlap and food diversity of the two fish species are presented, seasonal variability being taken into account. Comparisons are made of the two species caught jointly and separately. In both groups individual comparisons are made for feeding of fish of differing (5.5–35.0 cm long herring, 5.5–15.0 cm sprat) and equal (10.5–15.0 cm long herring and sprat) size. In the four data sets thus obtained, differences are found to exist between the two species in terms of their food composition, feeding intensity, diet overlap, and food diversity.

INTRODUCTION

The herring and the sprat, two principal – along with cod – commercially exploited fish species in the Baltic, are pelagic, which determines a number of their biological similarities. The two species feed basically on the zooplankton, on calanoid copepods in

particular. Similar life habits of sprat and herring, similar or identical ecological niches occupied by the two species, and closely related feeding specialisations, on the one hand, determine the similarity of the two species food composition; on the other hand, the much faster growth rate of herring and its larger sizes attained result in its food encompassing also larger macroplankters and benthic animals.

In the present paper, an attempt is made to carry out a multifaceted comparison between sprat and herring feeding. Based on numerous and fairly representative data collected during a 5-yr study on feeding of the Baltic commercial fish species (Problem PR-4, topic 09.1.7, coordinated by the Sea Fisheries Institute in Gdynia), only those sprat and herring were compared that had been caught jointly. The results obtained from the data selected in this way should – when combined with the results of the sprat and herring feeding studies within 1978–1982 (Załączowski et al., 1978–1983) including all the individuals caught – answer the question whether it is possible to compare feeding of fish most of which were caught at different times and places.

MATERIALS AND METHODS

The basic materials comprise herring and sprat individuals caught jointly in the Southern Baltic within 1978–1982. Food and feeding of a total of 2424 individuals (1311 herrings and 1113 sprats) were examined. Those fishes made up more than 31% of all the individuals caught in the period mentioned for the feeding studies. Table 1 summarises the numbers of fish in various years and seasons. Additionally, to elucidate the fish size-related effects in food composition, the feeding of individuals of the same size (the length classes 10.5–15.0 cm are considered only, as the abundances of jointly caught herring and sprat of the same size in other length classes were negligible) selected from all those caught jointly, was looked into. The group of individuals of the same size and caught at the same time included 546 herrings and 612 sprats.

The first step was to determine the food composition and feeding intensity of the two species. The role of various food items is presented in two ways: as daily coefficients (weight of a given item consumed during 24 h vs. fish weight, in prodecimille, ‰) and as percentages of a daily ration. The daily ration magnitude was calculated from consumption indices, using Bajkov's formula for which the evacuation time was computed by means of the formulae given by Załączowski et al. (1978).

Next, the herring and sprat diet overlap was determined as in Šorygin (1952) and food diversity of the two species compared using the diversity coefficient (Szypuła, 1971). In the latter case, in order to determine food diversity as precisely as possible, food items were identified to species rather than down to the order level only, as had been the practice in previous studies.

Table 1

Materials collected

Species	Season		1978	1979	1980	1981	1982	Total
Herring	Winter	A	73	—	—	—	63	136
		B	41	—	—	—	41	82
	Spring	A	—	118	432	14	10	574
		B	—	74	197	—	—	271
	Summer	A	195	—	—	—	3	198
		B	58	—	—	—	—	58
	Autumn	A	181	94	—	—	128	403
		B	55	7	—	—	73	135
Total	A		449	212	432	14	204	1311
	B		154	81	197	—	114	546
Sprat	Winter	A	4	—	—	—	70	74
		B	3	—	—	—	58	61
	Spring	A	—	244	307	24	14	589
		B	—	154	204	—	—	358
	Summer	A	136	—	—	—	81	217
		B	109	—	—	—	—	109
	Autumn	A	49	34	—	—	150	233
		B	19	8	—	—	57	84
Total	A		189	278	307	24	315	1113
	B		131	162	204	—	115	612

A = all the individuals from joint catches, B = individuals of the same size from joint catches

RESULTS

a) Feeding of jointly caught sprat and herring of different size (5.5–35.0 cm long herring; 5.5–15.0 cm long sprat)

Table 2 presents feeding intensities (‰) and food composition (%) of all the herring and sprat caught jointly. The comparison is rendered as brief as possible, the seasonal differences in feeding being considered only.

The smallest differences in feeding intensities of the two species as measured with values of the total daily coefficient, occurred in spring and autumn, when the herring feeding intensity was higher, by about 1/5, than that of sprat. In winter, herring fed three times as intensively as sprat did, while in summer a reverse was observed: the total sprat

Table 2

Feeding of herring (a) and sprat (b); fish of different – size (herring: 5.5 – 35.0 cm;
sprat: 5.5 – 15.0 cm) caught jointly

Season Food item		Winter		Spring		Summer		Autumn		Annual mean	
		‰	%	‰	%	‰	%	‰	%	‰	%
<i>Temora</i>	a	3.77	19.0	13.23	26.0	63.34	56.8	6.84	13.5	21.79	37.5
<i>longicornis</i>	b	0.65	9.3	9.35	21.6	192.78	45.2	13.49	33.6	54.07	41.9
<i>Pseudocalanus</i>	a	11.46	57.6	28.38	56.0	35.28	31.6	11.34	22.5	21.61	37.2
<i>elongatus</i>	b	4.31	61.7	26.93	62.2	128.88	30.2	14.87	37.0	43.75	33.9
<i>Acartia</i>	a	0.05	0.3	0.18	0.4	0.23	0.2	0.08	0.2	0.13	0.2
<i>sp.</i>	b	0.71	10.2	1.42	3.3	26.76	6.3	2.20	5.5	7.77	6.0
<i>Oithona</i>	a	0.00	0.0	0.07	0.1	–	–	0.02	0.0	0.02	0.0
<i>similis</i>	b	–	–	0.00	0.0	–	–	–	–	0.00	0.0
<i>Calanoida</i>	a	1.80	9.0	6.21	12.2	6.73	6.0	2.44	4.8	4.29	7.4
<i>indet.</i>	b	0.89	12.8	4.67	10.8	54.06	12.7	8.49	21.1	17.03	13.2
<i>copepodit</i>	a	0.48	2.4	1.64	3.2	1.17	1.1	0.68	1.3	0.99	1.7
	b	0.42	6.0	0.90	2.1	9.48	2.2	1.12	2.8	2.98	2.3
<i>Bosmina cor.</i>	a	–	–	–	–	0.10	0.1	–	–	0.02	0.0
<i>maritima</i>	b	–	–	–	–	5.34	1.3	–	–	1.33	1.0
<i>Podon</i>	a	–	–	–	–	0.43	0.4	–	–	0.11	0.2
<i>sp.</i>	b	–	–	–	–	5.28	1.2	–	–	1.32	1.0
<i>Evadne</i>	a	–	–	–	–	0.17	0.2	–	–	0.04	0.1
<i>sp.</i>	b	–	–	–	–	3.66	0.9	–	–	0.91	0.7
<i>Mysis</i>	a	2.29	11.5	0.27	0.5	–	–	18.51	36.6	5.27	9.1
<i>mixta</i>	b	–	–	–	–	–	–	–	–	–	–
<i>Neomysis</i>	a	0.04	0.2	0.00	0.0	0.16	0.1	0.24	0.5	0.11	0.2
<i>vulgaris</i>	b	–	–	–	–	–	–	–	–	–	–
<i>Pontoporeia</i>	a	–	–	0.37	0.7	3.89	3.5	0.42	0.8	1.17	2.0
<i>affinis</i>	b	–	–	–	–	–	–	–	–	–	–
<i>Pontoporeia</i>	a	–	–	0.36	0.7	–	–	–	–	0.09	0.2
<i>femorata</i>	b	–	–	–	–	–	–	–	–	–	–
<i>Gammarus</i>	a	–	–	–	–	–	–	0.03	0.1	0.01	0.0
<i>sp.</i>	b	–	–	–	–	–	–	–	–	–	–
<i>Diastylis</i>	a	–	–	0.05	0.1	–	–	–	–	0.01	0.0
<i>rathkei</i>	b	–	–	–	–	–	–	–	–	–	–
<i>Crangon</i>	a	–	–	–	–	–	–	0.87	1.7	0.22	0.4
<i>crangon</i>	b	–	–	–	–	–	–	–	–	–	–
<i>Antinoella</i>	a	–	–	0.03	0.1	–	–	–	–	0.01	0.0
<i>sarsi</i>	b	–	–	–	–	–	–	–	–	–	–
<i>Pisces</i>	a	–	–	–	–	–	–	9.09	18.0	2.27	3.9
	b	–	–	–	–	–	–	–	–	–	–
Total	a	19.89	100.0	50.79	100.0	111.50	100.0	50.56	100.0	58.16	100.0
	b	6.98	100.0	43.27	100.0	426.24	100.0	40.17	100.0	129.16	100.0

‰ = daily coefficient; % = contribution to daily ration

daily coefficient was almost four times that of herring. Such a large difference in the intensity of feeding between the two species in summer (when both herring and sprat consumed most of their food) resulted in the annual mean daily coefficient of sprat being twice that of herring.

The basic difference in food composition between herring and sprat is the fact that the food of the first contains certain macroplanktonic and benthic organisms (*Mysidacea*, *Amphipoda*, *Decapoda*, *Cumacea*, *Polychaeta*, and *Pisces*). Those items make up 57.7% of the food in autumn. The most important autumn items in the herring food are *Mysis mixta* and the *Pisces*. On the other hand, the sprat food contains exclusively mesoplankters (*Copepoda* and, to some extent, *Cladocera*) which are also the basic food items for herring in winter, spring, and summer.

The differences between contributions of various items to sprat and herring diets are usually not too big and most frequently do not exceed 10% (except for the autumn season). Still smaller differences are observed in the annual average diets of the two fish species: the largest differences here (5.8% each) are in the contribution of *Acartia* sp. and unidentified calanoids. With regard to the total food, however, the maximum difference involves *Mysis mixta* (9.1% in the food of herring and absent from the food of sprat).

Among the mesoplankters — food items for both herring and sprat, the most conspicuous species are *Pseudocalanus elongatus* and *Temora longicornis*. The first clearly predominates in the mesoplanktonic food of herring and in the sprat diet in winter and spring (and to a lower extent in autumn), while the other is a dominant in both diets in summer. Besides, all seasonal samples show a higher contribution of *Acartia* sp. to the food of sprat. Also the *Cladocera*, found in the two diets in summer only, are a much more important food item for sprat than for herring.

The first part of Table 4 contains data on the herring and sprat diet overlap by seasons. These data support the considerations presented above on differences between contributions of various organisms to herring and sprat diets. The highest food overlap (90.9%) is recorded in spring when herring consumes the fewest macroplankters and benthic animals. On the other hand, in autumn, the highest percentage of the macroplankton and benthos in the food of herring is accompanied by the lowest overlap (42.3%). The annual mean overlap, calculated as an arithmetic mean of the seasonal values, is rather high (73.8%) and points to herring and sprat feeding being closely related over the year.

The third method of comparing the feeding of sprat and herring was to determine their food diversities and compare them in various seasons. As seen from the data in the first part of Table 4, it is only in summer that the food diversity coefficient in sprat is higher than that in herring. In the remaining seasons, the food of herring was more diversified than that of sprat, which can be regarded as a result of herring feeding on the macroplankton and benthos; the largest difference between the food diversity coefficients was recorded in autumn.

Table 3

Feeding of herring (a) and sprat (b): fish of equal size (10.5–15.0 cm) caught jointly

Season – Food item		Winter		Spring		Summer		Autumn		Annual mean	
		‰	%	‰	%	‰	%	‰	%	‰	%
Temora	a	4.78	18.5	10.50	24.3	16.00	48.6	21.15	34.2	13.11	32.1
longicornis	b	1.16	6.6	9.09	22.5	150.24	51.2	15.67	41.2	46.54	45.4
Pseudocalanus	a	17.23	66.8	24.82	57.5	11.53	35.0	30.35	49.2	20.98	51.3
elongatus	b	12.77	72.1	25.76	63.9	85.28	27.3	14.04	37.0	34.46	33.7
Acartia	a	0.07	0.3	0.29	0.7	0.41	1.3	0.29	0.5	0.26	0.6
sp.	b	1.78	10.1	1.20	3.0	23.92	7.6	0.73	1.9	6.91	6.8
Oithona	a	—	—	0.13	0.3	—	—	0.13	0.2	0.06	0.1
similis	b	—	—	0.00	0.0	—	—	—	—	0.00	0.0
Calanoida	a	3.43	13.3	6.25	14.5	3.33	10.1	7.76	12.6	5.19	12.7
indet.	b	1.94	10.9	3.56	8.8	33.04	10.6	6.81	17.9	11.34	11.1
copepodit	a	0.29	1.1	1.20	2.7	0.63	1.9	2.03	3.3	1.04	2.6
	b	0.05	0.3	0.73	1.8	4.08	1.3	0.74	2.0	1.40	1.4
Bosmina cor.	a	—	—	—	—	0.96	2.9	—	—	0.24	0.6
maritima	b	—	—	—	—	5.68	1.8	—	—	1.42	1.4
Podon	a	—	—	—	—	0.06	0.2	—	—	0.01	0.0
sp.	b	—	—	—	—	0.72	0.2	—	—	0.18	0.2
Total	a	25.80	100.0	43.19	100.0	32.92	100.0	61.71	100.0	40.89	100.0
	b	17.70	100.0	40.34	100.0	312.96	100.0	37.99	100.0	102.25	100.0

‰ = daily coefficient; % = contribution to daily ration

Table 4

Diet overlap (%) and food diversity (a) of herring and sprat caught jointly

Season	Herring: 5.5–35.0 cm; sprat: 5.5–15.0 cm			Herring and sprat 10.5–15.0 cm		
	%	a		%	a	
		Herring	Sprat		Herring	Sprat
Winter	78.6	2.57	2.38	84.9	2.01	1.83
Spring	90.9	2.52	2.24	91.3	2.43	2.14
Summer	83.4	2.34	3.16	90.6	2.70	2.82
Autumn	42.3	4.20	3.35	86.3	2.66	2.95
Annual mean	73.8	2.91	2.78	88.3	2.45	2.43

b) Feeding of jointly caught herring and sprat of the same size (10.5–15.0 cm)

Table 3 contains data on feeding intensity of food composition of herring and sprat of the same size, caught jointly. Differences in feeding intensities of the two species in winter, spring, and autumn are not too wide; however, in every case – similarly to the feeding intensities of the fish differing in size – herring was shown to feed with a higher intensity. In summer, on the other hand, the two species differed in their feeding intensities by the factor of almost 10 in favour of sprat. It should be reminded here that among the fishes of differing size, sprat fed in summer with an intensity only 4 times higher than did herring. However, summer values of the total daily coefficient were clearly lower than those calculated for the fish of differing size. Relationships between the annual mean daily coefficients of sprat and herring looked similar to those in the differently sized fish: sprat fed with an intensity almost twice that of herring. It should be, however, pointed out that the feeding intensities of herring and sprat of the same size were clearly lower than those in the fish differing in size. Generally, though, the seasonal pattern of feeding intensity dynamics of the two species was fairly similar in the two size groups of fish.

On the other hand, the comparison of diet composition of herring and sprat of the same size brings results completely different from those obtained in the previous case. The food of the 10.5–15.0 cm long herring was found to contain neither the macroplankton nor the benthos, hence the diets of the two species were in this case more similar than when the diets of differently sized herring and sprat were compared. Differences in various food item percentages do not exceed few per cent. The highest absolute difference (17.6% in favour of herring) between the annual mean percentages was recorded in the contribution of *Pseudocalanus elongatus*, while the highest relative difference – in favour of sprat this time – could be assigned to *Acartia* sp., its contribution to the sprat diet being more than 11 times that in the food of herring.

Here, too, the data on herring and sprat diet overlap (the fish of equal size) (part two in Table 4) support the considerations presented above on differences between the two species' diets. The overlap between diets of the fish of equal size was much higher than that in the differently sized fish, the annual means differing by 14.5% in favour of the first. Moreover, the seasonal data showed always higher values to be found in the fish of the same size, the widest difference in the overlap values (44.0%) being recorded in autumn.

Food diversity of herring and sprat of equal size was clearly lower than that in the fish of differing size, both seasonally and in terms of the annual mean food diversity coefficient. Besides, discrepancies in food diversity of the two species were much lower in the fish of equal size than in the other group of herring and sprat, the respective differences between annual mean coefficients being 0.02 and 0.13.

DISCUSSION

A similarity in feeding, particularly the similar diet compositions in species occupying the same ecological niches, can be treated as a result of similar adaptations to feeding on a certain type of food. When the same resources are available to the fish species studied, the degree of overlap of their diets will be related to the availability of various food items to each of the species, and further related to the trophic adaptations mentioned.

A similarity of food compositions is a prerequisite of a possible competition for food. It should be, however, understood that even a high diet overlap does not automatically mean the competition as the competition for food may result only form a deficit of a resource relative to the requirements of species consuming a similar type of food. As stated by Nilsson (1967), diet overlap increases with increasing resources, so a large overlap is typical of situations when the species taking up a similar, abundant food do not compete. Thus a fairly large diet overlap of herring and sprat could be regarded as an evidence of good feeding conditions the two species were encountering over the period of study.

According to Hansson (1981), competition — both in terms of food as a resource and of certain ecological niches (the author determined the interspecific competition by means of an index combining the diet overlap index and an overlapping occurrence of the species in various fishing grounds) — can be treated as an important factor affecting the geographic distribution of various fish species.

The presented differences in feeding of jointly caught herring and sprat allow to single out the fish size as a factor affecting the similarity of diets. This is a result of larger (more than 15.0 cm) herring taking up additionally macroplanktonic and benthic items which are altogether absent from the food of sprat. This is the reason why the diet overlap of all the herring and sprat caught jointly is in every season (particularly in autumn) lower than that of the fish of equal size. Consequently, the mere fact of sharing a feeding ground is in itself insufficient to influence the diet overlap; fish size plays an important part.

To further elucidate the question whether the feeding of jointly caught herring and sprat differs from the feeding of these species caught separately, a comparison, identical as that in the results section, was made for all the materials examined within 1978–1982 (a total of 7793 individuals partitioned into 5074 herrings and 2719 sprats). The data on feeding intensity and food composition of the fish of differing size are given in Table 5; Table 6 contains respective data for the fish of equal size (10.5–15.0 cm), while Table 7 compares diet overlaps and diversity in the two size sets.

The seasonal dynamics of feeding intensity of the two species compared shows a different pattern in the entire material than was the case with respect to the jointly caught fish. For example, the maximum feeding intensity of herring differing in size is recorded in spring and is slightly lower in summer (the herring caught jointly with sprat showed the summer daily coefficient to be almost twice the spring one). Different are also seasonal relationships between feeding intensities of the two species: in the jointly caught fish, the sprat feeding was more intensive than that of herring in summer only,

Table 5

Feeding of herring (a) and sprat (b); fish of different size (herring: 5.5–35.0 cm; sprat: 5.5–15.0 cm) from the entire material examined within 1978–1982

Season Food item		Winter		Spring		Summer		Autumn		Annual mean	
		‰	%	‰	%	‰	%	‰	%	‰	%
Temora	a	2.05	16.1	30.49	26.7	46.84	43.8	8.34	15.2	21.93	30.4
longicornis	b	1.97	12.8	12.41	21.0	160.32	38.4	40.63	24.1	53.83	32.5
Pseudocalanus	a	5.82	45.8	52.99	46.5	32.81	30.6	14.12	25.8	26.43	36.7
elongatus	b	9.92	64.5	34.83	58.9	121.88	29.1	80.04	47.4	61.67	37.3
Acartia	a	0.03	0.2	0.44	0.4	0.35	0.3	0.08	0.1	0.22	0.3
sp.	b	1.93	12.5	2.12	3.6	21.76	5.2	5.79	3.4	7.90	4.8
Oithona	a	0.00	0.0	0.08	0.1	0.02	0.0	0.02	0.0	0.03	0.0
similis	b	—	—	0.00	0.0	—	—	—	—	0.00	0.0
Calanoida	a	1.53	12.0	13.66	12.0	13.65	12.7	2.80	5.1	7.91	11.0
indet.	b	1.25	8.1	8.34	14.1	79.79	19.1	32.99	19.6	30.59	18.5
copepodit	a	0.24	1.9	2.74	2.4	2.87	2.7	0.78	1.4	1.66	2.3
	b	0.32	2.1	1.41	2.4	13.48	3.2	9.20	5.5	6.10	3.7
Bosmina cor.	a	—	—	—	—	0.72	0.7	—	—	0.18	0.2
maritima	b	—	—	—	—	4.16	1.0	—	—	1.04	0.6
Podon	a	—	—	—	—	0.05	0.0	—	—	0.01	0.0
sp.	b	—	—	—	—	9.72	2.3	—	—	2.43	1.5
Evadne	a	—	—	—	—	0.28	0.3	—	—	0.07	0.1
sp.	b	—	—	—	—	7.32	1.7	—	—	1.83	1.1
Mysis	a	3.03	23.8	12.32	10.8	2.89	2.7	17.36	31.7	8.90	12.3
mixta	b	—	—	—	—	—	—	—	—	—	—
Neomysis	a	0.00	0.0	0.01	0.0	3.34	3.1	0.99	1.8	1.08	1.5
vulgaris	b	—	—	—	—	—	—	—	—	—	—
Pontoporeia	a	—	—	0.29	0.3	0.18	0.2	0.11	0.2	0.14	0.2
affinis	b	—	—	—	—	—	—	—	—	—	—
Pontoporeia	a	—	—	0.79	0.7	0.36	0.3	—	—	0.29	0.4
femorata	b	—	—	—	—	—	—	—	—	—	—
Gammarus	a	—	—	—	—	—	—	0.02	0.0	0.00	0.0
sp.	b	—	—	—	—	—	—	—	—	—	—
Hyperia	a	0.01	0.1	—	—	—	—	—	—	0.00	0.0
galba	b	—	—	—	—	—	—	—	—	—	—
Diastylis	a	—	—	0.11	0.1	2.77	2.6	0.66	1.2	0.88	1.2
rathkei	b	—	—	—	—	—	—	—	—	—	—
Crangon	a	—	—	—	—	—	—	0.17	0.3	0.04	0.1
crangon	b	—	—	—	—	—	—	—	—	—	—
Antinoella	a	0.01	0.1	0.02	0.0	—	—	5.67	10.3	1.42	2.0
sarsi	b	—	—	—	—	—	—	—	—	—	—
Pisces	a	—	—	—	—	—	—	3.81	6.9	0.95	1.3
	b	—	—	—	—	—	—	—	—	—	—
Total	a	12.72	100.0	113.94	100.0	107.13	100.0	54.93	100.0	72.14	100.0
	b	15.39	100.0	59.11	100.0	418.43	100.0	168.65	100.0	165.39	100.0

‰ = daily coefficient; % = contribution to daily ration

while in the whole set of individuals examined, sprat turned out to have fed with a higher intensity in winter, summer, and autumn. The annual mean daily coefficients were clearly higher in the entire set of data, by the factors of 1.24 and 1.28 for herring and sprat, respectively.

Qualitatively, almost the same food items occur in the diets of jointly and separately caught herring, the only difference being a very low percentage of *Hyperia galba* in the food of all the herring of different size and the absence of this item in the diet of herring caught jointly with sprat.

Quantitatively, however, the food composition of all the herring differing in size deviates somewhat from that found for the herring caught jointly with sprat. In the first group, clearly higher percentages of the macroplankton and benthos were observed in winter, spring, and summer, while in autumn (it was this season only that the macroplankton and benthos prevailed in the food of herring) the reverse was the case. However, the annual mean percentage of macroplankton and benthos (19%) was slightly higher in the first group of fish than in the other (15.8%).

With respect to sprat, the largest difference between the food composition of all the individuals of different size and the sprat caught jointly with herring is the contribution of *Temora longicornis* (a 9.4% difference in favour of the latter group). Another marked difference (this time in favour of the first group of sprat) is evident in the percentage of unidentified calanoid copepods.

The herring and sprat diet overlaps as determined in the entire set of differently sized individuals (first part of Table 7) was slightly lower than that determined for the jointly caught fish. Seasonal fluctuations in diet overlaps were lower in the first group as well.

The differently sized sprat and herring food diversity was larger than that in the jointly caught fish. The differences were particularly well-marked in herring (an annual mean of 3.63 vs. 2.91 for herring caught jointly with sprat). On the other hand, the corresponding difference in sprat is small (0.06). In the entire data set collected, the fish of different size show particularly large discrepancies in their food diversity (a difference of 0.79 in favour of herring).

When considering the feeding of all the 10.5–15.0 cm long herring and sprat (Table 6), it is seen that seasonal patterns of feeding intensity in the two species are similar to those recorded for the differently sized fish: it is in spring only that herring fed with a higher intensity, while sprat did so in the remaining seasons. The largest absolute difference between feeding intensities of the two species was observed in summer. The annual mean daily coefficient in sprat is twice the value in herring. Clearly smaller differences between feeding intensities of differently sized fish and the 10.5–15.0 cm long ones were observed in the entire material studied as compared with the corresponding differences determined for the jointly caught fish. The 10.5–15.0 cm long herring and sprat, similarly to the individuals differing in size, were shown to have fed with intensities higher by the factors of 1.87 and 1.54 for herring and sprat, respectively, when the entire material was taken into account.

Table 6

Feeding of herring (a) and sprat (b); fish of equal size (10.5–15.0 cm) from the entire material examined within 1978–1982

Season		Winter		Spring		Summer		Autumn		Annual mean	
Food item		‰	%	‰	%	‰	%	‰	%	‰	%
Temora longicornis	a	1.73	16.6	27.88	27.2	62.57	43.6	17.17	35.0	27.34	35.8
	b	1.49	12.2	8.78	21.7	171.78	41.4	38.12	23.6	55.04	34.9
Pseudocalanus elongatus	a	5.79	55.7	56.42	54.9	44.12	30.8	24.32	49.6	32.66	42.8
	b	8.11	66.4	23.94	59.3	125.04	30.0	76.87	47.6	58.49	37.2
Acartia sp.	a	0.06	0.6	0.37	0.4	0.53	0.4	0.29	0.6	0.31	0.4
	b	1.40	11.5	1.34	3.3	24.84	6.0	5.33	3.3	8.23	5.2
Oithona similis	a	0.00	0.0	0.18	0.2	0.04	0.0	0.03	0.1	0.06	0.1
	b	—	—	0.00	0.0	—	—	—	—	0.00	0.0
Calanoida indet.	a	1.72	16.6	14.42	14.0	24.17	16.9	5.66	11.5	11.49	15.0
	b	1.14	9.3	5.23	13.0	61.80	14.8	32.35	20.0	25.13	15.9
copepodit	a	0.20	1.9	3.40	3.3	6.99	4.9	1.57	3.2	3.09	4.0
	b	0.07	0.6	1.08	2.7	12.24	2.9	8.98	5.5	5.59	3.6
Bosmina cor. maritima	a	—	—	—	—	2.77	1.9	—	—	0.69	0.9
	b	—	—	—	—	3.42	0.8	—	—	0.85	0.5
Podon sp.	a	—	—	—	—	0.01	0.0	—	—	0.00	0.0
	b	—	—	—	—	9.78	2.3	—	—	2.44	1.5
Evadne sp.	a	—	—	—	—	2.18	1.5	—	—	0.54	0.7
	b	—	—	—	—	7.32	1.8	—	—	1.83	1.2
Mysis mixta	a	0.89	8.6	—	—	—	—	—	—	0.22	0.3
	b	—	—	—	—	—	—	—	—	—	—
Total	a	10.39	100.0	102.67	100.0	143.38	100.0	49.04	100.0	76.40	100.0
	b	12.21	100.0	40.37	100.0	416.22	100.0	161.65	100.0	157.60	100.0

‰ = daily coefficient ; % = contribution to daily ration

Table 7

Diet overlap (%) and food diversity (a) of herring and sprat from the entire material examined within 1978–1982

Season	Herring: 5.5–35.0 cm; Sprat: 5.5–15.0 cm			Herring and sprat: 10.5–15.0 cm		
	%	a		%	a	
		Herring	Sprat		Herring	Sprat
Winter	68.8	3.26	2.20	78.4	2.73	2.09
Spring	82.3	3.18	2.42	92.7	2.52	2.40
Summer	84.2	3.28	3.66	91.8	3.16	3.46
Autumn	47.6	4.79	3.07	86.5	2.61	3.06
Annual mean	70.7	3.63	2.84	87.3	2.75	2.75

The diets of the 10.5–15.0 cm long herring and sprat were similar in their composition, the differences in various items' contributions to seasonal samples not exceeding few per cent. *Pseudocalanus elongatus* was responsible for the highest difference (5.14% in favour of sprat) between annual mean compositions. One should mention here that the diet of the 10.5–15.0 cm long herring contained a macroplanktonic/benthic item, viz. *Mysis mixta* (0.6%), while the food of herring caught jointly with sprat was exclusively mesoplanktonic.

The diet overlap between the 10.5–15.0 cm long herring and sprat (second part of Table 7) was, similarly to that for the species caught jointly, much higher than that for the differently sized fish. When, however, one compares the overlaps for the 10.5–15.0 cm fish in the entire material and in the joint catches, the latter proves somewhat higher.

Food diversities of the 10.5–15.0 cm herring and sprat were very similar to each other as evidenced by the values of the annual mean food diversity coefficients, identical in the two species (2.75). However, sprat showed more pronounced seasonal fluctuations of the coefficient. Similarly to the case of the differently sized fish, the 10.5–15.0 cm herring and sprat of the entire material set showed a clearly higher food diversity than did this group of fish caught jointly.

CONCLUSIONS

1. Patterns of herring and sprat feeding depend to some extent on the selection of data, i.e., the entire material vs. the individuals caught jointly. An additional factor affecting the degree of similarity in feeding of the two species is the fish size.
2. Herring was found to have fed with a much lower intensity than sprat. Those individuals of both species caught jointly seemed to show a lower feeding intensity than that found for the entire material. Fish size-dependent differences in feeding intensity of one species were much more pronounced in the jointly caught fish.
3. Differences between the herring and sprat food compositions were much more clear-cut in the differently sized individuals than in those of equal size. The differences in food composition between the two species were somewhat more pronounced in the entire material than in joint catches. These regularities are confirmed by data on diet overlap between the two species.
4. Both in herring and sprat, food diversity was much higher when the entire material was analysed. A comparison between the species in terms of their food diversity showed usually herring to take up a more diversified food, the differences being much more pronounced in the differently sized individuals.
5. The differences between the two species with regard to their feeding, as determined by various criteria (conclusions 2–4) can be generally accounted for by the presence of macroplanktonic and benthic items in the food of larger herring and a complete absence of those items from food of sprat.

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**„PORÓWNANIE ODŻYWIANIA SIĘ ŚLEDZI I SZPROTÓW
W POŁUDNIOWYM BAŁTYKU W LATACH 1978–1982”**

Streszczenie

Zasadniczą częścią przeprowadzonych badań było porównanie odżywiania się śledzi i szprotów łowionych w okresie 1978–1982 we wspólnych zaciągach. Ogółem zbadano 2424 ryby, z czego 1311 śledzi i 1113 szprotów. Dodatkowo, z tak wyselekcjonowanego materiału wybrano tylko te śledzie i szproty, których rozmiary wynosiły 10,5–15,0 cm, a to w celu wyjaśnienia wpływu rozmiarów ciała na większe lub mniejsze podobieństwo odżywiania się badanych gatunków.

Dla przedyskutowania uzyskanych wyników i wykazania ewentualnych różnic w odżywianiu się ryb łowionych we wspólnych zaciągach i wszystkich zbadanych ryb, określono również odżywianie się śledzi i szprotów na podstawie całego zbadanego w omawianym okresie materiału (7793 ryby, w tym 5074 śledzie i 2719 szprotów). Zastosowano również w tym przypadku, poza określeniem odżywiania się ryb o zróżnicowanych rozmiarach, dodatkową selekcję materiału i wybranie tylko tych ryb, których rozmiary wynosiły 10,5–15,0 cm.

W badaniach uwzględniono intensywność żerowania obydwu gatunków (wyrażoną współczynnikiem dobowym), ich skład pokarmu, określony udziałem poszczególnych składników w racji dobowej, oraz zbieżność i zróżnicowanie pokarmu.

Uzyskane wyniki wykazały, że intensywność żerowania ryb łowionych we wspólnych zaciągach jest niższa, niż wyliczona dla całego zbadanego materiału. Różnice w intensywności żerowania wszystkich ryb i ryb złowionych we wspólnych zaciągach są większe w grupie ryb o tych samych rozmiarach (10,5–15,0 cm). We wszystkich przypadkach (biorąc pod uwagę średnie roczne wartości) stwierdzono znacznie wyższą intensywność żerowania szprotów, niż śledzi.

W składzie pokarmu wyraźniejsze różnice pomiędzy śledziem i szprotem wystąpiły w grupie ryb o zróżnicowanych rozmiarach, co można wiązać z występowaniem w pokarmie większych śledzi składników makroplanktonowych i bentosowych, które nie były spotykane w pokarmie szprota. Nieco wyraźniejsze różnice stwierdzono w całym zebranym materiale (w tym przypadku udział

makroplanktonu i bentosu w pokarmie śledzia był nieco wyższy, niż w przypadku ryb łowionych we wspólnych zaciągach). Natomiast przy porównywaniu składu pokarmu ryb o tych samych rozmiarach podobieństwo składu pokarmu śledzia i szprota było znacznie większe, chociaż i tutaj minimalnie większe rozbieżności zaobserwowano w całym zbadanym materiale. Omówione powyżej dane zostały potwierdzone określeniem zbieżności pokarmowej śledzia i szprota we wszystkich zastosowanych wariantach.

Zróżnicowanie pokarmu śledzia i szprota wykazywało znacznie większe rozbieżności przy badaniu tego zagadnienia u ryb o różnych rozmiarach (u śledzi i szprotów o wymiarach 10,5–15,0 cm współczynnik zróżnicowania przyjmował bardzo zbliżone, lub nawet identyczne – w odniesieniu do całego zbadanego materiału – wartości). Zaobserwowano również wyższe wartości współczynnika zróżnicowania przy badaniu całego materiału, zarówno u ryb o zróżnicowanych rozmiarach, jak i o rozmiarach 10,5–15,0 cm.

Jerzy Szypuła

СРАВНИТЕЛЬНЫЙ АНАЛИЗ ПИТАНИЯ СЕЛЬДИ
И ШПРОТ В ЮЖНОЙ ЧАСТИ БАЛТИЙСКОГО БАССЕЙНА
В 1978–1982 ГГ.

Р е з ю м е

Основной частью проведённых исследований было сравнение питания сельди и шпрот, выловленных за период 1978–1982 в смешанных тралениях. Всего исследовано 2424 особи, из которых 1311 особей сель-

ди и 1113 особей шпрот. Дополнительно, из предварительно отобранного материала были выбраны только те особи сельди и шпрот, размеры которых были в границах 10,5 - 15,0 см, с целью установления влияния размеров рыб на большее или меньшее сходство в питании исследуемых видов.

Для обсуждения полученных результатов и обнаружения возможных различий в питании рыб, выловленных в смешанных тралениях, и всех исследованных рыб, определено также питание сельди и шпрот на основе всего исследованного в указанном периоде материала (7795 рыб, из которых 5074 особи сельди и 2713 - шпрот).

В этом случае, кроме определения питания рыб дифференцированных размеров, применялась дополнительная селекция материала и отбор только тех рыб, размеры которых были в границах 10,5 - 15,0 см.

В исследованиях приняты во внимание интенсивность жора обоих видов (выражена суточным коэффициентом), состав корма, определённый долей отдельных составляющих в суточном рационе, а также сходство и различие корма.

Полученные результаты показали, что интенсивность жора рыб, выловленных при смешанных тралениях более низкая, чем вычисленная для всего исследованного материала.

Различия в интенсивности жора всех рыб и рыб, выловленных при совместном тралении, большие в группе рыб тех же размеров (10,5 - 15,0 см). Во всех

случаях (принимая во внимание среднегодовые величины) интенсивность жора шпротов значительно больше интенсивности жора сельди.

В составе корма более явные различия между сельдью и шпротами были выявлены в группе рыб дифференцированных размеров, что можно связывать с обнаружением в пище сельди больших размеров макропланктона и бентоса, которые не были обнаружены в пище шпрот.

Более отчётливые различия были определены во всём собранном материале (в этом случае доля макропланктона и бентоса в пище сельди была более высокая, чем в пище рыб, выловленных при совместных тралениях).

Зато при сравнении состава пищи рыб указанных размеров, сходство состава пищи сельди и шпрот было гораздо большим, хотя и здесь минимально большие расхождения наблюдались во всём исследуемом материале.

Оговоренные выше данные подтвердились определением сходства пищи сельди и шпрот во всех исследованных вариантах.

Неоднородность пищи сельди и шпрот обнаруживала гораздо большие расхождения при исследовании этого вопроса у рыб разных размерных групп (у сельди и шпрот 10,5 - 15,0 см коэффициент дифференциации принимал очень близкие, или даже идентичные значения, относительно всего исследованного материала). Наблюдались также более высокие значения коэффициента дифференциации при исследова-

нии всего материала, как у рыб неоднородных размеров, так и у рыб размером 10,5 - 15,0 см.

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