POLSKA AKADEMIA NAUK
INSTYTUT ZOOLOGICZNY

ANNALES ZOOLOGICI

Tom XXVIII Warszawa, 30 XII 1970 Nr 7

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Population variation in smelt – *Osmerus eperlanus* (Linnaeus, 1758) (*Pisces*) in Poland

[With 6 figures, 15 tables and 1 map in the text]

The smelt have been little studied in Poland. There are only a few papers on smelt concentrating mostly on their biology. Smelt have been considered mainly from a fishermen's point of view and as they are of little commercial value, that interest was rather limited. World literature on the family *Osmeridae* including the smelt is, however, quite extensive and McAllister (personal communication) mentions that his bibliography cards contains no less than 1250 references.

The genus *Osmerus* Linnaeus, 1758 contains now but single species *Osmerus eperlanus* (Linnaeus, 1758), divided into two subspecies *O. eperlanus eperlanus* (L.) and *O. eperlanus mordax* (Mitch.) (McAllister, 1963). Whilst the latter inhabits Western Atlantic, Pacific and Arctic Oceans as well as their drainages, the first has a more limited range and is known from North and Baltic Seas and their drainages. In Poland it occurs in lakes in the northern third of the country and penetrates rivers. While some data on distribution of smelt has never been analysed and the filling in this gap is the main purpose of the present paper.

The smelt samples analysed here came from the following 9 lakes, lagoons and sea.

1. Zatoka Pomorska. The only sea smelt population sample analysed in this paper was caught 0.5 kilometres from shore, NE from Świnoujście on May 14th, 1964. The salinity in that area of Baltic Sea is rather low and amounts to $7^0/_{00}$.

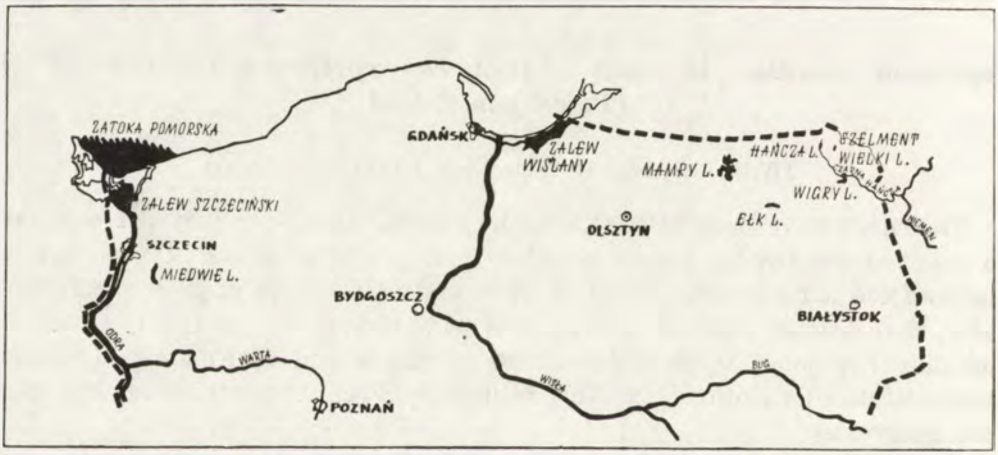
2. Zalew Szczeciński. Vast lagoon of the Odra River near its estuary, separated from the Baltic Sea by islands Uznam and Wolin but connected with it by three narrow branches of the river. The maximum depth is 8, mean depth 4 metres. Smelt were caugth on September 18th, 1962.

3. Zalew Wiślany. Long and relatively narrow lagoon formed by one of Wisła River delta branches. An intermediary brackish environment characterized by a considerable variation of hydrobiological factors, the salinity alone varying from 0.12 to $6^0/_{00}$ in relation

to seasonal flooding by fresh river water or marine transgression. The greatest width of the lagoon is 13 kilometres the biggest depth — 5 metres. The smelt sample was caught in June 1961.

4. Miedwie Lake. The largest lake in the Odra River drainage basin, narrow and long, is formed by River Płonia connecting it with neighbouring lakes. The shore line is poorly developed, shores low and in some places marshy. The surface 3377 hectares, maximum length 15.3 kilometres, maximum width 3.2 kilometres, maximum depth 42 and average depth 20 metres, altitude 14 metres above sea level. The fauna of the lake includes some glacial age relicts like *Mysis oculata relicta* LÖVEN, *Pallasea quadrispinosa* G. O. SARS and *Pantoporeia affinis* (BRUZELIUS). My material was caught on March 15th and 29th, 1966.

5. Ełk Lake. In the Narew River drainage basin, Ełk district, is one of the deepest lakes in that area. Its maximum depth is 57 metres, surface 409 hectares, length 6.5, width 1.58 kilometres, altitude 120 metres. My material was collected on April 23d — 26th, 1964.



6. Mamry Lake. Large lake in the Pregoła River drainage basin, Węgorzewo district connected by a channels system with several other lakes. Its surface is 2663 hectares, maximum length 9.2, width 4.6 kilometres, maximum depth 43.8, altitude 116 metres. Shore line well developed, shores low, gently sloping or flat, bottom undulating with numerous boulders often forming stony islets. My material was caught on January 29th, 1964.

7. Wigry Lake. In the Neman River drainage basin, Suwałki district. Shore line is very complicated and lacustrine conditions in different parts of the lake variable — from oligotrophic to eutrophic or even pond-like. Lake is formed by Czarna Hańcza River, which connects it with Hańcza Lake. Surface — 2166 hectares, maximum length 9.6, maximum width 2.7 kilometres, maximum depth 73, altitude 132 metres. My material was caught on December 3rd, 1965.

8. Hańcza Lake. Connected by Czarna Hańcza River with the Wigry Lake. Narrow, oligotrophic, deep lake (108.5 metres) with sand and moraine boulders covered bottom. Shores high, deforested, surface 306 hectares, maximum length 4.5, maximum width 1.2 kilometres. An altitude 227 metres. My material was caught in February 1968.

9. Szelment Wielki Lake. In the Neman River drainage basin, Suwałki district (there is another lake of the same name in the Ełk district), connected by a small river with Szelment Mały Lake. Surface 365 hectares, length 5.9, width 1.1 kilometres, maximum depth 45, altitude 176 metres. My material was caught on October 22nd, 1966.

Analysing the above mentioned lakes and lagoons from the point of view of smelt presumed environmental requirements we can see certain differences between the hydrological conditions in the lakes and the lagoons. In inland waters smelt occur in deep oligotrophic or mesotrophic lakes only and disappear when lake became eutrophic (STANGENBERG, 1936; WILLER, 1926). Both lagoons (Zalew Wiślany and Zalew Szczeciński) are, however, quite shallow (8 and 5.1 metres respectively). It appears that the smelt is only a seasonal visitor from the open sea to these two lagoons and it is a lack of suitable feeding and spawning conditions that make smelt less numerous in these lagoons (MARRE, 1931; WILLER, 1926).

METHODS

Research was done on a series of 50 smelts from each lake ane lagoon studied, from Miedwie Lake two series of 50 were taken to provide more material for study of two different populations — large and small — living there. Series from Zalew Wiślany and Zatoka Pomorska were smaller.

All specimens were preserved in a 2% formaldehyde solution. Stomach contents were analysed in 15 specimens from each series. Age of specimens was determined from scale annuli (following methods of MASTERMAN, 1913 and LAPIN, 1956). Vomerine dentition and ethmoid bones were studied in 15 to 20 skull alizarin stained preparations from each series of 50 smelt.

Mensural characters were measured with help of calipers and a ruler (reading precision — 0.1 mm). I limited myself to the following characters:

a) head length ratio, minimum body depth ratio, caudal peduncle length ratio and anal fin depth ratio (all expressed in percentages of the fork length).
b) head length to standard length ratio was calculated to enable comparison with MC-ALLISTER (1963) data.
c) eye diameter ratio, interorbital width ratio and gill raker length ratio (all expressed in percentages of the head length).

Other mensural characters studied usually in salmonids (PRAVDIN, 1939) are omitted here because of their great variability within each population — which makes them of little taxonomic value. Similar opinion was also expressed by KIRPIČNIKOV (1935).

Meristic characters were studied with a help of a stereo-microscope. I analysed following characters:

a) fin rays count in dorsal (*D*), anal (*A*), pectoral (*P*) and ventral (*V*) fins, branched and simple rays were counted separately, the two last rays in dorsal and anal fins were counted as one;
b) gill rakers count (on first gill arch);
c) lateral line scale count and pored scale count;
d) vertebral count (urostyle included) — made on alizarin stained preparations;
e) branchiostegal ray count;
f) pyloric caeca count.

Statistic methods of comparison of results included calculating of mea nvalue — $\overline{X}$, mean value error — $S_{\overline{x}}$, standard deviation — s and, for comparison of measurements and ratios between various populations, value t (following the formula $\frac{\overline{X}_1 - \overline{X}_2}{S_{\overline{x}1} - S_{\overline{x}2}}$ where $S_{\overline{x}1} - S_{\overline{x}2} = \sqrt{S_{\overline{x}1}^2 + S_{\overline{x}2}^2}$). For very striking differences, however, MAYR's et all. (1953) formula of difference coefficient $CD = \frac{M_1 - M_2}{\sigma_1 + \sigma_2}$ was used.

MERISTIC CHARACTERS

There is a tendency to sum up value of meristic characters of all smelt studied by certain authors without paying attention to differences characterising particular population (Berg, 1948; McAllister, 1963). I was more interested to find out whether certain populations differ and, if so, to which extent. Certain information on meristic characters populational variations were given by Kirpičnikov (1935), Berg (1948) and Jensen (1949). There are only meagre data from Poland: gill rakers were counted by Leskien (1942) and Dąbrowski (unpublished), vertebral counts were given by Marre (1931).

1. Fin ray counts:

a) The dorsal fin formula in studied material was (I) II–III 7–10. Single simple ray was found only once, the usual number is two, more rarely three. Branched rays were usually 8 or 9. There were no marked populational difference in this count.

Table 1. Branched rays frequency in dorsal and anal fins

Population	n	Number of dorsal fin branched rays				Number of anal fin branched rays					
		7	8	9	10	10	11	12	13	14	15
Zatoka Pomorska	37		21	16			1	20	12	4	
Zalew Szczeciński	53		23	30		1	2	24	23	3	
Zalew Wiślany	17		10	7				9	8		
Miedwie Lake (large pop.)	68	1	45	21	1			26	40	2	
Miedwie Lake (small pop.)	51	1	29	20	1			15	27	9	
Mamry Lake	50		32	18			1	30	17	2	
Ełk Lake	54	3	38	12	1		2	27	20	5	
Hańcza Lake	21		13	8				2	17	2	
Wigry Lake	50		25	25				5	24	19	2
Szelment Wielki Lake	53		21	32			1	5	32	13	2
n	454	5	257	189	3	1	7	163	220	59	4
Pechora River[1]		←	→					←	→		
Ozero Pskovskoye[1]			←	→				←	—	→	
Beloye Ozero[1]		←	—	→			←	—	→		
Gulf of Finland[1]			←	→			←	—	→		

b) The anal fin formula was (II) III–IV (10) 11–15. Usual number of simple rays was three, two found only once. There were 12 to 13 branched rays usually, more rarely 14 and even 15. Higher branched rays count was more frequent in Wigry and Szelment Wielki populations, other populations were quite uniform.

[1] After Kirpičnikov, 1935.

c) The pectoral fin ray count was I 10–13, with 13 being found only twice in specimens from Mamry Lake. The Wigry and Szelment Wielki Lakes populations tended to have higher ray counts, other populations were quite uniform (tab. 2).

Table 2. Branched rays frequency in pectoral and ventral fins

Population	n	Number of pectoral branched rays				Number of ventral branched rays		
		10	11	12	13	6	7	8
Zatoka Pomorska	37	27	9	1		1	36	
Zalew Szczeciński	53	33	19	1			53	
Zalew Wiślany	17	7	9	1			17	
Miedwie Lake (large pop.)	68	2	49	17			68	
Miedwie Lake (small pop.)	51	2	35	14			49	2
Mamry Lake	50	2	29	17	2		50	
Ełk Lake	54	33	20	1		1	51	2
Hańcza Lake	21	4	17				21	
Wigry Lake	50		21	29		1	49	
Szelment Wielki Lake	53	1	31	21			53	
n	454	111	239	102	2	3	447	4

d) The ventral fin ray count was I 6–8, the mean number 7 is by far the most frequent. There were no population differences in this count.

2. The pyloric caeca count was 3–7, usually 4, 5 and 6. No clear population differences.

Table 3. Pyloric caeca frequency

Population	n	Number of pyloric caeca				
		3	4	5	6	7
Zatoka Pomorska	35		6	18	11	
Zalew Szczeciński	20			7	12	1
Zalew Wiślany	17		1	9	6	1
Miedwie Lake (large pop.)	20		7	12	1	
Miedwie Lake (small pop.)	20	4	11	5		
Mamry Lake	32		5	20	6	1
Ełk Lake	20		3	17		
Hańcza Lake						
Wigry Lake	26		3	16	7	
Szelment Wielki Lake	30		14	16		
n	220	4	50	120	43	3

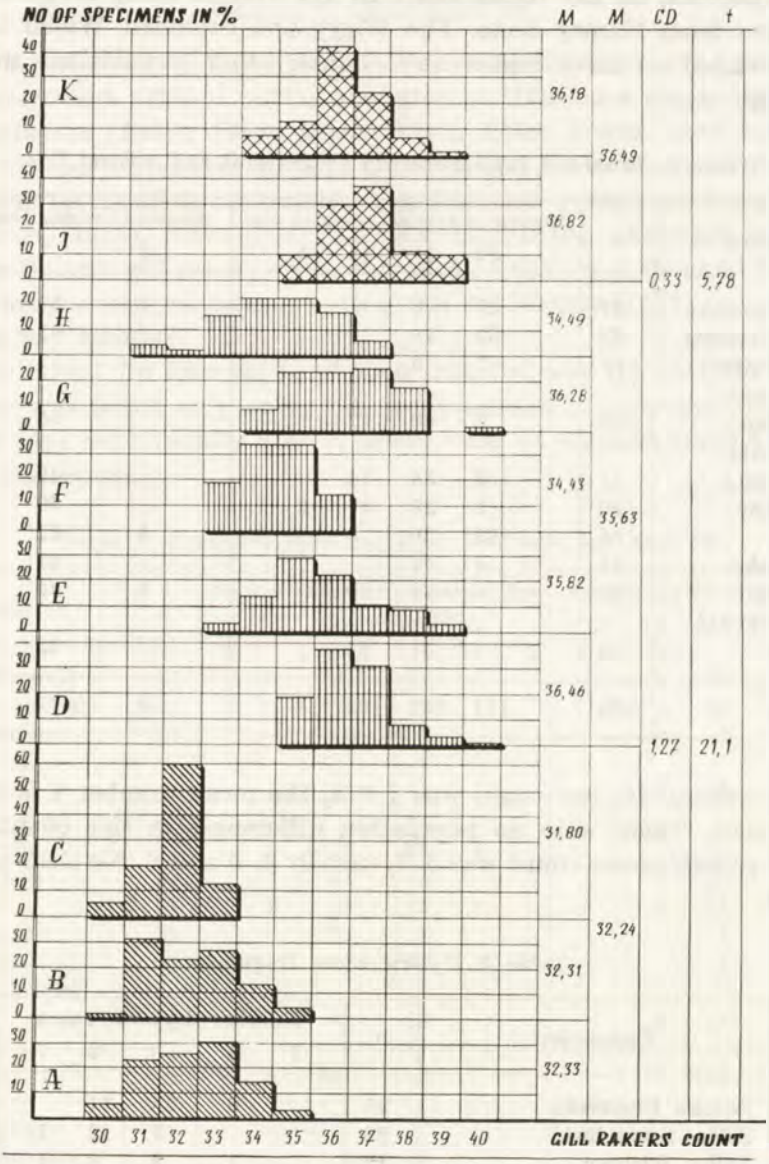


Fig. 1. Number of gill rakers. A — Zatoka Pomorska, B — Zalew Szczeciński, C — Zalew Wiślany, D — Ełk Lake, E — Miedwie Lake, small pop., F — Hańcza Lake, G — Mamry Lake, H — Miedwie Lake, large pop., J — Wigry Lake, K — Szelment Wielki Lake.

3. Gill raker counts — there are quite distinct population differences in this character, particularly between sea-brackish water and lake populations. The first have lower counts both in Poland and elsewhere in the Baltic sea (Leskien, 1942; Jensen, 1949). Certain exceptions from that rule quoted by Kir-

Table 4. Gill rakers count frequency

Population	n	Number of the gill rakers 26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	$\bar{X} \pm S_{\bar{x}}$	s
Author's data:																		
Zatoka Pomorska	36					2	8	9	11	5	1						32.33±0.20	1.20
Zalew Szczeciński	52					1	16	12	14	7	2						32.31±0.17	1.20
Zalew Wiślany	15					1	3	9	2								31.80±0.19	0.75
Miedwie Lake (large pop.)	51						2	1	8	14	14	9	3				34.49±0.19	1.36
Miedwie Lake (small pop.)	44								1	6	13	10	9	4	1		35.82±0.20	1.34
Mamry Lake	47									4	11	11	12	8		1	36.28±0.19	1.33
Ełk Lake	54										10	20	17	4	2	1	36.46±0.15	1.10
Hańcza Lake	21								4	7	7	3					34.43	
Wigry Lake	50										5	15	19	6	5		36.82±0.15	1.09
Szelment Wielki Lake	51									4	7	22	13	4	1		36.18±0.15	1.08
n	421					4	29	31	40	47	70	90	73	26	9	2		
Leskien, 1942:																		
Wigry Lake	53									←						→	36.98	
Pluszne Lake	11										←		→				36.14	
Drawskie Lake	20							←					→				34.58	
Kurskiy Zaliv	50			←							→						31.26	
Dąbrowski, unpublished:																		
Szelment Wielki Lake										←				→			36.20	
Szelment Mały Lake									←				→				35.70	
Wigry Lake											←				→		37.80	
Hańcza Lake										←			→				36.00	
Kirpičnikov, 1935:																		
Pechora River	5						1		1	1	2						33.60	
Ozero Pskovskoye	9							1	3	2	3						33.80	
Beloye Ozero	5							1	1	1		1	1				34.40	
Gulf of Finland	12						1	3	2	3	2	1					33.40	
Jensen, 1949:																		
Ringkobing Fjord	240			←						→							30.89±0.08	1.25
Randers Fjord	38	←							→								30.59±0.26	1.59
Kilen	116			←						→							31.16±0.11	1.15
Flade Sø	9				←					→							31.44	
Flynder Sø	38			←					→								30.34±0.18	1.12
Viborg Lakes	175						←						→				34.49±0.10	1.31
Silkeborg Langsø	72								←				→				34.69±0.11	1.16
Ivösjö	129																34.71±0.11	1.23
Furesø	56									←					→		37.07±0.17	1.29

Table 5. Vertebrae count frequency

Population	n	54	55	56	57	58	59	60	61	62	63	64	65	$\bar{X} \pm S_{\bar{x}}$	s
		Number of vertebrae													
Author's data:															
Zatoka Pomorska	20			2	6	7	5							57.75±0.21	0.95
Zalew Szczeciński	21	1			1	7	10	2						58.43±0.23	1.05
Zalew Wiślany	14				1	1	10	1	1					59.00±0.21	0.84
Miedwie Lake (large pop.)	20							8	11	1				60.65±0.15	0.65
Miedwie Lake (small pop.)	20						6	8	6					60.00±0.20	0.91
Mamry Lake	25						1	14	8	2				60.44±0.14	0.69
Ełk Lake	20						7	10	3					59.80±0.17	0.74
Hańcza Lake	19					1		10	6	2				60.42±0.21	0.90
Wigry Lake	23									3	15	3	2	63.17±0.16	0.75
Szelment Wielki Lake	23									2	10	11		63.39±0.15	0.71
n	205	1		2	8	16	39	53	35	10	25	14	2		
Kirpičnikov, 1935:															
Pechora River	107					6	22	45	27	6	1			60.08	
Ozero Pskovskoye	11					2	4	5						59.27	
Beloye Ozero	20				1	11	7	1						58.40	
Gulf of Finland	22						1	9	11	1				60.55	
Marre, 1931:															
Kurskiy Zaliv[1]	139				←				→					58.97	
Kurskiy Zailv[1]	61				←			→						58.79	
Kurskiy Zaliv[1]	100			←					→					58.87	
Baltic Sea[1]	100			←					→					58.89	
Zalew Wiślany[1]	100			←					→					58.86	
Łaśmiady Lake[1]	100					←					→			59.94	
Nidzkie Lake[1]	100			←				→						58.27	
Jensen, 1949:															
Ringkøbing Fjord	220				←				→					59.24±0.06	0.86
Randers Fjord	41				←					→				59.56±0.16	1.00
Kilen	130				←				→					58.85±0.07	0.76
Flade Sø	213			←					→					59.21±0.05	0.78
Flynder Sø	43			←					→					58.77±0.14	0.90
Viborg Nørresø	136			←					→					59.12±0.08	0.95
Silkeborg Langsø	71					←				→				59.80±0.09	0.77
Skanderborg Sø	8				←		→							59.80	
Viborg Søndersø	17				←					→				59.06±0.23	0.97
Vejle Sø	5					←				→				60.60	
Brassø	5					←			→					59.40	
Ivösjö	143					←			→					59.38±0.05	0.64
Furesø	108						←				→			61.39±0.09	0.93

[1] Marre's (1931) data ammended by an addition of the urostyle to the vertebral count.

PIČNIKOV (1935) and JENSEN (1949) are presumably due to insufficient number of specimens studied or to the marine origin of smelt caught in the lakes connected with sea (Lakes Fladesø and Flyndersø populations — JENSEN, 1949).

Uniformity of gill rakers counts in smelt populations in the lakes of the Suwałki Lake District has been stressed by DĄBROWSKI (unpublished); he has overlooked, however, that his own data indicate higher counts for the Lake Wigry population (tab. 4). Population difference have been noted by PETROV (1934).

The general range for gill rakers count in *O. eperlanus eperlanus* is 25–40, altough some authors gave it slightly lower (MCALLISTER, 1963, 25–37).

The sea-brackish water smelt in Poland have 30–35 gill rakers with a mean count of 32.24 (LESKIEN, 1942 gave that mean for Kurskiy Zaliv slightly lower — 31.26). Lake smelt have a count of 33–40 with a mean of 36.06 (LESKIEN gave a mean count for 3 lacustrine populations slightly lower — 35.90). The Wigry Lake population has a mean count of 36.82 and can be compared with Danish Furesø population with mean count of 37.07 (JENSEN, 1949). The mean count of Szelment Wielki population is 36.18.

4. Vertebral counts (trunk and caudal vertebrae together) have been taken from alizarin stained preparations made from about 20 specimens from each population. The results are given in fig. 2 and comparison with other authors data on tab. 5. The mean count in sea-brackish water smelt populations is 58.33, the same for lake populations (Wigry and Szelment Wielki excluded) is 60.25; the populations in the two excluded lakes differ in having even higher the mean counts and amounting to 63.23, which exceeds upper range suggested for *O. eperlanus eperlanus* by MCALLISTER (1963). The difference coefficient between the Wigry and Szelment Wielki populations and the marine populations is 2.55, the same coefficient between all the remaining lake populations and the marine populations in Poland is only 0.95. The difference coefficient between the Wigry and Szelment Wielki populations and all the remaining inland populations is again 1.86 (calculated according to MAYR et al., 1953, formula). Remembering that difference coefficient value exceeding 1.28 indicate subspecific difference, Wigry and Szelment Wielki Lakes populations seem to deserve promotion to a separate taxonomic rank. It seems to be impossible to explain so striking differences in gill rakers and vertebral counts by influence of environmental factors like temperature or salinity because these never give so high a difference. For establishing a separate subspecies more arguments would be necessary and these are not sufficiently prepared. This question is discussed more fully later on in this paper. To end with vertebral count problems I may add that differences in that count were used for separation of various smelt and also herring populations by JEAN (1967) and MCKENZIE (1964). It is worth of notice that even so small difference as 0.21 or even 0.11 in the mean vertebral count were considered significant by these authors.

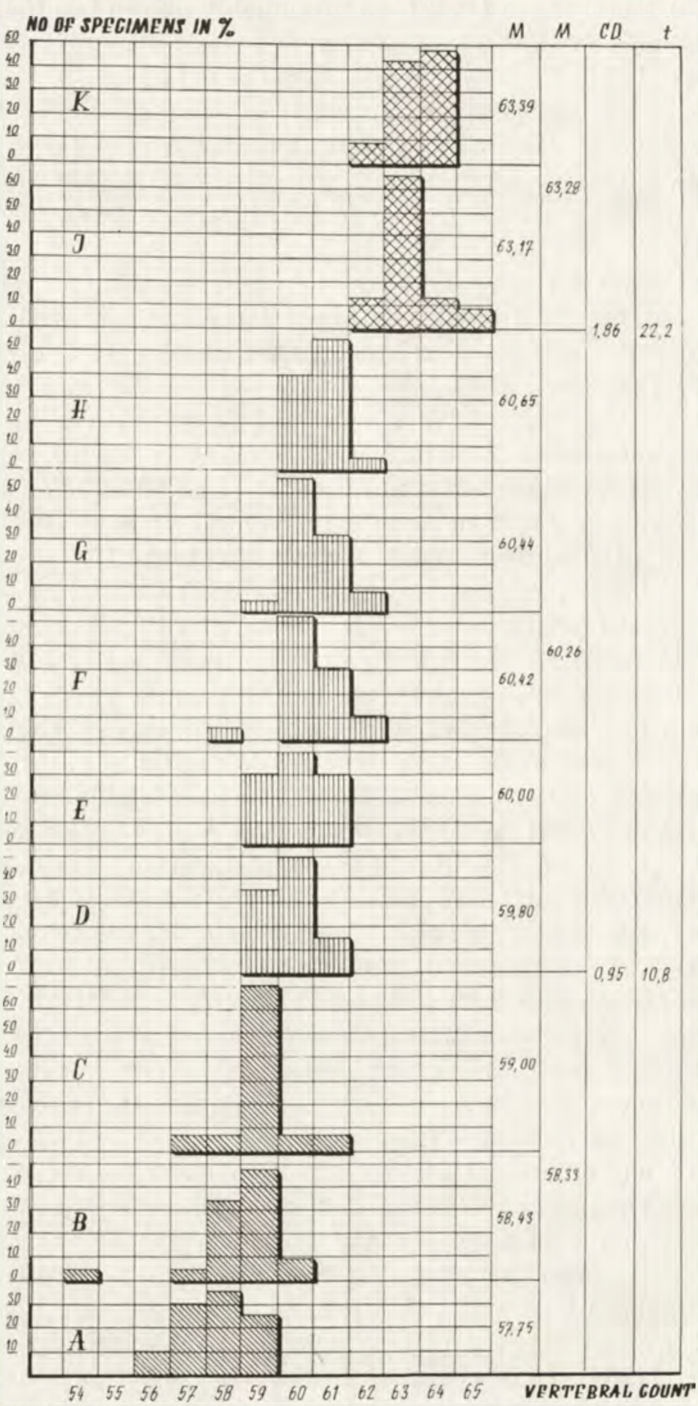


Fig. 2. Number of vertebrae. For explanation of symbols — see Fig. 1.

5. Lateral line scales count vary from 56 to 71 in Polish smelt. The differences within each population are considerable but the mean count seems to be characteristic for particular lake populations (fig. 3, tab. 6).

It appears that there is a correlation between the vertebral and scale counts and that smelts with higher vertebral count have more scales along

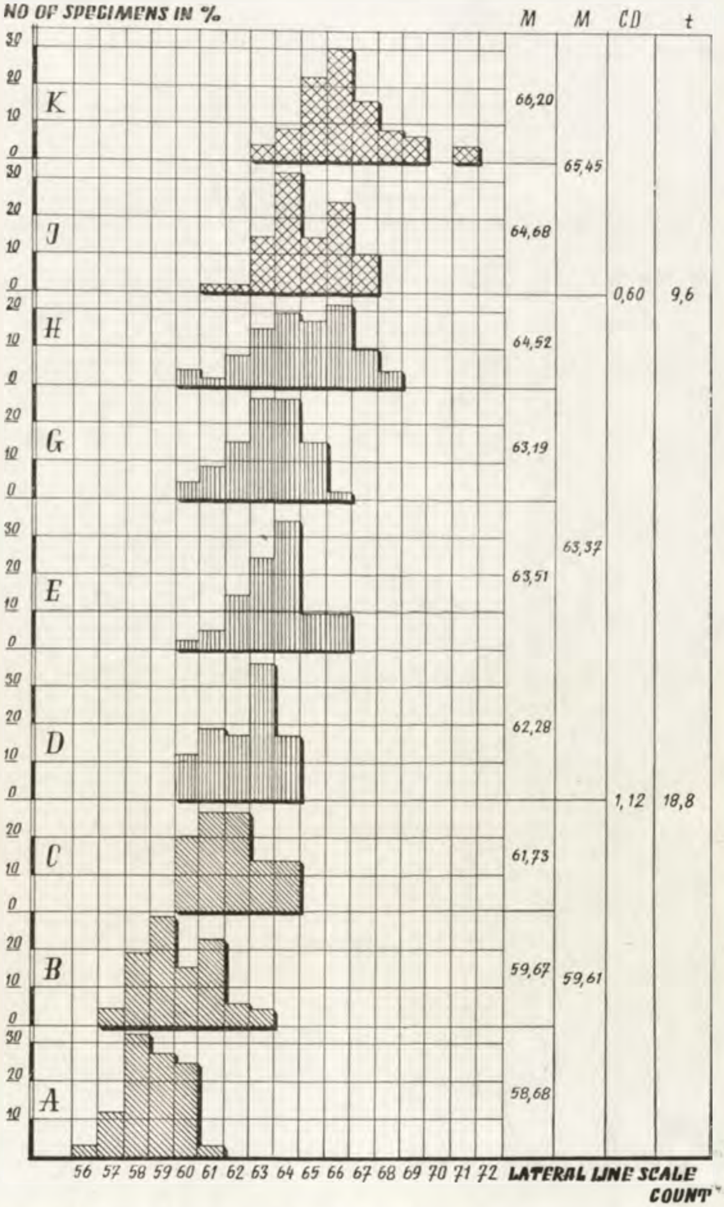


Fig. 3. Number of scales. For explanation of symbols — see Fig. 1.

Table 6. Lateral line scales frequency and the number of pored scales

Population	n	Number of scales																$\bar{X} \pm S_{\bar{x}}$	s	No. of pored scales
		56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71			
Zatoka Pomorska	37	1	4	12	10	9	1											58.68±0.18	1.11	0–5
Zalew Szczeciński	52		2	10	15	8	12	3	2									59.71±0.20	1.45	2–7
Zalew Wiślany	15					3	4	4	2	2								61.73±0.33	1.29	0–9
Miedwie Lake (large pop.)	52					2	1	4	8	10	9	11	5	2				64.52±0.26	1.87	0–11
Miedwie Lake (small pop.)	41					1	2	6	10	14	4	4						63.51±0.22	1.38	(0)2–8(9,10)
Mamry Lake	47					2	4	7	13	13	7	1						63.19±0.20	1.37	0–8
Ełk Lake	53					6	10	9	19	9								62.28±0.17	1.26	0–7
Wigry Lake	47						1	1	7	15	7	11	5					64.68±0.21	1.41	2–9
Szelment Wielki Lake	49								2	4	11	15	8	4	3		2	66.20±0.24	1.71	0–5
n	393	1	6	22	25	31	35	34	63	67	38	42	18	6	3		2			

their lateral line. This has been already noticed by Rolik (1967) in her research on *Barbus* sp. and has been found true in my studies. The mean scale count for sea-brackish water smelt populations in Poland is 59.61, the same for lake population is 63.37 and in those two Wigry and Szelment Wielki populations as high as 65.45. Unfortunately there are no comparable data in other papers.

The pored scales count vary from 0 to 11 and there are no population differences (tab. 6).

MENSURAL CHARACTERS

Mensural characters are more or less correlated with growth of fish and vary so greatly, especially in smelt, that it is difficult to discern any traits characteristic for particular populations. My studies on variations of mensural characters in the large and small smelt populations of Miedwie Lake have generally confirmed opinions of Kirpičnikov (1935) and in the following analysis I limit myself to a few more useful mensural characters.

While measurements of head length, minimum body depth, caudal peduncle length and anal fin depth increase with growth of fish, their ratio to caudal length remain relatively constant during the life span of fish. Some other ratios change, however, and for instance interorbital width to head length ratio slightly increases. Eye diameter and gill raker length to head length ratios decrease during life span of fish.

The values of characters in various smelt population are given on tables 7–13.

1. The head length ratio is almost invariable in the majority of smelt populations in Poland. The exception is the long headed large smelt population from Miedwie Lake, which differ from a Zalew Wiślany population by 12.32 Pravdin's (1939) difference coefficient, the same coefficient with the short headed small Miedwie Lake smelt population is 9.70. Such a high difference coefficient should be considered highly significant were there supporting meristic character differences; in want of these, the value of the coefficient in this case is rather doubtful.

The other exceptions are Wigry and Szelment Wielki populations which are short headed with the head length to standard length proportion equal to 4.7. This exceeds proportions seen in other smelt populations in Poland and can be compared with Pechora River and Pskovskoye Ozero populations (Kirpičnikov, 1935), but there are no other resemblances among these populations. Head length in the Furesø population is unfortunately unknown. Baltic Sea populations are also short headed.

2. The minimum body depth ratio (tab. 8) remained constant within particular populations, with Wigry and Szelment Wielki populations having it particularly low. The high value of this ratio is usually connected with better

Table 7. Mensural characters values

Population		Head length in % of caudal length					Head length in standard length		
		n	Range	$\bar{X} \pm S_{\bar{x}}$	*s*	*t*	n	Range	$\bar{X}$
Author's data	Zatoka Pomorska	37	20.3–22.7	21.69±0.11	0.70		37	4.1–4.6	4.3
						1.81			
	Zalew Szczeciński	53	19.8–23.9	21.42±0.10	0.73		53	4.1–4.6	4.3
						2.95			
	Zalew Wiślany	17	21.0–23.1	21.95±0.15	0.62		17	4.1–4.6	4.3
						12.32			
	Miedwie Lake (large pop.)	59	22.7–26.6	24.16±0.10	0.74		60	3.5–4.1	3.8
						9.70			
	Miedwie Lake (small pop.)	45	20.3–25.4	22.52±0.14	0.94		45	3.8–4.6	4.2
						1.64			
	Mamry Lake	50	20.6–23.7	22.23±0.11	0.71		50	4.0–4.6	4.2
	Ełk Lake	47	20.7–22.9	21.94±0.07	0.49	2.21	47	4.1–4.6	4.3
						8.52			
	Wigry Lake	50	18.8–22.8	20.86±0.11	0.81		49	4.3–5.1	4.7
						4.23			
	Szelment Wielki Lake	51	18.5–21.8	20.23±0.10	0.70		51	4.4–5.0	4.7
Kirpičnikov, 1935	Pechora River	25		20.70±0.12					
	Ozero Pskovskoye	11		20.90					
	Beloye Ozero	10		21.00					
	Gulf of Finland	12		22.50					
	Ozero Onega	100		22.80±0.08					
	Ozero Ladoga	224		21.80±0.12					
	Ozero Ladoga	4		22.50					
	Neva River	116		22.30±0.08					
	Norway	15		22.30					

feeding of fish, as Wigry and Szelment Wielki Lakes populations have appearance of being well fed, low value of the ratio in their case may be significant.

3. The caudal peduncle length ratio (tab. 9) was low in Baltic Sea populations and in that it resembles the Beloye Ozero population (Kirpičnikov

Table 8. Mensural characters values

	Population	Minimum body depth in % of caudal length				
		n	Range	$\bar{X} \pm S_{\bar{x}}$	s	t
Author's data	Zatoka Pomorska	37	4.6–6.2	5.41±0.07	0.43	0.33
	Zalew Szczeciński	53	4.5–6.9	5.44±0.06	0.45	4.95
	Zalew Wiślany	17	4.6–5.4	5.02±0.06	0.24	
	Miedwie Lake					4.93
	(large pop.)	60	4.8–6.1	5.35±0.03	0.25	
	Miedwie Lake					5.08
	(small pop.)	46	5.1–6.7	5.69±0.06	0.76	
	Mamry Lake	45	4.7–6.0	5.43±0.04	0.30	3.61
	Ełk Lake	47	5.0–6.1	5.58±0.04	0.26	2.66
	Wigry Lake	50	4.2–5.2	4.76±0.04	0.25	14.45
	Szelment Wielki Lake	52	4.3–5.5	5.00±0.04	0.27	4.25
Kirpičnikov, 1935	Pechora River	25		5.60		
	Ozero Pskovskoye	11		5.00		
	Beloye Ozero	10		5.50		
	Gulf of Finland	12		5.40		
	Ozero Onega	100		5.00±0.03		
	Ozero Ladoga	224		4.70±0.05		
	Ozero Ladoga	4		5.00		
	Neva River	116		5.30±0.06		
	Norway	15		5.10		

Table 9. Mensural characters values

	Population	Caudal peduncle length in % of caudal length				
		n	Range	$\bar{X} \pm S_{\bar{x}}$	s	t
Author's data	Zatoka Pomorska	37	8.4–11.9	10.45±0.15	0.90	2.55
	Zalew Szczeciński	53	8.2–11.4	9.99±0.10	0.71	6.01
	Zalew Wiślany	17	10.1–12.0	11.07±0.15	0.63	
	Miedwie Lake					0.53
	(large pop.)	60	10.1–12.7	11.16±0.08	0.64	
	Miedwie Lake					3.10
	(small pop.)	46	10.0–12.9	11.58±0.11	0.76	
	Mamry Lake	44	10.8–12.8	11.74±0.08	0.51	1.17
	Ełk Lake	47	10.2–12.7	11.64±0.09	0.60	0.83
	Wigry Lake	49	10.9–13.8	12.38±0.10	0.69	5.48
	Szelment Wielki Lake	50	9.8–11.9	11.05±0.09	0.68	9.88
Kirpičnikov, 1935	Pechora River	4		12.30		
	Ozero Pskovskoye	11		11.60		
	Beloye Ozero	10		10.60		
	Gulf of Finland	12		12.20		
	Ozero Onega	100		11.70±0.08		
	Ozero Ladoga	224		11.30±0.16		
	Ozero Ladoga	4		12.50		
	Neva River	116		12.30±0.09		
	Norway	15		11.20		

Table 10. Mensural characters values

	Population	Anal fin depth in % of caudal length				
		n	Range	$\bar{X} \pm S_{\bar{x}}$	s	t
Author's data	Zatoka Pomorska	37	9.4–12.6	11.24±0.13	0.81	3.11
	Zalew Szczeciński	53	9.5–12.4	10.75±0.09	0.66	4.51
	Zalew Wiślany	17	8.5–10.6	10.04±0.13	0.53	
	Miedwie Lake					4.19
	(large pop.)	59	9.5–11.9	10.69±0.08	0.58	
	Miedwie Lake					3.67
	(small pop.)	46	10.0–13.2	11.19±0.11	0.72	6.55
	Mamry Lake	49	9.2–11.7	10.39±0.09	0.61	1.67
	Ełk Lake	47	8.9–11.5	10.20±0.07	0.51	38.30
	Wigry Lake	50	12.8–15.9	14.76±0.10	0.74	38.20
	Szelment Wielki Lake	50	9.4–11.3	10.29±0.06	0.43	
Kirpičnikov, 1935	Pechora River	4		10.80		
	Ozero Pskovskoye	11		9.80		
	Beloye Ozero	10		10.70		
	Gulf of Finland	12		9.50		
	Ozero Onega	100		10.30±0.07		
	Ozero Ladoga	224		10.40±0.12		
	Ozero Ladoga	4		9.30		
	Neva River	116		9.90±0.08		
	Norway	15		9.20		

Table 11. Mensural characters values

	Population	Eye diameter in % of head length				
		n	Range	$\bar{X} \pm S_{\bar{x}}$	s	t
Author's data	Zatoka Pomorska	36	21.7–28.8	25.07±0.32	1.91	4.05
	Zalew Szczeciński	52	20.0–27.2	23.47±0.23	1.65	16.70
	Zalew Wiślany	17	15.8–19.7	17.88±0.25	1.02	
	Miedwie Lake					1.37
	(large pop.)	59	15.1–21.2	18.31±0.19	1.45	
	Miedwie Lake					17.38
	(small pop.)	45	19.0–27.9	23.37±0.22	1.49	7.18
	Mamry Lake	50	18.8–25.0	21.32±0.20	1.44	0.86
	Ełk Lake	47	19.2–23.2	21.10±0.16	1.10	2.93
	Wigry Lake	50	18.2–25.0	21.85±0.20	1.42	1.85
	Szelment Wielki Lake	51	20.0–25.0	22.35±0.18	1.31	
Kirpičnikov, 1935	Pechora River					
	Ozero Pskovskoye					
	Beloye Ozero					
	Gulf of Finland					
	Ozero Onega	100		22.3±0.14		
	Ozero Ladoga	224		20.60±0.24		
	Ozero Ladoga	4		24.80		
	Neva River	116		19.60±0.12		
	Norway	15		19.90		

1935). It is interesting to note that there are differences in this character between Wigry (high value) and Szelment Wielki (low value) Lakes populations.

4. The anal fin depth ratio (tab. 10) was constant and there are only minor differences among populations. Note higher value of this ratio in Wigry Lake population.

5. The eye diameter ratio (tab. 11) was directly correlated with head length — see Zalew Wiślany and Miedwie Lake large populations. Sea and brackish water populations have large eyes.

6. The interorbital width ratio (tab. 12) was rather constant and only Wigry and Szelment Wielki Lakes populations had lower values of this ratio.

Table 12. Mensural characters values

	Population	Interorbital width in % of head length				
		n	Range	$\bar{X} \pm S_{\bar{x}}$	s	t
Author's data	Zatoka Pomorska	37	18.8–25.7	21.36±0.25	1.50	4.08
	Zalew Szczeciński	53	15.8–25.2	20.33±0.03	2.24	2.91
	Zalew Wiślany	17	19.4–22.8	21.11±0.27	1.13	
	Miedwie Lake					0.55
	(large pop.)	52	18.1–25.7	21.31±0.27	1.92	
	Miedwie Lake					3.97
	(small pop.)	44	17.7–24.9	19.88±0.24	1.60	
	Mamry Lake	50	16.9–23.8	20.79±0.18	1.27	3.02
	Ełk Lake	47	20.2–25.2	22.77±0.18	1.24	7.83
	Wigry Lake	49	16.4–20.3	18.54±0.15	1.03	18.17
	Szelment Wielki Lake	51	15.8–22.3	19.50±0.23	1.62	3.51
Kirpičnikov, 1935	Pechora River					
	Ozero Pskovskoye					
	Beloye Ozero					
	Gulf of Finland					
	Ozero Onega	100		24.50±0.14		
	Ozero Ladoga	224		20.50±0.24		
	Ozero Ladoga	4		21.40		
	Neva River	116		23.70±0.17		
	Norway	15		25.10		

7. The gill raker length ratio (tab. 13) seemed to be inversely related to head length — this is particularly noticeable in Miedwie Lake large smelt populations. Wigry and Szelment Wielki populations have a higher value of this ratio.

Summing up the analysis of mensural and meristic characters of smelt in Poland shows that there are four groups of populations.

Sea or brackish water smelt populations (Zatoka Pomorska, Zalew Wiślany, Zalew Szczeciński) differ from all the remaining ones in having low gill raker

Table 13. Mensural characters values

Population	Gill raker length in % of head length				
	n	Range	$\bar{X} \pm S_{\bar{x}}$	*s*	*t*
Zatoka Pomorska	35	12.4–18.4	15.08±0.67	1.25	0.94
Zalew Szczeciński	52	12.2–16.9	14.43±0.16	1.18	7.21
Zalew Wiślany	15	10.5–14.2	12.58±0.20	0.80	
Miedwie Lake (large pop.)	17	9.6–14.5	11.21±0.33	1.37	3.56
Miedwie Lake (small pop.)	42	12.7–16.7	14.68±0.15	0.98	9.58
Mamry Lake	46	11.6–17.7	14.79±0.19	1.27	0.46
Ełk Lake	47	12.7–17.7	14.49±0.17	1.19	1.18
Wigry Lake	49	13.9–19.5	16.47±0.21	1.44	7.31
Szelment Wielki Lake	49	13.0–17.6	15.61±0.14	1.01	3.55

counts, low vertebral counts and low lateral line scale counts. Zalew Wiślany and Zalew Szczeciński populations have also lower caudal peduncle lenght ratio and higher eye diameter ratio.

Lake smelt populations, which represent the presumably prevalent type in Poland, differ from two further populations.

The large Lake Miedwie smelt population differs in having longer heads but similarities in other characters do not permit one to separate it from the wide-spread lake type populations. There is, however, a group of two strikingly different populations from Wigry and Szelment Wielki Lakes. Considering all their peculiarities, both in meristic and mensural characters, as well as their similiarities to that special smelt population from the lake Furesø in Denmark, I think that they deserve better attention and further research. The up to now studied data do not yet permit one to describe these three populations as a separate taxon of a subspecific rank although eventually it may appear possible. So I have decided to describe these populations provisionally as a new form, which I propose to call forma *jenseni* in honour of Inger Bohus Jensen, who discovered the peculiar character of the lake Furesø smelt population and has compared it with Wigry Lake smelt population.

Osmerus eperlanus forma *jenseni* f. n.

Definition. Differs from other inland populations of *Osmerus eperlanus* (Linnaeus, 1758) in higher vertebral count (62–65, most commonly 63–64, mean 63.28), higher lateral line scales count — mean 65.44, higher gill rakers count — mean 36.49, slightly higher anal fin branched rays count — (11) 12–15, more frequently 13–14. It is short headed, has a lower minimum body depth and interorbital width ratios value, and has longer gill rakers. Forma *jenseni* differs from *Osmerus mordax* (Mitch.) in having a lower pored scale count

0–9. Forma *jenseni* can be characterized by the following: *D* II–III 8–9, *A* III–IV (11) 12–15, *P* I (10) 11–12, *V* I 7(8), *l.l.* 0–9, scales (61, 62) 63–71, vertebrae 62–65, gill rakers 34–39, pyloric caeca 4–6, branchiostegal rays 7–8.

There are some minor differences within forma *jenseni* between Wigry and Szelment Wielki lakes populations, the first has longer caudal peduncle and deeper anal fin.

Forma *jenseni* described above has already been discussed by a number of authors. JENSEN (1949) who suspected that smelt from Furesø lake may be a separate race and compared their gill raker counts with those in Wigry Lake smelt, has called attention to its occurrence with postglacial relicts like *Mysis oculata relicta* LÖVEN and *Pantoporeia affinis* (BRUZELIUS) in lake Furesø. That is true and these also occur in Wigry Lake. There are, however, other lakes with postglacial relicts in Poland (Mamry, Miedwie, Hańcza) but there are "normal" lacustrine smelt in those and not f. *jenseni*. SWÄRDSON (1961) admits two invasions of smelt — this is concluded from comparison of gill rakers count in various populations of smelt. To this I may add that SWÄRDSON quotes gill rakers count values in a somewhat careless manner: White Sea smelt has not an "about 37" gill rakers count value but 32–37 (KIRPIČNIKOV, 1935; BERG, 1948), Western Europe coast smelt has not 30–31 but 25–33 value of this count (op. cit.). This reduces the credibility of his conclusions.

REMARKS ON OSTEOLOGY

The variation of the ethmoid bones in the studied smelt populations is quite wide. This seems to be worthy of some attention because of the taxonomic importance of these bones, being used as characters separating higher taxa in *Osmeridae* and also in *Stomiatoidei* and *Galaxioidei*. One may notice that conclusions drawn by various authors from the ethmoid bones structure were a bit contradictory. For instance GOSLINE (1960) classified *Osmeridae* within suborder *Salmonoidei* closely related to *Esocoidei*. GREENWOOD et al. (1966) seconded this and left the *Osmeridae*, and *Plecoglossidae* (which was once reduced to a subfamilial rank within *Osmeridae* by CHAPMAN, 1941) within the *Salmonoidei*. On the other hand WEITZMAN (1967) excluded the *Osmeridae* from the *Salmonoidei* and created a new suborder *Osmeroidei* related to *Galaxioidei* and *Stomiatoidei*. One may wonder whether these taxonomic rearangements were not connected with individual or population bone variation.

The ethmoid region is one of most characteristic parts of skull within the *Osmeridae* (WEITZMAN, 1967). It consists of the following parts.

a) Frontals — with their anterior parts covering dorsal surface of the ethmoid cartilago.
b) Proethmoids — two thin bony plates anteriorly to frontals.
c) Supraethmoids — thin bony plate lying directly on the ethmoid cartilago and partially hidden beneath the frontals and proethmoids.

d) Capsular ethmoid bone — thin bowl shaped bone covering lateral surfaces of the posterior part of the ethmoid cartilago.
e) Ventral ethmoid — anterior to the ventral part of the ethmoid cartilago, partially hidden beneath vomer and parasphenoid.
f) Single toothed vomer.
g) Parasphenoid.
h) Myodome bone — cone shaped bone lining the anterior conical cavity.
i) Lateral ethmoid — covering posterior wing-like projections of the ethmoid cartilago.

These bones may be reduced or fused in various genera of *Osmeridae*. Single proethmoid occurs in *Mallotus* Cuv. and *Hypomesus* Gill. Starks (1926) and Chapman (1941) reported a paired vomer in *Osmerus* sp. A myodome is known in *Spirinchus* Jordan et Everman, but is probably lacking in other osmerids.

Skull variation in smelt populations in Poland was studied on 107 skulls. I have found that both myodome and capsular ethmoid bones are lacking in the studied smelt populations. The ventral ethmoid occured only in the large smelt population from Miedwie Lake (in 8 specimens of 9 studied) and in the Zatoka Pomorska population (in 7 specimens of 19 studied). In the latter it occured also in small specimens. The supraethmoid varies from a small and barely conspicuous bony plate between proethmoids and frontals to a large bone covering large part of the ethmoid cartilago and hidden beneath proethmoids and frontals. I saw supraethmoid in only 88 of 107 specimens studied: in Wigry Lake population it was developped in 4 specimens of 12 studied in Szelment Wielki population in 9 of 12, in smaller Miedwie Lake population in 12 of 15, in Zatoka Pomorska in 14 of 19 specimens studied. A single proethmoid was found in three specimens of smelt (from smaller smelt in Miedwie and from Ełk lakes populations and this is a key character of the subfamily *Hypomesinae* (McAllister, 1963 following Chapman, 1941), separating it from the *Osmerinae*.

The vomer in studied smelt was single, which confirms previous descriptions (McAllister, 1963; Rembiszewski, 1964; Weitzman, 1967) but its dentition varies from 1 to 3 pairs of large canine-like teeth and 1 to 4 pairs of smaller teeth. McAllister (1963) reported a single large pair of canine-like teeth, sometimes accompanied by smaller ones. Branchiostegal rays vary from 7 to 8; their number often differ on left and right side (in 16 specimens of 107 studied). Similar variation has been found in infraorbital and postorbital bones, instead of normal 6 bones on each side, there may be 5–5, 6–5, 4–5, 7–6 (observed twice) and 6–4 (observed once).

According to Weitzman (1967), ethmoid bones are influenced by the life condition of fish and that may explain the wide range of variation found in smelt in Poland. As these characters were considered as cornerstones of taxonomic divisions their variation now discovered calls for special attention by taxonomists.

BIOLOGICAL OBSERVATIONS

Age and sexual maturity

From amongst various methods of fish age determination (otolith method of Čumaevskaja-Svetovidova, 1945, concentric layers on vertebral transverse section method of Nordquist, 1910 or the various bony elements method of Marre, 1931) the normal scale method as used by Masterman (1913) and Kirpičnikov (1935) seems to be the best for age determination in smelt. Masterman has described three types of ridges formed on scales during life span of fish: concentric, spiral and bilateral. The formation of these ridges is disturbed every autumn and resulting anomalies — scars — permiting precise age determination. Masterman himself considered only the first year scar as reliable and Nordquist (1910) doubted if the age of smelt exceeding 112 mm could be determined. I have found, however, that even in 5 or 6 year-old-smelt scars are visible although a little bit less distinct. I do not agree with Lapin's (1956) differentiation of scale ridges, which are said to be only bilateral during first year of life in lake smelt ("snetok") and concentric or spiral in sea smelt ("koryushka"[1]).

All three types of ridges occurred on the smelt I have seen and often all three on three neighbouring scales, also on young fish. Scales for determination of age were taken from beneath the dorsal fin or, if these were lacking, from around the ventral fin. In doubtful cases the concentric layers on otoliths and the scars on operculum were checked.

The life span of majority of smelt does not exceed 2 or 3 years. Out of 356 specimens studied 60% achieved 2 years, 19.6 % — 3 years, 3.1 — 4 years.

The details of smelt longevity in the studied area is given on the table below.

Population	I	II	III	IV	V	VI	VII	years
	6–12	14–24	26–63	38–44	51–53	65	77	months
Zalew Wiślany			5	10	2			spec.
Miedwie Lake (large smelt)			5	16	20	10	10	spec.
Zat. Pomorska, Zal. Szczeciński, Miedwie (small smelt), Mamry, Ełk, Wigry, Szelment Wielki Lakes	65	209	71	11				spec.
	18.3	60	19.6	3.1				%
Wigry, Szerpiły, Sajno, Serwy Lakes (after Koszutowski)	11.4	77.9	10.2					%
Wigry, Serwy, Szelment Wielki, Szelment Mały, Gaładuś, Hańcza, Boczne Filip. Lakes (after Natkański)	6	50.2	38.4	4.8	0.7			%

[1] McAllister (1963) spells "korioshka".

The data from two last groups of lakes are taken from raw data in unpublished papers of KOSZUTOWSKI and NATKAŃSKI and modified by myself. All these data show that only small fraction of smelt live more than 4 years, but some can live as long as 8 years (it means 7+). One should remember, however, that proportions of age groups among smelt caught are influenced selectively by type of nets used. Older specimens change their feeding habits and feed on small fishes (small smelt included) — the more intensive feeding allows them to achieve considerable dimensions (biggest specimens: 400 mm — JENSEN, 1949, and 375 mm — NORDQUIST, 1901) and contributes to higher mortality of smaller smelts.

While some "large" and "small" smelt populations like those studied by MARRE (1931) from Kurskiy Zaliv appears to be a result of selective catching, the two Miedwie Lake populations have some special features: large smelt spawn one month later than the little one and that is opposite to other fishes where larger specimens spawn first. Two large specimens (standard length ♂ 151 mm, ♀ 137 mm) caught there in March have still immature gonads, while normal smelt reach sexual maturily reaching about 80 mm standard length, I have even met 54 mm long mature female (in Zatoka Pomorska in May 1964). I cannot explain the delayed sexual maturity in larger smelt from Miedwie Lake. Smelt reach sexual maturity usually during second year of life, but this may vary quite widely and in some populations I studied maturity was reached during first year of life (Ełk and Mamry Lakes, Zatoka Pomorska). The reports I have read give different information on the age of maturity in smelt. NORDQUIST (1910) reported maturity during second year of life, MARRE (1930) found that lake smelt mature at the end of second year, but in sea (Kurskiy Zaliv) and also in some lakes at the end of the first year. In his next paper (1931) MARRE states that smelt mature during the first year and MOHR (1941) agrees; WILLER (1926) reports maturity during first and second year of life.

Growth and weight

It appears that the fastest growth occurs between 6th and 10th month of life of smelt. There are, however, differences in growth and weight of the same age smelt in various lakes. Such differences observed in 8 lakes are shown on figs. 4–6. The fastest growth is observed among Wigry, Szelment Wielki and Mamry Lakes populations, the slowest among Zalew Szczeciński, Zatoka Pomorska and smaller Miedwie Lake populations.

The increase in weight is slow and proportional to age (fig. 5), more intense growth in weight can be observed beginning in the third year of life — Wigry and Szelment Wielki Lake populations, as well as large Miedwie Lake population where some exceptionally heavy smelt were caught.

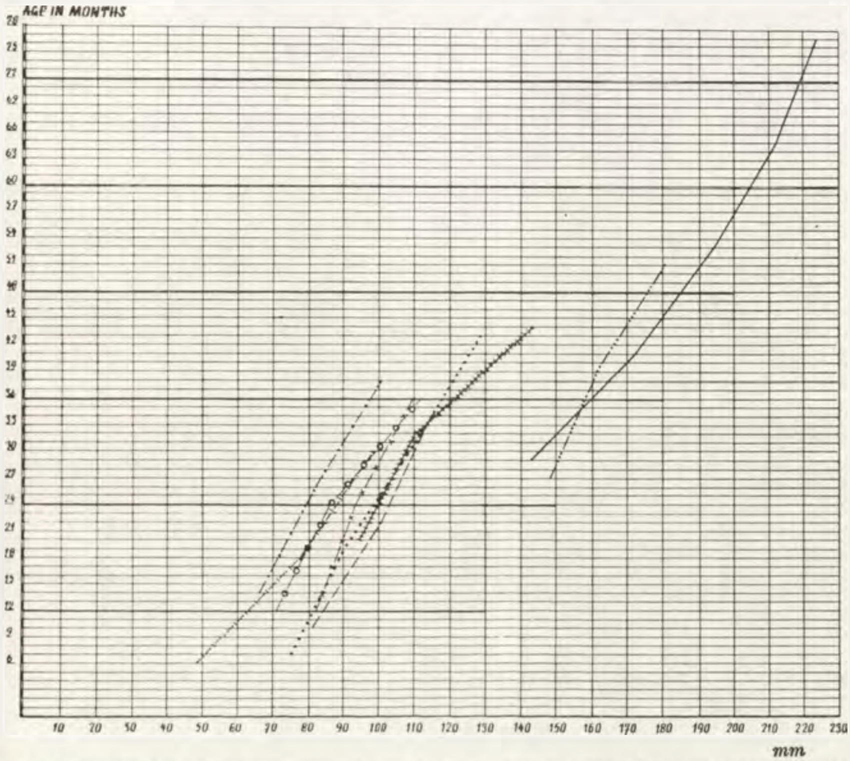


Fig. 4. Relationship between length and age. For explanation of lines see Fig. 5.

The correlation between length and weight is quite understandable (fig. 6) but it may be disturbed during the spawning period. Larger smelt populations from Miedwie Lake and Zalew Wiślany grow more rapidly than other populations. My observations agree with previous reports (tab. 14; MARRE, 1931).

The influence of environmental factors on growth of smelt was discussed by WILLER (1926), WIKTOR (1964), and ČUMAEVSKAJA-SVETOVIDOVA (1945). The importance of feeding conditions is clear but even in the same lake, where environmental conditions should be constant, different growth rates can be observed during consecutive years. This is presumably due to cool summer and delayed spawning. My observations do not confirm NORDQUIST's (1910) hypotheses on better growth of smelt in lakes with dark water, deep and with steep shores. Hańcza Lake which has lacustrine conditions corresponding with NORDIQUIST's descriptions has particularly small smelt.

Spawning and sexual dimorphism

The spawning period varies in Poland from beginning of February (Western Poland — for instance Zalew Szczeciński) to the end of May (in Eastern Poland — Hańcza, Wigry and Szelment Wielki Lakes). This is due to climatic variation and may vary from year to year. Spawning is always connected with water temperature reaching +4°C and begins usually when the remnants of ice float in the middle of lake and only narrow channel along shore is melted.

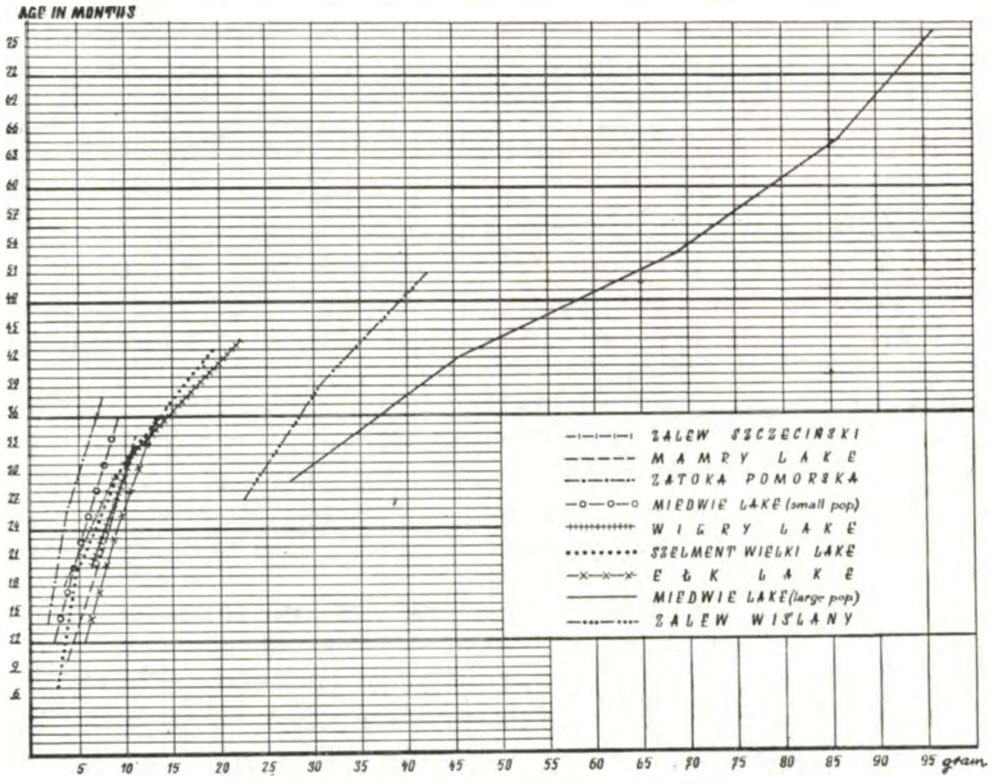


Fig. 5. Relationship between weigth and age.

Smelt spawn in shallow water (20 to 100 cm deep) over hard, gravel or stone covered bottom and there is a marked preference for air saturated water as at mounths of streams, mill dams etc. They can also penetrate into river, up to 30 kilometres upstream. Eggs are adhesive and stick to the bottom. Spawning lasts for several nights, being interrupted at dawn, and large shoals spawn at the same time and spot. It is quite easy to catch a quantity of smelt during spawning time with a help of a small hand net.

Sexual dimorphism is particularly marked at spawning time: nuptial tubercules are more distinct in males and cover the whole body, fins included, females are thicker and their body is deeper. Certain dimorphism is discernible in minimum body depth, caudal peduncle length, eye diameter and interorbital width, but this vary in various populations (tab. 15 — note Ełk and Wigry Lakes populations).

Table 14. Caudal length in mm (a) and weigth in gram (b) in relation to age smelt in Poland

	Population, month of catching		I year		II year		III year		IV year		V year		VI year		VII year	
			Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$
Author's data	Zatoka Pomorska,	a			54–77	66.87	75–97	8.2	95–109	101						
	May	b			0.9–2.5	1.80	2.0–4.9	3.84		7.52						
	Zalew Szczeciński,	a	43–55	48.5	66–90	77.30	95–101	98								
	September	b			(1.8)2.1–4.5	2.98		7.94								
	Zalew Wiślany,	a					146–153	149.2	157–166	161.4	178–183	180.5				
	June	b					20.1–23.6	22.4	27.4–35.3	30.7	37.9–46.2	42.1				
	Miedwie Lake (large pop.),	a					124–163	142.8	148–200	172.7	150–212	194.5	194–226	211.9	208–242	223.9
	March	b					20.1–36,1	27.4	36.0–66.3	45.7	36.7–85.5	69.5	70.3–101.0	85.9	79.7–139.4	96.2
	Miedwie Lake (small pop.),	a	62–77	71.0	82–93	87		112								
	March	b	2.05–2.74	2.35	4,5–6.6	5.57		9.2								
	Mamry Lake, January	a	73–89	81.5	87–108.5	101	112.5–117	114.8								
		b	2.25–5.0	3.71	5.15–11.2	7.8	9.7–12.1	11.2								
	Ełk Lake, April	a		82	91–109	94.4		110								
		b		5.6		9.1		13.6								
	Wigry Lake, December	a			85–102	94.4	99–130	110.4	126–149	133.4						
		b			4.6–7.5	6.3	7.3–14.5	10.6	17.4–32.7	22.3						
	Szelment Wielki Lake,	a	65–82	74.9	84–101	90.3	97–123	110.9		129						
	October	b		2.8	3.6–7.3	4.8	6.3–12.2	9.8		19.4						
Koszutowski, unpublished	Wigry Lake	a	63–90	78	80–123	107	115–120	117								
		b		2.54		8.23		10.55								
	Szurpiły Lake	a	76–89	83	88–102	105	112–135	123								
		b		3.0		7.63		13.25								
	Sajno Lake	a			102–136	116	120–154	143								
		b				10.45		21.10								
	Serwy Lake	a			92–117	99		118								
		b				6.0		10.90								
Natkański, unpublished	Boczne Filipkowskie Lake	a		74		96		112		134						
	Hańcza Lake	a				95										
	Gaładuś Lake	a				94										
	Szelment Mały Lake	a				109		127		147		171				
	Szelment Wielki Lake	a		67		94		121		147		176				
	Serwy Lake	a		69		91		113		150						
	Wigry Lake	a		74		103		113		128		157				
Czeczuga, 1957	Rajgrodzkie Lake,	a	68–87	78.5	84–99	92.7	105–127	111								
	February	b	2.2–4.9	4.1	4.6–8.5	6.7	9.6–21.0	13.5								
	Rajgrodzkie Lake,	a	71–89	86.5	86–104	95.7	105–125	111.5								
	July	b	3.5–6.1	4.5	5.5–9.0	7.0	7.5–13.5	11.3								
Willer, 1926	Dadaj Lake, January	a	62–78	71.6	80–113	101	118–125	121.4								
	Łaśmiady Lake, January	a			86–90(113, 126, 127)	101	110–119	115,2	121–129	125.8						
	Roś Lake, January	a			72–83	77.3	92–104									
	Ukiel Lake, November	a	58–61	59.5	66–73	70.3				111						
Leskien, 1942	Wigry Lake, April	a		93		11.1		124.5								
		b			2–7.1	5.09	4.9–10.2	6.97								
		a		80		111.4		126.6								
	Wigry Lake, December	b	0.8–2.8	2.15	2.5–9.3	6.14	7.2–10.5	8.51								

Table 15. Sexual dimorphism in selected mensural characters in % of caudal length (1 and 2) and in % of head length (3 and 4)

Population	n sex	1 Minimum body depth $\bar{X} \pm S_{\bar{x}}$	s	t	2 Caudal peduncle length $\bar{X} \pm S_{\bar{x}}$	s	t	3 Eye diameter $\bar{X} \pm S_{\bar{x}}$	s	t	4 Interorbital width $\bar{X} \pm S_{\bar{x}}$	s	t
Zatoka Pomorska	18 ♀♀	5.41±0.10	0.42	0.05	10.34±0.19	0.79	0.30	26.04±0.43	1.83	2.51	21.85±0.36	1.53	2.04
	19 ♂♂	5.42±0.16	0.46		10.43±0.23	1.02		24.41±0.49	2.10		20.87±0.32	1.40	
Zalew Szczeciński	33 ♀♀	5.50±0.07	0.40	0.94	9.88±0.13	0.74	1.62	23.72±0.30	1.71	1.19	20.75±0.39	2.23	1.63
	20 ♂♂	5.40±0.08	0.32		10.17±0.12	0.53		23.18±0.34	1.51		19.71±0.50	2.24	
Miedwie Lake (small pop.)	24 ♀♀	5.64±0.08	0.37	1.33	11.68±0.16	0.73	0.90	23.28±0.28	1.34	0.30	19.85±0.31	1.49	0.17
	21 ♂♂	5.80±0.09	0.41		11.47±0.17	0.80		23.44±0.32	1.47		19.93±0.34	1.61	
Miedwie Lake (large pop.)	47 ♀♀	5.35±0.03	0.23	0.83	11.18±0.08	0.57	0.13	18.43±0.19	1.30	1.50	22.55±0.45	1.48	2.80
	13 ♂♂	5.28±0.08	0.27		11.20±0.14	0.49		18.01±0.21	1.64		21.09±0.29	1.87	
Mamry Lake	31 ♀♀	5.38±0.06	0.30	1.29	11.52±0.09	0.43	3.29	—	—	—	—	—	—
	19 ♂♂	5.50±0.07	0.29		12.04±0.13	0.45		—	—		—	—	
Ełk Lake	29 ♀♀	5.42±0.02	0.11	4.84	11.88±0.09	0.47	3.73	21.52±0.19	1.00	2.72	22.24±0.21	1.12	4.62
	18 ♂♂	5.73±0.06	0.24		11.29±0.13	0.56		20.69±0.24	1.02		23.58±0.20	0.84	
Wigry Lake	34 ♀♀	4.68±0.04	0.24	3.60	12.22±0.02	0.65	9.80	—	—	—	18.40±0.19	1.10	1.28
	14 ♂♂	4.91±0.05	0.19		12.75±0.05	0.70		—	—		18.76±0.20	0.75	
Szelment Wielki Lake	27 ♀♀	5.01±0.05	0.26	0.38	10.89±0.11	0.57	1.23	22.49±0.27	1.42	0.39	19.45±0.31	1.63	0.90
	25 ♂♂	4.98±0.06	0.29		11.09±0.12	0.59		22.35±0.24	1.15		19.07±0.29	1.40	

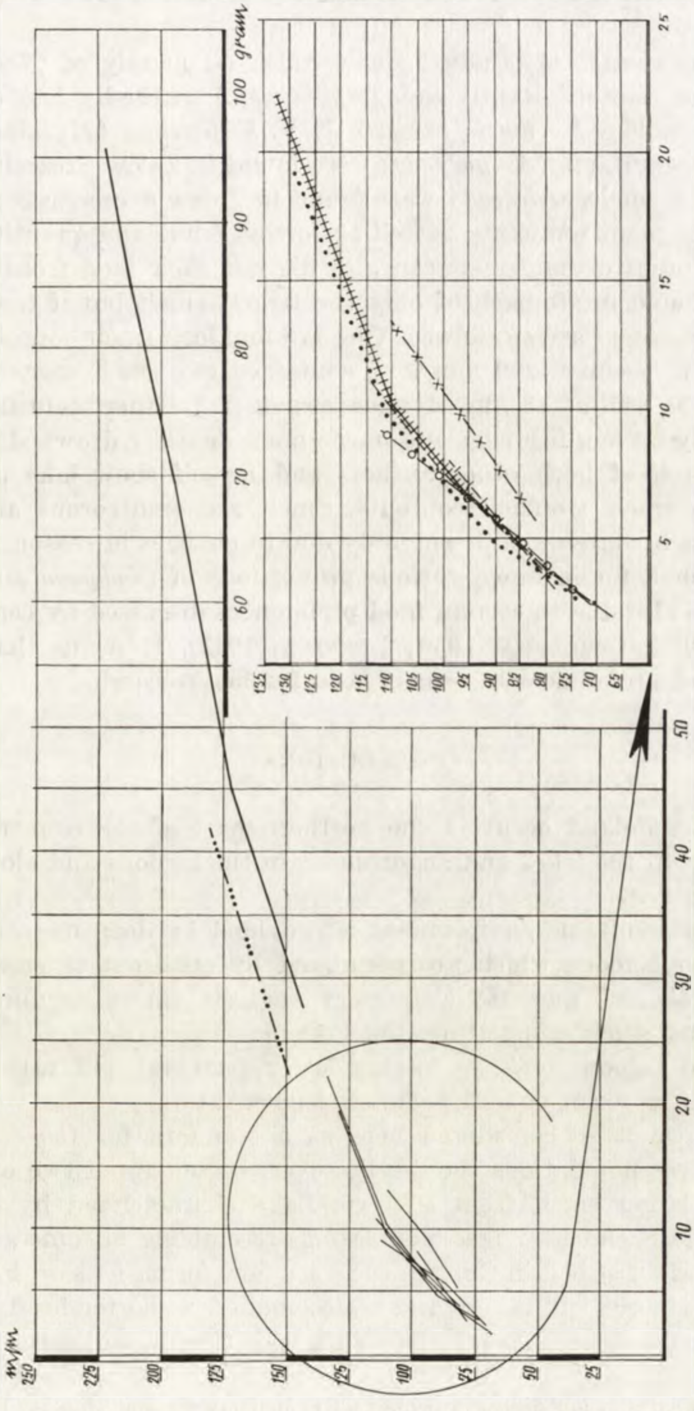


Fig. 6. Relationship between weigth and length. For explanation of lines see Fig. 5

Food

Stomach contents[1] in studied smelt consisted mainly of *Cladocera* (especially *Bosmina coregoni* BAIRD and *Daphnia* sp.) markedly less of *Copepoda*. Other *Crustacea* like *Neomysis vulgaris* J. V. THOMPSON (*Mysidacea*) and *Corophium volutator* PALL. (*Amphipoda*) were found in Zalew Szczeciński and Zatoka Pomorska smelt. *Ostracoda* were found in Zalew Szczeciński smelt. There were numerous plant remnants as well as bottom fauna and quantity of bottom mud, which indicate that smelt can also dig out their food from the bottom. Fishes were found in stomach of only the largest smelt but if they are eaten, quite large specimens are swallowed. One 178 mm long smelt contained 106 mm smelt, another specimen 200 mm long contained two smelt specimens (56 and 58 mm long) as well as 48 mm *Acerina cernua* (L.). Other identified remnants were dragonfly larvae, fish eggs and once an accidentally drowned harvestman.

The research of both other authors and myself show lake and seasonal differences in smelt stomach contents. Smelt are omnivorous and variation in their stomach contents is presumably due to changes in seasonal abundance of different food, for instance various proportions of *Copepoda* and *Cladocera*. These may be also due to certain food preferences discussed by certain authors (LITYŃSKI, 1922; CZECZUGA, 1959; LESKIEN, 1942). It seems that food relations and food preferences in smelt need further research.

CONCLUSIONS

1. Smelt in Poland occur in the northern part of the country. They are non-migratory in the lakes and anadromous in the lagoons and along the shore of the Baltic Sea.

2. The most suitable environment is provided by deep mesotrophic lakes, except for sea lagoons which are populated by anadromous smelts.

3. Mensural and meristic characters analysis shows certain differences among various smelt populations in Poland:

a) sea and lagoon smelt — having lower vertebral, gill rakers and scale counts as well as lower caudal peduncle length ratio;

b) inland smelt — considered here as a standard for *Osmerus eperlanus* (L.). From these populations should, however, be separated two other distinct populations: larger smelt from Miedwie Lake characterized by longer head, and Wigry and Szelment Wielki populations resembling in some aspect Furesø population and described in this paper as a a new forma *jenseni*. Forma *jenseni* has higher vertebral, gill rakers and scales counts, a shorter head, a lower minimum body depth, a lower interorbital width ratio and longer gill rakers

[1] I wish to express my deep gratitude to Dr. M. GLIWICZ and Mag. A. PREJS for identification of stomach contents.

(figs 1–3, tab. 1–14). Forma *jenseni* shows certain resemblances to both *O. mordax* (MITCH.) and *O. eperlanus* (L.). It should be rather included in the latter species.

4. Studies on ethmoidal region bones demonstrated a wide range of variation of these bones.

5. The life span of smelt in Poland is 8 years. The largest age groups are 2 and 3 years.

6. Length and weight increase are correlated in certain populations (fig. 4–6).

7. Spawning lasts from February in North Western Poland to the end of May in North Eastern Poland and is influenced by the weather.

8. Sexual dimorphism is not pronounced with except during spawning time when is distinct (tab. 15).

9. Stomach contents show seasonal variation, there are no marked food preferences.

10. I second KLJUKANOV's (1969) suggestion that the subspecies distinguished by MCALLISTER (1963), *Osmerus eperlanus eperlanus* (L.) and *Osmerus eperlanus mordax* (MITCH.), should be raised to full species, because of their sympatric distribution (White Sea — Pechora and Dvina North Rivers).

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STRESZCZENIE

[Tytuł: Zmienność populacyjna stynki – *Osmerus eperlanus* (Linnaeus, 1758) (*Pisces*) w Polsce]

W niniejszej pracy autor analizuje materiał stynek zebrany w 9 zbiornikach w Polsce: w Zatoce Pomorskiej, Zalewach Szczecińskim i Wiślanym oraz w 6 jeziorach śródlądowych. Wyniki analizy, porównane z dotychczasowymi danymi na ten temat, pozwoliły stwierdzić wiele różnic zachodzących między badanymi populacjami. Przy opracowywaniu materiału brane były pod uwagę głównie cechy merystyczne (przeliczalne) i niektóre plastyczne (wymierzalne). Cechy te analizowane były za pomocą metod statystycznych stosowanych w literaturze ichtiologicznej, a pozwalających stwierdzić, czy różnice między populacjami stynek z poszczególnych zbiorników są istotne. Badany był także wiek stynek, osiągane długości i ciężar, okres tarła, stosunki płci. Dla stwierdzenia przyczyn zaobserwowanych różnic między poszczególnymi populacjami autor zbadał także zawartość przewodów pokarmowych oraz osteologię etmoidalnej części czaszki. Przeprowadzone badania cech plastycznych a zwłaszcza merystycznych pozwoliły na wyodrębnienie kilku grup populacji w Polsce:

1. Populacje morskie i Zalewów o niższej liczbie kręgów, wyrostków filtracyjnych, łusek i krótszym trzonie ogonowym;

2. Populacje śródlądowe przyjęte jako standardowe dla *Osmerus eperlanus* (L.);

3. Populacja duża miedwiańska charakteryzująca się długą głową i pewnymi odrębnościami biologicznymi;

4. Populacje Wigier i Szelmentu Wielkiego o wysokiej liczbie kręgów, wyższej liczbie wyrostków filtracyjnych i łusek, krótszej głowie, niższej mini-

malnej wysokości ciała, węższym czole i dłuższych wyrostkach filtracyjnych. Populacje tych jezior zostały wyodrębnione jako nowa forma *jenseni*.

Na podstawie analizy materiałów własnych oraz w oparciu o literaturę autor uważa, podobnie jak Kljukanov (1969) na podstawie analizy osteologicznej, że traktowane przez McAllistera jako podgatunki *O. eperlanus eperlanus* (L.) i *O. eperlanus mordax* (Mitchill) należy podnieść do rangi samodzielnych gatunków także ze względu na ich sympatryczność (M. Białe — rzeka Peczora, Dwina Północna). W obrębie gatunku *O. eperlanus* (L.) należałoby umieścić wyodrębnioną formę *jenseni*.

Badania biologii stynki pozwoliły stwierdzić, że najodpowiedniejszym siedliskiem dla stynki są wody głębokie o charakterze przejściowym, mezotroficznym. Wyjątkiem są tu Zalewy Wiślany i Szczeciński, których stynkę zalicza autor do formy anadromicznej. Długość życia stynek w Polsce sięga 8 lat. Większość populacji przypada na drugi i trzeci rocznik. Tarło trwa od początku lutego w północno-zachodniej części Polski do końca maja w części północno-wschodniej w zależności od pogody w danym roku. Analiza zawartości przewodów pokarmowych wskazuje na znaczną różnorodność w pobieraniu pokarmu, uzależnioną głównie od pory roku.

РЕЗЮМЕ

[Заглавие: Популяционная изменчивость корюшки — *Osmerus eperlanus* (Linnaeus, 1758) (*Pisces*) в Польше]

В настоящей публикации автор анализирует материал корюшки, собранный из 9 водоемов Польши, в том числе из Поморской бухты, Щецинского и Вислинского заливов и из 6 внутренних озер (см. карту). Анализ полученных результатов в сравнении с имеющимися в литературе данными позволил установить ряд существенных различий между исследуемыми популяциями. При обработке материала принимались во внимание прежде всего меристические признаки, а затем лишь некоторые пластические. Как меристические, так и пластические признаки были анализированы при помощи статистических методов, применяемых в ихтиологических работах, которые позволили установить достоверность различий между популяциями из различных водоемов. Был исследован также возраст, длина тела и вес, период нереста, соотношение полов. С целью установления причин наблюдаемых различий между отдельными популяциями автор исследовал также содержимое пищеварительных каналов и остеологическое строение этмоидальной части черепа. Анализ пластических, а особенно меристических признаков позволил выделить несколько групп популяций:

1. Популяции морская и из заливов, отличающиеся меньшим числом позвонков, жаберных тычинок, чешуй в боковой линии и более коротким хвостовым стеблем;

2. Популяции из внутренних водоемов, рассматриваемые автором как типичные для *Osmerus eperlanus* (L.);

3. Популяция из озера Медве, характеризующаяся крупными размерами тела и некоторыми отличительными биологическими особенностями;

4. Популяции из озер Вигры и Большой Шельмент с увеличенным числом позвонков, жаберных тычинок и чешуй, более короткой головой, меньшей минимальной высотой тела, шириной лба и более длинными жаберными тычинками. Популяции из этих озер автор выделяет как самостоятельную форму *jenseni.*

На основании анализа собственных материалов, а также библиографических данных автор считает так же, как Клюканов (1969) на основании остеологического анализа, что *Osmerus eperlanus eperlanus* (L.) и *O. eperlanus mordax* (Mitchill), рассматриваемые McAllister'ом как подвиды следует считать самостоятельными видами, тем более, что их ареалы симпатричны (Белое море — реки Печера и Северная Двина). Новую, выделенную автором форму *jenseni* следует отнести к виду *O. eperlanus* (L.).

Исследования по биологии корюшки показали, что наиболее характерными для нее являются глубокие водоемы мезотрофического типа. Исключение составляют популяции из Вислинского и Щецинского заливов, которые автор причисляет к анадромной форме. Максимальный возраст корюшки в Польше достигает 8 лет. Анализ возрастной структуры популяций показал, что основная масса популяций состоит из двух и трехлетних рыб. Нерест продолжается с начала февраля в северо-западной Польше до конца мая в северо-восточной части страны в зависимости от метеорологических условий в данном году. Аналих пищеварительных каналов указывает на значительную дифференциацию питания, обуславливаемую прежде всего временем года.