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Analytic Survey of Coregonids of Three Polish Lakes: Miedwie, Pełcz and Wielkie Okonińskie

Analityczny przegląd koregonidów trzech polskich jezior: Miedwie, Pełcz i Wielkie Okonińskie

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[With 3 figures and 5 tables]

INTRODUCTION

In Poland whitefish is found in about 100 lakes; 64 of these situated in the Masurian Lake District (KORYCKI, 1953).

This paper deals with whitefish of three lakes only because in two of them — Miedwie Lake and Pełcz Lake — it is autochthonous and has survived unchanged up to our days. Into the third lake — Wielkie Okonińskie Lake — whitefish was introduced at some unknown time and this form has not morphologically changed since 1926 when it was investigated for the first time by KULMATYCKI (1926, 1927). In the other lakes all over Poland a more or less intensive stocking activity is being carried out using for this purpose home and imported forms of whitefish, mostly whitefish of Chudskoye Lake (Pejpus Lake) — *Coregonus lavaretus maraenoides* POLJAKOV.

The tendency to enlarge the stocking activity of the three above mentioned lakes has induced me to undertake a morphological analysis, first of all of autochthonous whitefish and then of the form, which though introduced long ago has avoided human interference and preserved its original character.

MATERIAL AND METHOD

The material was collected in the summer of 1962 and 1963 (Pełcz Lake), during the spawn period (November–December) in Miedwie Lake and Wielkie Okonińskie Lake. A total of 133 specimens were investigated: 45 adult specimens from Miedwie Lake with the total length of 490–740 mm and 3 juvenile specimens with the total length of 240–305 mm; 49 specimens from Pełcz Lake with the total length of 272–511 mm. The latter were adult specimens though of a smaller size than the whitefish from Miedwie Lake. Whitefish from Pełcz Lake belongs to a population with a low rate of growth in comparison with whitefish from other lakes. There were only 19 adult specimens from Wielkie Okonińskie Lake of the total length of 432–507 mm. The values of the plastic features were figured out with the statistic method referring all measurements to the fork leght (longitudo caudalis = fork length) according to the method ot PRAVDIN (1931) based on the method of SMITT (1886). By fork length we understand the distance between the oral end of the maxillare and the end of the middle rays of the caudal fin.

The elements composing the head were calculated in percentages from the lateral length of the head. Gill rakers were counted only on the first left branchial arch. The relative length of the gill rakers was not taken into consideration because according to the author's opinion this feature is not really important since the length of the gill raker is closely related to the number of gill rakers present. This was stated by DOTTRENS (1959) and confirmed by REŠETNIKOV 1963, p. 1190).

To differentiate the subspecies on the ground of plastic features the statistical method of E. MAYR, E. C. LINSLEY and R. L. USINGER (1956) was applied; according to this the Coefficient of Difference $C.D. = \frac{M_a - M_b}{\sigma_b + \sigma_a}$ amounts to no less than 1.28.

WHITEFISH OF MIEDWIE LAKE

The autochthonous whitefish of Miedwie Lake, the basin of the Odra River — *Coregonus lavaretus maraena* (BLOCH) — characterised by its moderate number of gill rakers, (mediospinati according to PRAVDIN, 1954). The gill raker counts indicate the range to be 27–35, mean 30.75. All of them have small teeth. THIENEMANN (1916, 1921) mentioned 27–34, the mean 30, whereas VOGT and HOFER (1909) stated that they possessed a specimen of whitefish from Miedwie Lake with 35 gill rakers on each side. In my collection, amounting to 47 specimens, I had two, with 35 gill rakers each.

This whitefish is characterized by a high frontal plate (fused intermaxillaria) forming an oral profile of the snout sloping downward and backward (Fig. 1), and the mouth opening is distinctly subterminal. Among the specimens of this form I have never come across individuals with a blunt snout and a vertically placed frontal plate or individuals with a slightly rounded fleshy snout which sometimes occurs in forms with a high number of gill rakers. The average depth of the frontal plate — 13.3 mm is greater than its width — 11.3 mm on the average. In general, the depth is 1.25 times that of the width.

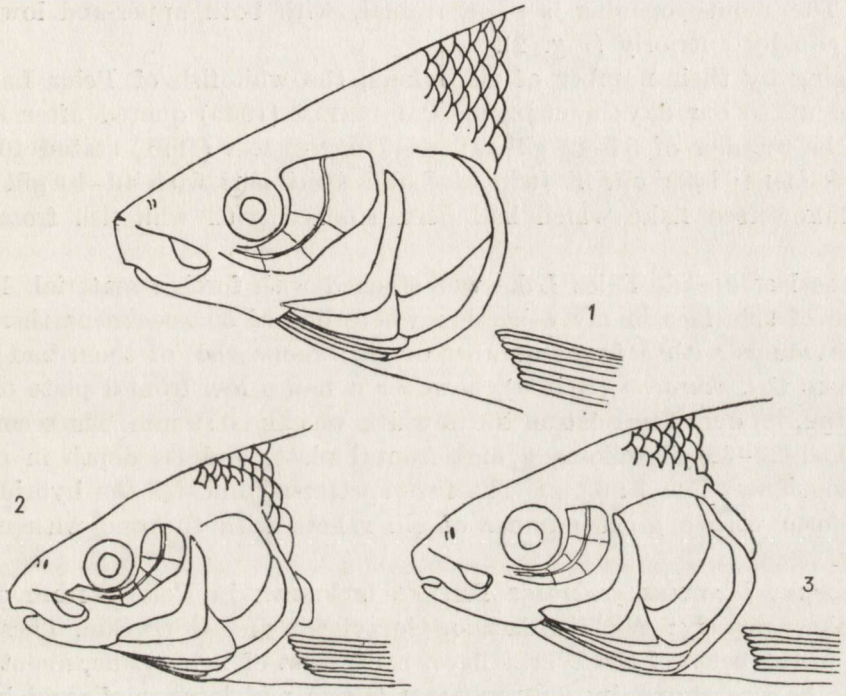

Fig. 1–3
1 — *Coregonus lavaretus maraena* (BLOCH). Miedwie Lake, 2 — *Coregonus lavaretus generosus* PETERS. Pełcz Lake, 3 — *Coregonus lavaretus holsatus* THIENEMANN. Wielkie Okonińskie Lake.

A detailed analysis of these features shows the following relationship: the frontal plate is higher than it is wide in 32 specimens, in 3 specimens these dimensions are equal and in 2 specimens its height is lesser.

The colouring of this form should be noted. The whole fish is light silver in colour, only the back and the head are slightly darker. The paired and unpaired fins are also light, almost transparent with a dark margin which is either wide or narrow.

In comparison with other forms of Polish whitefish it grows to a large size and acquires a notable weight. The females of 68.8–75.0 cm total length weigh 3.39–3.61 kg and the males 59.5–65.5 cm long weigh 1.65–2.1 kg.

THE WHITEFISH OF PEŁCZ LAKE

The second autochthonous form of whitefish occurring in Polish lakes is *Coregonus lavaretus generosus* PETERS. It was first found in Pełcz Lake, the basin of the middle course of the Warta River. Gill rakers counts for this form range from 37 to 45, on the average 41.3. It has a blunt snout and a frontal plate placed almost vertically, rerely do we come across individuals with a frontal plate sloping slightly backwards; its depth is always lesser than its width. The mouth opening is semiterminal, with both upper-and lower jaw ending equally antriorly (Fig. 2).

Judging by their number of gill rakers, the whitefish of Pełcz Lake has survived up to our days unchanged. PAPENHEIM (1905) quoted after PETERS (1874) the number of 37–42 gill rakers, THIENEMANN (1921) stated 40–45 in four specimens; later on, in 1928 he had 8 specimens with 40–46 gill rakers from Rakowersee Lake which had been stocked with whitefish from Pełcz Lake.

In the last decade Pełcz Lake was stocked with foreign material. I found evidence of this fact in my collection where out of 50 specimens there were two individuals with a fewer number of gill rakers. One of them had 34 gill rakers like *C. l. maraena* (BLOCH), however it had a low frontal plate of generosus type, its depth in relation to its width was like 6 : 9 mm. The second specimen had 27–25 gill rakers, a high frontal plate, and its depth in relation to its width was like 7 : 6 mm. The first specimen indicates the hybridization of the form with a great number of gill rakers with the one with a small number.

Coregonus lavaretus generosus PETERS is known in Poland from another three lakes, namely: Wielkie Tuczno, Gorzyńskie and Gorzyckie. These lakes also lie in the basin of the Warta River south-east of Pełcz Lake, about 70 km distant. As was stated by THIENEMANN (1928) and later confirmed by KAJ (1955) the whitefish of these lakes with numerous gill rakers is also autochthonous. In Wielkie Tuczno Lake it has preserved its relativly unchanged character, numbering 33–43 gill rakers, on the average 37.5, (KAJ, 1955). In two other lakes this form is mixed with the whitefish form with a smaller number of gill rakers, it was introduced in the period between the two World Wars or, perhaps, earlier. KULMATYCKI (1926) found 26–35, on the average 31, gill rakers in the specimens caught in Gorzyńskie Lake in 1923; KAJ (1955) stated 26–44, on the average 35, gill rakers in 115 specimens. Comparing the data given by THIENEMANN with those given by KAJ one may judge that a process of hybridization of the two forms is taking place in this lake, because the average number of gill rakers has fallen from the most frequent 38–39 to 35. The third lake — Gorzyckie Lake has at present whitefish with 28–44, on the average 35.8, gill rakers, according to KAJ (1955).

THE WHITEFISH OF WIELKIE OKONIŃSKIE LAKE

The whitefish of Wielkie Okonińskie Lake (district Tuchola, basin of the Brda River) — *Coregonus lavaretus okoniensis* KULMATYCKI according to KULMATYCKI (1926) and *C. l. holsatus* THIENEMANN according to BERG (1948) is a form with a small number of gill rakers (paucispinati). The 19 specimens investigated by the author in 1963 had only 18–24, on the average 22.5, gill rakers on the first branchial arch.

This whitefish was investigated for the first time by KULMATYCKI (1926, 1927) who found in 19 adult specimens 19–27, on the average 23–24, gill rakers taking the right and left branchial arch into account. This form was introduced into W. Okonińskie Lake at an indefinite time. SELIGO (1902, p. 113), when checking the fishes of W. Okonińskie Lake wrote „Blaufelchen eingesetzt", but he does not mention either the time it was done or the origin of the fish. There is little probability of it having been whitefish from the Subalpin lakes; this has also been stressed by KULMATYCKI (1927, p. 2). „Blaufelchen" — *Coregonus wartmanni* (BLOCH) is known to have a considerably greater number of gill rakers. It is much more probable that this form was brought over from Schaalsee Lake (Mecklenburg) since this lake is not so far away and, besides, the number of gill rakers seem to confirm it.

According to THIENEMANN (1921) the whitefish of Schaalsee Lake — *Coregonus holsatus* forma *scalensis* THIENEMANN, has 22–27, on the average 25, gill rakers. A typical form, *Coregonus holsatus* THIENEMANN, has on the average 23, ranging from 22 to 26. An extensive biometrical investigation concerning the whitefish of W. Okonińskie Lake was done by KULMATYCKI (1927), however, because of a different method of measurement it is incomparable with my data. It is therefore possible to identify it with the above mentioned form of Schaalsee Lake only on the basis of gill rakers counts and from the photograph of the head of *C. holsatus* forma *typica* (THIENEMANN, 1921, Table VIII, Fig. 12). Its characteristic feature is a fairly high frontal plate; its average height being ralated to its width as 8.4 : 7.5 = 1.1. The plate has an almost vertical position or is slightly bent downwards and backwards (Fig. 3). Therefore, in agreement with BERG (1948), we shall consider it as *Coregonus lavaretus holsatus* THIENEMANN. In comparison with the two forms of Polish whitefish previously described, this form is characteristic by its small body depth.

COMPARISON OF INVESTIGATED WHITEFISH

The three forms of whitefish here discussed (Table I) differ essentialy from one another in the following features: 1° the gill raker counts whose extreme values do not overlap (Table II); 2° shape of the snout and the position of the mouth opening; 3° proportion and position of the frontal plate (Fig. 1, 2, 3).

Table I. Meristic variation in the three Polish forms of whitefish: *Coregonus lavaretus generosus* PETERS (*C. l. g.*) from Pełcz Lake; *C. l. maraena* (BLOCH) (*C. l. m.*) from Miedwie Lake; and *C. l. holsatus* THIENEMANN (*C. l. h.*) from Wielkie Okonińskie Lake.

Feature	Name of fish	Range	Mean	Sample
Lateral line scales	*C. l. g.*	83–103	92.0	48
	C. l. m.	80– 97	90.6	44
	C. l. h.	84– 97	88.2	19
Gill rakers	*C. l. g.*	37– 45	41.3	48
	C. l. m.	27– 35	30.75	44
	C. l. h.	18– 24	22.0	19
Dorsal fin rays	C. *l. g.*	III–IV 10–11	—	48
	C. l. m.	III–IV 9–11	—	44
	C. l. h.	III–IV 9–11	—	19
Anal fin rays	*C. l. g.*	III–IV 12–15	—	48
	C. l. m.	III–IV 10–12	—	44
	C. l. h.	III 10–12	—	19
Vertebrae	*C. l. g.*	60–64	61.6	20
	C. l. m.	56–63	—	10
	C. l. h.	59–63	—	10

Table II. Frequency of occurrence of gill raker counts in the three forms of Polish whitefish 1. *Coregonus lavaretus generosus* PETERS, 2. *C. l. maraena* (BLOCH); 3a. *C. l. holsatus* THIENEMANN, 3b. *C. l. holsatus* THIENEMANN after KULMATYCKI.

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
1																				1	6	8	6	9	7	7	2	—	1
2										1	2	6	14	7	9	2	2	2											
3a	1	1	3	1	3	5	5																						
3b			1	3	3	4	3	3	2																				

As to their plastic features the investigated forms differ more or less from one another. Among the numerous features there are those whose value of Coefficient of Difference exceed 1.28 which means the value acknowledged by MAYR, LINSLEY and USINGER (1956) as admissible for differentiating subspecies units that complete morphological differences.

Coregonus lavaretus generosus PETER will represent the basis for a comparison of the investigated forms. We have stated 6 essential differences in the plastic features (Table III) between this form and *C. l. maraena* (BLOCH) when calculated in relation to the fork length: 1° preorbital distance (*C. D.* = 1.7) 2° diameter of the eye (*C. D.* = 1.35); in relation to the length of the head: 3° diameter of the eye (*C. D.* = 1.3), 4° preorbital distance (*C. D.* = 1.6); in relation to the interorbital width: 5° length of maxillare (*C. D.* = 1.3), 6° diameter of the eye (*C. D.* = 1.55).

Comparing *C. l. generosus* PETERS with *C. l. holsatus* THIENEMANN we find a difference in one feature only, this is the anal fin length in the fork length (*C. D.* = 1.3). Comparing *C. l. maraena* (BLOCH) with *C. l. holsatus* THIENEMANN we can state only two essential differences: 1° preorbital length in the head length (*C. D.* = 1.4), 2° maxilla length in the interorbital distance (*C. D.* = 1.5).

As to the similarities of the plastic features (Table III), they are numerous and concern the following seven features: 1° length of the head, 2° length of maxillare, 3° length of mandible, 4° interorbital width, 5° caudal peduncle length, 6° minimal body height, 7° ventral fin length.

The similarities of the plastic features in the investigated whitefish may be explained by the fact that their bodies were shaped in similar climatic and physical conditions since these lakes had been populated in the postglacial period. If we assume „a priori" that the whitefish of W. Okonińskie Lake originate from the whitefish of Schaalsee, we must remember that this lake as well as Miedwie Lake and Pełcz Lake, all being of postglacial origin, came into being in similar physico-chemical conditions. With the course of time they differentiated with regard to size, eutrophy stage and oxygen saturation at the bottom. It is quite possible that the lakes of the Polish-German plain were populated with whitefish with a different number of gill rakers after the glacier had retreated and that the selection of forms occurred as a result of the gradual transition of the lakes from the primary oligotrophic phase to the present meso-and eutrophic phase. Consequently only the type of whitefish which easily adapted itself to local conditions survived in the lake.

Miedwie Lake (area 36 km², length 16 km, maximal width 3 km, maximal depth 43.8 m) has, according to THIENEMANN (1928), a good oxygen saturation at the bottom — 60.7 % or 5.12 cm³/l and therefore, it represents a type of mesotrophic lake and the form of whitefish that has survived in it has a small number of gill rakers and is adapted to feeding on bottom fauna.

Table III. Proportionate measurments of plastic features of three Polish forms of whitefish: *Coregonus lavaretus generosus* PETERS, $n = 48$; *C. l. maraena* (BLOCH), $n = 44$; *C. l. holsatus* THEINEMANN, $n = 19$; calculated statistically.

Feature	Name of fish	Range	$M \pm m$	σ	Ratio	$\frac{M_x - M_y}{\sigma_y + \sigma_x}$
		in % of fork length				
Head length	*C. l. g.*	18.0–20.8	19.6±0.1	0.7	—	—
	C. l. m.	17.8–22.0	19.8±0.15	1.0	*C. l. g./C. l. m.*	0.1
	C. l. h.	18.6–21.4	19.9±0.2	0.8	*C. l. g./C. l. h.*	0.2
Head height	*C. l. g.*	12.4–15.0	13.7±0.1	0.5	—	—
	C. l. m.	12.7–17.0	14.6±0.2	1.1	*C. l. g./C. l. m.*	0.64
	C. l. h.	13.1–16.0	14.7±0.2	0.8	*C. l. g./C. l. h.*	0.80
Preorbital length	*C. l. g.*	4.0– 5.1	4.4±0.03	0.2	—	—
	C. l. m.	4.5– 6.4	5.6±0.1	0.5	*C. l. g./C. l. m.*	1.71
	C. l. h.	4.0– 5.2	4.7±0.3	0.3	*C. l. g./C. l. h.*	0.60
Maxilla length	*C. l. g.*	4.4– 5.7	5.0±0.1	0.6	—	—
	C. l. m.	4.7– 6.0	5.5±0.02	0.01	*C. l. g./C.l.m.*	0.80
	C. l. h.	4.2– 5.4	5.1±0.06	0.24	*C. l. g./C.l.h.*	0.10
Mandible length	*C. l. g.*	7.0– 8.6	7.9±0.05	0.35	—	—
	C. l. m.	6.5– 8.8	7.6±0.07	0.5	*C. l. g./C. l. m.*	0.35
	C. l. h.	6.7– 8.0	7.2±0.08	0.34	*C. l. g./C. l. h.*	1.0
Eye diameter	*C. l. g.*	3.8– 5.4	4.9±0.05	0.33	—	—
	C. l. m.	3.0– 4.7	3.9±0.07	0.4	*C. l. g./C. l. m.*	1.37
	C. l. h.	4.2– 5.0	4.6±0.02	0.3	*C. l. g./C. l. h.*	0.9
Interorbital width	*C. l. g.*	5.3– 6.7	6.3±0.04	0.3	—	—
	C. l. m.	4.7– 8.0	6.0±0.3	0.2	*C. l. g./C. l. m.*	0.6
	C. l. h.	5.6– 6.6	6.3±0.06	0.27	*C. l. g./C. l. h.*	0.0
Antedorsal distance	*C. l. g.*	39.0–46.0	42.7±0.13	1.5	—	—
	C. l. m.	39.0–48.2	44.6±0.34	2.16	*C. l. g./C. l. m.*	0.52
	C. l. h.	43.9–48.6	45.6±0.35	1.5	*C. l. g./C. l. h.*	1.0
Postdorsal length	*C. l. g.*	39.4–47.5	41.8±0.18	1.24	—	—
	C. l. m.	36.1–45.0	40.8±0.3	1.8	*C. l. g/C. l. m.*	0.32
	C. l. h.	39.0–42.4	41.0±0.2	0.9	*C. l. g./C. l. h.*	0.33
Caudal pedunel length	*C. l. g.*	10.9–14.2	12'9±0.13	0.9	—	—
	C. l. m.	10.0–15.6	12.8±0.17	1.1	*C. l. g./C. l. m.*	0.5
	C. l. h.	11.9–14.2	13.3±0.2	0.9	*C. l. g./C. l. h.*	0.22
Minimal body height	*C. l. g.*	6.9– 7.9	7.4±0.03	0.25	—	—
	C. l. m.	6.1– 8.5	7.4±0.07	0.5	*C. l. g./C. l. m.*	0.0
	C. l. h.	6.8– 7.7	7.2±0.07	0.3	*C. l. g./C. l. h.*	0.36
Dorsal fin length	*C. l. g.*	10.0–14.2	11.5±0.3	0.9	—	—
	C. l. m.	9.8–13.6	11.7±0.13	0.9	*C. l. g./C. l. m.*	0.11
	C. l. h.	7.8–11.9	10.7±0.14	0.6	*C. l. g/C. l. h.*	0.53
Dorsal fin height	*C. l. g.*	16.4–19.5	17.8±0.12	0.8	—	—
	C. l. m.	13.6–18.0	15.9±0.16	1.1	*C. l. g./C. l. m.*	1.0
	C. l. h.	16.1–18.4	17.3±0.17	0.7	*C. l. g./C. l. h.*	0.33
Anal fin length	*C. l. g.*	10.4–15.0	12.8±0.14	1.0	—	—
	C. l. m.	8.8–13.0	10.7±0.15	1.0	*C. l. g./C. l. m.*	1.0
	C. l. h.	8.5–12.0	10.5±0.18	0.75	*C. l. g./C. l. h.*	1.3
Anal fin height	*C. l. g.*	10.9–13.7	12.3±0.1	0.65	—	—
	C. l. m.	10.0–13.0	11.5±0.01	0.8	*C. l. g./C. l. m.*	0.55
	C. l. h.	10.4–13.6	11.5±0.1	0.45	*C. l. g./C. l. h.*	0.70
Pectoral fin length	*C. l. g.*	14.2–18.2	16.3±0.3	0.9	—	—
	C. l. m.	13.0–20.4	18.1±0.2	1.4	*C. l. g./C. l. m.*	0.78
	C. l. h.	16.4–18.7	17.3±0.14	0.6	*C. l. g./C. l. h.*	0.66

Feature	Name of fish	Range	$M \pm m$	σ	Ratio	$\frac{M_x - M_y}{\sigma_y + \sigma_x}$
			in % of fork length			
Ventral fin length	*C. l. g.*	14.5–17.9	16.1±0.1	0.7	—	—
	C. l. m.	13.0–18.4	16.0±0.16	1.07	*C. l. g./C. l. m.*	0.06
	C. l. h.	15.7–17.5	16.4±0.13	0.5	*C. l. g./C. l. h.*	0.25
P – V distance	*C. l. g.*	24.6–30.6	27.5±0.2	1.5	—	—
	C. l. m.	24.6–33.0	29.5±0.3	2.0	*C. l. g./C. l. m.*	0.57
	C. l. h.	24.0–31.8	29.4±0.4	1.8	*C. l. g./C. l. h.*	0.60
V – A distance	*C. l. g.*	21.6–28.2	25.6±0.22	1.5	—	—
	C. l. m.	19.5–30.0	27.8±0.3	2.2	*C. l. g./C. l. m.*	0.60
	C. l. h.	23.2–30.0	26.1±0.45	1.9	*C. l. g./C. l. h.*	0.15
			in % of head length			
Eye diameter	*C. l. g.*	20.0–27.8	25.0±0.2	1.5	—	—
	C. l. m.	14.0–24.5	20.2±0.3	2.2	*C. l. g./C. l. m.*	1.30
	C. l. h.	22.0–26.0	23.7±0.3	1.2	*C. l. g./C. l. h.*	0.5
Anteorbital distance	*C. l. g.*	20.0–25.0	22.7±0.16	1.14	—	—
	C. *l. m.*	23.1–33.0	28.4±0.3	2.1	*C. l. g./C. l. m.*	1.6
	C. l. h.	21.0–25.9	23.9±0.0	1.1	*C. l. g./C. l. h.*	0.05
Interorbital width	*C. l. g.*	29.0–35.0	31.7±0.2	1.35	—	—
	C. l. m.	25.0–35.0	30.0±0.3	2.0	*C. l. g./C. l. m.*	0.5
	C. l. h.	30.0–34.0	32.5±0.3	1.15	*C. l. g./C. l. h.*	0.32
Maxilla length	*C. l. g.*	21.0–31.0	25.5±0.26	1.86	—	—
	C. l. m.	25.0–32.6	28.0±0.26	1.65	*C. l. g./C. l. m.*	0.7
	C. l. h.	23.1–27.5	26.2±0.27	1.15	*C. l. g./C. l. h.*	0.23
Mandible length	*C. l. g.*	37.0–43.0	39.7±0.2	1.5	—	—
	C. l. m.	34.1–42.0	39.2±0.26	1.8	*C. l. g./C. l. m.*	0.15
	C. l. h.	34.7–40.0	37.8±0.3	1.2	*C. l. g./C. l. h.*	0.70
			in % of interorbital width			
Maxilla length	*C. l. g.*	71.5–100.0	80.9±0.7	4.5	—	—
	C. l. m.	82.0–104.0	90.8±0.64	3.0	*C. l. g./C. l. m.*	1.3
	C. l. h.	77.7–87.0	82.0±0.7	3.0	*C. l. g./C. l. h.*	1.15
Eye diameter	*C. l. g.*	70.0–86.3	78.5±0.6	4.0	—	—
	C. l. m.	50.0–74.9	62.5±0.9	6.3	*C. l. g./C. l. m.*	1.55
	C. l. h.	68.0–85.2	73.2±1.0	4.5	*C. l. g./C. l. h.*	0.6

Pełcz Lake is 8 km long, and is divided into two parts by a narrow strait only 80 m wide. Its maximal depth reaches 30 m and its oxygon saturation is 41.2 % or 1.28–3.96 cm^3/l. It is an eutrophic type of lake which can be populated with whitefish in a limnetic zone only and consequently with the form of whitefish with high gill raker counts feeding mostly on plankton.

Schaalsee Lake which is supposed to be the place of origin of whitefish living in W. Okonińskie Lake, has an area of 21.89 km, its maximal depth – 71.5 m, its oxygen saturation near the bottom 75 % or 3.7–6 cm^3/l according to THIENEMANN (1928). Therefore it is a lake at an early stage of eutrophy.

W. Okonińskie Lake has an area of scarcely 0.26 km^2 its maximal depth reaches 30 m, its oxygen saturation at a depth of 21 m is 1.5 cm^3/l (according to KULMATYCKI, 1927). A whitefish with small gill raker counts which was

introduced into this lake at the end of the XIX century has not as yet undergone any morphological changes, including the number of gill rakers, but the poor oxygen condition at the bottom make it impossible for it to live and find feeding matter in this region. Consequently this form of whitefish is declining in W. Okonińskie Lake. Already stressed by KULMATYCKI (1927).

THE RELATION OF THE MANDIBLE LENGTH TO THE MINIMAL BODY HEIGTH OF THE INVESTIGATED FORMS OF WHITEFISH

The relation of the mandible length to the minimal body height in the investigated whitefish was various. In the three mentioned forms there were individuals whose mandible was longer, equal to or shorter than their minimal body height. The numerical interdependence is illustrated in Table IV in which the fishes were divided into groups according to their length.

It is characteristic for these three forms that in all of them individuals with a mandible longer then their minimal body height dominate: *C. l. generosus* PETERS — 85.4 %, *C. l. maraena* (BLOCH) — 59.6 % and *C. l. holsatus* THIENEMANN — 63.2 %; the remaining individuals have eiter a mandible equal to or shorter than their minimal body height.

The ratio of the relative values of mandible length to the corresponding values of minimal body height (l_{md}: h) as is shown in Table IV amounts to in *C. l. generosus* PETERS and *C. l. maraena* (BLOCH) to more than 1, which indicates that both forms of whitefish belong to the group of *C. lavaretus lavaretus* L. according to BERG (1948) and GĄSOWSKA (1960). This ratio in *C. l. holsatus* THIENEMANN equals only 1, this may, however, result from the small number of investigated specimens; the fact that in general it is not smaller than 1 allows us to classify it in the group of *C. l. lavaretus* L. which differs from the group of *C. l. pidschian* (GMELIN) whose mandible is shorter than its minimal body height.

SOME REMARKS ON MORPHOLOGICAL DIFFERENCES BETWEEN MALES AND FEMALES

Completing the morphological character of the investigated whitefish, the differences depending of the sex should not be omitted. These differences were noted by several authors and recently REŠETNIKOV (1963) gave a tabular set of certain features of whitefish with a small number of gill rakers from Chun-Oz. Lake (Kola Peninsula). From the tabular set of REŠETNIKOV it results that males have a longer head. This phenomenon is quite known in fishes and PRITCHARD (1928, 1931) observed it in coregonids of the *leucichthys*-group of Lake Ontario. HILE (1938) was inclined to explain the smaller dimetions of a female's head not by sex but rather by the more rapid growth of females. HILE'S anticipations (1938, p. 63) saying that „Further study may show that sex differences in certain morphological characters are quite general in coregonids"

Table IV. Number of specimens in distinct length classes characterised by different relationships of length of the mandible (l_{md}) to minimal body height (h), expressed in percentage, and ratio of $l_{md} : h$.

Coregonus lavaretus generosus PETERS of Pełcz Lake

Length class of fish in cm	22.5–28.0	30.2–33.0	45.6–47.1		*n*	%
$l_{md} > h$	25	15	1		41	85.4
$l_{md} = h$	1	1	—		2	4.2
$l_{md} < h$	—	4	1		5	10.4
					48	
$l_{md} : h$	1.07	1.02	1.00			

Coregonus lavaretus maraena (BLOCH) of Miedwie Lake

Length class of fish in cm	22.5–28.0	45.2–49.0	50.1–59.5	61.0–69.0	*n*	%
$l_{md} > h$	3	2	15	5	25	59.6
$l_{md} = h$	—	—	5	1	7	16.6
$l_{md} < h$	—	1	7	2	10	23.8
					42	
$l_{md} : h$	1.11	1.00	1.01	1.05		

Coregonus lavaretus holsatus THIENEMANN of W. Okonińskie Lake

Length class of fish in cm	39.0–39.7	40.3–46.3			*n*	%
$l_{md} > h$	3	9			12	63.2
$l_{md} = h$	—	2			2	11.5
$l_{md} < h$	3	2			5	26.3
					19	
$l_{md} : h$	1.00	1.01				

do not provide sufficient ground for attributing any regularity to them as in my material I have discovered a quite different relationship:

Head length as counted in percentage of the fork length

sex	*C. l. generosus* PETERS	*n*	*C. l. maraena* (BLOCH)	*n*	*C. l. holsatus* THIENEMANN	*n*
♂♂	19.33	9	19.23	22	19.64	5
♀♀	19.52	27	19.90	13	19.80	11

As to the caudal peduncle length I have found in two forms of *C. l. generosus* PETERS and *C. l. maraena* (BLOCH) that males have a shorter caudal peduncle which is in conformity with REŠETNIKOV'S observation. In the case of *C. l. holsatus* THIENEMANN males have a longer caudal peduncle than females.

Caudal peducle length as counted in percentage of the fork length

sex	*C. l. generosus* PETERS	*n*	*C. l. maraena* (BLOCH)	*n*	*C. l. holsatus* THIENEMANN	*n*
♂♂	12.70	9	12.79	22	13.72	5
♀♀	12.92	27	12.93	13	13.23	12

This relation proves to be true if we limit our calculations to the number of 5 specimens in all cases.

COMPARISON OF THE COREGONID FORMS LIVING IN DIFFERENT AND REMOTE BODIES OF WATER AND CHARACTERIZED BY HIGH COUNTS OF GILL RAKERS

There is no doubt that both the autochthonous forms of whitefish which came over to our lakes at the postglacial period are very closely genetically related to the whitefish of the northern and north-eastern areas of Europe, since these forms are of Baltic origin. What is the present model of differentiation between these forms dispersed in numerous bodies of water, let us consider the case of whitefish with numerous gill rakers. To this purpose I shall compare one Polish form — *C. l. generosus* PETERS from Pełcz Lake with *C. l. pallasi* natio *aspius* SMITT from Muolanyarvi, Pyukhyarvi in the basin of Vuoksi River (Karelo-Finnish SSR), Ladoga Lake (PRAVDIN, 1954, p. 41) and *C. l. pallasi* VAL. from the Neva River (PRAVDIN, 1931, p. 192). The compared forms are characterised above all by: 1° the average number of gill rakers above 40, ranging from 41.3 to 45; 2° the blunt snout; 3° the height of the frontal plate is smaller than its width; 4° the pelagic way of life; 5° the preponderance of plankton in food. The similitude of plastic features in the compared forms is different (Table V). Comparing the whitefish from Pełcz Lake with that of Muolanyarvi Lake we state a great similarity in 10 cases: it concerns: 1° preorbital distance, 2° diameter of the eye, 3° maxilla length, 4° mandible length, 5° head height, 6° head length, 7° minimal depth, 8° postdorsal length, 9° P — V distance, 10° V — A distance. Comparing the whitefish of Pełcz Lake with the form of Pyukhyarvi Lake we find a similarity in six cases only, further we state 6 features of similar value to the features of the whitefish from Ladoga Lake and 5 cases of value similar to the whitefish of the Neva River.

Table V. Comparison of meristic and plastic features of five forms of whitefish with a high count of gill rakers

Features	*Coregonus lavaretus generosus* PETERS	*C. l. pallasi* natio *aspius* SMITT			*C. l. pallasi* VAL.
	Pełcz Lake	Muolanyarvi	Pyukhyarvi	Ladoga Lake	Neva River[1]
Lateral line	83–103	–	–	92–103	85–105
	92				
Gill rakers	37–45	–	–	32–47	41–50
	41.3	45	45	43	42
Dorsal fin rays	IV 10–11	IV 10	IV 10	IV 10	IV 11
Anal fin rays	III–IV 12–15	IV 10	IV 12	III 13	IV 13
Vertebrae	60–64				
	61.6	–	–	–	–
	in % of fork length				
Head length	19.6	19.8	21.1	18.8	17
Head height	13.7	13.6	12.9	12.9	13
Maxilla length	5.0	5.4	5.7	5.1	4
Mandible length	7.9	7.8	8.1	7.8	–
Preorbital distance	4.4	4.7	6.1	4.7	4
Postorbital distance	11.4	10.5	11.1	9.8	9
Eye diameter	4.9	4.7	5.0	4.7	4
Maximal body height	23.9	21.3	21.8	24.2	22
Minimal body height	7.4	7.4	7.1	7.5	6–8
Antedorsal distance	44.6	45.3	43.2	48.5	–
Postdorsal distance	41.8	41.5	43.2	42.4	–
Caudal peduncle length	12.9	14.3	12.9	13.3	–
P—V distance	27.5	27.5	26.8	29.0	–
V—A distance	25.6	25.6	23.9	25.9	–
D length	11.4	10.4	11.1	11.0	11
D height	17.8	16.3	16.1	16.5	14
A length	12.8	11.6	11.4	12.2	10
A height	12.3	10.1	8.9	9.8	10
P length	16.3	13.6	14.3	14.9	14
V length	16.1	14.3	13.6	15.3	14

[1] PRAVDIN (1931: 190)

Though among the forms living exclusively in lakes we state great differences, for instance in the length of the head of the form living in Pyukhyarvi Lake; yet the whitefish of the Neva River differ from all the other forms in head length; this is very small and consequently the elements composing the head also have smaller dimentions. Certain deviations are observed in the fins too. The height of the dorsal fin and the length of the anal fin are smaller than in all the other forms compared here.

Considerable differences in head length as shown in Table V do not, in my opinion, prove any deeper peculiarity of these forms. As results from the comparison of the head length of males and females of the three forms living in lakes, see above, females have longer heads than males; this observation contradicts the previous information from the literature (HILE, 1938; PRITCHARD, 1928, 1931; REŠETNIKOV, 1963). Thus it may be concluded that the head length as well as other features are shaped according to some essential conditions in the environment.

CONCLUSION

In *Coregonus lavaretus* L. the stable features are rather limited. The relation of the mandible length to the minimal body height is one of them. On this ground BERG (1948) divided *C. lavaretus* L. into two groups: *C. l. lavaretus* L. whoes mandible is longer than the minimal body height and *C. l. pidschian* (GMELIN) whose mandible is shorter than the minimal body height.

As to the other inherited feature – the number of gill rakers – the opinions differ. DOTTRENS (1959) and SVÄRDSON (1957) consider that this feature is stable. SVÄRDSON says that: „Gill rakers do not change with time" and „Gill rakers do not change in transplanted population". He considers the change to be a result of selection. The Russian investigator MAILJAN (1957) stated a change in the number of gill rakers when whitefish were transferred to very different environmental conditions. His observation concerns *C.l. ludoga* POLJAKOV, (paucispinati), bottom form Ladoga Lake, which has 20–26, on the average 23–24 gill rakers. This form when transferred to Sevan Lake (Gokcha) in Armenia in 1924–1927, when investigated in 1952–1953 proved to have 19–30, on the average 26.6, gill rakers. Another form *C. l. maraenoides* POLJAKOV from Chudskoye-Oz. Lake (Pejpus) with 35–45, on the average 38.9 gill rakers, transferred at those time to Sevan Lake, when investigated simultaneously with the previous form proved to have 32–45, on the average 36.2, gill rakers. In spite of certain changes in the number of gill rakers these forms have presented their own individual features. The classification was based on the following three features: 1° structure of the gill rakers, 2° shape of the frontal plate, 3_0 body shape. According to MAILJAN (1957) both forms have shown great ability in adapting themselves to new environmental conditions, particulary to thermal and oxygen conditions and to the kind of food. In new conditions some proportions in the body of these fishes underwent certain changes as compared with parental forms, and adapted themselves to a new way of feeding. Considering this fact MAILJAN classified them as separate populations of *C. lavaretus ludoga* natio *sevani* and *C. lavaretus maraenoides* natio *sevani*.

The metabolism of whitefish is enormous and so the question arises whether it is proper to form so many taksonomic units particulary within sub-

species and whether the units of subspecies are in all cases sufficiently proved. REŠETNIKOV (1963) described the variability of whitefish as follows, page 1193: „Practically each lake, each body of water has its own population a little different from the other populations". HILE (1938) expressed the same opinion and pondered over the splitting of the species *Leucichthys artedi* (LE SUEUR) into numerous subspecies (KÖLZ, 1929), on page 122 he writes: „However, pending the accumulation of adequate data for a separation of the *artedi* forms according to their true and natural relationships, it would appear that the designation of a local form can be made best through a description of its salient characters and a recording of the locality it inhabits".

It is the purpose of this paper to investigate the three forms of Polish whitefish, analysing with modern methods, the morphology of the forms which have already been classified. These are the forms ranging among the subspecies, living in basins isolated from one another and, as it was proved, preserving their morphological specifity. However, in the case of *Coregonus lavaretus generosus* PETERS which is very similar to the forms with numerous gill rakers living in other territories, as is seen in Table V, the question arises whether this forms is not a local form of the migrating Baltic whitefish with numerous gill rakers — *Coregonus lavaretus pallasi* VAL.

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STRESZCZENIE

Trzy formy podgatunkowe: *Coregonus lavaretus generosus* Peters *C. l. maraena* (Bloch) i *C. l. holsatus* Thienemann, z których dwie pierwsze są autochtonami w naszych wodach, zostały opracowane metodą statystyczną z uwzględnieniem cech merystycznych i plastycznych. Autorka zwróciła uwagę na małe różnice w cechach plastycznych tych form, tłumacząc to wpływem środowiska o zbliżonych cechach fizyko-chemicznych, w których te formy kształtowały się w czasach polodowcowych, zależnie od tempa eutrofizacji jezior przez nie zamieszkiwanych. Stwierdza odmienne niż podawane w literaturze (Hile, 1938; Rešetnikov, 1963, i inni) stosunki długości głowy samców i samic.

Przeprowadziwszy porównanie siei gęstofiltrowej *C. l. generosus* Peters z pokrewnymi formami gęstofiltrowymi niektórych jezior południowej części Karelskiej ASRR i jeziora Ładogi, autorka wysuwa sugestię, czy *C. l. generosus* Peters, jako pochodna od siei gęstofiltrowej bałtyckiej *Coregonus lavaretus pallasi* Val., nie jest tylko jedną z miejscowych populacji tego podgatunku.

РЕЗЮМЕ

Автор обработала биометрически с применением вариационной статистики три подвида: *Coregonus lavaretus generosus* Peters, *C. l. maraena* (Bloch) и *C. l. holsatus* Thienemann, из которых два первые являются автохтонами для водоемов Польши. Были приняты во внимание как меристические признаки, так и пластические. Автор обратила внимание на то, что различия в пластических признаках этих форм незначительны, объясняя это влиянием сходных в физико-химическом отношении условий среды, в которых формировались эти подвиды в послеледнико-

вом периоде, в зависимости от темпа эвтрофизации заселенных ими озер. Автор обнаружила иные пропорции головы у самцов и самок, чем приводятся в литературе (Hile, 1938; Решетников, 1963, и др.).

Сравнивая многотычинкового сига *C. l. generosus* Peters с родственными многотычинковыми формами из некоторых озер южной части Карело-Финской ССР и Ладожского озера, автор ставит вопрос, не является ли *C. l. generosus* Peters как производное многотычинкового балтийского сига *Coregonus lavaretus pallasi* Val. одной из локальных популяций этого вида.