Tomasz HEESE

**MORPHOLOGY OF TWO PLASTIC FORMS OF WHITEFISH
(*COREGONUS LAVARETUS* (L.))
OCCURRING IN THE POMERANIAN BAY AND SZCZECIN LAGOON**

**MORFOLOGIA DWÓCH FORM PLASTYCZNYCH SIEI
(*COREGONUS LAVARETUS* (L.))
WYSTĘPUJĄCYCH W ZATOCE POMORSKIEJ I ZALEWIE SZCZECIŃSKIM**

**Institute of Ichthyology,
Academy of Agriculture, Szczecin**

Morphology of whitefish (*Coregonus lavaretus*) was studied in the population inhabiting the Pomeranian Bay and Szczecin Lagoon. The whitefish migrate cyclically between the two areas and spawn in the Szczecin Lagoon. Detailed examination allowed to differentiate between two plastic forms of the whitefish within the sample studied. A number of characters were found that differed significantly between the two forms. The cluster analysis, however, suggests the existence of a whole gamut of intermediate individuals. Each form is shown to have sexual dimorphism-related characters.

INTRODUCTION

Problems of systematics of the whitefish (*Coregonus lavaretus*), its forms and related species have been frequently tackled (Kulmatycki, 1926/1927; Pravdin, 1931; Järvi, 1943; Steinmann, 1951; Svårdson, 1957, 1970; Gąsowska, 1960, 1967, 1970; Šapošnikova, 1968; Behnke, 1972; Mednikov et al., 1977; Ferguson et al., 1978; Rešetnikov, 1980; and many others). Basically, each author with his or her predecessor. As a consequence, no clear-cut and lucid taxonomic system has been applied to the whitefish

(*C. lavaretus s. lato*), various systems proposed being frequently chaotic and regional in their application. The reason may be sought in the high plasticity of the species, quickly adapting to environmental changes.

The form of whitefish occurring in the Pomeranian Bay and Szczecin Lagoon is interesting for a number of reasons, a possibility of intensive culture being one of them. Moreover, thanks to Pęczalska (1962, 1966) it was possible to follow morphological changes of the species in the area that have taken place over a period of more than 20 years. Still another reason for studying the species is the necessity to protect the native whitefish form which is best adapted to the local habitat and reproduces under natural conditions.

The samples collected in the two areas under study were found to contain two groups of individuals, differing markedly in their head profile. Thus an attempt was made to determine the degree to which the two forms differ from each other, meristic and plastic characters being considered and various methods of study being employed. The present work is aimed at analysing the whitefish systematics, with a due consideration to the plastic forms mentioned.

AREAS OF STUDY

The Szczecin Lagoon is connected with the Pomeranian Bay via three rivers: the Peene, Swina, and Dziwna. The Lagoon coastline is well developed and contains numerous coves; the total area of the Lagoon (with the connecting rivers included) amounts to about 910 km² (Majewski, 1980). The hydrological regime of the Lagoon is governed by the riverine inflows, periodical influxes of saline water from the Pomeranian Bay, and eutrophication. The two areas interact strongly, the connection between them allowing for water exchange in two opposite directions. The basic driving force of the exchange are the winds. Additionally, the exchange is enhanced by a slight water level difference between the Lagoon and the Baltic Sea (0.227 m on the average) (Kubiak, 1980).

Environmental conditions of the Szczecin Lagoon and Pomeranian Bay induce high fish productivity, the Lagoon itself belonging to the most productive reservoirs adjacent to the Baltic (Wiktor, 1971).

In spite of increasing pollution, the Lagoon environment has still a large potential for self-purification and serves as a kind of "biologic treatment plant" for the River Odra water. The growing eutrophication, however, contributes considerably to qualitative changes in the fish fauna, the changes favouring less valuable species.

MATERIALS AND METHODS

The fish individuals examined were collected mainly from commercial catches made by the „Certa” Fisheries Cooperative in the Szczecin Lagoon and Pomeranian Bay (Table 1).

Table 1

Description of the materials examined

Year	Month	No. of individuals	Total length (cm)	Age	Total
1983	July*	10	10.4–12.0	0+	57
	October	33	37.5–57.3	3+ – 6+	
	November	14	37.7–59.2	1+ – 8+	
1984	February	16	37.8–56.2	2 – 7+	244
	March	60	34.8–59.1	2 – 9+	
	April	35	37.6–64.1	2 – 9+	
	May	26	35.9–53.2	2+ – 8	
	August*	16	11.7–14.2	0+	
	October	24	36.0–58.0	1+ – 7+	
	November	67	37.7–64.4	1+ –10+	
1983–1984		301	10.4–64.4	0+–10+	301

* caught with juvenile fish trawl

Fresh individuals were examined, the fry only being formalin-preserved immediately after capture. The fish age was determined from scales taken from the first row behind the dorsal fin above the lateral line. The following meristic characters were included in the analysis: ray counts (hard and soft rays) were made in fins and gill membrane; number of scales along the lateral line as well as number of scale rows above and below it were determined; vertebrae count was made; and gill rakers on the external gill arch were counted on both sides of the fish. The number of scales along the lateral line was determined by counting those showing the lateral line canal aperture and disregarding the fine scales at the base of the caudal fin. The vertebrae were counted after removal of the right side muscles. Since the first vertebra in the coregonids is small and fused with the skull, it was disregarded, as was the urostyl.

The plastic characters of the fish body were analysed following Smith's diagram published by Pravdin (1966). The first gill arch was measured as described in that paper as well. All measurements were made with callipers to 0.5 mm, the gill rakers being measured to 0.1 mm. The total, body, and caudal lengths of a fish were measured to the nearest mm.

Statistical treatment of the results involved calculation of the arithmetic mean (M), standard error of the mean (m), standard deviation (S), and coefficient of variation (CV). Significance of differences between means was tested with Student's t and the t test for means with unequal variances, 0.05 and 0.01 probability levels being used. Analysis of variance was applied to comparisons of more than two means.

A hierarchical agglomerative cluster analysis based on the nearest neighbour sorting strategy was used to determine similarity between various individuals. Computer-aided techniques described by Kucharczyk (1982) were used to detect clusters. The relevant computer programmes were developed by Mr Leszek Biały, M.Sc.

RESULTS

Meristic characters

Meristic characters were studied on 301 whitefish individuals caught in the Szczecin Lagoon and Pomeranian Bay. The following formula was arrived at: $DIII-V\ 7/8-12$; $AII-V\ 9-14$; $V\ II\ 9-11$; $PI\ 12-16$; $C\ 18-20$; $l.l.\ 76/80-98/100/103/\frac{10-12}{12-16}$; vertebrae count $53/55-63$; gill rakers count $22/24-34/35$; gill membrane ray count $7-10$.

As mentioned in the introduction, two groups of fishes, differing in their head profile, were separated, one having a smooth profile (typical form) and the other steep in profile

Fig. 1. Plastic forms of the whitefish in the area of study: typical form (*); humpback form (**)

Table 2

Meristic characters of the typical and humpback forms of the whitefish studied

Character			Typical form					Humpback form				
			n	range	M ± m	S	CV	n	range	M ± m	S	CV
Fins	D	hard rays	104	3– 5	4.31±0.05	0.48	11.1	104	3– 5	4.28±0.05	0.49	11.4
		soft rays	104	7–12	10.05±0.07	0.73	7.3	104	8–12	9.95±0.07	0.75	7.5
	A	hard rays	104	2– 5	3.61±0.06	0.61	16.9	104	2– 5	3.65±0.06	0.57	15.6
		soft rays	104	9–14	11.49±0.10	0.97	8.4	104	9–14	11.58±0.10	1.01	8.7
	C	soft rays	99	18–20	18.99±0.04	0.44	2.3	102	18–20	18.97±0.03	0.30	1.6
	V	hard rays	101	2	2.00±0.00	0.00	0.0	104	2	2.00±0.00	0.00	0.0
		soft rays	101	9–12	10.28±0.06	0.60	5.8	104	9–11	10.27±0.05	0.52	5.1
	P	hard rays	104	1	1.00±0.00	0.00	0.0	104	1	1.00±0.00	0.00	0.0
		soft rays	104	12–16	13.99±0.08	0.86	6.1	104	12–16	13.88±0.09	0.90	6.5
Gill membrane rays			104	7–10	8.64±0.05	0.55	6.4	104	7–10	8.70±0.05	0.55	6.3
Lateral line scales count			140	76–98	88.88±0.39	4.60	5.2	127	80–103	89.36±0.39	4.38	4.9
Number of scale rows above lateral line			95	10–12	10.95±0.05	0.47	4.3	96	10–12	10.86±0.05	0.51	4.7
Number of scale rows below lateral line			90	12–16	13.76±0.09	0.82	6.0	95	12–15	13.85±0.08	0.78	5.6
Vertebrae count			138	55–63	59.77±0.13	1.54	2.6	122	53–63	60.26±0.14	1.60	2.7
Number of gill rakers on right arch			141	22–35	28.84±0.17	1.98	6.9	126	24–33	29.15±0.17	1.96	6.7
– bottom part			101	14–20	17.07±0.12	1.20	7.0	104	14–21	17.28±0.15	1.48	8.6
– upper part			101	8–13	11.76±0.08	0.82	7.0	104	9–13	11.73±0.08	0.85	7.2
Number of gill rakers on left arch			139	24–34	28.88±0.17	1.97	6.8	126	25–35	29.18±0.18	1.97	6.8
– bottom part			101	14–20	17.12±0.13	1.28	7.5	104	14–22	17.38±0.15	1.51	8.7
– upper part			101	9–13	11.71±0.09	0.86	7.3	104	10–13	11.68±0.08	0.81	6.9

(humpback form) (Fig. 1). The character bears no relation to fish sex, length, or age. In order to perceive the differences between them, the forms were analysed separately and subsequently compared. Table 2 gives meristic characters of the two forms. To avoid possible sex effect on each character, males and females were equal in numbers in each group.

A significant difference ($\alpha = 0.05$) was found to exist between the vertebrae counts only. The mean vertebrae count in the typical form was 59.77, the count being higher (60.26) in the humpback form. Values of t in Studnet's t test were: $t^\circ = 2.503$; $t_{0.05} = 1.97$; $t_{0.01} = 2.596$, which can be presented as

$$t_{0.05} < t^\circ < t_{0.01}$$

Thus the difference between mean vertebrae counts of the two forms proved significant at the probability level $\alpha = 0.05$.

Apart from the statistically significant difference in the mean vertebrae count, between-generations differences were observed (Fig. 2), in certain age classes the differences between counts being much higher than those between sample means.

Fig. 2. Variability in vertebrae count in various generations of the typical (1) and humpback (2) forms

The number of gill rakers is regarded as one of the most important meristic characters in the coregonids and is particularly useful in the intraspecific systematics. For these reasons, the growth-related variability in this character has been frequently discussed. Fig. 3 shows the number of gill rakers — total fish length relationship. The patterns in both forms differed slightly. Low correlation coefficients ($r = 0.33$ and $r = -0.41$) and a reverse relationship in one case point to the lack of changes in the number of gill rakers within the total fish length interval analysed (35–65 cm).

To supplement the previous data, gill rakers were counted in 21 juveniles caught in 1983 and 1984; a mean of 28.62 was obtained. It should be mentioned here that the

Fig. 3. Gill rakers count-total fish length relationship in the typical (1) and humpback (2) forms

juveniles aged 0+ and measuring several cm's could not be assigned to any of the two forms. Therefor the mean juvenile gill rakers count was compared, using the analysis of variance, with those of adults. The calculated $F^0 = 1.17$ is much lower than the tabulated value $F_{0.05} = 3.03$, thus a conclusion of the lack of differences between the plastic forms compared and juveniles can be drawn.

The analysis shows that, within the total length interval considered (ca 11–65 cm) no change in the number of gill rakers occurred.

In addition, the following meristic characters were determined in juveniles: scales count along the lateral line, vertebrae count, and number of gill rakers on the right and left gill arch (Table 3). No clear differences are seen when data in Table 2 (adults) and Table 3 are compared. The slightly lower means of the juvenile characters might be a result of environmental effects (temperature, salinity) (Heese, 1985) on fish meristic characters

Table 3

Meristic characters of the juvenile whitefish

Character	n	range	M $\pm$ m	S	CV
Lateral line scales count	21	80–95	88.48 $\pm$ 0.84	3.75	4.2
Vertebrae count	23	53–62	58.70 $\pm$ 0.36	1.71	2.9
Number of gill rakers on right arch	21	25–32	28.62 $\pm$ 0.38	1.72	6.0
Number of gill rakers on left arch	23	25–32	28.30 $\pm$ 0.41	1.92	6.8

Plastic characters

Plastic characters were analysed in 208 individuals (104 in each form). To avoid sex effects on the characters, each sample contained equal numbers of males and females. Table 4 presents detailed data on the plastic characters studied. Mean values were tested for significance of differences ($\alpha = 0.01$). Significant differences between means were found with respect to 9 characters (Table 5), some of them attaining relatively high calculated values of the test function relative to the tabulated values, e.g., the preentral distance (*distantia praeventralis*).

Six characters were selected from among the significantly different ones to find a correlation, if any, between them and the fish caudal distance, and to assess its effects on the measurement. Table 6 contains the relevant regression equations and correlation coefficients. The regression coefficients are relatively low such that changes in the caudal length (except for a single case) only slightly affect changes in the character analysed. For a better illustration of the between-forms differences in the characters studied, Figs 4–6 show regression lines with mean values for various length classes. Frequency polygons for each character are shown as well.

During spawning, due to a large size of female gonads, the female abdomen is very pronounced, which is not observed in males. At that time, too, the “pearl nodes” appear on both males and females. The nodes appear just before spawning and are somewhat more abundant in males, although the difference is not very conspicuous. The nodes were observed on the lateral scales in 1–2 rows above the lateral line (more seldom on the line itself) and in 2–4 rows below the lateral line. The most conspicuous nodes occurred on the tail. It should be borne in mind that, apart from the spawning season, it is virtually impossible to sex the whitefish without dissecting them.

Table 4

Plastic characters of the typical and humpback forms of the whitefish studied

Character	Typical form					Humpback form				
	n	range	M ± m	S	CV	n	range	M ± m	S	CV
longitudo caudalis in cm	104	31.7–55.3	43.52±0.45	4.63	10.6	104	32.3–60.5	45.17±0.53	5.43	12.0
longitudo caudalis = 100										
longitudo capitis lateralis	104	16.9–20.5	18.53±0.08	0.78	4.2	104	16.9–20.1	18.42±0.07	0.69	3.7
altitudo capitis	104	13.1–15.9	14.37±0.05	0.56	3.9	104	13.1–16.5	14.49±0.07	0.71	4.9
summa altitudo corporis	104	19.9–28.4	24.07±0.19	1.95	8.1	104	20.1–27.7	23.51±0.18	1.85	7.9
minima altitudo corporis	104	6.0–8.0	7.14±0.03	0.33	4.6	104	6.2–8.0	7.08±0.03	0.32	4.5
distantia praedorsalis	104	41.4–47.0	44.30±0.11	1.15	2.6	104	40.3–48.6	44.95±0.13	1.37	3.0
distantia praeventralis	104	44.8–52.4	48.21±0.14	1.46	3.0	104	41.6–49.7	46.42±0.14	1.47	3.2
distantia praeanal	104	68.8–75.5	72.40±0.14	1.39	1.9	104	66.7–75.6	71.34±0.14	1.47	2.1
distantia postdorsalis	104	38.5–46.9	41.48±0.15	1.48	3.6	104	39.5–45.7	42.09±0.13	1.37	3.3
spatium P–V	104	26.2–36.1	31.13±0.17	1.75	5.6	104	25.4–34.2	29.36±0.17	1.78	6.1
spatium V–A	104	23.5–28.9	26.62±0.12	1.19	4.5	104	24.0–30.8	26.31±0.12	1.26	4.8
summa altitudo D	103	13.4–18.3	15.40±0.10	1.06	6.9	104	12.6–18.0	15.22±0.12	1.22	8.0
longitudo basis D	104	8.5–12.9	10.58±0.08	0.82	7.8	104	8.1–12.4	10.62±0.09	0.91	8.6
summa altitudo A	104	8.5–13.7	11.25±0.09	0.87	7.6	104	9.2–14.3	11.53±0.09	0.89	7.7
longitudo basis A	104	8.0–14.5	10.53±0.09	0.90	8.5	104	9.2–13.7	10.71±0.09	0.89	8.3
longitudo pedunculi caudae	103	11.5–15.6	13.21±0.08	0.82	6.2	103	11.8–16.3	13.32±0.08	0.84	6.3
summa longitudo V	102	11.9–16.1	14.17±0.08	0.81	5.7	104	12.5–16.4	14.23±0.07	0.74	5.2
summa longitudo P	102	11.2–19.3	14.10±0.10	0.96	6.8	104	11.7–15.9	13.87±0.08	0.77	5.6
distantia interorbitalis	70	4.9–6.7	5.52±0.04	0.37	6.7	82	4.7–7.2	5.53±0.04	0.38	6.9
summa latitudo capitis	104	7.0–10.1	8.31±0.06	0.62	7.5	103	7.1–11.0	8.59±0.07	0.68	7.9
latitudo basis pedunculi caudae	104	4.7–7.1	5.91±0.04	0.41	6.9	104	4.8–7.3	5.96±0.04	0.40	6.7
diameter oculi	104	3.1–4.2	3.45±0.02	0.22	6.4	104	3.0–3.9	3.41±0.02	0.18	5.3
distantia praeocularis	104	4.3–6.8	5.74±0.05	0.49	8.5	104	4.1–8.5	5.75±0.05	0.56	9.7
distantia praeoperculum	104	12.5–15.6	13.93±0.06	0.65	4.7	104	12.2–15.2	13.82±0.06	0.65	4.7
longitudo ossis maxillae	104	5.1–7.3	6.24±0.07	0.44	7.1	104	5.0–7.2	6.12±0.04	0.45	7.4
summa altitudo maxillae	104	1.3–1.9	1.63±0.01	0.13	8.0	104	1.4–2.0	1.64±0.01	0.11	6.7
longitudo ossis dentale	104	5.6–7.4	6.43±0.04	0.39	6.1	104	5.9–7.5	6.51±0.03	0.32	4.9
distantia postorbitalis	104	7.2–10.5	9.69±0.05	0.52	5.4	104	8.9–10.9	9.75±0.04	0.39	4.0
latitudo rostri	104	3.3–4.7	3.92±0.03	0.32	8.2	104	3.3–5.1	3.99±0.03	0.30	7.5
altitudo rostri	104	3.1–5.2	4.31±0.04	0.37	8.6	104	3.6–5.3	4.46±0.04	0.36	8.1

Table 4 condit

Character	Typical form					Humpback form				
	n	range	M ± m	S	CV	n	range	M ± m	S	CV
longitudo capitis lateralis = 100										
altitudo capitis	104	68.7–88.1	77.70±0.35	3.62	4.7	104	68.5–89.5	78.59±0.41	4.20	5.3
distantia interorbitalis	70	25.9–38.6	30.00±0.23	1.96	6.5	82	26.8–34.0	30.19±0.20	1.79	5.9
summa latitudo capitis	104	38.4–56.2	44.92±0.38	3.91	8.7	103	38.5–57.9	46.73±0.41	4.16	8.9
diameter oculi	104	15.6–21.9	18.68±0.13	1.29	6.9	104	15.9–20.8	18.49±0.10	1.03	5.6
distantia praeocularis	104	27.6–36.1	30.93±0.17	1.75	5.7	104	23.8–36.1	31.15±0.21	2.11	6.7
distantia praeoperculum	104	68.0–79.4	75.21±0.17	1.75	2.3	104	68.7–80.7	75.07±0.19	1.91	2.5
longitudo ossis maxillae	104	29.4–38.1	33.72±0.17	1.69	5.0	104	28.2–39.2	33.23±0.18	1.87	5.6
summa altitudo maxillae	104	7.0–10.3	8.77±0.06	0.62	7.1	104	6.9–10.8	8.91±0.06	0.59	6.6
longitudo ossis dentale	104	30.8–40.9	34.74±0.17	1.75	5.0	104	30.5–39.9	35.40±0.18	1.81	5.1
distantia postorbitalis	104	39.6–56.4	52.42±0.20	2.07	3.9	104	49.4–57.1	52.91±0.15	1.54	2.9
latitudo rostri	104	17.3–27.0	21.18±0.19	1.89	8.9	104	16.7–28.2	21.71±0.19	1.98	9.1
altitudo rostri	104	17.6–27.7	23.31±0.20	2.01	8.6	104	19.4–29.2	24.27±0.21	2.11	8.7
longitudo partis inferioris arcus branchiale dextri	104	33.3–44.4	39.27±0.22	2.21	5.6	104	34.9–45.4	40.51±0.21	2.17	5.4
longitudo partis superioris arcus branchiale dextri	104	19.8–27.3	23.93±0.17	1.72	7.2	104	19.8–28.5	24.37±0.16	1.60	6.6
longitudo partis inferioris arcus branchiale sinistri	85	35.1–45.1	40.08±0.22	2.00	5.0	93	35.2–44.3	40.64±0.19	1.80	4.4
longitudo partis superioris arcus branchiale sinistri	85	21.8–28.5	24.82±0.16	1.47	5.9	91	21.5–28.8	24.66±0.15	1.46	5.9
summa longitudo arcus branchiale dextri	104	52.6–71.5	63.21±0.35	3.55	5.6	104	54.9–72.2	64.87±0.33	3.41	5.3
summa longitudo arcus branchiale sinistri	85	57.1–70.2	64.89±0.35	3.21	4.9	91	57.9–72.7	65.32±0.29	2.81	4.3
summa longitudo arcus branchiale dextri = 100										
longitudo spinae longissima	104	11.9–21.0	15.98±0.15	1.55	9.7	104	11.3–21.1	15.63±0.18	1.88	12.0
summa longitudo arcus branchiale sinistri = 100										
longitudo spinae longissima	85	10.9–18.5	15.24±0.18	1.66	10.9	94	11.5–18.6	15.06±0.17	1.67	11.1

Table 5

Comparison of significantly different ($\alpha = 0.01$) plastic characters of the typical (*) and humpback (**) forms

Character	Form	Range	M	F°	F _{0.05}	t°	t _{0.01}
longitudo caudalis = 100							
distantia praedorsalis	*	41.4–47.0	44.30	1.43 [*]	1.39	3.69	2.63
	**	40.3–48.6	44.95				
distantia praeventralis	*	44.8–52.4	48.21	1.02	1.39	8.82	2.60
	**	41.6–49.7	46.42				
distantia praeanalisis	*	68.8–75.5	72.40	1.11	1.39	5.33	2.60
	**	66.7–75.6	71.34				
spatium P–V	*	26.2–36.1	31.13	1.04	1.39	7.20	2.60
	**	25.4–34.2	29.36				
summa latitudo capitis	*	7.0–10.1	8.31	1.18	1.39	3.08	2.60
	**	7.1–11.0	8.59				
altitudo rostri	*	3.1–5.2	4.31	1.08	1.39	2.94	2.60
	**	3.6–5.3	4.46				
longitudo capitis lateralis = 100							
summa latitudo capitis	*	38.4–56.2	44.92	1.13	1.39	3.21	2.60
	**	38.5–57.9	46.73				
longitudo ossis dentale	*	30.8–40.9	34.74	1.07	1.39	2.66	2.60
	**	30.5–39.9	35.40				
altitudo rostri	*	17.6–27.7	23.31	1.12	1.39	3.36	2.60
	**	19.4–29.2	24.27				

* – F° > F_{0.05} t test for two means of unequal variances applied

Table 6

Regression equations for relationships between the
selected characters and caudal length: typical form (*);
humpback form (**)

Character	Form	Regression equation	r
distantia praedorsalis	*	$Y = 0.043 x + 42.30$	0.62
	**	$Y = 0.033 x + 43.50$	0.61
distantia praeventralis	*	$Y = 0.051 x + 46.02$	0.58
	**	$Y = 0.054 x + 44.09$	0.42
distantia praeanalisis	*	$Y = 0.070 x + 69.33$	0.77
	**	$Y = 0.068 x + 68.47$	0.67
spatium P-V	*	$Y = 0.104 x + 26.52$	0.87
	**	$Y = 0.043 x + 27.31$	0.50
summa latitudo capitis	*	$Y = -0.0014 x + 8.35$	-0.08
	**	$Y = 0.015 x + 7.97$	0.58
altitudo rostri	*	$Y = -0.0093 x + 4.68$	-0.50
	**	$Y = -0.0008 x + 4.46$	-0.13

Table 7

Comparison of sexual dimorphism-related plastic characters
in the typical and humpback forms; the significantly
different ($\alpha = 0.01$) characters considered only

Character	n	Sex	Range	M	F°	F _{0.05}	t°	t _{0.01}
longitudo caudalis = 100								
Typical form								
distantia praedorsalis	52	♀♀	42.5–47.0	44.61	1.16	1.60	2.89	2.63
	52	♂♂	41.4–47.0	43.98				
distantia praeventralis	52	♀♀	46.3–52.4	48.63	1.08	1.60	3.00	2.63
	52	♂♂	44.8–51.3	47.80				
spatium P–V	52	♀♀	27.6–36.1	31.93	1.40	1.60	5.23	2.63
	52	♂♂	26.2–33.2	30.32				
summa longitudo V	51	♀♀	11.9–15.8	13.80	1.23	1.60	5.29	2.63
	51	♂♂	12.9–16.1	14.54				
Humpback form								
spatium P–V	52	♀♀	25.6–34.2	30.00	2.81*	1.60	3.89	2.68
	52	♂♂	25.4–30.6	28.72				
summa longitudo V	52	♀♀	12.5–15.4	13.97	1.41	1.60	3.79	2.63
	52	♂♂	12.5–16.4	14.50				
summa longitudo P	52	♀♀	11.7–15.9	13.57	1.15	1.60	4.29	2.63
	52	♂♂	12.9–15.7	14.17				
longitudo basis A	52	♀♀	9.9–12.8	11.28	1.31	1.60	2.90	2.63
	52	♂♂	9.2–14.3	11.77				
latitudo basis pedunculi caudale	52	♀♀	4.8–6.8	5.85	1.00	1.60	2.88	2.63
	52	♂♂	5.3–7.3	6.08				

* – $F > F_{0.05}$ t test for two means of unequal variances applied

Fig. 4. Changes in the pre-anal distance in relation to the caudal length of the typical 1 and humpback (2) forms

Fig. 5. Changes in the pre-ventral distance in relation to the caudal length of the typical (1) and humpback (2) forms

Fig. 6. Changes in the P-V distance in relation to the caudal length of the typical (1) and humpback (2) forms.

Based on the plastic characters analysis, several characters allowing to separate males from females were identified in the two forms. The differences found were tested at the probability level $\alpha = 0.01$ (Table 7) by means of appropriate tests for paired means. Four and five sex-related characters were identified in the typical and humpback forms,

Fig. 7. Frequency polygons for the P-V distance in the typical (1) and humpback (2) forms

respectively. Two characters are common for both forms: the P-V distance (*spatium P-V*) and V length (*summa longitudo V*). Among those characters listed in Table 7, the P-V distance has a very interesting distribution: its frequency polygons (Fig. 7) show differences related to sexual dimorphism; moreover, the difference between the two whitefish forms is highly significant with respect to this character.

Among other plastic characters, neither measured nor statistically analysed here, the snout shape and termination, very variable in the coregonids, are worth mentioning. The typical whitefish showed a blunt (Fig. 8) or pointed (Fig. 9) snout, while the humpback whitefish always had bluntly-ended snouts, as in Fig. 8. All the juveniles examined had pointed snouts (Fig. 10).

Generally, 9 plastic characters were found that differed significantly between the two forms, although the question of the extent of similarity between individuals of the two forms is not resolved. To assess the degree of similarity between the two forms, a hierarchical agglomerative clustering based on the nearest neighbour sorting strategy was applied. Similar methods have already been used in taxonomic analyses of fish (Andreev and Resëtnikov, 1977; Borisovec et al., 1984). For the purpose of the analysis, 60 individuals were picked out at random (30 of each form), the group containing equal numbers of males and females, all within a similar length range. The calculations included 27 plastic characters, excluding the largest body height, varying seasonally, and the

Fig. 8. Bluntly-ending snout of the typical form

Fig. 9. Pointed snout in the typical form

Fig. 10. Juvenile snout

Fig. 11. Similarity dendrogram of the typical (*) and humpback (**) forms

interocular distance, due to incomplete data. The list of characters analysed is given in Table 4 (upper part).

The resultant dendrogram (Fig. 11) shows 4 large clusters denoted 1–4. The first cluster (6 individuals) includes only the typical whitefish. The second cluster (11 individuals) consists, except for one individual, of the humpback whitefish. The remaining two clusters comprise whitefish individuals of both groups. Those individuals located between clusters 2, 3 and 4 cannot be assigned to any of the clear-cut clusters.

In an attempt to interpret the structure obtained, one may say that clusters 1 and 2 are formed by individuals belonging to extreme phenotypes of the two forms, while clusters 3 and 4 consist of intermediate individuals. The division into two forms was originally based on the visual assessment of the body shapes, which is a rather subjective approach. Results of the classificatory method used confirm the assessment.

DISCUSSION

The first comprehensive studies on the whitefish in the Szczecin Lagoon and Pomeranian Bay were made by Pęczalska (1962, 1966). A comparison between her results (Pęczalska, 1966) and those of the present study revealed, among other things, differences in the mean soft ray counts in fins, the fins being higher (particularly the pectoral ones) in the forms occurring at present. On the other hand, numbers of the lateral line scales are similar in the two works, while a large difference was found in the numbers of scale rows below the lateral line. Pęczalska's value was about 10 rows, while the present result is about 14, which is a substantial difference for this relatively constant character. Changes were also revealed in the mean number of gill rakers, the number increasing — as compared with Pęczalska's earliest data for 1956–1958 (Pęczalska, 1962) — by about 3. Fig. 12 shows distributions of gill rakers in the present study and in that of Pęczalska. The figure is an evidence of the increasing, over more than 20 years, density of gill rakers. A comparison of vertebrae count distributions (Fig. 13) shows differences between the typical and the humpback forms as described in the section on meristic characters, the distribution presented by Pęczalska being similar to that of the typical form. Noteworthy is Pęczalska's finding (Pęczalska, 1966) of the vertebrae count ranging within 66–69 (Fig. 13), the values exceeding the *C. lavaretus* range as determined from numerous observations in the Soviet Union and North America. Rešetnikov (1980) gives this range as 54–65.

The description of plastic characters in Pęczalska (1966) lacks data on those characters significantly different in the two forms, thus it is impossible to assign the whitefish studied more than 20 years ago to any of the forms distinguished at present. Of the plastic characters possible to compare, the tail base proportions are markedly different. The tail base in the whitefish occurring at present is longer by 4.5% (per cent of the caudal length); it is also higher.

Fig. 12. Comparison of gill rakers distribution with results of Pęczalska (1962, 1966): the typical (*) and humpback (**) forms

With respect to the sex-related characters, Pęczalska (1966) found the eye diameter to be the only character differing males from females (she did not examine the characters revealing sexual dimorphism as found in the present work). Rešetnikov (1963) lists 5 sex-related characters. The presence of sex effects on fish morphology should always be taken into account. A good example is the P-V distance significantly different both between the two form and between males and females (Fig. 7). A change in sex ratio within a sample would result in a different mean value, etc.

Fig. 14, a diagrammatic comparison of the two forms, similarly to what Lindsey (1963) did in his work, sums up the analysis of plastic characters of the *C. lavaretus* population from the Pomeranian Bay and Szczecin Lagoon.

Fig. 13. Comparison of vertebrae count distribution with results of Pęczalska (1966): the typical (*) and humpback (**) forms

Fig. 14. A diagrammatical comparison of the typical (1) and humpback (2) forms

A better, albeit not completely satisfactory, explanation of the situation found is offered by the agglomerative hierarchical classification used. Presumably, the two groups of fishes contain individuals of both the extreme phenotypes and intermediate ones as well. The dendrogram (Fig. 11) allows to conclude that the whitefish in the areas studied form populations with two extreme phenotypes interconnected by a whole gamut of intermediate individuals. It is obviously difficult to predict the future development and to foresee a possible mechanism of reproductive isolation between the two forms; or perhaps such mechanism is already operating. For instance, an ethological factor can be envisaged with mating pairs being selected based on their similarity (homogamy). On the other hand, one may also assume that, due to a small size of the population, no isolation is possible as, should any isolation appear, it would be rapidly broken down.

In this context, it seems purposeful to discuss the problem of sympatric species, one of the most important issues pertaining to the coregonid taxonomy. Numerous authors (e.g., Svärdson, 1957; Himberg, 1970; Rufli, 1978; Salojärvi and Auvinen, 1981; Lehtonen, 1981) justify the fact of the existence of sympatric species. An important problem hampering the study on sympatricity is the considerable economic importance of coregonids: stocking operations can easily disturb mechanisms of population isolation. A good example of the presence of two sympatric coregonid species is provided by *C. lavaretus pischian* occurring in the Anadyr River (eastern Siberia): several clustering methods allowed to divide the population into the pointed nose whitefish ("sig vostryak") and the humpback whitefish ("sig gorbun") (Andreev and Rešetnikov, 1977). Later genetic studies (Viktorovskij et al., 1983) corroborated the separation of the two sympatric species. Similar proofs of the presence of sympatric species and their identification are presented by Lindsey (1963) with respect to the whitefish of the Lake Squanga (NW Canada).

Perception of the full range of variability in coregonids is of importance not only from the evolutionary, but also from the practical point of view, for instance to find a whitefish best-adapted to the environmental conditions and having valuable growth parameters which would render its culture worth supporting.

Among the whitefish individuals examined, two phenones were identified; they differed clearly in their plastic characters, and less so in their vertebrae counts. The typical form is dominant. The question if the two forms are sympatric species should be answered rather negatively, inasmuch as the biology, ecology, and ethology of the species in their changing environment are still inadequately known. Observations made so far have revealed the typical form to occur earlier in catches made on the fish migrating to spawn, and to clearly dominate in late October. Samples collected in the first decade of November contained more and more humpback form individuals. Thus it is suggested that the typical form enters the Szczecin Lagoon to spawn there before the humpback form does. However, the data are approximate only as the individuals examined were picked out from commercial catches, the exact time and location of each catch being not always possible to determine.

The intraspecific structure of *C. lavaretus* is at present widely discussed and difficult to test in practice. Table 8 lists the subspecies of *C. lavaretus* established by Berg (1948) for the waters of the Soviet Union and neighbouring countries; the list is then confronted with the subspecies established in Polish waters (Kaj, 1962) and with the division given by Rešetnikov (1980). Thus, out of the 21 subspecies reported, 6 only are recognised as such. Kaj (1962) recognised 4 subspecies in Poland, while Gąsowska (1970) listed 5: *C. lavaretus lavaretus*, *C. lavaretus maraena*, *C. lavaretus generosus*, *C. lavaretus holsatus*, and *C. lavaretus maraenoides*, the last two being introduced in late 1800's. The intraspecific division presented by Rešetnikov (1980) would recognise 2 subspecies only in Poland. According to that author, *C. lavaretus lavaretus* includes the whitefish of the ferra-holsatus group with sparse gill rakers (i.e., *C. lavaretus holsatus* occurring in Poland), *C. lavaretus generosus* and *C. lavaretus maraena* being lumped in *C. lavaretus maraenoides*.

Considering the data in Table 8, the Pomeranian Bay and Szczecin Lagoon whitefish studied should be assigned to *C. lavaretus lavaretus*, although – according to the taxonomy of Polish forms (Kaj, 1962) and based on the number of gill rakers – the individuals examined are closer to *C. lavaretus maraena*. Comparisons of meristic characters in various Polish whitefish populations reveal marked differences to occur, apart from those in the number of gill rakers, in the lateral line scales count. The count seems to be higher in *C. lavaretus generosus* than in the remaining forms (Kaj 1955; Gąsowska, 1967; Trzebiatowski, Heese, Wiszniewski, 1987). As seen from the discussion on taxonomy of *C. lavaretus*, referred to above, it is not possible to apply the proposed intraspecific subdivisions. A number of *C. lavaretus* subspecies occurring in the northern Europe are treated by some authors either as species (Svärdson, 1957) or ecotypes (Steinmann, 1951). The discussion is complicated by the occurrence of numerous intermediate forms with differing numbers of gill rakers. The remaining meristic and plastic (body shape, skull form) characters yield no desired diagnostic effect.

Table 8

Lists of *C. lavaretus* subspecies as recognised by Berg (1948), Kaj (1962), and Rešetnikov (1980). Number of gill rakers and the mean value (in parentheses) given under the subspecies name

Berg (1948): waters of USSR and neighbouring countries	Kaj (1962): Polish waters	Rešetnikov (1980): Euroasian waters
1) <i>C.l. pidschian</i> 16–25 2) <i>C.l. baicalensis</i> 25–33 (29)		<i>C.l. pidschian</i> sparse gill rakers whitefish of Arctic Ocean drainage 1 and 2 included
3) <i>C.l. karelicus</i> 17–25 4) <i>C.l. imandrae</i> 20–30 (26) 5) <i>C.l. vimbaeformis</i> 21–32 (25–27)		not considered
6) <i>C.l. lavaretus</i> 22–33 (25) 7) <i>C.l. baeri</i> average less then 30 8) <i>C.l. ludoga</i> 20–26 (23–24) 9) <i>C.l. holsatus</i> 20–28 (24–25) 10) <i>C.l. widegreni</i> 21–31 11) <i>C.l. oxyrhynchus</i> (31–32)	<i>C.l. lavaretus</i> 22–25 <i>C.l. holsatus</i> 16–24	<i>C.l. lavaretus</i> 16–48 sparse gill rakers whitefish of Baltic drainage; 6, 7, 8, 9, 10, 11 included
12) <i>C.l. mesiospinatus</i> 27–40 (35) 13) <i>C.l. lavaretoides</i> 26–43 (31–32) 14) <i>C.l. bergianus</i> 34–41 (37) 15) <i>C.l. chibinae</i> 25–38 (32) 16) <i>C.l. voronjensis</i> 26–35 (29–31)		<i>C.l. mediospinatus</i> intermediate form separated for practical purposes, occurring in Baltic drainage, Karelia, Kola Peninsula, Finland, Sweden and Denmark; 12, 13, 14, 15, 16 included
17) <i>C.l. pravdinianus</i> 29–37 (33–34)		not considered
18) <i>C.l. maraena</i> 29–34 (30) 19) <i>C.l. maraenoides</i> 34–45 (39) 20) <i>C.l. generosus</i> about 40 21) <i>C.l. pallasi</i> 39–48 (42–44)	<i>C.l. maraena</i> 24–34 <i>C.l. generosus</i> 33–44	<i>C.l. maraenoides</i> 30–45 occur in Baltic areas of the USSR, Poland, GDR, FRG and Denmark; 18, 19, 20 included <i>C.l. pallasi</i> 40 and more; distribution as in <i>C.l. mediospinatus</i>
		<i>C.l. baunti</i> 28–42 Baunti Lake, USSR

CONCLUSIONS

1. The whitefish occurring in the Pomeranian Bay and Szczecin Lagoon should be classified as *Coregonus lavaretus lavaretus* (L., 1758). although the intraspecific division of *C. lavaretus* ought to be revised.
2. The intraspecific taxonomy of *C. lavaretus*, based on the number of gill rakers, is difficult to apply in practice.
3. The whitefish population studied contains two phenones: the typical and humpback forms differing clearly in a number of their plastic characters and, less distinctly so, in their vertebrae counts.
4. The extreme phenotypes of the two forms are interconnected by individuals showing intermediate characters.
5. Sex-related characters were found to occur in the whitefish forms studied; thus the sexual dimorphism should be taken into account in morphological studies on coregonids.

ACKNOWLEDGEMENT

I would like to thank my wife, Zdzisława Heese, for her creative contribution to the present work.

REFERENCES

- Andreev V.L., Ju.S. Rešetnikov, 1977: Issledovanie vnutrividovoj i morfologičeskoj izmenčivosti siga *Coregonus lavaretus* (L.) metodami mnogomernogo statističeskogo analiza. Vopr. Ichtiol. 17, 5:862–878. (in Russian)
- Behnke R., 1972: The systematics of salmonid fishes of recently glaciated lakes. J. Fish. Res. Bd. Can., 29, 6:639–671.
- Berg L.S., 1948: Ryby presnych vod SSSR i sopredelnyh stran. Izd. AN SSSR, T. I, Moskva. (in Russian)
- Borisov J.E., Ju.Ju. Dgebuagze, V.Ja. Jermochin, 1984: Opyt issledovanija morfologičeskoj izmenčivosti ryb roda *Oreoleuciscus* (Pisces, Cyprinidae) metodami mnogomernoj statistiki. Zool. Ž., 63, 4:568–572. (in Russian)
- Ferguson A., K.-J.M. Himberg, G. Svårdson, 1978: Systematics of the Irish pollan (*Coregonus pollan* THOMPSON): an electrophoretic comparison with other Holarctic Coregoninae. J. Fish. Biol., 12, 3:221–233.
- Gaśowska M., 1960: Genus *Coregonus* L. discussed in connection with a new systematic feature of shape and proportion of os maxillare and os supramaxillare. Ann. Zool., Warszawa, 18, 26:471–513.
- Gaśowska M., 1967: Analytic survey of Coregonids of three Polish Lakes: Miedwie, Pełcz and Wielkie Okoniskie. Ann. Zool., Warszawa, 24, 3:343–359.

- Gąsowska M., 1970: Osteological analyses of the forms of the species *Coregonus lavaretus* (L.) from Poland and their relationship to forms other places. In: Biology of Coregonid fishes. Winnipeg, Univ. Manitoba Press: 209–217.
- Heese T., 1985: Charakterystyka morfologiczna i biologiczna siei *Coregonus lavaretus* (L., 1758) Zatoki Pomorskiej. Praca doktorska, Bibl. AR Szczecin. [Morphological and biological characteristics of whitefish, *Coregonus lavaretus* (L., 1758) from the Pomeranian Bay. Ph.D.Thesis, Academy of Agriculture, Szczecin].
- Himberg K.-J.M., 1970: A systematic and zoogeographic study of some North European coregonids. In: Biology of Coregonid fishes. Winnipeg, Univ. Manitoba Press: 219–250.
- Järvi T.H., 1943: Zur Kenntnis der Coregonenformen Nord-Finnlands insbesondere der Kuusamo-Gebietes. Acta Zool. Fenn., 40: 1–91.
- Kaj J., 1955: Sieja jezior Międzychodzkich. [The whitefish of the Międzychód lakes] PWN Poznań.
- Kaj J., 1962: Salmonidae. Klucze do oznaczania kręgowców Polski, część I – Kragłousto i Ryby, Cyclostomi et Pisces, pod red. M. Gąsowskiej. [Salmonidae. Keys to the identification of vertebrates of Poland. Part 1. Cyclostomi and Pisces./M. Gąsowska, ed.]. PWN, Warszawa-Kraków.
- Kubiak J., 1980: Studia nad eutrofizacją Zatoki Pomorskiej w rejonie oddziaływania wód Świny i Dziwniej. Praca doktorska, Bibl. AR Szczecin. [Studies on eutrophication of the Pomeranian Bay within the area affected by the rivers Swina and Dziwna. Ph.D. Thesis, Academy of Agriculture, Szczecin].
- Kucharczyk, 1982: Algorytmy analizy skupień w języku ALGOL. [Cluster analysis algorithms in ALGOL] PWN, Warszawa.
- Kulmatycki W.J., 1926/27: Studien an Coregonen Polens. Arch. Hydrol. i Ryb. I, II: 275–375.
- Lehtonen H., 1981: Biology and stock assessments of Coregonids by the Baltic coast of Finland. Finnish Fish. Res., 3: 31–83.
- Lindsey C.C., 1963: Sympatric occurrence of two species of humpback whitefish in Squanga Lake, Yukon Territory. J. Fish. Res. Bd. Can. 20, 3:749–767.
- Majewski A., 1980: Zalew Szczeciński. [Szczecin Lagoon]. Wyd. Komunikacji i Łączności, Warszawa.
- Mednikov B.M., Ju.S. Rešetnikov, E.A. Šubina, 1977: Izučenje rodstvennych sviazej sigovych ryb Coregonidae metodami gibridizacji DNK. Zool. Ž., 56: 3:333–341. (in Russian)
- Pęczalska A., 1962: Badania nad sieją (*Coregonus lavaretus* L.) Zatoki Pomorskiej i Zalewu Szczecińskiego w latach 1956–1958. [Studies on the whitefish (*Coregonus lavaretus* L.) of the Pomeranian Bay and Szczecin Lagoon in 1956–1958]. Prace MIR., 11-A:287–320.
- Pęczalska A., 1966: Sieja Zatoki Pomorskiej (*Coregonus lavaretus* L.). Praca doktorska, Bibl. ART Olsztyn. [The Pomeranian Bay whitefish (*Coregonus lavaretus* L.) Ph.D.Thesis, Academy of Agriculture and Technology, Olsztyn].
- Pravdin I.F., 1931: Sigi ozernoj oblasti SSSR. Izv. Len. nauc.-issled. icht. inst., 12, 1:166–235. (in Russian)
- Pravdin I.F., 1966: Rukovodstvo po izučeniju ryb. Izd. Piščepromizdat, Moskva. (in Russian)
- Rešetnikov Ju.S., 1963: Ob izmenčivosti sigov. Zool. Ž., 42, 8:1187–1199. (in Russian)
- Rešetnikov Ju.S., 1980: Ekologija i sistematika sigovych ryb. Izd. Nauka, Moskva. (in Russian)
- Von Ruffli H., 1978: Die heutigen sympatrischen Felchenpopulationen (*Coregonus* spp.) des Thuner- und Bielersees und ihre Morphologie. Schweiz. Z. Hydrol., 40, 1:7–31.
- Šapošnikova G.H., 1968: Sravnitelno-morfologičeskoje opisanije sigov Sovetskogo sojuza. Tr. Zool. in-ta AN SSSR, 46: 207–256. (in Russian)
- Salojärvi K., H. Auvinen, 1981: A computer program for classifying sympatric whitefish (*Coregonus lavaretus* L. s.l.) stocks. Finnish Fish. Res., 3: 23–28.
- Steinmann P., 1951: Monographie der Schweizerischen Koregonen. Teil. III. Schweizer. Z. Hydrobiol., 13, 1:54–156.

- Svårdson G., 1957: The Coregonid problem. VI. The palearctic species and their intergrades. Rep. Inst. Freshwater Res. Drottningholm, 33: 204–232.
- Svårdson G., 1970: Significance of introgression in Coregonid evolution. In: Biology of Coregonid Fishes. Winnipeg, Univ. Manitoba Press: 33–59.
- Svårdson G., 1979: Speciation of Scandinavian Coregonus. Rep. Inst. Freshwater Res. Drottningholm, 57: 3–95.
- Trzebiatowski R., T. Heese, J. Wiszniewski, 1987: The whitefish forms (*Coregonus lavaretus*) in the Miedwie Lake. Acta Ichtiol. et Piscat., in press.
- Viktorovskij R.M., L.N. Jermolenko, A.N. Makojedov, S.V. Frolov, A.A. Šerčišin, 1983: Divergencja kariotipov sigov. Citologija, 25, 11: 1309–1315. (in Russian)
- Wiktor K., 1971: The primary production of Szczecin Bay. Pol. Arch. Hydrobiol., 18, 1: 1–15.

Translated: Dr. T. Radziejewska

Tomasz Heese

MORFOLOGIA DWÓCH FORM PLASTYCZNYCH SIEI *COREGONUS LAVARETUS* (L.) WYSTĘPUJĄCYCH W ZATOCE POMORSKIEJ I ZALEWIE SZCZECIŃSKIM

STRESZCZENIE

Ryby do badań pochodziły z połowów gospodarczych prowadzonych przez Spółdzielnię Pracy i Usług Rybackich „Certa” na Zalewie Szczecińskim i Zatoce Pomorskiej. Łącznie pobrano 301 egzemplarzy siei (*C. lavaretus*). W oparciu o analizę cech merystycznych ustalono dla badanej siei następującą formułę: D III-V /7/8–12, A II-V 9–14, V II 9–11, P I 12–16, C 18–20, l.l. /76/80–98/100/103/ $\frac{10-12}{12-16}$ kręgi /53/55–63, wyr. filtr. /22/24–34/35/, promienie podskrzewowe 7–10. W pobranych próbach wyróżniono dwie formy plastyczne (Ryc. 1), sieje o łagodnym profilu głowy (forma typowa) i sieje o spadzistym profilu głowy (forma wygrzbiecona). Cecha ta nie jest związana ani z płcią ani z długością ryby, czy też wiekiem. Pomiary cech plastycznych ukazały szereg cech istotnie różniących obie formy (Tabela 5). W przypadku cech merystycznych istotną różnicę stwierdzono dla liczby kręgów, która u formy wygrzbieconej była wyższa. Badania dymorfizmu płciowego wykazały u obu form istnienie cech związanych z płcią.

W celu ustalenia stopnia podobieństwa obu form zastosowano jedną z metod analizy skupień. Otrzymany wynik w postaci dendrogramu (Ryc. 11) sugeruje, że zarówno u jednej jak i drugiej formy występują osobniki skrajnie fenotypowe i pośrednie. Przeprowadzone badania morfologii siei, stosując różne metody badawcze, nie są w stanie dać ostatecznej odpowiedzi o randze wyróżnionych form. Czy jest to tylko przejaw zmienności, czy też populacja siei ma bardziej złożoną strukturę w ramach której występują gatunki sympatryczne.

W celu ustalenia stopnia podobieństwa obu form zastosowano jedną z metod analizy skupień. Otrzymany wynik w postaci dendrogramu (Ryc. 11) sugeruje, że zarówno u jednej jak i drugiej formy występują osobniki skrajnie fenotypowe i pośrednie. Przeprowadzone badania morfologii siei, stosując różne metody badawcze, nie są w stanie dać ostatecznej odpowiedzi o randze wyróżnionych form. Czy jest to tylko przejaw zmienności, czy też populacja siei ma bardziej złożoną strukturę w ramach której występują gatunki sympatryczne.

Struktura wewnątrzgatunkowa *C. lavaretus* jest obecnie tematem licznych dyskusji i w praktyce trudna do zastosowania. Sieję występującą w Zatoce Pomorskiej i Zalewie Szczecińskim należałoby zaliczyć do podgatunku *C. lavaretus lavaretus* (L., 1758), jakkolwiek wewnątrzgatunkowy podział *C. lavaretus* wymaga rewizji.

Author's Address: Kazimierza Królewicza 4
Dr Tomasz Heese SZCZECIN 71–550
Instytut Ichthyologii Polska (Poland)