Morphometrical Features of the Sea-Trout of Polish Rivers.

By

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A statistical comparison has been made of the variations of two different races of sea-trout established by us for the river Reda, the large race from the river Dunajec, and the small 4 year old *Salmo salar* ("mielnica") caught every year along the shores of the Gulf of Danzig.

The material for these comparisons was obtained from our investigations on the biology and morphology of the *S. trutta*, conducted on the rivers Dunajec and Reda.

In the years 1923 and 1924, while carrying out the artificial propagation of Salmonidae on the river Dunajec (an upper tributary of the Vistula) and having at our disposal abundant material, we were able to establish the fact that, contrary to the opinions expressed in the Polish ichthyological literature, *S. salar* is not to be found in this river and that this form is replaced in the Dunajec by a local race of sea-trout. The results of these investigations have been given in a report by myself and Dr. Lubecki, issued by the Department of Agriculture in 1926. (Compte rendu de campagne de pêche aux saumons réproducteurs en 1923 et 1924. Warsaw 1926. Edition of the Ministry of Agriculture. Serja D. N. 22.)

The race in the river Dunajec described by us belongs to the group which enters the Vistula with undeveloped gonads a year before spawning; this takes place during October and November in the upper parts of the Dunajec between the towns of Nowy Targ and Nowy Sacz. This race differs from the sea-trout of smaller rivers by its larger size and

weight. It is generally fished during the spawning migration in the Vistula and Dunajec, but is not taken in the sea-fishery in the Polish Baltic, which consists exclusively of *S. salar*.

Continuing the investigations our attention was drawn to the river Reda, which flows into the northern part of Danzig bay ("Putziger Wieck"), noted by Dr. SELIGO as the spawning ground of *S. salar*. Our investigations conducted in the years 1928 and 1930 likewise shewed the absence of *S. salar* in that river, as the boundary of the extension of this species in Danzig Bay is the shallow water, called in the German maps "Moven Riff".

The examination of the material collected on the river Reda convinced us that there are two peculiar races of *S. trutta* inhabiting that river. The results of these investigations will be given in a special paper in "The Memorials of Pulava Institute".

On the river Reda we distinguished two peculiar races; the "black" race, called by the local fishermen "black salmon", and the "silver" race.

The "black" race is the form that runs up the Reda, as its mother river, for spawning, which takes place in October, November and the beginning of December. Representatives of this race may be found in the river Reda as early as June, that is, 3 months before spawning.

The "silver" race, which does not spawn in the Reda, begins its migration at the time when the "black" race spawns in November and is to be found there till May. Between the ages of 3 to 6 years the representatives of this race with their gonads undeveloped journey to the Reda for feeding.

The fact of that race feeding in the river, as stated by us, as well as the small development of the gonads in the period of spawning, the presence of the 3 year old fish in that river, and the peculiar morphometrical features all indicate that the "silver" race is only a temporary visitor to the Reda, travelling from Puck Bay to the lower parts of the river, and back.

The difference between the size of the 4—5 year old fish of the Dunajec race and that of the races of the Reda is shewn by comparing the over-all body length (in centimetres):—

Average length			Greatest length			Smallest length		
Dunajec	Reda Black	Reda Silver	Dunajec	Reda Black	Reda Silver	Dunajec	Reda Black	Reda Silver
80.5	57.2	57.3	105	84	82	67	34	38

The fourth object of investigation dealt with in this paper is the small *S. salar* (called "mielnica"), the fishery for which takes place near the shores of Danzig Bay in the early spring. The characteristic feature of "mielnica" is that the stock consists exclusively of fish of the same age, i.e. of 4 year old fish which have had 3 years of river life, the males predominating. One can say that all "mielnica" examined by us appear to conform to one standard, their weight being 300—500 g. and their length 37—45 cm. with no great range and within the limits of length peculiar to the Reda and Dunajec sea-trout.

The material for comparison is as follows:—

1) The biometrical analysis, according to SMITT's scheme, of 25 specimens of sea-trout (Reda).
2) The over-all body lengths of 80 specimens of sea-trout (Reda).
3) The scales for age-determination of 119 specimens of sea-trout (Reda).
4) The weights of 45 specimens of sea-trout (Reda).
5) The biometrical analysis according to SMITT's method of 28 specimens of sea-trout from the Dunajec sent us by Dr. FR. LUBECKI, and 15 specimens of small (36—50 cm.), 4 year old *S. salar*.

In working out the statistical material we made use of the following calculated quantities 1) mean (M), 2) standard deviation (σ) and 3) mean error.

On the basis of these quantities we define the mean error of the difference (m) Dif. $= \sqrt{m_1^2 + m_2^2}$ and give the relation between $(M_1—M_2)$ and the above-mentioned mean error of the difference $\left(\sqrt{m_1^2 + m_2^2}\right)$.

This relation may be called the index of certainty of the difference between means $(M_1—M_2)$, as on the basis of GAUSS's law of error two means will belong to two separate classes, only when the difference between $M_1—M_2$ is three times greater than the mean error of the difference, i. e. $\frac{M_1 — M_2}{\sqrt{m_1^2 + m_2^2}} > 3$.

Detailed data confirming the presence in the river Reda of two different biological races of sea-trout are given by us in a special paper published in the "Memorials of Pulava Institute". At present our statements are confined to the results of comparison of morphometrical features which gave real differences when comparing the Reda sea-trout with salmon, as well as among themselves.

In order to give a full orientation of the results of measurements we give below a comparison of the means (M), expressed in percentages, respecting the over-all length of the body.

Measurements, after Smitt.

	S. salar	S. trutta (Dunajec)	S. trutta (Reda) black race	S. trutta (Reda) silver race
1. Longitudo capitis totalis.....	19.0	19.9	19.9	18.7
2. — mediae partis capitis ..	12.1	12.7	14.8	13.8
3. Spatium praeorbitale	5.7	6.5	6.6	5.4
4. Longitudo mandibulae superioris..	6.4	7.3	7.6	7.2
5. — maxilae inferioris	11.4	12.2	12.2	11.5
6. Spatium praedorsale.....	39.0	41.5	40.5	40.3
7. Longitudo pinnae dorsalis.....	10.6	10.2	11.2	10.5
8. Altitudo pinnae dorsalis.....	10.4	10.1	12.3	11.8
9. Longitudo pinnae pectoralis	12.5	12.0	13.2	12.4
10. — anterioris partis ventralis.....	28.9	29.5	28.2	28.8
11. — praeventrale	45.7	48.5	47.7	46.8
12. Altitudo pinnae ventralis.....	11.1	9.8	11.0	10.7
13. Spatium postventrale	21.9	21.5	22.0	21.8
14. Longitudo pinnae analis.....	7.7	8.1	8.5	8.3
15. Altitudo pinnae analis	8.6	10.5	12.5	12.2
16. Longitudo dorsalis pedunculi caudae	13.3	11.4	8.7	10.6
17. — lateralis pedunculi caudae	20.5	17.7	16.8	17.6
18. — ventralis pedunculi caudae	16.4	12.0	10.8	13.3
19. Altitudo minima corporis	6.3	7.6	8.2	7.8

Only a superficial comparision of the above data tells us how essential is the difference between the series of morphometrical features of the small *S. salar* and the races of the sea-trout, as well as that of the sea-trout among themselves.

Let us analyse the difference between *S. salar* and *S. trutta* of the Reda river and then of the races of *S. trutta* of the Dunajec and Reda rivers.

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$
Altitudo pinnae dorsalis	Sea-trout, silver race	11.8	0.83	0.24	10.4-13.1	$\frac{11.8 - 10.4}{\sqrt{0.24^2 + 0.20^2}} = 4.6 > 3$
	S. salar	10.4	0.7	0.2	9.4-11.8	
Altitudo pinnae analis	Sea-trout, silver race	12.2	0.67	0.19	10.5-13.1	$\frac{12.2 - 8.6}{\sqrt{0.19^2 + 0.22^2}} = 12.8 > 3$
	S. salar	8.6	0.78	0.22	7.3-9.9	
Longitudo dorsalis pedunculi caudae	Sea-trout, silver race	10.6	1.1	0.31	8.7-12.4	$\frac{13.3 - 10.6}{\sqrt{0.35^2 + 0.31^2}} = 6 > 3$
	S. salar	13.3	1.21	0.35	10.6-14.3	
Longitudo ventralis pedunculi caudae	Sea-trout, silver race	13.3	0.68	0.19	12.1-14.5	$\frac{16.4 - 13.6}{\sqrt{0.27^2 + 0.19^2}} = 9.4 > 3$
	S. salar	16.4	0.95	0.27	14.5-17.0	
Longitudo lateralis pedunculi caudae	Sea-trout, silver race	17.6	0.69	0.20	16.2-18.6	$\frac{20.5 - 17.6}{\sqrt{0.24^2 + 0.20^2}} = 9.6 > 3$
	S. salar	20.5	0.86	0.24	19.6-22.2	
Altitudo minima corporis	Sea-trout, silver race	8.2	0.58	0.16	7.1-8.3	$\frac{8.2 - 6.3}{\sqrt{0.16^2 + 0.18^2}} = 7.9 > 3$
	S. salar	6.3	0.56	0.18	5.7-7.3	

Comparison of the means of the *pedunculi caudae* shews that the side of the *pedunculi caudae* as well the edges of the dorsal and ventral fins of *Salmo salar* are considerably longer than those of the "silver" trout, but the *altitudo minima corporis* of the *S. salar* is considerably less.

The extent of the difference of the morphometrical features of the *pinnae caudalis* of the species compared can be seen from the fact that the difference between these features are twice, or even more than three times, the difference which is considered to be real according to the law of statistics. Comparison of the *altitudo pinnae dorsalis*, as well as the *p. analis* also gives a considerable difference; the height of the "silver" sea-trout's fins is considerably greater. One must note the special difference between the lengths of the anal fin.

The comparison of the *Salmo salar* with the "black" sea-trout gives the following results:—

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$
Altitudo pinnae dorsalis	Sea-trout, black race	12.3	1.0	0.27	10.5-13.8	$\frac{12.3 - 10.4}{\sqrt{0.27^2 + 0.20^2}} = 5.7 > 3$
	S. salar	10.4	0.7	0.20	9.4-11.8	
Altitudo pinnae analis	Sea-trout, black race	12.5	0.06	0.02	11.8-13.6	$\frac{12.5 - 8.6}{\sqrt{0.02^2 + 0.22^2}} = 17.3 > 3$
	S. salar	8.6	0.78	0.22	7.3-9.9	
Longitudo dorsalis pedunculi caudae	Sea-trout, black race	13.3	1.21	0.35	10.6-14.3	$\frac{13.3 - 8.7}{\sqrt{0.35^2 + 0.37^2}} = 12.1 > 3$
	S. salar	8.7	1.18	0.37	7.0-11.3	
Longitudo ventralis pedunculi caudae	Sea-trout, black race	16.4	0.95	0.27	14.5-17.8	$\frac{16.4 - 10.8}{\sqrt{0.27^2 + 0.5^2}} = 10.8 > 3$
	S. salar	10.8	1.8	0.5	8.2-14.2	
Longitudo lateralis pedunculi caudae	Sea-trout, black race	20.5	0.87	0.25	19.6-22.2	$\frac{20.5 - 16.8}{\sqrt{0.25^2 + 0.38^2}} = 8.4 > 3$
	S. salar	16.8	1.4	0.38	13.5-18.4	
Altitudo minima pedunculi caudae	Sea-trout, black race	8.2	1.2	0.33	7.1-8.8	$\frac{8.2 - 6.3}{\sqrt{0.33^2 + 0.18^2}} = 5.1 > 3$
	S. salar	6.3	0.56	0.18	5.7-7.3	
Longitudo mandibulae superioris	Sea-trout, black race	7.6	0.81	0.22	6.8-9.4	$\frac{7.6 - 6.4}{\sqrt{0.22^2 + 0.28^2}} = 3.5 > 3$
	S. salar	6.4	0.86	0.28	5.8-6.9	
Spatium praeventrale	Sea-trout, black race	47.7	1.5	0.41	46.2-50.7	$\frac{47.7 - 45.7}{\sqrt{0.41^2 + 0.43^2}} = 3.4 > 3$
	S. salar	45.7	1.5	0.43	42.9-47.4	

From these comparisons it results that, as regards the morphometrical features, the black race of Reda sea-trout is still farther from *Salmo salar* than the silver one, as is seen in the following comparison of the differences between M_1 and M_2.

	Sea trout (silver race)	Sea trout (black race)
Altitudo pinnae dorsalis	—4.6	—5.7
— — ventralis	—12.8	—17.3
Longitudo dorsalis pedunculi caudae	—6.0	—12.1
— ventralis pedunculi caudae	—9.4	—8.8
— lateralis pedunculi caudae	—9.6	—8.4
Altitudo minima corporis	—7.1	—5.1
Longitudo mandibulae superioris		—3.5
Spatium praeventrale		—3.4

Thus *p. dorsalis* and *analis* of the sea-trout of the black race are still longer than those of *S. salar*. The *pedunculi caudae*, as in the silver race, are shorter than in *Salmo salar*; the minimum height of body is greater. We found, too, real differences between M_1—M_2 with the black race for *mandibulae superior* and *spatium praeventrale*, which is also longer than with *Salmo salar*.

The *mandibula superior* of the silver race is nearly as long as that of *S. salar* and, when comparing the class frequency, one obtained an unreal difference, i.e. 2.6; but with the black race it is much longer and reaches distinctly beyond the hinder edge of the eye. Separate figures of the morphometrical elements of body mentioned as well as the results of comparison of class frequency, prove that the silver race of sea-trout of the Reda, which possesses morphometrical and anatomical features (quantity of *appendices pylorici*) proper to sea-trout, occupies in a morphometrical respect a position between the black race and *Salmo salar*, being near the latter according to their morphometrical features.

Let us pass to the morphometrical analysis of the races of *Salmo trutto* of the Reda, the comparative material for which is given in the table below:—

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_1^2}}$
Longitudo capitis totalis	Silver race	18.7	0.86	0.24	17.0-23.0	$\frac{19.9 - 18.7}{\sqrt{0.24^2 + 0.27^2}} = 3.3 > 3$
	black race	19.9	1.0	0.27	18.7-22.8	
Spatium preaorbitale	Silver race	6.6	0.9	0.25	5.6-8.9	$\frac{6.6 - 5.4}{\sqrt{0.25^2 + 0.17^2}} = 4 > 3$
	black race	5.4	0.62	0.17	4.3-6.6	
Longitudo ventralis pedunculi caudae	Silver race	13.3	0.68	0.19	12.1-14.5	$\frac{13.3 - 10.8}{\sqrt{0.19^2 + 0.5^2}} = 4.8 > 3$
	black race	10.8	1.8	0.50	8.2-14.2	
Longitudo dorsalis pedunculi caudae	Silver race	10.6	1.1	0.31	12.1-14.5	$\frac{10.6 - 8.7}{\sqrt{0.31^2 + 0.37^2}} = 5.2 > 3$
	black race	8.7	1.18	0.37	7.0-11.3	

Thus, as regards the head and the *dorsalis pedunculi caudae*, we succeeded in establishing real differences which confirm the opinion that the special biological silver race of sea-trout (not spawning in the Reda)

is accompanied by definite morphometrical features. The black race (spawning in the Reda) possesses a longer head and a longer *spatium praeorbitale*. The comparison of the fins shews that the *pedunculum caudae* of the silver race is longer that of the black one.

Let us pass to the morphometrical analysis of the sea-trout of the Dunajec, comparing them with the races of the sea-trout of the Reda, first with the black and then with the silver race.

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$
Longitudo capitis med.	Dunajec	12.7	0.8	0.5	12.2-15.4	$\frac{14.8 - 12.7}{\sqrt{0.5^2 + 0.33^2}} = 3.5 > 3$
	black race	14.8	1.38	0.33	12.4-16.7	
Altitudo pinnae dorsalis	Dunajec	10.1	0.8	0.15	8.2-11.9	$\frac{12.3 - 10.1}{\sqrt{0.15^2 + 0.27^2}} = 7.3 > 3$
	black race	12.3	1.0	0.27	10.5-13.8	
Longitudo pinnae pectoralis	Dunajec	12.0	0.51	0.1	11.1-13.1	$\frac{13.1 - 12.0}{\sqrt{0.1^2 + 0.2^2}} = 5 > 3$
	black race	13.1	0.75	0.2	12.1-14.7	
Longitudo anterious partis ventralis	Dunajec	29.5	1.46	0.27	26.5-32.5	$\frac{29.5 - 28.2}{\sqrt{0.27^2 + 0.24^2}} = 3.6 > 3$
	black race	20.2	0.89	0.24	26.3-29.3	
Altitudo pinnae ventralis	Dunajec	9.8	0.51	0.09	8.5-19.6	$\frac{11.0 - 9.8}{\sqrt{0.09^2 + 0.19^2}} = 6 > 3$
	black race	11.0	0.71	0.19	9.6-12.3	
Altitudo pinnae analis	Dunajec	10.5	0.65	0.12	9.5-11.7	$\frac{12.5 - 10.5}{\sqrt{0.12^2 + 0.02^2}} = 9 > 3$
	black race	12.5	0.06	0.02	11.8-13.6	
Longitudo dorsalis pedunculi caudae	Dunajec	11.4	0.67	0.31	10.2-12.7	$\frac{11.4 - 8.7}{\sqrt{0.31^2 + 0.37^2}} = 5.5 > 3$
	black race	10.8	1.8	0.50	8.2-14.2	

Summarizing the results of the above comparisons we come to the conclusion that, in relation to the black sea-trout of the Reda, the Dunajec fish has 7 special morphometrical features, namely:—

1) shorter middle part of the head,
2) shorter fins, *dorsalis*, *lateralis*, *ventralis* and *analis*,
3) longer front part of stomach,
4) longer *dors. pedunculi caudae*

The comparison with the silver race gives the following results:—

Features	Species	M	σ	m	Fluctuations of means	$\frac{M_1 - M_2}{\sqrt{m_1^2 + m_2^2}}$
Longitudo capitis totalis	Dunajec	19.9	0.59	0.11	18.9-21.5	$\frac{19.9 - 18.7}{\sqrt{0.11^2 + 0.24^2}} = 5 > 3$
	silver race	18.7	0.86	0.24	17.0-20.3	
Longitudo ventralis pedunculi caudae	Dunajec	12.0	1.01	0.2	10.1-14.2	$\frac{13.3 - 12.0}{\sqrt{0.2^2 + 0.19^2}} = 5 > 3$
	silver race	13.3	0.68	0.19	12.1-14.5	
Altitudo pinnae dorsalis	Dunajec	10.1	0.8	0.15	8.2-11.9	$\frac{11.8 - 10.1}{\sqrt{0.15^2 + 0.24^2}} = 6 > 3$
	silver race	11.8	0.83	0.24	10.4-13.1	
Longitudo pinnae ventralis	Dunajec	9.8	0.51	0.09	8.5-10.6	$\frac{10.7 - 9.8}{\sqrt{0.09^2 + 0.21^2}} = 4.1 > 3$
	silver race	10.7	0.75	0.21	9.2-11.9	
Spatium praeventrale	Dunajec	48.5	1.31	0.24	45.1-52.1	$\frac{48.5 - 46.8}{\sqrt{0.24^2 + 0.37^2}} = 3.9 > 3$
	silver race	46.8	1.3	0.37	44.0-49.2	
Altitudo pinnae analis	Dunajec	10.5	0.65	0.12	9.5-11.7	$\frac{12.2 - 10.5}{\sqrt{0.12^2 + 0.19^2}} = 7.7 > 3$
	silver race	12.2	0.67	0.19	0.5-13.1	

Hence the sea-trout of the Dunajec possess the following morphometrical features which distinguish them from the silver sea-trout of the Reda:—

1) longer head,
2) shorter middle part of head,
3) shorter fins, *dorsalis*, *ventralis*, *analis*,
4) longer front part of stomach,
5) longer *spatium praeventrale*,
6) longer *ventr. ped. caudae.*

The above results of statistical comparisons as well as the earlier data at our disposal enables us to state that in the fauna of Polish rivers *Salmo trutta* is represented by 3 local races — "silver" and "black" in the Reda, and the Dunajec, wandering by way of the Vistula to the upper Dunajec.

The question of the presence of sea-trout in other tributaries of the Vistula, as for instance in Brda, where a few examples of *S. salar* are taken at the spawning time, is not yet solved, as for the time being no specimens of sea-trout have reached the investigators hands.