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Alterations in Fat, Water and Protein Content of Vistula Sea-Trout in Connexion with their Biology

by

J.T.Kukucz

1.Problems

It was commonly known that two species viz.: true salmon (Salmo salar L.) and a big race of sea trout (Salmo trutta L.) enter the river Vistula only with undeveloped gonads as winter salmon and winter sea trout.

In 1951 Zarnecki succeeded in discovering in both species besides these winter populations the existence of a summer form, which enters the mouth of the Vistula chiefly in autumn with gonads in an advanced stage. Investigating the run of sea trout in a year cycle 1952 Zarnecki stated furthermore that this population is much less numerous and does not represent more than 20% of the whole run and that the time of entering lasts from June to October. Further investigations of the same author (Zarnecki, 1954) proved that between both seasonal populations great differences exist in their metabolism.

This can be seen in the amount of agglomerated fat on the intestines, thickness of the body walls in the ventral part, the weight of the liver, the remainder of food in the alimentary tract etc. Before leaving the sea, the summer population produces a great amount of sexual products attaining sometimes up to 20% of the total weight of the fish; the winter population in the same period and in the same sea habitat accumulates an enormous amount of fat which enables the fish to undertake migration over 1000 km long. The peak of their entering the Vistula mouth is in November and the spawning season achieves its top in November one year later. The winter population remains in the river for about one year.

The existence among the above mentioned species of two seasonal forms so strongly different in their metabolism, evolved the problem of a more exact investigation of the differences between these two populations. These differences - as it might be presumed - should appear in the content of fat, protein and water.

Fat, protein and water distribution in different parts of the body of sea trout was unknown till now. It was interesting, therefore, to investigate also the content of these components in the dorsal, ventral and caudal parts of the sea trout; this has both a biological and a technological aspect.

After investigating specimens belonging to the winter population at the very beginning of their spawning migration, data have been gathered also concerning some specimens caught on the spawning grounds in the river Dunajec one year later at the end of the spawning period. This last question is important in order to explain the biochemical changes of the sea trout undertaking such a long and distant spawning migrations.

2. Material and methods.

The sea trout caught in the Vistula, in the region between its estuary and the town of Tczew, that is 30 km upstream from the mouth of the river, was the subjects of investigation. 64 individuals caught in this region were examined between November 1958 and November 1959, apart from them 6 spawners caught on spawning places in the Dunajec river in November 1959.

The true salmon (S.salar) appears only in small quantities and an adequate number of specimens was difficult to obtain. Therefore only sea trout (S.trutta) were examined.

The particular samples were ground and the fat content was determined by means of the Soxleth apparatus, the protein content with the Keildahl method and the water content was stated.

3. Division of the material into groups.

The whole material may be divided into two groups on the basis of gonad development:

1) with gonads more or less developed, considered as the summer populations,

2) with undeveloped gonads, considered as the winter population.

On the basis of these features 47 individuals from among 63 were selected, namely: 21 summer and 26 winter ones. The remaining individuals, 16 in number, had undeveloped gonads. In the period between February and June it was impossible to determine whether they belonged to the summer or to the winter population.

As results from former papers (Zarnecki 1959) the development of gonads starts at the end of May or the beginning of June in summer population individuals entering the Vistula estuary; similarly the development of gonads in the winter population individuals, staying already on spawning grounds high up the river, also starts at the end of May and the beginning of June. Therefore it can not be stated before June whether a given individual belongs to the last specimens from the winter run, or to the first of the summer one. It is not known to what extent both runs overlap each other in this period.

In the 16 previously mentioned individuals fat content could be the basis for dividing into the following two distinct groups:

the first group composed of 10 individuals caught in the estuary in February, March and the first half of April; both males and females have on the average about 12.5% fat in the anterior ventral lobes,

the second group (6 individuals) also caught in the estuary in the second half of April and in May, revealed in the anterior ventral lobes a mean fat content of 23% in the females and 20% in the males.

The first group is similar to individuals of the summer population as regards the fat content; the second one has a fat content similar to that of the winter population individuals.

Finally one spent specimen (kelt) was found in the examined material.

4. Differences between the winter and summer population.

A). Data concerning the anterior parts of ventral lobes.

a) Fat content is as follows:

	females	males	
summer	11.70 (11)	9.28 (10)	x)
winter	24.45 (20)	20.73 (6)	

x) the figures in brackets stand for the number of examined individuals.

Both sexes of the winter population have more than a double amount of fat, as compared with the summer population.

Even without a statistical analysis it can be stated that these differences are significant.

The analysis proved as well, that the females of both seasonal populations have a mean amount of fat greater than the males. In spite of the scarce data, it seems probable that the phenomenon of sexual demorphism of this feature is of a general character.

b) The water content is as follows:

	females	males
summer	67.62 (11)	69.07 (10)
winter	56.05 (20)	59.47 (6)

The water content, as expected, was directly reverse to the fat content; it is considerably lower in the winter population. The tissues of the males revealed a greater amount of water in the samples than those of the females.

c) Protein content is as follows:

	females	males
summer	19.97 (11)	20.54 (10)
winter	18.38 (20)	18.27 (6)

The mean content of protein in winter individuals oscillates about 18%, while in the summer ones about 20%. At any rate the differences in protein content in both seasonal "races" are not so distinct, as the differences in the fat and water contents.

B). Data concerning the posterior part of the ventral lobes, the anterior and posterior region of the dorsal part and the caudal part.

The above data are presented in the table below:

Fat

Place where sample was taken		Winter females (n = 20)	Winter males (n = 6)	Summer females (n = 11)	Summer males (n = 10)
ventral	2	24.45	20.73	11.70	9.28
part	4	21.00	16.72	10.10	8.76
dorsal	1	13.09	11.17	5.98	6.02
part	3	14.47	12.52	7.54	5.93
caudal part	5	11.60	7.93	4.75	4.46
mean		17.04	13.82	7.91	6.86

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Water

Place where sample was taken		Summer females (n = 2o)	Summer males (n = 6)	Winter females (n = 11)	Winter males (n = 1o)
ventral	2	56.05	59.47	67.62	69.07
part	4	58.20	63.82	68.35	69.22
dorsal	1	61.85	66.72	71.50	70.69
part	3	63.61	67.02	70.10	70.96
caudal part	5	66.49	69.92	72.77	72.55
mean		61.81	65.07	70.04	70.44

Protein

ventral	2	18.38	18.27	19.97	20.54
part	4	19.58	19.87	20.76	21.33
dorsal	1	20.97	21.30	21.99	22.11
part	3	20.91	21.58	21.79	22.44
caudal part	5	21.22	21.77	22.02	23.52
mean		20.26	20.53	21.31	21.76

As appears from the above tables the content of fat, water and protein in other parts of the body shows as a rule analogical alterations to those in the anterior part of ventral lobes in summer and winter populations.

5. Distribution of fat, water and protein in the different parts of the body.

It may be concluded from the data presented in tables that the greatest amount of fat in sea trout us accumulated in the anterior ventral lobes in the region of pectoral fins. The amount of fat in the posterior parts of ventral lobes is as a rule distinctly smaller than in the anterior part.

On the ventral side of the body, therefore, the fat content diminishes from the head towards the tail; on the contrary the fat content increases slightly in the dorsal part towards the tail. The smallest amount of fat is always found in the tail itself; a similar distribution was also found in the salmon by Thurow (1959).

Water content is in a reverse relation to the fat content. In the protein content the differences are comparatively smaller in certain parts of the body than in the fat content. The lowest protein content was stated in the anterior part of the ventral lobes.

6. Alterations in content of fat, water and protein at the beginning and at the end of the spawning migration.

A. Data concerning the anterior part of the ventral lobes.

a) Fat content:

As already stated, individuals of the winter population have: 24.45% of fat in females, 20.73% of fat in males in the anterior part of the ventral lobes. The respective fat content in the spawners of the winter population after their stripping was the following:

females	males
4.97 (4)	3.35 (2)

During their stay in the river connected with the migration to distant spawning grounds, the females consumed more than 80% of their fat supply; the males consumed 85%.

b) The water content is given below:

	females	males
at the beginning of the migration	56.05% (20)	59.47% (6)
at the end of the migration	78.22% (4)	78.75% (2)

Kelts of the winter population show a considerable increase of water content in the anterior part of the ventral lobes.

c) Protein content

Protein content in anterior ventral lobes is given below:

	females	males
at the beginning of the spawning migration	18.38% (20)	18.27% (6)
at the end of the spawning migration	15.97% (4)	16.55% (2)

As appears from the above figures, the loss of protein in this part of the body of the fish is quite considerable reaching about 15% of the initial protein content.

B. The mean data.

The description of alterations given above was based on the analysis of fat, water and protein in anterior ventral lobes. Here follow average data obtained from analysis of samples from five parts of the body of the sea trout caught at the beginning and the end of their migration.

Mean values obtained from samples taken from five parts of the body:

	females	males
a) Fat		
at the beginning of the migration	17.04 (20)	13.82 (6)
at the end of the migration	4.05 (4)	2.85 (2)
b) Water		
at the beginning of the migration	61.81 (20)	65.07 (6)

	females	males
at the end of the migration	78.30 (4)	78.80 (2)
c) Protein		
at the beginning of the migration	20.26 (20)	20.53 (6)
at the end of the migration	16.62 (4)	17.30 (2)

These figures represent an analogous picture of alterations to that which was obtained in one part of the body i.e. in the anterior part of ventral lobes.

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It should be stressed as a specific circumstance, that besides the considerable loss of fat (80%) during the migration period of sea trout the loss of protein is also significant, though it varies in lower limits (about 15-20%). As results from the above not only the fat in the sea trout but also the protein was consumed during the spawning migration in the Vistula.

Additionally the chemical composition of samples taken from one female kelt, 77 cm long, weighing 3.83 kg caught on February 21, 1959, on its downstream migration in the Vistula estuary shows an obvious analogy of values already described for stripped spawners from the spawning places of the Upper Dunajec. Only the protein content was higher but the paucity of material does not permit any general conclusion.

7. Conclusions.

1. Considerable differences in the fat content of the individuals from winter and summer populations were stated. The fat content is more than twice greater in the anterior ventral lobes in winter population specimens esp. those entering the river in autumn.

2. The above mentioned differences also appear distinctly in these two seasonal populations of sea trout in the posterior part of the ventral lobes, in the dorsal parts and in the caudal ones.

3. It was found that the accumulation of fat is considerably greater in the ventral part than in the dorsal parts of the body. It was also stated that there is less fat in the posterior part of the ventral lobes than in their anterior part; on the contrary, the fat content increases in the dorsal part towards the tail. A distinctly smaller amount of fat is accumulated in the tail itself. This last phenomenon may be explained by the fact that the sea trout, being a very good swimmer, uses the caudal part for movement. The statements concerning the distribution of fat in the body of sea trout are very important esp. from the technological point of view.

The water content in all examined samples is in an opposite relation to the distribution of fat content.

The differences in protein content are smaller and therefore a greater amount of material would be needed to draw general conclusions.

4. The comparison of fat content in winter populations individuals at the beginning of the spawning migration with the

content of fat in spent fish allowed to state that spawners of sea trout lose about 80 - 85% of their fat supply during their spawning migration in the Vistula.

The protein content decreased considerably (about 15%) during this migration. The highest content of water was found in kelts.

5. Both in the winter and summer population the mean values for the fat content are always greater for the females than for the males; this phenomenon is in an opposite relation to the water content since, in the majority of cases especially in the winter form, it is higher in the males.

No differences were found in the content of protein between the sexes of both populations.