Free translation from the Russian by:

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Blood of the Burbot During Complete Prolonged Food Deprivation and Subsequent Feeding

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Complete and prolonged cessation of feeding by fishes occurs fairly often under natural conditions (during winter, spawning migration and at other times). According to literature data, it does not cause changes in the morphological composition of the blood of fishes (1-4). During our study of the seasonal changes of the blood of fishes, we noted both this and the direct dependence between feeding and the number of leucocytes. Since the influence of complete and prolonged cessation of feeding on the morphological composition of the blood of fishes is not yet completely clear, and the reverse of this process is not well documented in the literature, it appeared advisable to study this problem experimentally.

The experiments were conducted on burbot (Lota lota L. - translator) (400-700 g.) which were kept in large aquaria with flowing well aerated water. Control burbot were fed with living crucian carp (Carassius carassius L. - translator). Determined were: the quantity of haemoglobin, the number of erythrocytes and leucocytes, the total quantity of serum albumen of the blood (with the aid of an I.R.P.-22 refractometer), haematocrit index and volume of the blood (by extracting the tissue of the fishes). In each series of experiments there was from 9 to 12 burbot (equally of males and females). Analyses of blood of the burbot were conducted simultaneously for the control and experimental fishes. In Table 1 and on figures 1 and 2 the values for the controls are combined.

Starvation over the course of 15 days did not yield changes in the composition of haemoglobin and erythrocytes (figure 1). Through 30 days the number of erythrocytes increased almost 2 times, but up to 60 days of starvation it attained 3000 thousand/mm$^3$, subsequently the number of erythrocytes fell somewhat and stabilized at a level of 2810-2840 thousand/mm$^3$ for an additional 55 days. The quantity of haemoglobin
was also heightened; it attained a maximum within 45 days, but subsequently fell and stabilized at a uniform level for 145 days, remaining very high in comparison to the control. As the starving continued the index of the haematocrit rose from 17-21 to 38-42. The significant increase of the haematocrit index for the starving fishes is due not only to an increase of the number of erythrocytes per unit volume, but apparently also to a certain perturbation of the osmotic equilibrium in the blood, bringing about swelling of the erythrocytes.

Saturation of the erythrocytes with haemoglobin increases through 30 days of starving, but subsequently decreases and at 90-145 days becomes lower than the control.

Within 3 days the feeding of the fishes leads to a decrease of haemoglobin and erythrocytes especially. After 20 days of feeding these indices return to the level of the control fishes. The index of the haematocrit also gradually returns to the original level. Saturation of the erythrocytes with haemoglobin increases for 10 days following feeding, and within 20 days decreases to the control values.

The increase of blood color indices during complete and prolonged food deprivation (without water restriction) for men, horses, dogs and rats has long been known (6-10). The results of experiments on burbot also testify to thickening of the blood (increased concentration of haemoglobin, quantity of erythrocytes and haematocrit index), caused by mobilization of blood depots and the transfer of water from the circulatory system into boundary tissue reservoirs.

The sharp inadequacy of feeding leads, apparently, to perturbation of the activity of the blood forming organs. Therefore, the retention of blood color indices at a high level over the course of several months is determined, likely, by the duration of the life of the erythrocytes. During this the erythrocytes become intensely impoverished of haemoglobin. Following feeding of the fishes the quantity of erythrocytes decreases (hydremia), but the saturation of their haemoglobin increases.
According to my determinations, the volume of the blood (expressed as - translator) percentages of the weight of the body does not change noticeably even during 145 days of starvation or following feeding over the course of 20 days (Table 1).

The quantity of leucocytes is reduced during starvation: at 15 days they are 3 times fewer than those of the control fishes. Subsequently the number of them increases, probably as a result of a general thickening of the blood, but at 145 days it again becomes of minimal significance. Particularly significant during this is the ratio of the number of leucocytes to erythrocytes which, according to the degree of starving, drops steadily. However, within 3 days after the beginning of feeding the number of leucocytes increases almost twofold, but through 20 days it exceeds the index for the control fishes (figure 2). In figure 2 may also be seen a change in the relationships of the types of leucocytes. During starvation the percentage of phagocytes and their absolute magnitude rises. After feeding the total quantity of leucocytes increases on account of the increase of the mass of lymphocytes. The absolute quantity of phagocytes during this is reduced.

The increase of the number of leucocytes at the beginning of feeding can be explained by the fact that they receive spontaneous sharing in the process of digestion by fishes, in the transport of the fractions of fat, and secretion of digestive enzymes (11).

For the characteristics of the fluid portion of the blood we determined the total quantity of serum albumen. The results of these determinations once again confirm indications in the literature (12, 13) about lowering of the percentage of total albumen in the blood serum of fishes during starvation. In our experiments the quantity of it steadily drops and over 145 days amounts to only 1.9% as opposed to 6.31% for the control. In spite of thickening of the blood, the content of albumen in the serum diminishes as a result of the fact that during starvation in the first instance there is a loss of blood albumen. Over the 20 days after feeding the percentage of albumen approaches the initial (Table 1). It should be noted that total
normality of blood composition probably ensues sometime after 20 days. To such a form, the restoration of a normal picture of the blood required considerably less time than for its deviation during the period of starvation.

It is possible that not all species of fishes possess the mechanism of blood change during complete prolonged starvation as do burbot, however according to our observations, the picture of the blood for bronze bream (Abramis brama L. - translator) subjected to starvation repeats that for burbot.

Literature Cited

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Figure 1. Haemoglobin and erythrocytes in the blood of burbot during prolonged starvation and subsequent feeding. 1 - haemoglobin, 2 - erythrocytes.

Figure 2. The total quantity of leucocytes and leucocytic composition of burbot blood during prolonged starvation and subsequent feeding. 1 - lymphocytes, 2 - monocytes, 3 - polymorphonuclears.
Table 1. Volume of burbot blood and total serum albumen during complete and prolonged food deprivation and subsequent feeding.

<table>
<thead>
<tr>
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<th>Blood volume as % of body weight</th>
<th>Total serum albumen %</th>
<th>Number of specimens examined</th>
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<tbody>
<tr>
<td></td>
<td>Control 15 days 30 days 60 days 90 days 145 days 3 days 6 days 10 days 20 days</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood volume as % of body weight</td>
<td>1.90 1.81-1.99 1.98 1.91 2.00 1.96</td>
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<tr>
<td>Total serum albumen %</td>
<td>6.31 5.78 5.44-8.62 2.16 2.70 3.81 5.49</td>
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<tr>
<td>Number of specimens examined</td>
<td>81 10 11 12 10 10 12</td>
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<table>
<thead>
<tr>
<th></th>
<th>18 days 30 days 60 days 90 days 145 days 3 days 6 days 10 days 20 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood volume as % of body weight</td>
<td>1.88 1.30-2.00 1.55-2.27 1.85-2.00 1.64-2.36 1.45-2.18 1.69-2.12 1.30-2.35</td>
</tr>
<tr>
<td>Total serum albumen %</td>
<td>4.42 3.63 2.26-5.37 1.19-2.80 1.72-2.34 2.03-3.05 2.34-5.48 5.19-5.89</td>
</tr>
<tr>
<td>Number of specimens examined</td>
<td>12 10 10 12</td>
</tr>
</tbody>
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Note: The values in the table represent averages and ranges for the specified periods of starvation and feeding.