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**ECOPHYSIOLOGY OF A HOST-PARASITE SYSTEM: EFFECT OF INFECTION OF A PARASITIC COPEPOD, LERNAEA HESARGATTENSI S ON THE OXYGEN CONSUMPTION OF THE FISH, LEBISTES RETICULATUS PETERS**

Work on the physiology of copepods, especially of the parasitic forms, is wanting. A new species of a parasitic copepod *Lernaea hesargattensis*, infecting the cyprinodont fish *Lebistes reticulatus*, has been recently described. The adult female parasites are found to be firmly embedded in the muscular tissue of the host and thus obtain their nutritional requirement.

One of the vital ecological factors affecting the survival of fish is the availability of oxygen in the aquatic habitats and the oxygen consumption of the fish is a direct index to its metabolic rate and food requirement. Hence, in the present paper, the effects of infection of *L. hesargattensis* on the oxygen consumption of the fish *L. reticulatus* is described.

The test fish were collected from the fish ponds of Hesaraghatta, near Bangalore. The fish were separated into the following experimental series: (1) Normal, (2) infected, with the parasite intact and (3) infected, with the parasites removed. Oxygen consumption of all these fish were estimated for males and females separately, using the modified Winkler's method. In many of the infected fish, at the region of penetration of the parasite, certain tissue damage and inflammation around the area was observed. This reaction was local and did not extend beyond the area of infection. Similar local reactions were recorded in salmonids due to infection by the leech *Piscicola salmositica*.

Table I represents the average values of oxygen consumed by males and females of the experimental series. A normal male fish consumed $0.2685 \pm 0.051$ cc of oxygen/gram body weight/hour. During the same period the infected fish consumed as much as $0.3314 \pm 0.139$ cc of oxygen/gram body weight.

**Table I**

<table>
<thead>
<tr>
<th>Material</th>
<th>Sex</th>
<th>Body weight (mg)</th>
<th>Oxygen consumed/ g body weight/hour (cc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Male</td>
<td>196.80</td>
<td>0.2685</td>
</tr>
<tr>
<td>Controls</td>
<td>Female</td>
<td>264.27</td>
<td>0.7725</td>
</tr>
<tr>
<td>Infected,</td>
<td>Male</td>
<td>174.87</td>
<td>0.3314</td>
</tr>
<tr>
<td>with parasite</td>
<td>Female</td>
<td>329.05</td>
<td>0.8981</td>
</tr>
<tr>
<td>Infected,</td>
<td>Male</td>
<td>114.58</td>
<td>0.2608</td>
</tr>
<tr>
<td>without parasite</td>
<td>Female</td>
<td>330.20</td>
<td>0.6614</td>
</tr>
</tbody>
</table>

The corresponding value for normal and infected females were $0.7725 \pm 0.320$ and $0.8981 \pm 0.084$ cc of oxygen/gram body weight/hour, respectively. The higher consumption by female Lebistes, despite a larger body weight when compared to males, may be due to the fact that these experiments were conducted during March 1973 when the laboratory water temperature was $32^\circ$ C, five degrees more than the temperature at which the males were experimented (November, 1972).

In both male and female Lebistes, when the parasites were removed, the oxygen consumption dropped back almost to the normal values. In the males, on removal of the parasite, the fish consumed $0.2608 \pm 0.159$ cc of oxygen/gram body weight/hour and in the females, the corresponding value was $0.6614 \pm 0.332$ cc. Moreover, the oxygen consumed by the parasite alone (after it was removed from the host's tissue) was found to be negligible. Hence, this increased oxygen consumption of the infected Lebistes, irrespective of the sex of the fish, can be attributed to a 'stress reaction' due to parasitic infection of the copepod.

The percentage increase in the oxygen consumed, from the normal to infected males, was 20.42 while in females this increase was slightly less (16.30%).
A respiratory increase of 5% of the host's normal metabolic rate was observed in the sculpin Myxoccephalus scorpius infected by the leech, Malpighian nuda. Even here, the increase was attributed to the increased rate of blood and tissue formation and to stress caused by the mechanical irritation of the feeding leeches. Thus, it may be surmised that though large respiratory increases may not be observed with smaller burdens of parasitic infection under natural conditions, oxygen deficient waters and/or heavy parasitic infections may be detrimental to the fish.

Further work on the ecophysiology of this host-parasite system is in progress.

The authors are grateful to late Professor K. Pamapathi Rao for his valuable suggestions and discussions during the present study and to Dr. A. R. Kasturi Bai, Head of the Department of Zoology, for encouragement.


Changes in Calcium and Phosphate Levels in the Bones of Baby and Adult Loris, Loris Tardigradus

The extracellular constituent of bones is a system of collagen and calcium phosphate. The latter has a structure identical or similar to hydroxyapatite, \( \text{Ca}_{10} (\text{PO}_4)_6 (\text{OH})_2 \). It contains crystalline and amorphous fractions, the crystalline ones, increasing with age. Concurrently, the Ca/P ratio shifts towards higher calcium values. The major constituent of bone is collagen. Its content amounts to approximately one-third of the total bone mass.

Various substitutions and ion exchanges leading to the hydroxyapatite structure occur during maturation of human bones. In man, it is also known that the Mg content is highest in the bones of the youth which, as the age progresses, is replaced by the deposition of Ca. This process of ion exchange is known as 'slagging'.

Whether such ion exchanges or slagging occurs with age in the slender loris, a prosimian, has been investigated in this paper.

Marrow free and oven dried humerus, femur and parietal bones of baby (1 month old) and adult (2 years old) were weighed and dissolved in 100 ml of 0.6 N HCl and the extract was analysed for calcium, magnesium, phosphorus and non-protein nitrogen. Calcium of the bone extract was precipitated as oxalate and titrated with standard potassium permanganate following the method of Clark and Collip. After removal of calcium, magnesium of the extract was precipitated as magnesium ammonium phosphate according to Denis. The resultant phosphate was estimated by Fiske-Subba Row method. The bone extract was deproteinized with 5% trichloroacetic acid and the phosphorus of the protein-free filtrate was estimated according to Fiske-Subba Row. The non-protein nitrogen (NPN) of the extract was determined by micro-Kjeldahl method as described by Oser.

Analysis of bone extract revealed that the inorganic constituents varied with age and the bone. Calcium content significantly increased in the parietal bones but decreased in the femur during aging; phosphorus increased in the humerus in contrast to the femur and the parietal but the nitrogen content decreased in general, on aging.

In mammals (including man), the magnesium content of the bone is very low, but in baby and adult loris it is higher than in other mammals. Magnesium, however, decreased in all bones on aging (Table I). In loris, blood also contains a high magnesium content which might account for the high magnesium content in the bone. Long bones showed a lower and the parietals a higher phosphorus content in comparison with other mammals.

The theoretical molar ratio (Ca/P) for hydroxyapatite is 1.667 which differed with age and individual bones of loris (Table II); it increased on aging in the parietals and the femur in contrast to humerus. The ratios relatively higher than the theoretical ratio (Table II) probably indicate that calcium occurs in forms other than hydroxyapatite also. Molar ratios Ca/P, Mg/P and Ca/Mg (Table II) indicated that calcium might exist in different forms like calcium carbonate, in addition to its occurrence as hydroxyapatite. The high magnesium and low phosphorus contents of baby bones suggest the occurrence of a low hydroxyapatite content in young bones.