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Heat Production of Japanese Killi-fish,
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By

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The chief purpose of ecology, in our opinion, is to clarify the structures and functions of an ecosystem. The conceptions of an ecosystem have been proposed by many authors, especially by Tansley (1935). It means a system composed of physical-chemical-biological processes acting within a space-time unit of any magnitude, i. e., the biotic community plus its abiotic environment (from Lindeman, 1942). A pond including all its biotic communities and abiotic materials, for an example, is one of ecosystems. Various animals and plants of a pond are distributed in a definite order, in other words, the pond has the structure as an ecosystem. This structure is not static but dynamic and changes as time progresses. This change can be seized formally on the one hand and functionally on the other. Investigation of metabolism in pond such as performed by Lindeman (1942) is one of the latter courses of approach to the ecosystem problem.

One of the authors, Mori, has been attempting to clarify the metabolic mechanisms existing in an ecosystem which is composed of killifishes, pondweeds and waters. The present report aim to demonstrate the heat production of Japanese killi-fish, *Aplocheilus latipes*, and to consider its relation, if any, to heat metabolism of the ecosystem in which the fish lives. We wish to express our sincere thanks to Prof. Denzaburo Miyadi, Prof. Ryo Kiyama and Mr. Takeo Hirota of Kyoto University who gave us many valuable advices and criticisms.

Method

Material fishes were always collected several days before the experiments from small streams or pools in the vicinity of Kyoto Uni-

versity and preserved in a large aquarium. At the time of experiment, a small dewar vessel, filled with 250 cc of distilled water, was charged with eleven to twenty adult fishes from the aquarium, and was dipped in the water thermostat. Changes of temperature were read directly from Beckmann's thermometer at every 5 or 10 minutes. The water equivalent of the apparatus was 269 cal/deg. The whole set of the apparatus, principal parts of which are arranged after Horiba (1937), is illustrated in Figure 1. Temperature of the water thermostat, whose accuracy was $\frac{2}{1000}$ — $\frac{4}{1000}$ °C, was maintained 2—3° C higher than the room temperature at the time of experiment. When there were no fishes, the temperature of water in the dewar vessel could be maintained constant. But when the fishes were put in, they were soon asphyxiated due to exhaustion of oxygen. So that the circulation of

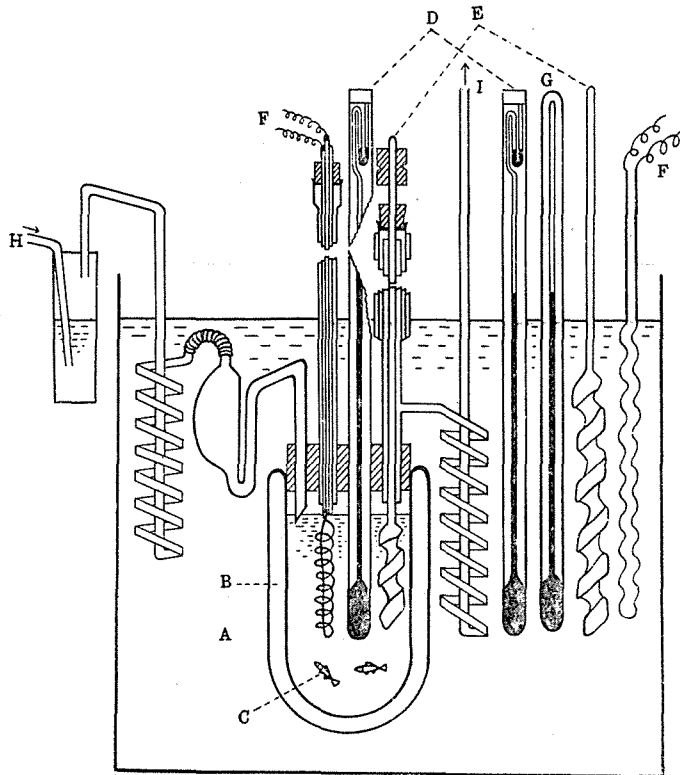


Fig. 1

A: Water thermostat, B: Dewar vessel, C: Fishes, D: Beckmann's thermometer, E: Stirrer, F: Heater, G: Standard thermometer, H: Inlet of air, I: Outlet of air to suction pump.

air contained in the dewar vessel was necessary (ca. 150 cc/min) in order to keep the fishes in good condition. By this operation, however, the water evaporated and caused the descent of temperature. This loss of heat may be calculated by the equation:

$$\frac{\text{vapor pressure} \times \text{volume of air circulated per minute}}{760 \times 22146} \times (1 - \text{relative humidity}) \times \text{latent heat of vaporization}$$

The experimental results were corrected by adding these values. The experiments were always completed within an hour, and to get the dry weight the fishes were desiccated at 105° C.

Results

The results are shown in Table 1 and Figure 2.

Table 1
Heat production of *Aplocheilus latipes* throughout a year

Date	Temperature of water thermostat		Material fish		Heat generated		
	deg.C.=T	$\frac{1}{T+273}$	Nos. used	dry weight (gr)	deg./hr	cal/gr/hr =H	log H
1948							
16/VII	29.10	0.00332	11	0.57	0.0495	23.364	1.369
19/VII	28.75	0.00332	11	0.71	0.0475	17.999	1.255
11/VIII	29.58	0.00330	13	0.55	0.0450	22.013	1.343
14/IX	27.02	0.00334	15	0.62	0.0570	24.735	1.393
30/IX	23.10	0.00338	16	0.51	0.0318	16.775	1.225
1/X	23.20	0.00338	16	0.50	0.0358	19.263	1.285
16/XI	15.36	0.00348	15	1.02	0.0243	6.409	0.807
24/XI	15.81	0.00348	15	0.95	0.0238	6.740	0.826
1949							
18/I	6.32	0.00359	18	0.58	0.0138	6.401	0.806
21/I	8.06	0.00356	19	1.10	0.0168	4.109	0.614
22/I	8.10	0.00356	20	0.99	0.0178	4.837	0.685
28/V	24.91	0.00337	15	0.63	0.0360	15.374	1.187

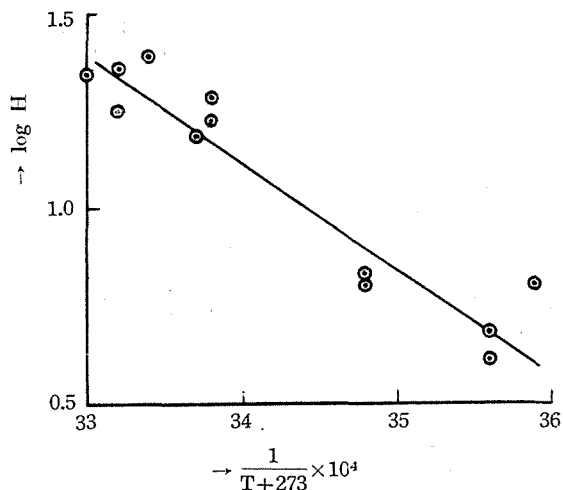


Fig. 2

Relation between the environmental temperature (abscissae) and the heat produced (ordinates).

There is a clear correlation between the change of environmental temperature and the heat produced, i. e., the logarithmic values of the heat generated (cal/gr/hr) decrease in linear correlation to the reciprocals of the absolute environmental temperatures. This fact suggests that the temperature has a similar influence on the metabolic reactions as on the chemical reactions, because the heat generated is assumed to be proportional to the velocity constant of the metabolic reactions.

Considerations

It is known that the generation of heat in some kinds of poikilothermic animals, such as honey bees, is useful for the maintenance of their lives. Honey bees can keep the inside temperature of their nest relatively constant in winter, ca. 25—30° C, by active movements. The character of the ecosystem around the honey bees is thus altered by their reactions to the environmental condition of low temperature. Then, does the heat production by our *Aplocheilus latipes* play any role useful for the maintenance of its life by changing the character of the environment? It is obvious that the killi-fish generates heat in close correlation with change of the environmental temperature, but its amount is negligible in comparison to a large scale of the whole heat metabolism taking place in the ecosystem. Our experiments show that a group of killi-fish composed of ten adult individuals raise, in a closed system, the temperature of 250 cc milieu-water ca. $\frac{3}{1000}$ ° C per hour in summer and ca. $\frac{9}{1000}$ ° C per hour in winter. These values are of course too small to alter the natural environmental conditions under

the open system even when they live in the smallest of pools; namely, the heat production of the killi-fish plays no significant role in the heat metabolism of an ecosystem.

Summary

1. The killi-fish, *Aplocheilus latipes*, generates heat ca. 23—25 cal/gr (dry weight)/hr in summer and ca. 4—5 cal/gr/hr in winter (Table 1 and Figure 2). In other words, ten adult animals raise, in the closed system, the temperature of 250 cc water ca. $3\frac{8}{1000}^{\circ}\text{C}$ per hour in summer and ca. $\frac{9}{1000}^{\circ}\text{C}$ per hour in winter.

2. As the quantity of heat produced by the fish is so small that it has no significant meaning in the heat metabolism of the ecosystem in which the fish is living in nature.

Literature

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