Metabolic Differences Associated with Altitude

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The purpose of this project was to begin an investigation of certain physiological aspects of altitude, particularly those concerned with animal metabolism and possible metabolic differences associated with altitude. Of the ways in which this could be studied, two seemed to lend themselves best to the problem, (1) exposure of the same animal or group of animals to various altitudes and (2) measurements on different populations of the same or closely related species of animals which are distributed over a range of altitudes.

One of the major tasks of the summer was the location of suitable sites and animal subjects for study and a considerable amount of time was consumed in exploring various possibilities. It was necessary to find elevations of appropriate height and accessibility. Equipment had to be made which was sufficiently sturdy and reliable to withstand rough roads and pack trips. Probably most important was the location of experimental animals which fulfilled the requirements of the project, namely, that they be present in sufficiently large numbers to provide adequate replication and in a distribution pattern where the same species or very closely related species occur at different elevations. Before discussing the work of the summer it should be mentioned that a culture of flour beetles (Tribolium) proved of particular value and interest. They were brought from Appleton, Wisconsin and were originally from the same stock that provided material for work on simulated altitude. For this reason, a good deal is known about the response of these beetles at lower altitudes and in simulated altitudes, a fact which makes them especially valuable for comparisons to be discussed later.

The choice of animals to be used as possible experimental subjects rapidly narrowed down to two groups, mammals and arthropods. Of the mammals two rodents, the picket pin squirrel and the pocket gopher were present in adequate numbers and suitable locations. Several squirrels were collected during the first few weeks of the summer from altitudes of 6,700 to 8,500 feet, and tests were made on the dehydrogenase activity of various tissues using Thunberg's methylene blue technique. No clear-cut differences were observed on animals from different altitudes and this approach to the problem was postponed until more precise equipment became available. Unfortunately there was not enough time to begin work on the pocket gopher although its tendency to "stay put" in a given habitat and its wider altitudinal distribution (up to at least 11,000 feet) make it probably the most promising mammalian material for an investigation of this type.

The most productive work of the summer centered around metabolism tests on two groups of arthropods, the flour beetles already mentioned and various species of ants, particularly the carpenter ant Camponotus sp., which seemed to be present in almost all areas. Metabolism determinations were made using a modification of the Gerard-Hartline tissue respiration technique.

Camponotus from biological station altitude (6,750 feet) were transported to the top of Two Ocean mountain in Togwotee Pass (10,600 feet) and paired tests were run against Camponotus collected in Togwotee Pass area (it was necessary to run paired tests in all cases away from the laboratory because temperature could not be controlled). Similarly Camponotus from the Togwotee Pass area were brought down to the station laboratory for comparison with Camponotus collected in the station area. The major findings from this series of experiments can be summarized as follows:

1. At a given temperature Camponotus native to the station altitude (6,750 feet) used less (approximately $\frac{1}{4}$ to $\frac{1}{2}$ as much) oxygen per unit weight (cc. O_2/gm./hr.) than Camponotus native to Togwotee Pass area altitudes (10,000 to 10,600 feet).

2. Oxygen consumption in the station Camponotus was reduced by about half (61% in a representative series) when they were tested at Togwotee altitude. No doubt part of this occurs as a result of the lower average temperature (about 17 degrees C. as compared with around 25 degrees C. at the station) but more than temperature must be involved since the Camponotus from Togwotee area actually showed a slight decrease (8%) in oxygen use when brought to the higher oxygen tension and temperature of the station, rather than an increase which might be expected. Speculation on these results would be premature since they need to be more fully documented but they suggest a difference associated with altitude.

Results obtained with Tribolium are essentially an extension of those with Camponotus, with the addition of data taken using simulated altitudes. An apparatus was constructed in which it was possible to simulate altitudes from about 3,000 to 14,000 feet. It was used at the station altitude to simulate both lower and higher altitudes and at 10,600 feet to simulate lower altitudes. It served as a useful check on observations made in the open and provided additional data outside the range of natural altitudes in the Jackson Hole area. The most important results using Tribolium are as follows:

1. With temperature constant, Tribolium confusum used more oxygen per individual adult per hour as the altitude (both simulated and real) increased. The range of altitudes studied extended from that of Appleton, Wisconsin (about 600 feet) to 10,600 feet on Two Ocean mountain in Wyoming. It should be mentioned that experiments carried out in Appleton at Lawrence College the previous winter provided data for the lower altitudes.

2. A culture of T. confusum was left for 18 days at the top of Two Ocean mountain and at the end of that time was compared with a second culture kept at the biological station. There was virtually no difference between the two suggesting that little or no acclimatization took place in that time.

These results are presented with the understanding that they are tentative and need extension and documentation.

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