INDUSTRIAL PHYSIOLOGY

Heat Stress

THE environmental conditions in which people work can markedly affect their mental and physical condition. The reason for some of these effects is obvious; athletes at the peak of their condition and ability perform well below their best in the rarefied atmosphere of Mexico City. Other causes are more subtle; the businessman who flies from London to New York and makes a wrong decision could blame a lapse in the regularity of his biological clock rather than in his judgment. Against this background, a report by a WHO working party (*World Health Organization Technical Report*, No. 142) on the factors involved in work under conditions of heat stress makes several pertinent points perhaps the most important of which is that there is a paucity of data for analysing this kind of problem.

A country's standard of living is related to its commercial productivity, which in turn is related to the average health of the work force. This is particularly true of developing countries, where skilled workers are scarce and difficult to replace. The problem of heat stress is most acute in these countries, since most of them are located in the tropical and subtropical belts.

The report outlines what is known of the two most important aspects of the problem—the response of human beings to heat stress and the methods by which heat stress may be evaluated—but urges that governments and industrial managements should stimulate and support more research.

The most important responses to heat stress are sweat loss, change in heart rate and change in deep body temperature—the temperature of those tissues most remote from the body surface. Evaporation of sweat from the skin deals quite adequately with small increases of temperature. If the body is subjected to greater heat stress, the pulse rate will increase as the cardiovascular system responds to the need for a greater volume of sweat to be evaporated from the skin surface. Extreme heat stress results in an increase in deep body temperature, which is most undesirable.

Several indices of heat stress are in general use, and four of these are recommended by the report for use in industry—the corrected effective temperature scales (CET), the predicted four-hour sweat rate (P4SR), the Belding and Hatch heat stress index (HSI) and the index of thermal stress. The last two indices involve the construction of mathematical models to describe the thermal balance between the body and its environment. None of the indices is entirely satisfactory, particularly with regard to the combined effect of work stress and heat stress. The report suggests, however, that the time taken for the heart rate to return to its resting level after work may be a promising index of combinations of work and heat stress.

Several personal factors—age, weight, sex, physical condition, extent of acclimatization and the type of work—must be considered when assessing the heat stress that an individual can tolerate. The report does, however, recommend that there should be, on the basis of CET values, environmental limits of 30° C for sedentary workers, 28° C for moderate work and 26·5° C for heavy work. 2° C could probably be added to these figures for acclimatized workers.

The report concludes that the thermal balance range seems to have the best promise in the long run. Further research should centre on the understanding of the physiological response to heat stress, especially under actual work conditions, and relating the physiological stress to a realistic numerical index. Too little is known about the influence of unfavourable environments on both physical and mental capacity.

COMPARATIVE ZOOLOGY

Convergent Evolution

COMPARATIVE zoologists are increasingly concerned with behaviour and ecology and, according to Dr Ernst Mayr, director of the Museum of Comparative Zoology at Harvard University, in the museum's report for 1967–68, this has recently led to the redefinition of systematics as the study of the diversity of organisms. The museum itself is diverse enough, and the research by staff and graduate students embraces evolution, morphology, behaviour, ecology, zoogeography, physiology, biochemistry and taxonomy.

According to the report, Dr George Gaylord Simpson has carried out a study of an extinct family of South American marsupials, the Argyrolagidae, which are so different from any other marsupials known that they have evidently been separated from an early date. They are also an example of evolutionary convergence, however, for they are similar morphologically and in inferred behaviour to the North American kangaroo rats and the Old World jerboas. Earlier belief that the argyrolags indicate phylogenetic and zoogeographic relationships between South America and Australia has thus been proved to be incorrect.

Dr Kenneth J. Boss has been studying the freshwater gastropods in Lake Tanganyika. These snails are unique in the shape and sculpturing of their shells, which resembles that of certain marine species. These are also an example of convergent evolution and it has been shown that the snails are not remnants of the marine fauna of a Jurassic sea as was once suggested. Preliminary studies by Dr Boss have shown that the great age of the lake—nearly 2 million years—and its limnological similarities to oceanic conditions led to the convergent evolution of its freshwater snail fauna.

It is well known that ship worms (teredinids) can digest wood, but it is not known whether the worms produce their own digesting enzymes, or whether the reduction of the wood is carried out by cellulytic bacteria. From preliminary studies by Dr Ruth Turner of the museum, in collaboration with Dr Frederick Rosenberg of Northeastern University, it seems as if the cellulase is in fact provided by the bacteria. These are probably taken into the gut with the first wood ingested when the young larvae settle.

Although research and teaching play an important part in the museum's activities, it has heavy curatorial responsibilities which are reflected in the number of the enquiries received. During 1967–68, for example, the museum made loans totalling more than 7,000 specimens, and estimates of the size of the collections show that there are about 10 million specimens of molluscs, 5 million mounted and labelled insects, 315,000 birds, 200,000 echinoderms, 102,000 lots of reptiles, 64,000 lots of amphibians and 50,000 lots of fishes.