PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Discussion on the Preceding Papers

J. E. Smith, G. De Q. Robin, J. A. Heap, M. W. Holdgate, J. E. Hay, S. W. Greene, A. H. Rose, S. E. Allen, R. B. Heywood, O. W. Heal, T. J. Hart, G. E. Fogg, M. Ashwood-Smith and P. J. Tilbrook

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Discussion on the preceding papers

J. E. Smith. May I ask, at the outset of our discussion of this morning's papers, whether there is any evidence of long- or short-term secular changes of climate in the Signy Island area?

G. de Q. Robin. J. A. Heap, in preparing an ice atlas of the Antarctic seas, drew upon the long period of meteorological records from the Argentine station 'Orcadas' on Laurie Island, South Orkney Island, and from the British station at Grytviken, South Georgia. He was able to show that in the late 1920s there were several years with mean annual temperatures 1 or 2 degC below average, while in the 1950–60 period moderate fluctuations in climate could be associated with fluctuations in the pack ice.

M. W. Holdgate. Because of the lack of suitable 'indicator species' in the land flora, pollen analysis from the Antarctic zone is not likely to help in this problem. However, some evidence of climatic change may be derived from the fluctuating fortunes of the small elephant seal population at Signy Island. When first studied by R. M. Laws in 1948 this was producing 80 to 100 pups annually: latterly numbers have fallen off dramatically and in some seasons only four or five have been born. This is a marginal population of a species not penetrating deeply within the ice zone, and hence will probably be a good indicator of changing climate and ice conditions.

J. E. Hay. A similar fluctuation has been found in the world's southernmost Adelie penguin colony at Cape Royds, Ross Island, by B. Stonehouse. These variations can be correlated quite closely with ice conditions, a low colony size being associated with a failure of the ice to break up, or a late break up.

S. W. Greene. Quaternary studies farther north, in the Sub-Antarctic Zone, may well prove productive in solving such problems. At South Georgia deep peat deposits are present, and a radiocarbon date of 6500 years has been obtained for a sample only 40 in. deep in a *Sphagnum* bog. The base of the deposit is about 7 ft. below the surface and deeper deposits are known so that a very substantial time span may be available for study.

A. H. Rose. In what form was the phosphate at Signy Island—organic or inorganic?

S. E. Allen. Most of the phosphorus extracted from the soil was present as phosphate. This is to be expected since the extractant would not dissolve the organic phosphorus so readily. Organic phosphorus was present in the soils from the contaminated areas although less abundant than the inorganic phosphorus.

A. H. Rose. The high nitrogen content may indicate a low rate of denitrification, which would be important in relation to cycling of nitrogen in the soil.

S. E. Allen. The high level of available ammonia and the presence of an abundant external supply of mineral nitrogen would not encourage soil mineralization but these conditions are not comparable with many soil types.

J. E. Smith. How much sea spray is carried inland? This is known to be an important ecological factor in Britain.

R. B. Heywood. In the winter of 1963 I analysed various snow samples on Signy Island, both from just below the surface and at depth. At this time the sea was frozen for some distance all round the island. The chloride content of the snow was very variable, but reached 50 mg/l. in the lower sample. Very high winds prevailed at this time, and it seems evident that there was substantial contamination even when the nearby sea was not open. Some downwash of salts probably occurred within the snow bank during periodic thaws.

S. E. Allen. All precipitation samples—rainwater as well as snow—that we have had from Signy Island have been extremely high in marine elements.

R. B. Heywood. I have seen a publication by Drischel (1940, *Balneologe*, **7**, 321–34) referring to Europe in which the rapid falling off of the marine influence with distance from the coast was brought out. At 0·1 km distance up to 700 parts/10^6 of chloride were present in rainfall: at 1 to 2 km, the amount had fallen to 30, and thereafter diminished slowly. In considering Signy Island we must remember that almost the whole island—and certainly almost all the biologically productive parts of it—is within 1 km of the coast.

O. W. Heal. I had omitted the term 'psycrophil' from my paper as there has been some confusion over its definition. But it is clear that all the micro-organisms from Signy that we have dealt with come within the scope of this term as used by Rose & Stanley. Our soil organisms would appear rather less psycrophilic than Stanley's freshwater samples. Samples brought back frozen and enumerated at 10 °C and also at 25 °C gave the same results, whereas Moor House (England) isolates at 10 °C gave lower counts than those at 25 °C. Consequently we can generalize that Moor House micro-organisms are less cold adapted than those in Signy Island soils, which are in turn less well adapted than those in Deception Island freshwater. These differences probably reflect the temperature ranges which the organisms experience in these situations.

M. W. Holdgate. Bunt, working at McMurdo with marine phytoplankton, demonstrated that primary production at the ambient temperature of −1·9 °C was only one-tenth as efficient as at 10 to 15 °C, the latter representing the optimum for these plants. Hence we appear to have the paradoxical situation that in this very stable marine environment the primary producers are not fully adapted to the relatively constant conditions.

T. J. Hart. Early culture experiments at South Georgia showed that plankton diatoms there appeared to be cold adapted. *Fragilariopsis striata*, living at 3·5 °C, failed completely at laboratory temperatures: those maintained at normal ambient temperatures produced more oxygen than those at higher temperatures.

G. E. Fogg. The temperature effect on algal photosynthesis depends on light intensity. If light is saturating, temperature does have an effect. The nature of the adaptation to low temperatures appears to take the form of production of large quantities of

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enzymes, and, as a result, while production at around 0 °C will be enhanced, the reaction will retain its temperature sensitivity if the light intensity is high. The important thing is to compare Antarctic algae at 0 °C with non-adapted organisms at 0 °C, not to study Antarctic algae in isolation.

A. H. Rose. It is obviously valuable to measure rates of decomposition and turnover in the soil. But cellulose films seem unsatisfactory for this purpose: might not lipids, for example, be better?

O. W. Heal. I agree that cellulose is not an ideal substrate; it was chosen for these very preliminary trials because of its ease of handling. More tests with other materials are certainly required.

M. Ashwood-Smith. Was any increased tolerance of freeze/thaw cycles noted in strains isolated from the Antarctic?

O. W. Heal. There are no data on this point, but it is clear that the present general assessment of the capacity of organisms to grow at various temperatures merely scratches the surface of the problems in this field of work.

A. H. Rose. Ability to grow at low temperatures may be correlated with an increased concentration of unsaturated fatty acids in the membrane phospholipids.

M. Ashwood-Smith. This might suggest a comparison with insects. Overwintering larvae can have as much as 35 % glycerol in the haemolymph. The metabolism of glycerol and phospholipids is similar.

A. H. Rose. But the mechanisms will not be the same. Unsaturated fatty acids in the membrane phospholipids might increase the screening out of ice crystals. It is not a simple water protein reaction.

P. J. Tilbrook. Testate amoebae have been shown to be important on Signy Island. What is known about the other protozoa?

O. W. Heal. Many other protozoa certainly occur. The biomass at Signy in respect of testate amoebae is more or less the same as at Moor House in this country and one might expect that this would hold for the other groups represented.

S. E. Allen. The range and amount of chemical nutrients in Signy soils are strongly influenced by the large fauna populations. Do the faunas also affect the nature of the soil microflora?

O. W. Heal. Soils from areas heavily affected by the fauna—as from penguin colonies or seal wallows—have different microfloras. It has been suggested that antibiotics derived from krill, alleged to reduce the gut microflora of penguins, will in turn influence the microflora of the breeding grounds.

A. H. Rose. It is clear that phosphate is unlikely to limit the activity of soil organisms. Temperature and carbon sources may prove of higher significance.

There is one other point. It has been said that some organisms can find their way to Signy Island but are not specifically adapted to conditions there. Dr Heal suggests that those capable of initial colonization subsequently become rapidly adapted; that

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other species although equally capable of reaching the island do not adapt. This appears to run counter to the results of mutagenic studies.

O. W. Heal. There is no question of the organisms capacity to reach the island. This has been proved by spore-trapping techniques and by the exposure of sterile plates to the air. Such plates produce cultures of organisms not present in the soil microflora. We assume therefore that the difference is essentially one of preadaptation: that certain species or groups with an initial capacity to grow to some degree at the prevailing temperatures are able successfully to colonize the Antarctic habitats and thereafter become better adapted by natural selection processes. Those which arrive, but which cannot even grow at a low level of efficiency under prevailing conditions, are excluded from the selection processes leading to true adaptation.

M. W. Holdgate. In the Antarctic we have a set of free-living micro-organisms capable of growth at low temperatures and apparently unable to survive at temperatures in the same range as mammalian body temperatures. Conversely, it may be presumed that warm-blooded animals support their own microflora. In the Antarctic, do these two elements form distinct systems each unable to survive under the conditions exploited by the other? Does this in any way suggest that potential pathogens from warmer latitudes may be unable to survive outside their hosts in the Antarctic?

A. H. Rose. The gut microflora of birds and mammals is not active at the outside ambient temperature range in the Antarctic. However, *Escherichia coli* and other organisms can remain viable for some time near former human habitations. The same would apply to cysts or spores of pathogens, and the potential import of such organisms by human agency into the Antarctic bird and mammal fauna is a serious problem.

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