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Discussion on the Preceding Papers

P. D. Brown, M. W. Holdgate, R. E. Longton, S. W. Greene, C. H. Gimingham, A. H. Rose, T. J. Hart, Anne Holtom, M. H. Thurston, J. E. Smith, N. V. Jones, G. de Q. Robin, J. P. Harding and R. B. Heywood

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Discussion on the preceding papers

P. D. Brown. In Spitzbergen *Polytrichum alpestre* and *P. alpinum* both fruit freely, but the climate is warmer there owing to the influence of the Gulf Stream.

M. W. Holdgate. How much decomposition occurs in Antarctic bryophyte communities? We have heard average annual growth rates of 3 to 5 mm suggested, yet radiocarbon data suggest a mean accumulation of only about 1 mm per annum in peat banks which, admittedly, are compacted.

R. E. Longton. The data we presented come from South Georgia and are not strictly comparable with the Antarctic.

S. W. Greene. Moreover, we have information only for one or two years, which may be atypical.

C. H. Gimingham. On the whole, however, I would consider 3 to 5 mm growth per annum a reasonable general estimate.

A. H. Rose. The measurements of temperature made by Dr Longton were, I think, made with probes in contact with the surface of the moss. But recent data from Australia indicate that the tissues within the leaves are to some extent buffered against temperature oscillations. Hence the actual photosynthetic areas may not be exposed to the same dramatic fluctuations as Dr Longton has recorded. Internal thermocouple measurements are needed.

R. E. Longton. On the other hand, work on flowering plants in temperate regions has shown that tissue within the leaves may often be warmer than at the surface. It will be interesting to determine temperature fluctuations within moss tissues in Antarctic regions, but the present data are of value in demonstrating that the plants exist in a much more favourable microenvironment than that suggested by standard meteorological data.

A. H. Rose. Bergmann's rule states that the sizes of organs and cells increase as the temperature of the environment declines. This is true of micro-organisms: bigger cells are to be found in cold places. It probably depends on growth control, the cell size increasing as the growth rate declines. This could have some bearing on seed size in *Deschampsia antarctica*.

S. W. Greene. I had thought that Bergmann's rule only applied to animals. Owing to the inadequate information available on the various dimensions of cryptogams, and doubts about the relationship of many southern forms, it is not possible to say, at present, if any such increase occurs with decrease in temperature. However, it was noted in the experimental work with *Deschampsia* and *Colobanthus* that, in both species, the largest seeds were formed at the lowest temperatures.

P. D. Brown. Material ascribed to *Ceratodon purpureas* from the Antarctic does have larger cells than that from Europe, but could belong to different species.

T. J. Hart. Many years ago we looked for fruiting mosses in the South Shetland Islands. We followed a hypothesis by A. G. Bennett that species succeeded best in sheltered spots away from the main bird colonies but near where gulls or terns had been nesting. Bennett commented that *Larus dominicanus*, which brings limpet shells to its nest sites, as 'the best Antarctic Gardener'.

S. W. Greene. Dr Hart has touched on a very important point—namely that different ecological factors can become limiting in different instances. Nutrients are very important in some areas while temperature or water availability may be of paramount significance elsewhere.

M. W. Holdgate. Nitrophily is certainly a feature of vegetation in inland areas of continental Antarctica, and in Dronning Maud Island the only bryophyte patches that have been found are near to breeding colonies of snow petrel. P. A. Siple similarly reported the concentration of the richest vegetation around bird colonies in the Victoria Land ranges.

C. H. Gimingham. What is the effect of free flowering on the subsequent history of the plants—in the following season, for example? In the field, *Colobanthus* seems to die back.

Anne Holtom. Under experimental conditions *Colobanthus* will flower every year and there appears to be no difference in vigour from season to season.

M. H. Thurston. Seed size obviously varies widely. What is the limit for viability?

S. W. Greene. Germination tests have demonstrated that in *Colobanthus* and *Deschampsia* small seeds are not viable even at the end of the season. However, it is just possible that there is a compensation mechanism producing slow maturation under winter snow cover and leading to germination in the following spring. This suggestion is at present hypothetical and needs testing by more critical research.

J. E. Smith. For how long are these seeds viable?

A. Holtom. They certainly retain this germination capacity for 18 months, in water as well as dry, and longer periods are being tested.

M. W. Holdgate. It is striking to see how, at South Georgia, both *Colobanthus crassifolius* and *Deschampsia antarctica* are common close to the sea, in the strand. In the Antarctic both species characterize the coastal zone. Is anything known of the viability of the seeds in sea water?

S. W. Greene. Not at present. This is a subject which we plan to investigate.

J. E. Smith. If *Colobanthus crassifolius* also occurs in Macquarie Island and the New Zealand shelf area this might be good evidence for its transoceanic dispersal capacity.

S. W. Greene. I agree, but unfortunately there is uncertainty about the relationships of the South American *C. crassifolius* to the New Zealand plants. For instance partial reproductive barriers have been obtained in crosses between material from the two areas. However, these populations presumably were more closely related in the not too distant past, and when the situation is better understood, it may be possible to infer likely migration routes.

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J. E. Smith. How good, in this context, is the taxonomy of these plants, and to what degree have modern genetic methods been applied?

S. W. Greene. For the flowering plants the situation is encouraging. Dr D. M. Moore of Leicester has recently visited the Falkland Islands and has obtained material from many other areas in the southern circumpolar belt to which he is applying modern cyto-taxonomic methods. For the cryptogams, on the other hand, the situation is less well advanced.

N. V. Jones. Residents on Signy Island tend to look upon the Argentine Islands and the nearby western zone of the Peninsula as 'the banana belt'. The botanical results we have just heard do suggest that this area is perhaps more favourable than the South Orkneys.

R. E. Longton. The bryophytes and flowering plants do parallel one another in some respects. Three species—*Drepanocladus uncinatus*, *Pohlia cruda* and *P. nutans*—have been found in fruit on Argentine Islands but not at Signy Island. Sunshine figures, which are higher for the former locality, are probably important in this connexion. It is clear that considerable temperature fluctuations are tolerated if the accompanying benefit of really warm days is obtained thereby.

S. W. Greene. Exactly. It is not the ability to withstand low temperatures that is critical, but the capacity to use brief warm spells and tolerate great fluctuations.

R. E. Longton. It is interesting to compare the air temperature regimes in the Maritime Antarctic with those in the Arctic. Scholander has shown that, in the north, rich vegetation exists even where the mean air temperature may fall to −20 °C for 5 months. The cool short summers are what distinguish the far south.

S. W. Greene. Availability of species is another factor. Bryophytes are fairly abundant in the Antarctic regions—almost as numerous as in the north.

M. W. Holdgate. There is some support from the invertebrate occurrences for the concept that Antarctic terrestrial life depends very much on brief periods of warming. H. Janetschek, working with *Gomphiocephalus hodgsoni*, and M. E. Pryor with *Isotoma klovstadi*, have both indicated that these Collembola are inactive except at temperatures significantly above 0 °C and their life must therefore follow a highly irregular pattern.

G. de Q. Robin. Local climatic differences must not be forgotten in comparing Antarctic areas. On the north side of Laurie Island in 1947 I was impressed by the low sunshine figures even by comparison with Signy Island, where the effect of Coronation Island as a barrier causes significant breaks in the cloud. Rather similarly, the north-east side of South Georgia is subject to more rime formation than the south west and the west coast of the Antarctic Peninsula is appreciably warmer and more maritime than the east coast. Such gradients make one question how 'typical' a sample Signy Island, or any other locality can be.

J. P. Harding. I have a small point to make concerning the distribution and salt-tolerance of Anostraca. *Artemia salina* is certainly the most tolerant species, but there are many others with *salinus* as their trivial name and rather specialized habitats. Only last week

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a saline pool near Khartoum yielded specimens of a species last seen 100 years ago in another salt pool in Central Asia. Birds are the likely dispersal agent, and Loeffler has done experiments in which *Artemia* eggs were fed to ducks and nauplii hatched from the faeces. Which raises the question of whether birds eat Anostraca in the Antarctic.

R. B. Heywood. Terns (*Sterna vittata*) can be seen apparently feeding over some lakes, and their most likely prey is the anostracan, *Branchinecta*. Birds thus probably do use the lakes as a food source, and while energy flow pathways are commonly confined within the lake system, this is one of the few outlets. Bird dispersal could in part explain the remarkable seasonal sporadicity of anostracan distribution on Signy Island. There are variations in abundance from year to year and some lakes are unaccountably without *Branchinecta* when small puddles draining into them are stocked.

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