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Discussion on the Preceding Papers

J. E. Smith, R. E. Longton, M. W. Holdgate, S. W. Greene, G. M. Dunnet, C. H. Gimingham, P. D. Brown, O. W. Heal, S. E. Allen and P. J. Tilbrook

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Discussion on the preceding papers

J. E. Smith. Dr Longton's slides of orange patches of *Xanthoria* lichens on Antarctic cliffs were reminiscent of coastal cliffs in temperate regions. Is this lichen community essentially maritime in the Antarctic?

R. E. Longton. The *Caloplaca–Xanthoria* community certainly resembles the associations of orange crustose lichens of coastal cliffs in temperate regions. It is particularly well developed on coastal cliffs in many places in the Antarctic, but smaller areas occur inland, for example in the Tottanfjella, some 300 km from the sea. There are other parallels between growth form, and indeed in the genera represented, in the cryptogamic vegetation of Antarctic and temperate regions, an example being the associations of lichens and cushion mosses on montane rocks.

M. W. Holdgate. To what extent does South Georgia vegetation resemble that of the Maritime Antarctic in the composition and distribution of its cryptogamic communities? To what degree could one describe the plant communities of the former as corresponding to those of the latter, but with the superimposition of a vascular plant element?

R. E. Longton. South Georgian bryophyte vegetation is more varied than that of the Maritime Antarctic, but there are many similarities in growth form. Thus the deep banks formed by turfs of *Dicranum aciphyllum* and *Polytrichum alpestre* are common to both areas, but on South Georgia they often occur among open tussock grassland.

S. W. Greene. There is a striking difference between the Maritime Antarctic vegetation described by Dr Longton and the vegetation I saw near McMurdo Sound which, as far as is known, is fairly typical of that developed in Continental Antarctica. In this area the usual concept of a community is almost inapplicable, as one is normally dealing with isolated populations of single species rather than the interaction between species. Only rarely does one find two or more species or bryophytes growing side by side, and it is only on rock faces that communities with a larger number of species are encountered, these being composed almost entirely of lichens. The essential ecological relationship is that of an individual population directly linked with its environment, whereas along the Peninsula the greater variety of growth forms and the larger number of species results in more complex situations. In fact there are only some 10 to 12 species of bryophytes known from the whole continental area compared with 100 or more in the more oceanic region of the Peninsula.

G. M. Dunnet. How permanent are the plant communities in the maritime area? Are there definite successions? How long have some of the deep carpets which have been described been present?

R. E. Longton. In the South Sandwich Islands the erosion of *Polytrichum alpinum* appears to be more rapid, and even shallow peats show evidence of succession. Bare ash patches are often found surrounded by exposed peat profiles. Centrally *Ceratodon* seems to

be the first colonist, followed by *Polytrichum*, and hummocks of *Polytrichum* often prove on dissection to overlie wedge shaped masses of peat, tapering downwards and with *Ceratodon* remains at the base.

C. H. Gimingham, The large peat banks on Signy Island appear rather uniformly composed of *Polytrichum alpestre* and *Dicranum aciphyllum* all the way to the base.

M. W. Holdgate. Radiocarbon dates for the base of one such bank (obtained through the kindness of Professor H. Godwin, F.R.S.) indicate that it has been in existence for 1900 years, during which time it has grown at least 180 cm. However, this sample was taken near the periphery of the bank, and slumping may well have affected the site: such slumping is conspicuous in shallow sections of the bank margin. Central cores from banks of this kind are required to date them precisely. It is perhaps of some interest to note that this single dating suggests an overall accretion on the bank at the rate of 1 mm per annum, and that by an interesting coincidence (if no more) the basal date does correspond rather closely with the transition from the Sub-boreal to Sub-Atlantic period in Fuego Patagonia described by V. Auer.

S. W. Greene. In the Arctic the effects of permafrost on the vegetation are very evident but in the Antarctic the effect appears to be less. The bryophytes presumably grow in the active layer, and it would be interesting to know its depth in the different communities and how it varies from year to year.

R. E. Longton. There is certainly a thaw of the top few centimetres in summer, while all communities probably freeze to some depth in winter.

M. W. Holdgate. On Signy Island the permafrost level varies a great deal from community to community. In deep *Polytrichum–Dicranum* turf, permafrost is met with even in February to March at only 25 to 30 cm below the surface. On the other hand, communities on wet ground often thaw out to far greater depths. The difference here is probably that the large air space in the former vegetation is a good insulator, while the percolating meltwater in the latter penetrates deeply. In all communities patterns of solifluxion disturbance are conspicuous: Dr Longton has referred to the sinuous cracks which commonly traverse *Polytrichum–Dicranum* turf, while Dr Gimingham has shown a slide in which an *Acrocladium* mat is thrown into a typically rippled pattern. These patterns no doubt relate to differences in growth among the species involved.

C. H. Gimingham. Growth form certainly determines whether a moss turf splits or buckles. In the latter case mounds often yield centrally to provide an open hole available for colonization by other species, or as a focus for erosion, and in some cases cyclical changes may ensure. Another major and allied influence consists in fluctuations in the area of permanent snow. The fringe of a community with an eroded, dead surface killed out by prolonged snow cover is often colonized by other species. This kind of advance and retreat of vegetation types has much to do with the determination of detailed patterns.

S. W. Greene. I am uncertain of the criteria used by Dr Gimingham for distinguishing between a mat composed of erect stems such as occurs in *Acrocladium* and a turf formed by erect shoots as occurs in *Dicranum*. Is it largely a question of stem density?

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I would also like to ask Dr Gimingham about the growth forms of *Drepanocladus*, and their relation to water holding capacity. Are these growth forms the result of plasticity or may they represent distinct ecotypes?

C. H. Gimingham. On the first question, I agree the term is unsatisfactory. In Britain, a *mat* applies to a growth form like that in *Hypnum cupressiforme*: on Signy Island the nearest related type seems to be that shown by the smaller forms of *Drepanocladus uncinatus*. The growth form of *Acrocladium* spp., the larger forms of *Drepanocladus*, and some others, should really have a different name. In appearance it is nearer to the turfs than to the mats. It consists of closely packed aggregations of shoots of pleurocarpous mosses, adopting an almost vertical growth habit: in Britain there is a similar form referred to as a 'tall turf with divergent branches of limited growth'. The Signy type is very different from a true moss mat. Possibly 'moss carpet' might be better: a carpet, like the community we are considering, has close packed ascending shoots from a connecting, more horizontally lying basal layer.

On the second point, *Drepanocladus* in the field appears to show a complete gradation which suggests plasticity in growth forms. Its wide range of types parallels its wide ecological amplitude. At Signy Island there is a third form, not treated so far in this discussion, the so-called 'plicatus' forms, which could be a chemical ecotype since it is associated especially with marble flushes. Culture experiments are needed here. In the same way, all *Drepanocladus* in Signy Island looks very different from *D. uncinatus* in Britain, and while this may arise from relaxed interspecific competition allowing a wider habitat range and hence different growth forms, comparative experiments would be of value.

S. W. Greene. There is an interesting parallel here with *Drepanocladus* in Alaska where I saw a range of growth forms very comparable to those in the far south.

P. D. Brown. At Spitzbergen *Drepanocladus* shows much the same gradations in form as in the Antarctic. Where competition is high it has a tight mat form: on the shingle of outwash fans with lower competition it grows more loosely.

O. W. Heal. Studies in grassland areas shows that decomposition keeps pace with production. Yet under some mosses, at least, it appears not to. Is this due to the formation of a permafrost layer or to waterlogging or to some structural or chemical feature of the moss mat?

R. E. Longton. It seems unlikely that waterlogging or permafrost are the main factors leading to peat formation in the Antarctic Peninsula. The bryophyte communities forming the deepest peats are on fairly dry north-facing slopes where day temperatures are high in the summer. Permafrost does not occur until 25 cm below surface in summer. Differences in chemical conditions or community structure could be involved. *Polytrichum alpestre* does form some peat in the northern hemisphere.

S. W. Greene. Could the *Polytrichum alpestre* peat banks on Signy Island have been formed under different conditions to those now prevailing?

C. H. Gimingham. The species forming the deepest peats are the ones which go on growing up from a single growing point leaving dead remains behind them. I agree that it

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may well be that they have largely formed under different conditions from the present. Today marginal erosion is prominent about many banks and in a number of areas there is also surface erosion in progress.

S. E. Allen. The accumulation of dead mosses under cold waterlogged conditions leads to anaerobic hydrolytic changes producing acid peats. This, in the widest sense, is an arrested form of decomposition.

J. E. Smith. How advanced is the taxonomy of the Antarctic land fauna, and what light can be thrown on its origins?

P. J. Tilbrook. The taxonomy of nematodes, tardigrades, rotifers and some protozoa is still a problem, but the arthropod groups are better served. A monograph dealing with Antarctic arthropods is currently in preparation by Dr J. Linsley Gressitt of the Bishop Museum, Hawaii. Dr Gressitt and his colleagues have analysed the biogeographical relationships and origins of the Antarctic arthropod fauna and it seems likely that these animals are dispersed to the area via air currents. However, little is known at present of their exact origins, or of how long they have been in the Antarctic.

C. H. Gimingham. If the wettest moss patches have low arthropod faunas, what about the species such as *Andreaea* and *Polytrichum alpinum* with low external water? These might be expected to have a large fauna.

P. J. Tilbrook. All the arthropods were patchy in distribution. Locally, fairly large aggregations have been found in *Andreaea*. But the overall pattern appears to be that greatest abundance does not occur in open habitats, perhaps because of the temperature regime. *Polytrichum alpinum*, being well drained and less exposed, offers a more favourable habitat for arthropods.

M. W. Holdgate. It has been suggested that Collembola are one of the main groups of secondary producers in this ecosystem. What are they feeding on?

P. J. Tilbrook. It seems probable that they are microbial or fungus feeders. They certainly occur where there is no macroscopic vegetation.

S. E. Allen. Mr Tilbrook's results suggest that the arthropod fauna is largest in areas of moss, and not very high below grass patches. Yet it is these grass sites that approximate to temperate soils and where aerobic decomposition is present. This appears to be an anomaly.

P. J. Tilbrook. Only a small number of samples have been taken from grass patches but results from these show a drop in arthropod numbers in such sites.

O. W. Heal. If Collembola do feed on bacteria and fungi, they are certainly likely to find abundant food even on vegetation-free sites. There is even quite an abundance of organic material in morainic soils.

C. H. Gimingham. What is the critical factor underlying the infertility of *Polytrichum alpestre* in Signy Island? In this last summer I saw only antheridia there. Are archegonia eliminated first under adverse conditions?

R. E. Longton. *Polytrichum alpestre* has so far been seen in fruit only once in the Antarctic

zone, in a population on Anvers Island. On Signy Island archegonia were in fact recorded in several colonies during the 1964–65 season, and I have also seen them in a specimen collected in 1965–66, though they are, of course, borne in much less conspicuous inflorescences that those containing antheridia. In 1964–65 I was unable to find antheridia of *P. alpestre* on Signy Island, despite a thorough search, and a specimen collected in 1965–66 contained abundant young male inflorescences, but none persisting from previous years, Antheridial production thus appears to vary from year to year, and it will be interesting to see whether sporophytes develop on Signy Island as a result of their occurrence in 1965–66.

I also studied *P. alpinum* in some detail, and saw it in fruit in a few widely scattered colonies in the Antarctic zone. Examples of bisexual colonies lacking sporophytes were noted, however, and there is evidence that sporophyte production varies from year to year. Moreover, all the capsules from the Antarctic were smaller than those from South Georgia, where this species fruits freely, suggesting that sporophyte development itself may be limited by the environment. The behaviour of these two species in the south differs from that of several dioecious mosses in Britain, where rarity of sporophytes has been attributed to segregation of male and female plants into different tufts, often combined with a rarity of antheridia, the occasional bisexual colonies fruiting regularly year after year.

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

S. W. Greene. One of the most interesting features of the reproductive cycle of *P. alpestre* on South Georgia is that antheridia are produced at the end of one season while archegonia do not appear until the start of the next, and one wonders what mechanism underlies this difference. Possibly there are different environmental stimuli for each sex received at different times, but it may be that the stimulus for both sexes is taken simultaneously, and the time of expression varies.

R. E. Longton. The difference in the time of antheridial and archegonial appearance is by no means confined to Antarctic bryophytes and has long been known in many north temperate species. Control experiments will be necessary to determine the reasons.

J. E. Smith. Of the annual increments on the stem, demonstrated by Dr Longton, how many are actually alive? Are only the terminal 3 or 4 mm in an active state?

R. E. Longton. Up to twelve increments may be seen on a stem, but only the tips of the stems are green. However, branches can emerge from well below the green upper layer, and under these circumstances it is impossible to say at the present how deep the living layer extends.

M. W. Holdgate. There is a *Bryum* (or *Mniobryum*) species on Signy Island, in calcareous flushes, which shows a beautifully distinct pattern of banding in dry specimens. Do these bands correspond to annual increments?

C. H. Gimingham. Beautiful banding can be seen in *Pohlia nutans*, *Bryum*, and even *Dicranum aciphyllum* on Signy Island. Up to eleven bands were noted in one *Bryum* tuft,

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each 3 to 4 mm wide. This pattern seems especially marked in cushion forming species. The bands may well represent increments.

S. W. Greene. In northern Alaska banding of this kind is very widespread, certainly more so than in the Antarctic.

M. W. Holdgate. Are these bands highly variable locally within an area or within a single tuft, or have they sufficient consistency to allow one to recognize a 'good year'?

C. H. Gimingham. R. L. Smith is looking into this at the moment. The first guess is that there is too great a variation in band width even within a single moss tuft to allow of any generalization. Competition between shoots within a tuft may be involved here.

S. W. Greene. On the other hand, since much of this banding is associated with reproduction, methods of satisfactorily assessing its relationship to reproductive behaviour might give a better indication of good and bad seasons.

J. E. Smith. I was surprised to note the wide geographical range of *Colobanthus*. Have other Antarctic species a comparable distribution?

R. E. Longton. *Polytrichum alpestre* and *P. alpinum* are bipolar, and numerous other bryophytes range very widely. This is partly why these species have been selected for study.

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