BIOLOGICAL INVESTIGATIONS IN TOTTANFJELLA AND CENTRAL HEIMEFRONTFJELLA

By G. T. Bowra, M. W. Holdgate *and* P. J. Tilbrook

Heimefrontfjella, with Tottanfjella (approx. lat. 75°S., long. 10°W.) which constitute their south-western part, are an extension of the Dronning Maud Land ranges along the east coast of the Weddell Sea. Very little biological information is available about any of these mountains. During the Norwegian-British-Swedish Antarctic Expedition of 1949–52, O. Wilson collected mosses, lichens, algae and two species of mite from two widely separated inland nunataks, both of which had been occupied in the recent past by breeding colonies of snow petrel, *Pagodroma nivea* (Dalenius and Wilson, 1958). The presence of lichen vegetation in the Sør-Rondane mountains has been mentioned by Van Autenboer (1964). The latter author also discovered snow petrel colonies in the Sør-Rondane (Loy, 1962), as did Lovenskjöld (1960) farther west in Dronning Maud Land. These bird colonies attracted great interest by their distance (200–300 km.) from the coast and by their evident high level of chick mortality.

British Antarctic Survey personnel first visited Tottanfjella in 1961 and reported further colonies of *Pagodroma nivea* and what appeared to be lichen cover on some rocks (Sumner, 1963). Specimens of the latter proved on analysis to lack organized structure and to be chemical crusts possibly derived from bird droppings (Ardus, 1964; Jones and Walker, 1964). In the 1963–64 summer, however, extensive growths of lichens, some mosses and areas of algae were discovered in many localities and a substantial collection was made both in Tottanfjella and central Heimefrontfjella by G. T. Bowra. Several large snow petrel colonies were also visited. No insects or mites were noted in the field, but a search of the plant collections has revealed numerous Acarina and one collembolan. The present paper is a preliminary account of these collections and of the habitats in these biogeographically important mountains. A fuller evaluation of the material will be published in due course.

Collecting Stations

Fig. 1 shows the stations in Tottanfjella and Heimefrontfjella at which biological material was searched for. Plant or animal specimens were obtained in 12 of these localities, and the collections are itemized in Table I. In addition, stations Z.60, 75, 89, 98 and 101 were recorded in the field as supporting the more conspicuous lichens. Bird colonies were found in three areas, and snow petrels were recorded in several other places without proof of breeding.

Vegetation

The field notes, and the restricted range of material collected, alike confirm that Tottanfjella and central Heimefrontfjella have a sparse, species-poor and rather uniform flora. The most exposed rocks appear to lack all vegetation and to bear only local patches of mineral encrustations. White crusts of this kind were especially prominent at the southern end of the range, on "Peaks A, B and E", up to an altitude of 2,100 m. Brownish deposits were also widespread on "Peak A", while greenish copper stains were confused with lichens on "Peak J". Low down on "Peak E" white mineral encrustations were especially common on the northern and western faces of the rocks, and they also occurred locally under loose rocks and in scree where they were noticeably friable. These features, as in the Sør-Rondane mountains farther east (Van Autenboer, 1964) testify to the aridity of climate on the exposed unshaded slopes of the mountains.

Crustose lichens have been collected from a wide range of stations in Heimefrontfjella. *Lecidea* is the most widespread genus, the black and white species *L. cancriformis* being particularly common. Yellow crusts of *Acarospora* and *Xanthoria elegans* and yellow-green patches of *Lecanora* sp. are also not uncommon. These species, and the other lichens of similar habit, are generally restricted to crannies and crevices, but sometimes they grow also

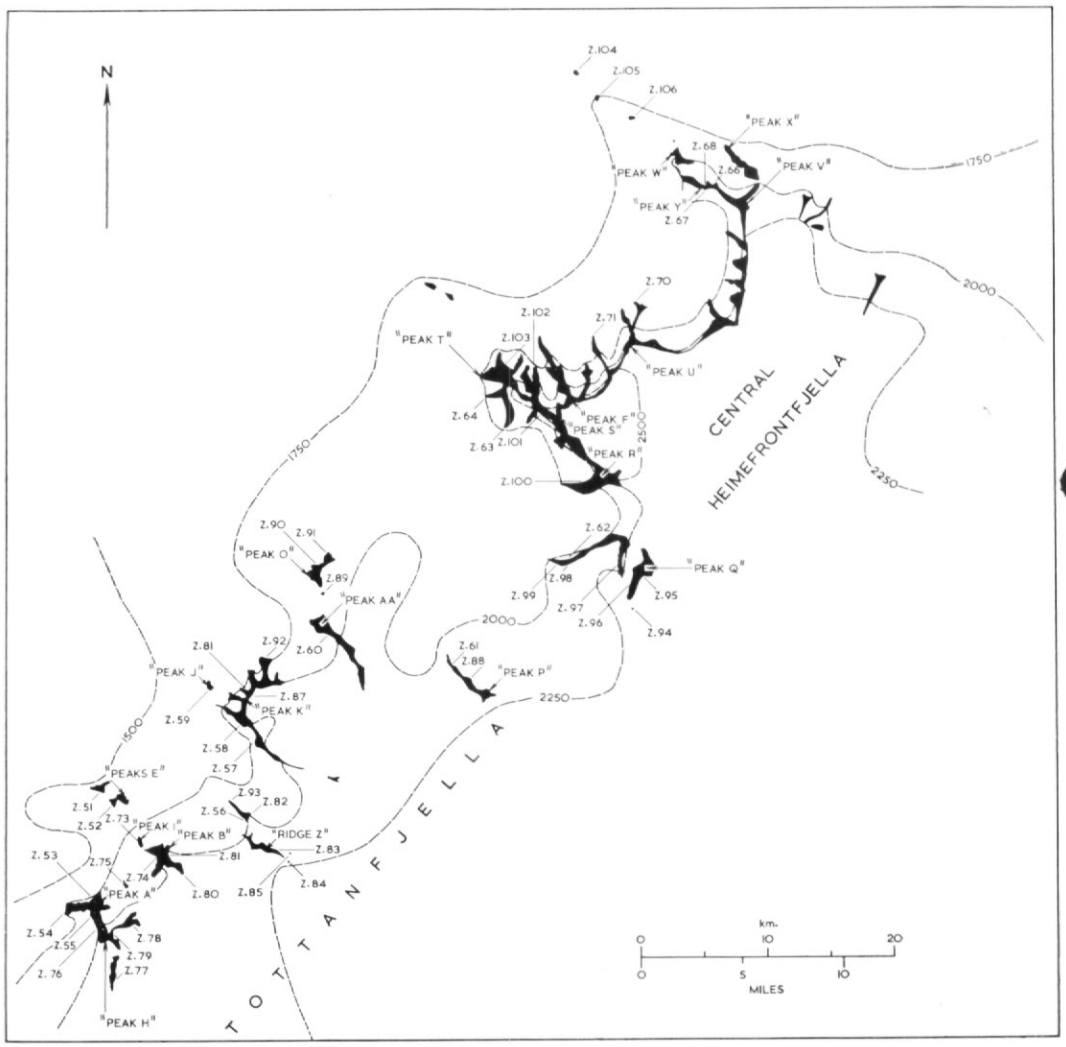

Fig. 1. Tottanfjella and central Heimefrontfjella, showing the localities mentioned in the text. The form lines are in metres.

on loose pebbles. At station Z.98 crustose lichens grew in holes formed by "honeycomb weathering" of the gneiss, where they were accompanied by the black thallose *Umbilicaria* sp.; a habit directly paralleling that described by Van Autenboer (1964) in the Sør-Rondane.

Of the larger lichens, *Umbilicaria* spp. are the most widespread, being noted in the field in many stations from which no specimens are available. Like the crustose species, they are most prominent in sheltered crevices and also on moist ledges. The vegetation is richest and shows the greatest diversity in a few areas where there is an accumulation of stable fine debris kept moist in summer by percolating melt water and moderately sheltered from the wind. Station Z.73, on "Peak B", had abundant *Umbilicaria* cf. *leiocarpa* on damp ledges, accompanied by *Toninia* sp. and locally by the moss *Grimmia* sp. Even richer vegetation was found at stations Z.91 and 92, both of which lay in natural "radiation traps" below north-facing embayed cliffs (Fig. 2). At stations Z.92, 103 and also in a similar embayment in which the main northern massif of central Heimefrontfjella terminates near stations Z.66–68, there are nearby

TABLE I. PLANT AND ANIMAL RECORDS IN TOTTANFJELLA AND HEIMEFRONTFJELLA

Species	*Station*											
	51	57	73	74	78	81	83	88	91	92	100	103
BRYOPHYTA												
Sarconeurum glaciale	—	—	—	—	—	—	—	—	—	x	—	—
Grimmia sp.	—	x	x	—	—	—	—	—	x	x	—	—
LICHENES												
Usnea sulphurea (Koenig) Th. Fr.	—	—	—	—	—	—	—	—	—	x	x	x
Alectoria minuscula (Nyl. ex Arnold) Degel.	x	—	—	—	—	—	x	—	x	x	x	x
Alectoria pubescens (L.) Howe Jr.	—	—	—	—	—	—	—	—	—	—	x	—
Umbilicaria cf. *leiocarpa*	x	—	x	—	—	—	—	x	x	x	—	x
Omphalodiscus decussatus Vill. Zahlbr.	—	—	—	—	—	—	—	—	x	x	—	—
Candellariella vitellina (Hoffm.) Mull. Arg.	—	—	—	—	—	—	—	—	—	x	—	—
Xanthoria elegans (Link) Th. Fr.	—	—	—	—	—	—	—	—	x	x	—	—
Lecidea cancriformis Dodge and Baker	x	—	—	x	—	x	x	—	—	x	—	—
Lecidea (*Eulecidea*) sp.	x	—	—	—	—	—	—	—	x	—	—	—
Lecidea cf. *autenboeri* (on moss)	—	x	x	—	—	—	—	—	—	x	—	—
Lecidea sp.	—	—	—	—	—	—	—	—	—	—	x	—
Lecanora (sect. *Placodium*) sp.	—	—	—	—	x	—	—	—	—	x	—	—
Lecanora (sect. *Eulecanora*) sp.	—	—	—	—	—	—	—	—	—	x	—	—
Lepraria cf. *incana*	—	—	—	x	—	—	—	—	—	—	—	—
Acarospora (sect. *Xanthothallia* Magnusson)	—	—	—	x	—	—	—	—	—	—	—	—
Toninia sp.	x	—	x	—	—	—	—	—	—	—	—	—
Rhinodina sp.	—	—	—	—	—	—	—	—	—	x	—	—
Physcia cf. *muscigena*	—	—	—	—	—	—	—	—	—	x	—	—
ALGAE												
Prasiola sp.	—	x	—	—	—	—	—	—	—	x	—	—
INVERTEBRATA												
Collembola sp.	—	—	—	—	—	—	—	—	—	x	—	—
Tydeus erebus Strandtmann	—	—	x	—	—	—	—	—	—	x	—	—
Eupodes tottanfjella Strandtmann	—	—	—	—	—	—	—	—	—	x	—	—
Nanorchestes bifurcatus Strandtmann	—	—	—	—	—	—	—	—	—	x	—	—
VERTEBRATA												
Pagodroma nivea	—	—	(x)	—	—	(x)	—	—	—	x	—	x
Catharacta skua	—	—	—	—	—	—	—	—	—	x	—	x

colonies of snow petrel, so that these areas probably receive nutrients from droppings, and provide the most favourable habitats in the entire range.

Station Z.91, which lacked birds, had only a small productive area at the cliff foot, and here *Grimmia* sp. was collected with a lichen flora including *Alectoria minuscula*, and two species of *Umbilicaria* as well as *Xanthoria elegans* and *Lecidea* sp. At station Z.103, near the base of a ridge on which about a dozen pairs of snow petrel had occupied nests, the foliose lichen *Usnea sulphurea* was present "in moderate profusion", and *Alectoria minuscula* and *Umbilicaria* cf. *leiocarpa* were associated. The area about stations Z.66, 67 and 68, although noted in the field as exceptionally rich botanically, was not sufficiently sampled for description but it seems to resemble most nearly station Z.92, the most productive place visited in the entire range. This site, at about 1,700 m. below the northern buttress of "Peak K", consists of broken cliffs occupied by a substantial snow petrel colony (Fig. 2). On moist ledges two mosses, *Sarconeurum glaciale* and *Grimmia* sp. are locally luxuriant, in association with *Physcia* cf. *muscigena*, *Lecanora* (sect. *Placodium*) sp., *Candellariella vitellina*, *Alectoria minuscula*, *Usnea sulphurea* and *Rhinodina* sp. *Lecidea* cf. *autenboeri* grows on some of the moss patches. Lichen communities are established on rocks in the vicinity, *Usnea sulphurea* dominating patches covering up to 1 m.^{2} in area, with *Alectoria minuscula*, *Omphalodiscus decussatus*, *U.* cf. *leiocarpa*, and *Xanthoria elegans* and other crustose species in association. Locally, *Usnea* and *Omphalodiscus decussatus* are well developed, with branches over 2·5 cm. in length. Wet seepage zones with much effluent from the bird colony support a third vegetation type in which the green alga

Fig. 2. View south-westward over Tottanfjella, with "Peak K" in the foreground. Station Z.92, biologically the most productive area so far discovered in the entire range, lies at the foot of the nearest spur. (Photograph by courtesy of the Commonwealth Trans-Antarctic Expedition, 1955–58.)

Prasiola is most abundant with *Xanthoria elegans*, *Lecanora* (sect. *Placodium*) sp., *Candellariella vitellina* and *Lecidea cancriformis* on stones. In this area, therefore, it is clear that there is a point-to-point variation in vegetation type according to drainage, substratum and level of organic contamination, and the same pattern may be looked for in other parts of the range where the ecological factors show similar diversity.

The vegetation of Heimefrontfjella is broadly typical of continental Antarctica. It shows obvious affinities with the other Dronning Maud Land ranges to the north. Here, Dalenius and Wilson (1958) have recorded that plants are generally scarce, lichens alone occurring, except in the vicinity of bird colonies. On two of these nunataks a locally luxuriant growth of lichens has been recorded, *Omphalodiscus decussatus*, *O. spongiosus*, *Alectoria minuscula*, *Usnea sulphurea*, *U. fasciata* and *Caloplaca elegans* being most prominent. Five species of moss, of which *Sarconeurum glaciale* was commonest, were noted. Unnamed algae were prominent in areas influenced by the petrels. The association of the richest vegetation with bird colonies in these ranges parallels the situation described by Siple (1938) and Perkins (1945) in Marie Byrd Land, and the correlation is attributed by Llano (1965) to the nitrophily characteristic of many lichens. The availability of water in summer in these cold arid regions of low precipitation is also important, and this factor probably accounts for the concentration of vegetation in ledges and crannies low down on slopes open to solar radiation and probably percolated by drainage. Away from these moist zones of high organic influence, communities of crustose

lichens and *Umbilicaria* (*s.l.*) are probably most typical of continental Antarctic regions (Llano, 1965).

Invertebrate Fauna

The invertebrate fauna of Heimefrontfjella is very imperfectly known, since the small size of the animals involved (mostly less than 0·5 mm.) makes field collecting by eye very difficult and optimally requires special extraction apparatus, which has not yet been employed. Nevertheless, the microscopic examination of plant debris from the 1963–64 collection revealed more than 150 invertebrates, although many of them had been badly damaged in their brittle desiccated state. One of the specimens came from station Z.73, and all the remainder from station Z.92, where the vegetation was richest.

Three species of Acari (mites), all belonging to the Order Prostigmata, are represented, together with a single badly contorted specimen of a collembolan. Dr. R. W. Strandtmann has examined the mites and considers two to be species new to science. These he has named *Eupodes tottanfjella* and *Nanorchestes bifurcatus*. The other one, although slightly smaller than the type series, is referable to *Tydeus erebus*, a species discovered in 1963 on Mule Island, near Davis station. *Nanorchestes bifurcatus* is of particular interest, since it differs in the form of its body setae from all other representatives of the genus known to Dr. Strandtmann. *Nanorchestes antarcticus* Strandtmann 1963 is the common Antarctic form, and is circum-polar in its distribution (Wommersley and Strandtmann, 1963). Recently it has been discovered only about 300 miles (480 km.) from the South Pole in the Queen Maud Range, at lat. 84°S. The species thus clearly tolerates extreme cold temperatures and it is strange to find it replaced in Heimefrontfjella by a distinct species.

The only other collection of arthropods known to have been made in the interior mountains of Dronning Maud Land was obtained by Wilson in 1950–52 (Dalenius and Wilson, 1958). Only two localities, both with bird colonies, yielded specimens. The collection contained "two species of mites, representing the groups Trombidiiformes and Oribatidea". Nothing more is known about the former, but presumably it could be one of the three prostigmate species mentioned above. The oribatid, however, was given new generic status and named *Maudheimia wilsoni* Dalenius 1958. It is so far known only from the two nunataks (Passat, at an altitude of about 150 m., and Ekberget at 1,650 m.) 165 km. apart and lying between lat. 71 and 72·5°S., and long. 0° and 4°W. A second member of the genus has recently been described from Hallett Glacier in Victoria Land, where it feeds on arborescent lichens (Gressitt, 1965).

The biogeography of *Maudheimia* has been discussed by Dalenius and Wilson (1958), and by Gressitt (1964, 1965). The first authors have pointed out that the mite, although found only on nunataks with a rich vegetation including bryophytes, itself was most abundant among stones. They suggested that the development of a rich flora and the presence of an acarine fauna are alike to be correlated with the presence of snow petrels, and interpreted this correlation as indicating that the birds are acting as dispersal agents. This interpretation seems dubious, but the correlation itself seems to be upheld by the present very preliminary observations in Tottanfjella and Heimefrontfjella. It is clear that further specialized collecting must be done in these regions and this may reveal whether the restricted distribution of the invertebrates so far found justifies the definition of the area as a separate faunistic province.

Vertebrate Fauna

Snow petrels, *Pagodroma nivea*, have been sighted in many parts of Tottanfjella and central Heimefrontfjella, and in some areas (as in the southernmost ridge of "Peak A" and "Peak H", or on "Peak B") small flocks have been seen perching upon the rock or snow surfaces. Breeding colonies have so far been located only at three places (stations Z.92 ("Peak K"), Z.63, "Peak R" and Z.66–68 ("Peaks W, X and Y")). In addition, breeding is suspected on the north face of "Peak K", high up, about station Z.87.

The colony at station Z.63 is small, and in 1963–64 only a dozen unoccupied nests were found, together with evidence of skua predation in the form of scattered bones. At station Z.92, however, the population is much bigger. In October 1964, the earliest date on which the area has been visited, snow cover was extensive on the slopes and birds were absent. In

November and December 1963, however, thousands of petrels were present, and this colony remained in great strength up to 9 January 1964. On 14 January 1964 several young petrels were on the nest, but only three adults remained, one still incubating an addled egg. This indicates a general exodus of adults around 10–13 January in this season. About stations Z.66–68 many thousands of birds were found breeding in 1963–64, the nests ranging in altitude from 1,500 to 2,400 m. Locally there were as many as six nests per m.^{2}. On 17 November 1963 many birds were seen displaying and mating in the nest areas, while eggs were abundant on 9 December. On that date two nests contained very newly hatched chicks. By 28 February, when the colony was last visited, only young birds remained at the nests, while a few adults were flying in the vicinity. The surviving chicks varied widely in their stage of development, many being fully fledged apart from a wisp or two of down on the head while others were still fully down-covered on body and head.

Mortality among *Pagodroma* in this region appears to be high. Many nests around station Z.66 appeared to have been destroyed by landslides in the 1963–64 summer. Relatively few of the nests occupied early in the season retained living chicks by January–February, and the abundance of bones suggested heavy predation by skuas (*Catharacta skua maccormicki*). Skuas were seen in small numbers (up to 12 birds) whenever the main colonies were visited, but there was no proof of their breeding.

The discovery of these large snow petrel colonies in the mountains, over 300 km. from the coast, is of great interest, and provides yet another link with the other ranges of Dronning Maud Land to the north. There, too, skua predation is described as causing heavy mortality (Prévost, 1964). Detailed comparison of the dates on which various events in the life cycle have been recorded in different localities (Table II), however, suggest that the Heimefrontfjella colonies may be somewhat anomalous. The record of two newly hatched chicks at station Z.66 on 9 December 1963 is about a month earlier than ever recorded for this species elsewhere. Even if this is disregarded as aberrant, the record that all eggs at station Z.92 had hatched

TABLE II. SNOW PETREL LIFE-CYCLE DATA

Locality	*Arrival*	*First Egg*	*First Hatching*	*Parents Leave Chick*	*All Depart*
Tottanfjella (Ardus, 1964)	Before 14 November	After 17 November	—	—	—
Tottanfjella (station Z.92)	After late October	—	All hatched by 14 January	Between 10 and 14 January	—
Heimefrontfjella (central range; station Z.66)	Before 17 November	Before 9 December	About 9 December (2 nests)	—	After 28 February
Dronning Maud Land	—	30 November	10 January	—	—
Sør-Rondane	12 October	6 December	—	—	—
Cape Hallett	End of October	25 November	10 January	—	19 March
Pointe Géologie	Late September (some all winter)	2 December	10–14 January	By late January	Mid-March
Signy Island	Some present all winter	23 November	2 January	About 15 January	By end February

Data for Tottanfjella from Ardus (1964) and Bowra (1964); for Signy Island from Jones and Pinder (1962) and Topliffe (1963). All other data from Prévost (1964).

(apart from one bad specimen) before 14 January 1964 suggests an unusually early breeding cycle, since in other localities the *first* hatching is recorded on 10–14 January. Moreover, adult birds do not normally leave their chicks to fend for themselves between feeding visits until they are about 7–10 days old; the general exodus of adults at station Z.92 between 10 and 14 January 1964 would therefore suggest a hatching date at the start of that month. The observation that many chicks at station Z.66 were fully fledged by 28 February may also indicate an earlier departure date for young birds than recorded at Point Géologie by Prévost (1964). All in all, while new data are greatly to be desired, there does seem to be an indication that the breeding cycle at this inland colony in 1963–64 was some weeks in advance of that described on the coasts of Dronning Maud Land and Terre Adélie. If this is so, the change may be adaptive in view of the shortness of the available season in the area. On the other hand, the possibility that 1963–64 was an abnormal season may be indicated by the observation by Ardus (1964) that on 14–17 November 1961 the colony at station Z.92 was still without eggs; this would support a laying date at the "normal" time of late November-early December. Bowra (personal communication) comments that there may be year-to-year variations in the abundance of breeding petrels, related to weather; in 1963–64 he states "we were lucky in being there in a hot year, but the following season, based on radio reports, appeared to have a greater proportion of rock with snow cover. I gather that snow petrels were not in fact so common". Only further observations can clarify this confused situation.

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