The Second South African Biological Expedition to Marion Island, 1971 - 72

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Introduction

The first South African scientific expedition to the sub-Antarctic islands Marion and Prince Edward in 1965-66 did extensive work, mostly of a descriptive nature, on the geology, zoology and botany of the islands including the history of the biota. The monograph on the results of the expedition contains 37 chapters devoted to the climate, topography, geology, palaeomagnetism, geochronology, geochemistry, plant ecology, ornithological studies and a wealth of taxonomic information. (*Van Zinderen Bakker Sr. et al.,* 1971). This work forms an important basis for future research which will be mainly of an experimental kind. In future annual expeditions will be organized from December to April of the following year, after which 7 to 8 months are available for working up the results at the Department of Botany of the University of the Orange Free State at Bloemfontein.

The Second Expedition (1971-72) was again organized under the supervision of SASCAR (the South African Scientific Committee for Antarctic Research) and sponsored by the South African Department of Transport. The members of this expedition were four botanists: Messrs JU Grobbelaar (lecturer at U.O.F.S., the leader for the field work), RL Croome (University of Hobart, Tasmania), AF de Villiers (University of Cape Town) and VR Smith (University of the Witwatersrand, Johannesburg). This paper is in the main a review of their work.

Before the arrival of the expedition in December 1971, the old field laboratory in Governor's House was renovated. A new wooden laboratory was erected in 1972 on a site with a wonderful view of Gentoo Lake and the King Penguins and Elephant Seals which make their home on its shores. The laboratory consists of a large central room surrounded by four small rooms which can be used for atomic absorption, for spectrophotometry, for dark-room purposes and for storing collections.

The aim of the new research programme is to obtain a better insight into the interesting food cycles of the ecosystem of the oceanic island Marion, which has an area of only 290 square kilometres. The island is volcanic in origin and consists of plateaux, hills, mountains and some 130 volcanic cones. It is only in the lowlands, up to an altitude of about 450 m, that closed plant communities are found. The general ecological pattern of an island of this nature is extremely interesting, as the small area covered by the terrestrial communities is exposed to the rigours of the sub-antarctic climate and is largely influenced by the food production of the surrounding ocean. This ecological situation, coupled with the small number of species involved, makes the island an ideal model for basic ecological research. The heavy rainfall of 260 cm per annum and the high humidity together with regular frost at higher altitudes cause a fairly rapid disintegration of the volcanic rocks. The debris thus formed is constantly leached by the percolation of rainwater so that the plant communities tend to become oligotrophous.

The primary production on the island depends to a great extent on the percentage of solar radiation transmitted through the atmosphere. Throughout the year this quota is of the order of 50% (*Schulze,* 1971), while large daily variations occur because of the high degree of cloudiness. The total solar radiation received per day at ground level varies from about 500 cal/cm^2 in midsummer to 82 cal/cm^2 in winter.

Very special conditions prevail in the narrow coastal area which is exposed to heavy salt water spray when strong gale-force winds occur, as they do on about 100 days per annum. In the area near the sea margin, millions of birds and thousands of seals add to the enrichment of the mineral content of the soil. These processes result in food webs of an interesting nature in which several chemical elements such as sodium, potassium and nitrogen may play an important part.

A research programme of a duration of several years has been planned to cover different parts of the food and energy cycles of the island. The first steps have concentrated on primary production in the different water bodies, mineral cycling in the various plant communities, and the role of nitrogen in the ecosystem. In addition to this, work has been done on the interesting relationship between the soil fauna of some swamps and the bird population, while the research programme for pollen analysis has continued.

Table 1

Conductivity and pH values of water from various sources on Marion Island

Source of water samples	Number of samples	Conductivity μmho/cm at 25°C			pH		
		Lowest recorded	Mean	Highest recorded	Lowest recorded	Mean	Highest recorded
Glaciated lakes	76	42,2	64,7	83,0	5,77	6,35	7,26
Lakes	18	42,0	109,9	258,0	4,49	5,96	6,50
Crater Lakes	11	33,0	51,5	127,0	5,86	6,23	7,03
Van den Boogaard River	33	29,0	51,4	60,0	6,70	7,13	7,50
Streams	9	44,5	60,7	112,0	6,72	6,99	7,25
Wallows	43	36,0	140,5	420,0	4,50	6,71	8,25
Pools	6	0,5 m mho/cm	32,1 m mho/cm	92,0 m mho/cm	6,01	7,18	8,10
Tarns	45	29,0	44,07	94,5	5,20	5,93	6,78
Rain	19	8,6	41,31	192,0	5,50	5,73	6,10
Snow	4	7,15	15,59	31,5	5,45	6,03	6,40

Limnological Studies

(JU Grobbelaar)

Extensive measurements were made of the light transmission of different water bodies using an underwater lightmeter and selective filters. The records of solar radiation kept by the Meteorological Station on the island are of great value in this connection. The trophogenic layer (> 10% light intensity) was mostly 70–100 cm deep as the water is usually fairly clear. The temperature profile of lakes and tarns was also studied and it was found that except on very calm sunny days hardly any thermal stratification occurred. Much time was devoted to the chemical analysis of 267 water samples from all over the island. The following determinations were made: conductivity, pH, alkalinity ($CO_3^{=}$ + HCO_3^{-}), Cl^{-}, PO_4^{-}, SO_4^{-}, NO_3^{-}, NH_4^{+}, Na^{+}, K^{+}, Ca^{++}, Mg^{++}, Fe, Mn, Cu, Zn, and O_2 content.

Some results are given in Table 1.

A detailed analysis of the water of the Van den Boogaard River was made over a period of 30 days. Drainage was found to be fast and the mineral content of the water depended upon the rainfall.

A total of 44 primary production experiments were carried out *in situ* using ^{14}C and O_2 methods. An average nett production of 10,1 mg C/m²/hour in several lakes was determined by the O_2 method.

The metabolic activity of algal populations was studied using the chlorophyll/phaeophytin ratio from chlorophyll extractions from many different water bodies (Table 2).

A total of 85 samples of algae was brought back for taxonomic studies. Thirty different genera have already been determined in a preliminary survey.

Table 2

Chlorophyll values of algal populations from a few different environments. Results are given as Tp = total pigment (mg/g), Re = relationship between chlorophyll and phaeophytin and % Chl = percentage chlorophyll present. As far as possible a genus identification was made before each extraction.

Source	No. Extracted	Tp	Re	% Chl
Lakes	51	0,348	1,646	86,92
Streams	16	0,853	1,922	98,40
Tarns	39	0,319	1,678	85,23
Wallows	29	1,706	1,744	96,90
Pools	16	0,782	1,932	89,19

Mineral Cycling

(VR Smith)

On Marion Island two volcanic phases can be distinguished: the older grey and the more recent black lava. Chemical and topographical differences in the two lava types influence the vegetation. Besides this a large number of animals and the salt spray near the coast affect the chemical cycling. To study this process three representative sites were selected: one on black and one on grey lava inland, and one on black lava right on the shore. Each area measured approximately 150 × 120 m.

The topography of these sites was accurately mapped and the different plant associations were then drawn in. Some 140 plant samples from the different plant communities were collected and dried for ash analysis. For a better understanding of the water conditions of the plants and their mineral content approximately 150 samples of plant sap were collected using the method of *Walter* (1931).

For a study of the chemical composition of the soil about 150 soil samples and 23 rock samples were collected from the study sites.

A short micro-climatic project was carried out in order to obtain information on the relative volumes of rain falling on slopes with different aspects, tops and bottoms of hillocks, sides of valleys, etc. Records were collected during four periods of two weeks each.

It is hoped that the analysis will provide quantitative information on the rock-soil-plant mineral cycle of a number of plant communities.

Nitrogen Fixation by Cyanophytes in Mires

(RL Croome)

Small central portions of mire areas where no lakes have developed are covered by a mucilaginous algal "mat" 0,25-8,00 cm thick. Numerous determinations of biomass and water quality were made. This research was concentrated on "Study Area One" on black lava where mineral cycle studies were conducted by Mr VR Smith. The water in the area of the algal mat contained a higher concentration of solutes than in the surrounding mire. No definite evidence of an enrichment in nitrogen was found in the soil water analysis, but many soil samples were taken back to Bloemfontein for further analysis.

The algal mats consist mainly of green algae mixed with some Cyanophytes. For the determination of possible nitrogen fixation 22 acetylene incubations were made, and gas analyses were subsequently made in Bloemfontein. Similar experiments were carried out in the seal wallows. The results of these studies are discussed elsewhere in this Journal (*Croome*, 1973).

Influence of Birds on Plant Growth

(RL Croome)

During the short reconnaissance in 1963 van Zinderen Bakker Sr. noted the typical distribution of *Poa cookii* which was often found near nest sites, especially on the slopes below rookeries. The possible stimulating effect of bird excreta on the germination or growth of this grass was therefore studied. Thirty-two samples of fresh guano of known birds were analysed for their salt and nitrogen content. In addition 47 soil samples taken from 10 different nests were taken back to Bloemfontein for analysis.

In connection with this project the effect of various guano extracts on germination and growth of seeds of a number of plants was studied and compared with that of *Poa cookii*.

Palynological Research

(AF de Villiers)

The analysis of peat cores from Marion and Prince Edward Islands has given valuable information on the Late Glacial and Post-Glacial evolution of vegetation and climate on these islands (*Schalke & van Zinderen Bakker Sr.*, 1971). One of the aims of the new project was to obtain new cores, if possible older than the former ones, on Marion Island.

It appeared to be impossible to collect a good core from the bottom of the very cold glacial lake on Skua Ridge with the available outfit. Two promising cores of 385 and 150 cm in length were, however, collected. Valuable samples for ^{14}C age determination were also brought back from the island.

It is of great importance for the explanation of the fossil pollen spectra to have more information on the present-day pollen deposition. For this reason 63 surface soil and snow samples were collected and the vegetation surrounding the sample sites was accurately described.

Soil Fauna

(AF de Villiers)

Van Zinderen Bakker Sr. noted in 1965 that large flocks of Dominican Gulls foraged for worms and caterpillars on swamps between Junior's Kop and the Meteorological Station. This behaviour was subsequently studied by *Huntley* (1971). The exploitation of these swamps by birds has now been investigated in more detail. Foraging in the swamps was at a peak during the incubation period of the birds' eggs and ceased altogether when the chicks

were fledged. The reasons for the selection of certain swamps, and the regeneration of the vegetation were studied. Biomass determinations of the worms and caterpillars showed that as much as 3,756 g could be found in an area of 400 cm^2 in swamps which had not been visited by gulls.

In order to obtain more information on the food cycles in the soil many samples of microfauna were collected in vertical and horizontal sequences. The influence of birds on the soil microfauna will also be studied.

Of great interest was the abundance of at least two species of Harpacticoid copepods (Entomostraca) in the moss beds. These may feed on organic detritus and may form important links in the food cycles. Harpacticoids have not previously been recorded in moss from Marion Island.

Lichens

(A de Villiers)

A lichen collection of 60 specimens was made to replace the former collections, many of which were lost when distributed to specialists. A description of the different habitats of the lichens on the island has been prepared and it appears that these cryptogams are good indicators for certain ecological conditions.

Besides detailed work on these projects, interesting observations have been made on stray birds and rare fishes which will add to our knowledge of this nature paradise.

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