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Ornithological research at the Prince Edward islands: a review of progress

W.R. Siegfried

Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7700.

Captain Cook, who sighted but did not land at the Prince Edward islands in 1776, mentions seeing 'penguins and shags, the former so numerous that the rocks seemed covered with them as with a crust'. This appears to be the earliest reference to the birds on these islands which had been 'officially' discovered by the French explorer, Marion Dufresne, in 1772. However, it is likely that Dufresne was preceded by skipper Ham, of the Dutch galleon *Maerseveen*, in 1663 (Leupe, 1868). In any event, it was Harris, a ship's engineer and sealer, who made the first detailed observations

of the birds on the islands in 1832 (Hutton, 1865). Additional information was collected by members of the *Challenger* expedition, who spent eight hours ashore on Marion Island in 1873 (Moseley, 1879). No further ornithological records were made until the South African annexation of the islands in 1947-48. Indeed, the islands were seldom visited prior to their annexation and their natural ecosystems, in large part, escaped the man-made changes which have occurred on many other oceanic islands.

Sealing and whaling ships occasionally visited the Prince Edward islands, and the men left ashore supplemented their diet with seabirds (Goodridge, 1843). However, some organised exploitation of the birds took place as well. Moseley (1879) mentions that the king penguin, *Aptenodytes patagonicus*, colony on the north side of Marion Island 'was only inhabited to about a quarter of its extent, but it was everywhere strewn with the bones of the penguins in heaps . . . . The sealers probably employed their spare time in making penguin oil and perhaps taking skins, which are made up into rugs and mats at the Cape of Good Hope, often only the yellow streaked part about the neck being used. Hence the many bones and emptiness of the rookery.' It seems likely, too, that penguins were used for making oil at Ship's Cove, Trypot and Bullard beaches, where the remains of cooking pots and huts are still to be seen.

Both islands, Prince Edward and Marion, were declared nature reserves by the South African government at the time of annexation. Protective legislation, and the regulations governing the meteorological personnel at Marion Island, help to ensure that the birdlife is not disturbed unnecessarily. In the light of this, it is unfortunate that domestic cats, *Felis catus*, were taken to Marion Island in 1949, in order that they might reduce mice, *Mus musculus*, in and around the meteorological station (Anderson & Condy, 1974). The house mouse apparently reached the island from sealers' boats in the 19th century. The feral cat population now may exceed 2 000, and these cats could kill as many as 600 000 small birds every year (Van Aarde, 1977). A campaign aimed at controlling the cats is in progress. By contrast, Prince Edward Island, which has been more isolated, is free of cats and mice, and is the more natural island. It has been recommended that Prince Edward Island should be a wilderness area (Williams *et al.* 1979).

Soon after annexation of the islands, two members of the staff of the meteorological station published notes on the birds of Marion Island (Bennets, 1948, 1949; Crawford, 1952), but it was Robert Rand who provided, in a series of papers (Rand, 1952, 1954, 1955, 1956), the scientific basis for future ornithological studies at the island. Following Rand's term on Marion Island in 1951–1952, 15 years went by before an ornithologist again visited the island, though La Grange (1962), another meteorologist, made an assortment of ornithological observations. During 1965–1966, Van Zinderen Bakker Jr. spent 15 months studying birds on Marion Island, and he also visited Prince Edward Island. The results of his work appear in four papers (Van Zinderen Bakker Jr., 1967, 1971a, b & c) dealing with comparative avian ecology, and the breeding biology and behaviour of the gentoo penguin, *Pygoscelis papua*, and the albatrosses, *Diomedea* spp.

At about the same time, Winterbottom (1971) published a paper on the position of Marion Island in the sub-Antarctic avifauna. He concluded that each of the sub-Antarctic island groups has an avifauna recognisably different from any of the others; that, nevertheless, the avifaunas of the Crozets and Heard Island are impoverished versions of that of Kerguelen; that the influence of the physical properties of the surface waters has been over-emphasised in explaining seabird distribution, especially in respect to their breeding ranges; that the influence of the west winds and of mere distance has been underestimated; and that the avifauna of Marion Island has most in common with those of the Crozets and Kerguelen, the two nearest island groups. Although some of these conclusions may be correct, particularly the close affinity between the avifaunas of Marion and the Crozet islands, Winterbottom's analysis involved errors and omissions and, since he did not disclose the sources for the data he used, it is difficult to judge the accuracy of the results.

After Van Zinderen Bakker Jr. left Marion Island in 1966, 8 years elapsed before any significant ornithological research was taken up again on the Prince Edward islands. This new thrust was largely the result of the fortitude and persuasion of Prof. E.M. van Zinderen Bakker Sr., who repeatedly pleaded for an ecological study of the bird populations as a vital link between the ecosystems of the ocean and the islands (Van Zinderen Bakker Sr., 1971). In this context, it is necessary to appreciate that the Prince Edward islands are part of a volcanic shield in the southern Indian Ocean. Extensive lava flows occurred at Marion Island during two main periods of volcanic activity. The earlier pre-glacial phase occurred between about 275 000 and 100 000 years ago, and the first of the most recent lava flows occurred about 15 000 years ago (McDougall, 1971). In short, geologically speaking, the islands are relatively youthful. Heavy rainfall and high humidity, together with regular frost and high winds, prevail at the islands (Schulze, 1971), and a constant leaching of minerals occurs. Consequently, the islands' soils generally are poorly developed. More particularly, the soils are deficient in inorganic nitrogen and phosphorus (Smith, 1976a); and, in many areas, the vegetation depends on a supply of nutrients transported from the sea by wind, seals and birds (Van Zinderen Bakker Sr., 1971). It should be noted that the islands' ecosystem contains a paucity of herbivores feeding on the aerial vegetation, and that a detritus cycle, rather than a grazing cycle, is the most important route for the recycling of nutrients (Smith, 1977).

Moseley (1879), in describing aspects of the vegetation on Marion Island, stated: 'The plants are, no doubt, rendered especially luxuriant by the dung of the numerous seabirds'. According to Huntley (1971), the manuring influence of birds and seals is of more importance than salt-spray in determining the distribution of *Poa cookii* tussock grassland at Marion Island, since stands of this grassland are frequently found several kilometres from the coast, where salt-spray deposition is slight but where numerous burrows of small petrels (Procellariidae and Pelecanoididae) occur. Smith (1976b) demonstrated that the soils under stands of tussock grassland associated with burrowing petrels have considerably higher contents of inorganic nitrogen and, in proportion to their organic carbon contents, of total phosphorus than do soils under other plant communities on Marion Island. The plants growing in the tussock grasslands have higher contents of nitrogen, phosphorus, potassium, iron and sodium than do plants of the same species occurring in non-tussock grassland areas. Smith (1976b) ascribed these higher soil and plant nutrient contents to manuring by seabirds.

There may be more than 2 million seabirds breeding annually on Marion Island alone (Williams *et al.* 1979)

which has a relatively small area of about 300 km²; the majority of the birds concentrate in the coastal lowland covering about 100 km². These birds introduce significant amounts of minerals and energy, and biotic propagules (seeds, spores, etc.) into the island's ecosystem and, by contrast, they cause extensive soil erosion which results in the return of minerals to the sea. This presumably enriches the intertidal zone, potentially leading to an abundance of food for those birds and other animals which feed in the marine littoral.

The pelecypod, *Gaimardia kerguelensis*, which grows on the laminae of the kelp, *Macrocystis pyrifera*, surrounding Marion Island, is a common food organism of the kelp gull, *Larus dominicanus* (De Villiers, 1976). The gulls transport the pelecypods to the island, where deposits of *Gaimardia* shells occur locally. The accumulations of shell fragments of marine molluscs may be an important local source of calcium for plants and soils which otherwise have a low calcium content at Marion Island (Smith, 1976a).

The lesser sheathbill, *Chionis minor*, is the only bird which forages almost exclusively in the terrestrial environment at the Prince Edward islands. The sheathbill's diet includes a large proportion of earthworms and insect larvae, and the bird's foraging activity, together with that of the kelp gull, causes a regression in the plant succession of swamps (Huntley, 1971). The lesser sheathbill, kelp gull, sub-Antarctic skua, *Catharacta antarctica*, and the giant petrels, *Macronectes* spp., all feed to some extent on the products of elephant seals, *Mirounga leonina*, and fur seals, *Arctocephalus tropicalis*, on Marion Island, acting as yet another link in the island's terrestrial food chain.

In 1973, a long-term ornithological research programme was initiated by the South African Scientific Committee for Antarctic Research (SASCAR), as part of that organisation's overall programme of biological research. The FitzPatrick Institute of African Ornithology, at the University of Cape Town, was entrusted with the task of operating the ornithological programme. Although SASCAR's overall programme of biological research encompassed a number of different objectives, a common rationale underpinned all biological studies at Marion Island. In essence, the research aimed at obtaining an understanding of the structure and functioning of the island's ecosystem. The primary purpose of the ornithological work was to determine the roles of marine birds in the transfer of nutrients from the sea to, and within, the terrestrial ecosystem at Marion Island.

Corpses, feathers, eggs and guano are the main avian products introduced into the island's ecosystem. Taking into account the approximately two million seabirds belonging to the 26 species which breed on Marion Island, it was decided to restrict research during the period 1973–1978 to the relatively conspicuous, large and surface-nesting species. The species are: king penguin, *Aptenodytes patagonicus*, gentoo penguin, *Pygoscelis papua*, macaroni penguin, *Eudyptes chrysolophus*, rockhopper penguin, *E. chrysocome*, wandering albatross, *Diomedea exulans*, grey-headed albatross, *D. chrysostoma*, sooty albatross, *Phoebetria fusca*, light-mantled sooty albatross, *P. palpebrata*, northern giant petrel, *Macronectes halli*, southern giant petrel, *M. giganteus*. imperial cormorant, *Phalacrocorax atriceps*, sub-Antarctic skua, *Catharacta antarctica*, kelp gull, *Larus dominicanus*, Antarctic tern, *Sterna vittata*, Kerguelen tern, *S. virgata* and lesser sheathbill, *Chionis minor*. This list includes all of the 16 diurnally active, surface-nesting species found on Marion Island. About 1,5 million birds are included in the combined annual breeding populations of these species. The balance of the known breeding avifauna consists of 10 species of small petrels (Procellariidae and Pelecanoididae) which nest underground and are mainly nocturnally active. They will be studied after 1978.

Field work on Marion Island commenced in January 1974. Ornithologists were based permanently on the island in two spells: January 1974–June 1975 and April 1976–May 1977. Censuses of the breeding populations of the 16 species selected for study were made by observers who covered the coastal lowland and parts of the interior of Marion Island on foot. In addition, all large colonies of penguins were photographed from a helicopter. Aerial photographs were of great value in checking counts made on the ground of colonies of penguins, and in censusing colonies of birds in isolated and extremely rugged parts of the island.

The breeding biology of the individual species (with the exception of the grey-headed albatross and the terns) was studied in a range of sub-populations (Williams *et al.* 1975). These studies yielded data on egg and nestling production and mortality respectively, facilitating estimates of the numbers of eggs and nestlings, at various stages of development, which potentially become available for entering the energy flows and mineral cycles in the island's ecosystem. This part of the fieldwork has yielded a by-product in the form of reports dealing with the incubation and social behaviour of selected species, and ecological segregation between species (Berruti, 1977, 1979a & b; Berruti & Harris, 1976; Burger, 1979; Burger & Williams, 1979).

All four penguin species moult their feathers on Marion Island. Consequently, the mass of feathers shed by moulting penguins was determined, in association with other supporting work (Williams *et al.* 1977). Guano production by selected species of moulting and breeding penguins, and by other birds as well, was assessed by both direct and indirect methods (Burger *et al.* 1978).

Samples of the eggs, feathers, guano and carcasses of the birds under study were analysed for water, protein, lipid and energy contents, and concentrations of selected mineral elements. The selection included copper, manganese, zinc, cadmium, sodium, potassium, magnesium, calcium, strontium, nitrogen and phosphorus. These particular elements were chosen for three main reasons: their potential use as indicators of pollutants in areas remote from places of artificial application of certain metals; their importance to plants and the botanical research on Marion Island; and to contribute information potentially useful to the project on global biogeochemical cycles initiated by the Scientific Committee on Problems of the Environment (SCOPE) of ICSU (Eriksson & Rosswall, 1976).

Apart from anything else, the considerable effort involved in analysing many hundreds of samples restricted the work, at this stage of the ornithological programme, to the elements named above. However, in the future, it is intended to determine concentrations of at least some of the obviously essential elements such as sulphur. Additional chemical analyses will have to wait until more is known about the concentrations and standing crops of mineral nutrients in the organic soils and in the tissues of plants on Marion Island. In this context, Pomeroy (1970), in a review of mineral cycling in ecosystems, stated that 'the most important substances in ecosystems often are those present in least concentration'.

Preliminary results of the investigation into the mineral

and energy contributions of eggs, feathers, guano and corpses of selected species of seabirds to the Marion Island ecosystem are contained in a series of papers (Burger *et al.* 1978; Siegfried *et al.* 1978; Williams *et al.* 1978a, b & c). In summary, the 16 diurnally active, surface-nesting species deposit annually at least 33 000 t (fresh weight) of avian derived matter on Marion Island or 0,42 t (dry weight) ha^{-1} yr^{-1}, assuming an even spread of birds over the island's 100 km^2 of coastal lowland. This material represents a relatively large compartment, or 'reservoir', of energy and chemical elements. The energy amounts to about 63×10^9 kJ, and the deposition of nitrogen alone is about 56 kg ha^{-1} or about 12 per cent of the total content of nitrogen in the plant matter (above and below ground) of the island's low-altitude terrestrial vegetation (cf. Smith, 1976a). It should be noted that, apart from some preliminary data on nitrogen (Croome, 1973), no attempt has been made to study the dynamic fluxes of elements between different compartments in the island's biogeochemical cycles.

Very little is known about where the birds obtain the food for the mineral and energy increments to the island's ecosystem. There have been few observations made of birds at sea in the southern Indian Ocean, and the best modern data available are those gathered in 1976 (Frost *et al.* 1976; Frost, in press). Similarly, there is very little quantitative information on the food taken by seabirds breeding on Marion Island, although a start has been made with a study of the two sooty albatrosses (Berruti & Harcus, 1978). In the future, it is intended to expand the research to include investigations of both the food of the birds and their distribution at sea in the vicinity of the Prince Edward islands.

Bird-ringing can be a useful tool in learning about the distribution of seabirds. For instance, it appears likely, from recoveries of birds ringed on Marion Island, that many wandering albatrosses frequent Australian coastal waters during the non-breeding season (Burger & Morant, 1977). In 1950, meteorological officers on Marion Island marked wandering albatrosses with crude wire rings, but Robert Rand was the first person to use scientifically-approved methods in ringing birds on the island (Rand, 1952). Two hundred and seventy-three birds were ringed between 1951 and 1954. Thereafter, no ringing was done until Van Zinderen Bakker Jr. pushed up the total to 1 284 birds in 1965–1966. Almost 10 years again went by without any significant increase in ringing activity (Berruti *et al.* 1975). In 1977, however, the grand total stood at 3 654 for all birds ringed at the Prince Edward islands (Burger & Morant, 1977). Difficulties have been experienced in tracing some of these ringing records, because many of the rings used were supplied by the United States Fish and Wildlife Service. Since 1974, however, only South African rings have been fitted to birds at the Prince Edward islands.

Twenty-nine foreign-ringed birds were recovered or controlled (released alive) at the Prince Edward islands between 1960 and 1977. These recoveries indicate that gene exchange occurs between the wandering albatross populations, and between the king penguin populations, of Possession (46°25′S, 51°45′E) and Marion Islands. Only 10 birds ringed at the Prince Edward islands have been recovered or controlled elsewhere, but 240 birds ringed at Marion Island prior to May 1975 were subsequently recovered there (Burger & Morant, 1977). The main lesson that has emerged from the results gained through ringing birds on the Prince Edward islands is that species which receive regular attention from resident biologists, and/or species which are relatively long-lived, long-distance migrants, are likely to yield the most useful information in return for ringing effort.

Records have been kept of sightings of stray birds on Marion Island. Thirty-three individuals belonging to 15 species of land birds were recorded during a total 'observation period' of 31 months between January 1974 and December 1977; vagrant seabirds were recorded as well. These observations are potentially useful to an improved understanding of island biogeography theory (McArthur & Wilson, 1967), and in studies of the role of birds as transporters of biotic propagules (seeds, spores, etc.). Huntley (1971) drew attention to the potential role of albatrosses as distributors of seeds of *Acaena adscendens*, and Kok (1975) contributed additional information on the association between certain seabirds and seeds of plants on Marion Island. However, much remains to be learnt about the relationship between seabirds and the dispersal of plant seeds on oceanic islands.

Another subject in need of further study is the part played by seabirds in causing soil erosion on Marion Island. Preliminary observations indicate that the birds promote the erosion of bare rocks, and that they are responsible for the movement of many tons of soil. For instance, the burrowing petrels alone might have moved 10^6 m^3 of soil, and amongst the surface-nesting species the annual impact on the substrate of a combined biomass of 9 000 t (fresh weight) of breeding king and macaroni penguins concentrated in 90 ha (Siegfried *et al.* 1978) is likely to be significant in promoting soil erosion.

This review of ornithological research on Marion Island has touched on aspects of the close relationship between biotic and abiotic components of the island's tundra-like ecosystem. It appears that birds play an important role in the cybernetic pathways for energy flow and nutrient cycling on Marion Island. Elsewhere, in other ecosystems, birds are relatively unimportant in the biogeochemical cycles of nutrients (Sturges *et al.* 1974; Wiens & Nussbaum, 1975; Wiener, 1975).

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