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RESEARCH CURRENTLY BEING UNDERTAKEN BY THE REPUBLIC OF SOUTH AFRICA ON "DEPENDENT AND RELATED SPECIES" WITHIN THE ANTARCTIC MARINE ECOSYSTEM

Abstract

Selected components of the biological sciences programme are described. The primary objective of the sudies being undertaken is to improve our understanding of the ecology of important predators (especially seals and seabirds) and their prey (especially krill and squid) in the Antarctic, and closely related marine ecosystems.

RECHERCHES ENTREPRISES ACTUELLEMENT PAR LA REPUBLIQUE D'AFRIQUE DU SUD SUR "LES ESPECES DEPENDANTES ET VOISINES"

Résumé

Les composantes sélectionnées du programme des sciences biologiques sont décrites. Le principal objectif des études entreprises est d'améliorer notre compréhension de l'écologie des pédateurs importants (surtout les phoques et les oiseaux marins) et de leurs proies (en particulier le krill et le calmar) en Antarctique et dans les écosystèmes marins étroitement liés.

ИССЛЕДОВАНИЯ, ПРОВОДИМЫЕ В НАСТОЯЩЕЕ ВРЕМЯ ЮЖНО-АФРИКАНСКОЙ РЕСПУБЛИКОЙ ПО ВОПРОСУ "ЗАВИСИМЫХ И СВЯЗАННЫХ ВИДОВ" В МОРСКОЙ ЭКОСИСТЕМЕ АНТАРКТИКИ

Резюме

Описаны выделенные компоненты биологической программы. Главной задачей проводимых исследований является усовершенствование знаний об экологии основных хищников (особенно тюленей и морских птиц) и их жертвы (особенно криля и кальмаров) в Антарктике и тесно связанных с ней морских экосистем.

INVESTIGACIONES QUE LA REPUBLICA DE SUDAFRICA ESTA LLEVANDO A CABO ACTUALMENTE RESPECTO A "LAS ESPECIES DEPENDIENTES Y AFINES" DENTRO DEL ECOSISTEMA MARINO ANTARTICO

Extracto

Se describen componentes seleccionados del programa de ciencias biológicas. El objetivo principal de los estudios que se están efectuando es mejorar nuestra

comprensión de la ecología de los depredadores importantes (especialmente las focas y las aves marinas) y sus presas (especialmente el krill y los calamares) en la Antártida, y en los ecosistemas marinos estrechamente relacionados.

INTRODUCTION

South Africa carries out a wide variety of scientific research in the Convention area and on the Sub-antarctic islands. These all fall under the auspices of South African Scientific Committee on Antarctic Research (SASCAR).

This report deals with selected components of the biological sciences programme of the South African National Antarctic Programme. As such, these components are of direct relevance to improving our understanding of the status of and ecological relationship between dependent/related populations of Antarctic marine living resources and their prey.

(1) MARINE MAMMALS

Introduction

Scientists based at the Mammal Research Institute of the University of Pretoria spend up to three months each year in the Antarctic, and from three to eighteen months at a time on Goush Island in the South Atlantic Ocean and on the sub-Antarctic Prince Edward (incorporating Marion Island), Amsterdam and Kerguelen islands in the South Indian Ocean studying the mammals in these regions. Between visits they carry out laboratory and statistical analyses of material and data collected. There is a low species diversity of mammals adapted to the Antarctic and Subantarctic environments,

but the few that do occur provide an ideal opportunity for scientists to investigate their interaction with their environment.

Seals

Research on various aspects of the mammal fauna - mainly seals - in the southern oceans and on the islands south of southern Africa, began in earnest during 1973. Since then several projects have been completed and a number are still in progress. Research priorities have been set in accordance with those of national and international programmes, their objectives conforming with those of the South African National Antarctic Programme, the international Scientific Committee on Antarctic Research (SCAR) and the international BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks) programme.

Research on the four species of truly Antarctic seals - the Weddell, crabeater, leopard and Ross seals - originally concentrated on their spatial and temporal distribution in the King Haakon VII sea off the Fimbul Ice Shelf, upon which the South African Antarctic base, SANAE is situated. The results indicated that the rarest of the species, the Ross seal, was present in larger numbers in that region than anywhere else surveyed up to that time. A long-term project investigating various aspects of Ross seal population ecology, reproduction and feeding was consequently initiated. This research, conducted in the pack ice from the supply and research ship, S.A. Agulhas, is carried out annually

during the SANAE relief voyages each austral summer.

Research on different seal populations around the sub-Antarctic islands is carried out since these islands serve as 'platforms' upon which seals breed and moult each year. Studies on several aspects of the biology of the sub-Antarctic fur seal and southern elephant seal are being investigated on temperate Gough Island in the South Atlantic Ocean and on the sub-Antarctic Prince Edward (incorporating Marion Island) and Kerguelen islands in the South Indian Ocean.

Since 1974, studies at Gough Island have concentrated on the behaviour, population ecology and reproductive physiology of the fast expanding fur seal population. This particular population, which now reresents nearly 93 per cent of the world stock of this species, has been estimated at 200 000 and is increasing at a rate of about 16 per cent per year. Distribution of these seals around the shore of the island during the breeding season - in summer - appears to be limited by the seal's inability to physiologically regulate its body temperature during spells of relatively high ambient temperature experienced on the island between October and March. Behavioural adaptations (body postures and local movement) which are of importance in overcoming this problem have been identified. Social organization and seasonal changes in the age and sex composition of the population have also been described. In addition, studies have been undertaken

on population dynamic characteristics and reproductive physiology.

Investigations of the fur seal population at Marion Island started during 1973 and soon indicated that two fur seal species were intermingling and possibly interbreeding on the island. The initial study on the abundance, distribution and annual cycle of fur seals was therefore followed by an investigation of the ecological and genetic separation of these species. Considering that the Prince Edward islands are one of the only two localities where both species breed, the results of this study were of importance to the understanding of the mechanisms which make it possible for related species to co-exist.

Research on the elephant seal populations at Gough, Marion and Kerguelen islands (on the latter in co-ordination with France) forms a major component of activities on the sub-Antarctic islands. These investigations began during 1973 and indicate a decrease of 5 to 11 per cent per year in the populations at Marion (4 500) and Kerguelen (118 000) islands. This trend apparently results from competition for food with fishing fleets, although social factors, resulting from differential changes in bull and cow numbers, may also be of importance - the latter aspects is being investigated.

The activities of elephant and fur seals when ashore at Marion Island to breed or moult have an important effect on the nutrient

and energy cycles of the plant and invertebrate communities of the adjacent coastal plains. This effect is mainly through trampling and enrichment by manuring. An attempt has been made to quantify these influences.

The long-term monitoring of these seal populations through an intensive tagging programme is providing information on local and large-scale (inter-island) distribution and movement of seals, the age of sexual maturity, longevity and mortality patterns. Environmental variables of importance in the habitat preferences of these species form an important component of the investigation.

Wild Cats

Most of the exotic mammalian species introduced onto sub-Antarctic islands through human activities have had a deleterious effect on the islands, particularly on their birds.

An investigation into the influence of the cat population on Marion Island was initiated during 1974. This indicated that approximately 600 000 petrels were being killed annually by the feral or wild cat population, which was estimated at approximately 2 000. The high rate of annual increase (17-23 per cent per year) of this cat population could eventually have resulted in the burrowing petrel fauna of the island being exterminated, so measures were taken to control the cats. A biological control factor was introduced during 1977 which was successful in reducing

the number of cats to about 600 in 1983.

Mice

House mice were introduced to Marion Island through sealing activities. Genetic studies suggest that the present-day mouse population is of Scandinavian origin. Studies of the feeding patterns of these mice indicate that they feed mainly on invertebrates. They are widely distributed around the periphery of the island, seasonal in their breeding activities, and well adapted to survive under the prevailing environmental conditions. Information on the population ecology and its interaction with the fauna and flora of Marion Island is now being analyzed.

(2) SEABIRDS

Introduction

Research on seabirds within the South African National Antarctic Programme is carried out by the Percy FitzPatrick Institute of African Ornithology, University of Cape Town. The scope of the work is primarily ecological, aimed at an improved understanding of how seabirds contribute to the structure and functioning of ecosystems.

South Africa's Prince Edward islands and the seas around the country's continental mainland support some of the most abundant pelagic seabird populations found anywhere in the world. The

country is well placed and equipped to take a major share in the international responsibility for seeing that these birds continue to thrive, which depends on the state of the ecosystems of which the birds are an integral part. Man needs to exploit the resources of these ecosystems but should do so only within certain bounds. Ecological studies of pelagic seabirds can help determine these bounds.

A seabird may be defined as one that obtains its food from the sea. Broadly speaking, seabirds may be arranged ecologically as inshore, offshore or pelagic species. Among the inshore birds are the cormorants and gulls, which seldom move out of sight of land and normally roost ashore at night. The gannets are typical representatives of the predominantly fish-eating offshore seabirds which tend not to range beyond the continental edge. Pelagic seabirds can live for many months far from land, obtaining their food from the open sea. The albatrosses, characteristic inhabitants of the Southern Ocean, belong to this community. More than half the seabirds found in South African waters belong to the pelagic group, most of whose members only go ashore to breed on remote oceanic islands.

The seabirds of the world comprise some 250 species, of which about 65 are found in South African waters. However, only 13 species breed within South African territory, excluding the sub-Antarctic oceanic islands of Marion and Prince Edward, and

none of these belongs to the pelagic community. In contrast, 26 species breed at the Prince Edward islands, the majority being pelagic.

South African research

South African research on pelagic seabirds in the Southern Ocean is carried out mainly in four areas: the Prince Edward islands; Gough island; the Benguela Current region; and that part of the Southern Ocean bounded by latitudes 30-70 S and longitudes 10 W to 40 E.

Research is primarily ecological, aimed at an improved understanding of how seabirds contribute to the structure and functioning of ecosystems. The continued possibility for exploitation by man of renewable natural resources, such as fish, depends not only on the rate at which they are exploited but on the maintenance of the ecosystem. Thus, much of the direction of South African seabird research is aimed at understanding the ecological roles of seabirds as top-order predators, either of pelagic shoaling fish, such as pilchards and anchovy, in waters around the southern African subcontinent, or of krill and squid in the Southern Ocean.

Birds of the Prince Edward islands

Penguins, petrels, albatrosses, skuas, gulls and terns are among the wide variety of seabirds encountered when voyaging southward

from Cape Town. Most of these birds - also the sheathbills and cormorants - breed on islands in the Sub-antarctic ocean. Apart from occasional strays from lower latitudes and a few true land birds, the avian communities of the islands are exclusively marine. The species are either ocean-feeders or are dependent, as scavengers and predators, on other seabirds.

Some of the largest bird colonies in the world are to be found on sub-Antarctic islands. Penguins usually occupy the coastal slopes, cormorants and smaller albatrosses the cliffs, larger albatrosses the higher, flatter ground, and petrels honeycomb the inland surface with their nest-burrows. Marion Island harbours about one million breeding Macaroni penguins, and about 500 000 breeding King penguins, accounting for some 10 and 30 per cent, respectively, of the world populations of these species.

What accounts for this great abundance of birdlife? Birds need a stable, solid surface on which to lay and incubate their eggs and rear their young. Nowhere is the proportion of sea to land greater than in the southern hemisphere between latitudes 40 and 60 degrees S. This vast oceanic area is very productive - especially in the region of the Antarctic Polar Front where cold surface water from Antarctica meets and sinks below the warmer waters of the sub-Antarctic - providing food for millions of seabirds. Most of the sub-Antarctic islands are situated in this

region.

Reference to the birds sighted on the Prince Edward islands was made by Captain Cook in 1776, who mentioned seeing 'penguins and shags, the former so numerous that the rocks seemed covered with them as with a crust". Harris, a ship's engineer and sealer, made the first detailed observations of the birds on the islands in 1832. Additional information was collected by members of the Challenger expedition in 1873. No further ornithological records were made until the South African annexation of the islands in 1947-48.

The Marion Island ecosystem

In a description of the vegetation on Marion Island given more than 200 years ago, it was stated that the plants are probably especially luxuriant because of a surfeit of the duns of numerous seabirds. About 10 years ago, a long-term research project was initiated by SASCAR, aimed at determining the roles of birds in ecological processes affecting the structure and functioning of the terrestrial ecosystem at Marion Island, more particularly to determine the amounts of essential nutrients transferred by birds from the marine ecosystem to, and within, the terrestrial ecosystem.

Carcasses, feathers, eggs and guano are the main avian products introduced into the island's ecosystem. Of the 26 birds

species which breed on Marion Isdland, research was restricted during the 1970's to the relatively conspicuous, large and surface-nesting species. These comprise about 1,5 million birds of 16 species. The balance of the known breeding avifauna, consisting of 10 species of small petrels which nest underground and are mainly active nocturnally, are now being studied.

The results to date show that birds significantly affect virtually all parts of the island's ecosystem. The nutrients introduced, recycled and distributed appear to be crucial for the maintenance of many vital processes. The amount of nitrogen alone introduced annually by avian carcasses, manure, eggs and feathers is about 56 kg/ha or approximately 12 per cent of the total content of nitrogen in the plant matter (above and below ground) of the island's low-altitude vegetation. The island's soils are inherently deficient in nitrogen.

Avian products deposited annually on Marion island are of the order of 32 000 tones of fresh guano, 500 tonnes of feathers, 350 tonnes of dead birds and 200 tonnes of eggs. The eggs alone contain enough energy to drive a small motor car eight times around the world, or sufficient energy to sustain an active human being for 300 years. These calculations take no account of the input of hundreds of thousands of burrow-nesting petrels.

Seabirds have a profound influence on the island's vegetation,

guano and other fertilizing products promoting luxuriant growth of plants, as recorded earlier. On the other hand, the steady tramp of penguin kills vegetation along regular routes, leading to soil erosion. In places the birds even erode bare rock. After rain, which falls almost daily, the sea abutting on the major colonies of breeding penguins is stained with slush and eroding soil. Yet this erosion is part of a cycle returning material to the sea, enriching inshore waters and promoting the production of food for animals which feed close to the coast.

Birds indicate changes in population of prey

The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), of which South Africa is one of the contracting nations, defines these resources as all species of living organisms found south of the Antarctic Polar Front. It thus recognizes the interdependence of all components of the Antarctic marine ecosystem, not only the exploitable ones.

The Antarctic ecosystem differs from other marine ecosystems in the dominant role occupied by krill in the food web. The term "krill" here is used to describe pelagic, shoaling crustaceans generally, not merely the euphausiid Euphausia superba. These small shrimp-like creatures comprise a large part of the zooplankton biomass, and are the main food item contributing either directly or indirectly, to the diets of many seabirds, especially certain penguin species. Significant changes in populations of

krill, which may be caused by man's exploitation of them, are likely to affect the populations of many animals, including seabirds, further up the food chain in the Southern Ocean. Currently, the overall consumption of krill by seabirds probably approximates that of either seals or whales.

Since the Prince Edward islands harbour a substantial proportion of these seabirds, South Africa chose to study selected species in this area with a view to using them for monitoring any future changes which might occur in krill populations. This research incorporates three components: first, determination of the diets of the different species, including seasonal and annual variations; secondly, determination of their energy requirements, which vary from species to species according to their life styles; and, thirdly, monitoring of their numbers and breeding success. Similar, but less intensive, studies are also being carried out by South African scientists at Gough Island. This work will provide the information needed to understand the relationship between the population dynamics of these selected species, chiefly penguins, and of their prey, mainly krill and squid.

Studies of birds at sea

Where do the millions of birds which breed at the Prince Edward islands obtain their prey? Where do they feed, and on what, when not breeding? How important are the seas around South Africa for

pelagic seabirds, including populations which breed at the Prince Edward islands? Do these seabirds consume significant quantities of resources exploited by man? Can the distribution of birds at sea be used to predict peculiar oceanographic conditions, perhaps associated with concentrations of the birds' principal prey types, for example krill and fish, which are also exploited by man? What effects do man's exploitation of marine resources have on pelagic seabirds? These and a host of other questions can only be answered fully through studying birds at sea.

One particular project of the international BIOMASS programme accordingly aims to improve current estimates of the amount of krill consumed at sea by the avian community of the Southern Ocean. South African scientists are taking an active part in this programme, providing information on the densities of birds and of their food requirements. For this research South African scientists have available to them two modern, deep-sea research ships, S.A. Agulhas and Africana, supported by a number of smaller vessels, fixed-wing aircraft and helicopters.

This form of ornithological research is part of a fairly recent development in international science. It reflects modern conservation standards which require that the state of the ecosystems as a whole, not merely the effects of exploiting resources, should be taken into account by management authorities.

To overcome these problems, SASCAR established a Prey Identification Service at the Port Elizabeth Museum in 1983 to cater for the needs of those Southern Ocean biologists studying top predators, especially seals and seabirds.

The initial task of the Service is to assemble comprehensive collections of suitable reference material, particularly the less digestible part of fishes, squids and crustaceans, which form the bulk of the prey of top predators in the Southern Ocean. Fresh material is collected where possible, and supplemented with material extracted from specimens held in collections in South Africa or abroad. These reference collections will consist primarily of fish ear stones or otoliths, squid mandibles or beaks and crustacean exoskeletons.

Otoliths, calcareous structures found in the inner ear of nearly all fish with bony skeletons (teleost fishes) vary sufficiently to be identifiable to species in most instances, even when eroded slightly by stomach acid.

Squid beaks, so-called because they resemble the beak of a parrot, are composed of chitin and are extremely resistant to digestion. The identification of squids from their beaks is a comparatively new field, limited somewhat by the innate difficulties of squid taxonomy and man's inability to capture useful numbers of pelagic squids - those that live in the open sea -

(3) SEAFOOD OF SEALS AND SEABIRDS

Introduction

Research aimed at a comprehensive understanding of Southern Ocean food webs and the interaction between predators and prey is an integral and important part of the South African biological research around Marion and Prince Edward islands and in the Southern Ocean.

Report on work

As part of the ecological study of seals and seabirds in relation to their environment, work is focused on their diets. Some of the bird species are potential indicators of the availability of their major prey, particularly squid and krill, and it is therefore important to study their feeding habits.

Information on the diets of these predators is derived almost entirely from the analysis of stomach contents collected from live aimals with the aid of stomach pumps, or from carcasses. As marine predators digest their prey rapidly and efficiently, intact items are rarely found in their stomachs and the identification of most prey items must be based on the less digestible fragments. The specialized nature of such identifications is generally outside the experience of those concerned with more tradional taxonomy of prey groups, and their normal reference material is often ill-suited to the purpose.

especially the larger forms. However, identification to genus is possible and, with some local knowledge, often also identification to species.

The most important crustaceans are euphausiids, amphipods and copepods. Their identification is usually based on traditional features such as the structure of the appendages, mouth parts and carapace.

With these research tools, the Prey Identification Service aims to identify all prey items to the lowest possible classifiable level and eventually to provide estimates of the original body size and mass of each item consumed, using appropriate length to mass relationships derived from reference specimens.

Although the Service at the Port Elizabeth Museum is intended primarily for the use of South African researchers in the National Antarctic Programme, applications for identifications from other biologists both in South Africa and abroad are welcome, since such identifications provide useful comparative information.
