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THE AGE OF DESPAIR

"The peculiar fur-seal of the Galapagos, although formerly abundant, is probably near extinction as none have been seen during recent years." This was the gloomy opinion of Dr Townsend of the New York Zoological Society in 1930. It can have caused little surprise in scientific circles. As long ago as 1905-6 the highly important expedition of the California Academy of Sciences, which visited every island of the archipelago and made the first systematic survey of the flora and fauna, reported that it had seen only one fur-seal during its year-long investigations.

This was what we might call "the age of despair" for the Galapagos; scientists realized the outstanding importance of the islands to biology but thought there was little future, not only for the fur-seal but for the wildlife in general. The idea of conservation was still in its infancy and not considered practical for the Galapagos. So it seemed that the only reasonable thing to do was to collect as many birds, reptiles, mammals, insects and plants as possible for the museums and zoos before these unique species became extinct. The Academy expedition collected voraciously – 8691 specimens of birds and 266 giant tortoises, to take but two examples.

For the scientists, the fur-seal was already beyond hope. Which was a pity as this delightful creature had once been so numerous. It may seem odd to find fur-seals breeding right on the equator but not more so than the Galapagos' endemic penguins and albatrosses. Presumably the seals had found their way north following the cold waters of the Humboldt Current and the harsh volcanic shores of the islands provided plenty of dark caves and overhangs where they could escape the worst of the heat. Anyhow, they flourished – until man came. Even then the pirates and naval crews cannot have done much enduring harm, if only because they were never there in large numbers for long enough. The real trouble came in the nineteenth centry when the whalers and sealers began the exploitation of the Galapagos on a commercial basis. By the end of the century they came no more: the sealers, like the whalers, had destroyed their own occupation by overkilling.

But somewhere hidden among those fierce black rocks a nucleus of fur-seals survived in secret, while the concept of conservation slowly developed in the world outside. The far-sighted legislation of the Ecuadorean Government, the establishment of the Darwin Research Station and now the creation of a National Park Service, have all contributed to the rescue of the fur-seal. Because it is by no means extinct: in fact it can now be counted in thousands. It is much more difficult to watch than the sea-lion, partly because it is still less numerous and partly because it is much more shy – a characteristic which is unusual among the wild animals of the Galapagos and may be due in some degree to the way in which it was massacred in the past. The fur-seal is afraid of man – at least of man approaching by land or in a boat. But man, when swimming, is a new phenomenon and not recognized as an enemy. Joan and Alan Root, when making their splendid film, "The Enchanted Isles", found the fur-seals friendly enough so long as they met in the water where they could frolic together.

So Dr Townsend proved wrong; but nobody would be more happy than Dr Townsend to know it. And *we* know that conservation can succeed. The helpless despair of earlier years has no longer any validity. Given sufficient support, there is so much in the Galapagos that can still be saved and, to varying extents, restored to something approaching its state before man came.

G T CORLEY SMITH

GALAPAGOS CONSERVATION: PRESENT POSITION AND FUTURE OUTLOOK

Based on a paper read on 1 March 1974, to the Annual Meeting of the American Association for the Advancement of Science by

PETER KRAMER

Director of the Charles Darwin Research Station, 1971-1973

Conservation in the Galapagos Islands is the responsibility of the National Park Service of Ecuador with the co-operation of the Charles Darwin Foundation. The latter is an international body created under the auspices of the Government of Ecuador, UNESCO and the International Union for the Conservation of Nature. It receives further support from a number of learned societies in Europe and North America and notably from the World Wildlife Fund; but directly or indirectly it is chiefly dependent on individual benefactors for the means to maintain its scientific research station and carry out its conservation task in the archipelago.

This task differs only in details from conservation work in other parts of the world. It includes programmes to protect species in danger of extinction; programmes to protect or rehabilitate natural ecosystems; and programme to stabilize ecosystems in which human activities form an integral part.

The best-known example of the first type has been the surprisingly successful effort to save the remaining subspecies of giant tortoises after long years of wholesale slaughter. Today eleven of the original fourteen subspecies still survive and nine of them breed in the wild. Their breeding areas have now been discovered with some accuracy and campaigns are waged year after year to protect the eggs and young from exotic predators such as black rats, pigs, dogs, cats and men. Where the situation has deteriorated so far that even such protection cannot ensure survival, eggs are brought to a hatching centre at the Darwin Research Station. Here the young are raised until they are big enough to defend themselves when returned to their home island. Two races were found to be so reduced that they no longer reproduced in the wild. Most of the survivors on the island of Espanola (about 15) were removed to the Station where they had produced 42 young by 1973, but the recently discovered male of the Pinta subspecies (which was formerly believed extinct) will probably prove the last of its kind unless a mate is still hidden somewhere in the rugged terrain of this island. Nevertheless there is some satisfaction in reporting that the giant tortoises are on the increase for the first time in two centuries.

Among the other species causing concern (and there are several with small populations which are found nowhere else in the world) is the Dark-rumped Petrel *(Pterodroma phaeopygia).* It breeds only in Hawaii and the Galapagos and in both archipelagoes it is the black rat that threatens it with extinction. Rat control is being pursued within the limits set by technical and financial considerations but the problem remains obdurate. Likewise the control of dogs and pigs, on those islands where they now run wild, still awaits an effective solution.

The influence of introduced predators is only irreversible once they have exterminated a native animal species – though this can happen quickly on oceanic islands. But other exotic organisms introduced by man, such as goats, can destroy the plant cover and cause erosion to a degree that is virtually irreversible. This is why goat and pig control play such a large role in the efforts to save the unique ecosystem of the Galapagos. On a tiny island such as Plaza, it was possible to eliminate goats completely as early as 1960. In the late sixties, with the establishment of the National Park Service, control programmes were steadily expanded. By 1971, goats were eradicated on Rabida and Santa Fe. On the latter island the goats had grievously damaged the vegetation; recovery is now being monitored in sample quadrats. On larger islands such as Espanola and Marchena complete eradication seems impossible with current resources but systematic control keeps numbers in check. The alarming proportions of the goat problem can be judged from the example of Pinta. Three goats were introduced into this island as recently as 1957, shortly before the Darwin Station was set up; yet, since 1971, the Park Service has shot no less than 30,000. There are still far too many left but thanks to this policy the vegetation is recovering very well considering the severe degradation; at least danger of erosion on Pinta's steep slopes seems to have been averted.

The case of Pinta demonstrates dramatically the important of the time factor. Measures to control introduced organisms and to prevent further introductions must be given the highest and most immediate priorities. And these direct measures must be integrated with holistic ecological research. We must monitor the systems and try to simulate them with the object of making predictions and setting priorities for practical conservation. Such monitoring has begun on a modest scale with the setting up of permanent quadrats and by making regular sea-bird counts. But monitoring needs to be greatly extended on the lines drawn up at the 1972 Galapagos Science Conference in Washington.

So far I have dealt only with animals, plants and habitats. The problem of the Galapagos becomes more complicated and more difficult when we include man. Without the support of public opinion, particularly in the islands but also in mainland Ecuador, there can be no confident future for conservation. Yet the Galapagos, if protected, could contribute so much to Ecuadorian development and science could begin to repay Ecuador for all that Ecuador has contributed to science. The French Academicians in the 18th century, then Humboldt, Darwin and an ever-increasing stream of foreign scientists enriched the world's knowledge by their investigations in Ecuador; but the Ecuadorians themselves were little involved in these researches and the study of natural sciences remained neglected. The outstanding scientific importance of the Galapagos together with the existence of the Darwin Research Station in the islands form an educational resource which should be developed for the good of the whole country. A beginning has been made.

Some years ago the staff of the Darwin Station began to give conservation lectures in the little local schools but scant progress was made as the children did not know enough natural science to understand our approach to conservation. We had to learn other approaches. We also became involved in science teaching, both directly and through teacher training courses, which are now an annual feature at the Station.

For the islanders in general there is a weekly conservation talk on Radio Galapagos and a regular hand-out bulletin. Last year we made a new departure by inviting all local adminstrations to join in a seminar on the theme of "How should we use the Galapagos?".

To give university students direct experience of scientific work, 4-6 undergraduates from the mainland are invited to the Station each year to work under the supervision of staff or visiting scientists. This is a programme of the highest importance but more than this handful of students should be involved – and this means more funds and more supervisors.

An educational project of a different but very valuable nature was the organization of a series of courses to train park wardens and tourist guides. This has now been taken over by the National Park Service but the Station still co-operates.

Galapagos is an integral part of Ecuador and it is highly desirable that the whole republic should know the archipelago better. It is symptomatic that you can get a pretty good book on the natural history of the Galapagos in Bulgarian or German and dozens of them in English – but not a single one in Spanish. To remedy this a small but significant series of books and pamphlets on the National Park is being produced, all but one written by Ecuadorians. At the same time we are opening a Galapagos information centre at the Central University in Quito, which will include a library and a large collection of scientific papers on Galapagoan subjects.

To me, these educational projects seem the most vital element in our entire programme for the conservation of the Galapagos.

Finally, the Galapagos Islands were last year established as a separate province and two important reports on their future were published: one by an inter-departmental committee appointed by the Minister of Agriculture to consider the resources of the archipelago and the possibilities of developing them; and one by a small group of Ecuadorian administrators, United Nations park experts and biologists, who drafted a master plan for the future of the National Park. Although the two groups had such different terms of reference, they both started from the same premise: that as 88% of the Province of Galapagos was National Park, its development must be conceived on entirely different lines from the development of other provinces. Much planning still remains to be done but this start is in the right direction.

SYMPOSIUM ON THE GALAPAGOS ARCHIPELAGO

American Association for the Advancement of Science
San Francisco, California
1 March 1974
Programme Organizers: Robert T Orr & Robert I Bowman

Abstracts of Papers*

PHYSICAL SCIENCES SESSION
Chairman: Tom Simkin

Cox, A V, Department of Geophysics, Stanford University.
AGE OF THE GALAPAGOS

Johnson, G L, Ocean Floor Analysis Division, United States Naval Oceanographic Office.
MARINE GEOLOGY AND GEOPHYSICS

The Galapagos Islands are located just to the south of the axis of the Galapagos Ridge. This ridge was only recently discovered to be an axis of sea-floor spreading, and thus a branch of the world-encircling Mid-Oceanic Ridge, which is an ever widening crack, constantly filled by accretion of mantle derivatives along its crestal zone. The Galapagos Island platform (specifically Fernandina and Isabela Islands) apparently is situated directly over a "hot spot" or "mantle plume" which is responsible for the unique characteristics of the sea floor in the vicinity of the Galapagos Islands and its similarity to the sea floor near Iceland. The sea floor in the vicinity of Galapagos and Iceland is generally elevated with high magnetic anomoly amplitudes within 600 km of the center and with the exception of active volcanic centers and fracture zones a low level of seismicity. Near the plume center the morphologic shape of the spreading axis is an elevated arch similar to the Reykjanes Ridge; whereas farther from the plume center it resembles normal Mid-Oceanic Ridge terrain. The plume center is also characterized by a petro-chemical uniqueness of the basalts on the island and adjacent sea floor.

McBirney, A R, Center for Volcanology, University of Oregon.
RESULTS OF RECENT WORK IN THE CENTRAL AND SOUTHERN GALAPAGOS ISLANDS

The Galapagos Archipelago has become the focus of much recent interest, because it offers an unusual opportunity to evaluate several currently popular theories about the evolution of the oceanic crust and volcanic islands. Detailed work on Santiago, Jervis, Duncan, Santa Cruz, and Floreana has greatly improved our knowledge of the volcanic history and structure of the central and southern part of the archipelago. The proposed scheme for growth of the islands on a moving plate that passes over a stationery "Hot Spot" is difficult to substantiate. Unlike Hawaii, the Galapagos Islands follow no simple pattern

**Papers for which no abstracts were available at press time are listed by title only.*

of development; each seems to be distinct, both in the nature of its volcanic activity and its structural development. Some of the islands have been uplifted relative to previous sea levels, while others have subsided. Some display a strong system of east-west fissures and faulting – others do not. There is a crude increase in age from north to south, but Floreana seems to be anomolous in that it is probably younger than Santa Cruz. It is probably too early to attempt an interpretation of these complex patterns, but further studies of individual islands can certainly be expected to raise our confusion to a higher level of sophistication.

Simkin, T E, Division of Petrology and Volcanology, Smithsonian Institution.

RECENT VOLCANISM IN THE GALAPAGOS ISLANDS

During the last two centures, 42 eruptions are known to have taken place from six major Galapagos volcanoes and as many others show evidence of recent volcanism that passed unnoticed or unrecorded. Volcan Fernandina has been particularly active in recent years, and this paper will discuss Fernandina's six eruptions of the last 16 years with some mention of their effect on the biota.

In 1958 fissure eruptions from the summit poured lava into the caldera lake. Three years later came a large eruption on the SE flank, near the former home of the only tortoise ever observed on this island. In 1968 another eruption occurred on the SE flank and this was followed in three weeks, by a major explosive eruption in the cladera that blanketed the western slopes with up to 4 m of pyroclastic deposits. This eruption removed critical support from the main caldera block which then dropped, during the next nine days, a total of 350 m. The lowering of the 8 km^2 floor ranks as the largest collapse known on earth since 1912. The walls of the caldera are continuing to stabilize, a large lake has grown on the lowered floor, and revegetation of the pyroclastic deposits has been impressive. In the spring of 1972 a small eruption took place on the caldera's SE bench and on 19 December 1973, a large eruption came up the 1968 boundary fault on the E wall of the caldera. This eruption, first recognized as a 200 km long plume on NOAA satellite imagery and first observed by SKYLAB astronauts, spilled an estimated 13 x 10^6 m^3 of lava into the caldera lake in 5 days. The 120 x 10^6 m^3 lake has steamed vigorously, its sulphate-rich waters have been further concentrated by evaporation, and its formerly rich organic content has been gently simmered. Later chapters in the history of this unquiet volcano remain to be written.

(The following persons have made substantial contributions to the work to be reported: Keith Howard, John Filson, Lana Everett, Bruce Nolf, Jim Case, Beth Zigmont, Tony Onyeagocha, Art Kreuger, and the staff of the Charles Darwin Research Station.)

Colinvaux, P A, Department of Zoology, Ohio State University.

ENVIRONMENTAL HISTORY OF THE GALAPAGOS

The history of El Junco Lake, San Cristobal Island, suggests that the climate of the Galapagos and the eastern Pacific Ocean has fluctuated broadly in synchrony with glacial and postglacial climatic events in the northern hemisphere. Drought on the Galapagos during a time of glacial advance suggests that the intertropical convergence was then north of the geographic equator at all seasons of the year. That the climate of the Galapagos has never been wetter than now, strongly suggests that the stable inversion

which is a feature of the climate of the region has been present at least as commonly as at present for more than 48,000 years. Conclusions from this study provide data useful for constructing tentative models of atmospheric circulation over the Pacific Ocean in the past.

BIOLOGY SESSION
Chairman: George Bartholomew

Porter, D M, Program in Systematic Biology, National Science Foundation.
RELATIONSHIPS AND DISPERAL MECHANISMS OF THE GALAPAGOS FLORA.

Johnson, M P, Division of Biology, Kansas State University.
SPECIES NUMBERS, ENDEMISM AND EQUILIBRIUM IN THE GALAPAGOS ARCHIPELAGO.
Statistical analyses of the species-area relation, plant distributions and the distribution of endemism are given. Attempts to explain the observed patterns are based on island histories, evolution, dispersal, and the balance between extinction and immigration rates. The analyses are largely based on plant data, but reference is also made to bird and insect data. Several approaches are made to determine if the islands are at MacArthur-Wilson equilibrium. The most promising of these approaches is one based on an analysis of the number of species common to each pair of islands.

Reeder, W G, Department of Zoology, University of Wisconsin.
ARID AND TRANSITION ZONE GRADIENTS ON SANTA CRUZ ISLAND.

MacFarland C, Department of Zoology, University of Wisconsin, and Charles Darwin Research Station, Galapagos.
THE EVOLUTION OF REPRODUCTIVE RATES AND LIFE HISTORY STRATEGIES IN GALAPAGOS TORTOISES.
The 11 surviving races of Galapagos tortoises fall broadly into three categories: those of small adult size which inhabit smaller, less-elevated islands with relatively harsh, more fluctuating physical environments; those of large adult size which inhabit larger, more-elevated islands with relatively milder, less fluctuating physical environments; and a group of races of intermediate adult size from islands with intermediate physical environments. Comparative studies of several races indicate that the smaller-sized races mature at a smaller size and younger age, have a shorter life span, produce a greater number of eggs per season per female than the larger-sized races. These results provide a test of some recent theoretical predictions.

Werner, D, Zoologisches Institut, Universitat Basel.
APPEARANCES AND BEHAVIOUR IN *TROPIDURUS* LIZARDS.
All species of *Tropidurus* in the Galapagos Islands show distinct sexual dimorphism in size and coloration. One of these seven species, *T. delanonis* has been investigated in respect to the correlation between appearance and behaviour. Besides the different coloration in adults, there are other types of coloration in young lizards. Together they can be categorized into two main types, namely, cryptic and semantic (bright,

display) coloration. In respect to intraspecific communication, it has been found that the behaviour is cryptic or semantic accordingly. The functions of colorations and sizes has been investigated experimentally. The results show that each type of coloration has its specific function within the social system. The semantic coloration can be understood as "ritualized behaviour" which means that the idea of ritualization is also valid for coloration patterns in terms of energy statements. The sexual dimorphism in size is understood as a necessary consequence of the type of social system present in *T. delanonis.*

BIOLOGY & CONSERVATION SESSION
Chairman: Robert Bowman

Boersma, D, Department of Zoology, Ohio State University.

AN ECOLOGICAL STUDY OF THE GALAPAGOS PENGUIN.

The land and water environment of the Galapagos Islands is unpredictable. In this environment the Galapagos penguin has evolved unusual breeding adaptations. Unlike other seabirds, which breed annually and on a fixed cycle, the Galapagos penguin breeds irregularly on a more than annual cycle. Males and females are sexually dimorphic and can be distinguished by the size of their bill, foot, toe nail, and flipper. The timing and frequency of molting in Galapagos penguins also appears adapted to the unpredictable environment. For other species of penguins, molting occurs annually and at the conclusion of breeding. Galapagos penguins, in contrast, molt more frequently than annually as a prelude to breeding. Comparisons with Flightless cormorants and Brown pelicans indicate that other seabirds have similar breeding adaptations in an unpredictable environment.

Abbott, I, Department of Biology, McGill University.

ECOLOGY OF *GEOSPIZA* FINCHES

The foraging of six species of *Geospiza* finches and variation in their bill dimensions among islands will be discussed in terms of the stocks of seeds and fruits of different sizes and hardnesses (Bowman's hypothesis) and the morphology of competing finches (Lack's hypothesis).

Dunson, W A, Department of Biology, Pennsylvania State University.

SOME ASPECTS OF SALT AND WATER BALANCE OF FERAL GOATS FROM ARID ISLANDS.

Water intake and renal concentrating capacity of goats were studied in order to evaluate the possible use of sea water by feral goats living on desert islands. Galapagos goats were observed on the beach at Espanola Island in the dry season apparently drinking sea water; urinary electrolytes often exceeded sea water concentrations. Goats will voluntarily drink sea water if no fresh water is available and it appears that consumption of less than 4% body wt/day of sea water during dehydration has a beneficial effect in reducing the rate of weight loss. However, balance could not be maintained on sea water when eating food of 9-13% water content. Goats living on Esk Island in the dry season gain sufficient water from food plants of 52-67% water content to maintain balance. These goats have kidneys with unusually high relative medullary thickness (5.8) in comparison with domestic goats (4.9). The

maximum osmotic pressure of domestic goat urine was 2300 mOsmolal. The minimum water requirement to maintain balance under moderate temperature conditions (18-24°C) was 1.0-1.5% body weight/day for domestic goats. During dehydration a large decrease in evaporative water loss appears to be the major factor leading to reduction of total water loss.

Kramer, P, Gesamthochschule, Universitat Essen.

CONSERVATION IN THE GALAPAGOS
(See Page 3).

Owings, M, Big Sur, California.

ENDANGERED SPECIES: A WORLD VIEW

SUNFLOWER TREES OF THE GALAPAGOS

ROGER PERRY
Director of the Charles Darwin Research Station, 1964–1970

Many people know that there are different kinds of tortoises and finches in the Galapagos Islands. That each of these groups should have produced a variety of living forms in the geographically compact area of an archipelago is a subject that has been of the greatest interest to scientists ever since Charles Darwin's famous visit to the islands in 1835. "I never dreamed," he wrote as he began his long searching enquiry into the origin of species, "that islands fifty or sixty miles apart would have been differently tenanted."

Not surprisingly the unique animal life, which includes a host of spectacular reptiles and birds, has dominated evolutionary studies in the Galapagos Islands. Plants have never had quite the same popular appeal even though the giant arborescent cacti, which strike such a bizarre note amid the black frozen wastes of lava, are among the first outlandish features seen by visitors to those remote shores. Yet, from the viewpoint of diversity, perhaps even more remarkable than the giant tortoises are plants belonging to the genus *Scalesia*, locally known as the *lechosos.*

Scalesias are members of the dandelion or sunflower family. They are peculiar to the Galapagos and grow in all parts of the islands from dry coastal lowlands to the humid summit plateaux of the great volcanoes. They have been divided into a score of different species and varieties, which range in habit from low shrubs to trees forty or fifty feet high.

The 'sunflower tree' forests of the larger and higher islands are among the most distinctive biological features of the archipelago. There are three tree species forming compact woodlands, most of which have straight trunks and dome-shaped or rounded canopies of foliage. The whitish flowers are borne in heads which appear either singly or in small clusters near the ends of branches. The largest of the tree species, *Scalesia pedunculata*, grows in the highlands of San Cristobal, Santa Cruz, Santiago and Floreana, and has flattened flower heads about half an inch across. Varieties of the smaller-flowered *S. microcephala* are trees some 10-12 feet tall found on the high mist-swept cinder slops of Fernandina and northern Isabela. Forests flanking the volcanoes of southern Isabela are represented by the third species, *S. cordata*, which reaches thirty feet in height and is intermediate in some respects between the other two. This last species is rare in botanical collections.

The earliest herbarium specimen was collected by Archibald Menzies of the Vancouver Expedition in 1795. Following Darwin's visit forty years later, *S. pedunculata* was described for the first time together with three species from the lowland zones. The latest to be described (in 1941) was *S. crockeri*, which brought the total established by various authors to twenty-two.

The fortunes of the scalesias, like those of the Darwin's finches, have grown and declined at the hands of taxonomists. The necessity for name changes arises because of increased knowledge, following closer study of characters and a fresh examination of stocks isolated on the different islands or parts of islands. In the most recent published study of *Scalesia*, Dr Uno Eliasson of the Department of Systematic Botany, University of Goteborg, recognizes fourteen species, and of these five are regarded as having diverged sufficiently to warrant further division into sub-species or varieties.

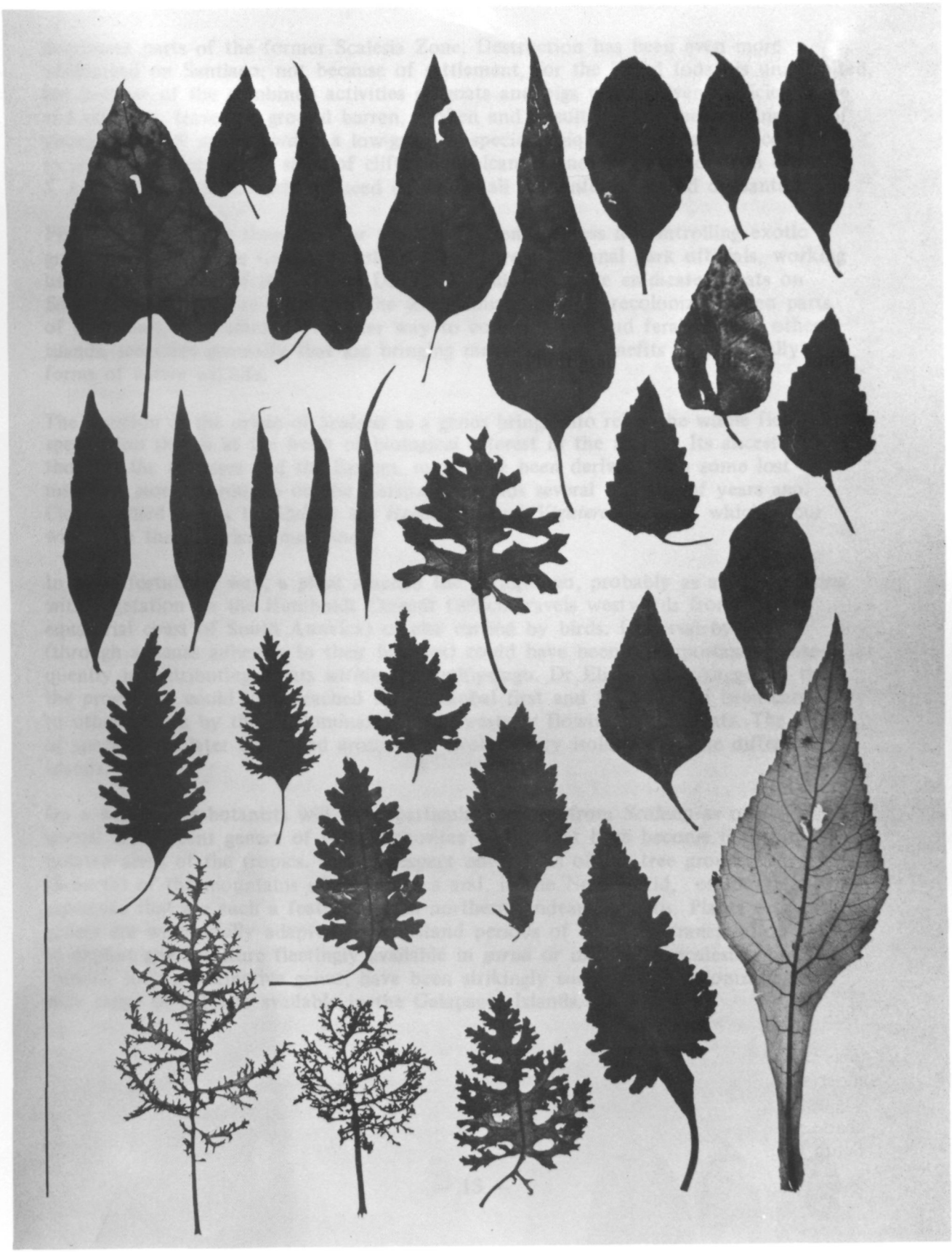
The small islands of Baltra, Pinta, Pinzon, Santa Fe, Seymour and Wolf have each one species of scalesia; the larger islands of Isabela, San Cristobal, Fernandina, Santiago and Floreana have two or three species, whilst Santa Cruz is remarkable in having six. The main island without scalesia is Marchena – an island, interestingly enough, which also lacks its own race of tortoise. It is however the lowest and driest of the islands to have been swept by volcanic activity in recent (historic) times and therefore possible that a previously existing scalesia population has been exterminated by lava flows.

The most widespread species is *S. affinis*, which grows on all the large volcanoes of Isabela and on the islands of Fernandina, Santa Cruz and Floreana. The bright green foliage is conspicuous on the bare lava fields, where the plant is often one of the first colonizers. Its leaves have a sweet fragrance, not unlike poplar, which permeates the warm close air of the Galapagos lowlands. Other notable features are daisy-like flowers with white ray-florets, a resinous sap (characteristic of the genus as a whole) and a tendency for the old leaves to persist and cloak the growing stems of the plant.

An important feature separating the different scalesias is variation in leaf shape. This may vary from the broadly ovate leaves of southern Isabela trees to the finely incised foliage of certain shrubs of the hot lowlands. Leaf shape and size, it is believed, are adaptive in character: a more divided surface increases the rate of heat dissipation by convective cooling. Again, there are parallels with the giant tortoises which tend to be smaller, lighter and to have thinner shells on the more arid islands of the Galapagos.

Ten years ago scalesia forests were widespread in the highlands of Santa Cruz. Seen from the sea they appeared as a broad undulating band of dark green beneath the reddish-coloured Miconia Belt (the latter, shrubs of the Melastomaceae with purple flowers and large red-tinged leaves). Today, both the endemic *Miconia robinsoniana* and *Scalesia pedunculata* have largely disappeared as a result of land clearance, grazing by domestic animals and burning – the formidable trilogy of destruction that was the bane of conservation work in the Galapagos Islands during the 1960s.

The tree scalesia has also declined on San Cristobal, an island which has suffered the most sustained pressures of human settlement. Interestingly enough one of the reasons suggested for its disappearance has been the introduction of guavas, trees which out-shade young scalesias. A corresponding exotic, equally troublesome in its way, on Santa Cruz is mora (*Caesalpinia bonduc*), a spiny rambling plant which now completely



Range of Leaf Variation of Scalesias. Photograph by Dr Uno Eliasson.

dominates parts of the former Scalesia Zone. Destruction has been even more widespread on Santiago, not because of settlement, for the island today is uninhabited, but because of the combined activities of goats and pigs which, given sufficient time and numbers, leave the ground barren, broken and unsuitable for the germination of young trees. *S. atractyloides*, a low-growing species unique to Santiago, is confined to isolated places on the sides of cliffs and volcanic cones out of the reach of goats. *S. helleri* has been similarly reduced on the small goat-infested island of Santa Fe.

Fortunately, the last three or four years have seen progress in controlling exotic grazing animals in the Galapagos Islands. Ecuadorean national park officials, working under the guidance of the Charles Darwin Foundation, have eradicated goats on Santa Fe and there are signs that the indigenous scalesia is recolonizing open parts of the island. Programmes are under way to control goats and feral pigs on other islands, measures generally that are bringing much-needed benefits to practically all forms of native wildlife.

The question of the origin of *Scalesia* as a genus brings into relief the whole field of speculation that is at the heart of biological interest in the islands. Its ancestor, like those of the tortoises and the finches, must have been derived from some lost mainland stock marooned on the Galapagos Islands several millions of years ago. Closely allied genera to *Scalesia* are *Helianthus* and *Viguiera*, both of which occur widely on the American mainland.

In some fortuitous way, a plant reached the archipelago, probably as a fruit drifting with vegetation on the Humboldt Current (which travels westwards from the equatorial coast of South America) or else carried by birds. Dispersal by birds (through achenes adhering to their feathers) could have been of importance subsequently in distributing plants *within* the archipelago. Dr Eliasson has suggested that the progenitor could have reached San Cristobal first and from thence been carried to other islands by the predominantly northwesterly flowing sea currents. The range of species that later developed arose from evolutionary isolation on the different islands.

On a wider note botanists will draw particular interest from *Scalesia* as one of several arborescent genera of the Compositae family that have become dominant in isolated areas of the tropics. In this respect one thinks of the tree groundsels (*Senecio*) of the mountains of East Africa and, in the New World, of the giant espeletias that are such a feature of the northern Andean *paramos*. Plants of these genera are wonderfully adapted to withstand periods of excessive transpiration and to exploit any moisture fleetingly available in *garua* or mists. The scalesias, besides forming such a distinctive genus, have been strikingly successful in colonizing the wide range of habitats available in the Galapagos Islands.

GALAPAGOS SCIENCE CONFERENCE, 1972

In 1969 an outline scientific programme for the Charles Darwin Foundation was published in Noticias de Galapagos. The object was to establish priorities both for practical conservation research and for fundamental scientific investigation. Most research work in the Galapagos is undertaken by visiting scientists, funded by outside sources, with the Darwin Station providing a base, services and advice. The programme was drafted largely with a view to helping these visitors in their choice of projects.

In 1972 it was decided that this programme needed revision and expansion and a major conference of distinguished scientists was held at the Smithsonian Institution in Washington to elaborate a new programme for the co-ordination of research in the Galapagos over the next few years and the establishment of priorities. The participants divided into working groups. Among the appendices included in the published proceedings of the Conference is the following report of the sub-committee on conservation. It members were J Dorst, P Kramer, E Laso, C MacFarland and F Ortiz.

CONSERVATION

Preamble

Galapagos conservation problems extend far beyond those that are usually thought of as being part of the functioning of a national park. Most human activities in the islands directly affect the environment, and the effects of many events on mainland Ecuador eventually are felt in the Galapagos, at least in part as a result of immigration. Added to the threat of human exploitation are the severe effects produced by introduced plants and animals.

The suggestions presented below are made with full recognition of the following :

(1) The Ecuadorian Government has passed strict laws protecting the Galapagos environment; the major problems now are enforcement, education, more research, and development of additional conservation management procedures;

(2) the Galapagos National Park Service and its parent organization, the Ecuadorian Forest Service, are responsible for formulating and effecting conservation programmes for the Galapagos;

(3) the Darwin Foundation (and Darwin Research Station), in accord with its agreement with the Ecuadorian Government, acts primarily to advise and co-operate with the National Park Service in carrying out these programmes;

(4) visiting scientists offer aid by co-operating with the National Park Service and the Darwin Research Station.

No specifics as to which organizations or individuals should carry out these suggestions are given below. Since most of the problems involve complex political issues, they clearly must be solved by the combined efforts of the National Park Service and Forest Service, other Ecuadorian governmental agencies, Ecuadorian scientists and researchers, and the Darwin Research Station. Visiting scientists can aid these efforts by such activities as:

(1) providing basic information from their studies;

(2) helping to plan conservation research programmes and design management schemes;

(3) providing field research opportunities for Ecuadorian students;

(4) teaching in courses given by the Park Service and Darwin Station;

(5) giving guest lectures, slide shows, etc, in the islands.

Threats to the Galapagos Environment

1. Human exploitation

   A. Local Population. The population of the islands has tripled since 1960, and now numbers approximately 5,500. Immigration was heavy from the late 1950's until recently and, as pressure for land ownership increases in continental Ecuador, this factor could become important again. At present a strong population growth results from a very high birth rate coupled with a decreasing death rate due to improved medical care. The lack of natural resources would eventually restrict the spread of population, but several uninhabited islands and areas on the inhabited ones are arable and have been threatened recently. This situation will rapidly worsen if the population is not controlled. The local lobster fishery is over-exploited already and others (some edible fishes, green sea turtle) could rapidly become so.

   B. Tourists. More tourists have visited the Galapagos in the 1970's than ever before. Most come via one of the major companies operating ships in the islands. So far, these companies have co-operated with the Park Service and Darwin Station and tours have been responsibly managed. Most damage done by tourists has been caused by those coming on private yachts or chartering local yachts and fishing boats. As tourism increases, the disturbance of natural habitats and the biota must be carefully monitored.

   C. Scientists. The number of scientific missions has been rapidly increasing, ie: from six in 1965 to seventeen in 1971. It is vitally important that scientists demonstrate sound conservation principles in the islands. Though the total damage has been minimal, some scientists have disturbed animal populations, allowed camp-fires to get beyond control, denuded some areas of wood (for camp-fires), and left extensive amounts of litter. Appendix III contains a list of requirements for scientists set by the National Park and Darwin Station.

D. General. Pollution is increasing in the Galapagos, especially in the marine environment. In addition to the more obvious forms (petroleum residues, litter), there is evidence that chlorinated hydrocarbons may be entering the ecosystem through atmosphere and oceanic circulations. Farmers are beginning to use "hard", long-lived pesticides. There is a continual danger of the introduction of exotics from the mainland and inter-island transfers of biota; this includes both purposeful and accidental (ticks, seeds on clothing or in soil) transport of organisms.

II Introduced species

A. Feral mammals continue to be the greatest threat to plant and animal species and to the Galapagos ecosystem as a whole.

B. At least one introduced invertebrate, the fire ant, is a major threat to many native invertebrates, eg: other ants, centipedes. Also, at least several crop pests and several diseases of domestic animals are known from the islands. Without strict quarantine procedures, these will certainly increase in number, to the detriment of the native biota and the human inhabitants.

C. A large number of introduced plants are already in the islands. Several of these have become major weeds and are replacing whole native plant communities in some areas, especially in the more elevated, wetter zones of the larger islands.

Conservation Needs

I Research

A. Socio-economic studies

1. Population dynamics – gather basic data on birth rates, death rates, immigration and emigration for the recent past, and continue such studies from now onward; it is especially vital to determine the root causes of immigration from the mainland and to follow up the movement patterns of the immigrants and their offspring; the feasibility of introducing birth control methods and population planning centers should be investigated (many local inhabitants frequently ask how to obtain such aid, but virtually none is now available).

2. Agriculture and land utilization – determine total arable areas now occupied and unoccupied, population densities, agricultural methods employed and land use patterns, crop and livestock yields, crop and livestock pests and diseases present and the amount of damage they cause, and types and amount of pesticides and herbicides being used; it will then be possible to investigate methods of improving yields without increasing the total land area utilized and to determine the carrying capacity of presently settled areas. This will require compilation of existing meteorological records

and the establishment of careful environmental monitoring.

3. Fisheries – begin compilation and evaluation of catch statistics and start long-term studies of the population dynamics of important species such as the spiny lobster, green sea turtle, and edible fishes; it would then be possible to set and control cropping levels and fishing methods.

B. Effects of tourism

Studies of the effect of tourism have been started by M P Harris at the most frequently visited sites. An Ecuadorian assistant is being trained to continue them. These should be expanded whenever necessary, continued as long as is necessary, and followed up by practical measures immediately.

C. Introduced plants and animals

1. Baseline information – detailed autecologies, long-term population dynamics, and the effects of these species on the native biota should be studied in selected sites where control programmes are not in operation; besides the rats that are presently being investigated, other destructive species urgently require attention, ie: goats, pigs, cats, dogs, and a variety of introduced invertebrates and plants.

2. Control methods – the only method now widely used is systematic hunting (for some feral mammals) and it needs to be more carefully evaluated; other methods should be tested for specific cases.

D. Endangered species

1. Studies on the basic population dynamics of the following species are needed soon: Hawaiian petrel, flamingo, land iguana, Galapagos snakes, Galapagos geckoes, the centipede, certain ant species and other invertebrates, and certain plant species.

2. Continual monitoring

   a. Animals – in some cases detailed studies of population ecology are being continued; for others, a minimal requirement is that frequent counts be made in standardized quadrats or along established transects; the following species are most critical: flamingo, Hawaiian petrel, cormorant, penguin, albatross, plus some cross section of the land birds, rice rats and fur seal, all reptiles. Furthermore, the status of the invertebrate fauna urgently needs investigation.

   b. Plants – regularly sampled, permanent quadrats should be established on a number of islands at various altitudes and where introduced mammals are both present and absent.

E. Pollution monitoring

1. Pesticides – studies should begin immediately to establish baselines, followed by frequent checks; the following species are suggested :

   marine: brown pelican, sea lion, a predatory fish;
   terrestrial: lava lizard, hawk or owl, a predatory invertebrate.

2. Petroleum wastes, plastics, other pollutants – routine surveys should be made, at least in some of the most affected areas such as main ports and anchorages.

F. Marine studies

The paucity of marine studies in the Galapagos is obvious, and it is important to extend the National Park boundaries beyond the shoreline; as a first step we need:

(1) a faunal survey;

(2) regularly sampled permanent quadrats in the littoral zone;

(3) basic population studies of some cross section of at least the more prevalent species.

II Education

A. Local population

1. Adults – at present, discussions, lectures or slide shows are occasionally presented in the port village on Santa Cruz; these should be expanded to include all the inhabited islands and the meetings ideally should take place in local villages, both in the highland agricultural zones and in the ports; important discussion topics include the unique natural history of the Galapagos, comparison of the islands to polluted industrialized countries, and the common interests of settlers and conservationists (eg: maximizing agricultural production in already settled areas, elimination or control of crop pests and ferals such as the black rat, the value of establishing quarantine procedures). Conservation and natural history courses and radio programmes for local authorities, teachers, park wardens, and other community leaders should be continued and expanded.

2. Children – the present teaching by station and Park Service personnel should be continued; additionally, special lectures, slide shows, and movies could be given occasionally, and course teaching packets, demonstration materials (photos, slides and simple projectors, charts) etc, could be provided to school-teachers.

3. General – exhibits will be prepared soon at the Darwin Station and National Park Service headquarters; similar smaller exhibits could be installed on the other three inhabited islands; an additional tortoise breeding/raising center is planned for San Cristobal – such a "conservation in action" demonstration could be placed on southern Isabela also.

B. Tourists

1. Guided tours – the current courses for guides should be expanded and improved.

2. Other tourists – two simple pamphlets explaining National Park laws and the important of the Galapagos are being prepared for private yachts and tourists travelling on chartered yachts and fishing boats.

C. Mainland Ecuador

Educational methods such as Galapagos Information Centers, courses for schoolteachers, films, and lectures need to be extended to the continent; a secondary school level textbook is currently being written, and a primary level one has been completed.

D. Ecuadorian scientists and students

1. Students – present programmes should be expanded; this will depend upon additional funds and the willingness of visiting scientists to become involved in such training; the Darwin Station can act as a clearinghouse for matching up scientists and students, and scientists could request money for field assistance when applying to granting agencies.

2. Scientists – money for basic research is rarely available in Ecuador; research grants and fellowships for Ecuadorian scientists to study in the Galapagos should be sought from international sources; this would include encouraging Ecuadorian students who are pursuing doctoral studies in other countries to do their research in Galapagos.

E. Foreign scientists and students – every researcher working at the Darwin Station must be made aware of his responsibility strictly to follow the National Park and conservation laws of the country and must understand the need of his contribution to Ecuadorian science as a teacher and technical advisor.

III Enforcement of laws

A. Monitoring – it is proposed that permanent wardens be stationed on boats in certain critical areas; initially Isla Genovesa and the Punta Espinosa area are considered the prime sites for both conservation and scientific needs; additional sites for future stations are suggested to be Espanola, North Seymour, and Punta Albemarle and Iguana Cove (both Isabela).

B. Quarantine procedures should be established in the near future at all ports; proper educational programmes should prepare the way for their acceptance.

GIANT TORTOISE BREEDING AT THE DARWIN STATION

The latest figures show that 470 young tortoises belonging to 7 subspecies have now been raised at the Station.

The transfer of eggs of the Pinzon (Duncan) race to the Station's hatchery was begun in 1965/66, when it became clear that black rats had killed off every hatchling on this island for half a century. Repatriation of young tortoises, once they were big enough to stand up to the rats, began in 1970. So far 122 young, born at the Station, have been returned to their native island, where regular inspection shows them to be thriving.

By 1965 the tortoises on Hood (Espanola) were reduced to perhaps 15 survivors, so scattered that they had lost touch and were no longer breeding. To save the race from extinction, as many as could be found were removed to the Station. Since 1971, they have been producing fertile eggs and there are now 52 young, bred from one male and 11 females. This year a second male has been discovered and has joined the breeding stock, which should further improve the prospects for this subspecies. Transfer of young to their ancestral island will begin in 1975.

The Darwin Foundation is now confident that, provided the rearing programme and the control of introduced animals are continued, 10 out of the 11 surviving subspecies can be saved for posterity. The exception is the Pinta (Abingdon) race. Once believed extinct, a single male was recently discovered and brought to the station; but even the demonstrated skill of the Station staff can hardly ensure breeding unless a female can be found on rugged Pinta Island or unless some zoo can produce a certified specimen of this otherwise doomed race. Crossing with subspecies from other islands would be scientifically undesirable.

The spectacular breeding successes of the Station, gratifying as they are, cannot result in any immediate population explosion as it appears that the long-lived giant tortoises do not begin to reproduce until they are something like 50 years old. Some distant day they may again lumber across the lava in the incredible numbers that so astonished the good Bishop Tomas de Berlanga in 1535 when he accidentally discovered "Las Islas de los Galapagos", (The Islands of the Tortoises). Meanwhile we can at least be thankful that, in the nick of time, the Darwin Station's rescue operation has reversed the fatal trend after so many years of tragic decline.

NEWS ITEMS FROM THE GALAPAGOS NATIONAL PARK SERVICE AND THE CHARLES DARWIN RESEARCH STATION

GALAPAGOS: A NEW PROVINCE

In a special ceremony on 17 January 1973 at Puerto Baquerizo, Ministers, officers of the Ecuadorian Navy and other guests assembled to hear General Guillermo Rodriguez Lara, President of the Republic, declare the Galapagos archipelago a province. In his speech, the President placed special emphasis on "the promised support for the development of the colonized areas which will in no way disturb the areas dedicated to conservation".

PRESIDENT'S VISIT TO THE STATION

The President visited the Darwin Station on 20 February and inspected the buildings and installations. He was particularly impressed with projects which the Station is carrying out in collaboration with the National Park Service and the growing Ecuadorian interest in protecting Galapagos flora and fauna for scientific and recreational use which this co-operation signifies. The Park Service and the Darwin Station extended their thanks to the Head of State and his party for their visit.

INTER–MINISTERIAL STUDY GROUP

On 20 January 1973, a Commission representing eight government Ministries and Agencies began a four week visit to the islands to plan the future development of the Province of Galapagos. Organized by the Ministry of Agriculture's Department of Forestry, the Commission's principal object was to compile information on Galapagos development requirements and to study the economic and social situation with a view to finding solutions compatible with the well-being of the population and the conservation of the unique resources of the National Park. A full report of the Commission's findings, plans and programmes was produced in April.

RAT CONTROL

It seems certain that introduced rats cannot be totally eradicated from the Islands, but there is hope that they can eventually be controlled in areas where they are endangering certain species, particularly the Giant Tortoise and Hawaiian Petrel. On Pinzon, black rats had destroyed every young tortoise for the last half century, while in the highlands of Santa Cruz, they were eating almost all eggs and young of the rare Hawaiian Petrels.

In readiness for the last tortoise hatching season, a rat poisoning scheme was organized in the nesting area on the western slop of Pinzon, and no hatchlings were killed during that period. Protecting the offspring of the Hawaiian Petrels at first sight seemed

somewhat easier since one had only to make sure that no rats entered the Petrel burrows until the young fledged, but rain and high humidity in the highlands quickly spoiled the bait. We are trying to overcome this difficulty by mixing the poisoned bait with parafin which makes it waterproof. Much further investigation is needed and a small research team is spending two years camping in the Santa Cruz highlands, where the endangered Petrels breed.

VISITORS TO THE NATIONAL PARK AND DARWIN RESEARCH STATION

In addition to persons already mentioned, we had the pleasure of receiving the following visitors in 1973 :

Dr M ACOSTA S, President of the Ecuadorian Institute of Natural Sciences;
Sr C BONIFAZ J, Member of the Executive Committee of the Darwin Foundation;
Dr T FEINANGER, Professor of the Polytechnical School of Quito;
Dr A ARMAS, of the Ministry of Public Education;
Ing A MARTINEZ, of the Ecuadorian Institute of Agrarian Reform and Colonization;
Sr J LOPEZ P, Chief of the Aerological Station of San Cristobal;

visited us for the IV Natural Sciences Course which took place between 24 July and 4 August.

Dr H JUNGIUS, Conservation Officer of the World Wildlife Fund – 10/16 January.
Ing A PONCE, Chief of the Department of National Parks and Wildlife – 16/20 March.

Mr G T CORLEY SMITH, Secretary General of the Charles Darwin Foundation for the Galapagos Islands – 28 April to 22 May.

Research Expeditions which ended their work in the months of July 1972 through May 1973:

Miss D BOERSMA and Miss S CLONINGER, Ohio State University, Dept of Zoology, Columbus, Ohio 43210, USA : Studies on the Ecology of the Galápagos Penguin. *(Spheniscus mendiculus).*

Dr B NORDLIE and Assistants, Dept of Geosciences, University of Arizona, Tucson, Ariz 85721, USA : Vulcanological studies on Fernandina and Isabela.

Expedition of the Cambridge and London Universities, led by Mr Ian CLARK, Fitzwilliam College, Cambridge, CB3 0DG, England: Study on the Movement and Food of the Giant Tortoises.

Dr C RACINE, Ohio State University, Dept of Botany, Columbus, Ohio 43210, USA: Co-evolution of Darwin's Finches and Plants.

Miss M HARO, Institute of Sciences, Catholic University of Quito, Ecuador. Distribution of introduced plants in the archipelago.

Miss E CACERES, Institute of Sciences, Catholic University of Quito: Observations and Experiments on the Ecology of Certain Species of the Interstitial Fauna.

Mr Ole HAMANN and wife, University of Copenhagen, Institute for Systematic Botany, Gotherscade 140, Copenhagen, Denmark: Mr Hamann worked for a year as UNESCO Associate expert in Galápagos. He investigated the distribution of plants and plant associations and the influence of introduced herbivores on the indigenous plant. cover. He also assisted in the administration of the Darwin Station.

Dr R MITCHELL, Ohio State University, Dept of Zoology, Columbus, Ohio 43210, USA: Specific aspects of the Ecology of the Red Crab *(Grapsus grapsus)* and the Marine Iguana.

Dr J DOWNHOWER, Ohio State University: Study on the Interrelation between the Darwin's Finches and the plant species they feed upon.

Dr R U GOODING, Smithsonian Institution, Washington, DC 20560, USA: Study on the simbiosis of the Sea Urchin with other Marine Invertebrates.

Dr Peter C H PRITCHARD, Dept of Zoology, University of Florida, Gainsesville, Florida, 32601, USA, and Mr M CIFUENTES, Institute of Sciences, Catholic University of Quito, Ecuador: Continuation and Extension of the Study on the Pacific Green Turtles.

Mission of the II. Zoological Institute of the University of Gottingen, 34 Gottingen, Berliner Strasse 28, German Federal Republic, composed of Drs P AX, R AX, J EHLERS, S HOXHOLD, P SCHMIDT, and W WESTHEIDE: Study of the Composition and Ecology of the Microfauna of the Beaches of Galapagos.

Dr T SIMKIN, Secretary for the Americas of the Charles Darwin Foundation, Smithsonian Institution, Washington, DC 20560, USA: Continuation of Studies on the Geology of Fernandina Island.

A NEW DIRECTOR OF THE

CHARLES DARWIN RESEARCH STATION

Dr Peter Kramer resigned in December 1973 from the post of Director, which he had filled so successfully since September 1971, in order to take up new duties at the Gesamthochschule, Universitat Essen. He first visited the Galapagos in 1962-63 when he was a member of an ornithological research mission. The Darwin Foundation and his many friends in three continents will long remember his great work for conservation in the Galapagos during these critical years in the development of the islands and their National Park. Our best wishes go with him, Frau Kramer and their young son.

Dr Kramer was succeeded by Dr Craig MacFarland of the University of Wisconsin. Like his predecessor, he first came to the islands as a research worker. He and his wife devoted two strenuous years to the study of the giant tortoise. His expert knowledge, arduously won amid the lava slabs and the cactus, will now stand him in good stead as the rescue of these unique tortoises from the threat of extinction has been and remains one of the Darwin Foundation's chief preoccupations. We wish him and his family another happy and successful stay in the Galapagos.

During the interim between Dr Kramer's departure and Dr MacFarland's arrival, Dr Tjitte de Vries gallantly volunteered to take on the onerous duties of Acting Director of the Station, in addition to his scientific work. The Darwin Foundation is deeply indebted to him for his stalwart services on this as on many previous occasions.

FUNDACION CHARLES DARWIN PARA LAS ISLAS GALAPAGOS

CHARLES DARWIN FOUNDATION FOR THE GALAPAGOS ISLANDS

FONDATION CHARLES DARWIN POUR LES GALAPAGOS

Créée sous les auspices de l'Organisation des Nations Unies pour l'Education, la Science et la Culture (UNESCO)

Buts et objectifs de la Fondation Charles Darwin pour les Galapagos (Art 2 des Statuts, Bruxelles, 23 juillet 1959)

L'Association est chargée de l'organisation et de la gestion de la Station de recherches "Charles Darwin", dont le gouvernement de la République de l'Ecuador a autorisé l' établissement dans l'archipel des Galápagos à l'occasion du centenaire de l'énoncé de la doctrine de l'évolution (1858–1958).

L'Association propose aux autorités compétentes toutes mesures propres à assurer, dans l'archipel des Galápagos et dans les mers qui l'entourent, la conservation du sol, de la flore et de la faune, et la sauvegarde de la vie sauvage et de son milieu naturel. Elle arrête le programme de recherches de la Station biologique et la charge de toutes etudes scientifiques en rapport avec les objets ci-dessus.

Elle recueille et gère les fonds destinés au fonctionnement de la Station et à la promotion des recherches qui y ont leur base.

L'Association veille à la diffusion, par tous moyens appropriés, du résultat des travaux de la Station et de toutes informations scientifiques relatives aux réserves naturelles.