NOTICIAS DE GALAPAGOS

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CONTENTS

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NEWS FROM ACADEMY BAY

PRESIDENT FEBRES CORDERO VISITS THE GALAPAGOS

Just 450 years after their accidental discovery by Bishop Tomás de Berlanga and 150 years after Charles Darwin's visit, the President of the Republic, Ing. Léon Febres Cordero, made a personal tour of the Galapagos Islands before defining his new government's policies and re-drafting the Master Plan for the archipelago. He visited the National Park Service and the Darwin Research Station and in a major speech dealt with the respective interests of the local population, the tourist industry, conservation and science. He promised improvements in education, health care and housing and paid tribute to the important role that tourism now played in the national economy. He continued:

> "You can be confident that the scientific work which the Charles Darwin Station has carried on since 1964 will continue to be encouraged by the national government and that we shall strengthen the National Park. Although we have been concerned with the promotion of tourism in the islands, we have never for a moment had, nor ever can have, the idea of subordinating to tourism the essentials of what are both a national heritage and a world heritage: cultural values, scientific research and ecological conservation, which will continue to excite the admiration of the whole world."

On his return to the mainland the President declared that his visit had been a marvellous experience and had revealed to him why the islands were called a World Heritage. He said:

> "We need to endow the islands with a basic infrastructure but without commercializing them ... which would be a crime not only against the nation but also against humanity."

The President added that the National Park would be provided with a staff adequate for its protection and that tourists' fees would in future be paid into a special account for the Park instead of going into the general funds of the Treasury.

ORDEAL BY FIRE AND WATER

The Galapagos National Park Service and the Charles Darwin Research Station are accustomed to crises — they are to be expected in the wild Galapagos — but these last two years have produced even more emergencies than usual. First there was the extraordinary El Niño phenomenon of 1983 with temperatures, rainfall and floods disrupting the normal breeding process and endangering some populations of endemic species, as well as halting various conservation and scientific projects.

This was followed by a drought in 1984 and the lack of water contributed to the difficulty of fighting the fire that broke out in the station's administrative building. This was a severe blow to the CDRS but the situation is now being restored thanks to the generosity of supporters and in particular of the Ole Enquist Fund which contributed $70,000 through the agency of WWF — Sweden.

In 1985 much worse occurred. A great conflagration broke out on 26 February when farmers at Santo Tomás on southern Isabela set fire to diseased coffee bushes and this spread into the National Park. The El Niño rains had induced an abnormally heavy growth of vegetation which had dried during the drought and become highly combustible. International aid was organized in addition to support from continental Ecuador but inevitably took a long time to take effect because access to Sierra Negra volcano, where the main danger was concentrated, was so difficult. Ecuador mobilized some 300 soldiers and 140 local residents to dig a 50 kilometre trench to halt the spread of the fire. Canada sent two flying boats to dump tons of seawater (there was no water available on land) on critical areas. The U.S. Agency for International Development sent fire-fighting experts from the U.S. Forestry Service whose spokesman described the inferno:

> "In my 25 years of fighting forest fires I have never encountered problems like the ones we have faced here. The heat is so intense we have become delirious at times."

By April the fire seemed under control but still far from being completely extinguished, as it is fuelled by ancient humus and roots as much as two metres in depth. The rescue operation has apparently made sure that most of the Sierra Negra race of Giant Tortoise will survive though they may have to be transferred to other areas where food supplies have not been destroyed. The four other races of tortoise on Isabela seem safe as each is confined to its own volcano, separated from the others by bands of naked lava. The marine animals — iguanas, fur seals, sea lions, penguins and flightless cormorants — should be safe, likewise the

flamingoes and nesting seabirds, but no-one can guess the damage to small birds, reptiles, insects and plants, including quite possibly species still unknown to science, as the investigation of this wilderness is still incomplete. All we know is that some 40,000 hectares of unique terrain have been devastated with unpredictable ecological consequences.

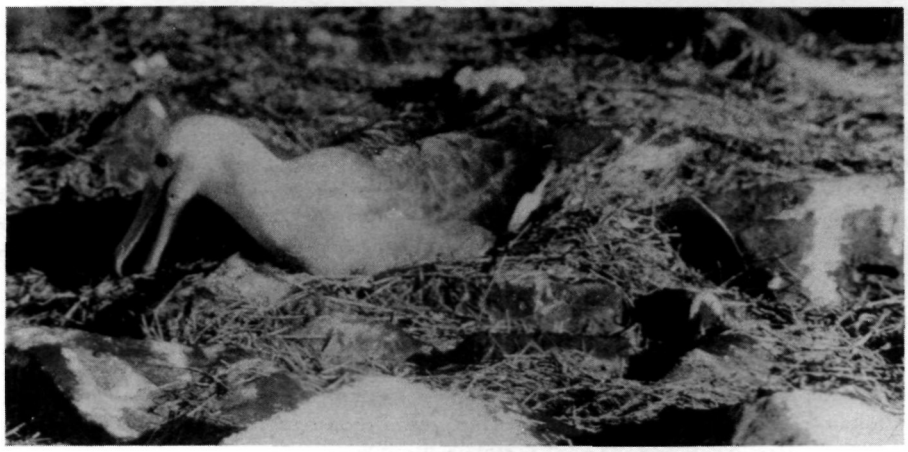
Another complication, with even less predictable consequences, is the mass human invasion of this ecologically fragile area. When scientists and park wardens go into the more strictly protected zones of the National Park, they disinfect their clothing, equipment and food so as to avoid introducing alien organisms. Even with these precautions accidents occur. The very thought of several hundred fire-fighters with all their transport, equipment, supplies, food and water entering this restricted area fill conservationists with apprehension.

In this and recent issues of Noticias, various reports have tentatively tried to assess the outcome of the El Niño event of two years ago. It will take much longer to assess the consequences of the Isabela fire. One of the few things that can be predicted with confidence is that the inadequate resources of the Charles Darwin Foundation and the National Park Service will be put under greater strain than ever.

UNUSUAL REPORTS ON THE GALAPAGOS ALBATROSS

There are some 12,000 pairs of the Waved Albatross of the Galapagos *(Diomedia irrorata)* but apart from a few pairs on Isla de la Plata, off the coast of mainland Ecuador, it breeds only on Española (Hood) Island and healthy birds have not hitherto been reported elsewhere on land. Outside the breeding season it roams the Pacific off Ecuador and Peru. However, in 1984, several Naturalist Guides reported sightings of this, much the largest Galapagos bird with a wingspan of 7-8 feet, at Tower (Genovesa) Island. On March 29, Godfrey Merlen observed for 10 minutes a single Albatross flying over the cliffs lining Darwin Bay. On 11 April, Alison Prideaux reported 7 birds at the top of Prince Philip's Steps on the same cliffs; all 7 were on the ground; 3 pairs were in courtship and two copulations or attempted copulations were observed. A further 3 Albatrosses were seen in the same area on 25 April, flying over the lava slabs where an estimated 200,000 pairs of Wedge-Rumped Storm Petrels nest. Finally, on 2 May Lynn Fowler watched an Albatross on the beach at the head of Darwin Bay for 10 minutes before it took flight.

The Waved Albatross lays a single, large, white egg between mid-April and June and the last young fledge the following January. The egg is deposited on the bare ground and many birds have a curious and unexplained habit of rolling their egg from place to place, which often results in the egg falling into a hole or coming to rest against a large stone in a position which prevents incubation. Catherine Rechten reported that in 1983 large numbers of eggs were simply washed away by the El Niño floods. It was therefore with surprise and interest that Godfrey Merlen, on 14 October 1984, watched and photographed a Waved Albatross building a nest on Hood. The bird, which had lost one eye, was sitting in the middle of its nest, drawing material to it from all sides and forming a well developed concave nest, out of which an egg could only be rolled with difficulty.



Waved Albatross
photographed in the unusual act of nest-building
by Godfrey Merlen

Could there be any connection between these instances of unusual behaviour and the drastic effects of the previous year's El Niño, which virtually eliminated breeding? Because of the heavy rains, the scant vegetation on arid Hood had flourished abnormally and there was an unusual supply of twigs and stems; but it scarcely explains how this particular bird had the instinct to build a nest. And there is still no adequate explanation of why the Albatross should roll its egg.

As they travel constantly between the different islands, the Naturalist Guides can act as the eyes and ears of the National Park Service and the Darwin Station and their expert observations make a valuable contribution to both science and conservation.

PROTECTING THE HAWAIIAN PETREL

Felipe and Justine Cruz are satisfied that the 72 Petrel chicks, which they reported as fledged in Noticias 40, eventually flew off successfully. By the time the chicks are fledged they are considered quite big enough to fend off an attack by a black rat though they could still be eaten by a cat or a pig and therefore need continued protection.

The Hawaiian Petrel lays only one egg. It is highly gratifying that 72 young birds should be raised from 100 nests. The 28 failures were attributed to a variety of causes, mostly to loss before the eggs hatched, though a few unfledged chicks were abandoned by their parents. It is interesting to note that so far there seems little evidence to justify the fear that constant visiting by the wardens might interfere with breeding success, either by disturbance or by attracting predators to the nests. A "control" colony of 40 active nests, situated within the same protected zone on Floreana but visited only twice in the season, fledged roughly the same percentage of chicks.

A new breeding season is already well under way on Floreana and the protecting team, with continued WWF support, has two new initiatives: to discover whether the rate of success can be maintained with a smaller expenditure of labour and money; and to investigate the possibility of extending the protective scheme to Santiago (James) Island with the help of students from Guayaquil University.

SEALION GIVES BIRTH TO TWINS

On other pages in this issue, there are reports on the unusual fertility in 1984 of animals which suffered heavy population losses during the 1982-83 El Niño event. The sealions fell into this category and Sylvia Harcourt has sent this graphic account of a Galapagos sealion actually giving birth to twins, a most unusual occurrence.

"At 8.30 am on December 14th, I was on the beach at Punta Suarez, Española (Hood Island) and observed a female sealion that had just given birth to a pup. Both female and pup were calling and nuzzling each other. The pup was still wet and the umbilical cord trailing. The female then started straining and groaning and I assumed she was about to expel the afterbirth. This went on for at least half an hour and she was obviously in some discomfort. Finally something started to be expelled but it looked too thick and black to be the afterbirth and after a few more minutes it was apparent that it was another pup. The mockingbirds were constantly following the female and started pecking at the emerging pup. Finally, after about 20 more minutes it was expelled and the female ripped open the birth sac. The pup started to call within a few minutes.

The female seemed confused at hearing two calls and was definitely paying more attention to the first pup. If both pups called together, she would check that she had the first one beside her and then she appeared satisfied. However, she made no aggressive move against the second one and nuzzled it and called when it too was beside her. As the tide started to rise, she moved up the beach; the second pup got left behind and had to struggle up on its own, while the first one was carried.

We watched the family intermittently until 4.30 and by that time both pups had been seen to suckle well. Unfortunately we then had to leave Punta Suarez so we could not follow them through their first few days to see if both survived. The whole process was recorded on film by Dieter & Mary Plage of Survival Anglia Television and sound recordings were made.

As far as is known, this is the first unequivocal evidence of a twin birth of Galapagos Sealions *(Zalophus californianus wollebaeki).*"

CDF OFFICERS DECORATED BY THE GOVERNMENT OF ECUADOR

On their respective retirements from the posts of President and Secretary General of the Charles Darwin Foundation, Peter Kramer and G.T. Corley Smith were awarded the National Order "Al Mérito" for their services to science and conservation in the Galapagos Islands. In various capacities they have been concerned with the protection of the archipelago's environment since the early 1960's and both have served as the principal officers of the CDF for more than ten years. Peter Kramer's farewell address on relinquishing the office of President is printed on another page.

STAFF CHANGES

José Villa, deputy director, has resigned and returned to the mainland after 5 years' service at the Darwin Research Station. His connection with the Galapagos goes back much further, as he and Juan Black were the first two conservation officers of the Galapagos National Park Service when it was created in 1968. He transferred from the GNPS to the CDRS in 1979 and has given distinguished service to both bodies. José has been succeeded by Mario Hurtado who, owing to the Station's straightened financial circumstances, has also taken over the functions of staff marine biologist. As a member of the National Institute of Fisheries and as a collaborator of Derek Green in his long-term studies of the Galapagos marine turtles, Mario has already been associated with the CDRS for years.

Luong Tan Tuoc, staff botanist, has returned to the United Kingdom on completing his term of service. His duties have been temporarily taken over by Henning Adsersen.

THE QUESTION OF RE-INTRODUCING GALAPAGOS HAWKS TO CERTAIN ISLANDS — A CLARIFICATION

Tjitte de Vries wishes to clear up a possible ambiguity in his article in Noticias 40 (page 12). He did not mean to assert positively that *Buteo galapagoensis* had never existed on Floreana or San Cristóbal but only to say that he had never found any definite record. He would be grateful if anyone having evidence would communicate with him.

VISITS AND EVENTS AT THE CHARLES DARWIN RESEARCH STATION

June 1984

Ping-Hong Tze, University of Hamburg, embarked in the research vessel "Sonne".

Malcolm Coulter concluded his latest period of study of the Blue-footed Booby and returned to the USA.

John Stupakoff arrived from USA to assist Yves Finet, Belgian marine biologist.

Kent Beaman and Floyd Haynes came to continue the study of the Giant Tortoises on the Alcedo volcano.
Robert Cedeno, CDRS scholarship-holder, began his thesis on "The role of conservation in the Galapagos economy".
Tomyo Sasaki and Ernest Gusella completed their video tapes of the flora and fauna.
The President of the High Court of Justice, Guayaquil, visited the Charles Darwin Research Station (CDRS).

July

Stamford Smith, Lynn Hendrix, Penny Wolf and John Thomson began their study of the growth of plants on the Fernandina volcano since the 1968 eruption.
Raul Moscoso (Charles Darwin Foundation), Manual Valencia (Vice-president of the Chamber of Representatives), José Cuenca (Univ. of Guayaquil) and Patricio Alvear (National Council for Development) came to discuss current problems.
David & Lee Steadman began their research on Galapagos vertebrate paleontology.
CDRS Director, Günther Reck, left for Quito to take part in the 25th anniversary celebrations of the Galapagos National Park and the Charles Darwin Foundation.
After serving nearly 3 years as staff botanist, Luang Tan Tuoc returned to Britain.
Ashley Boren of The Nature Conservancy visited the station prior to opening the campaign to raise an endowment fund for the Charles Darwin Foundation (CDF).
Training course for National Park Service Wardens began.
Ole Hamann, CDF Vice-president, arrived for administrative and botanical purposes.
Wallace Harmon, Albert Hawbecker and Richard Christiensen came to assess the incidence of *Trichomanas gallinae* among Galapagos doves.

August

Kenneth Margolis, Director of The Nature Conservancy, arrived with his wife.
Bonnie Barnes left on completing her collection of molluscs for the Univ. of Brussels.
Dieter and Mary Plage, Friedemann and Heidi Köster of the Anglia Television team, left on vacation.
Efráin Pérez and Pablo Intriago, National Institute of Fisheries, came to re-organize the marine laboratory and take water samples.
A technical commission representing various official bodies began a study of the present and potential value of the agricultural zones of San Cristóbal, Floreana and Española with the aid of satelite photographs.
Derek Green, in charge of turtle research and protection 1975-80, paid a return visit to CDRS.
Training Course for Auxilliary Tourist Guides began.
Peter, Rosemary and Thalia Grant left after yet another spell in their long-term research on Darwin's finches.
Fritz Trillmich, Max-Planck Institute, returned with his assistant, Carlos Drewes, to continue their study of the Galapagos Fur Seal.
Robert Pratt and Juan Nieto of the U.S. Field Engineering Corp. came to repair the seismograph.
Linwood Fiedler (Denver Wildlife Research Inst.) and Fausto Maldonado (U.S. AID) came to develop methods of rat control.
José Villa, Deputy Director of the Darwin Station, left on retirement. He began as one of the first National Park conservation officers in 1968.

September

Malcolm Coulter returned to help with the census of Galapagos Penguins and Flightless Cormorants and to monitor the Blue-footed Boobies.
Training course for Naturalist Guides began.
Nematullah Sharaf came to make large-scale maps of various islands with the help of aerial photographs.
Eduardo Arboleda and Marco Robles took up their posts as station manager and accountant, respectively.
A Japanese commission arrived to examine possibilities of using solar energy.
Dalton Maridueña, Dean of the natural sciences faculty of Guayaquil Univ., came to update the agreement between the University and the Darwin Research Station.
Phyllis Bentley arrived from U.S.A. as a volunteer assistant.
Gerry Kooeyma and Phil Thorson joined Fritz Trillmich in his Fur Seal studies.

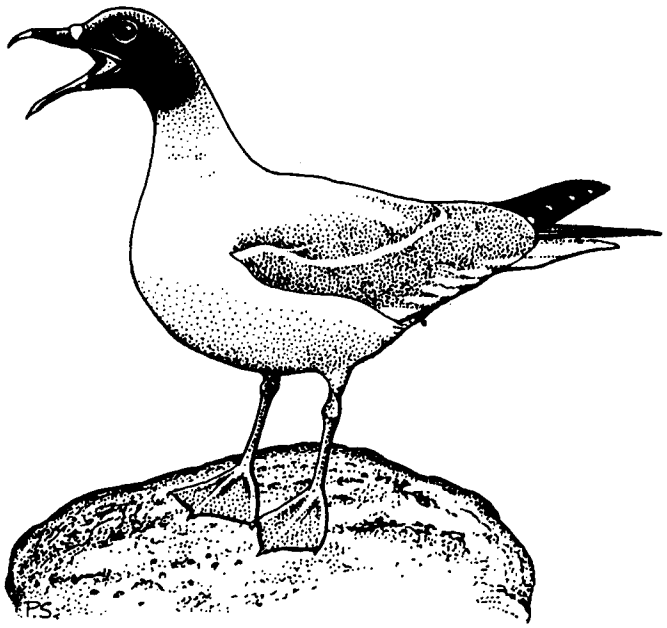
HAROLD JEFFERSON COOLIDGE: A TRIBUTE

Harold J. Coolidge has died at the age of 81. He was born in 1904 and became a pioneer in the field of international wildlife conservation. From an early age he devoted his life to the protection of the world's natural resources and, through sixty years of relentless endeavour, lived to see conservation grow from the eccentricity of a few to a preoccupation of many. Even the words "wildlife conservation" and "ecology" had scarcely entered the general vocabulary when he began his career.

Hal was a Founder Member of the Charles Darwin Foundation and a driving force in its activities. I first met him in the Galapagos when he marshalled the proceedings for the inauguration of the Research Station in 1964 under the blazing equatorial sun. Our last meeting, only two years ago, was also in the Galapagos, where he had returned to view with deep pride how much had already been achieved in the struggle to rescue these unique islands from environmental degradation. The Galapagos owe him a tremendous debt of gratitude.

But his role in the Galapagos enterprise, enormously important though it was, was only a fraction of his achievement. His influence extended to every continent. He was involved in the promotion of the major environmental organizations of our time, including The World Wildlife Fund. For years he presided over the International Union for Conservation of Nature and until his death remained its Honorary President. He was a great leader and he will be sorely missed but his work will live on and his name will be remembered in the recently created Coolidge Center for Environmental Leadership.

G.T. Corley Smith



Swallow-tailed Gull
Drawing by Peter Scott

FAREWELL ADDRESS OF PETER KRAMER TO THE COUNCIL OF THE CHARLES DARWIN FOUNDATION

Dear Colleagues and Friends,

I take leave of you with a little sadness and also a little relief: sadness because I am going away (but only a little way) from you, from this kindly country and from the Galapagos Islands which have played such a large role in my life; relief because I no longer have the principal responsibility for what happens to the Foundation and the Research Station.

But my chief feeling is one of confidence: confidence in my successor who is my friend and a man with the heart and mind needed for this responsibility, confidence in all of you, who as individuals or institutions have contributed, are contributing and will continue to contribute to the conservation of these irreplaceable islands, the patrimony of both Ecuador and Humanity.

I take advantage of this meeting to offer two basic recommendations:

I introduce the first with a bit of personal history. On my first visit, 22 years ago, I came by ship; it took me three weeks to Guayaquil where I had to wait another month for a boat to Galapagos. In those days the trip in the legendary "Cristobal Carrier" took four days. Altogether two months to reach Galapagos, while today one can do it in two days!

The difference between then and now is that the isolation of the islands has been reduced. These islands, like any others, owe their specific character entirely to their historic isolation and, as a former resident of the islands who has experienced the social reality of island life, I want to mention that human life too owes its character to the isolation of island communities.

In all the future master plans, action plans and operational plans for Galapagos that indubitably will be elaborated and, one may hope, implemented, please remember:

a) The uncontrolled introduction of alien plants, animals and micro-organisms means the destruction of the unique, endemic biotic communities and at the same time threatens the healthy development of agriculture, animal husbandry and the human communities.

b) In the matter of social isolation, I consider it absolutely essential to maintain a living standard, which, as at present, is clearly on average higher in the islands than in continental Ecuador. Nevertheless, it must be added that isolation is not just something to be endured but is also something to be enjoyed, a specific quality of island life.

The second recommendation that I want to leave with you is that you should maintain international collaboration for the conservation of the Galapagos. You, the Ecuadoreans, are the ones who are responsible for these islands and no-one can deny you this responsibility that for a century and a half you have discharged so admirably. We, the foreigners, who come from countries which not only have their own environmental problems but also are the cause of environmental problems in the third world, must understand and recognize that there are good historical reasons for the suspicions that sometimes exist in this country that we want to meddle and intervene in national matters. You, Ecuadoreans, I beg you to recognize that even if we are impatient and sometimes even rude (as indeed we are in our own countries) we are never trying to interfere but simply fighting as internationalists in the cause of future generations of all the peoples of this earth.

I repeat and reaffirm with satisfaction that the international conservationist community unanimously recognizes the positive results of the efforts, past and present, of this country in favour of Galapagos conservation.

Let us continue to work together. Our movement was relatively feeble when it had only minority support from Ecudoreans; if international collaboration were lost, that too would lead to weakness. Together we are strong.

THE 1982-83 EL NINO: SOME OF ITS CONSEQUENCES FOR GALAPAGOS WILDLIFE

by

Godfrey Merlen

Casilla 2542, Quito, Ecuador

Noticias has published several reports on the effects of the phenomenal El Niño event of 1982-83. These have been written by scientists and have mostly been concerned with the particular section of the flora or fauna which the author was studying. Godfrey Merlen has been serving as a Naturalist Guide in the Galapagos National Park for over four years and his occupation, which involves much travelling around the scattered islands of the archipelago, has given him an unequalled opportunity to gain an overall view of the consequences of the most catastrophic El Niño for at least a century. He has assembled his impressions in this article, which has already appeared in ORYX, the very distinguished journal of the Fauna & Flora Preservation Society. Because it provides a more complete picture of the consequences of the extraordinary event, we have thought it of interest to our readers to reproduce it here and Godfrey Merlen has very kindly added a postscript, bringing the story up to January 1985. As mentioned in Noticias 40, page 23, he is also selling prints of his watercolours in aid of the conservation work of the Darwin Research Station. — Ed.

At irregular and unpredictable intervals exceptionally warm surface waters appear in the central and eastern tropical Pacific Ocean, disrupting climate and ocean coditions. The occurrence is referred to as El Niño* and it usually begins in December, around Christmas time (El Niño is Spanish for Christ-child).

In order to place El Niño in context, it is worth outlining the usual seasonal pattern in the eastern equatorial Pacific. In the cool season, when many Galápagos animals breed, the south-east trade winds blow. These winds are a vital climatological facet in the productivity of the eastern Pacific, drawing surface water off the coast of South America and allowing cold nutrient-rich water to the surface to recycle its wealth. On these nutrients depend the organisms which are food for millions of birds, mainly boobies, cormorants and pelicans, and which are also the base for the extraordinarily productive anchovy fishery on the west coast. The winds also drive huge sections of the surface waters of the Pacific Ocean westwards, causing a rise in sea-level in the western Pacific. Part of the return system is via the North Equatorial Countercurrent, which passes well to the north of the Galápagos archipelago. Another section returns as the cold (15.5°C at 100m depth) Cromwell Under-Current. Its core may be 200m thick and 400km wide and somewhere between 20 and 250m below the surface and within 50km of the equator. It is this current that causes unstable water mixing within the Galápagos and is of great importance in preserving the extraordinary diversity of animals, some of which are of subantarctic origin. The sea surface temperatures may fall as low as 16°C. In December there is a change to a warmer climate as the Intertropical Convergence Zone (area of convergence of the north-east and south-east tradewinds and also represented by the Galápagos front which separates warm freshwater from the North from cool saltwater from the South, waters advected by the wind systems) moves southwards and the sea temperature increases.

Since 1940 there have been 10 'warm events' or Niños. The most obvious feature of one of these exceptional years is a rise in sea surface temperatures. The question is, where does this come from? In 1982-83 there were believed to be two sources: (1) warm water in large quantities from the northern Panama area, and (2) an unprecedented supply of warm water travelling from the western to the eastern Pacific. Some believe this first source to be principal cause of most Niño years, with hot water appearing off the west coast of South America and moving westwards until it may affect the whole equatorial region. The second source is apparently more rarely associated with the Niño years, although studies are in their infancy. There is a suggestion that the 1982-83 Niño was in fact two events, the first triggered in the western Pacific, which peaked in the east in December-January and perhaps masked the arrival of the hot conditions from the north, which persisted as high sea surface temperatures (4-8°C higher than normal) until June-July in the Galápagos, and which might have been a Niño in its own right.

* According to the definition of the Scientific Committee on Ocean Research (Working Group 55), El Niño occurs when the monthly mean departures of sea surface temperatures from the 25-year long-term monthly mean value exceed 1 standard deviation for four consecutive months at three of five coastal stations of Peru (Talara, Puerto Chicama, Chimbote, Isla Don Martin and Callao). At the end of 1982 surface temperatures exceeded the long-term means by 5 or more standard deviations at most of these stations (Halpern *et al.*, 1983).

Although little is yet known about the ultimate cause, or causes, of El Niños it seems that the abnormal conditions may be associated with changes in the normal relationships between pressure areas in the Pacific: the pressure gradient is virtually reversed, allowing equatorial westerlies to blow (i.e. from the west, whereas the normal wind flow is towards the west). The gradient in 1982 was greater than had been ever recorded since records began 35 years previously and the resultant winds were strong. Because of the imbalance already set up in sea-level heights across the Pacific, these winds triggered sub-surface wave patterns to surge across this ocean, carrying warm water with them. The Eastern ocean level rose by up to 45cm (about twice the usual annual change), due to decreased density in the upper water column caused by increased temperature; this in turn may be related to local heating or advected water. With the wind behind the sea, extensive flooding occurred on the coast of mainland Ecuador. It also allowed troughs to form in both hemispheres and the formation of tropical cyclonic storms, some reaching hurricane force, which in unprecendented strength and number hammered their way through French Polynesia. The westerlies, which began in July 1982, had by December 1982-January 1983 reversed the current flow of the equatorial surface waters and from mid-January to mid-February the cold Cromwell Under-Current disappeared to at least 250m depth at 109°W. The temperature at 100m was 27.5°C, 1°C cooler than the surface. This is 12-13°C warmer than in inter-Niño years. This huge volume of very warm water inundated the tropics of the eastern Pacific as far as the west coast of the Americas and set the scene for ecological drama.

Warm water invasion

Having summarised the background environmental changes that occurred during the period July 1982 to December 1983, I would like to make specific reference to the main Niño area, the coastal areas of South America within the tropics, and the Galápagos Islands in particular. The unparalleled invasion of warm water into the region had two major outcomes. First, a very high rate of evaporation developed and strong convection currents wafted the wet air to high altitudes, producing magnificent cumulus and cumulo-nimbus cloud formations, which resulted in storms of exceptional intensity. Between October 1982 and July 1983, 3264mm of rain were recorded at the Charles Darwin Research Station; an average figure is 254mm a year and the area is classified as a botanical desert. Secondly, the upper 100m of the sea became very stable. The blue, clear warm water may have been aesthetically pleasing but, nutritionally, it was a frightening, empty place. The productivity of the sea is extremely complicated, but the one most important factor is the recycling of essential elements to the surface, or at least to the zone that is reached by sunlight. I do not believe that anyone envisaged how rapidly this altered environment would be reflected in the web of life.

Tortoise exodus

If we consider two zones in the Galápagos, the arid, low-altitude areas characterised by scrub and cactus forest, and the rich intertidal and submarine environment, we find the effects of the two major features of El Niño are to reduce species diversity and abundance. The super-abundance of rain causes considerable damage to crops, removes topsoil, sends torrents of water surging and cascading down the ravines to the coast. According to Alf Kastdalen, a Norwegian who arrived in the islands in 1935 and was a keen observer of Galápagos nature, these ravines were filled 14 times in 1940-41, when there was another exceptional El Niño which also began out of season. In 1982-83 the ravines flowed more than 30 times. But Kastdalen also pointed out that since the 1940s man has damaged the ground in the farming areas by fires, by removal of the spongy moss-liverwort cover and protective shrubs, and by the development of a hard pan by ever-increasing cattle movement; thus these factors could account for the increased run-off, at least in part.

Flood waters coursed through the Tortoise Reserve on Santa Cruz and so unnerved the giant tortoises that they abandoned their highland homes for the drier coastal lands. Linda Cayot, studying tortoise — plant relationships, give up her study as an initial migration turned into a rout, and no tortoises were seen in the highlands for several months. Although in the past it has been difficult to imagine inter-island colonisation by these enormous beasts, it is not now difficult to visualise them being swept into the ocean by the violence of the floodwaters. Where the waters flowed they left a swath of destruction, with *Opuntia* cacti snapped like twigs in a gale.

The effect of the rain varied with species. Some plant families, especially the Convolvulaceae, responded with extraordinarily luxuriant growth. *Ipomoea* sp. and *Merremia aegyptica* on the coast, and *Stictocardia tiliifolia* in the highlands, climbed up and over rock, bush and small tree, submerging all in undulations of verdure, as if green snow had fallen. The appearance of ponds all over the islands offered great opportunities to insects. Hood Island became untenable by human beings because of the massive

explosion of mosquitoes (*Aedes* sp.) and perhaps by the blue-faced boobies *Sula dactylatra,* whose chicks had bare necks from irritation by these parasites. And on the land, insect larvae, which stripped bushes of their leaves, provided abundant food for terrestrial birds whose populations are usually limited by the lack of protein foods for the young. The amazing comparison between the breeding seasons of the Darwin's finches in the years 1982 and 1983 on the small island of Daphne Major will serve as an example. In 1982 60 nests were started at the beginning of the rainy season; all were abandoned for lack of food. But from December 1982 to the following June 1000 young birds were ringed. Some pairs bred four or five times and some birds hatched early in the season were themselves breeding by June. The genetic variation which must now be available is staggering. Soon selection pressure will bear down more heavily as more stringent times approach, but the future of the species must be optimised by these explosions in numbers.

Diasaster for seabirds

I would like to remark here, albeit unscientifically, that the impression one had in 1983 was of organisms caught in the circumstances of the times and as victims of fate rather than as finely-adapted results of evolution. The solid, water-storing trunks of the tall *Opuntia* cacti may adapt the plants to outcompete other species in normal conditions but that endowment did not stop the engulfing vines, nor did it prevent them being felled by their own weight as the pads became engorged with life-giving or death-bringing moisture.

The coastlands are the main reproductive area for the seabirds and here disaster struck, an outcome not restricted to Galápagos. From Christmas Island (157°W, 2°N), which has huge populations of terns — the colony of sooty terns *Sterna fuscata* alone is estimated at 14 million — shearwaters, frigatebirds, red-footed and blue-faced boobies, Ralph and Anne Schreiber (1983) reported: 'During our visit in November 1982 we discovered virtually a total reproductive failure on the island; the bird populations had essentially disappeared, and many dead and starving nestlings were present.' Although Galápagos cannot boast of such enormous colonies, the effect on its seabirds was similar. Heavy rains swamped the nesting areas of the boobies, ruining many eggs, and pathetically sodden birds were trying to ease the eggs out of puddles with their bills.

The waved albatros *Diomedea irrorata* of Galápagos had a very poor year in 1982, with about 60 per cent egg desertion, most probably from lack of food, and 1983 was even worse. Cathy Rechten abandoned her studies of this species after she ended up watching, within her whole study area, one incubating adult, and that not even incubating its own egg. Not only were eggs destroyed by rain, but many fell through the dense ground cover which had grown up, and were lost. By the end of December 1982 there was a stark contrast between the lush vegetation and the desperately begging young albatrosses finding no succour from their parents, which had spent days scouring the blue, vacant water. Despite the disastrous season, they returned at the end of March 1983 to try again, even though the productivity of the seas had not improved.

The shortage of food became acute and affected all animals that have a relationship with the sea. There was a remarkable correlation between increasing sea surface temperatures, rainfall anomaly and sardine catch (Chavez *et al.*, 1983). By December 1982 the catch was falling; in February-March 1983 it checked itself momentarily as the temperature fell slightly; in April 1983 it plummeted to zero as temperatures soared to 25°C — a 10°C anomaly.

Soon, those animals that could flee did so. Blue-footed boobies *Sula nebouxii* vanished from their colonies and were not seen in any numbers on their breeding grounds until June-July 1983. Although the blue-faced boobies *S. dactylatra* persisted in trying to raise their young well into 1983, by the time the blue-foots were returning the blue-faced boobies had vanished. The beautiful endemic swallow-tailed gulls *Creagrus furcatus* also disappeared early in the year and only started to return in June. Even now, in December 1983, I have only seen one bird with an egg, although much courtship is in evidence. One missed their buoyant flight of white over black basaltic rocks.

The breeding of the Red-footed Booby, *Sula sula,* was less affected by El that that of the other seabirds.

Frigatebird failure

The great frigatebirds *Fregata minor* had a spectacular display season in April-May 1983 and then apparently completely abandoned all attempts to breed. The salt bush *Cryptocarpus pyriformis* plants on top of which they breed, would be growing lank by now if it were not for the fact that the red-footed boobies *S. sula* have moved in, taking advantage of the absence of the frigatebirds, and are keeping them cut back by removing twigs for nesting material. The red-foots have bred continuously during this difficult time, although at a lower rate, for they are adapted to feeding far from land in impoverished water on prey species such as flying fish and squid.

The failure of the great frigatebird is interesting because they are apparently catholic feeders as far as fish species are concerned. This either means that a large number of shore species disappeared or went deeper in the water, or that frigatebirds are much more dependent on stealing other birds' food than I had realised: with boobies not returning to their colonies, food of this kind was indeed scarce. The traditionally fished grouper, bacalao *Mycteroperca olfax,* was not caught for many months. In its place we had a prodigious influx of yellow-finned tuna *Thunnis albacorus,* dorado *Coryphaena hippurus* and wahoo *Acanthocybium solandri,* all blue-water predatory species. Sharks and turtles fled south, as did many birds, probably following the boundary of water masses where some mixing was still occurring.

Plight of the flightless

Some could not flee. Surveys of Galápagos penguins *Spheniscus mendiculus* and Galápagos flightless cormorants *Nannopterum harrisi* revealed that the numbers of penguins fell from 1720 in 1980 to 398 in 1983, and that numbers of flightless cormorants were reduced to 409 from 802 in the same period (Valle, in press). It will require another survey in 1984 to verify the damage done to the populations as these figures may reflect a very wide scattering of members of the species and could account for the setting up of new colonies of flightless cormorants, normally an extremely sedentary species.

Seaweeds and corals died everywhere. On average about 90-95 per cent of hermatypic corals (reef-forming corals — which are characterised by the presence of symbiotic unicellular algae in their tissues) died. The loss of the endosymbiotic algae *(Dinophyceae),* whose photosynthesis contributes food and aids in skeletal formation, appears to be critical for these animals. Stress from various sources may cause the loss; amongst these may be pollution and shading, also rain run off may cause an imbalance in osmotic pressure causing rejection of the algae. This may have been the reason for the separation within the Archipelago. This was true of genera such as *Pavona, Porites* and *Pocillopora,* and soon the naked white domes were covered with a monotonous filamentous alga. However, I was fascinated to see that the unattached fungus corals, which, when I last saw them in June 1983, were looking extremely vulnerable, alive but transparent, revealing every detail of their fine calcareous skeletons, had in fact survived and by November 1983 were once again clothed in green and brown.

Iguanas starved

The marine iguanas *Amblyrhynchus cristatus* have shown themselves to be very vulnerable and poorly adapted to these changed times. They seem to depend upon certain species of algae and are unable to deal with many others because of the limited ability of their stomach microbes to break down the cellulose of cell walls (Andrew Laurie, pers. comm.). With the death of whole carpets of algae such a *Ulva* spp., the iguanas were doomed. Thousands died. Their skeletons now lie under nesting cormorants.

The population of Galapagos Fur Seals, *Arctocephalus galapagoensis,*
suffered heavy losses during the 1982-83 El Niño but is since making a vigorous recovery
Photo by Fritz Pölking

The fur seals *Arctocephalus galapagoensis* and *A. australis* in Peru both fared very badly. These animals are shallow divers (30m or so) and feed mostly at night, perhaps largely on squid, and the rise in water temperature may have inhibited the vertical migrations of these animals or may have caused them to migrate laterally. In any case, by mid-February all but one pup of 90 originals were dead from starvation at Cape Hammond on Fernandina Island. It was a pathetic sight to see the hard outlines of vertebrae and ribs as food became more and more scarce. Pup mortality, from limited observation, was 40 per cent in 22 days for *A. australis* at Punta San Juan in Peru, where water temperature anomalies were similar to Galápagos (+9°C). In 1979 pup mortality was estimated to be 10 per cent during the first month of life.

The turn of the wheel

The event ended abruptly, in July 1983. Rainfall figures at the Darwin Station for July were 278.2mm and for August 5.2mm. This coincided with a strong increase in the south-east trade winds and a 2-3°C drop in sea temperatures. Up to December 1983 there was no sign of a re-entry of warm water.

Although all life was affected, with some species experiencing a population explosion and others a dramatic decline, none was, as far as we know, eliminated by these changes and perhaps many survive as they are because of these periodic 'tests of strength'. It is difficult now (December 1983) to appreciate the extent of the events that occurred; the islands seem so normal. The swallow-tailed gulls, sharks and turtles are back; boobies are displaying in their old haunts; marine iguanas lie fat beside new green algal beds; the grouper are back and fishing is good; flamingos and flightless cormorants are raising their young; penguins are moulting, a sign of possible breeding. And the old giant tortoises, which may have lived through several such seasons, have ambled back to their highland ranges, using the stream beds cleaned by the thundering waters. The wheel has turned.

POSTSCRIPT: JANUARY 1985

1984 has been a cool dry year, and although the cyclic events of tropical rainstorm and *garua* seem to be establishing themselves again into thier regular seasons, the Niño year of 1982-83 has left in its wake changes that will take many years to eradicate.

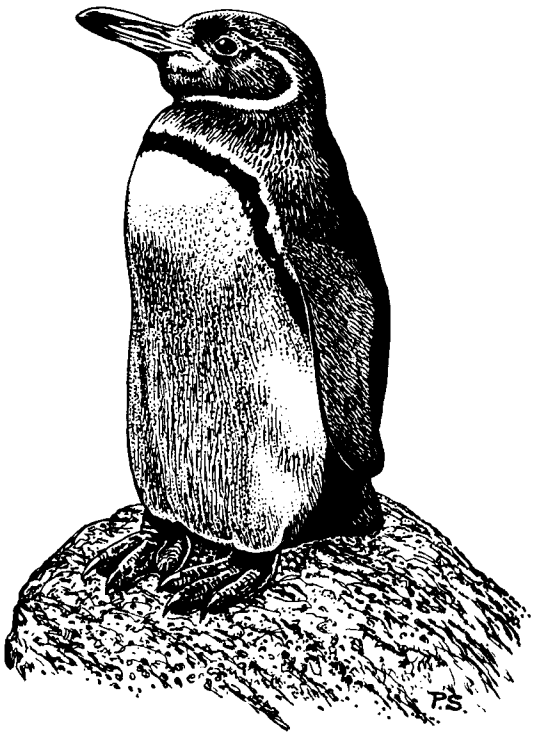
The enormous quantities of rain that fell (3264mm) were followed by a mere 151.2m for the same period a year later (November-July 1983-1984), according to records at the Charles Darwin Research Station. This is a low precipitation even when compared to other dry years and it has tended to reverse the trend of the Niño year with aquatic organisms being more successful while terrestrial species suffered in some cases severe reductions in their swollen numbers.

It has become obvious that the Flightless Cormorant, although needing man's assistance to face the peril of invading dogs, is quite capable of responding unaided to improved natural conditions. The latest (September 1984) census figure of 869 shows that there are possibly more birds now than before the Niño season, with vigorous reproduction being maintained into 1985. Unfortunately that other flightless bird, the Galapagos Penguin, is not showing the response that had been hoped for. The census of these small marine birds is extremely difficult and the fact that one can see recently moulted and post-Niño juveniles gives hope for the future. However, there is still cause for concern, especially since we do not know the factors restricting their recovery. Knowledge of the physiology of these birds and their environment is still very limited.

The response of other organisms has been as varied as that of these two flightless seabirds. The Fur Seals, having lost nearly all the young born in the four years 1980-83 and possibly 30% of the adult population, have responded with a very active breeding season, there now being no less than 250 pups in the study area of Fritz Trillmich; the females are in good condition and the yearlings heavier than in other years. Not only do the oceanic waters seem to have become once again highly productive, from primary producers on up, but also the reduced intraspecific competition gives each individual a greater chance to improve its condition and therefore to breed more successfully. This may also be said of the Marine Iguanas, where Andrew Laurie's study on Santa Fe is showing females to be in excellent condition, heavier than expected. At this time (January 1985) the males are jousting fiercely on the Galapagos shores to establish their territories.

The underwater environment shows masses of near-shore fishes, turtles and sharks, especially the hammerhead, while the *bacalao* fishery is characterized by heavily laden boats low in the water. For the Heliaster Starfish (2 species, one endemic) and that attractive bright green urchin *Lytechinus semiturberculatus* the outlook still seems dubious because they are conspicuous only by their absence, though perhaps they survive in some remote areas.

The corals still show a very slow regrowth. On many coral heads the die-off has been complete and the invading filamentous green alga covers everything; but on other heads, where small patches remained living, regrowth is occurring although it will take decades at the present rate before the pre-Niño condition is restored. It should be noted that, because of weak coral reef development in the Galapagos due to the low average sea temperatures, the highly complex ecosystems of reefs in other seas are not dominant, so the present loss of much of the hermatypic coral may not have such a profound effect on other organisms.



Galapagos Penguin *Spheniscus mediculus*
Drawing by Peter Scott

On the whole I think it fair to say that Galápagos is already showing its old face again. On a recent journey around the archipelago we saw amazing nesting activity of the teeming Blue-footed Boobies at Vicente Roca, where the cold, upwelling waters (15.8°C) were recycling the vital minerals to the upper photic zone. We saw Galapagos Penguins at the Mariela Islands, Punta Espinosa and Tagus Cove. Masked Boobies were busy in courtship at Punta Suarez, Hood Island, and the Great Frigatebirds were just beginning their courtship on Tower. The ubiquitous sealions have given birth to countless pups, even two pairs of twins are recorded. One of the symbols of Galápagos, the beautiful Swallow-tailed Gull, has been breeding successfully and many ethereal black and white fledglings are to be seen. The flamingoes, even after losing the Espumilla lagoon as a feeding area due to sedimentation, do not appear to have been greatly affected; a calculated 11.6% reduction in adult birds after the Niño year is not important. Perhaps the extreme tolerance of salinity changes by the Artemia brine-shrimp may have helped them to survive. A very good breeding year in 1984 was recorded on Floreana for that otherwise endangered seabird, the Hawaiian Petrel.

That most organisms are opportunistic seems to have been borne out by the 1982-83 El Niño experience. Cuckoos, anis, finches and rice rats multiplied enormously in the wet weather only to be violently cut back by the re-establishment of more normal regimes of climate. On the other hand, seabirds and aquatic mammals, reduced by the nutritionally impoverished state of the ocean, became prolific breeders as soon as advantageous conditions returned.

REFERENCES

Chavez, F., Barber, R.T. and Vazquez, F. 1983. Progression of the 1982-83 El Niño off northern Peru. *Tropical Ocean-Atmosphere Newsletter,* **21**, Special Issue II, pp. 26-28.

Halpern, D., Hayes, S.P., Leetma, A., Hansen, D.V. and Philander, S.G.H. 1983. Oceanographic observations of the 1982 warming of the tropical Eastern Pacific. *Science,* **221**, pp. 1173-1175.

Schreiber, R. and E.A. 1983. Reproductive failure of marine birds on Christmas Island, fall 1982. *Tropical Ocean-Atmosphere Newsletter,* **16**, pp. 10-12.

Valle, C. Amilcar. In press. Census of cormorants *(Nannoptrum harrisi)* and penguins *(Spheniscus mendiculus)* around Fernandina and Isabela. *Charles Darwin Research Station 1983 Annual Report.*

TWO GALAPAGOS BOOKS

Boletín Científico y Téchnico, Vol. VI, No. 3, published by the National Institute of Fisheries, Guayaquil, 1984, 163 pages, 300 sucres.

This collection of papers (in Spanish with short English summaries) on the marine biology of the Galapagos includes:

A preliminary evaluation of the characteristics of *Mycteroperca olfax* from the biological and fishing points of view, by W. Tito Rodriguez P.

Lobster fishing in the islands, 1974-1979, by Günther K. Reck.

A statistical study of the nesting of the Green Turtle, *Chelonia mydas,* 1976-82, by Mario Hurtado.

Investigations into the exploitation of Black Coral (Antipapthes panamensis) by Priscila Martinez and Gary Robinson.

The population structure of the Sally Lightfoot Crab (Grapsus grapsus) and the human impact on this species, by Edith Herrera V.

Methods of improving the production of salted and dried fish in the islands, by Tim Bostock and René Mosquera.

Report on the stranding of six Beaked Whales on Baltra Island, by Gary Robinson, Friedemann Köster and José Villa.

Galapagos : Studies and Investigations of the Gruppo Ricerche Scientifiche e Tecniche Subacquee of the Zoological Museum of the University of Florence. Edited by Baldassare Conti. 426 pages. (1982).

This beautifully produced volume includes sixteen essays by members and associates of the first Italian scientific expedition to the Galapagos (1971), sponsored by Ludovico Mares. Half the articles are in Italian, half in English. The emphasis is largely but by no means entirely on marine biology. The book is richly illustrated by black & white and colour photographs, drawings and maps.

G.T.C.S.

FRIGATEBIRDS, AGGRESSION AND THE COLONIAL HABIT

by

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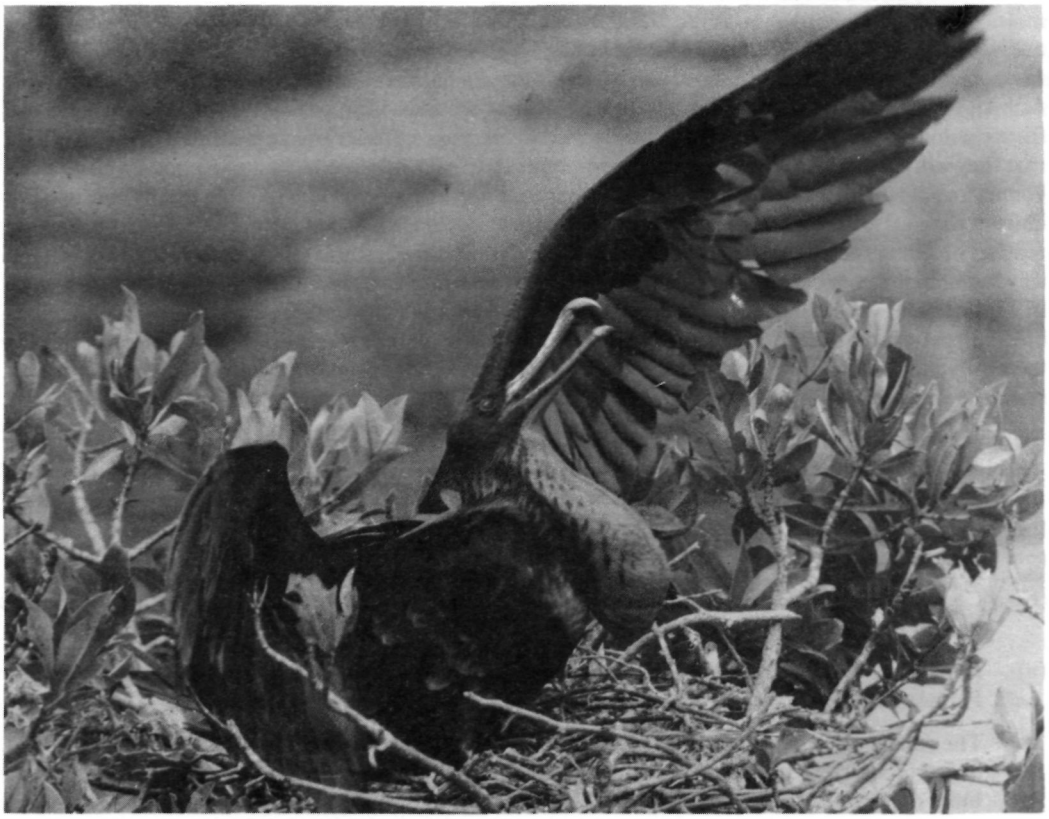
Since I first studied *Fregata minor* on Tower Island (Genovesa) in 1964, establishing that the breeding cycle took considerably longer than a year and suggesting that successful breeding could occur only once in two years (Nelson 1968, 1976), substantial work has been conducted in other parts of the world, particularly the Carribbean (Diamond 1975) and on Aldabra in the Seychelles (Reville 1980). To this reason must be added the results of several years' further work in the Galapagos by de Vries and his helpers. This article addresses some of their findings and in particular the interpretation, reported by de Vries (1984). Except where stated otherwise, 'frigate' refers to *F. minor*, the Great Frigatebird.

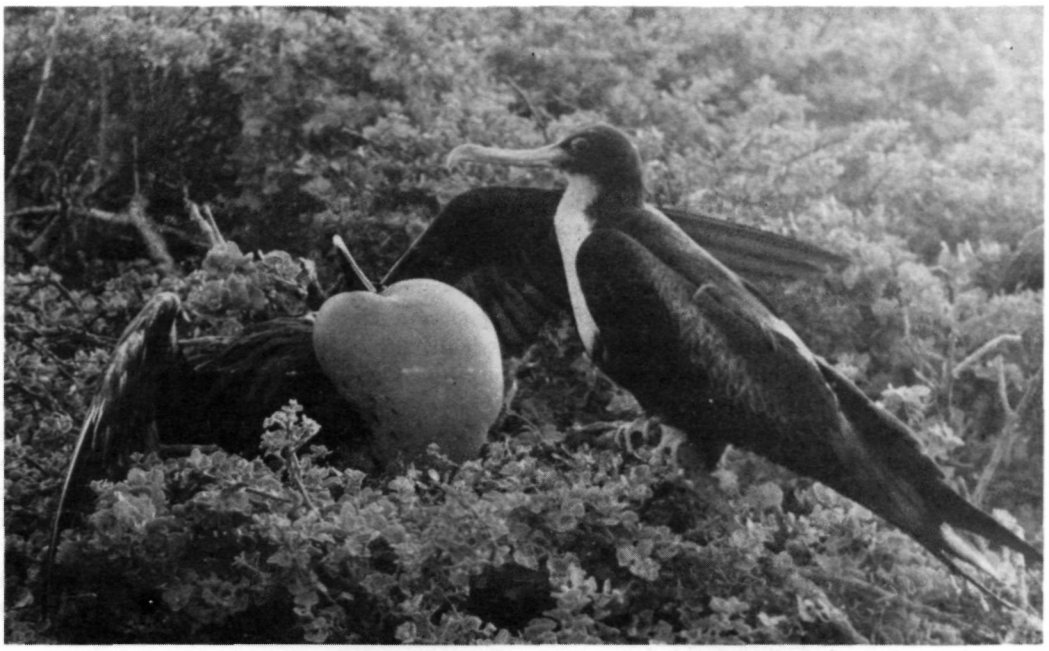
One of the functions of aggressive behaviour is to ensure that the breeding unit, usually a pair, has an adequate territory. It may therefore seem anomalous that a species should be both territorial and colonial, spaced-out and concentrated into (often large) breeding aggregations. For seabirds, however, the smallness of the territory implied by their colonial habit is readily understandable since their territory is merely a land-base, a patch on which to establish a pair-bond and then to breed. It need furnish only a meeting place and a site for egg(s) and young. Nevertheless, some seabird species compete extremely strenuously even for such a small patch, implying by the efforts and risks thus involved that adequate sites are to some extent limited. It is often (though not always) plain to see that there are plenty of *physically* adequate sites and that the competition relates to less obvious features. At this point evidence becomes extremely thin and each species must be assessed within its own particular context. To ascribe the advantages of colonial nesting to *social* factors merely invites the question: what sort of social factors?

Because of their unusual (biennial) breeding cycle frigates complicate this particular question even more than most seabirds. To begin with, they are highly unusual in that they are in fact notably *un*-aggressive in defence of their territory. Most seabirds begin to defend a particular site *before* they build a nest and lay their egg(s). Frigatebirds do not. On the contrary, the males gather into close-contact clusters in which they display to over-flying females, but they do not vigorously defend their display perch. They do not fight in defence of it nor do they possess an aggressively-motivated, site-ownership (territorial) display. Indeed, it would be maladaptive to do so, since the perch is often transitory; it may be abandoned if the male is unsuccessful in attracting a female, in which case he moves elsewhere. As I will describe, this remarkable lack of territorial aggression has important correlates later in the breeding cycle. Once the male has paired, which he does on his display site where he is 'chosen' by a female (who thus acquires site and mate in a single response) he *does* defend that spot, which will shortly hold the nest. He lunges, snaps at and briefly grapples with potential intruders but, even now, he has no ritualised territorial display.

The frigate's unusual territorial system may be discussed in terms of its causes and consequences. The causes seem clear: at least two of the major advantages enjoyed by highly territorial seabirds are denied to the male frigate. These are (i) the occupancy of a static site on which to display and advertise his receptive state to a prospecting female and (ii) the ownership of a site to which both he and his mate of the previous cycle can return to be re-united for subsequent cycles. This semi-permanence of site and pair-bond is of significant benefit to a long-lived seabird and has evolved in many of them. These two advantages are denied to the frigate because the habit of moving his display site precludes (i) above, and this display habit, together with the biennial cycle, precludes (ii). Biennial breeding means that there are *two* breeding populations (not necessarily or even likely to be halves), one laying, let us say, in years A, C, E, etc. and the other in B. D. F., etc. Thus there can be no guarantee that the site which a particular male used in year A will not be in use, in year C, by *another* pair whose dependent offspring (egg laid year B) will still be in possession of it. Further, if such a male *were* to insist on re-occupying his former site he would necessarily forfeit his habit of joining any display group that happened to be elsewhere. And group-display is obviously an important characteristic. So, for the frigate, a semi-permanent territory is simply not an available option and the territorial behaviour which would support it is not necessary. It is important to have de Vries' concrete evidence from marked individuals, that, as I predicted, frigates do not in fact return to the same site or the same mate in successive cycles.

The biennial cycle which affects so much frigate behaviour is the result of the slow growth of the chick and its prolonged dependence which in turn stems from the extremely demanding circumstances of the frigate's foraging and feeding mode in the context of the impoverished tropical oceans which it inhabits.





Top: Male Great Frigate-bird displaying; orienting to female flying over, sac mainly deflated.
Bottom: Great Frigate-bird. Male with throat sac inflated, and female.
Photos by J.B. Nelson

One correlate of this notable absence of territorial defence seems to be that interference by conspecific males is extremely common, with the dramatic consequences that I described from my 1964 observations and which others have confirmed. Eggs and young are tossed out of the nest or (in the case of some young) eaten, carried away or simply mauled on the nest. This can happen even if, as is normally the case in pairs with an egg or very small chick, one parent is on or near the nest (incidentally, we still lack evidence that frigate colonies which are completely undisturbed by humans suffer in this way, although it seems likely that they will do so). The advantages to the perpetrators of such behaviour (excluding those which eat the young, an act which, incidentally, is *feeding* rather than *aggressive* behaviour) remain totally obscure. It is quite erroneous to use a "preservation of the species" argument, as for instance that such behaviour reduces breeding success and thus regulates the population, since natural selection cannot operate in this way but only through individual or kin-selection (see, for example, Dawkins 1978). Why, then, do they do it? I do not know, but one may speculate that there may be social advantages, such as that by disrupting breeding pairs, non-breeding males increase the supply of available and experienced females and thereby their own chances of acquiring such a mate. The key to understanding may be to establish the identity and status of the disrupting males.

Clearly, aggressive behaviour in defence of territory is a cost/benefit equation and although the costs of the frigate's sytem may seem high, either they are bearable (otherwise frigates would not have survived) or the populations which have been studied are a-typical, which seems unlikely. But what are the benefits of the *colonial* habit which, in conjunction with the poor territorial defence, makes interference by conspecifics so easy? There are several possibilities.

(i) Communal display facilitates pair-formation. It is energetically extremely costly for the male to remain on land, displaying. Reduction of this period would confer worthwhile advantage.

(ii) It may be advantageous for a female to be able to choose a mate from a group of displaying males. Female choice evidently *is* exercised, though on what grounds we have no idea.

(iii) The enhanced synchronisation of egg-laying which results from communal nesting may make the use of temporarily abundant food (as often happens in the tropics) more effective as a proximate timer of laying. That is, more birds are enabled to take advantage of a temporary flush to complete the early and costly stages of breeding. Another potential benefit of synchronisation is that it reduces the period during which interference by conspecifics can occur. Reville (1980) has shown that on Aldabra, where both *F. minor* and *F. ariel* breed, the former is more synchronised and has greater success than the latter. Yet, of course, colonial breeding itself makes conspecific interference easier — again a cost/benefit equation that applies to both species.

The control of the size of the frigate population is a matter of immense interest. Is it the case that factors external to the frigate, such as food shortages, and *inescapable* social costs in the cost/benefit equations (such as the one discussed above in connection with territorial aggression) keep productivity low? Or can one plausibly suggest that the frigates themselves "keep" productivity low, implying an element of choice? I adhere firmly to the first of these and do not accept that the second is a viable alternative. In the seabird species that I have studied, and in all detailed work of which I am aware, the evidence supports the contention that each species rears as many young as it can, within the constraints imposed by factors such as the need to avoid damaging stress on adults. In the frigate's case, environmental factors can cause heavy loss of eggs and young and this is compounded by losses due to conspecific interference. Certainly we need to understand the nature of that interference, but I see no justification for interpreting it as a mechanism of population control. The low productivity is a fact and it is the nature of the factors that keep it low which we must investigate. For example, the evidence given by de Vries (1984), even if inconclusive, that frigates may wait three or four years after breeding before attempting another cycle accords well with other evidence that breeding is an extremely demanding process. Such an interval may be necessary to avoid damaging stress on the highly non-expendable adults. It is interesting to note that Abbott's booby *(Sula abbotti)* which, like the frigate, is one of the very few biennially-breeding tropical seabirds, also takes 'rest' years (Nelson & Powell, in press). There is no need to postulate that these aspects of breeding are mechanisms for *reducing* recruitment, and every justification for supposing that they have evolved because they *maximise* lifetime productivity.

In sum: frigates breed in groups (whether one calls such a group a 'colony' or the whole aggregation of groups a 'colony'); they are rarely if ever forced to do so by physical shortage of sites. As a consequence of their particular *social system,* including biennial breeding, which system itself derives from slow breeding due to ecological factors, frigates are relatively un-aggressive and un-territorial. This exacerbates the

effect of intra-specific interference by non-breeding males, a phenomenon which is not aggressive in the usual 'defence of territory' sense but is a special behaviour whose function we do not understand. Despite this cost, colonial breeding presumably confers important social benefits, some of which I have suggested. Apart from this, all aspects of its breeding biology may plausibly be interpreted as mechanisms which maximise lifetime productivity of individuals, even though this is unavoidably low. However, the frigate has no important enemies except man, it is probably extremely long-lived, and so has become reasonably successful (numerous and widespread).

REFERENCES

Dawkins, R. (1976) The Selfish Gene. Granada.

Diamond, A.W. (1975) Biology and behaviour of frigatebirds *Fregata* spp. on Aldabra Atoll. Ibis *117:* 302-323.

Nelson, J.B. (1968) Galapagos: Islands of Birds. Longman.

Nelson, J.B. (1976) The breeding biology of frigatebirds — a comparative review. The Living Bird 14.

Nelson, J.B. & Powell, D. (In press) The Breeding Biology of Abbott's booby.

de Vries, T. (1984) Why are Frigate-birds Colonial? Noticias de Galapagos *40:* 19-22.

Reville, B.J. (1980) Spatial and temporal aspects of breeding in the frigatebirds *Fregata minor* and *F. ariel.* Ph.D. Thesis, Aberdeen University.

SANTA FE NEWSLETTER

by

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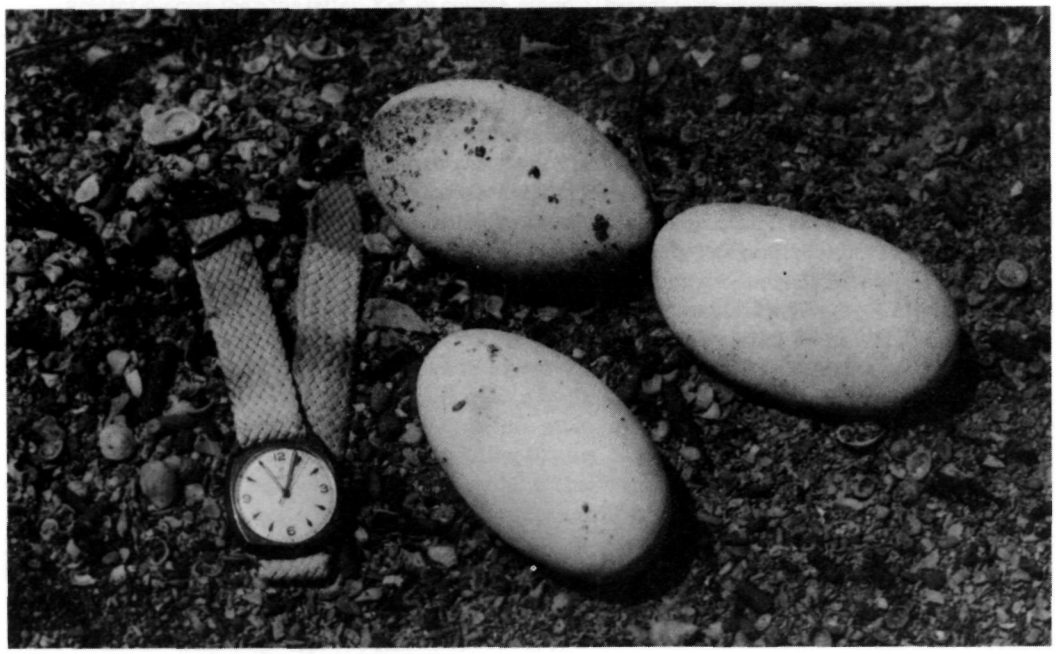
Writing from his camp on Santa Fe (Barrington) Island on 14 January 1985, during the fifth year of his study of the population dynamics of the Marine Iguana (see Noticias 35-40), Dr Laurie has encouraging news about the recovery of these unique Galapagos lizards after the disastrous reduction of their numbers during the 1982-83 El Niño. — Ed.

For sun-lovers the last few months have been disappointing with many totally overcast days and hardly any completely clear ones. Conditions for the marine iguanas, however, have been excellent. The sea temperature has been low and, despite the persistent clouds, there has been no rain or really cold weather. The algal flora has returned to a state very similar to that in 1981 before the influence of El Niño, and is dominated by red algal turf, in particular *Gelidium* spp. Apart from the return of their preferred food species the iguanas have been favoured by very calm seas, with little swell, permitting easy access to their intertidal grazing grounds almost every day, and the unusual sight of iguanas so replete that they remain on shore some days and miss opportunities to feed.

The effects of increased food availability have probably been significantly augmented by the reduced grazing pressure which has resulted from the heavy mortality during El Niño. They include enormously increased growth rates among the younger animals and very high body weights among the adults, both males and females. Iguanas of up to five years old have grown in body length at double the rates recorded in 1981-82 before El Niño, and adult body weights are 30% higher than at the same time of year in 1981 and 1982. The increased growth rates may lead to females breeding at only three years of age next season, two years earlier than the previously recorded mean age at first breeding.

We saw this season's first mating on 2 December and the last, to date, on 4 January. This is a larger span than usual, and the males are still territorial as I write, on 14 January. Only about 40% of females bred each season in 1981-82 and 1982-83, (i.e. before El Niño) and I suspected that the energetic requirements of



The Marine Iguana's eggs are large
in proportion to the female's body weight.
Photo by Roger Perry

nesting and egg production were so great that breeding was restricted to an average of once in every two or three years. As very few females bred last season and as the animals are obviously in such good condition, I predicted that significantly more than 40% of the surviving females would breed this season. Initial indications from the observations of mating are that this is so, but as the programme of observations was more extensive this year, aimed at collecting slightly different information of the proportion of females which breed, confirmation will have to wait until after nesting.

The first females started digging burrows on 4 January and nesting is expected to continue until mid-February. One of the Galapagos Hawks' early victims at the nesting area was carrying three eggs, the first time that I had recorded more than two here. The relative weight of the total clutch, however, was 22% of body weight, approximately the same as in previous years. Possibly, although it is too early to say, the females' increased body weight has allowed them to increase their clutch sizes this year.

The calm seas had an interesting effect on the relative mating success of the males holding upper and lower territories, which illustrates very clearly the dangers of making conclusions from studies that are short in relation to the life spans of the animals being studied. I had been puzzled that the upper territories, where the females spent most time, were occupied by significantly smaller males than the lower territories, and that the upper males, although they lost more weight (20% vs 10%) between mid-November and mid-January than the lower males and did not breed in consecutive years, still had a higher overall mating success than the larger, and presumably stronger, lower males. But this season, as a result of the calm seas, the females spent most of their time in the lower territories and the lower territorial males have achieved 73% of the matings compared with 34% in 1981 and 1982. Furthermore, they lost a mean of 15% of their body weight between mid-November and mid-January, whereas the upper territorial males only lost 5%. Indeed 20% of the upper males actually gained weight and have spent the whole breeding season in almost deserted territories. Now I want to know what happens in 1985-86!

We will stay on Santa Fe until March to cover the nesting season in full and recapture all the marked individuals for the annual measurements of growth rate and survival in all age groups. Then we will work for a month on other islands looking in particular at food availability, nesting and clutch sizes, before returning to Santa Fe for the hatching season in April and May.

FILMING GALAPAGOS WILDLIFE

by

Sylvia Harcourt

Twenty years ago Alan & Joan Root made a famous film of Galapagos wildlife for Anglia Television with the Charles Darwin Foundation's Honorary Life Member, H.R.H. Prince Philip, speaking the commentary. This was the most important of the early films in Anglia's *Survival* series, and it raised substantial funds for the Charles Darwin Research Station. Since then there have been hundreds more *Survival* films and now an Anglia Television crew is at work on a whole new series of Galapagos wildlife films. The crew consists of Dieter & Mary Plage, a renowned camera team; Friedemann Köster, until recently Director of the CDRS; and Sylvia Harcourt, formerly the Station's acting ornithologist, who gives this account of work in progress. — Ed.

We have now been at work for a year and a lot of "footage" is already "in the can", but there is still much to be achieved. The Survival Anglia crew have been filming in the islands since December 1983 and hope to be here until June 1986, making several one-hour films for television.

So far, we have concentrated particularly on Española (Hood Island) and the life of the albatrosses and sealions. Some thrilling moments have occurred while filming surfing sealions, both underwater and on the surface. Not being a diver, I have not experienced the dramas under the waves but those above have been quite enough! Trying to surf the waves in a rubber dinghy alongside the sealions and getting caught between two rollers is excitement enough for one day. Any change in the speed of our boat would have meant either getting swamped by the breaker behind us or falling off the top of the one in front. "Don't worry", says the ever-calm Friedemann as I struggle into my life-jacket, "the waves will take you to the shore; you just get rolled around a little".

Albatrosses on their egg are easier to film; they just sit there. However we have had some fun as we try to photograph them taking off from the water. They start running across the sea into the wind and finally launch themselves off the top of a wave with much wing-flapping and leg-kicking. To judge just when and where they are going to take off required much time and experimenting in the little rubber boats.

Further trips are planned for 1985 with camps on Genovesa, Fernandina and Santiago, as well as several long diving trips and also flying trips, this latter a new venture for Galapagos. We now have a two-seater ultralight plane which can alight on either water or land and this will enable us to get aerial shots of the islands, craters, coastlines and, with luck, of whales, dolphins and birds flying close by, once the engine is cut and the plane glides in silence. A new view of Galapagos will be opened up to us and to worldwide television audiences.

The actual filming is not our only work. There are always repairs and cleaning of cameras, lenses, boats and camp equipment. Time is spent planning when and where trips should be made and working out the logistics of food, water and boats. And then there is the carrying! All the equipment has to be moved from the Darwin Research Station, where we are based, to the boat; then off the boat, up the shore, and from the shore to its temporary resting place in camp. This is then repeated in reverse order 3 weeks later to return to CDRS, recoup, restock and start off to the next site.

On the days when we set up or break camp, I wonder why I do this job. On all the other days there is ample compensation. It is wonderful to have the time to sit and watch new dramas unfold themselves before your eyes and know they are being recorded for eventual release on TV to be shared with millions. A further amazing thought is that these same sights were observed by Charles Darwin 150 years ago. Will future generations still be able to say the same in another 50 years?

That such a question can even be asked is a tribute to the foresight of the Charles Darwin Foundation and to the continuing determination of the Galapagos National Park Service to keep the islands as they are. The co-operation between GNPS, CDRS and the CDF is vital as insistent demands are made for commercial development. The beauty of these islands is their wildness, the fearlessness of the animals and the opportunity to escape from man's obsession with 'progress'. Let us hope they remain that way and that the Survival Anglia films will be a documentary and not an obituary.

DARWIN'S FINCH "PLOUGHS" FOR WATER

by

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In the Galapagos Islands fresh water is usually scarce despite the occsional El Niño event, yet it is essential to sustain life, whether of plants, animals or the human race. In an article in Noticias 34, D. Duffy (1981) described how members of the Galapagos National Park Service and scientists working in the field have found methods to collect drinkable water from holes hidden under vast and barren lava fields, or from mist, fog and occasional rains on the slopes and rims of the higher volcanos. Not much information, however, seems to be available on the methods used by native Galapagos land-vertebrates to obtain their vital water supply. The same appears to be true for introduced animals such as goats and cats, which live on a number of islands that are bone-dry for most of the year, and thus — at first sight — under conditions which seem to threaten their existence. Questions as to where and how they find their water more often than not are met by rather generalized and hence disappointing answers, such as that land-birds drink dew in the morning, that reptiles derive their water from their food and (always repeated but never scientifically proven) that feral goats walk down from the dry hills to the sea shore and drink pure salt water. Some of these explanations, however incomplete, are possibly true, while others are pure speculation or downright wrong. A good deal more sound ecological research is needed on the Galapagos before any such simple answers can be accepted.

Having asked for more studies in this important and interesting field of investigation, I would like to present here a preliminary report on recent observations on the drinking habits of one of Darwin's Finches.

In June 1982, while my family and I were camped at Punta Suarez, on Española (Hood) Island, our camp, as usual, was crowded by a large flock of inquisitive and mischievous Hood Mockingbirds, *Nesomimus macdonaldi,* and a number of the less impertinent Large Cactus Finches, *Geospiza conirostris.* Anyone who has camped on Española, knows about the many problems of how to keep the "mockers" away from tents, kitchen, scientific equipment, chairs, table, water and food, lest it all be messed up by scores of probing bills and countless droppings. Therefore, in order not to attract an even larger number of birds, great pains are normally taken to hide all food carefully away and to avoid spilling any of the water stored in plastic containers around camp.

One day, however, while pouring water into a pot, I tripped and some of our precious drinking water spilled on the sandy soil. As I stood watching, speculating jokingly whether my carelessness would jeopardize our stay on Española, mockingbirds rushed in from all directions to drink. Soon, however, the puddle of water changed into a muddy patch from which no mockingbird's beak was apparently capable of extracting any more water. Then, to my astonishment, one of the Large Cactus Finches drew nearer. As soon as the mockingbirds had lost their interest and were leaving the wet spot, the finch took a close look at it. Suddenly, creeping forward in a hunched posture, he started to "plough" through the moist sand with his beak, digging furrow after furrow not unlike a farmer ploughing a field. The only explanation for this behaviour is — I think — that by "ploughing" the bird drew in moisture through the sides of his seemingly closed beak: in fact, the finch was drinking!

In November 1984, when filming for Survival Anglia's television series on the natural history of the Galapagos Islands, our crew camped on the same site and I was able to repeat my observation of this peculiar drinking behaviour. This time I spilled some water intentionally and, as I had dared to predict, a Large Cactus Finch approached as soon as the mockingbirds had left and "ploughed" the wet sand in the way described above.

This "ploughing" for water by the Large Cactus Finches on Española Island is clearly distinguished from their "bill-bracing" technique, by means of which they dig into loose ground to expose food (De Benedictis, 1966) and by means of which the Sharp-billed Ground Finch, *Geospize difficilis,* on Wolf (Wenman) Island has become a very efficient thief of booby eggs (Köster & Köster-Stoewesand, 1983). When "bill-bracing", the beak is firmly stuck into the ground or braced against a rock, while legs and feet are forcefully kicked backwards; when "ploughing", the finch pushes the beak forward along a straight line through the wet soil.

Thus, apart from obviously being able to drink from open water sources like puddles on the ground, or waterholes in cracks and crevices in the lava rocks, or dew on grass and leaves, the Large Cactus Finches on Española — and the future may show that other Darwin's Finches do the same — have developed an additional and rather special way of drinking by extracting water from moist ground.

Admittedly, my observations were made under partly artificial conditions, as I provided the water which the finches then extracted by "ploughing". However, I believe that their very spontaneous and obviously experienced behaviour warrant the conclusion that "ploughing" for water is not merely a behaviour adopted by those finches hanging around a campsite on Española, waiting for someone accidentally to spill some water. By being capable of extracting water from moist soil, these finches must benefit from occasional rains much longer than other birds possibly can. Even after all open water has evaporated or has disappeared into the ground, damp soil remains for quite a time after the rain under bushes, trees, rocks and ledges. It is in these places that I expect the Large Cactus Finch to "plough" under completely natural conditions.

Darwin's Finches are remarkably resourceful. Probing with a stick for insect larvae hidden in dead wood (Gifford, 1913/19); drinking boobies' blood from their growing feathers (Bowman & Billeb, 1965); "bill bracing" to extract food from the soil (De Benedictis, 1966); stealing and drinking booby eggs (Köster & Köster-Stoewesand, 1983); and now "ploughing" for water: what other tricks have this amazing group of drab-coloured birds invented in their struggle to survive in the Galapagos?

LITERATURE CITED:

Bowman, R.I. and S.L. Billeb (1965): Blood-eating in a Galapagos finch — Living Bird, 4.

DeBenedictis, P.A. (1966): The bill-brace feeding behaviour of the Galapagos finch *Geospiza conirostris.* — The Condor, Vol. 68, No. 2.

Duffy, D.C. (1981): Water, water anywhere: the search for the potable in Galapagos. — Noticias de Galapagos, No. 34.

Gifford, E.W. (1913/19): The birds of the Galapagos Islands, with observations on the birds of Cocos and Clipperton Islands. — Proc. Calif. Acad. Sci. 2.

Köster, F. and H. Köster-Stoewesand (1983): Twelve Days among the "Vampire Finches" of Wolf Island — Noticias de Galapagos, No. 38.