NOTICIAS DE GALAPAGOS

Published by

THE CHARLES DARWIN FOUNDATION FOR THE GALAPAGOS ISLES

An International Organization

created under the auspices of

THE GOVERNMENT OF ECUADOR

UNESCO

THE INTERNATIONAL UNION FOR CONSERVATION OF NATURE

CONTENTS

Published with the financial assistance of UNESCO

NEWS FROM ACADEMY BAY

A SPATE OF GALAPAGOS BOOKS

During the early part of 1984, no less than three major collections of papers on Galapagos science and conservation are to be published. There will be a volume on the Galapagos in the new series entitled "Key Environments", which considers and compares the present status and degree of danger of a number of environments of capital importance to science and, indeed, to humanity. The authors of the twenty specialist chapers have all worked in the Galapagos.

At about the same time the Linnean Society of London will publish the proceedings of a symposium held in December 1982 on "Evolution in the Galapagos Islands". Again the authors of the various papers are old hands at the Charles Darwin Research Station.

Yet another scholarly volume, "Patterns of Evolution in Galapagos Organisms", will shortly be published by the Pacific Division of the American Association for the Advancement of Science.

That three such books (of which details are given elsewhere in this issue) should be published just twenty years after the inauguration of the Darwin Research Station is a striking coincidence in itself. But it is much more than that: it gives a clear indication of the important role the Charles Darwin Foundation has played in two decades of conservation and scientific investigation. It also draws attention to the CDRS's second function of providing a base from which scientists from every country can do research in this unique environment. Visiting scientists, who are the principal contributors to these three works, within very broad limits choose their own projects. They are usually funded by their universities or learned societies and are not a charge on the Foundation's resources in the way that the Station's staff scientists are. Their contributions to scientific knowledge have by now reached an enormous total, thus supporting the CDF's claim to further the advancement and diffusion of knowledge as well as the protection of the environment.

Equally worthy of note is the re-issue of two older Galapagos scientific publications. "Darwin's Finches", by the late David Lack, first appeared in 1947 and marked an epoch in the study of Galapagos evolution. The need for a new edition of Mike Harris's invaluable "Field Guide to the Birds of Galapagos" demonstrates the growing number of students of the islands' birds. Both books are reviewed on other pages.

The worldwide interest in the Galapagos is further illustrated by the increasing number of books and articles on less academic aspects of the archipelago. John Treherne, who did research at the CDRS on those peculiar aquatic insects, *Halobates,* and is general editor of the "Key Environment" series, took time off from his biological duties to write "The Galapagos Affair", in which he re-examines the stories of hatred and sudden death among the handful of settlers on Floreana in the early 1930's. Frau Margret Wittmer's personal account of these mysterious events in "Post-lagernd Floreana: Eine Moderne Robinsonade" has been re-issued. Finally, Sir Peter Scott, Founder Member of the CDF and Chairman of the WWF, devotes no less than three chapters of his copiously illustrated "Travel Diaries of a Naturalist" to his many visits to the archipelago over the years.

THE PHENOMENAL EL NINO

It had been suggested that a whole issue of Noticias should be devoted to the El Niño event of 1982-83 but its unprecedented intensity and duration and its varied effects on different species made it impossible to deal adequately with so much material in our small journal. It was therefore decided to produce yet another Galapagos book. Gary Robinson and Eugénia del Pino are the editors and they have invited contributions from some thirty authors who were involved in different aspects of the event.

However some reports on El Niño have been included in this issue. Peter Kramer describes the general impact. Ole Hamann considers the role this recurrent event may have played over the centuries in aiding new plants to establish themselves. P.R. Grant sets the 1983 event in its historical context while he and B.R. Grant discuss the effects on the breeding of Darwin's Finches. The Grant group of ornithologists is engaged in a ten year study of the finches and mockingbirds and the advantages derived from such a long-term investigation are immediately apparent from their reports.

Similarly the fact that Andrew Laurie had already devoted three years to the study of the marine iguanas' population dynamics (Noticias 35, 36, 37, 38) placed him in a position to assess more authoritatively the effects of El Niño on the numbers of this unique animal. The following is an extract from a personal letter written from his camp on Santa Fe island on 5 January, 1984.

"The iguanas are being rather puzzling. The males have been territorial for more than 2½ months and have been making frequent approaches to the females, but the females avoid each and every approach and it appears that they may not allow themselves to be mated at all this season. They are still slightly (average of 10%) underweight compared to pre-El Niño weights, and this may be enough of a drop in condition to put them off producing their 2 eggs, which together weigh 25% of their own body weight. We shall just have to wait and see whether the males give up or make a sudden breakthrough: we are already past the end of the normal mating season. Then we shall visit Isabela and Fernandina to see what is happening in other colonies, especially those affected by cat predation. Overall mortality here on Santa Fe has been about 65%, I would say, although we will do our annual census a bit later on and get more accurate figures for that. It has greatly affected the territorial lay-out, with only about ¼ the number of territorial males this year dividing up the same areas between them: i.e. much larger territories, but about the same number of females in each.

The sea temperature is back to normal and the algae are returning to normal rapidly. The iguanas are again feeding on their normal food, although some of the invading algae still persist in places. The weather has been unusually cool for the time of year, with a lot of *garua,* even in the afternoons, and several heavy showers. Of course it has been nothing like last year, but a lot more rain than in 1981-82."

THE GALAPAGOS ON TELEVISION

When HRH the Duke of Edinburgh paid his first visit to the Galapagos in 1964, he was accompanied by Aubrey Buxton, director of Anglia Television. They were both fascinated by the wildlife but somewhat apprehensive about its future preservation. So an outstanding camera team, Alan and Joan Root, were sent to the islands and the outcome was "The Enchanted Isles", a most distinguished film, with Prince Philip doing the commentary. The brilliant photography was used to emphasise the need for protection. But that was nearly twenty years ago, when the Darwin Station had only just been inaugurated and there was no Galapagos National Park Service. The great conservation successes such as the captive breeding of endangered species and the control of destructive feral animals were still in the future and could not figure in the film. Organised tourism had not begun. The situation is so completely altered today that Anglia Television has sent out another team to bring the story up to date by making eight or ten Galapagos documentaries during the next 2-3 years for its "Survival" series. "The Enchanted Isles" was seen by millions of viewers in all six continents, at a time when the Galapagos were little known outside scientific circles; it gave a wonderful general picture of the islands and their wildlife. The new films, illustrating conservation as well as wildlife, will deal in much greater detail with different aspects of the ecosystem and will likewise be seen by a worldwide audience. There could hardly be a more admirable way of celebrating the 150th anniversary of Charles Darwin's visit in HMS Beagle.

GALAPAGOS TOURISM

Fausto Cepeda, chief naturalist of the Galapagos National Park, reports that in 1983 there were 16,783 visitors to the Park. This compares with 17,124 in 1982. Of these, 6,067 were from mainland Ecuador, the largest number of Ecuadoreans to visit their island province in any one of the 150 years since annexation, and a proof of the growing public interest since the Galapagos were accorded World Heritage status by UNESCO.

THE CDRS DIRECTOR IN THE SOVIET UNION

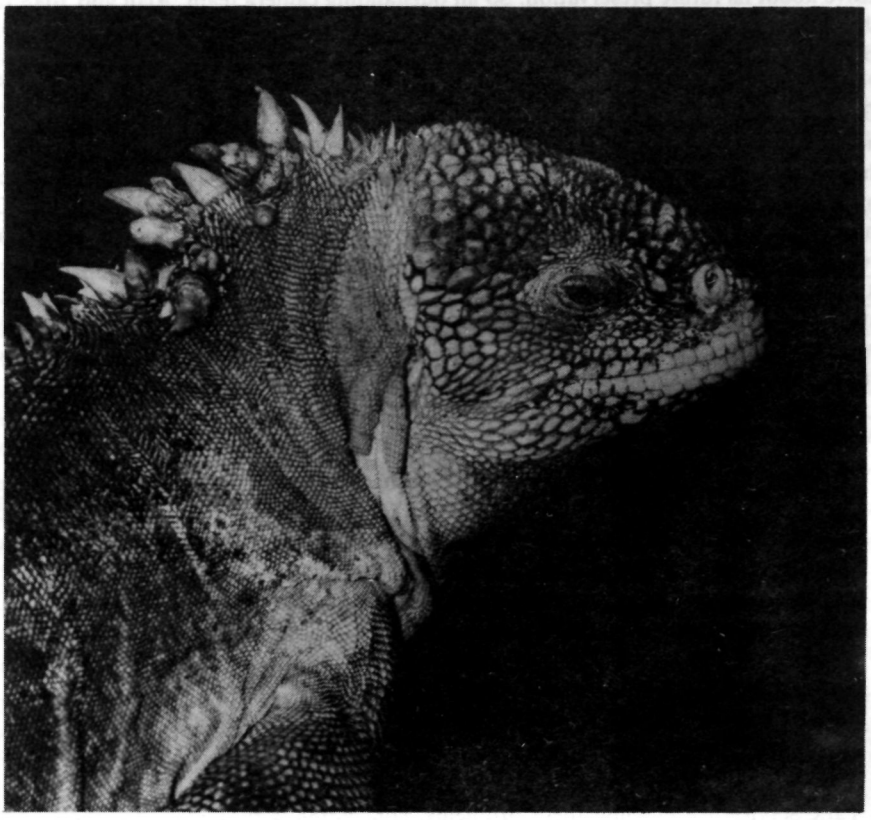
On the invitation of UNESCO, Friedemann Köster attended the First International Congress on Biosphere Reserves at Minsk in the USSR and read a paper on "Science for Conservation in the Galapagos", written by himself and his deputy director, José Villa. The address dealt with the various threats to the flora and fauna of the archipelago and the methods by which the Darwin Station and the National Park Service are tackling these problems, concluding with a plea that the Galapagos will eventually be declared a Biosphere Reserve.

SAVING THE HAWAIIAN PETREL

At last there has been a break-through in the long struggle to save the Hawaiian (or Dark-rumped) Petrel (see Noticias 35 and 37). After years of research, it was clear that extinction was not far away as breeding success was declining towards zero. It was also clear that the rats and pigs could not be eliminated before they had exterminated the last of the petrels. As David Duffy explains in his account in this issue of the years of study under appalling conditions by dedicated researchers from four continents, time was running out and the need was for action. But it was difficult to devise any method that would be effective against rats without endangering other species. Then, when a project was worked out to protect the Santa Cruz petrels, it had to be called off for lack of funds.

Finally a more modest plan was adopted. A *cordon sanitaire* was thrown round the biggest and the most concentrated breeding area on Floreana. Under Malcolm Coulter's guidance, Felipe Cruz and Tina Beach, working under the worst weather conditions ever recorded, succeeded in keeping the Black Rats out of the colony. Owing to the abnormal El Niño rains, some nesting burrows collapsed and, again because of El Niño, there was a shortage of food for the young (see Peter Kramer's letter). But no young were lost through predation and the dreadful annual decline in breeding success was actually turned into an increase of 20%. Of course this is not the end of the story: a battle has been won, not a war. Protection must be continued year after year and the rats may stage a comeback. Nevertheless it has been shown that, given the resources, the petrels CAN be saved.

This is an appropriate moment to thank all those men and women who have worked to achieve this end and to express our gratitude to the World Wildlife Fund, the Council for the Preservation of Birds, the New Zealand Wildlife Service, the U.S. Fish and Wildlife Service and, not least, to the settlers on Floreana, whose spontaneous support can be regarded as a landmark in the story of Galapagos conservation. Finally congratuations to Felipe Cruz and Tina Beach for a job well done under abominable conditions and further congratulations on turning their conservation partnership into marriage.



Land Iguana at the Darwin Station's captive breeding centre. *Photo:* F. Köster

WILD DOGS AND LAND IGUANAS

In the difficult terrain of the Galapagos it is seldom that any conservation project exceeds expectations — but it can happen. A few years ago, packs of feral dogs almost exterminated the population of Land Iguanas on Isabela and Santa Cruz islands, as well as threatening other endemic species. The surviving iguanas were taken to the Darwin Station, where eventually it proved possible to breed them in captivity. So successful was the programme that feeding and housing the growing numbers became an embarrassing problem. But they could not be released in the wild so long as the dogs were still there. After careful study, a major campaign was launched against the dogs by the Park Service and the Darwin Station with the support of the Frankfurt Zoological Society. Luis Calvopiña, in charge of feral mammal problems, now reports that the dogs have been virtually or completely eliminated on both Southern Isabela and Santa Cruz.

This is not necessarily a final solution of the problem. A few dogs might have escaped and there is the constant danger of more domestic dogs running wild on the inhabited islands. Also the feral cats are still a threat to the young iguanas. Nevertheless the situation has been immeasurably improved so that the captive-bred youngsters are being released in their ancestral breeding grounds and preliminary monitoring gives ground for hope that they will survive.

FRANKLIN DELANO ROOSEVELT AND THE GALAPAGOS ISLANDS

In a recent letter to Peter Kramer, former President Galo Plaza told this story about his relations with FDR, who had visited the Galapagos before the Second World War on board the cruiser, USS Houston.

"When I presented my credentials as Ambassador of Ecuador to President Roosevelt in 1944, instead of dealing with the subjects conventionally discussed on these ceremonial occasions, he talked to me at length about the Galapagos and his concern for their conservation. I reported this to the Government of Ecuador and eventually the necessary legislation was enacted, opening the way to international participation in the conservation of the Galapagos, to the great satisfaction of President Roosevelt. Shortly thereafter, Mrs Roosevelt asked me to make periodical visits to the President to chat with him about the Galapagos; she begged me to avoid all other subjects, as he found talking about Galapagos very relaxing. This arrangement obliged me to brush up my knowledge of Galapagos matters so that I could discuss them on an equal footing with President Roosevelt."

MORE ABOUT THOSE BLOODTHIRSTY "VAMPIRE FINCHES"

Heide and Friedemann Köster returned to Wolf (Wenman) Island in November 1983 to continue their study and filming of the sea-birds and particularly of the Sharp-beaked Ground Finches *(Geospiza difficilis).* As they reported in Noticias 38, these peculiar finches — but only those resident on remote Wolf Island — have developed a very special technique of pecking at the bases of the boobies' feathers until they bleed and then sipping the blood. But an even more remarkable and hitherto unrecorded extension of this practice is recounted by Friedemann:

"It is really impossible to walk about Wolf without getting one's legs and arms scratched by cactus, lava rocks, dense *Alternanthera* bushes and low *Croton* trees. This happened to me and, when I noticed blood oozing from a small wound in my arm, I decided to try an experiment and offer it to one of the curious finches surrounding me. Without a moment's hestitation it inspected the cut, took a little sip and, finding it to its taste, finished the blood to the last drop. When there was none left, it began with complete unconcern to peck at my arm, removing bits of skin from the edges of the wound until it began to bleed again. We recorded all this on film and, at the height of the demand for my blood, we counted 14 finches on or around me, opening up new sources with their bills or re-opening cuts that had congealed."

What we do for science!

AUF WIEDERSEHEN, FRIEDEMANN!

Friedemann Köster has ended his three-year term as Director of the Darwin Station. His last year was a difficult one. The abnormal weather increased the hardships of life on the islands and interfered with conservation programmes, while lack of funds meant severe cuts in his highly qualified scientific staff.

Nevertheless there were notable successes, for instance with preserving the Hawaiian Petrels, the Land Iguanas, and the control of wild dogs. Friedemann and Heide will still be seen from time to time around Academy Bay as they are temporarily attached to the Survival/Anglia Television team, with whom they can share their devotion to wildlife filming.

If the CDF had to lose the Kösters it is a consolation to learn that they have been succeeded by old friends of the CDRS, Günther Reck and his wife. Günther, who was previously serving with the Undersecretariat of Fisheries, has for some years been fruitfully co-operating with the Park Service, the Station and the University of Guayaquil in joint programmes of marine conservation. He is already "one of us".

HAROLD JEFFERSON COOLIDGE AT EIGHTY

Hal Coolidge celebrated his 80th birthday in January 1984. Sixty of his years have been devoted to wildlife science and conservation in every continent. He has been involved in promoting the major environmental organizations of our time, including the World Wildlife Fund and the International Union for Conservation of Nature, of which he is still Honorary President. It was therefore particularly appropriate that he should now have been honoured by the creation of The Coolidge Center for Environmental Leadership.

Hal was a Founder Member of the Charles Darwin Foundation and marshalled the proceedings at the inauguration of the Research Station when he was a mere stripling of 60. He recently revisited the Galapagos and, like the other surviving Founders, could take deep pride in seeing the conversion of an idealistic vision into a thriving reality. Saving the Galapagos environment from the threat of doom was only one of the many exploits in which Hal played a leading role. We wish him many more happy birthdays.

EVENTS AND VISITS AT THE DARWIN RESEARCH STATION

April 1983

Bruce Barnett returned to continue his work on feral dogs. Drs. Engelhardt and Bijleveld, scientists from the International Union for Conservation of Nature (IUCN), visited the Station.

May

The Italian entomologist, Giovanni Honore, came to study the insect pest damaging the settlers' crops.

David Steadman arrived to study fossils on Floreana — but the abnormal weather made his task impossible.

June

Dieter Plage discussed with the Station and the Park Service a project to make a series of television films for Survival-Anglia Ltd.

The Italian Ambassador and party visited CDRS.

Peter Grant and family returned to continue their group's long-term study of Darwin's Finches.

July

Bill Jordan of The People's Trust for Endangered Species and Elizabeth Suerdsen of International Donkey Protection visited CDRS.

M.D.F. Udwardy, ornithologist from the University of California, visited CDRS.

Gonzalo Concha and Pablo Montoya arrived from Colombia to give instruction in diving to a class of 30.

John Wright began his herpetological studies on Floreana.

Yael Lubin, staff entomologist, left on completing her term of service.

Renate Penrie of the Tinker Foundation visited CDRS.

A group from Woods Hole Oceanographic Institution came to collaborate on a master plan for the management of coastal and marine resources.

Manuel Cifuentes resumed his duties as Superintendent of the National Park on completing his studies in Costa Rica.

Fernando Ortiz, head of the National Institute for Galapagos, led a group of French parliamentarians on a visit to the CDRS.
Peter Kramer, President of the CDF, arrived at the Station.
A group from Esmeraldas University came to discuss relations with CDRS.

August

Catherine Rechten concluded her study of the Waved Albatross.
Arturo Ponce of the Ministry of Agriculture and Allan Putney visited CDRS.
Gonzalo and Paola Oviedo ended their term of service as staff scientists.
Ruperto Pinos returned to the Chimborazo Polytechnic on concluding his study of the wild cattle on Isabela.
The Executive Council of the Charles Darwin Foundation held its 43rd meeting at the Research Station. Members were invited to make a short trip round the islands as guests of Metropolitan Touring. This was followed by a symposium on introduced organisms.
Gary Robinson returned to USA on conclusion of his service as staff marine biologist.
A group from the Casa de Cultura in Quito visited CDRS.

September

Four-week training course for naturalist guides began with 30 candidates.
Manuel Utreras returned to Quito on completing his work on the use of herbicides to erradicate guava trees.
Christine French of the National Science Foundation came to discuss with the Station and Park Service the possibility of sending research scientists to Galapagos.
Linda Cayot returned to USA on finishing her studies on the relationship between the giant tortoises and the vegetation.
Friedemann Köster left for Moscow and Minsk to take part in the First International Conference on Biosphere Reserves.
Rolf Meier came from Switzerland to continue his work on fire ants.

October

Conley McMullen from the Virginia Polytechnic Institute began his botanical project.
Robert R. Given of the University of Southern California came to discuss the problems of establishing a marine park.
Training course for Park wardens began.
Humberto Ochoa succeeded Ruth Quezada as chief protection officer of the Galapagos National Park Service.
Elizabeth Potts of the Royal Botanical Gardens at Kew came to serve as a volunteer assistant.
A commission from the Chamber of Representatives led by Gonzalo González visited CDRS.
The annual course to qualify auxiliary guides began.
Richard Faust, Director of the Frankfurt Zoo, visited CDRS.
Richard Lyons of New York Times visited the islands.
Andrew Laurie returned from England with David Harris to begin a fourth year of studies of marine iguana population dynamics.

November

Friedemann and Heide Köster to Wolf Island to continue their study and filming of the "vampire finches".
Fritz Trillmich, Dominique Limberger and Thomas Dellinger left after another spell of work on the Galapagos Fur Seals.
A group from NOAA came to check their tidal measurement instruments.

December

Robert Curry, Lisle Gibbs, Barbara Coffman, Chriss Chappell, Sophie Webb, Linda Hamilton, Steven Latta and Scott Stoleson, members of the Peter Grant group, arrived to continue the long-term research project on Darwin's Finches and Galapagos Mockingbirds.
Adrian Matson returned to USA on completing his oceanographic studies in collaboration with the National Institute of Fisheries and Duke University.
Dieter and Mary Plage and Sylvia Harcourt of Survival Anglia Ltd. began filming a series of wildlife and conservation documentaries for television.
William A. Weber returned with three students for further studies of mosses and lichens.

A NEW YEAR'S LETTER FROM THE PRESIDENT OF THE CHARLES DARWIN FOUNDATION

Dear Friends of the Galapagos,

Last year I spent from July to September in Ecuador, mostly in the Galapagos. I discussed current activities with our scientific staff and we drew up the plans for 1984. In August I took the chair at the 43rd CDF Council Meeting, held on Santa Cruz Island.

Beyond all doubt the most important event of 1983 was neither planned nor expected: the warm, rainy season was not merely warmer and wetter but it lasted from November to July instead of from December to April. It is always warmer and wetter when the archipelago comes under the influence of the ocean current known as *El Niño*. The effect varies enormously but in 1982-83 it was more extreme than at any time since records were kept. Rainfall at the Darwin Station was ten times the average and twenty times the level of dry years. The temperature of the sea rose to 30°C and warm surface water has an important characteristic: it is poor in nutrients.

Neither the Masked Booby nor the Swallow-tailed Gull bred successfully in 1983.

Photo by Fritz Pölking

The abnormal warmth and the nutrient-poor seawater had a powerful influence on Galapagos plant and animal communities. All animals which depend directly or indirectly on marine vegetation suffered heavily. Not only sea-lions, fur seals, marine iguanas, penguins, flightless cormorants but corals, sea-urchins and many other marine animals also died in large numbers or, if they could, wandered away in search of food. The sea-birds, particularly swallow-tailed gulls, albatrosses and boobies, disappeared completely until July-August, when they returned in smaller numbers.

On land, where lack of water usually restricts growth, the picture was quite different: plants flourished, the vegetation grew extraordinarily lush and the animals profitted from the plenty. The finches multiplied and the land iguanas sat well-nourished amid the rich greenery.

A catastrophe for some, a lotus-land for others, one might think. But these events have a different meaning when we see evidence that such Niño years have occurred in the past, even though scattered at long intervals in the islands' history. It is simply that we have never experienced them in our time. For proof, look for instance at the deep gullies eroded by floods on the normally arid island of Santa Fe. But the Galapagos animal and plant species have survived thanks to the way they have adapted. This they will surely do again, except where man has reduced their numbers to the point where they cannot survive such crises. If such a disastrous *El Niño* year had occurred in the 1940's, the Galapagos Fur Seal might well have become extinct. Because of human persecution, its numbers had been drastically reduced at that time but fortunately years of conservation have successfully restored the size of the population.

For us visitors, who have almost always known the islands to be arid, this was an overwhelming experience: endless rainstorms, huge fresh-water lakes on the plains and rushing rivers on the slopes of the volcanoes, which often lasted for weeks and ended as waterfalls as they tumbled into the sea.

In many ways, the extraordinary weather conditions have made conservation more difficult but that makes last year's achievements even more significant. On Floreana, for the first time it proved possible to protect the threatened Hawaiian Petrels from the introduced Black Rats. This was done by using poisoned baits contained in plastic tubes to keep them from the rain and from other animals. The persistent rain caused the collapse of many nesting burrows and many adults could not find enough food for their young in the impoverished sea but for the first time the rats killed no young. The work goes on and, if the funds are forthcoming, it will be extended to other petrel colonies and other islands.

Another important success was with the Land Iguanas: some of the captive-bred young of the almost exterminated populations of southern Isabela and Santa Cruz were released on their native islands. Several months later, some of these youngsters were observed again. They were very lively (perhaps the abundant vegetation had helped them) so we know that at least a proportion of them had escaped the feral cats.

These are only two of a great many conservation projects which your contributions to our funds made possible last year and I thank you cordially on behalf of our Foundation. Please continue to support this work in the coming year. In case you have overlooked your subscription for 1983 you can still send it to any of the addresses given on the inside front cover.

I take this opportunity of offering you my very best wishes for 1984.

Peter Kramer
President, Charles Darwin Foundation

EXTRAORDINARY RAINFALL DURING THE EL NINO EVENT OF 1982-83

by

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The recent El Niño event in Galapagos started in October 1982 when sea surface temperatures climbed rapidly (Smith 1983). The heavy rains began in the following month. On Wolf Island, for example, the first heavy rain fell on November 9 (Köster and Köster 1983), on Genovesa it probably fell between November 15 and 20 (D. Day, pers. comm.) and by the end of the month all major islands were wet. The rains continued throughout the archipelago into the middle of 1983. The last heavy rain fell on San Cristóbal on July 13, on Santa Cruz on July 17 and on Genovesa on July 21.

The length of the rainy period (8 months) and the amount of rain that fell exceeded all previous records for the Galápagos.

Rainfall records have been kept continuously at the Charles Darwin Research Station since 1965. These reveal that in none of the preceding 18 years had as much rain fallen in November and December: this last El Niño began exceptionally early. In none of the preceding 18 years had as much rain fallen in the months April to July: it ended exceptionally late. And in none of the comparable periods, November to July inclusive, had as much rain fallen together. The previous maximum was 888mm in 1974-75, but in the recent period 3528mm was recorded, nearly four times as much.

The same story is told everywhere in the archipelago. The highlands were deluged with rain, on Floreana (Cruz and Beach 1983) as well as on Santa Cruz. Genovesa received 2408mm, whereas we had never recorded more than 200mm since we first began taking rainfall records there in 1978. Genovesa was different from Santa Cruz in one respect. The wettest month on Santa Cruz was May, but on Genovesa July, the last month, was the wettest. In fact the heaviest rain fell in the last 24 hour period of the rainy season. The total, 153mm, seems small though in comparison with the 254mm registered on Santa Fe on December 17, 1982 in only 20 hours (Laurie 1983).

Just how exceptional was the rainfall during the recent El Niño event, or the El Niño — Southern Oscillation (ENSO) to give it its modern label (Philander 1983?) Apart from records on Baltra in the years 1943-45, the earliest rainfall records in the archipelago date back to only 1950 when a weather station was established at Puerto Bacquerizo Moreno on San Cristóbal (Grant and Boag 1980). Records were kept continuously until 1967, erratically thereafter, but, fortunately, fully during the recent El Niño event. Previous events had occurred in 1953, 1957-58, 1965, 1972-73 and 1975. From records on both San Cristóbal and Santa Cruz it is clear that none of these events was as severe, in terms of rainfall, as the recent one. The previous strongest was in 1952-53 when 1399mm fell in the November — July period; in 1982-83 the total was 3648mm.

Prior to 1950 we can only make guesses about the severity of the wet seasons. Rainfall records at Ancón on the Santa Elena peninsula of the Ecuadorian mainland show that, in the interval 1925-1980, 1939 was the wettest year, followed by 1925; from several reports it seems likely that these two years were the wettest ones in the first-half of the century (Grant 1984). This is a rough guide as to what Galápagos might have experienced too, because the rains at Ancón and Galápagos vary in parallel (Grant 1984). And we have Alf Kastdalen's opinion that it was wetter on Santa Cruz in 1939 than in any other year in the period 1935 to 1965, which of course included the outstanding El Niño year of 1953 (Kastdalen 1982).

The question is whether more rain fell in 1925 and 1939 on the Galápagos than in the recent El Niño event. By a fortunate coincidence biologists visited Galápagos in each of the three wettest years preceding in the recent event: William Beebe in 1925, David Lack in 1939 and Robert Bowman in 1953. Nothing they wrote hints at such extreme conditions as those prevailing in 1983. Bowman (1961, pp. 9-10) briefly mentioned the El Niño event of 1953, but only described the climate in a "normal" year. Lack (1947) did not even mention the event of 1939. Rain began to fall in late December 1938 and ended in late February 1939. There was no rain on the coast of Santa Cruz between February 20 and April 1 when Lack departed (Lack 1950). The unusually heavy rains that fell in 1939 (Kastdalen 1982) were therefore either restricted to the

first eight weeks, or else resumed in April or May after a hiatus of at least five weeks. A temporary cessation is quite common (Grant and Boag 1980); for example in the recent event February was the driest month. But these reports do not suggest that the rains in 1939 rivalled those in 1983.

How about 1925? Beebe (1924, 1926) visited the islands in 1923 and 1925, and was thus able to compare their appearance in years of different rainfall. The log of the vessel *Arcturus* makes frequent reference to rain falling in April 1925. For example, an entry on April 8 reads: "Rain in the afternoon and showers in the evening. Nothing like this three [actually two!] years ago." (Beebe 1926, p. 398). Clearly, extensive rains were experienced in the Galápagos in 1925, for a pond half a mile in length was seen on Española. But from other entries in the log it is also clear that conditions were not as wet as in 1983. In April 1925 masked boobies had chicks on Española, and on Genovesa the breeding of frigate-birds, boobies, gulls and noddy terns was observed. In contrast, by the month by April in 1983 all these species except frigate-birds had abandoned breeding on those islands and elsewhere (R.L. Curry and M. Jones, pers. comm.).

Oceanographic conditions off the coast of Peru in 1982-83 have been described as the most extreme of the century (Kerr 1983). We shall never be able to prove it, but it seems likely that rainfall conditions on the Galápagos were also the most extreme of the century.

ACKNOWLEDGEMENTS

I thank J. Villa R., and G. Robinson for helping me assemble recent rainfall rcords.

This article is dedicated to the memory of Alf Kastdalen, who, tragically, did not live to see the end of the recent El Niño event (Noticias 38, p.3, 1983).

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Postscript: ***The Kastdalen family have since been interviewed and confirm that the 1982-83 rainfall was much the highest in their long experience. Their creek flowed 40 times compared with 14 times in 1939, their previous wettest year.***

PLANT AND FINCH RESPONSES ON ISLA GENOVESA TO THE EL NINO EVENT OF 1982-83

by

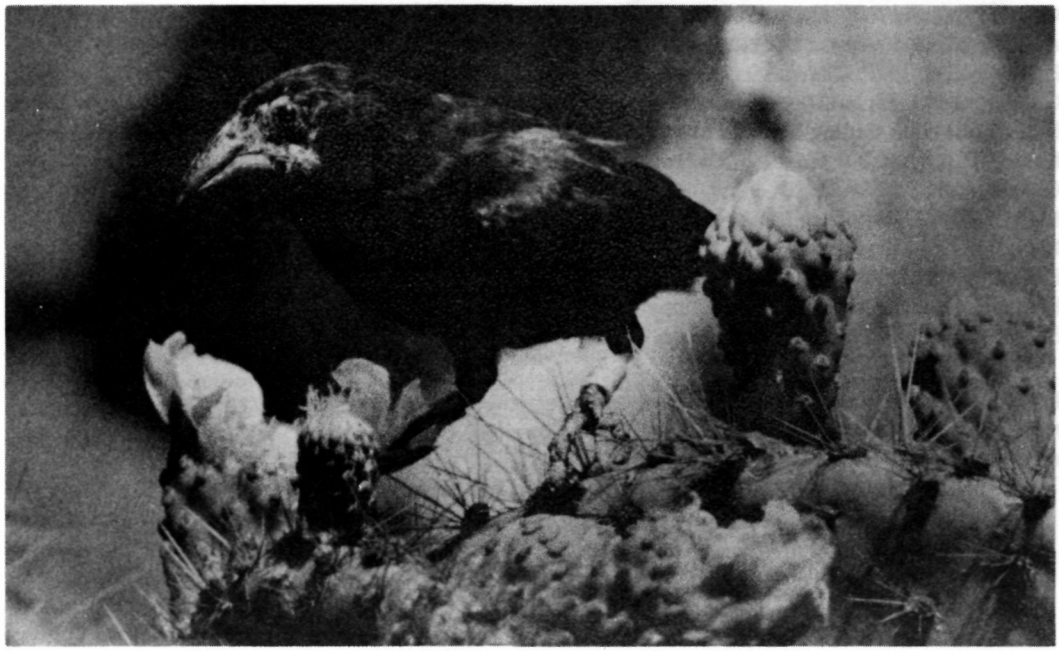
B. R. Grant and P. R. Grant

The unusually heavy and extensive rains produced by the recent El Niño event of 1983 had a substantial effect upon the vegetation on Genovesa and, as a consequence, on the breeding of the Large Cactus Finch *Geospiza conirostris.* The amount of rain that fell and the length of the rainy season in the Galápagos archipelago in 1983 exceeded all previous records for these islands (Grant 1984). On Genovesa the first heavy rains probably fell about November 15-20, 1982 (D. Day, pers. comm.), and lasted for 8 months. 2408mm of rain were recorded on the island; this was 14 times greater than the amount in any of the previous 5 years. Heavy rains occurred every month from December 1982 to July 1983, with the minimum monthly total being 70.1mm (February) and the maximum being 517.9mm (July) (See Grant 1984).

We have studied *Geospiza conirostris* on Genovesa since 1978 (Grant and Grant 1979, 1980, 1983). Therefore we are able to compare the responses of the vegetation and the finches in the extreme conditions of 1983 to those in the preceeding five years.

Sufficient rain fell in November 1982 to produce a leafing response from the major trees and shrubs in the third week of that month (D. Day, pers. comm.). In the period 1978 to 1982 the initial leafing response occurred between late January and March. We compared the data from quadrats and the flowering and fruiting phenology in different years (Abbott et al. 1977, Grant and Grant 1980) and found that the vegetation showed four classes of responses to the El Niño event.

The first was no unusual response in the lengths of flowering and fruiting periods. The species in this group were *Bursera graveolens* and *Opuntia helleri.* After fruiting, *Bursera* trees produced a few small leaves sporadically throughout the wet season but did not flower and fruit a second time. Fertile fruits of *Opuntia* were relatively scarce in July 1983. Water saturated the pads and whole *Opuntia* bushes were blown down in the unusually high winds associated with heavy rainstorms, while other *Opuntia* bushes were overgrown by the vines *Ipomoea habeliana* and *Merremia aegyptica.*



On Daphne Island, Cactus Finches *(Geospiza scandens)* bred in the same season in which they were born.
Photo by Peter T. Boag

A second group produced flowers and fruits repeatedly throughout the wet season. This group includes *Croton scouleri, Lantana peduncularis, Heliotropium angiospermum, Cyperus* spp, the grasses *Eragrostis* spp and *Trichoneura lindleyana, Abutilon depauperatum* and *Sida salviifolia.* Another feature of this group was their unusual height and rapid vegetative growth. For example, a *Croton* seed produced in December was a flowering 2m tree in May (R.L. Curry, pers. comm.).

A third group scarcely flowered at all. This includes *Walteria ovata* and *Cordia lutea. Waltheria* normally flowers sporadically in the wet season, profusely in the dry season. *Cordia* showed an exuberant and rapid vegetative growth but flowering was mainly postponed until after the rains finished in July.

A fourth group comprised the sole *Erythrina velutina* tree on the island. It is apparently only capable of breeding under exceptionally wet conditions. Seeds, but no saplings, were found beneath the tree on all previous visits. In July 1983 we found 7 saplings between 0.25 and 0.75m tall within 5m of the parent tree.

From the finches' point of view there was a surfeit of small soft seeds produced by the second group of plants and a paucity of *Opuntia* fruits. The increase in vegetation produced a corresponding increase in caterpillars and spiders. Caterpillars, spiders and *Croton* seeds are important food items in the nestling diets. Thus there was an abundance of food available for rearing young.

Geospiza conirostris bred uninterruptedly for 8 months throughout the wet season. This was nearly twice as long as in any of the previous 5 years. The number of pairs breeding was 3 times higher than in 1978 which was a year following a drought (Grant and Grant 1979, 1980). Numbers have increased gradually since 1978, but the density increased sharply in 1983 due to the recruitment of young birds, including one-year old males and females, into the breeding population. These new breeders did not cause a reduction in average territory size, but established territories of normal size in areas with little or no cactus that had not been previously occupied by *conirostris.* As a consequence only 43 percent of all *conirostris* nests were found in cactus in 1983, the remainder being in *Cordia, Croton* and *Bursera* trees; this is in contrast to 1978 when 95 percent of *conirostris* nests were found in *Opuntia* cactus.

The average number of clutches per pair was 6.8, which is more than twice that of 1978 and three times the numbers in 1980 and 1981 (Grant and Grant 1980, 1983). The average number of eggs per clutch did not increase. Despite the large number of clutches produced per pair, the average number of fledglings produced per pair (8.1) did not differ from that in 1978 when pairs had half the number of clutches. The relatively poor nesting success can be attributed to predation of eggs and nestlings by young mockingbirds, *Nesomimus parvulus,* and to a lesser extent to the predation of nestlings by short-eared owls, *Asio flammeus.* Predation occurred in all previous years (Grant and Grant 1980) but was particularly heavy this year due to the large production of mockingbirds. The range of variation in breeding success was especially large in 1983. The most successful pair laid 29 eggs in 7 clutches and fledged 20, while the least successful pair laid 24 eggs in 8 clutches and fledged none.

The other species of finches on the island were not studied in detail. These species are the Large Ground Finch *G. magnirostris,* the Sharp-beaked Ground Finch *G. difficilis* and the Warbler Finch *Certhidea olivacea.* Breeding of all of them was underway in December 1982 and ceased in July 1983. Breeding densities were high but reproductive success per pair relatively low, possibly due to predation by mockingbirds. Nevertheless, because of the large number of breeding pairs, the density of young finches of all species on the island was exceptionally high by July 1983.

To what extent was the breeding of finches on Genovesa typical of Darwin's Finches in the archipelago? On Daphne Major, breeding spanned 9 months. Breeding was more successful on Daphne than on Genovesa owing to the absence of nest predators (H.L. Gibbs, pers. comm.): there are no resident mockingbirds on the island. Unlike *conirostris* on Genovesa, finches *(G. fortis* and *G. scandens)* born early in the season on Daphne were themselves breeding later in the season (H.L. Gibbs, pers. comm.). An extended breeding season almost certainly occurred on other islands. Observations of finches breeding in late November and December 1982 were recorded on Wolf (F. Köster, pers. comm.), Santiago, Isabela and Española (M. Jones, pers. comm.) and Santa Cruz (D. Day, pers. comm.). Breeding ceased in July or August 1983. No breeding activity was observed on brief visits to Bartolomé on August 18, Isabela (Tagus Cove) and Fernandina on August 19, Seymour on August 20, Española on August 21 and Santa Cruz (the vicinity of the Charles Darwin Research Station) on August 18-22. Therefore the breeding of finches on Genovesa was probably typical of the archipelago.

The proliferation of finches resulting from the El Niño rainfall, and the altered pattern of winds and currents may have resulted in an increase in migration between islands. In July 1983 we found 5 immature *G. fortis* on Genovesa. These 5 individuals were almost certainly immigrants as the species has not been found breeding on Genovesa. Immature *G. fortis* have been observed on the island before, but never more than two on any of our visits.

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TWO IMPORTANT RE-ISSUES

DARWIN'S FINCHES: by David Lack, edited and introduced by Dr. P. Boag and Dr. L. Ratcliffe, Cambridge University Press, 1983. 52 + 208 p.p. Hardback £19.50 ($39.50) Paperback £7.95 ($13.95).

With the encouragement and support of his mentor, Julian Huxley, later a Founder Member and Honorary President of the Charles Darwin Foundation, David Lack spent five months of 1938-39 in the Galapagos, mostly around Academy Bay, satisfying his ambition "to compare territorial behaviour in a group of related species". Darwin's finches provided admirable material. Owing to the outbreak of war, his fascinating work was not published until 1947; fortunately so because, during this long, almost Darwin-like period of gestation his views changed radically and his final version marked a new departure in the understanding of evolutionary biology. For some years his opinions were strongly contested but eventually the importance of his book came to be widely recognized and it remains today an outstanding treatise on the origin of new species. It is this that justifies its inclusion in the Cambridge Science Classic Series.

This reprint is technically superior to the 1947 edition, produced while wartime shortages still persisted. Both the black and white and the colour plates are notably improved. In addition there is a long and scholarly introduction by Peter Boag and Laurene Ratcliffe, who have themselves been studying Darwin's finches in recent years. They bring the arguments up to date and provide a comprehensive list of modern references. Because Lack's book did not exhaust the subject. Rather it proved an inspiration to carry his investigations further and further, a task taken up with vigour and persistence, particularly by R.I. Bowman and the group of scientists led by P.R. Grant. This is a timely reissue, falling between Darwin's centenary and the 150th anniversary of his visit to the Galapagos.

FIELD GUIDE TO THE BIRDS OF THE GALAPAGOS: by Michael Harris. Illustrated by Barry Kent Mackay. Collins. 160 p.p. £8.95 (also available in U.S.A.).

Huxley was Lack's mentor and Lack in turn became Mike Harris's teacher at the Edward Grey Institute of Field Ornithology in Oxford. Harris did years of research in the Galapagos when the Darwin Station was first opened, has since returned at intervals in various capacities and so has acquired a knowledge of the birds equalled by few. The new edition updates the information on migrants but otherwise differs little from the 1974 edition, which has been of such value of visiting naturalists of all standards of proficiency: only the greatest experts and the reckless imagine that they can separate all Darwin's finches infallibly. Newcomers are particularly advised not to skip the long introductory sections, which give a succinct account of the birds and their distribution between the various islands and the different altitudinal zones, together with other indispensable background information.

G.T.C.S.

PLANTS INTRODUCED INTO GALÁPAGOS — NOT BY MAN, BUT BY EL NINO?

by Ole Hamann

Having seen in the Galápagos some of the effects of the extreme El Niño year 1982-83 it is tempting to speculate on what influence Niño conditions could have on the colonization of plant species in the islands. Are there some indigenous plant species, of which it may be assumed that El Niño conditions in former times could have played a crucial role for their establishment? A closer look particularly at the drift plants in the Galápagos seems to be relevant in ths context.

TROPICAL DRIFT PLANTS

A number of tropical seeds, fruits and plant fragments (Table 1 and Fig. 1) are able to drift in seawater for weeks, months or even years. Their buoyancy is achieved in various ways: some seeds, such as species of *Muncuna* and *Ipomoea,* have air-filled cavities within; some have very light tissue in the cotyledons in the seeds, as in species of *Dioclea;* some have fruits with corky or fibrous, air-filled layers, like *Hippomane mancinella;* and still others have very light and thin dissiminules, like *Avicennia germinans.* Combinations of these buoyancy factors are frequently realized, as in *Cocos nucifera* (Palmae) (Gunn & Dennis 1976).

The drift species display an effective long-distance dispersal mechanism, by which they have been able to reach the remotest oceanic islands. However, the ability of a plant dissiminule to float to a new place (and still retain its viability) is just one part of colonization; another is establishment in the new place. Drift seeds and fruits sometimes reach regions of the world that they are not suited for. Already in 1765 the Norwegian bishop Gunnerus published a record of tropical seeds and fruits washed ashore in Norway, including such species as *Entada phaseoloides, Mucuna urens, Cassia fistula* (all Leguminosae), *Cocos nicifera, Lagenaria vulgaris* (Cucurbitaceae) and *Anacardium occidentale* (Anacardiaceae). Also from the Danish North Sea coast various tropical drift seeds and fruits are recorded, the SE Asian & Australian mangrove-palm *Nypa fruticans* probably being the most curious (Hansen 1973). Obviously in those cases the dissiminules reached places wholly unsuitable for their establishment.

DRIFT PLANTS IN THE GALAPAGOS

In the Galápagos some of the indigenous members of the flora belong to the group of plants having seeds or fruits adapted to long-distance dispersal by oceanic drift. Notable are the mangroves, several beach plants and some in inland habitats. But also in the Galápagos establishment may be very difficult. For example, in August 1983 large seeds, which probably belonged to the palm genus *Phytelephas,* were found on the beaches of Genovesa and Española. No trees of this genus are known in the islands, though they are common in continental South America. So while it may be assumed that these seeds came drifting to the islands, whether they will succeed in establishing the species is another matter. Drift seeds and fruits arriving at the islands get washed up in an inhospitable environment, at least for plant germination and establishment, namely the arid coastal area.

Carlquist (1967 & 1974) and Porter (1976) investigated the dispersal mechanisms of the indigenous Galápagos plants in connection with discussions on the flora's geographical relationships and the ways in which the plants (or their ancestors) arrived in the islands. Carlquist estimated that 23% of the original introductions could be accounted for by oceanic drift. Porter found this figure much too high: he listed 9% original introductions (35 out of 378) as having arrived by oceanic drift. Porter argued that oceanic drift has had a minor role in plant colonization in the archipelago, and that the plants which arrived in this way were all members of the mangrove, beach or salt-flat vegetation. Furthermore, he found that the small number of species that arrived (and were derived) through oceanic drift was not surprising: "Although drift-dispersed species have relatively high immigration rates in comparison with those which are dispersed by birds and wind, very few species are adapted to this mode of introduction. In addition, their higher immigration rates and the small numbers of habitats available to them in the Galápagos also reduce the opportunities for endemism in this group." This means that 1) drift species in the Galápagos should be few, 2) that they should display a low grade of endemism, and 3) that they should be restricted in occurrence to coastal habitats. As discussed below there seems to be no doubt about the first two points, but interesting exceptions to the third point may be encountered.

MANGROVES

The four mangrove species in the islands all have dissiminules that float. The dispersal properties of three of these species were recently studied in detail in Central America by Rabinowitz (1978). The propagule of *Rhizophora mangle* (red mangrove) retains its viability for a year or more, and may remain floating for 20 to 100 days or more. *Avicennia germinans* (black mangrove) propagules are light, float easily and retain their viability for more than 100 days. *Laguncularia racemosa* (white mangrove) has seeds that may float for about a month in seawater, still retaining their viability. The fourth species in the Galápagos, *Conocarpus erecta* (button mangrove), was not part of the above mentioned study but is known to disperse by oceanic drift by means of the buoyant pericarp of the fruits (Ridley 1930).

The mangrove species in the Galápagos are the same as those encountered in coastal areas in the western part of tropical South America. No speciation has taken place in the islands. The distribution of the mangroves in the Archipelago reflects their effective dispersal and establishment properties. They grow in practically all localities where the ecological conditions suit them, thus indicating that neither dispersal from one place to another nor establishment present a barrier to their colonization.

BEACH PLANTS

Many of the beach and salt flat plants of the Galápagos are notorious drift species, such as *Scaevola plumieri, Canavalia maritima, Ipomoea pes-caprae, Luffa astorii, Batis maritima* and *Salicornia fruticosa.* These species are, however, rather different with regard to propagules and to their distribution in the Galápagos.

Scaevola plumieri occurs practically all over the tropics and is a member of a genus containing some effective drift species. The fleshy drupes may also be bird-dispersed, but the general distribution of the species indicates that oceanic drift is more important. In the Galápagos Scaevola plumieri is found on at least three of the larger islands.

Ipomoea pes-caprae is one of the most widely distributed seashore plants, being circumtropical. The seeds of this species may float for at least 2 years, according to Gunn & Dennis (1976). In the Galápagos it is common on sandy beaches on several islands.

Batis maritima has a dissiminule consisting of a number of seeds enclosed by connate bracts in a corky to fleshy mass, which is able to float. This species is found on both sides of the Americas as well as in the Hawaiian Islands. In the Galápagos it grows in salt flats and on beaches on several islands.

According to Guppy (1906) both seedlings and fragmented joints containing seeds of *Salicornia fruticosa* are able to float. Interestingly he observed this in the Guayas River in Ecuador. *Salicornia fruticosa* is a seashore and marsh plant found throughout the world; in the Galápagos it has been recorded from three islands.

The above mentioned four species represent widely distributed drift species, which in the Galápagos have managed to colonize several islands. A different picture is given by *Canavalia maritima* and *Luffa astorii. Canavalia maritima* is one of the rather numerous Leguminosae with drift seeds ("sea-beans"); *Canavalia* seeds stay buoyant for at least 1.5 years (Gunn & Dennis 1976). The species has a wide distribution in the tropics, but in the Galápagos it only occurs on Marchena. *Luffa astorii* has a dry fruit, fibrous within, which gives it buoyancy. It grows on the coasts of Ecuador and Peru, but in the Galápagos it is only known from Floreana.

These spot-like distributions appear to be the result of one successful immigration of each species, and could also indicate that it is difficult for them to establish in the Archipelago, even though they are well adapted to long-distance dispersal through oceanic drift.

Some other coastal species in the Galápagos may have arrived by drift, but speciation and the number of endemics in the littoral vegetation is limited. *Nolana galapagensis* seems to be the only endemic littoral species, which may have been derived from a drift seed ancestor.

PLANTS OF MAINLY INLAND HABITATS

In the Galápagos the littoral vegetation often covers just a narrow fringe at the coast, being replaced shortly inland by the prevalent arid zone vegetation dominated by *Opuntia* and *Bursera*. A few drift seed plants are found both in coast-near habitats and further inland, while a larger number of drift species actually are only encountered in typical inland habitats.

Belonging to the first category are species like *Caesalpinia bonduc, Hibiscus tiliaceus* and *Hippomane mancinella. Caesalpinia bonduc* seeds float by the means of an intercotyledonary cavity and may stay buoyant and viable for at least 2 years. It is one of the most common "sea-beans", and the plant is a cosmopolitan shrub of both tropical and subtropical regions. In the Galápagos *Caesalpinia bonduc* grows on S. Isabela close to Villamil, on Cerro Azul, and on Santa Cruz, where it is a conspicuous member of the vegetation in the Tortoise Reserve and the adjacent farmland.

Hibiscus tiliaceus has seeds, which float by means of air-cavities between the cotyledons and the testa. It is a native of both the Old and New World tropics, mostly at low elevations, and often in littoral habitats. In the Galápagos it is recorded from Santa Cruz and Isabela; on both islands it grows in the littoral and the arid zone vegetation. Apart from that it may be planted as an ornamental or hedge plant (Santa Cruz).

According to Gunn & Dennis (1976) *Hippomane mancinella* fruits may float for at least 2 years, during which time about half of the seeds stay viable. The tree grows in the West Indies, as well as along the Atlantic and Pacific coasts of Central America and northern South America. In the Galápagos it has a curious distribution, being found both in coastal and inland vegetation, e.g. in the littoral vegetation around Puerto Ayora and in the *Scalesia* forest in the Tortoise Reserve on Santa Cruz (Hamann 1981). It is known from four of the larger islands.

Caesalpinia bonduc, Hibiscus tiliaceus and *Hippomane mancinella* are oceanic drift plants, which have colonized both coastal and inland habitats in the Galápagos. At least *Hippomane* fruits may easily have been transported from the original coastal habitats of the species to the interior of an island by giant tortoises. Tortoises eat *Hippomane* fruits, which then, often after several days, get passed almost unchanged in appearance.

The second category of drift plants mentioned, those that only occur inland, includes such species as *Vigna luteola, Cardiospermum corindum, Mucuna rostrata, Dioclea reflexa, Sapindus saponaria, Stictocardia tiliifolia* and *Ipomoea alba*. Of these, only *Cardiospermum* and *Vigna* are wide spread in the archipelago, in arid and humid vegetation types, respectively. The five other species are all notorious drift plants, but in the Galápagos they have distributions that are restricted and spot-like. *Sapindus* is a conspicuous large tree, which is particularly common on southern Isabela, but which also occurs on Santa Cruz and in the highlands of Santiago. *Stictocardia* is locally abundant in, for example, the Scalesia forest on Santa Cruz and Isabela. *Ipomoea alba* is locally common on Isabela, Santa Cruz and Santiago, while *Mucuna* only grows in a few places in the Tortoise Reserve on Santa Cruz and *Dioclea* has so far only been recorded from one small locality in the highlands of Santa Cruz (Hamann 1974).

Such spot-like distributions are difficult to explain in relation to the plants' effective dispersal mechanisms. Therefore it has been suggested that such species may have been introduced by man (e.g. by Wiggins & Porter, 1972, for *Stictocardia*). Alternatively, their distribution patterns may reflect that although they are well adapted for long-distance dispersal through oceanic drift, they could be less well adapted for establishing themselves in a place like the Galápagos, because they require mesic habitats. Thus, once arrived on the beaches they would have to cross a barrier of unfavourable arid habitats, which could limit their success as colonizers.

Seemingly there is no way in which such crossings could be made. However, Carlquist (1974) mentioned that "an interesting phenomenon apparently not yet appreciated is that seeds in the drift floras are not forced to grow only on the spots where the surf deposits them." For example, he observed viable seeds of *Mucuna* in and around nests of boobies, far above the surf on one of the Hawaiian Islands, and a similar phenomenon was observed among Laysan Albatrosses on several islands of the Hawaiian Leward chain during an expedition in 1966. So Carlquist concluded that seabirds possibly may act as agents facilitating the deposit of drift seeds in non-coastal habitats.

Among the endemic Galápagos plants a few inland taxa may be hypothesized as being derived from drift seed ancestors. For example *Dodonaea viscosa* var. *galapagensis* (Sapindaceae), *Ipomoea habeliana, Cardiospermum galapageium* and, perhaps, *Gossypium barbadense* var. *darwinii* and *Gossypium klotzschianum* (Kalvaceae). But in general, the number of endemic inland plants with drift seeds ancestors is low in the Galápagos.

DISCUSSION OF THE POSSIBLE ROLE OF THE NINO

The drift plants in the Galápagos flora have excellent dispersal properties, but some may be less well adapted to establishing themselves. Drift plants adapted to life in the mangrove and the littoral vegetation are generally wide-spread in the islands; when their dissiminules arrive they are likely to be washed up in places where they can germinate and establish themselves.

Not so with those plants that prefer mesic habitats. In addition to the ocean barrier, they have to cross the barrier of the arid Galápagos lowlands in order to reach favourable habitats. The present distribution patterns of species like *Hippomane mancinella, Caesalpinia bonduc* and *Hibiscus tiliaceus* indicate that some have succeeded once in a while. The distribution of species like *Mucuna rostrata* and *Dioclea reflexa* shows that at one time the large seeds of these species could have been transported from the coast to the interior of an island. It should be noted that the seeds of *Mucuna* and *Dioclea* are among the most common of all tropical drift seeds, so drift to the islands by these species is presumably fairly frequent.

El Niño conditions could play an important role in the colonization of certain drift species. Several of the extraordinary weather conditions brought about by the Niño would favour not only the transportation of drift plants to the islands but also their establishment. During the Niño the Galápagos experienced very high tides, heavy swells and big waves pounding on the shores. This resulted in the disappearance of some beaches, but also in the depositing of flotsam up beyond the normal high-tide level. So during the Niño year drift seed plants adapted to littoral habitats may actually have been deposited in just the right places for germination and establishment. Furthermore, the heavy rains that lasted for nine months helped to break the resting period of many seeds buried in the soil. The enormous amount of vegetation growing from usually desert-like areas (like Baltra) showed that a large seed-reserve had been mobilized. Water was suddenly no longer a limiting factor for plant germination and growth. Many seeds, which are able to rest viable for years, have a very hard seedcoat; in order to germinate they have to be softened by prolonged soaking or they have to be mechanically bruised. The large seeds of *Mucuna, Caesalpinia, Dioclea* and other "sea-beans" are very hard; to germinate them in a greenhouse, the seed coat has to be scraped or filed. During the Niño year, the torrential rains created rivers, lakes and waterfalls all over the islands. Undoubtedly, under such conditions, many hardcoated seeds got soaked or got bruised, which gave them a chance to germinate.

The present spot-like distributions patterns of some notorious drift seed plants in the Galápagos suggest that successful colonization by these species is a rare phenomenon. However, extreme environmental conditions such as those in a Niño year could be a decisive factor. Observations during the next couple of years will tell us whether this suggestion is plausible: We should expect to see that some plants have established themselves in new localities, or even to see some species, which did not grow in the islands before. Probably, such species will turn out to be drift seed plants, whose colonization was helped by the Niño.

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TABLE 1. Some drift seed plants in the Galápagos.

	Species & Family	Propagule	Distribution in the islands
MANGROVES	Rhizophora mangle *(Rhizophoraceae)*	Hypocotyl	+++
	Avicennia germinans *(Avicenniaceae)*	Seedling/ sprouted fruit	+++
	Laguncularia racemosa *(Combretaceae)*	Seed	+++
	Conocarpus erecta *(Combretaceae)*	Fruit	+++
BEACH PLANTS	Ipomoea pes-caprae	Seed	
	Ipomoea pes-caprae *(Convolvulaceae)*	Seed	+++
	Batis maritima *(Batidaceae)*	Fruit-stand	+++
	Scaevola plumieri *(Goodeniaceae)*	Fruit/seed	++
	Salicornia fruticosa *(Chenopodiaceae)*	Seed/seedling/ joints	++
	Canavalia maritima *(Leguminosae)*	Seed	+
	Luffa astorii *(Cucurbitaceae)*	Fruit	+
PLANTS OF COASTAL AND INLAND HABITATS	Caesalpinia bonduc *(Leguminosae)*	Seed	++
	Hibiscus tiliaceus *(Malvaceae)*	Seed	++
	Hippomane mancinella *(Euphorbiaceae)*	Fruit	++
PLANTS OF MAINLY INLAND HABITATS	Cardiospermum corindum *(Sapindaceae)*	Fruit/seed	+++
	Vigna luteola *(Leguminosae)*	Seed	+++
	Sapindus saponaria *(Sapindaceae)*	Seed/fruit	++
	Stictocardia tiliifolia *(Convolvulaceae)*	Seed	++
	Ipomoea alba *(Convolvulaceae)*	Seed	++
	Mucuna rostrata *(Leguminosae)*	Seed	+
	Dioclea reflexa *(Leguminosae)*	Seed	+

1. Note: This is not a complete list of drift plants in the Galápagos, but only some of the more conspicuous.
2. +++: Wide-spread
   ++: Common or locally abundant
   +: Spot-like distribution

Data compiled from the references and personal observation.

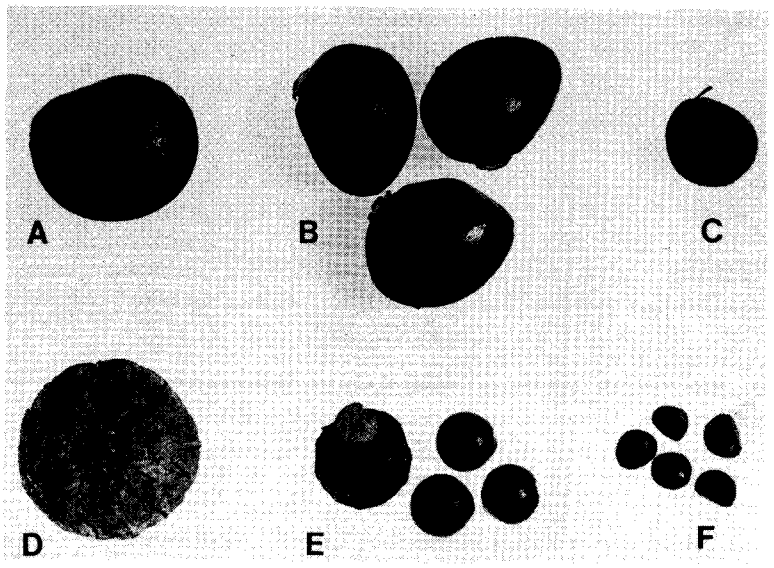

Figure 1. Some of the most common tropical drift seeds and fruits
A. *Mucuna* sp., seed. B. *Dioclea* cf. *reflexa*, seeds. C. *Caesalpinia bonduc*, seed. D. *Hippomane mancinella*, fruit. E. *Sapindus saponaria*, fruit and seeds. F. *Ipomoea pes-caprae*, seeds.

FURTHER THOUGHTS ON "LONESOME GEORGE"

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I read with great interest the article by my colleagues Robert Reynolds and Ronald Marlow in *Noticias* No. 37, in which they outlined available options for the sole surviving Pinta (Abingdon) Island tortoise, "Lonesome George". I have had a sentimental interest in this animal ever since it was discovered. I was on Pinta when he was found, and a valued personal archive is a brief motion picture of the last minutes this tortoise spent on his native island, and his being loaded aboard a *panga* and then transported into exile on Santa Cruz. Bob and Ron's title, "Lonesome George, the Pinta Island Tortoise: a case of limited alternatives" is extremely accurate; but I find myself at variance with their opinions as to which of those limited alternatives is the most desirable. I was not present at the March 1982 meeting in Quito, and there may have been important arguments raised of which I was unaware. However, the points on which I differ are as follows:

i) I agree that there are almost certainly no Pinta tortoises in zoos anywhere in the world, and even if one were to be presented by a claimant of the $10,000 reward, its identity would be difficult to prove. However, the report in *Noticias* No. 35 that a tortoise scat had been found on Pinta in March 1981, nine years after the removal of George to Santa Cruz, should be exhaustively pursued before we give up on finding a wild female.

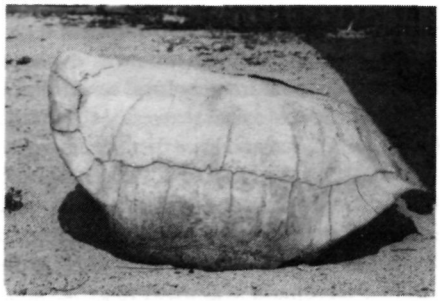
ii) While a back-crossing experiment would indeed take a long time, it still remains possible for one adult male tortoise to father a large number of offspring in a short space of time, if suitable females are available. A twenty-year experiment with George and morphologically suitable females might thus produce many dozens of young which, at the end of the twenty years, would be about adult and could be hand-picked on the basis of appropriate morphology to be the Pinta tortoises of tomorrow.

iii) While cloning remains a theoretically possibility only, the fact is that for the majority of chelonian species that have been studied, sex is *not* genetically determined and thus cultured cells could be made to produce male or female tortoises, as desired, by manipulation of incubation temperature.

iv) Yes, until the possibility mentioned in i) becomes real, George should be mated with morphologically suitable tortoises from Volcan Wolf. The extreme variability in shape of these tortoises should make it possible to find one that looks like a Pinta female. However, the mating should be done in captivity, not in the wild. It is thought that the Pinta Island tortoise reached its catastrophic population level in part because of accidents in which the animals fell into steep-sided ravines and died (Snow, 1964). George is safer at the Darwin Station for the time being! It should also be remembered that, even if George is released along with a number of female *becki,* mating may well not take place. Simple disperal may be a factor: it should be remembered that the two male tortoises and the twelve or so females on Hood Island apparently had not bred for years, simply because they could not find each other. Tortoises released into the thick, recovering vegetation on Pinta today would probably lurch off into the undergrowth and never be seen again, by mankind or each other.

Furthermore, George has not exactly distinguished himself as a prime stud animal, and reportedly studiously ignores the females with which he shares his enclosure. Artificial techniques will be needed to reawaken his drives or at least make artificial paternity possible. This should start by George and his potential mates being exposed to the most sexually active tortoises that can be found, in case the visual impression or the sounds made by mating tortoises stimulate similar activity on George's part. Failing that, more drastic means (such as electroejaculation) should be attempted. Indeed, it is of cardinal importance that sperm samples be obtained and deep-frozen if this hasn't been done already. Otherwise, if George expired tomorrow, we would be left with nothing.

v) Releasing George and a few friends on Pinta is unlikely to help in any detectable way with control of weedy plant species. The vegetation of Pinta in any case had no significant numbers of grazers between the collapse of the tortoise population in the 1860's and a century later when goats were introduced. It is true that the 150,000 plus tortoises on Aldabra keep the grass pretty short, but it is quite a different question as to whether a nuclear population of tortoises reintroduced to an island like Pinta would have any overall



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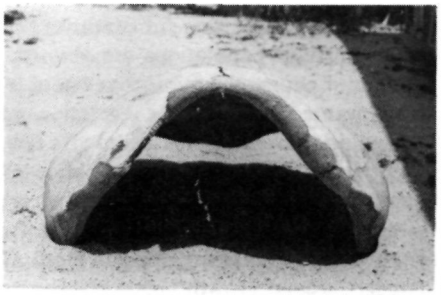

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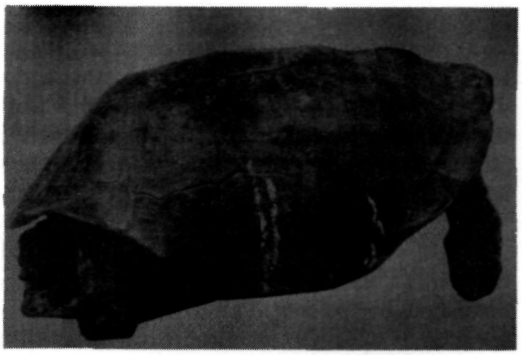

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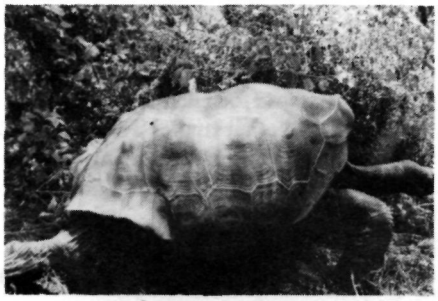
KEY TO PLATES

Plates 1 and 2: Carapace of female Pinta Island Tortoise, collected by P.C.H. Pritchard, 1972.

Plate 3: Lateral profile of Pinta Island Tortoise, reported female (carapace length 50.8cm) collected by R. Beck, 1901. (From Rothschild, W.: Novit. Zool., 1915).

Plates 4 and 5: 'Lonesome George', male Pinta Island Tortoise at the Darwin Station.

Plate 7: Male Duncan Island Tortoise, living.



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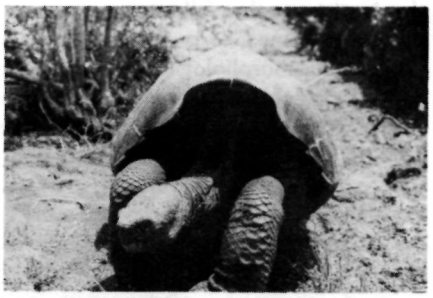

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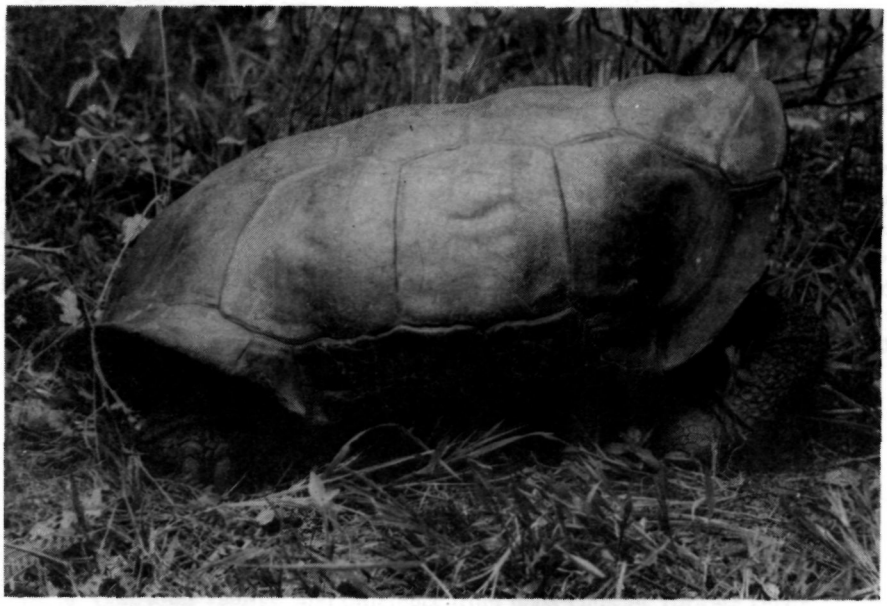

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effect on the vegetation for centuries to come. Indeed, there are surely few islands in Galapagos today where tortoise populations are abundant enough to have much effect on the vegetation as a whole, though of course the influence even of individuals may be profound on an extremely local scale. If one really wanted to have some vegetation cropping by tortoises on Pinta for ecological reasons, perhaps the best solution would be to "borrow" a few dozen large males from Santa Cruz, and have them get to work. Their large size would presumably correspond to large appetite, they are available in appropriate numbers, no genetic pollution would take place if only males were introduced, and if they died their remains would be easily distinguishable from true Pinta tortoises — an important point for morphological study of old tortoise skeletons on Pinta. However, my belief is that the dense growth on Pinta today is the typical "second growth" phenomenon one finds when artificially cleared land is allowed to grow back. The density is doubtless heightened by the El Niño rains of 1982-83. As the wettest year of all recedes into memory and the seedlings grow into young trees, a more penetrable climax ecosystem will surely result.

vi) The argument that the part-Pinta tortoise stock reintroduced to Pinta would allow natural selection to re-shape the new population along Pinta tortoise lines is spurious. The vegetation on Pinta today is dense enough that the Pinta saddleback shell shape would confer no significant survival advantage, since the latter only becomes a significant benefit when food is scarce and tortoises need to increase their vertical feeding range to get enough to eat. In any case, the saddleback shape is only developed as the tortoises approach maturity. The forces exerting selection on a handful of reintroduced tortoises, especially on hatchlings that might be produced on the island, would be random and surely unrelated to the ultra-long-term minor statistical survival advantage conferred by having the "right" shell shape for the island. On the other hand, artificial selection (by captive breeding) would not only eliminate the random loss of individuals by accident, if husbandry techniques were good, but would also allow one to make a positive selection of tortoises that had the correct morphological charactertistics in a far more careful and less wasteful fashion than is possible by natural selection, in which the tortoise with the best shell shape might also be the one that fell into a ravine and expired.

vii) Lonesome George, in hand, is a scientific resource of considerable value. As long as he lives, he is available for morphological, genetic, behavioral, and other studies. When he dies, he can be mounted by the best available taxidermic techniques and used as an important centerpiece for Galapagos education and fund raising in Ecuador. Organ systems can be taken for biochemical and other studies. He should end up in the fine new natural history museum in Quito, not at the bottom of a ravine on Pinta, unavailable to science or conservation. Perhaps, in a Quito museum, his sad story would inspire a new generation to "do better next time". Perhaps even the story would not be so sad, if last-ditch efforts are successful, and by the time of his demise there could conceivably be dozens of young half-Pinta tortoises, approaching maturity, and being carefully selected for the right characteristics by experts with vernier calipers and chromatography labs rather than by the vagaries of natural selection.

To assist in the definition of what is the "right stuff" for a good facsimile Pinta female, I add photographs of the only two known female Pinta tortoises, one collected by Rollo Beck in 1901, deposited in the Tring Museum collection (now part of the British Museum collection, housed at Acton), and the other the carapace of an individual slaughtered by man (hence the absent plastron) a year or two before I found its shell on Pinta in 1972. It was deposited at the Darwin Station but was apparently lost a year or two later. It is noteworthy that these two carapaces show greater differences than are evident among the considerably larger number (about eight) of male *abingdoni** shells and mounted specimens available. Specifically, the 1901 carapace shows the bulging second vertebral scute, slightly higher than the anterior carapace margin, typical of male *abingdoni,* while the latter has a sloping, almost straight top that reaches its highest point at the very front, like a Duncan Island tortoise. Indeed, since the animal was only 20 inches (50.8cm) in carapce length, the possibility that it was an immature male rather than a female cannot be excluded. Rothschild (1915) mentioned that it was a young specimen, still growing.

*The Pinta tortoise is usually called *Geochelone elephantopus abingdoni.* However, a more accurate name would be *Chelonoidis nigra ephippium.* Bour (Bull. Mus. natn. Hist. Nat., Paris, 4e Ser., 1980: A (2): 541-546) presents the case for use of *Chelonoidis* rather than *Geochelone.* The specific name *nigra* Quoy and Gaimard 1824 antedates *elephantopus* Harlan, 1827, and has the additional advantage of an extant holotype. *Testudo elephantopus* has only been in use since 1961 (Wermuth & Mertens: Schildkröten, Krokodile, Bruckenechsen, Jena) as a collective name for Galapagos tortoises, while *nigra* is not a *nomen oblitum,* having been in use for much of the 19th century and early 20th century. Actually, there are earlier names still for Galapagos tortoises. *Testudo californiana* Gaimard was described a few months earlier than *Testudo nigra,* in Bull. Sci. nat. Géol., 1824, pp. 90-91. However, this name has not been utilized subsequently, and can be dismissed as a *nomen nudum.* Bell's 1838 monograph on the Testudinata showed a Galapagos tortoise labelled with Schneider's 1783 name *Testudo indica.* However, this name applies properly to an Indian Ocean giant tortoise (Bour, C.R.Acad. Sc. Paris, t. 295, Ser. III, 117-122 (1982)), although it is the oldest available name for a giant tortoise.

Pritchard (1979): Encyclopedia of Turtles, p. 374) presents the argument as to why the holotype of *Testudo ephippium,* shown below in Plate 6, was from Pinta rather than Duncan (a male Duncan tortoise is shown in Plate 7).

Testudo rotunda Latreille 1801 is an even older name than *nigra* or *californiana,* and the type, a juvenile Galapagos tortoise, is still in the Paris Museum. However this name achieved no subsequent use for Galapagos tortoises and is a homonym of a subsequent name for the European pond tortoise (*Testudo rotunda* Merrem, 1820). It should therefore be considered a *nomen oblitum.*

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Snow, D.W. 1964. The giant tortoises of the Galapagos Islands. *Oryx* 7 (6): 277-290.

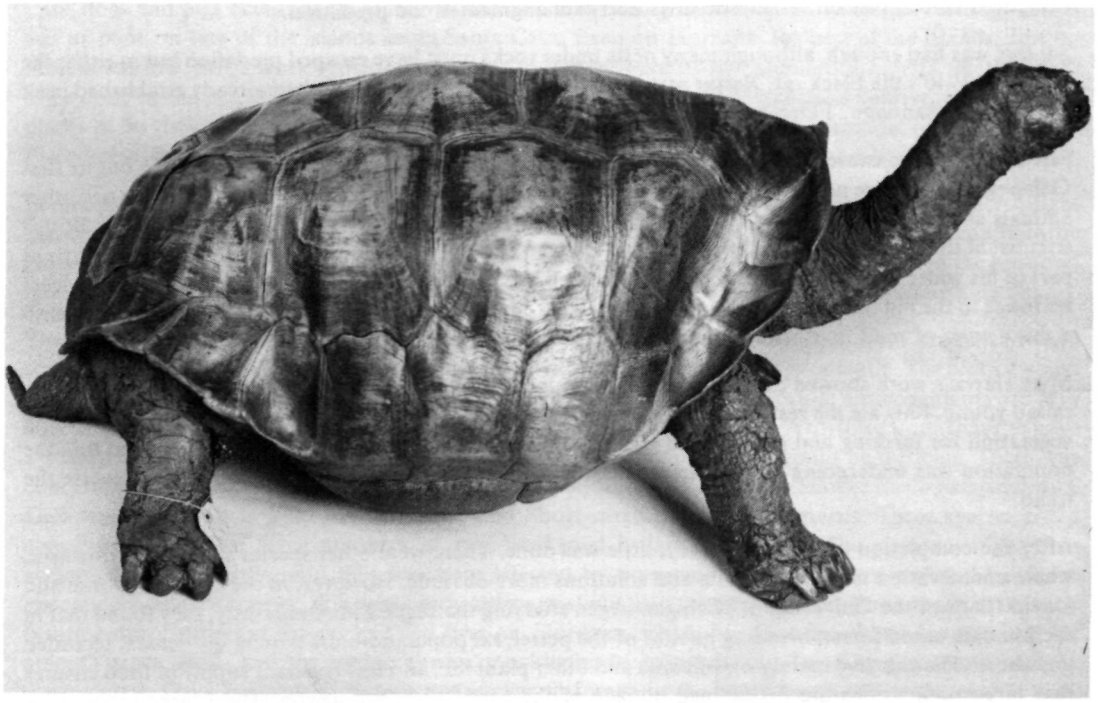

Plate 6: Holotype of *Testudo ephippium* Gunther 1875, in Edinburgh Museum. Note similarity of shell profile to that of 'Lonesome George' and difference from male Duncan Tortoise (Plate 7).

THE ENDANGERED PETREL OF THE GALAPAGOS VOLCANOES

by David Duffy

Dr. Duffy, formerly staff ornithologist at the Darwin Station, is now doing research on sea-birds at the Percy Fitzpatrick Institute, University of Cape Town, Rondebosch, 7700. Distance has in no way reduced his concern for Galapagos conservation.

To most of us, the Galapagos Islands bring images of low, dry, lava-strewn ground and cactus, of tame boobies, giant tortoises and Darwin's Finches. There is however another side to Galapagos, one that fewer tourists see: the upper zones of the larger volcanoes. This is a land of cloud and drizzle, of steep, rugged slopes covered in unique plants and trees. It is also unfortunately the part of Galapagos most in danger. A horde of introduced plants, insects and mammals are upsetting an environment which has been too long isolated to tolerate the abrasive new arrivals.

In this world of mist, a thousand feet or more above the sea, there nests a large seabird, the Dark-rumped (or Hawaiian) Petrel, *Pterodroma phaeopygia.* The petrel is nocturnal, finding its way through the night mist and dense brush to a burrow scraped out beneath a Miconia tree or dug into the side of a lava tube. This choice of nest site makes the petrel vulnerable to the changes that are taking place in the highlands. As a result it is now the only Galapagos bird in immediate danger of extinction.

The Dark-rumped Petrel nests only in the Hawaiian and Galapagos Islands. The Hawaiian population is small, perhaps a few thousand pairs, the remains of much greater numbers which were decimated by introduced mammals. The Galapagos population is much larger, perhaps as many as one hundred thousand pairs, but it is being rapidly reduced by the same problems as in Hawaii. The same result can be expected. Extinction is not far off unless protection is provided.

The early settlers in the highlands found petrels in immense numbers. Sleep was difficult during the nesting season when birds would come in, howling and cackling their weird calls. Whole hillsides were honeycombed with burrows. The settlers had to cease hunting feral pigs during the petrel breeding season because the pigs dug up and ate so many birds that pig flesh tasted of petrel — a flavour unfavorably compared to codliver oil. Domestic dogs and cats augmented the predation.

All this was bad enough, although many nests under rocks must have escaped predation but in either the 1930's or 1940's the black rat, *Rattus rattus,* arrived on Isla Santa Cruz. It had already established itself long ago on Santiago, Floreana, San Cristóbal and Isabela, and other islands.

Scientists were unaware of these problems. The petrel had been described as early as 1876 but its first Galapagos nests were not discovered until 1906. Early scientists naturally devoted their attention to other animals such as giant tortoises or Darwin's Finches. It was not until 1966 that M.P. Harris, a British scientist at the newly created Charles Darwin Research Station, began to study the petrel on Santa Cruz as part of his wider study of the seabirds of the archipelago. The logistical difficulties were severe. There were no roads to the highlands so he had to set out at 3 a.m., stumbling up a rocky trail, much of it carpeted with a thick layer of mud, and with the visibility often close to zero.

Mike Harris's work showed that the situation was alarming. In two seasons, only 4% of 92 occupied nests raised young. Rats ate the rest, and dogs and pigs killed many of the adults. Harris suggested that clearing vegetation for farming and grazing had greatly reduced nesting sites for petrels. He concluded that the population was undergoing a "spectacular decline" and that there would be no easy way to reverse the trend.

After the completion of Harris's survey, little was done. There were other species such as the tortoises, where conservation needs were acute and solutions more obvious. However, in the 1970's Deborah and David Clark of the University of Michigan began studying the Black Rat. Ominously, they found that in the Miconia cloud forest, breeding habitat of the petrel, rat populations are among the densest recorded anywhere. The rats live mainly on Miconia and other plant life, and this constant supply of food ensures that large populations are maintained outside of the petrel breeding season. The Clarks proposed a

trapping program to control rats during the petrel nesting season. The plan was never implemented because the traps would not have lasted long enough in the 100% humidity and mud, and tending them daily would have made severe demands on even the most dedicated park wardens or scientists.

In 1978, Robert Tomkins arrived from Australia to study the Waved Albatross and the Dark-rumped Petrel. He soon found himself so caught up in the fate of the petrel that he gave up his other plans. He started by repeating Harris's study on Santa Cruz, hoping the situation had improved in the intervening 11 years. Bob added three more study colonies to Mike's original one. To do so, he had to live up in the cloud forest for several days at a time. The Darwin Station lacked the funds to construct a house and tents cannot keep out the mist, rain and mud of the Miconia forest. There was only enough money to construct a very small hut, about the size of a two-seater outhouse, with just room for two narrow field cots. These had to be propped up if one wanted to stand inside or cook on a thin counter along one wall. The windows were heavily screened to keep out the mosquitos and rats which swarmed when the sun went down.

Even two or three day periods in the hut were taxing. Keeping the mud out was hopeless. Fetching cooking water became an exciting adventure in zero visibility and Bob or his helpers often got lost on the 100 metre walk to a small pond.

The results justified the hardship but the news was not good. Nesting success was as low as Harris had found. Tomkins concluded that the petrel would be extinct on Santa Cruz by the end of the century.

Tomkins' work was greeted with some scepticism. Galapagos did not need another endangered species. There were enough problems facing the Park Service and Darwin Station and there was still the pious hope that, although the Santa Cruz population of petrel might be in desperate trouble, perhaps even beyond hope, there were known populations of petrels on four other islands, which might be in less critical danger.

In the second year of his study, Tomkins tackled this possibility. Hitching rides on fishing and tourist boats and staying with islanders to stretch his limited funds, he studied the petrels on Santiago, Floreana and San Cristobal.

The results were disturbing. All these islands had had rats for a century before they arrived on Santa Cruz. Cats, dogs and pigs occurred on Floreana, San Cristobal and Isabela, pigs on Santiago. Nesting success was as poor on two of the islands as on Santa Cruz. Even on Floreana, the best of the islands, nesting success was low. Bob's work provided a warning that there were no safe populations, that something had to be done or the petrel would sooner or later be lost. A few pairs might somehow survive in inaccessible places as do the congeneric petrels such as the Cahow, *Pterodroma cahow,* of Bermuda, or the Diablotin, *Pterodroma hasitata,* of Haiti, but even this was doubtful.

Before Bob returned to Australia, he investigated possible methods of helping the petrel. Fences might exclude dogs, pigs, even cats, but not rats: there were too many crevices and lava tubes honeycombing the ground. Rat traps might work but would require enormous amounts of time and effort in the mist and mud. Bob suggested that the only answer lay in some of the newer rat poisons or anticoagulants.

The anticoagulants would be placed in bait blocks and protected against the moisture. Each block would contain a lethal dose for a rat but not enough for larger mammals such as dogs or cattle. The blocks would only be used where farm animals were legally excluded. More important, while anticoagulants are very effective on mammals, birds and reptiles need massive doses to be affected. A tortoise would have to have a steady diet of bait blocks to be affected. With blocks 50m apart, this would be difficult. There was concern however about the possibility of secondary poisoning of Galapagos Hawks *Buteo galapagoensis,* Galapagos Barn Owls *Tyto punctatissima,* and Short-eared owls *Asio flammeus.* These species could conceivably consume large numbers of rats weakened by anticoagulants. The poisons might then accumulate in the birds until they too were affected by poisoning. Since the barn owl and hawk are endemic Galapagos species, this possibility, although slight, could not be ignored. Bob suggested that any future control program should be tried first on Floreana, which has been inhabited by man and his animals since 1832, and the native hawks, mockingbirds, tortoises and Land Iguanas have already disappeared. Owls are present but do not appear to forage in the heavy brush where the petrels nest.

It took several years before a program could be launched. Since effective action required a commitment to decades of work, some questions had to be answered first to ensure that the work was really needed and that Floreana, far from the Darwin Station, was the best place for it. Were there already too few birds on Santa Cruz to justify a protection program? Was their population actually collapsing? Could the study methods used by Mike Harris and Bob Tomkins have been responsible for the low nesting success they found?

Ruth Baker, a New Zealand medical doctor, who like so many Kiwis had decided to take a few years off to see something of the world, volunteered to do a census of petrels on Santa Cruz. Experience with the birds was not important. Given the terrain and conditions, determination was the main qualification. She had that in abundance.

Ruth and an Ecuadorian student, Geraldo ("Lalo") Corrales, decided to ask the people of Santa Cruz what they knew of the petrel. As a result of their talks, they found their search area considerably enlarged from just the Miconia cloud forest to everywhere above 200m elevation. What was supposed to have been the work of a few weeks was turning out to be a task for several months. They explored throughout the highlands, from the giant 'sinkholes', or collapsed lava bubbles, on the island's summit to the Scalesia sunflower tree forest of the north. Instead of a few hundred or thousand pair, Ruth estimated that there might be as many as 40,000 birds still nesting on Santa Cruz alone.

Geraldo having returned to his studies at the university, Ruth ws joined by Fiona Bass, a British naturalist. They tried to determine if the methods used by Tomkins and Harris might have been responsible for the low nesting success. Could the whole thing have been a false alarm, the result of disturbance by investigators? Could investigators have scared birds off nests, allowing access for rats? Could frequent visits have attracted dogs, pigs and cats to burrows?

Fiona monitored several breeding sites, visiting them only four times during the breeding season instead of weekly or bi-weekly as had been done previously. The fewer the visits, the less the disturbance and the higher the nesting success should have been, if scientists were responsible. Unfortunately, nesting success remained low as in previous studies. Rats, cats, dogs and pigs, not scientists, were putting the petrels in jeopardy. With the data from all these studies, it was time to stop studying the birds and do something for them.

Aided by the International Council for Bird Preservation, the National Park and Darwin Station planned to construct a patrol hut for park guards at Media Luna in the heart of the Santa Cruz petrel nesting area. The hut would allow guards to be permanently stationed in the highlands, so that they could keep cattle and dogs out of the National Park. The post would also help control the increasing numbers of tourists visiting the highlands. Above all, the guards would be able to start an intensive rat-control program. Living on the spot, putting out and tending bait would be the job of hours rather than days as previously.

Unfortunately, by this time the Ecuadorian economy was suffering from the world-wide recession. The park budget was cut, barely leaving funds for guards' salaries and existing conservation programs. Projects with demonstrated success such as the tortoise and iguana captive rearing programs, feral goat and dog control, and the education of Ecuadorian students could not be sacrificed to start a new project which offered only an uncertain prospect of success and that only after a decade or more of work.

The plan to save the Santa Cruz petrels having collapsed, it was decided to attempt Tomkins' alternative scheme on Floreana with the long-term support of the World Wildlife Fund. Logistically this was more difficult as both the Darwin Station and the National Park Service are based on Santa Cruz but it was hoped to offset this by obtaining the support of the local settlers, who had already spontaneously declared their island's chief petrel nesting colony, Cerro Pajas, a "Protected Area". (Such an initiative on the part of the local people is in itself a development of great significance for the future of Galapagos conservation). The Floreana project was more modest as it did not propose to protect all petrel nests but only to throw a "cordon sanitaire" round the largest and most concentrated colony in the archipelago. The plan was started by Malcolm Coulter, staff ornithologist at the CDRS, who was to take charge during the breeding season, assisted by Tina Beach, a U.S. naturalist. They were most fortunate in recruiting the

services of Felipe Cruz, son of a local family who had taken the lead in declaring the nesting hill a protected area. Felipe had become a keen naturalist and conservationist and, with his brother, had already eliminated the island's wild dogs, both because they were attacking the settlers' livestock and because of their effect on the wildlife. Based on his home, he agreed to run the rat erradication programme throughout the year and Tina agreed to stay on with him.

The first two years were devoted to research on levels of nesting success and to discovering the most effective way of using anticoagulants against the rats, without endangering other species (the tortoises, iguanas, hawks and mockingbirds had already been exterminated). The third season, 1983, looked initially to be set for disaster. The extraordinarily heavy El Niño rains caused the collapse of many nesting burrows and the constant renewal of the 200 baits in plastic tubes was made much more difficult, while life was exceptionally hard for Felipe and Tina, even by previous standards of suffering in the cause of saving the petrel. In spite of the abnormal conditions, breeding success actually rose by 20% instead of falling by 33% as previously; and predation by rats was apparently reduced to zero.

This was a famous victory but to win a great battle is not the same as winning a war. What has been demonstrated is that, for a limited time in a restricted zone, rats have been effectively controlled. The method could be applied with modifications to other petrel populations and to other islands. As usual it is a question of making men and resources available. After all the setbacks over the years, I cannot disguise my continuing apprehensions.

Against this pessimism, I hope someday to be able to return to the Galapagos and, on a moonlit night on Floreana, to make my way up the steep slopes of Cerro Pajas with the weird, howling cackling calls of the petrels. I would like to sit on the edge of the half-moon shaped crater and watch as the big petrels fly past just a few feet overhead, flashing white in the moonlight as they turn to plunge into the mist of the crater. To see the clumsy lumbering Dark-rumped Petrel of the sea transformed into a night bird as fast and agile as any falcon is a sight that future visitors should not be deprived of because of the unthinking actions of the past. Even if I never return to the islands, it would be nice to sit in the night air, far from Galapagos, and know that the same moon that shone on the snow or African veld was shining on the petrels as they returned to breed again.

Dark-rumped or Hawaiian Petrel *Drawing by M. Estey*

POTENTIAL FOR RESTOCKING GALAPAGOS HAWKS ON ISLANDS WHERE THEY HAVE BEEN EXTIRPATED

by John Faaborg

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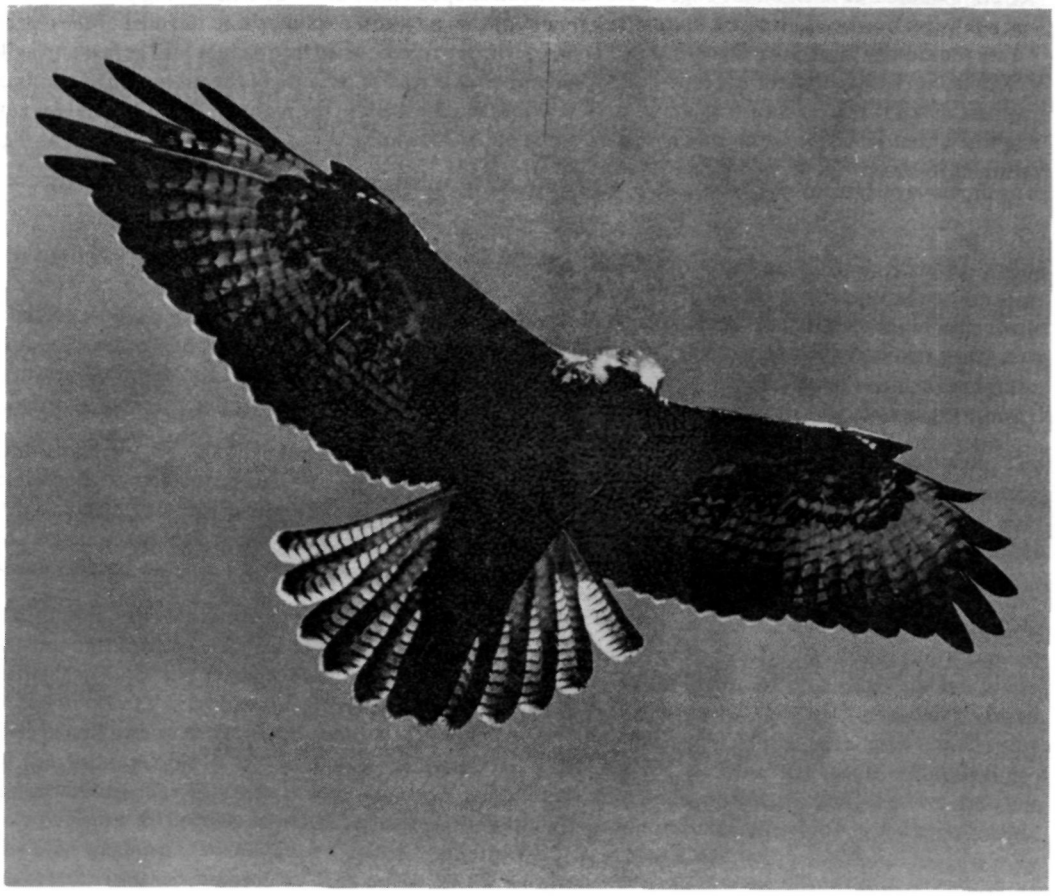
The endemic Galapagos hawk *(Buteo galapagoensis)* formerly occupied all the major islands of the archipelago. Its present status is highly variable from island to island, a fact which may have led to its listing on the white sheet of the Red Data Book of I.U.C.N. Primarily due to human activities, it is now extinct on San Cristobal where there is considerable human settlement; no more than 2 pair may remain from a formerly large population on Santa Cruz and its associated islands of Baltra and North Seymour; and it has long been extinct on Floreana. In contrast, the hawk is still quite common on Santiago, Española, Isabela, Fernandina, Pinta, Marchena and Santa Fe. These populations have been suggested to total 130 breeding pairs or groups.

The absence of this integral component of the terrestrial ecosystem on so many islands is both biologically and aesthetically unfortunate. While doing our studies on the evolution of cooperative polyandry in the Galapagos Hawk, we have been struck that the demographic properties of at least some of the island hawk populations show the presence of a "harvestable" surplus of birds. These birds could be used to restock an island where the bird has been extirpated, without any long-term effect on the source population. While we realize that restocking involves certain risks and numerous considerations other than purely biological ones, we feel the idea should be given serious consideration.



Galapagos Hawk *Photo by* Fritz Pölking

A Source of Birds

Before any restocking can take place, one needs a source of birds such that removal of some individuals does not injure the source population. Our findings on the demography of the Galapagos Hawk on Santiago suggest a large pool of available birds and similar conditions may exist on other islands. Let us begin by noting that published estimates of the number of breeding pairs or groups (as the hawk is polyandrous) can be misleading in terms of total hawk populations. For example, it has been estimated that Santiago supports breeding birds on 50 territories. Due to cooperative polyandry, we estimate that these territories support 180 adult birds, rather than the 100 one would expect with monogamy. In addition, Santiago supports large numbers of non-breeding, non-territorial birds, mostly juveniles and adult females. These birds live primarily in highland areas where the hawks do not breed. Our counts of these on Santiago often exceed 100 birds. Thus, Santiago alone may support over 250 individual hawks.

Our measurements on mortality rates of these two groups of hawks on Santiago show the existence of a harvestable surplus of birds. The territorial birds seem to remain on their territories for the remainder of their lives. Banding studies over a four year period estimate less than a 10% annual mortality rate among these birds. While reproduction is highly variable, it appears that even in the poorest years enough young are produced to match the mortality of breeding birds. In climatically favorable years, a great amount of overproduction may be occurring. During our July 1981 survey of Santiago, we found the poorest reproductive success of our three visits, yet a sample of 12 breeding groups produced 7 fledged or nearly-fledged young. Extrapolating this to the estimated 50 territories would suggest that 29 young were produced. Yet estimated mortality of breeding adults for 50 territories would be only 18 birds. Thus the production of young even during this unusually poor year would have been enough to replace the mortality of breeding adults and this does not include any renestings that may have occurred later in 1981. In contrast, a sample of 8 nests during wet conditions in 1979 produced 14 young. This would extrapolate to the production of over 80 young on the island, an excess of nearly 50 birds over what is needed to replace mortality.

With the production of young exceeding the replacement requirement of the breeding population by such a wide margin, it is not surprising that there is a high mortality rate among this non-territorial population. Non-breeding birds are forced by territorial birds to live in less favorable environments. Analyses of our own and Tjitte de Vries's banding data for the highland birds on Santiago suggest that about 50% of these non-territorial birds die each year, even when accounting liberally for recruitment into the breeding groups. This rate may be artificially low on Santiago due to the goat population there. These goats both serve as food to the scavenging hawks and also tend to open up the vegetation to make food more accessible to foraging birds. In 1981 we found some birds establishing breeding territories in the highlands, something they will not do when these areas have their native covering of fern and bracken. While this non-territorial population fluctuates in size to some degree, our estimates have always exceeded 75 birds. We also have never made counts in November or December, when the young of the year enter this population. Thus, for example, the 1979 production of young may have added 80 juveniles to the 100 birds estimated in the non-territorial population. It is obvious that this is a large, crowded population.

Putting all this together, it appears that removing as many as 30 birds would have little effect on even a single year's population levels. While finding an adequate number of adult males could be a problem, adult females and juvenile males are abundant. Tjitte de Vries has recorded the pairing of an adult female and juvenile male, so using juveniles for restocking may not be a problem.

Potential Problems with Restocking

I can envision no major natural problems with introducing these birds on empty islands where the species occurred previously. While observations of birds on islands with saturated populations suggest relatively little variation in territory dimensions and nest sites, there is evidence that they do shift territory boundaries or add new nests occasionally. In terms of diet, the hawk is generalized enough to adapt to about any combination of available foods on these islands, while all the prey species have coexisted with hawks for many years in the past.

Since the Galapagos Hawk is a tame, generalized predator and scavenger, it does not always interact well with humans. Hawks like to eat chickens and are so tame they will enter yards and even chickenhouses to feed. One of the chief causes of the demise of this species on Santa Cruz was this factor. Where birds are able to establish territories away from human settlement, the hawk-human conflict should be minimal, but in settled areas the introduction of non-territorial birds and their subsequent offspring might well give rise to conflicts. With the increasing awareness of the value of wildlife on these islands, perhaps the public can be induced to protect the hawks. Some sort of compensation for substantiated damage might be possible without too great an expense.

Summary and Potential for Population Increase

Our conservative estimate is that 30 birds could be removed from Santiago annually without affecting breeding populations there. Apparently hawk populations on other islands could also support some removal. It is possible that stocking a mixed population would be a good idea to maximize genetic variation. All of our evidence supports the view that hawk reproduction greatly exceeds the number of adults needed to replace the yearly mortality among the space-limited breeding birds. In fact, the evolution of such a rare mating system as cooperative polyandry is probably a result of this factor. This is definitely a "harvestable" population.

What is the potential for increase in the numbers of the Galapagos Hawk? We can only make an educated guess. It has been suggested that Santa Cruz was once the population center for this species with up to 250 territories there. Less is known about the previous populations on Floreana and San Cristóbal. Assuming the hawks set up territories only in the arid and transition zones (about 300 metres elevation and below) and recognizing that Santa Fe holds 17 territories, I would guess that Floreana could easily support 20-25 breeding groups and San Cristobal 60-75. While it would take many years for these population levels to be achieved, the result could be a tripling of the total population of the Galapagos Hawk. Perhaps as importantly, it would restore the top carnivore to the natural communities of these islands.

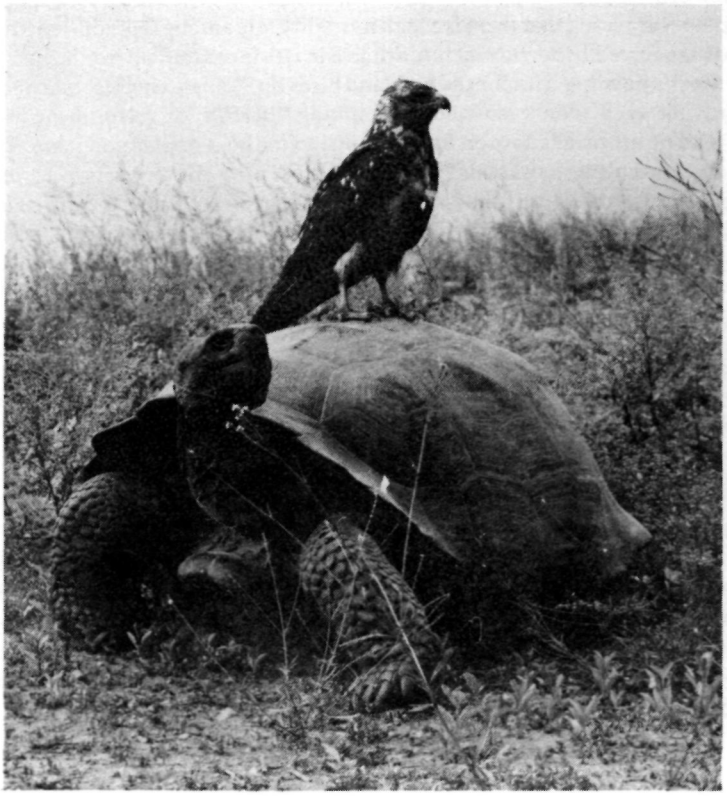


Photo by Tjitte De Vries

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