

NOTICIAS DE GALAPAGOS

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NEWS FROM ACADEMY BAY

PLANNING

Friedemann Köster, the Director of the Charles Darwin Research Station, reports that the latter part of 1982 was dominated by a series of planning exercises. Taking advantage of a week-long visit by the Foundation's President, Peter Kramer, and with the co-operation of the National Park Service and the National Institute for Galapagos, every research and educational programme was re-examined and some 30 scientific projects were approved for 1983. Much time was also devoted to briefing a mission from the World Wildlife Fund, sent to assess the conservation work of the Station during the last ten years. The CDRS staff also collaborated in drafting a new version of the Master Plan for the Galapagos National Park, revised to meet changing circumstances and to strengthen the park service both administratively and financially.

Over and above all this, another high level commission was preparing a plan for the entire archipelago, including the one-tenth which has human settlements and lies outside the boundaries of the National Park. This commission, which has to consider the interests of settlers, tourists and armed forces as well as scientists and conservationists, is essentially a government body and the CDF is not officially represented on it. However the Darwin Station has granted leave of absence to its Deputy Director, José Villa, to serve for a year as Technical Director of the Commission. This is another of several encouraging examples of the interchange of personnel between the national and international organizations concerned with the future of the islands. Congratulations are extended to Freddy Herrera, formerly Station meteorologist, on his appointment as Governor of the Galapagos. Such developments can only go to strengthen harmonious relations and make co-operation in conservation the more effective.

A GALAPAGOS MARINE PARK

The demarcation of the land boundaries of the National Park was completed years ago but nothing has been finally decided about the surrounding seas, although the question has been under discussion since the 1960's. One reason for the delay may have been that the underwater resources were for the most part still in a pristine state, so attention was concentrated on the terrestrial species, which were in urgent need of protection. There were also administrative complications as different ministries were responsible for national parks, fisheries, defence and the law of the sea. In practice, a good deal of progress has been made and 1983 may see legal confirmation of the inclusion of a marine zone, which may well prove as fascinating as the land area of this outstanding World Heritage. Meanwhile the CDRS has built a modest marine laboratory and has added a marine biologist to its staff. Elsewhere in this issue, Gary Robinson gives his views on the form the marine park might take. It is an involved question needing a great deal more research and it should be borne in mind that the combined coastlines of the Galapagos Islands are greater than those of mainland Ecuador.

THE FERAL ANIMALS ON SANTIAGO ISLAND

Introduced species are the major conservation problem on all the islands with human settlements, and even on some others. There are no longer any human residents on Santiago (James) Island but nevertheless it has the largest population of feral animals. An estimated 100,000 goats are destroying the vegetation with the aid of some 20,000 pigs, which also dig out the nests of tortoises and turtles. It has been possible for the GNPS and CDRS to eliminate the goats on five (virtually six) of the smaller islands but Santiago has hitherto been beyond the available resources in men and money. Now that the goats on Pinta and the dogs on southern Isabela have been brought under control, a large-scale campaign to clean up Santiago is under study. Professor Bruce E. Coblentz has proposed that priority should be given to controlling the pigs rather than the goats. He argues that it would be more effective to hunt them while the goats are devastating the vegetation in which the pigs would otherwise find cover. The Frankfurt Zoological Society has generously offered its support in the first stages of what will inevitably be a long struggle in a particularly harsh terrain.

CAN THE HAWAIIAN PETREL BE SAVED?

The Dark-rumped (or Hawaiian) Petrel is in danger of extinction in both its breeding areas — the Hawaiian and Galapagos archipelagos. There is still a considerable Galapagos population but, as its breeding success is declining uncomfortably close to zero, it is only a question of time before it dies out (Noticias 35). A large pelagic bird, it is safe over the ocean during much of the year, but it nests in burrows in the moist uplands, where black rats and pigs prey on eggs, chicks and adults. (During the petrel's breeding season, pigs are considered uneatable because of the strong fishy flavour of their flesh). Years of study have hitherto failed to find any way of eradicating the rat which is the biggest threat to the petrel, but a limited project to ensure at any rate the survival of the species was started in 1982 with the support of the World Wildlife Fund. A *cordon sanitaire* was thrown round the most concentrated breeding area on a hilltop in Floreana, where there are still some 1,500 birds. If rats cannot be eliminated, it may at least be possible to exclude them from this zone for the duration of the six-month nesting season. The CDRS is deeply grateful to Bryan Bell, New Zealand Wildlife Service, and Jim Keith, U.S. Fish and Wildlife Service, who came to help with their specialized knowledge of rat control in planning this campaign.

The black rat was probably the first "old world" mammal to be introduced into the archipelago. The ships of the late seventeenth century buccaneers were certainly infested and they used some Galapagos beaches for careening their vessels. The buccaneer, Alexander Selkirk (the original of Robinson Crusoe) found that rats were already a pest on Juan Fernandez, an island off the coast of Chile, when he was marooned there around the year 1700.

EDUCATION AND TRAINING PROGRAMMES

The regular annual courses and examinations kept the CDRS and GNPS busy throughout August and September: first the training course for national park wardens, then the course for auxiliary tourist guides, and finally the longer and more rigorous course for naturalist guides.

An important new departure was the month-long visit of the Technical Head of the Rural Education Department of the Ministry of Education to collaborate with the CDRS education officer, Gonzalo Oviedo, in drafting plans to improve the curricula of the schools on the four inhabited islands. Their report, in addition to recommending improvements of a general nature, concentrated on the need for the schools to pay greater attention to environmental education with a view to equipping young people for employment in the islands' only growth industries — tourism, conservation and scientific research. This would imply putting a new emphasis on the teaching of science. The suggested reforms have been submitted to the Minister of Education.

VISITORS AND EVENTS AT THE CHARLES DARWIN STATION: MAY — OCTOBER 1982

MAY

Gregory Estes, Mike Jackson and Barry Meatyard of the Cambridge University Darwin Centenary Expedition to Galapagos began their study of the feeding of the marine iguana.

Party sailed to Cartago Bay (Isabela) to restore to their ancestral home the first 37 of the young land iguanas, captive-bred at the CDRS.

Yael Lubin to Santiago to investigate the recently observed occurrence of cockroaches there.

Gary Robinson, Ted McConnaghey and their wives to Champion to study white coral and water temperatures.

Andrew Laurie and Arnaldo Tupiza began a 15-day trip sailing round Isabela to observe marine iguanas.

Pepe Villa, formerly Deputy Director of CDRS, began work on the new Master Plan for the Galapagos Archipelago.

JUNE

Bruce Barnett left CDRS on completing his studies of the feral dogs.
Juan Black, Secretary General of the Darwin Foundation arrived at CDRS.
Pepe Villa, Juan Black and the Master Plan commission left for San Cristóbal, where they were joined by Ing. Arturo Ponce, Director of the Department of Natural Areas and Wildlife.
Catherine Rechten, Max-Planck Institute, returned to Española to continue her studies of the Waved Albatross.
José Elías Cárdenas of the Ministry of Education came to work with Gonzalo Oviedo on the joint educational programme of the Ministry and the CDRS.
Peter Grant and his daughter arrived to continue their long-term studies of Darwin's Finches.
Ruperto Pinos, from the Chimborazo Polytechnic, came to study problems of wild cattle.
Bryan Bell, expert on rat control, arrived from New Zealand to help Malcolm Coulter in his project to save the Hawaiian Petrel from extinction.

JULY

Jim Keith, Denver Wildlife Center, came to help with the rat problem.
Malcolm Coulter, Bryan Bell, Jim Keith and assistants to Floreana for the campaign to save the petrel.
Mario Hurtado from the National Institute of Fisheries and Byron Mora of the Subsecretariat of Fisheries arrived to work out with CDRS a joint plan for artesanal fishing in 1982/83.
Allen Putney, adviser on the Master Plan, arrived at the Station.
Tjitte de Vries came to continue his study of the Frigate-birds.
Gunther Reck and Merilio Morell came on a WWF mission.
Malcolm Coulter left to take part in the conference of the International Council for Bird Preservation at Cambridge, England, and the International Ornithological Congress in Moscow.
Ana Cristina Sosa, Catholic Univ. of Quito, began work on the birds of the Isabela lagoons.
Jaqueline Peñaherrera to Isabela for a 3-month project on human ecology.
Dominique Limberger and assistant began their marine iguana studies on Fernandina.

AUGUST

The annual training course for National Park wardens began at the Station.
Yael Lubin, staff entomologist, left for four months to lecture at Univ. of Gainesville, Florida. Her assistant, Krista Connors returned to the U.S.A.
Luis Calvopiña, staff scientist for feral animals, to Cambridge to take part in a conference.
Richard Darwin Keynes, Cambridge Univ., a member of the CDF's Executive Council, paid another visit to the Galapagos.
The annual training course for auxiliary tourist guides began.
Bruce Coblenz, his wife, Mike Hansen and Bill Barber came to study problems of the wild pigs on Santiago.
Yoland Celeri went to the islet of Venecia to report on the artificial breeding colony of land iguanas.
Frank Talbot, Peter Bedford and their wives, California Academy of Sciences, visited CDRS.
Zev Naveh, Univ. of Haifa, visited CDRS.
Oswaldo Chapi and his team returned to Isabela for another stage in the dog control campaign.
Wolf volanco on Isabela erupted. Alan and Tui Moore set out with Ruth Quezada to observe.
Larger party including television team followed later.

SEPTEMBER

Annual course for naturalist guides began.
Mary Curran de Espinoza left after serving 18 months as librarian.
Dwight and Martha Simpson visited CDRS on behalf of the National Wildlife Federation.
Price Waterhouse representatives audited Station accounts.
United Nations' film team, led by Simone Di Bagho, began filming at CDRS.
Jorge Lara of the GNPS married Cecilia Solís of the CDRS.
A second child was born to Paola and Gonzalo Oviedo, staff scientists.
Fabiola de Calvopiña returned to Quito for further study after serving since 1979 as assistant in the mammal ecology programme.

Andrew Laurie returned to continue his marine iguana investigations, assisted by Thomas Woollard and Charles Fairhurst.

OCTOBER

Joint fish studies of National Institute for Galapagos, National Institute of Fisheries and CDRS began.

Peter Kramer, CDF President, spent a week at the Station.

Juan Black, Sec. Gen. of CDF, and Raúl Moscoso, Chairman of the Ecuadorean Group of the CDF, arrived for consultations.

Arturo Vizcaino, National Director of IECE, came to discuss educational problems with Gonzalo Oviedo, CDRS co-ordinator of education.

Phyllis Bentley began a 6-month project collecting plants for Paul Colinvaux, Ohio State University.

BOOK REVIEW

Conservation and Evolution: by *O.H. Frankel and M.E. Soulé*, Cambridge University Press, 1981. 335 p.p. Hardback £25. Paperback £7.95.

The authors outline their purpose in their first paragraph: "In this book we attempt to bring together the genetic principles for the conservation of all forms of life, wild or domesticated, lions or lizards, oaks or orchids, cattle or ducks, rice or potatoes. The unifying factor underlying survival and adaptation, in time and space, is genetic diversity; and the nature, distribution and preservation of genetic diversity is the central theme of this book."

This is a pathfinding study of the relationship between evolutionary theory and practical nature conservation, the long-term problem that underlies the Charles Darwin Foundation's task in the Galapagos and the management of nature reserves anywhere. It also deals with the genetic diversity of cultivated plants and domesticated animals. The chapter headings indicate the ground covered: The process of extinction; Population genetics and conservation; Evolutionary genetics and conservation; Nature reserves; General principles and the genetics of captive propagation of animals; The role of botanical gardens in conservation; The genetic diversity of plants used by man; The conservation of plants used by man; Conservation of livestock genetic resources.

Sir Otto Frankel and Dr. Soulé are to be congratulated on this bold effort to ally genetic theory with practical conservation management, emphasizing the significance of genetic diversity and the long-term consequences of the accelerating increase in the rate of extinction of species.

G. T. C. S.

GALAPAGOS EVOLUTION CONTINUES

by

Peter T. Boag

With the Darwin centenary year now drawn to a close, it is already clear that it has produced a rich harvest of new information on the man and his work. Of the many papers, books and symposia produced in his honour, Darwin himself might have liked most to attend the last public event — a symposium on ‘Evolution in the Galápagos’, organized by R. Berry and hosted by the Linnean Society on 8 December in London¹.

Before Darwin, there was little appreciation of the biological uniqueness of islands, as A. Cain pointed out in his historical introduction. Cain ascribed this failure to the ‘naive taxonomy’ of the time. The lack of explanations for disjunct distributions of taxa or for the difference between convergence and affinity hindered ‘amateur naturalists’ such as Darwin when he set sail on the *Beagle* in 1831.

This theme was pursued further by F. Sulloway in discussing his own historical detective work on Darwin and the Galápagos^{2,3}. Sulloway dismissed as a myth the idea that Darwin had been converted to the theory of evolution by a ‘Eureka!’-like experience in the Galápagos; instead his fuzzy grasp of systematics blinded him to the evolutionary significance of inter-island variation in the tortoises, mockingbirds and the now famous Darwin’s finches. Darwin not only failed to separate correctly his finch specimens by island in the Galápagos, but also helped his shipmates eat their way through tortoise variants that were not collected again until years later.

What did happen was that in the second week of March in 1837, after his return to England, Darwin had a meeting with John Gould to discuss the *Beagle* bird specimens. Darwin was stunned by Gould’s findings, and hastily scribbled the main points on the back of a scrap of museum paper. It seemed that, among other things, the motley group of birds Darwin had identified as a mixture of finches, wrens and blackbirds was in fact a closely related subfamily of passerines, new to science. Realizing the importance of knowing which forms had come from where, Darwin began the frustrating task of quizzing Captain Fitzroy and other shipmates, who had fully labelled specimens. Darwin was never entirely happy with the result, and perhaps for this reason omitted any mention of the finches from his *Origin of Species*. Sulloway suggested that this group of birds became closely identified with Darwin and evolutionary theory largely because of David Lack’s book *Darwin’s Finches*.



The “Warbler” Finch (*Certhidea olivacea*): one of the unfinchlike finches that puzzled Darwin

Photo by Alan Root



Large Ground Finch (*G. magnirostris*) on Daphne Major, beside *Bursera* berries

Photo by Dr. Peter T. Boag

Recent geological work in the Galápagos and an improved understanding of the plate tectonics of the region (B. Rosen and T. Simkin) show that the islands are younger than previously thought — no older than 3-5 million years. They have never been connected to the mainland, and remain among the 12 most active areas of volcanism on Earth. The likely evolutionary age of several Galápagos vertebrates was reduced further still in J. Patton's discussion of genetic processes in Galápagos organisms. His electrophoretic studies of the finches, tortoises, lizards and rats suggest that with the possible exception of the land and marine iguanas, the small genetic distances among most taxa indicate evolutionary histories of under one million years^{4 5}. Biochemical characters produce phylogenetic trees very similar to those suggested by traditional taxonomic approaches but show a small and constant rate of change relative to changes in some morphological characters. This supports recent suggestions that evolutionary changes in structural genes occur in a clock-like fashion, while morphological changes can occur at different rates as selection acts on 'regulatory genes'.

Recent research on Galápagos land birds, and on Darwin's ground finches in particular (P. Grant), shows interesting developments in at least four areas, including the origin of Darwin's finches, the discovery of the first fossil finches, the study of contemporary evolution in the *Geospiza* and the confirmation of David Lack's model of adaptive radiation^{6 7}. A widely distributed South American emberizid, the blue-black grassquit (*Volatinia jacarina*), has recently been proposed by D. Steadman as the direct ancestor of all the Darwin's finches. Steadman has also discovered the first vertebrate fossil in the Galápagos, confirming the previous abundance of two finch populations rendered extinct since Darwin's time and suggesting that other finches as well as native rats went extinct before ever having been recorded^{8 9}

Specific island populations of tortoise are being identified by T. Fritts, partly to aid captive breeding programmes by including animals of unknown origin located in zoos. The small genetic distances between tortoise populations have hindered this task, as has the apparently high degree of morphological convergence seen in different tortoise populations in similar environments. H. Snell has also looked at the

similarity of various iguana populations in the Galápagos, as recent assaults by feral dogs have nearly obliterated two land iguana populations. Prompt work by Snell and his colleagues has led to the successful captive breeding and reintroduction of these animals, in concert with programmes to eliminate the dogs¹⁰. Snell found that on the basis of morphology, land and marine iguanas are very similar to each other and different from mainland species. Patton had suggested that the large genetic distances between the marine and land iguanas indicated that they were unrelated and colonized the Galápagos separately a long time ago. But in a surprising announcement Snell revealed that he had been studying what appears to be a land-marine iguana hybrid for three years. The hybrid shares features of each genus — it has, for instance, unwebbed front toes but webbed rear toes.

Y. Lubin and D. Porter discussed recent work on introduced invertebrates and plants. Lubin has been following the invasion of the fire ant (*Wasmannia*), which probably arrived in the islands in the 1930s, but is still dispersing at rates of up to 170m yr⁻¹. As it enters an area, native ant species disappear, as do other arthropods such as scorpions and spiders. Porter pointed out that up to 26 per cent of the 738 known Galápagos plant taxa are now introduced, most within the past century¹¹. There is no sign that the rate of invasion or redistribution of introduced plants is slowing and although many of the 'weeds' occur in disturbed habitats, several invaders threaten natural areas.

Finally, in a discussion of the role of man in the accelerated rate of 'evolutionary' change in the Galápagos, P. Kramer argued that in addition to trying to understand how native Galápagos plants and animals evolved and attempting to control introduced species, biologists should also monitor the process of invasion. Understanding why particular introduced plants or animals succeed or fail and how native species respond to introduced species may in the long run contribute as much to our understanding of evolution as research on native organisms¹². This brought home a bitter-sweet message about evolutionary research in the Galápagos: much less is known about evolution in the Galápagos than most people think, but Galápagos populations and communities are probably now changing faster than ever.

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¹. The symposium will be published in *Biol. J. Linn. Soc.* in 1983.

². Sulloway, F.J. *J. Hist. Biol.* 15, 1 (1982).

³. Sulloway, F.J. *Bull. Br. Mus. Nat. Hist. (Zool.)* 43, 49 (1982).

⁴. Yang, S.Y. & Patton, J.L. *Auk* 98, 230 (1981).

⁵. Marlow, R.W. & Patton, J.L. *J. Zool. Lond.* 195, 413 (1981).

⁶. Boag, P.T. & Grant, P.R. *Science* 214, 82 (1981).

⁷. Grant, P.R. *Am. Sci.* 69, 653 (1981).

⁸. Steadman, D.W. *Proc. 8th int. Congr. Speleo.* 2, 549 (1981).

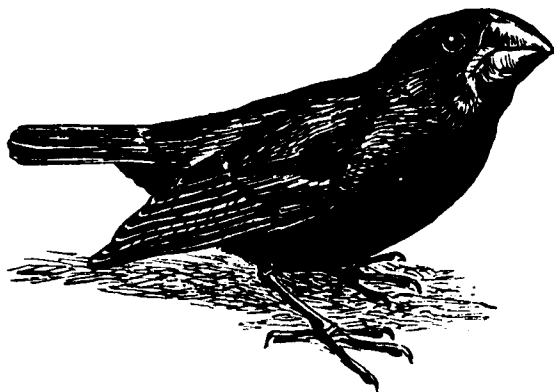
⁹. Steadman, D.W. *Trans. San Diego Soc. Nat. Hist.* 19, 279 (1982).

¹⁰. Reynolds, R.P. *Not. de Galápagos* 36, 13 (1982).

¹¹. Eliasson, U. *Not. de Galápagos* 36, 7 (1982).

¹². Duffy, D.C. *Not. de Galápagos* 33, 21 (1981).

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Large Ground Finch
Geospiza magnirostris
Drawing by Peter Scott

A MARINE PARK IN THE GALAPAGOS

by

Gary Robinson

Gary Robinson, staff marine biologist at the Darwin Research Station, has presented a long paper as a contribution to the continuing discussions on the protection of the Galapagos underwater resources. Large sections of his report deal with the history of previous schemes, which failed to win agreement in spite of much goodwill, and with the various problems arising from conflicting interests of fishermen and others or from the administrative complications due to different ministries being responsible for national parks, for fisheries, for tourism or for sovereignty and defense. These sections are not reproduced here but the author's proposals for a future marine park based on a new zoning system are given in full.

INTRODUCTION

The extension of the Galapagos National Park to include marine areas as well as the terrestrial environment has long been desired. It is the logical step in order to provide total ecosystem protection both for the numerous terrestrial animals that frequent shoreline habitats and are intimately dependent on the ocean's resources for survival, and also for the varied marine communities that characterize Galapagos waters. Of 57 resident bird species in Galapagos, 27 depend for food on the surrounding ocean or on the physical interaction between ocean and the terrestrial environment — for example, salt lagoon habitats utilized by flamingos, stilts and ducks (Harris, 1974). Some endemic birds have specific habitat requirements which are encountered only in certain regions of the archipelago. Flightless cormorants and Galapagos penguins, for example, are virtually confined to the western islands where the cold subsurface Cromwell current meets the Galapagos platform and upwells, thereby enriching ocean productivity. With the exception of a few individuals nesting on Plata Island, the waved albatross nests only on Hood (Española). Outside the breeding season this seabird is seen off the coast of Peru and Ecuador feeding in the reproductive waters found there. Other examples of Galapagos fauna intimately related to the marine environment are sea lions, *Zalophus californianus wollenbecki* (an endemic Galapagos sub-species), and Galapagos furseals, *Arctocephalus galapagoensis* (an endemic species hunted close to extinction earlier in the century). They are found on most of the islands and provide much attraction for thousands of tourists. Mention of the enigmatic marine iguana, *Amblyrhynchus cristatus*, is sufficient to conjure up prehistoric images of Galapagos as these 2-3 foot long black lizards descend into the intertidal zone or swim offshore and dive to feed on the marine algae that encrust the rocks.

The waters between the islands are populated by a diversity of marine creatures. Baleen whales (fins, seis, minkes, humpbacks and toothed whales) pilot, killer, falsekiller and sperm whales, take advantage of the varied oceanographic conditions which are the hallmark of these islands. Boats are nearly always joined by bottlenose dolphins (*Tursiops truncatus*), riding and leaping with apparent enjoyment in the bow wave as boats travel between islands. Dolphin fish, wahoo, sailfish, the curious sunfish (*Mola mola*) and an abundance of sharks inhabit the island waters.

The Masterplan for the Galapagos National Park drafted in 1973 and published in 1974 recommended the extension of the park boundary 2 miles seaward of the coastline around all islands to protect Galapagos ecosystems in recognition of the interrelationships between marine and terrestrial environments. However, at that time, knowledge of the marine area was inadequate to make decisions on the mechanism for protection and management of the marine environment. During the years of 1973-75, a Peace Corps volunteer, Gerard Wellington, was assigned to the National Park Service and the Charles Darwin Station to help remedy this lack of information. Assessment of the marine environment resource and recommendations for the zonation scheme for the marine area of Galapagos resulted from this study. Wellington's voluminous report (extracts in Noticias No. 24, 1976) is still the only reference work on marine life and habitats of Galapagos presently available. Despite early advances, the marine extension of the Galapagos National Park has not yet been realized, fully seven years after the proposal was submitted in 1975.



Gerard Wellington with the Giant Sea Star (*Luidia superba*) he discovered while diving at Tagus Cove. This is only the second specimen to be recorded and the largest five-armed sea star ever known.

Zonation Scheme for a Marine Park

There has been some discussion on the desirability of applying to the marine area the same zonation scheme as that in force in the terrestrial areas of the park (Noticias No. 23, 1975). One argument correctly asserts that a continuum exists between the terrestrial, intertidal, and subtidal environments. On the other hand, there are some significant differences in the manner in which visitor activities in the various marine zones may be permitted and regulated. Also the zoning itself is conceptually different from the terrestrial areas. It is not possible to place a boundary on masses of water which are in dynamic interchange with neighbouring masses of water. Thus, when one considers the zoning of the marine environment, what is actually under consideration is delimitation of the ocean bottom; but what occurs in one marine zone can have impact on other zones through the transport of larvae or contaminants, for example, via the water column. Therefore, a simpler zone classification has been adopted here. A distinct intertidal zone classification is not recognized in the present scheme. Intertidal areas are integrated with their respective adjoining subtidal zones.

Zone 1

The exploitation of marine resources by artisanal fishermen would be allowed to continue within this zone at present levels. This zone includes over 90% of the coastal area. Subsistence harvesting of intertidal and subtidal organisms would be permitted subject to the regulation of bag limits, size limits or season limits when there is evidence that this is a conservation necessity. SCUBA diving by tourists would be permitted throughout this zone and rights of anchorage would not be regulated. Basically, under this zone the status quo would be maintained except that commercial or semi-commercial activities would not be allowed.

Zone 2

Certain areas in Galapagos have proven themselves over the years to be of great value to science, tourism, and education. These marine areas are often adjacent to terrestrial tourist sites, therefore the integrated protection of terrestrial and marine areas at these sites is called for. In Zone 2, collection of all marine species would be prohibited except by specific permit, which would be granted by the park authority only upon submission and approval of scientific projects. These zones would be delimited on the basis of identifiable landmarks and their seaward extension would be determined on a site-by-site basis. Since the exploitation of most marine resources is in waters of less than 50 meters depth and as this is the realistic limit for SCUBA diving by tourists and scientists, seaward extension of Zone 2 to this depth contour might be a suitable guideline. Although similar in concept to the 'intensive use' zone in the terrestrial areas of the park, visits should be allowed past sunset to permit night diving. In terrestrial intensive use zones, tourists are not allowed to remain on shore after sunset.

Zone 3

This zone would consist of all coastal areas and bays adjacent to ports. The reason for including this zone within the marine park is that it would provide the park with authority to control marine pollution and inconsistent recreational activities, such as water skiing. All marine areas are in dynamic fluid connection with each other, so indiscriminate dumping in ports, small scale oil spills, etc., could affect adjacent sensitive areas such as nesting beaches of marine turtles and marine iguanas.

Marine traffic would remain under the authority of the port captain. Right of innocent passage through Zone 3 of the marine park would be granted.

Zone 4

Certain areas representative of each of the major marine habitats would be given complete protection in order to serve as control areas for environmental monitoring and assessment of tourist impact. The list of marine habitats and their locations has yet to be agreed but should include examples of mangroves, sandy beaches, coral reefs, back lagoons, vertical rock walls, etc. Wellington's (1975) report should serve as a useful guideline.

Zone 5

It has been considered necessary to provide a further type of zone which would serve to delineate areas that have been identified as refuge areas for the repopulation or recuperation of exploited marine species. Responsibility for identifying and recommending areas for refuge status would lie with the National Fisheries Institute. Areas would remain under Zone 5 status for whatever period of time the National Fisheries Institute decided and the exploitation of specified marine species would be prohibited.

The zonation scheme must be flexible. The marine park plan should provide for a mechanism to review the zone status of any area and a process for changing its classification from one zone to another. Recommended sites that have been considered for Zone 2 classification along with their priority of protection (A, B, C) have been listed for the entire archipelago; the following table gives a brief sample to illustrate the method of classification.

TABLE 1. Sites under consideration for inclusion under Zone 2

| Site No. | Priority | Location | Notes |
|----------|----------|-----------------------------|---|
| 1 | C | Roca Redonda | No anchorage, no shore visit. High priority tourist dive site. Heavy utilization in artesanal fishery. Steep vertical wall community. |
| 2 | B | Punta Vicente Roca, Isabela | Small anchorage, no shore visit. Large booby colony. High priority tourist dive site. Steep vertical wall community. |
| 3 | A | Punta Espinosa, Fernandina | Anchorage, shore visit. Large marine iguana colony. Comorants, penguins, sealions. Rock-sand community. Mangrove communities. |
| 4 | A | Tagus Cove, Isabela | Anchorage, shore visit. High priority tourist dive site. Steep vertical wall community. Sandy bottom community. |
| 5 | B | Islas Marielas | Anchorage, no shore visit. Colony of penguins. Rock-sand community. |
| 6 | C | Punta Morena, Isabela | Anchorage, shore visit planned for the future. Steep vertical wall community. |
| 7 | C | Caleta Iguana, Isabela | Anchorage, no shore visit. Rocky community. |
| 8 | C | Cape Bucanero, Santiago | Anchorage, shore visit. Steep vertical wall community. |
| 9 | B | Isla Albany | No anchorage, no shore visit. Tourist dive site. |
| 10 | B | James Bay, Santiago | Anchorage, shore visit. Adjacent to fur seal grottos. |
| 11 | C | Punta Baquerizo, Santiago | Coral reef formation. |
| 12 | B | Rabida | Anchorage, shore visit. Sand communities. Coral communities. |
| 13 | C | Islas Beagle | Coral communities. Steep vertical wall communities. |
| 14 | B | Sombrero Chino | Anchorage, shore visit. Snorkeling. Rock-sand communities. |
| 15 | C | Rocas Bainbridge | No anchorage, no shore visit. Steep vertical wall community. |

Final Considerations

In this ultimate section I pose two questions:

- 1) Is the two nautical mile boundary of the marine park enough?
- 2) Is it desirable to permit exploitation of marine species within the national park?

The first question is reasonable since there have been so many divergent proposals for the extent of the future Galapagos marine park (1km, 2 nautical miles, 5km, 15 miles, all the interior waters). The 2 nautical mile zone would provide protection for nearly all the Galapagos marine life associated with coastal habitats, but not necessarily for migratory marine mammals, such as whales and dolphins, nor for sealions and seabirds that often feed far out at sea. Might it not be reasonable to consider inclusion within the national park of all interior waters, or perhaps certain less extensive interior waters of the archipelago, in order to provide as complete protection as possible? Under the recommendations made above, all forms of commercial pelagic fishing (purse-seining, and longlines) would be prohibited from the national park. Reasons for doing so, other than providing species protection, would be the maintenance of control areas of unexploited marine mammal populations for monitoring the impact of pelagic fishing upon similar populations elsewhere; and the maintenance of reproductive stocks of commercial pelagic species such as tuna and mackerel. Additionally, inclusion of all the interior waters within the park boundaries would provide a buffer zone sufficiently large to really protect coastal marine organisms.

In regard to my second question, since the bacalao fishery has been a traditional source of livelihood for Galapagos residents and will continue to be so, would it not be of value to include all the marine area of Galapagos in a national park scheme and permit the continued exploitation of resources within Zone 1 (even though this is at present technically in conflict with the National Parks Law, 1971) while leaving the administration of this zone principally with the General Direction of Fisheries, which was created for the promotion of fisheries by the improvement of capture methods, catch processing, marketing, and exploitation of alternative fish stocks, as well as the routine monitoring of catch and biological studies of exploited fish species? My answer is an unequivocal "yes", since the operating principle of the marine park is to serve as a mechanism to conserve marine-terrestrial relationships. Inclusion of all the marine area of Galapagos under the national park will provide the buffer needed to provide complete protection for those critical areas in need of it.

The value of an urgent declaration of the marine area of the Galapagos National Park is illustrated by the following case. The National Fisheries Institute, in recognition of the evidence of possible over-exploitation of bacalao stocks, has proposed that production of salted-dry fish to be held to a limit of 200 metric tons per year. In order to reduce the fishing pressure on bacalao stocks, the Institute has initiated a program to locate new fishing areas within the islands and to experiment with new fishing methods, including the use of longlines and wired fish traps, with the aim of spreading the pressure out among several other fish species. From a conservation point of view there is concern over the possible threat these new fishing methods, particularly the use of fish traps, represent to unique Galapagos organisms. As it stands now, without a legal marine park area, if experiments with new fishing methods were to result in death by drowning by cormorants, penguins, sealions or turtles, the program could not be compulsorily terminated on those grounds. Also there is no present legal power to stipulate that certain fishing methods be banned from sensitive areas, such as the breeding range of cormorants or penguins, or rookeries of sealions. Fortunately, the National Fisheries Institute has a high regard for conservation issues in Galapagos and consults with the park service on its activities in the marine area even though it is not legally required to do so.

The advantages of declaring all the marine area of Galapagos as national park, while permitting the continued exploitation of resources at the present level in most of the coastal environment, are:

- 1) provision of buffer areas to sensitive marine habitats in need of absolute protection;
- 2) establishment of a national policy with respect to the future development and management of the entire Galapagos ecosystem; and
- 3) provision of a mechanism by which all projects submitted for execution in Galapagos must undergo a process of review to assess their impact on the environment, including those projects of the National Fisheries Institute, even though it would retain legal responsibility for the management of Galapagos marine resources.

Although there is much work still to be accomplished on the resolution of the actual marine zoning problems of the park and the jurisdictional responsibilities of the various governmental authorities, there is now optimism that the Galapagos National Marine Park will indeed become a reality.

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LONESOME GEORGE, THE PINTA ISLAND TORTOISE: A CASE OF LIMITED ALTERNATIVES

by

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Over much of the last 300 years the giant tortoises (*Geochelone elephantopus*) of the Galápagos have been persecuted by man, first by buccaneers and naval vessels, then, more importantly, by United States and British whalers in the nineteenth century (Townsend, 1925; Slevin, 1959). The early settlers in Galápagos slaughtered thousands for their meat and oil, and tortoises were regularly killed for food until the middle of the twentieth century (Thornton, 1971; MacFarland et al., 1974a).

Since 1959, tortoises have received complete legal protection (MacFarland and Black, 1971) and human depredations are no longer permitted. However domestic animals introduced by man have established feral populations throughout much of the archipelago, and these ferals along with the introduced black rat presently constitute the greatest threat to the well-being of the surviving tortoise populations. Black rats, dogs, and pigs destroy hatchling and immature tortoises, and dogs and pigs are also very efficient at discovering and destroying nests. In addition, burros, cattle, goats and horses compete with tortoises for the limited food and water resources available.

It was widely believed that several, or perhaps most, races of the Galápagos tortoises were extinct, and that the surviving populations would soon meet the same fate. Since 1959, when the Charles Darwin Foundation was established, field research has been conducted for the purpose of determining the actual status of the remaining tortoise populations. Fortunately, the information gathered has significantly modified this dismal view of the survival potential of tortoises in Galápagos. The status of the existing populations and current conservation practices have been reviewed by MacFarland et al. (1974a, 1974b). Fifteen races of Galápagos tortoises were originally described by Van Denburgh in 1914; 11 of these are known to survive today. Of the other four races described, the tortoise described from Rábida is thought to have been based on an introduced animal, and tortoises may now be extinct on Fernandina perhaps as a result of active volcanism there (Snow, 1964). The tortoises of Floreana and Santa Fé went extinct during the latter part of the nineteenth century, largely due to depletions by whalers and settlers. The remaining populations, have benefited from the protection and captive breeding programs of the Galápagos National Park Service (GNPS) and the Charles Darwin Research Station (CDRS). Today they are all increasing in numbers — with one exception.

The exception, the Pinta (Abingdon) Island tortoise race, *G. e. abingdoni*, provides us with a fairly well documented example of man's impact in a relatively short time on a fragile island ecosystem. Townsend (1925) studied the logbooks of 79 American whaling vessels and reported that 455 tortoises were removed by these whalers from Pinta between 1831 and 1868. However, there were more than 700 vessels in the American whaling fleet during his period, and the majority made repeated journeys to the Pacific (Townsend, 1925). In addition, Townsend did not take into account the British whaling ships and other vessels passing through Galápagos waters at that time. Therefore, the above figure must represent a small fraction of the actual number of tortoises taken from Pinta.

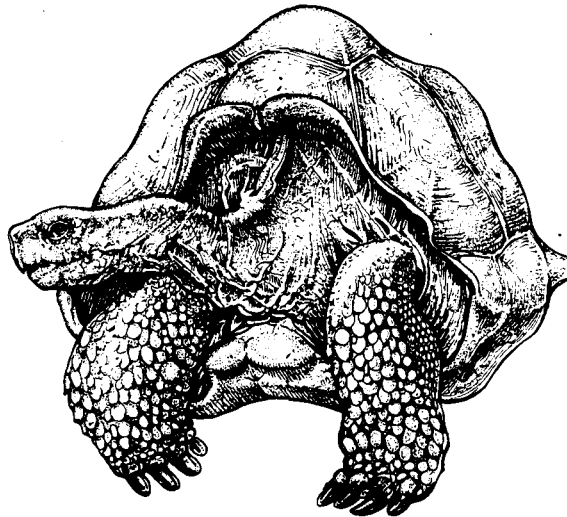
Tortoises were considered to be rare on Pinta in 1906 when the California Academy of Sciences expedition was able to find only three specimens (Van Denburgh, 1914). This was partly due to the Academy scientists' inability to penetrate the dense and thorny coastal vegetation, a situation which over the years has proven crucial to the survival of several other tortoise populations.

It is known that local fishermen, when working in the waters around Pinta, landed there and slaughtered tortoises for food as recently as the 1950's (pers. comm. J. Villa). No information is available, however, indicating how many tortoises were removed from Pinta during that decade. When the fishermen began

having difficulty finding tortoises they released goats on the island to provide an alternative supply of fresh meat. This introduction in 1954 had devastating effects on the vegetation, (Weber, 1971; Hamann, 1979). The goats multiplied and destroyed vast amounts of the island's vegetation, chewing through the bark of *Opuntia* trees, destroying peat accumulations, and causing erosion on the higher slopes of the island (Hamann, 1979).

In 1957 fresh tortoise tracks were found on Pinta (Eibl-Eibesfeldt, 1959), but no living tortoises were seen there during the 1960's and the race was presumed to be extinct. However, in 1971 GNPS wardens working on goat control found signs of living tortoises and in November of that year Joseph Vagvolgyi, a scientist working out of CDRS, discovered an adult male Pinta Island tortoise (Vagvolgyi, 1974). "Lonesome George", as this tortoise has become popularly known, was brought to the CDRS in early 1972 with the hope of starting a captive breeding program for this race once a female Pinta tortoise was found. To date, however, no *abingdoni* females or additional males have been located on Pinta or in zoological parks around the world, despite the Charles Darwin Foundation's long-standing offer of a \$10,000 reward for the return of a female Pinta Island tortoise.

The issue of what to do with the sole surviving *abingdoni* tortoise was discussed at some length at the Charles Darwin Foundation meeting in Quito, Ecuador, in March 1982. One point agreed on by all participants was that it is unlikely that a female Pinta tortoise will ever be found. Without such a mate, the Pinta Island tortoise race will become extinct with the eventual death of Lonesome George.



Lonesome George (*Geochelone elephantopus abingdoni*). Drawing by Dan Clapp

The remaining options appeared to be extremely limited. One suggestion was that George could be mated to females of a race similar in size and shape to *abingdoni* and the offspring back-crossed through succeeding generations until a form closely resembling *abingdoni* could be reached. While it is not known exactly at what age Galápagos tortoises become sexually mature, female giant tortoises (*G. gigantea*) on Aldabra are able to reproduce at approximately 20 years of age (Swingland and Coe, 1978). If we assume that female Galápagos tortoises mature at a similar age, it would take an extraordinarily long time for the back-crossing experiments to bear fruit.

In the past concerned individuals have even suggested that George should be cloned to produce more Pinta tortoises. Even if cloning were possible, it would not provide a satisfactory solution as it would result in individuals genetically indical to George, all of which would be as lonely for female companionship as he is today.

It was decided at the Foundation meeting that perhaps the best solution was to return Lonesome George to Pinta with males and females of a race most similar in size and shape to *abingdoni*. This would give George the opportunity to inject his genes into the population and at the same time it would re-establish tortoises on Pinta. Tortoises most closely resembling the Pinta race are *G. e. becki* from Volcan Wolf, Isabela Island. Tortoises are abundant on Volcan Wolf and the population could easily withstand the transfer to Pinta of a limited number of animals without any deleterious effects.

There is a sound ecological argument in favor of the latter option. Tortoises were the only natural large herbivores on Pinta and assuredly played an important role in the development of the plant community structure there; tortoises on Aldabra have been shown to have a great effect on its vegetation (Merton et al., 1976; Hnatiuk et al., 1976). Goats have now been almost eliminated from Pinta through the efforts of the GNPS and, as a result, there has been a rapid recovery of the vegetation (Hamann, 1981). Therefore tortoise grazing could play a crucial role in returning the island's ecosystem to as near to its previous condition as possible. Even so, the plant community structure on Pinta will never be exactly as it was due to the elimination of tortoises in the past and drastic overgrazing by goats. However, it is feared that without the re-establishment of the natural large herbivore, the difference in the vegetation would be much more significant.

A second supporting argument is based on the findings of Marlow and Patton (1981) that the various races of Galápagos tortoises share an inordinately high level of overall genetic similarity. A biochemical analysis of blood protein samples from seven of the eleven extant races showed that between 92% and 98% of the genetic composition is shared among the various races of Galápagos tortoises, despite the striking differences in shell shape and size found among the various described forms (Van Denburgh, 1914).

At present we are in a most unusual situation with Lonesome George. He is the only known survivor of his race. He can live the remainder of his life in captivity and, when he dies, *G. e. abingdoni* will go extinct though this will not mean a great loss in genetic diversity because a high percentage of the *abingdoni* genes are present in other populations. However, a portion of Lonesome George's genes are unique to himself, some of which may have been unique to the former Pinta population and, if he is truly the last of his kind, these genes reside only in his cells. If Lonesome George were returned to Pinta with tortoises of the *becki* race, he would at least have the opportunity to pass on some of his genes, although the offspring from such a cross could not be considered taxonomically *abingdoni*. Also, according to mathematical genetic theory, we would expect the genes of Lonesome George to be lost from the resulting lineage within a few generations. If, however, some of the Pinta tortoise genes proved to be selectively advantageous to life on Pinta, they might become incorporated in the lineage.

Maybe the best consequences of reintroducing Lonesome George to Pinta with Volcan Wolf tortoises would be that he could spend the rest of his life on his home island in the company of other tortoises and the island's vegetation could continue to evolve in the presence of a natural herbivore.

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AN ANT-EATING CRAB SPIDER FROM THE GALAPAGOS

by

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One normally associates crab spiders (Thomisidae) with those brightly colored, but well-camouflaged predators that sit in flowers during the day and seize unsuspecting bees and flies that come to find nectar. Not all crab spiders, however, share this habit. *Tmarus stoltzmanni* Keyserling¹ from the Galapagos Islands is nocturnal and specializes on ants.

Tmarus stoltzmanni was first collected in the arid zone at Tagus Cove on the western side of Isabela by R.E. Snodgrass, a member of the Hopkins Stanford Galapagos Expedition of 1898-1899, and identified by Banks (1902) as the same species described from Peru (by Keyserling, 1880). In 1925 Alf Wollebaek of the Norwegian Zoological Expedition collected the same species on Floreana (Banks, 1932) and Roth and Craig (1970) noted its presence on Santa Cruz, but did not give any collection records.

A keen collector and observer of natural history, Snodgrass noted that "when disturbed they (*T. stoltzmanni*) attempt to escape notice by remaining perfectly motionless on a twig, with the long anterior legs stretched out straight in front of them." *Tmarus stoltzmanni* is indeed highly cryptic; a mottled gray-brown, it blends in perfectly with the background of dry twigs on which it sits during the day. Although I found hundreds of individuals at night at Los Guayabillos camp, located in the Tortoise Nesting Zone D at about 300m elevation on Santiago Island, only two were found during the day after a careful search of the vegetation. In the cryptic resting posture, legs I and II are held forward and pressed against the substrate while legs III and IV are pressed against the body. The abdomen has a pronounced dorsal hump, which gives the spider the appearance of a small protuberance or leaf scar on the twig. At night, when disturbed, the spider adopts the same posture.

At Los Guayabillos, *T. stoltzmanni* was particularly common on shrubs of *Castela galapageia* (Semaroubaceae), an evergreen, woody plant particularly attractive to ants. Nearly every *Castela* plant examined had ants active on it both day and night. *Tmarus stoltzmanni* individuals were found feeding exclusively on ants. I recorded the prey of 32 spiders, 21 of which (68%) were feeding on *Conomyrma pyramica*, a 3mm dolichoderine ant, 5 on *Camponotus macilentus*, a 5-6mm ant, 3 on *Paratrechina nesiotis*, about the same size as *Conomyrma*, and 2 on *Camponotus planus*, a robust ant of 6-7mm long. The latter three species all belong to the subfamily Formicinae. None of these ants possesses a sting, but all utilize chemical defenses. *Tmarus* apparently does not attack myrmicine ants with powerful stings. Indeed, *Tmarus* seems to be absent from areas near Los Guayabillos that have been invaded by the little, introduced fire ant, *Wasmannia auropunctata* (Myrmicinae), to the exclusion of other species of ants.

The spiders become active at night; the first signs of activity were observed at about 6.30 p.m. As the direct light of a torch disrupted prey capture behavior (the spiders either moved away or adopted the cryptic resting posture), most observations were made with a dim light covered with red cellophane.

Hunting behavior may be divided into three stages: search, wait and attack. Searching begins when the spider drops from its twig on a silk thread and remains hanging and swinging in the breeze. The first and second pairs of legs are held straight out at an angle of 45° from the body and slightly below the plane of the body. The spider may remain in this posture for several minutes, at the same time apparently releasing fine threads of silk from the spinnerets. These threads, which are invisible to the naked eye, are wafted by air currents and attach to branches or twigs downwind from the spider. One can observe the spider suddenly pull itself along one of these invisible lines, trailing a visible dragline behind it, until it reaches the new support. The spider may then assume a waiting posture on the twig, with legs I and II held out from

¹The identification of this species remains tentative; voucher specimens have been deposited at the Institut Royal de Sciences Naturelles de Belgique (L. Baert).

the body anteriorly and slightly flexed, and invariably facing downward on the twig or branch. On one occasion, a spider was seen to run about 2cm down the twig, attach a dragline to the twig and return to resume its former hunting position. Possibly the dragline serves as a tripwire to alert the spider to the presence of an ant on the twig.

Although I saw numerous spiders feeding on ants, I observed the actual attack on only four occasions — and with good reason, because the capture is completed in less than one second! In all four instances, the spider leapt upon the ant from a distance of 4-5mm (a distance equal to the length of the spider's body), seizing it in the jaws by the anterior-dorsal part of the thorax, the "nape of the neck", as it were. The spider continued to hold the ant by the neck while feeding, often dropping on a dragline with the prey. The two anterior pairs of legs were never used in either seizing or holding the prey, nor were spiders seen to manipulate prey with their legs. One can only guess that the first two pairs of legs function primarily to detect ants, using either chemical or tactile cues.

One curious and unexplained aspect of the hunting behavior is the observation that spiders adopt a "wait" posture while hanging from a thread suspended between twigs and appear to spend a large part of their active time in this posture. The posture is similar to that adopted while waiting on a twig (see above); both legs I and one leg II are held out from the body anteriorly and slightly flexed, while one leg II holds the line in front of the spider and legs III and IV hold the line behind. I never witnessed any captures from this position. Possibly the spider maintains this position in order to monitor movement of ants on a branch from a safe distance, before deciding to move onto the branch itself, where it is likely to be exposed to other predators. Three further observations favor this hypothesis. First, on one occasion I could see a number of very fine threads connecting the resting thread to different points on the branch in front of the spider, suggesting a trip-wire function of these threads. Second, spiders were seen to move very swiftly from the wait position on a thread to a hunting posture on the twig itself; and third, after sitting for some time (up to 20 min) in a wait posture under the thread, spiders often moved off to another location (by dropping on draglines as described earlier).

Nocturnal hunting habits and specialization on ants occur in other thomisid crab spiders. For example *Xysticus californicus* Keyserling attacks harvester ants in California (Snelling, in ms.) and many Australian species of *Tmarus* are nocturnal, cryptic spiders that sit on branches and tree trunks and include ants in their diet (Mascord, 1980).

It might be advantageous to *T. stoltzmanni* to hunt at night for two reasons: first, there is more ant activity at night in the arid zone than during the day; and second, most predators on arboreal invertebrates (e.g. birds, lizards) are active during the day. Likewise, it is easy to imagine the evolution of a specialization on ants in this habitat where ants are the most abundant and conspicuous group of arthropods active in the vegetation.

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SANTA FE IN AN EL NINO YEAR

by

Andrew Laurie

Dr. Laurie is engaged on a three-year study of the population dynamics of the marine iguana as a basis for future conservation policy. (Noticias 35 and 36). He uses Santa Fe Island, where there are no introduced animals, as a control for comparison with other islands where the species is under threat from alien predators such as cats and dogs. He tells how in 1982-83 the normally desertic conditions of Santa Fe were rudely upset.

Holding an umbrella in one hand and a torch in the other I waded back, up to my knees, through the fast-running river and checked the water level once more before hurrying inside to the relative dryness of our tent. It was lucky that we had dug drainage channels so deep around the tent, for they were full and discharging a lot of rainwater which would otherwise have flowed straight through. I set my alarm again and sank back into a state of semi-wakefulness in which the sounds of the wind and the rain on the tent merged with the roar of the river and the waterfall just 20 metres away and the pounding of the waves on the rocks below. Two hours later I was out again, but by then the river level had dropped and the danger of being swept off the cliff in our sleep had passed for the moment. By 0900 the next morning, 17 December 1982, when the rain finally ceased; 10 inches (254mm) had fallen within 20 hours.

Never had I imagined that we would see such rain on arid Santa Fé (Barrington Island). I had always wondered and marvelled at the stream beds and ravines which we saw filled with well worn rocks and giant boulders swept into position by ancient rivers. But when the sun beats down relentlessly day after day, month after month, on this low-lying island of grey rocks and scattered cacti it is hard to imagine floods on such a scale. I don't need to imagine them any more. Between 15 November 1982 and 23 January 1983, 24 inches (600mm) of rain fell at Miedo on the south-eastern coast of the island. Flash floods had covered the whole island in sheets of water, and several times we had watched, hardly believing our eyes, deafened by the roar, as raging torrents of muddy water swept down nearby ravines to form waterfalls off the cliffs, colouring the ocean red and brown in vast concentric and overlapping rings which spread far out to sea. One could not possibly cross the main river near the sea, but my wife, Haruko, and I walked up it on the day after the biggest storm, climbing an inland waterfall, skirting torrents of water by inches, still we reached the upper plateau, a cactus plain where all was green and criss-crossed by braided water channels. The cacti looked distinctly out of place among all that water and lush green vegetation. Most plants were still putting their resources into vegetation growth but a few, such as the *Cordia*, sported bright yellow flowers, as did some of the tiny annuals. The ground, normally baked as hard as brick, was so soft that we frequently sank to our knees or higher in mud. Stepping stones, even enormous safe-looking boulders, were little help for they also sank rapidly into the mire under our weight.

Adrian Matson at the Research Station had mentioned in October that the sea temperatures were above normal and we might expect an 'El Niño' year. This results from the southward flowing El Niño current displacing the cooler, northward flowing Humboldt current, and is characterized by anomalously high sea surface temperatures off the coasts of Ecuador and Peru, heavy rainfall, 'red tide', and sometimes the mass mortality of various marine organisms. According to W.H. Quinn and his colleagues¹, the average interval between 'strong' "El Niño type events", with sea-surface temperatures more than 3.0°C above the mean, is 12.3 years, the last one having taken place in 1972-73. This year's, however, appears to have been exceptionally 'strong'.

October and early November were dry on Santa Fé but there was a noticeable lack of the persistent sea mist or 'garua' which generally occurs in the mornings at that time of year, sometimes not clearing until 0900 or later. The sea was noticeably warmer and by mid November we were experiencing windy

¹Quinn, W.H. Zopf, D.O., Short, K.S. and Kuo Yang, R.T.W. (1978) Historical trends and statistics of the Southern Oscillation El Niño, and Indonesian droughts. *Fishery Bulletin* 7(3) 663-678.

rainshowers which swept in rapidly from the sea. Some of them were quite heavy. The plants responded rapidly, with the *Bursera* and *Cordia* bursting into leaf and a few of the *Cordia* flowering. There were high winds then and the rain beat horizontally at us or at our tents. Such showers became heavier and more frequent towards the end of November and the sky was often overcast for much of the day.

The mockingbirds busied themselves after every shower collecting nesting material and the island continued to become slightly greener, but it was not until after 7 December, when it rained steadily all day and all night, that the birds started to lay and the island became generally green to the eye with a host of herbs and grasses growing up between the rocks and immediately falling prey to the land iguanas. The resident pair of Galapagos Buzzards mated and laid 2 eggs (which did not hatch) in a nest 30 metres from camp; a pair of fly-catchers nested just up the hill; and finch and mockingbird nests sprang up in cacti and bushes all about us. At night, the lanterns began to attract a myriad of beetles and moths which I had never seen before. And the rain went on and on. Hawk-moth caterpillars roamed in armies right down to the shore, devouring the green leaves almost as soon as they emerged, and the grass grew higher and higher until it is now (in late January) almost a metre high in places. The rain became harder and came with less wind. Now the days are very still, the sea is calm and the sun shines fiercely from dawn to dusk with shade temperatures of up to 34.5°C at midday. The period of heaviest rain appears to have passed, but we are still getting occasional heavy showers and the mosquitoes continue to plague us at night and in the early morning.

Already we have observed several changes among the marine iguanas compared with last year, possibly effects of 'El Niño'. First there were the mysterious deaths of several animals, mostly adult males, during October and early November. They lost weight rapidly and died, apparently from lack of food (algae), having in some cases halved their weights within a few weeks. We found flukes in all their upper digestive tracts but have since found the same flukes in mouths of apparently healthy individuals. Second, the first year mortality of 1982 hatchlings appears, on first assessment, to be higher than it was for 1981 hatchlings, although this has to be confirmed during the next few weeks. Third, both mating and nesting started 3 weeks earlier than in 1981-82 and nesting has continued over a considerably longer period than last year with a far higher number of females nesting this year. The land iguanas also nested earlier this season.

The marine iguanas started nesting on 23 December and are still nesting now, a month later. We sit up above the sandy nesting ground under a sun shelter watching and identifying females with a telescope and binoculars as they bask on the surrounding rocks and then come out on to the sand to dig or fill in their burrows. They are very timid as they can fall easy prey to the hawks when out in the open, and we mount an almost continual watch so that we can record the identities of as many females as possible. So far the results tend to confirm that most females do not nest every year: up to now we have seen only 3 out of more than 50 marked females who nested here in 1982 whereas we have seen more than 50 other marked females whom we did *not* see nesting here in 1982.

Mating on Santa Fé started on 30 November, and we watched with interest, with the rain pouring down our necks, as the prime territories (those with most females most of the time) were occupied throughout by new males this season, while the less good territories were defended by the same males as last season. It appears that the effort involved in defending a prime territory may only be sustainable for one year at a time. Perhaps there are two different ways of being territorial, both more or less equally rewarding in terms of numbers of matings: defence of a prime territory with 12-30 matings in the season (or seasons?), or the less demanding defence of an inferior territory with 2-5 matings in successive seasons. Next year's observations will clarify this further, but we still do not know what effect the El Niño phenomenon may have had on the subsequent condition of last year's territorial males.

Next we will turn our attention to an accurate assessment of 1982 hatchling survival and growth rates and compare them with those for 1981 hatchlings here and 1982 hatchlings on Caamaño. As soon as the nesting finishes we will recapture, or at least identify with binoculars, as many as we can. We shall also

make another attempt to attach enclosing cages to the rocks to observe and measure any increased growth of algae in the absence of iguana grazing. So far the heavy swell on the southern coast of Santa Fé has proved too much for us, and the cages have been torn off by the waves within a few days. In the one cage which did stay attached there was actually less algae inside than outside after a few days! We shall return to Santa Fé for the hatching season in April and the next breeding season in November, but apart from that we have work to do on Tower and Fernandina and we have to look in more detail at the predation of hatchlings by cats on northern Isabela.



A muddy torrent roars past the Lauries' camp on desertic Santa Fé Island. *Photo by Haruko Laurie*

**LIMITATIONS TO ALGAL GROWTH IN THE GALAPAGOS ISLANDS:
ITS CONSEQUENCES ON THE BREEDING STRATEGY OF THE
MARINE IGUANA *AMBLYRHYNCHUS CRISTATUS***

by

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The intertidal rocks of Academy Bay, Santa Cruz are covered almost exclusively by carpet-like mats of the marine alga *Ulva*. Several studies have documented that marine algae are the principle food source for the Galapagos marine iguana *Amblyrhynchus cristatus* (Carpenter, 1966; Dawson et al, 1977). Consequently, exclusion caging experiments were used to determine if the short, cropped appearance of the *Ulva* was due to heavy grazing by the iguana. At the end of the three week study period, negative algal growth was found in both the excluded and grazed areas. This suggests factors other than iguana grazing are involved in limiting *Ulva* growth. Grazing by invertebrates, particularly crabs, may have a significant limiting effect. We suggest however, it is more likely that the short blade length of the alga is an adaptation to minimize the damaging effects of dessication by the intense tropical sun.

Unusually sunny conditions during our study period in August of 1981 caused the death of much of the intertidal *Ulva* exposed for long periods during the tidal cycle. It has been found that intense sunlight can raise the surface temperature of black lava rocks which form much of the intertidal region to 137 degrees F. Such extreme temperatures create a severe dessication problem and have been suggested as a reason for the paucity of algal species found in the archipelago (G. Robinson, personal communication). The average blade length of *Ulva* in our study site by the Hotel Galapagos was one centimeter. This compares with the 20 centimeter length frequently attained by *Ulva* in the damp, cloudy climates typical of eastern Canadian and north-eastern U.S. shorelines where the dessication problem is minor. In these regions, the long blades of *Ulva* have earned it the name of sea lettuce.

Since *Ulva* forms similar carpet-like mats on many intertidal regions of the Galapagos, it is likely that this adaptation is a common solution to a problem which occurs throughout the archipelago. Dessication is likely to be most severe during the "rainy" season from January to April when temperatures are generally higher due to reduced cloud cover. Upwellings of cold water resulting from a shift in the ocean currents create the other season known as the *garua* (Houvenaghel, 1974). It brings cooler temperatures and cloudy conditions to the islands which reduce the severity of the dessication problem. However, in some years the *garua* influence is minimal or, as evidenced by our study, is broken by short periods of hot, dry weather. Short blade length of *Ulva* may therefore be a necessary year round adaptation to prevent dessication during frequent periods of intense sunlight throughout the year. While the effect of the dessication problem on growth of other types of algae has not been examined, it is probable that similar constraints apply.

Ulva is the main alga available to the iguana population of Academy Bay. Therefore, its availability as affected by periods of severe dessication becomes an important limiting factor to the iguana population. We speculate that both the breeding and foraging strategies of the iguana must be adapted to temporal fluctuations in food supply which frequently arise.

Marine iguanas are synchronous breeders. Copulatory behaviour, within a population, typically occurs over a period of one to three weeks (Carpenter, 1966; Boersma, unpublished manuscript; Trillmich, 1979; Bartholomew, 1966). Breeding synchrony suggests that environmental cues might be responsible for initiation of breeding behaviour and that environmental conditions govern the timing of the breeding season. The Galapagos penguin and the Galapagos finches follow a similar reproductive strategy where breeding is timed to coincide with environmental conditions which ensure sufficient food supplies (Grant, 1979; Boersma, 1978).

Nesting behaviour in the marine iguana is variable from year to year but typically occurs during January or February (Carpenter, 1966; Trillmich, 1979; Boersma, unpublished m.s.). Hatchlings emerge from June to July (Carpenter, 1966). Carpenter (1966) suggests that the annual breeding season is geared to avoid the cool *garua* climate. Boersma (unpublished m.s.) argues that it is the fixed periods of lowest tides which occur yearly during January and February which provide the necessary environmental conditions to initiate breeding. During these extremely low tides, the significant energetic costs of egg production to the female can be minimized due to the abundance of food exposed. However, low tides which occur with each lunar cycle expose large intertidal areas and probably provide sufficient quantities of food to achieve the same effect. In addition, larger females can feed sub-tidally and therefore, the availability of intertidal algae for the females is not likely to be the critical factor governing breeding time.

Hatching of the iguanas occurs about one month after the usual arrival of the *garua* season in May. We hypothesize that intertidal algae are likely to be more abundant during the *garua* season because climatic conditions at this time reduce the desiccation problem. At the same time, upwellings of cold, nutrient rich water which bathe the islands during the *garua* may help to increase algal growth. Iguana hatchlings are unable to feed sub-tidally (Carpenter, 1966; Boersma, unpublished m.s.). Abundant supplies of intertidal algae are therefore critical for their survival. It appears that the breeding season is timed to coincide with environmental conditions which will most likely ensure available food for the young.

Carpenter (1966) has found that the breeding times of a population may vary by as much as a month from year to year. As arrival and termination of the *garua* season is also variable, the annual plasticity in the iguanas' breeding times can be explained. The hatching of the eggs appears to have a cushion provided by its occurrence approximately one month after the onset of the *garua*. Again, this is probably an adaptation to the frequent late arrival of the *garua* season.

Our hypothesis predicts that the breeding season is timed to provide hatchlings with the promise of abundant intertidal algae. Yet, some environmental cue must provide the necessary conditions for initiation of the breeding behaviour. Breeding behaviour first appears around early January in most populations (Carpenter, 1966). This coincides with the usual termination of the *garua* season and suggests that onset of the "rainy" season might provide the cue necessary for breeding behaviour to begin. Variability in the arrival of the "rainy" season each year might also account for the annual variability in onset of the marine iguanas' breeding season.

It appears that both the annual variability and timing of the iguanas' breeding season can be accounted for in our hypothesis. However, definitive scientific studies must be done on the relationship between food availability, breeding time and weather conditions before our hypothesis can be rigorously tested.

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SOME THOUGHTS ON THE CONTROL OF INTRODUCED PLANTS

by

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Conservation efforts in the Galapagos have hitherto been chiefly directed to saving the unique animals which seemed to be in the most immediate danger, although they constitute but a fraction of the archipelago's species. To this end campaigns have been waged to overcome the most serious threat to their survival — the introduced domesticated animals which have run wild and multiplied. The resources of the National Park Service and the Charles Darwin Foundation have never been sufficient to tackle concurrently all the manifold problems, and plants have received less attention than tortoises, iguanas or birds. The elimination of feral goats from five islands (and a sixth is nearly free) has led to a gratifying regeneration of the native vegetation but too little has been achieved in checking the spread of introduced plants from the colonized areas into the National Park, where many of them can out-compete the indigenous species. Wiggins & Porter (1971) reported 77 recent invading species, Black (1972) gave a figure of 152 and Porter (1979) gave an increased estimate of 192. From personal observation I believe the true figure to be over 200. I shall deal here with the two most widespread and dangerous introductions on the four islands with human settlements: guava (*Psidium guajava*) and cinchona (*Cinchona succirubra*). On Floreana, Isabela and San Cristóbal, guava has covered vast areas of the humid highlands and has even descended to the arid zones of the last two (pers. obs.). The situation is less severe on Santa Cruz but is nevertheless a major problem.

The Control Programme of the Galapagos National Park Service

The GNPS began its eradication campaign in 1971, using a four man team to destroy guava and cinchona trees with machetes. Recent figures show that they cut down 69,477 guava and 14,396 cinchona trees in 1980 and 26,380 guava and 30,818 cinchona in 1981, but the programme has encountered serious problems:

- (a) Machetes are inadequate tools for destroying the strong roots of the bigger trees and, a year after felling new shoots — perhaps even 4 or 6 — may spring up round the old stump.
- (b) Cattle from the farms eat guava fruits and then wander across the National Park boundaries and spread the seeds with their dung.
- (c) The light cinchona seeds are blown into the National Park by the wind.

Some Suggestions for Control

Until effective eradication methods can be devised some immediate steps should be taken:

- 1) Farmers on Isabela, San Cristóbal and Floreana should be induced to keep their cattle inside fences, as is already the case on Santa Cruz.
- 2) The National Park team should be equipped with a small chain-saw and military shovels to get rid of the bigger trees.

Experiments which should be undertaken

- 1) On Santa Cruz, where guava is not yet dominant, herbicides could be used experimentally on stumps which cannot be rooted out, basing the choice of chemicals on the successful combinations used by the Hawaii Agricultural Experimental Station in dealing with the same species. To minimise waste and side-effects and reduce resistance, the right time for action would be between the end of the *garua* season and the fruiting of the guava. The same methods could be tried on the cinchona trees, plus painting the bark with herbicides.

- 2) On Isabela, San Cristóbal and Floreana, where guava has already spread over large areas, two experiments should be tried:
- (a) Using controlled fire on a small scale;
 - (b) Cutting the stump as low as possible.

In both cases fast-growing endemic or other native species should then be planted to create shade and deny a come-back to the guava, which cannot grow without strong light.

THE REPRODUCTIVE BEHAVIOUR OF THREE BLENNOID FISH ENDEMIC TO THE GALAPAGOS ISLANDS

by

Peter Wirtz

“Blennies” are marine fish belonging to the suborder Blennioidei. Most are small (5-10cm) bottom-living species which lack a swimbladder. The suborder Blennioidei consists of 15 different families.

The blennies of the Galapagos Islands belong to the four families Blenniidae (3 species), Clinidae (8 species), Chaenopsidae (2 recognized species and 1 undescribed), and Tripterygiidae (1 species); nine of the 15 species are endemic to the islands (Wellington, 1975, McCosker pers. comm.). The behaviour of more than 50 species of the Blenniidae has been described, but little is known about the behaviour of the other three families (Breder, 1941, Stephens et al 1966, Wirtz, 1978). In a long-term study I am collecting records of behaviour patterns of blennioid fish. Such records can be compared and similarities and differences can be analyzed from either a taxonomic point of view or in search for rules guiding the evolution of different reproductive and parental strategies.

During six weeks in December 1981 — January 1982 I observed the reproductive behaviour of the three endemic species *Acanthemblemaria castroi* (Chaenopsidae), *Malacoctenus zonogaster* (Clinidae), and *Enneapterygius corallicola* (Tripterygiidae).

Acanthemblemaria castroi males and females (approximately 4cm long) live in empty tests of the barnacle *Balanus tintinnabulum*. From this shelter they feed on organisms floating past. Females occasionally move from one barnacle to another within their home range. Reproductively active males always return to the same barnacle; instead of the reddish brown colour of the females and the young males, they are dark grey with conspicuously white faces. Males court females by quickly projecting the body out of the barnacle test and then immediately withdrawing it again. During these movements, in which the body is held upright with the tail always remaining inside the shell, the mouth is half opened, the gill membranes are spread, and all unpaired fins are erected. The "jack in the box" movement can be repeated one to six times with a frequency of four movements per second. Females deposit eggs inside the barnacle occupied by the male. The male continues to court females, and thus eggs in up to four different stages of development were found in the same barnacle test. The same "jack in the box" movement has been observed in the closely related *Acanthemblemaria macrospilus* in the Gulf of California (Stephens et al. 1966).

Males of *Malacoctenus zonogaster* occupy territories of less than 50cm diameter on vertical or slightly overhanging open rock faces. They court females by changing colour from light brown to a conspicuous chocolate brown and white pattern and by swimming towards the female with spread fins. A female may enter the territory and slowly glide along the substrate with wriggling movements during which time she deposits the eggs. The male frequently swims into a position parallel and close to her and performs quivering movements with his whole body, presumably fertilizing the eggs at this moment. After spawning females leave the territory. The male guards the eggs from predators such as small wrasses and gobies and continues to court other females and to spawn with them on his territory.

Males of *Enneapterygius corallicola* occupy territories similar to the ones of *M. zonogaster*, but usually in darker places. Courting males change colour from the drab greybrown, also shown by females, to a brilliant orange. They erect the first dorsal fin, which is pitch black with two conspicuous yellow dots. On the territory the male's body forms a semi-circle in front of the female. The female adjusts her position so that her head is next to a conspicuous black dot at the base of the male's tail and performs slow wriggling movements to deposit eggs. There is no obvious fertilization movement of the male. Sperm may be carried to the eggs by a water current produced through pectoral fin beats of the male, or perhaps the male impregnates a patch of the substrate with a sperm suspension before guiding the female over it. After a few seconds the male moves to a different place in the territory and takes up the semi-circle position again. The female follows. This spawning pattern is different from the one shown by the Mediterranean tripterygiids, which spawn in a manner similar to *M. zonogaster* (Wirtz, 1978). After spawning, females leave the territory. The male guards the eggs and continues to court and attract other females.

In all three species, and in fact in all studied members of the families Blenniidae, Chaenopsidae, Clinidae and Trypterygiidae, the male is the only guardian of the eggs. In striking contrast, the male and female or only the female guard the eggs in the blennoid fish families Pholidae, Stichaeidae and Anarhichadidae. What could be the evolutionary reason for this difference?

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THE BREEDING AND BEHAVIOUR OF MOCKINGBIRDS ON THE GALAPAGOS

by

Nicola Grant

Mockingbirds are commonly encountered on all the major islands of the Galapagos archipelago except Floreana. They did occur on Floreana as well but went extinct there in the latter half of the last century (Harris, 1973). There are four species of mockingbirds on the islands: *Nesomimus trifasciatus* (on Champion and Gardner — near Floreana), *N. macdonaldi* (on Española), *N. melanotis* (on San Cristóbal), and *N. parvulus* (on the remaining large islands).

They have been studied for short periods of time by Venables (1940), Hatch (1966) and S. Groves (unpubl.) (See also Abbott and Abbott, 1978). Because there is still so little known about their life histories and their breeding and feeding habits I initiated a project on *N. parvulus* on Isla Genovesa in January of 1978. My father and I studied the breeding, feeding and general behaviour of these birds from January until May (Grant and Grant, 1979). By banding the birds with colored rings we were able to identify different individuals. We returned to Genovesa in 1979, 1980 and 1982 from June to August. The project was also continued in March of 1979 and for the whole breeding season in 1980 by Margaret Kinnaird, and for the breeding seasons of 1981 and 1982 by Bob Curry.

During the breeding seasons we studied the social breeding of the mockingbirds and during the non-breeding seasons we concentrated on the activities of young birds and their family groups.



Two groups of Galapagos Mockingbirds displaying aggressively at a territorial boundary

Photo by Hendrik Hoeck

CO-OPERATIVE BREEDING

In 1978, by watching mockingbird nests every other day for four hours each day, I observed that at some nests three, and very occasionally four, individuals were bringing food to the nestlings. By banding nestlings at the nest I later discovered that 11% of the visits to the nest were made by the "helper" which was, in all but one case, the eldest son of the previous brood. Subsequent studies involving larger samples by Margaret Kinnaird and Bob Curry confirmed both observations, and also revealed that the helper may continue to help his parents rear his siblings for up to three years rather than attempt to breed himself.

Therefore the earlier suspicions of Hatch (1966) and S. Groves (pers. comm.) that the Galápagos Mockingbird is a co-operative breeder are correct. In general co-operative breeding is not common among birds, since usually only the parents raise their young, but de Vries (1975) has described another form of co-operation among Galápagos Hawks (*Buteo galapagoensis*): this is described in detail by Faaborg et al. (1980).

CONSEQUENCES OF THE HELPING BEHAVIOUR

Our combined studies of mockingbirds on Genovesa have shown that nests with help fledge more young than do those without help. However, helpers have no effect on the growth rate of the nestlings, although they do increase the total frequency of the nest visits. When there was a helper, the number of visits made to the nest by the father decreased while the female's work load remained unaltered.

During the non-breeding seasons (May through December) we have observed that the helpers are active participants in "flick-fights". "Flick-fights" are displays of aggression between family groups at territorial boundaries by the males and occasionally the females of a family group: they were first described by Venables (1940) for the mockingbirds (*N. melanotis*) on San Cristóbal, who referred to them as dances, and then described in more detail for all four species by Hatch (1966). The birds alternately crouch and straighten their bodies continuously flicking their wings and making a "chirrup" sound. Sometimes violent pecking and grappling with the feet ensues. The helpers are, however, always subordinate to both the mother and the father of the family group to which they belong.

THE COSTS AND BENEFITS OF HELPING AT THE NEST

Why do mockingbirds breed co-operatively? To try to answer this we have looked at the advantages and disadvantages to the helpers and to the parents (Kinnaird and Grant 1982). The advantages to the parents of having a helper at the nest are apparent. My study of the mockingbirds, Woolfenden's (1975) study of scrub jays in the USA and the Brown et al (1982) experimental study of babblers in Australia have all shown that the parents raise more young with helpers at a lower cost to the father. Possibly the mother also benefits by producing more offspring during her lifetime than she would otherwise, but our studies have not been going on for long enough to ascertain this: we still do not know the life expectancy of an average mockingbird.

The advantages to the helpers are not so obvious. W.D. Hamilton has suggested that an individual, by helping his parents rear his siblings, benefits by passing on a portion of his genes (in his brothers and sisters) to the next generation. By helping his parents to breed an individual also gains the experience of breeding without suffering any loss if the nestlings die.

It is possible that young male mockingbirds remain on their natal territory and help their parents rather than breed themselves because they have difficulty in establishing territories or gaining mates. From our observations in 1978 to 1982 we have found that: 1) mockingbird territories are close together, with no vacant spaces between them, and they are vigorously defended by flick-fighting during the non-breeding season. 2) The sex ratio is biased towards males. There are approximately one third more males than females on territories with breeding owners. 3) Adult breeding mockingbirds appear to be long lived because approximately a quarter of our banded adult mockingbirds in 1978 were alive and breeding in 1982. Thus relatively few new breeding opportunities exist each year. 4) New birds establishing territories either took the place of lost breeders or took a piece of their parent's territory. These four points indicate how difficult it is for a young bird to find a mate, set up a territory, and start breeding.

DISPERSAL AND THE UNEQUAL SEX RATIO

In point 2.I mentioned a sex bias in favour of males. Captures of mockingbird fledglings in May of a given year approximately one month after the end of the breeding season show the ratio of males to females to be almost 1:1. By the following breeding season, however, the ratio is 1.3:1 in favour of males. This inequality can partly be accounted for by the dispersal and high death rate of young females. While young males often remain on their natal territory to help their parents with the next brood, young females usually disperse. We have seen banded females wandering far from their natal territory. In July of 1982, there were nine females for every male that wandered, unbanded, into our study area.

Dispersing young birds entering a new territory squeak and display the submissive posture but are nevertheless chased out and occasionally vigorously attacked. However, in some instances, persistent intrusions by a young male or female have resulted in acceptance by the group. We have observed that females often return to their parental group during the non-breeding season after breeding far from their natal territory. As yet we do not know the reason for this behaviour.

The hazards of dispersal, i.e. attacks by territory owners and the poor chances of finding and holding a territory, may, in part, account for the loss of females, for presumably many dispersing birds die. Another reason for the unequal sex ratio may be that since helpers aid males more than females, females may put more effort into breeding and consequently may not live as long.

INBREEDING

Some authors (e.g. Greenwood, 1980) have suggested that the greater dispersal of one sex has evolved to avoid the disadvantages of inbreeding. Many ornithological studies have shown that it is usually the females that disperse furthest. Aggressive sibling rivalry between sisters and brothers, resulting in the departure of the sisters, may have been selected for to minimize the chances of inbreeding.

But inbreeding does occur. On Genovesa we have observed two cases. In the first instance an adult breeding male died and the helper bred with his mother. They produced two broods with three to four nestlings each in successive years. The young all died prior to fledging. The second case was a sister-brother mating when the sister did not disperse. They produced one brood from which all three nestlings fledged, but later all three disappeared.

N. TRIFASCIATUS ON CHAMPION ISLAND

On the little island of Champion-near-Floreana there are better opportunities to observe the effects of inbreeding. Champion is a circular island a quarter of a mile in diameter. It has a mockingbird population of between 40 and 50 individuals in about a dozen family groups.

The mockingbirds on Champion are of a different species than those on Genovesa. They are *Nesomimus trifasciatus* and the only other island on which they exist in Gardner-near-Floreana, another small island about 8 miles away from Champion. There appears to be no dispersal of *N. trifasciatus* between the two islands. Champion is, therefore, an ideal island on which to study inbreeding and its effects.

In August of 1980 my father and I measured and banded almost every bird on Champion and mapped the territory boundaries of the groups. We found less variation between the measurements of different individuals than between those on Genovesa, indicating that the Champion birds are closely related and rather inbred. Another possible indication of inbreeding is their behaviour. On Champion, as on Genovesa, territories were tightly packed together, but despite this, we saw no flick-fighting and very little aggressive behaviour, although Hatch (1966) did note four sightings of flick-fighting. This raises an unanswered question: Why is there little aggression *between* groups, which may be related, when there is typical dominant-subordinate aggression *within* groups, whose members are likely to be more closely related (for example, parents and offspring)?

FUTURE FIELD WORK

In the future it would be interesting to find out if there is a mechanism to minimize inbreeding, such as the recognition of parents, siblings, and cousins.

Bob Curry visited Champion in 1981 and 1982, but none of us has yet been on the island during the breeding season and therefore we do not even know if *N. trifasciatus*, like *N. parvulus*, is a social breeder. We strongly suspect that it is.

Our studies have only been going on for four years. In this amount of time we have not been able to answer many important and interesting questions. For example, it is important to find out if males have longer life spans than females. If they do it would support our observations that *N. parvulus* males benefit much more from the helper's assistance than do females, i.e. sons help fathers more than mothers. Some birds help their parents, instead of breeding themselves, until they are three years old. Are they more successful in rearing their own offspring than those who have never helped their parents? We have found that a small minority of the helpers do not appear to be related to those they help. Why then are they helping? Is this a sacrifice they make to increase their own chances of breeding at a later date?

Eventually, by answering these and similar questions, it will be possible to compare the breeding strategies and success rates of all four species of Galapagos mockingbirds, and then to interpret the differences in terms of the different environmental conditions they are subjected to on the various islands.

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