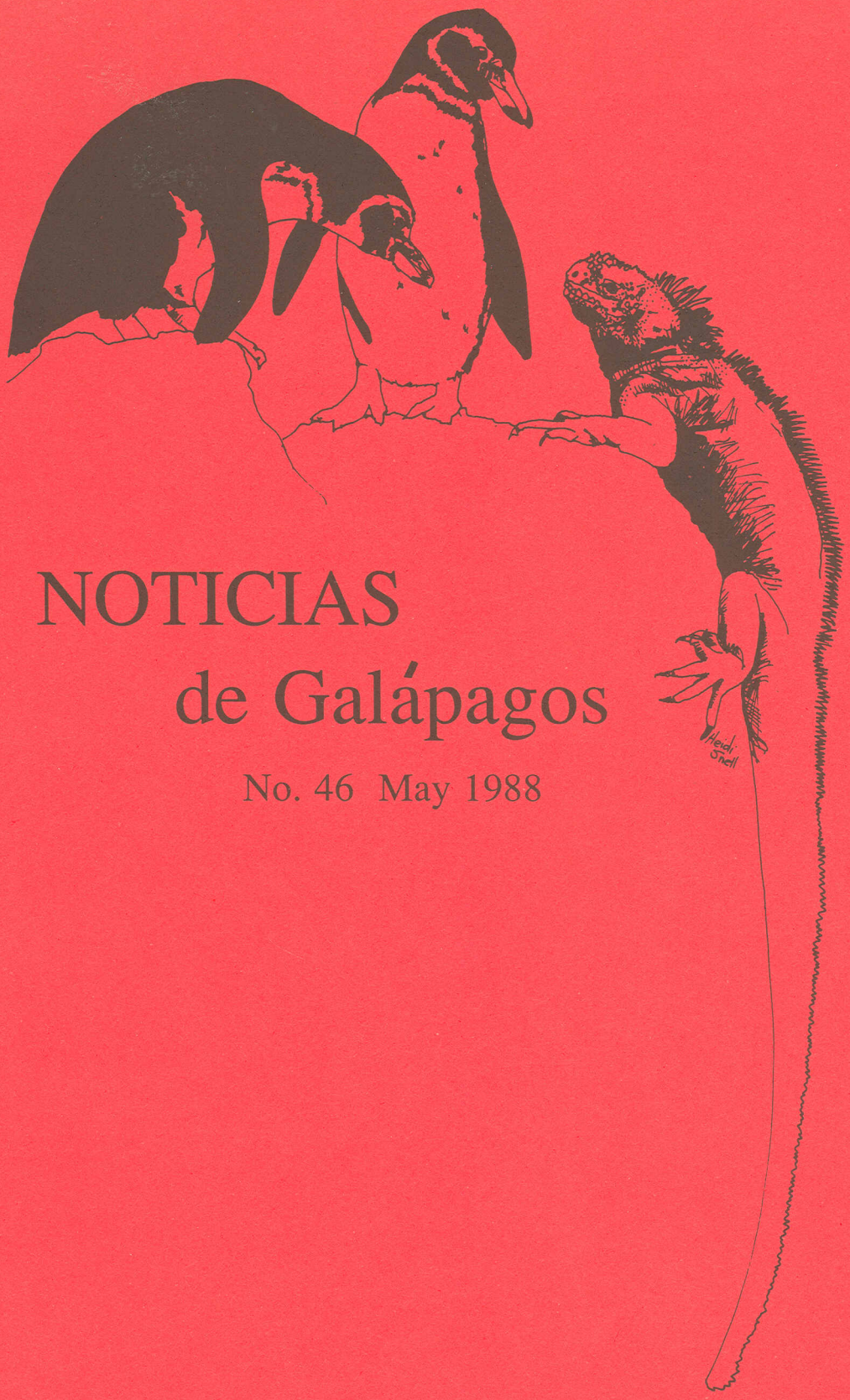

NOTICIAS de Galápagos

No. 46 May 1988

INFORMATION FOR SUPPORTERS OF THE CHARLES DARWIN FOUNDATION

The Charles Darwin Foundation for the Galápagos Islands is supported by several national and international institutions, but nevertheless remains largely dependent on the generosity of individual donors for the funds needed to finance its programs.

General Support and Specific Projects.--In the United States, contributions, which should be accompanied by a note indicating that they are to be used **"for conservation and science in the Galápagos Islands,"** may be sent to the following organizations which support Galápagos programs.

SMITHSONIAN INSTITUTION, c/o Secretary for the Americas (Administration), P.O. Box 37481--OBC, Washington, DC 20013.

WORLD WILDLIFE FUND--U.S., 1601 Connecticut Avenue N.W., Washington, DC 20009.

Endowment Contributions.--The Darwin Scientific Foundation, Inc., is a nonprofit organization devoted to building and managing an endowment fund from which the income is used for the advancement of scientific research, education, and conservation of natural resources in Galápagos. Funds placed in the endowment are managed for the long-term benefit of Galápagos and the annual income is used to support the most deserving activities and projects. Donations and inquiries should be addressed to:

DARWIN SCIENTIFIC FOUNDATION, INC., c/o Smithsonian Institution, Washington, DC 20560.

All three of the organizations listed above can receive tax deductible contributions from U.S. donors. No overhead is charged on contributions; all funds go to work for science, conservation, and education in the islands.

Alternative Organizations.--Elsewhere contributions earmarked **"for the Galápagos"** may be made through the donor's national WWF organization or through the:

WORLD WILDLIFE FUND--INTERNATIONAL, Avenue du Mont Blanc, CH-1196 Gland, Switzerland.

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CHARLES DARWIN FOUNDATION, Greensted Hall, Ongar, Essex, England.

CHARLES DARWIN RESEARCH STATION, Isla Santa Cruz, Galápagos, Ecuador.

While emphasizing that the continuing success of conservation in the Galápagos is directly dependent on the receipt of future contributions, we wish once again to place on record our deep gratitude to all those supporters whose generosity has made it possible to achieve so much since the establishment of the Charles Darwin Research Station and the Servicio Parque Nacional Galápagos.

NOTICIAS DE GALAPAGOS

A Biannual News Publication about Science and Conservation in Galápagos,
the Galápagos National Park Service, and the Charles Darwin Research Station

No. 46 May 1988

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NEWS FROM ACADEMY BAY

Recent Appointments in Washington Office.--In January 1988, Dr. David Challinor became Executive Director of the Darwin Scientific Foundation, Inc. He has served as Secretary for the Americas (Administration) for the Charles Darwin Foundation since 1966 and he is a longtime associate of the Galápagos community.

In March 1988, the Galápagos program gained a new full-time staff member, Lisa Minichiello, who is based in the Smithsonian Institution. Ms. Minichiello is Program Assistant to Dr. Challinor for Charles Darwin Foundation and Darwin Scientific Foundation matters. She previously worked in the Smithsonian's Quincentenary Program. Lisa is a native Washingtonian and is fluent in Spanish.

Lisa's first tasks in her new position involve preparing a financial report of the Darwin Scientific Foundation for the Leiden meeting and publishing the minutes of the first meeting of the Darwin Scientific Foundation's Board. She is also in charge of organizing the mail solicitation program directed at recent Galápagos visitors. Gradually, she will be absorbing many of the duties previously performed by Mrs. Marsha Sitnik. Lisa is delighted to be working on furthering the causes of Galápagos through the Darwin Scientific Foundation, Inc. and the Charles Darwin Foundation.

El Niño Volume Available.--Copies of *El Niño in the Galápagos Islands: the 1982-1983 Event* (*El Niño en las Islas Galápagos: el Evento de 1982-1983*) edited by Gary Robinson and Eugénia M. del Pino are now available through the Smithsonian Institution, Secretary for the Americas (Administration), P.O. Box 37481--OBC, Washington, D.C. 20013 for $15. This bilingual collection of articles totaling 543 pages and focusing on the El Niño phenomenon was produced by the Charles Darwin Foundation. El Niño events occur frequently but the climatic swings experienced in 1982-83 were of unprecedented magnitude and resulted in a myriad of biological and physical effects on the islands and the surrounding ocean waters. Due to production and transportation problems, some of these copies are not in perfect condition, but all are serviceable for anyone wanting to know more about this complex and fascinating subject.

Ira Wiggins Dies.--The Galápagos community was saddened to hear of the death on 28 November 1987 of Ira L. Wiggins, Emeritus Professor of Biology at Stanford University and eminent authority on plants. Dr. Wiggins, together with Duncan M. Porter, authored the classic work entitled *Flora of Galápagos* first published in 1971. This compilation has been the primary base for much subsequent work on the plants of Galápagos and has guided the thoughts of many researchers interested in the terrestrial ecology and distribution of organisms in the Archipelago.

Nominations to the Royal Society.--Two longtime associates of Galápagos, Sir Peter Scott and Dr. Peter Grant, were honored in 1987 by being elected as Fellows of the Royal Society in England.

Peter Grant is the author of numerous publications on the ecology and evolution of Darwin's finches. A review of his recent book appears in this issue. He has worked on Galápagos subjects during a majority of his years as a professional biologist and his election reflects favorably on his achievements as well as on the importance of scientific research in Galápagos. Sir Peter Scott has made numerous contributions to science and conservation globally as well as in England and in Galápagos. Both men deserve the honor and best wishes of the Galápagos community.

Index to *Noticias de Galápagos*.--Through the personal interest and enthusiasm of John Woram, a *Noticias* reader with a flair for detail and computers, an index to *Noticias de Galápagos* has been written and made available to the editors. Woram wrote a computer program using the BASICA language and then assembled a computer file by scanning all back issues of *Noticias*. He catalogued all articles recording author, title, citation, major subject headings, and a brief annotation. The program allows a rapid search through the file, selecting citations on the basis of author, title, or subject headings. The index runs on any MS DOS micro-computer and probably could be adapted to other machines with minimal changes. At present the index spans 344 citations from *Noticias* Numbers 1-44.

The index may be useful to persons interested in the history of the Foundation, Research Station, Park, or Galápagos in general. Anyone desiring more information or wishing to volunteer to help improve and maintain this index is encouraged to contact the editor. Readers are reminded that back issues of *Noticias* are available for use in many university and museum libraries.

Dictionaries Wanted--Used or New.--Anyone familiar with the educational, interpretive, research, and conservation programs in Galápagos is also aware of the importance that both the Spanish and English languages play in day-to-day activities. The Park and Station, and their programs that extend throughout Galápagos, need significant numbers of Spanish/English and English/Spanish dictionaries. Talks, reports, proposals, and educational materials must be prepared and presented; visiting students, researchers, and guests need to be oriented; and information must be exchanged between people whose predominant language is either Spanish or English. Nearly everyone has at least occasional need to

communicate in more than one language. Acquiring up to 50 dictionaries is one step toward doing a better job in all of these tasks. Thus we are asking readers of *Noticias* to consider donating one or more dictionaries, either used or new, for use in Station and Park facilities and programs. Donations can be sent to the editor who will forward them to Galápagos.

International Workshops Focus on Galápagos.--Under the leadership of Ing. Humberto Ochoa, Servicio Parque Nacional Galápagos, and Dr. Gunther Reck, Charles Darwin Research Station, a variety of Galápagos programs are undergoing review and renewed focus. For two of these complex programs, plants and reptiles, this process has stimulated the organization of international workshops to bring together experts in their respective fields with the objectives of reviewing and evaluating these areas, and recommending the directions future research and management should take.

The Botany Workshop, funded by the MacArthur Foundation, was held 11-18 April 1987 and attracted attendees from throughout Ecuador and the world. The proceedings of the workshop will be published with the aid of the Missouri Botanical Garden.

The Reptile Workshop, funded by the Tinker Foundation, will take place 29 May-8 June 1988. The results of this workshop will be published with the help of the Tinker Foundation and the University of New Mexico.

Both events were located in Galápagos to maximize the number of Park and Station personnel in attendance and to promote a feeling of direct involvement of local, national, and foreign participants alike. The participants included: research scientists, academic personnel, government representatives, students, managers, and distinguished guests. The workshops were organized to sequentially review the current scientific knowledge for these organisms, to identify priorities for future research, to evaluate past and ongoing management programs, and, most importantly, to develop management priorities and strategies for the future.

Important topics during the Botany Workshop included: control of introduced plant species, recovery of plant communities damaged by introduced mammals, documentation and monitoring of plant communities throughout the islands, evaluation of human impacts on plants in colonized zones, and rational use of plants to minimize changes in the Galápagos flora.

Primary topics in the Reptile Workshop will be: endangered species recovery, the role of captive propagation, minimal population sizes, interisland and populational diversity, and the management of reptile communities.

THE LOSS OF *BEAGLE IV*

The Galápagos community suffered a tragic loss just prior to dawn on 30 August 1987 when the Charles Darwin Research Station's research vessel, *Beagle IV*, was destroyed after going ashore on a rocky beach on the southern coast of Santa Cruz. Fortunately, no serious injuries were sustained by the three crew members aboard at the time of the incident. The *Beagle IV* was en route to Daphne Major to pick up biologists who had completed a several-month study of Darwin's finches when the accident occurred. After departing Academy Bay at about 0300, the *Beagle* took an easterly course. Within an hour of her departure from port, she was stranded on the rocky shore near Punta Nuñez. With each successive wave, she was buffeted higher onto the rocks lining the coast at this point. An official investigation of the accident determined the cause to be human error in failure to use proper procedures in setting the *Beagle's* course. Once the boat had run aground, the crew was helpless to do anything but struggle ashore through the heavy surf. One crew member then made his way on foot back to the Darwin Station to summon help.

By mid-morning, several vessels from Academy Bay, personnel from the Darwin Station and the National Park, visiting scientists, and Galápagos residents alike mobilized to offer assistance. Many people made the 2 hour hike along the rugged coastline from Puerto Ayora to the accident site carrying food, water, dry clothing, and camping gear to prepare for the eventuality of having to remain for some time to aid in the rescue. Others swam ashore in heavy surf from boats gathered offshore. All worked unselfishly for long hours lightening the boat and salvaging removable equipment. Everything taken from the boat had to be carried across the slippery, uneven rocks, from the *Beagle IV* to the shore. Many rescuers suffered bruises, sprained backs, and abrasions in the process. Fifty-gallon barrels and ropes were floated ashore from an offshore barge for possible use in floating the *Beagle.* It was heartening to watch the cooperation of everyone working tirelessly side by side in what was not just a tragedy for the Darwin Station, but rather a loss to the entire Galápagos community.

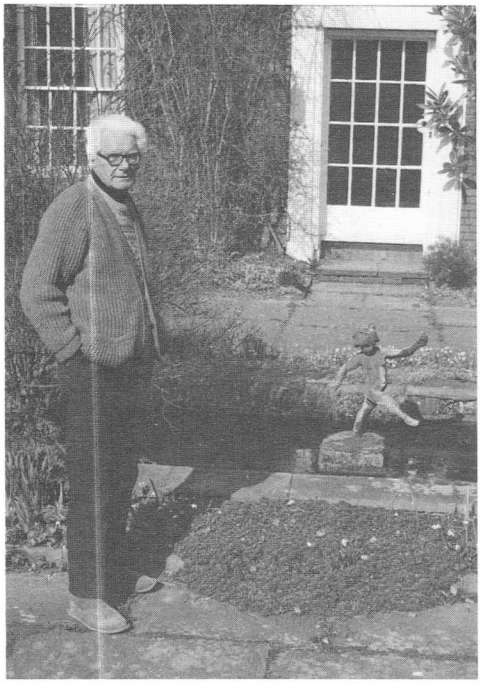
In the end after careful assessment of the situation, refloating the *Beagle* was judged impossible. The exceptionally high tides on the day of the accident had pushed the vessel too high onto the shore, the rocks had gouged major holes in the fiberglass hull, the high waves coming ashore all day had continually crushed and dislodged any flotation aids attached alongside the vessel, and the potential for injury to workers near the wreckage was too great.

With no hope of saving the vessel, what remained to be done was to salvage the remaining records, equipment, and supplies and to post an around-the-clock guard. A comprehensive accident report was assembled, insurance claims were filed, and all property was inventoried. Although the vessel was insured, the final cost of buying a replacement suited for today's needs will be nearly twice that of the insured value of the *Beagle IV*. Finding an appropriate vessel, outfitting it to meet Galápagos needs, and transporting it to the islands will be a significant financial drain on both resources and personnel.

The *Beagle IV* arrived in Galápagos in August 1980 and served a large number of visiting researchers, Station staff, and Park personnel. Originally purchased as a utilitarian replacement for the *Beagle III*, the *Beagle IV* was faster, cheaper to operate, and better-suited for carrying personnel and research equipment than her predecessor. *Beagle IV* greatly facilitated research efforts in Galápagos, and she will be sorely missed.

Anyone wishing to contribute funds or guidance in securing a replacement vessel is encouraged to contact the President of the Charles Darwin Foundation, Craig MacFarland, Box 36, Arlee, Montana 59821, USA or the editor.

The *Beagle IV* on the coast of Santa Cruz where she went aground near Punta Nuñez on 30 August 1987 (photograph by P.R. Fritts). *Beagle IV* en la costa de Santa Cruz donde se varó cerca Punta Nuñez 30 de agosto de 1987.



Corley Smith at his home Greensted Hall in Ongar, England. Corley Smith en frente de su casa, Greensted Hall, Ongar, Inglatera.

RETIREMENT OF G.T. CORLEY SMITH AS EDITOR

By: Patricia R. Fritts and Thomas H. Fritts

The retirement of G.T. Corley Smith from the editorship of *Noticias de Galápagos* culminates his major 14 year contribution to the publication. Corley's editorship of *Noticias* began with Volume 22 published in 1974, but his contributions to the Charles Darwin Foundation began much earlier. His first association with Galápagos came in 1964 while serving as British Ambassador to Ecuador even before he became formally affiliated with the Foundation. He joined the Foundation's Executive Board after his retirement from the British Foreign Service, and by 1973, became the Board's primary administrator as Secretary General.

The first formal meeting of the Foundation that Corley attended was held at the home of Charles Darwin in England. Corley enjoys recounting the story of that first meeting. He was seated under a portrait of Thomas Huxley and several people present at that meeting commented that he bore a striking

resemblance to the painting of Huxley. With a wry smile, Corley says he has often pondered whether this resemblance to the famous evolutionist prompted his election to the Foundation Board! However, one only needs to know Corley for a short period of time to realize that the energy, style, dedication, and tenacity he evinces have been of far greater value to the Foundation than his distinguished resemblance to Huxley. Anyone not familiar with the depth of Corley's involvement with Galápagos is encouraged to consult the 1987, Volume 45 article in *Noticias* entitled "Looking Back."

Although less involved with *Noticias*, Corley still plans various activities related to Galápagos. He will continue to act as a representative of the Charles Darwin Foundation in England and to receive contributions from European supporters. He also plans to work on a history of Galápagos, and we sincerely hope that he will regularly contribute articles to *Noticias*. We wish him the best in all of his endeavors and wholeheartedly appreciate his unselfish contributions to the Foundation and to Galápagos over the years.

SANTA CRUZ FACT SHEET

Text By: Amrit Work Kendrick
Map By: Heidi M. Snell

Size.--Second largest of the Galápagos Islands, surface area of 986 km^2, nearly one third the size of Luxembourg, and nearly twice as large as Curaçao.

Elevation.--Highest point is Cerro Crocker at 864 m. Unlike some of the major islands and volcanoes in Galápagos, Santa Cruz lacks a central caldera.

Geographical and Geological Features.--This island occupies a central position in the Archipelago and from appropriate vantage points it is possible to see the islands of Santa Fe, Floreana, Pinzón, Santiago, Rábida, Isabela, Baltra, Seymour, Plaza Sur, and Plaza Norte. The oldest rocks of Santa Cruz were formed 0.98-1.03 million years before present.

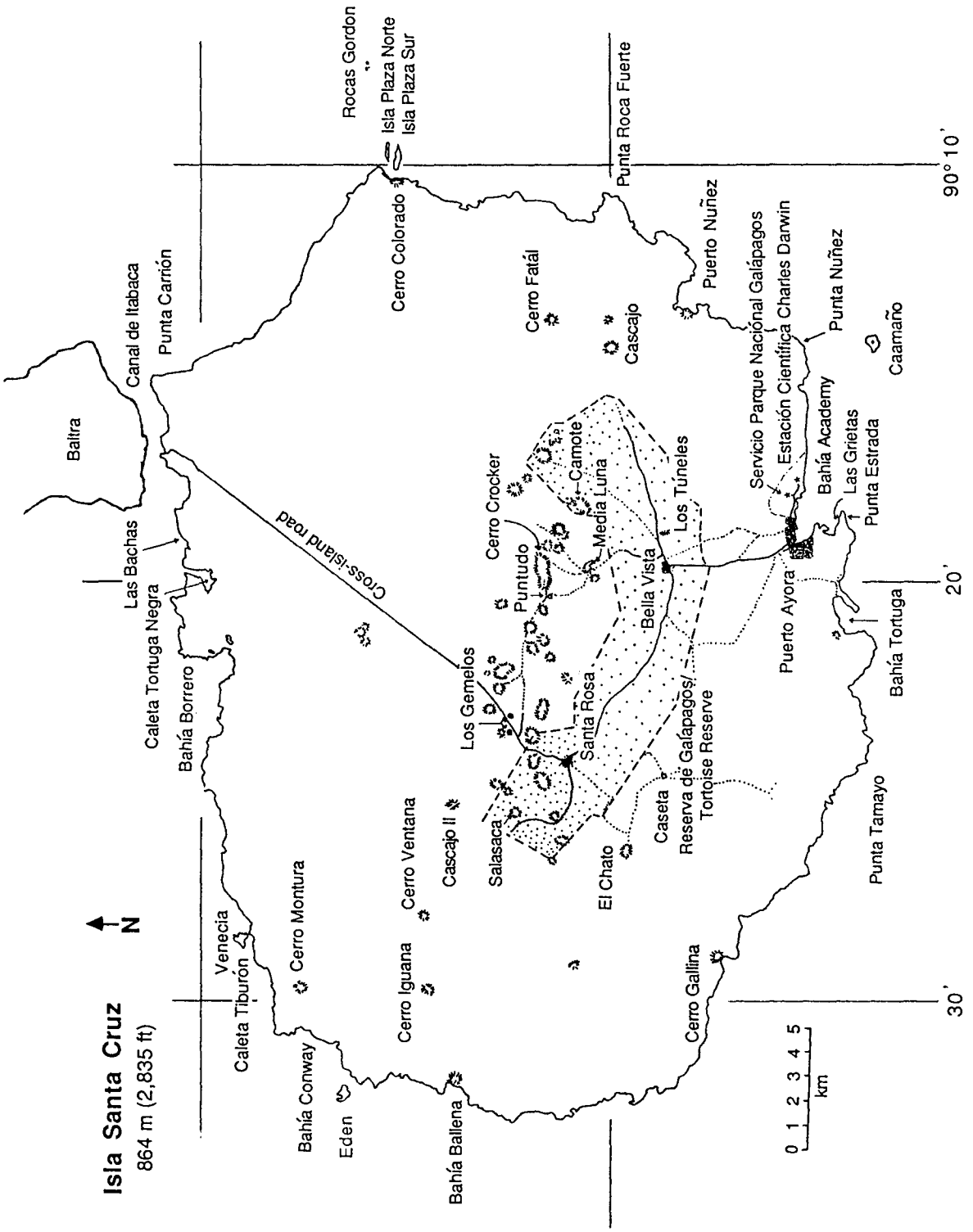
Ecology.--Santa Cruz has a diverse flora with all six vegetation zones recognized in Galápagos occurring on the island. At low elevations are the Littoral, Arid, and Transition Zones. Moist winds from the south produce the *Scalesia* Zone at 200-500 m where rainfall and garúa are greatest. The *Scalesia* forests were devastated by the heavy rains of the 1982-83 El Niño, but are now recovering. Higher yet on the slopes of Santa Cruz are the slightly drier *Miconia* and Fern-Sedge Zones. The *Miconia* Zone is better developed on Santa Cruz than elsewhere in the islands. At the highest elevations, sedges and ferns are predominant because they tolerate the extremes of temperature and humidity found there. Low elevations and northern exposures that receive less moisture from the winds out of the south are driest with abundant cactuses, deciduous trees, and spiny shrubs. The fauna of Santa Cruz is rich and includes eight species of finches, a mockingbird, both vermilion and broad-billed flycatchers, yellow warblers, Galápagos hawks, two species of owls, and a variety of sea birds. The Santa Cruz tortoises are among the largest of the dome-shaped tortoises. The tortoises can be seen in their native habitats within the Tortoise Reserve and occasionally along roads in the colonized areas. Introduced predators such as pigs, dogs, and cats have created special conservation problems for tortoises, land iguanas, and dark-rumped petrels.

Human Population.--The largest concentration of Galápagos inhabitants is in Puerto Ayora, adjacent to Bahía Academy, and near the headquarters of the Galápagos National Park Service and the Charles Darwin Research Station. Several smaller villages exist in the humid climates of the agricultural zone further from the coast: Bella Vista, Santa Rosa, El Carmen, and El Cascajo. Coffee, papaya, avocados, and a variety of other fruits and vegetables are grown for local consumption. A significant cattle industry exists which depends in part on artificial insemination to avoid the importation of breeding stock which might carry diseases and parasites. Cattle are exported to other islands and to the mainland, but most of the beef and dairy products Santa Cruz produces are consumed on the island. The settlement of the island (primarily for agricultural purposes) began in the 1920s, but since the establishment of the Galápagos National Park in 1959, the principal industry has shifted to tourism and activities that support tourism.

Current Problems.--Santa Cruz is a major population center and the hub of most tourist traffic. Cargo brought by air (via Baltra airport) and by sea to Santa Cruz presents a continual danger of introducing plants and animals to the Galápagos ecosystem. Problems exist at present with the introduced fire ant which destroys native invertebrates; the smooth-billed ani which may impact native finches; and introduced plants including: *Lantana*, *Cinchona*, and *Psidium* (the guayaba), all of which are aggressive plants that have displaced native species.

Sites of Interest.--Bahía Tortuga - A 1 km beach of fine white sand reached from Puerto Ayora via an easy to navigate 5 km foot trail through a variety of Arid Zone vegetation and lava formations.

Bahía Academy - This picturesque anchorage which is home to many tourism boats was named in honor of *Academy*, the ship used by the California Academy of Sciences Expedition in 1905-06. Marine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Punta Carrión
Las Bachas
Caleta Tortuga Negra
Bahía Borrero
Cross-island road
Rocas Gordon
Isla Plaza Norte
Isla Plaza Sur
Cerro Colorado
Punta Roca Fuerte
Cerro Fatál
Cascajo
Puerto Nuñez
Servicio Parque Nacional Galápagos
Estación Científica Charles Darwin
Punta Nuñez
Caamaño
Bahía Academy
Las Grietas
Punta Estrada
Cerro Crocker
Camote
Media Luna
Los Túneles
Puntudo
Bella Vista
Puerto Ayora
Bahía Tortuga
Los Gemelos
Santa Rosa
Reserva de Galápagos Tortoise Reserve
Caseta
Salasaca
Cascajo II
El Chato
Punta Tamayo
Venecia
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iguanas, pelicans, blue-footed boobies, frigate birds, noddies, lava gulls, and three species of herons are commonly seen feeding in and around the bay.

Las Grietas - These large fissures in the lava shoreline are not far from Puerto Ayora. Where they join with the sea, they are home to resting sea turtles and sharks. Further inland where the water is brackish due to mixing of seawater with freshwater draining from the island, blind cave fish and crayfish are found.

Cerro Crocker and Media Luna - The best views of adjacent islands exist from this high vantage point on a clear day. Media Luna, an old volcanic crater covered with *Miconia* plants and surrounded by moisture-loving ferns, is a major nesting area for the dark-rumped petrel.

Los Túneles - This complex of lava tubes located on private land allows the visitor to appreciate the magnitude of volcanic eruptions. For a small admission charge, the visitor equipped with a flashlight can explore one of the longest lava tubes in South America, a natural tunnel nearly 1 km in length.

Tortoise Reserve - The tortoise reserve is located near the boundary between the Galápagos National Park and the Colonized Zone and can be reached on foot or horseback by following the trail from Santa Rosa. Here the visitor can see giant tortoises in their native habitats. During the wettest seasons, ponds form at various sites and the tortoises regularly soak in the water to remove ticks and other parasites.

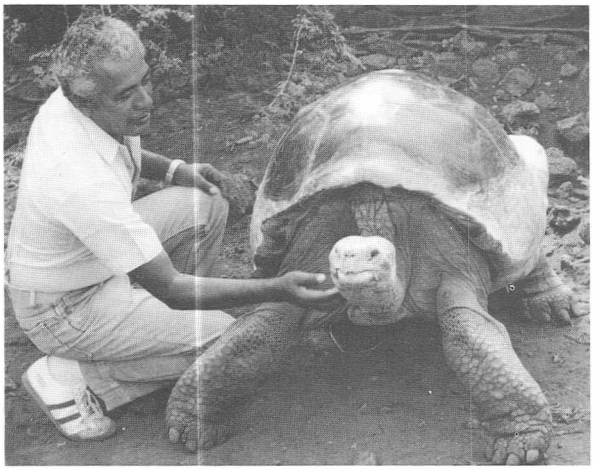
Los Gemelos - The twin craters with nearly vertical walls produced by major collapses are located near the Cross-island Road. Surrounding Los Gemelos is a dense forest of regenerating *Scalesia* trees where vermilion flycatchers are common.

Caleta Tortuga Negra - A mangrove lagoon which opens into the ocean and which is accessible to visitors only by boat, these waters are frequently used by sea turtles, rays, and sharks as a feeding and resting area. Herons commonly nest in nearby trees.

Las Bachas - This small beach where sea turtles haul out to bask and to nest is on the northwestern side of Santa Cruz. Flamingos are occasionally seen in the lagoon nearby. Formerly the removal of sand from the beaches in this area for construction on Santa Cruz threatened to produce a shoreline of barren rock. Use of alternative construction materials has allowed preservation of many small beaches that were threatened.

Canal de Itabaca - This narrow body of turquoise-blue water between Baltra and Santa Cruz is often a visitor's first view of Galápagos when arriving at the Baltra airport. The visitor traveling to Puerto Ayora by the Cross-island Road must cross the canal by ferry. Pelicans, boobies, shearwaters, and noddies are frequently sighted over the canal. The cliffs at the eastern end of the canal are inhabited by fur seals.

Amrit Work Kendrick, Charles Darwin Research Station, Isla Santa Cruz, Galápagos, Ecuador. Present address: Star Route, Stonewall, Texas 78671, USA.



Bernardo Gutiérrez with the male tortoise he raised as a pet. Bernardo Gutiérrez con el galápago macho que crió como mascota.

HOW OLD IS THAT TORTOISE?

By: Thomas H. Fritts

Visitors to Galápagos frequently ask about the age, growth, and maximal life span of the giant tortoises. Often, the visitor has previously heard that turtles, and especially land tortoises, are capable of living more than a century, but the question resurfaces when confronted with the large size and regal aspect of the adult tortoises in Galápagos. Just how old are the various male tortoises in the corrals at the visitor site near the Park/Station tortoise complex on Santa Cruz? In general, little information exists on these tortoises because they are animals confiscated or voluntarily returned to the Park by people who had the tortoises in captivity at the time the Park was declared. Because no one can be sure from which island or population these tortoises came, they are held at the visitor site for educational, research, and interpretive uses.

Recently during a casual conversation with Captain Bernardo Gutiérrez, a native of San Cristóbal and operator of the tourist boat *San Juan*, a story unfolded that allows tentative establishment of the age for one of the large tortoise males seen by nearly every visitor to Galápagos. Bernardo's story follows. When

he was about 10 years old, he found a small tortoise about the size of a dinner plate on the outskirts of Puerto Baquerizo Moreno on San Cristóbal. Only a short time previously, several tortoises had escaped from a makeshift corral at the Port Captain's headquarters. The juvenile tortoises had been confiscated by local authorities from a fishing boat that had brought the tortoises from the northern coast of Volcán Wolf on Isabela. It was common knowledge among Galápagos fishermen that in contrast to most areas of Galápagos, tortoises nested near the shoreline on Volcán Wolf, and it was possible to find juvenile tortoises living within a few 100 m of the coast. Since no tortoises lived on San Cristóbal near the port, the tortoise found was undoubtedly one of the escapees.

Bernardo took the tortoise home where he and his brothers and sisters raised it as a family pet. The tortoise was found around 1945, and based on its size at the time, it must have been 3-5 years of age. The tortoise stayed with the Gutiérrez family and had grown to a large size by the late 1960s when the tortoise was returned to Santa Cruz to comply with the law prohibiting tortoises being maintained as pets. However, Bernardo is still able to distinguish the tortoise that he raised from the others in the captive herd on Santa Cruz by a particular scar on the shell resulting from an injury which the tortoise received when it unwisely tried to invade the Gutiérrez kitchen.

With some allowance for an error of 1 or 2 years in the calculation of the probable age of Bernardo's tortoise, the tortoise is 46 to 48 years of age and probably hatched from an egg between 1940 and 1942. Thus, this tortoise measuring 121 cm in shell length and having the demeanor of a giant patriarch is in fact less than halfway to attaining a century of life, and younger than many of the admiring visitors that visit the corral where he lives. These facts testify to the fact that Galápagos tortoises reach their large sizes in only a few decades, but this does not preclude the possibility that they do indeed live to ages matching or exceeding maximal longevity for humans. Recent field data collected as a part of Park conservation programs strongly suggest that some tortoises reach maturity 15-20 years after hatching and that after maturity, growth nearly stops in females and slows significantly in males. Thus the tortoise probably had achieved most of his growth prior to arriving on Santa Cruz and has grown quite slowly over the last 20 years.

Should you visit the tortoise corrals at the Park/Station Headquarters, you might recognize the tortoise pictured in this article. Among Park and Station personnel, he is known as "Guardian" and he bears a codified registration number of 48. He may be big and even majestic, but please don't consider him old. Tortoises have feelings too!

TWO NEW BUTTERFLY FISH RECORDS FROM WENMAN ISLAND

By: Godfrey Merlen

Last summer (29 May-2 June 1987) I had the opportunity to revisit the northwestern outposts of Galápagos--the islands of Culpepper and Wenman. I had visited Wenman several times over a number of years while working on the *Beagle III*. Originally I was part of a crew responsible for the placement and maintenance of a series of tide-temperature gauges organized by NOAA, the National Oceanographic and Atmospheric Administration of the United States, and Wenman had been one of the selected sites. It was marvelous to return to this island where the cliffs are alive with seabirds. Especially notable was the occasional sight of the pelagic sooty tern *Sterna fuscata*, which is an extremely abundant species in the Central Pacific, but within the Galápagos Archipelago only breeds on inaccessible Culpepper.

However, this time we were on a diving expedition, again on the faithful *Beagle III*, and we dropped our anchor in the familiar anchorage facing the western ocean in a flat, calm sea. We chose as our main diving area the two rocks, one large and the other small, just offshore from the southwestern point of Wenman (Fig. 1). We dived first on the outer vertical wall of the large rock, but later found that the channel between the rocks and the precipitous cliff of the main island was much more productive with its steep walls, boulder slopes, and stronger currents.

A questionable highlight of the dives was encountering several schools of hammerhead sharks with up to 20 individuals in a group. The sharks occasionally came so close that we could count their teeth. Numerous bottlenose dolphins in the area also showed an active interest in us.

The most exceptional fish sightings for me were two fish which have not been recorded from the Galápagos (Fig. 2): the raccoon butterfly fish (*Chaetodon lunula*) and the threadfin or golden butterfly fish (*Chaetodon auriga*) which were seen in close proximity to one another just to the southeast of the small rock. They had found something of a lee from the swirling foamy waters in a depression behind some rocks. The bottom between the two exposed rocks was rather flat and shallow (2.5-3.0 m or 8-10 ft). These fish were exceptionally attractive and recognizable with their bold stripes and markings. I had previously observed both species while diving off Christmas Island in the Central Pacific and in the Hawaiian Islands, where they are common.

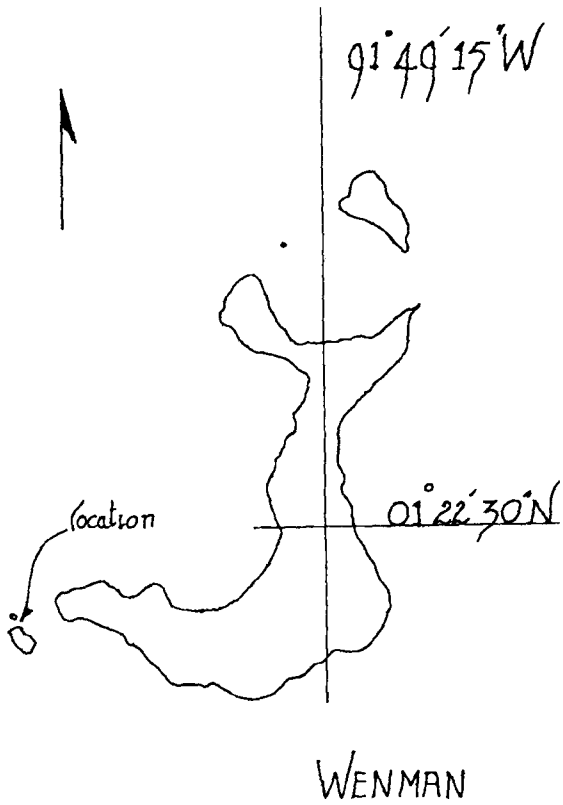


Figure 1. Wenman Island and the location where observations of butterfly fish were made. Isla Wenman y el lugar donde se realizaron las observaciones de los peces mariposas.

A third butterfly fish (*Chaetodon kleinii*) was seen for the first time after the 1982-83 Niño season. Jack Grove observed one at Marchena; I saw one at Bartolomé and, as recently as January of 1986, I found a pair at Bartolomé.

There are three butterfly fish resident in the Galápagos Archipelago which are all found only in the Eastern Pacific. These are: 1) *Chaetodon humeralis*, three-banded butterfly fish; 2) *Chaetodon falcifer*, scythe marked butterfly fish; and 3) *Johnrandallia nigrirostris*, barberfish.

Butterfly fish are associated with reef systems, and in the Galápagos, rocky shorelines. To travel the distance from the Central Pacific is an amazing feat, even if completed in a larval form, as the nearest islands are well over 3,000 nautical mi away. It is of interest, however, that the equatorial countercurrent, which is an east-going water mass sandwiched between the north and south equatorial currents which flow westward, may have an effect on the two northernmost islands of Culpepper and Wenman, and allow them to experience a warmer, more tropical climate potentially offering a haven for fish drifting across the vastness of the ocean. The red-tailed trigger fish (*Xanthichthys mento*) is a common resident at Wenman but occurs nowhere else in the Archipelago and is perhaps a good example of this method of arrival from the Central Pacific.

Finally, it may be worthwhile to ask how long these two vagrants had been here. This we cannot answer. Had they arrived during the Niño season of 1982-83 and managed to survive for several years, representing a rare occurrence? Or do fish of these species arrive regularly but fail to breed successfully and thus remain scarce? Increased diving and research activity in Galápagos will hopefully result from the declaration of the Galápagos Marine Reserve and may help resolve these and other questions about the marine biology of the area.

Godfrey Merlen, Isla Santa Cruz, Galápagos, Ecuador.

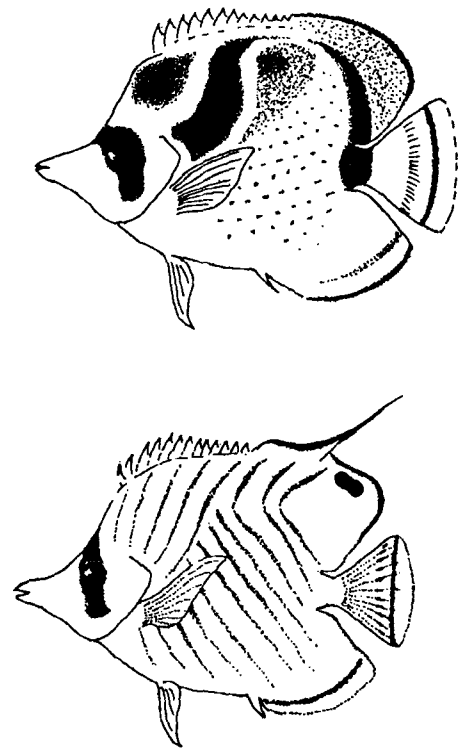


Figure 2. The raccoon butterfly fish, *Chaetodon lunula* (above), and the threadfin butterfly fish, *Chaetodon auriga* (below), found near Wenman Island in 1987. El pez mariposa mapache, *Chaetodon lunula* (arriba), y el pez mariposa aleta hilada, *Chaetodon auriga* (abajo), encontrados cerca Isla Wenman.

DOS NUEVOS REGISTROS DE PEZ MARIPOSA DE LA ISLA WENMAN

Por: Godfrey Merlen

En el verano pasado (29 de mayo-2 de junio de 1987) tuve la oportunidad de visitar nuevamente los puntos fronterizos noroccidentales de Galápagos--las islas de Culpepper y Wenman. Había visitado la Isla Wenman varias veces en el transcurso de algunos años mientras trabajaba en el yate *Beagle III*. Originalmente yo fuí parte de la tripulación responsable de instalar y mantener una serie de indicadores de mareas y temperaturas, organizado por la Administración Nacional Oceanográfica y Atmosférica de los Estados Unidos (NOAA), y Wenman fué uno de los sitios seleccionados. Fué maravilloso regresar una ves más y ver nuevamente los barrancos llenos con aves marinas. Fué especialmente notable observar ocasionalmente al gaviotín pelágico *Sterna fuscata*, la cual es una especie muy abundante en el Pacífico Central, pero dentro del Archipiélago de Galápagos solamente anida en la inaccesible Culpepper.

Sin embargo, esta vez estábamos en una expedición de buceo, nuevamente en el fiel *Beagle III*; botamos ancla en el conocido fondeadero, mirando hacia el océano occidental, en un mar tranquilo y sereno. Escogimos como nuestra área principal de buceo las dos rocas, una grande y una pequeña, situadas a corta distancia de la punta suroeste de Wenman (Fig. 1). Buceamos primero en la pared vertical de afuera de la roca grande, pero luego encontramos que el canal entre las rocas y los precipitosos barrancos de la isla misma era mucho más productivo con sus empinadas paredes, sus grandes rocas en declive y corrientes más fuertes.

Las atracciones principales, a veces cuestionables, fueron los cardúmenes de hasta 20 tiburones martillo, que ocasionalmente venían tan cerca que podíamos contar sus dientes. Los numerosos delfines del área también demonstraron un activo interés en nosotros.

La observación de peces más excepcional para mí fué dos que no han sido registrados en Galápagos (Fig. 2): el pez mariposa mapache (*Chaetodon lunula*) y el aleta hilada o pez mariposa dorado (*Chaetodon auriga*) que fueron vistos a corta distancia uno de otro justo al sureste de la roca pequeña. Habían encontrado una pequeña protección de las turbulentas aguas en una hondonada detrás de algunas rocas. El fondo entre las dos rocas era bastante plano y poco profundo (2.5-3.0 m o 8-10 pies). Estos peces eran excepcionalmente atractivos y fáciles para reconocer con sus pronunciadas franjas y marcas. Yo había visto anteriormente las dos especies cuando estuve buceando fuera de Christmas Island en el Pacífico Central y en las islas de Hawaii, en donde son comunes.

Un tercer pez mariposa (*Chaetodon kleinii*) fué visto por primera vez después de la temporada del Niño en 1982-83. Jack Grove lo vió en Marchena; yo ví uno en Bartolomé y tan reciente como enero de 1986 encontré un par en Bartolomé.

Hay tres peces mariposa residentes en el Archipiélago de Galápagos, los cuales se encuentran solamente en el Pacífico Oriental. Estos son: 1) *Chaetodon humeralis*, pez mariposa con tres franjas; 2) *Chaetodon falcifer*, pez mariposa "guadaña;" y 3) *Johnrandallia nigrirostris*, pez barbero.

Los peces mariposa están asociados con sistemas de arrecifes, y en Galápagos, con costas rocosas. Viajar la distancia desde el Pacífico Central es una hazaña asombrosa, aunque sea en forma de larva, ya que las islas más cercanas están a más de 3,000 mi nauticas. Sin embargo, es de interés notar que la contracorriente ecuatorial, que es una masa de agua que viaja hacia el este intercalada entre las corrientes ecuatoriales del norte y sur que van hacia el oeste, podría tener un efecto en las dos islas norteñas de Culpepper y Wenman que les permita experimentar un clima caliente y más tropical, lo cual ofrece un refugio para peces a la deriva en la inmensidad del océano. El pez ballesta de cola roja (*Xanthichthys mento*) es un residente común en Wenman pero no se lo encuentra en ninguna otra parte del Archipiélago, y tal vez es un buen ejemplo de este método de arribo desde el Pacífico Central.

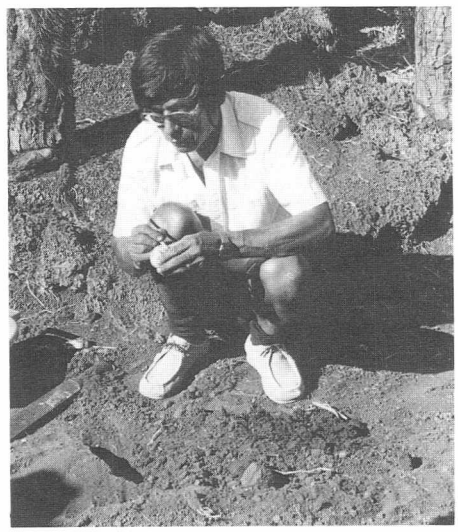
Finalmente, tal vez sea importante preguntarnos desde cuándo están aquí estos dos vagabundos. Esto no podemos contestar. Tal vez llegaron durante la temporada del Niño de 1982-83 y han podido sobrevivir por algunos años, lo cual representa una rara ocurrencia. ¿O peces de estas especies llegan regularmente pero no pueden reproducirse satisfactoriamente? Una de las ventajas del aumento de actividad de buceo en Galápagos y de un aumento en la actividad de investigación que va a resultar después de la declaración de la Reserva Marina de Galápagos, será la de contestar estas preguntas acerca de la biología mariana del área.

Godfrey Merlen, Isla Santa Cruz, Galápagos, Ecuador. (Traducción por Maria Eulalia de Balfour.)

RECOGNIZING FAMILIAR FACES

By: Thomas H. Fritts

The Galápagos community includes many dedicated people whose commitment to conservation, research, and the quality of life in the Archipelago contributes significantly to the programs of the Galápagos National Park Service and the Charles Darwin Research Station. As a means of recognizing the contributions of a few of these people, *Noticias de Galápagos* will periodically include brief profiles of people (some with familiar faces) who have given much and continue to give to Galápagos. This is our way of saying thank you to these people and to the many other dedicated employees of the Park and Station. The dedication, experience, and creativity of employees like those described below are the keys to continued success in the conservation and management of the Galápagos.



Fausto Llerena S. excavating a tortoise nest deposited by a female in captivity. Fausto Llerena S. excavando el nido de un galapágo en cautiverio.

FAUSTO LLERENA SANCHEZ
Park Warden, Galápagos National Park Service

Fausto Llerena was born on the mainland of Ecuador, but he and his family moved to the highlands of Santa Cruz in Galápagos when Fausto was a young boy. He has worked as a warden with the Park Service since 1971 when the National Park Service was first organized under the Ministry of Agriculture. At present, Fausto works behind the scenes for the Park on Santa Cruz in a position of major importance to the success of the conservation programs. The captive reproduction and rearing programs for land iguanas and giant tortoises involve endless monitoring, problem solving, and record keeping. Fausto first worked with the iguana program, but for several years has been supervising the tortoise program, handling both the paperwork and the maintenance of nesting females, incubating eggs, and growing tortoises. People needing information on the status of the reptile breeding program frequently seek out Fausto in his crowded office near the pens where the young tortoises from five islands are reared.

Fausto was one of several early Park wardens who endured difficult field conditions in exploring the fledgling National Park, censusing the native animals, and initiating control of introduced mammals.

In October 1987, Fausto's field experience was again called into play when he assisted five other Park wardens in an intensive tortoise census on the island of Pinzón. The census was a resounding success. Forty-five tortoise nests were found, and all participants agreed that it was Don Fausto who recognized the best nesting areas, found the most nests, and ensured the success of the trip.

Fausto is also well known and admired for his talents as a wood carver. His carvings of both saddleback and domed tortoises are so distinctive that they are recognizable thousands of miles from Galápagos. He occasionally, by special request, carves other animals ranging from penquins to land iguanas, but his tortoises are particularly prized by Galápagos residents and visitors alike. As a person who has lived near tortoises since his early childhood, and as a warden who has worked with them in the field and in captivity, Fausto is uniquely suited to conceptualize a tortoise and to turn a block of wood into a work of art.

LUIS RAMOS VELOZ
Chief Purchasing Agent, Charles Darwin Research Station

Luis Ramos (respectfully and affectionately known to nearly everyone as Don Ramos) has worked for the Charles Darwin Research Station since November 1971. For many years he has served as the principal person responsible for purchasing food, supplies, equipment, and other miscellaneous items needed from local suppliers. He also receives all purchases arriving by cargo ship from the mainland.

In times past, when motor vehicles were less reliable and less available, it was Don Ramos in his indispensable *panga* (skiff) who ferried scientists, supplies, and equipment from the Station to the boats anchored in Academy Bay waiting to carry them to their research sites on outlying islands. He was always there to pick them up on their return and take them back to the Station. He has made countless trips

by *panga* through the narrow channel from town across Academy Bay to the Station with materials arriving on supply ships from the continent. When drinking water was in short supply, he provisioned the Station with fresh water acquired from supply ships.

Luis Ramos V. in his mobile office. Luis Ramos V. en su oficina móvil.

But, as roads improved and the Station grew, Don Ramos began to use Station vehicles to complete his daily rounds for purchases, deliveries, and errands. No matter how busy he is, Ramos always seems to find time to provide a ride for someone needing to go to town or to offer his advice on where something can be most conveniently purchased. Everyone, from Station employees to visiting scientists, has benefited from his ability to find those items in short supply, buy them at a reasonable price, and even secure credit in times when cash is unavailable.

Don Ramos' creativity also evidences itself in his personal hobby of sewing. When zippers, cloth, and a need exist, he skillfully fabricates a variety of field and camping equipment including daypacks and tents. He has successfully duplicated the quality of professionally-made equipment and incorporated modifications specifically useful to Galápagos situations. "Hecho por Ramos" (Made by Ramos) may not be a world-famous designer label, but it is one greatly appreciated by people in Galápagos who have a variety of needs ranging from equipment for the field, puppets for environmental education programs, or upholstry for a vehicle.

RECONOCIENDO CARAS FAMILIARES

Por: Thomas H. Fritts

La comunidad de las Islas Galápagos incluye mucha gente dedicada comprometida a la conservación, la investigación, y la calidad de vida en el Archipiélago quienes contribuye grandemente a los programas del Servicio Parque Nacional Galápagos y de la Estación Científica Charles Darwin. Como una manera de reconocimiento a las contribuciones de algunas de estas personas, *Noticias de Galápagos* incluirá periodicamente breves representaciones de personas (algunas con caras familiares) quienes se han dedicado y continuarán dedicando para el bien de las Galápagos. Esta es una manera de dar gracias a esta gente y a muchos otros empleados del Parque y de la Estación. La dedicación, experiencia, y creatividad de empleados como estos descritos más abajo son los factores determinantes del éxito continuo en la conservación y manejo de las Galápagos.

FAUSTO LLERENA SANCHEZ
Guardaparque, Servicio Parque Nacional Galápagos

Fausto Llerena nació en la tierra continental del Ecuador, pero su familia mudó a la parta alta de Isla Santa Cruz en Galápagos cuando Fausto fue muy joven. El ha trabajado como un guardaparque con el Servicio Parque Nacional Galápagos desde el año 1971 cuando el Servicio estuvo organizado dentro del Ministerio de Agricultura.

Actualmente Fausto se encuentra trabajando para el Parque en Santa Cruz en una posición de gran importancia para el éxito de los programas de conservación. Los programas de reproducción y crianza en cautiverio de iguanas de tierra y tortugas gigantes consiste en un interminable monitoreo y solución de problemas. Fausto trabajó primeramente con iguanas, pero en los últimos años ha estado supervisando el programa de tortugas, balanceando el trabajo de control de datos y la vigilancia de hembras con nidos, huevos baja incubación, y las pequeñas tortugas. Las personas con necesidades de información sobre el programa de la reproducción de reptiles frecuentemente buscan a Fausto quien se encuentra en medio de su oficina estrecha cerca de las jaulas donde se crian tortugas jovenes procedentes de cinco islas.

Fausto fue uno de los primeros guardaparques quienes sobrellevó las difíciles condiciones del campo explorando el naciente Parque Nacional, censando los animales nativos e iniciando el control de los mamíferos introducidos.

En octubre de 1987, la experiencia de campo de Fausto fue llamado a cumplir el importante papel de asistir a otros cinco guardaparques en un intenso censo de tortugas en la Isla Pinzón. El censo fue todo un éxito--fueron encontrados 45 nidos de tortugas--y todos los participantes estuvieron de acuerdo que fue Don Fausto quien reconoció las mejores áreas de anidamiento, quien encontró el mayor número de nidos, y quien aseguró el éxito del viaje.

Fausto es también conocido y admirado como un escultor en madera. Sus tallados de madera de tortugas tipo montura y tipo cúpula son tan características que son reconocidas a miles de millas de Galápagos. A pedidos especiales Fausto hace otros animales desde pingüinos a iguanas de tierra, pero sus tortugas son particularmente apreciados tanto por los residentes de Galápagos como por los visitantes. Como persona que ha vivido cerca de las tortugas desde su niñez, y como guardaparque que ha trabajado con ellos en el campo y en cautiverio, Fausto es único en reproducir tortugas de un pedazo de madera a una pieza de arte.

LUIS RAMOS VELOZ
Jefe Proveedor, Estación Científica Charles Darwin

Luis Ramos (con respecto y cariño conocido como Don Ramos), ha trabajado para la Estación Científica Charles Darwin desde noviembre de 1971. Por muchos años ha servido como el responsable principal en la compra de alimentos, materiales, equipos, y cualquier cosa necesaria del abastacimiento local y recibiendo la carga procedente del continente.

En tiempos pasados, fue Don Ramos quien con su indispensable panga proveyó a los científicos a los barcos en el puerto con destino a otras islas, con sus materiales, y fue el quien recogió a los científicos de retorno de sus actividades. Don Ramos realizó incontables viajes en panga a través del angosto canal desde el pueblo cruzando Bahía Academy a la Estación con materiales llegados del continente en el barco de abastecimientos. Pero, a medida que los caminos mejoraron y la Estación creció Don Ramos comenzó a utilizar los vehículos de la Estación para completar sus viajes para conseguir las provisiones y repartirlas. Para Don Ramos no importa lo ocupado que se encontrase, siempre encuentra tiempo para llevar a álguien que necesita ir al pueblo o para aconsejar sobre lugares para hacer compras. Todos, desde los empleados a los visitantes, se han beneficiado de la habilidad de Don Ramos de encontrar cosas necesarias de escacez en poco tiempo, comprarlas al precio más rasonable, y de asegurar crédito cuando el dinero no fue disponible.

La ingenuidad de Don Ramos también le serve en coser, para el un hobby útil. Cuando cierres, telas, y la necesidad existe, el puede fabricar cualquier cosa desde mochilas a carpas. Don Ramos tiene la habilidad de copiar la calidad de equipos profesionales e incorporarles modificaciones especiales útiles para la situación de Galápagos. "Hecho por Ramos" no es marca de un presitigioso diseño, pero para la gente de Galápagos, es un lujo local que es disfrutado por todos quienes necesitan reparar o remplazar equipos esenciales de campo, fabricar títeres para programas de educación ambiental, remplazar las cubiertas de asiento de los vehículos, o hacer los interminables arreglos para aseguarar el bienestar de todos en la isla.

(Traducción por Aida Luz Aquino.)

FISH IN ASSOCIATION WITH WHALE SHARKS *RHINIODON TYPUS* NEAR THE GALAPAGOS ISLANDS

By: Tom Arnbom and Vassili Papastavrou

The whale shark (*Rhiniodon typus*) is the largest shark and, in fact, is the largest fish. It reaches lengths in excess of 12 m (Castro 1983). Virtually nothing is known about its life history (Wolfson 1983). Four observations of whale sharks have been recorded in the Galápagos Islands (Gudger 1927, 1933; Kasteleyn 1986; Wolfson 1986).

While tracking sperm whales (*Physeter macrocephalus*) off the Galápagos Islands, 91°00'W, 01°00'S, aboard a 10 m sloop, we sighted whale sharks on four separate occasions between 23 February and 20 April 1985 (Table 1). The observations were in an area which is seldom visited (Fig. 1). Little fishing if any is carried out in the area, and no tourist boats pass this way. Tour boats normally cruise along the coastlines. On three occasions, we observed other species of fish in close proximity to whale sharks. The encounters allowed us to make underwater observations and to take photographs.

The whale sharks were estimated to be between 10 to 12 m long by comparing their sizes to the length of the research vessel. None of the whale sharks were moving in any particular direction and their speeds were less than 3 km/hour. One whale shark circled around the stationary boat and approached it within 0.5 m several times.

The first observation was on 7 March and the other three were on 13 April. The distance and time between the second and third observations suggest that they were two different individuals. The fourth observation was of an individual with a noticeably deep cut in the trailing edge of the dorsal fin and therefore was considered to be a different individual from the second and third observations.

Whale sharks appear to prefer areas where the surface water temperatures are between 21 to 25°C with cold water of 17°C or less upwelling into it (Compagno 1984). The four observations south of Isabela Island (Fig. 1) were in an area known for its upwelling and noted for high primary productivity (Feldman et al. 1984). The recorded water surface temperatures were between 23.5 and 26.5°C.

The remoras (Escheneidae *sp.*) observed with whale sharks off the Galápagos were positioned on the dorsal side of the head, underside of the jaw, and close to the pectoral fins and the gill slits. Remoras are hitchhiking fish that attach themselves to all manner of hosts, e.g., sharks, rays, turtles, and whales (Tinker 1978). They feed upon various animals in the plankton, scraps of large food items that fall from the mouth of their host, and potentially on external parasites and feces (Tinker 1978). Numerous unidentified small teleosts (lengths < 0.2 m) were present around the mouth and gill slits of one of the whale sharks. Off the Galápagos, one whale shark was surrounded by a school of yellow-finned tuna (*Neothunnus macropterus*) with individuals approximately 0.75 m in length. Springer (1957) noted that whale sharks were feeding on small fish in the middle of schools of black-finned tuna (*Thunnus atlanticus*). Although the whale shark and the tuna species may compete for the same prey, their association may also be beneficial for both species. Foraging tuna which "herd" prey species into denser schools would benefit a whale shark which was feeding on the same prey. The prey species may be more vulnerable to tuna when the whale shark feeds and creates confusion among the prey species. However, no feeding behavior of whale sharks was observed off the Galápagos.

Two species of sharks, a tiger shark (*Galeocerdo cuvieri*) and a hammerhead shark (Sphyrnidae *sp.*), were observed within 10 m of the whale shark. The smaller sharks recorded together with the whale shark may have been attracted to the concentrations of organisms exploited by whale sharks or may just have been casual visitors. Normally, whale sharks feed on food much too small to be attractive to other large sharks. Sharks (other than whale sharks) have been reported as following sperm whales (Gambell 1970) which are of a similar size to a whale shark. Many fish of the open ocean seek protection in the vicinity of larger fish (Eibl-Eibesfeldt 1970).

While the whale shark swims at a relatively slow speed and often at the surface, it would be worth pursuing a behavioral study of the whale shark and its relationships to other species of fish. The present observations and earlier reports of sightings west of the Galápagos Islands suggest that this area may be suitable for such studies. We suggest that photographic identification of natural markings, such as spots on the whole body and the shape of the dorsal and caudal fin, could be used for individual identification of whale sharks. The techniques proposed are discussed by Arnbom (1987) with reference to sperm whales.

ACKNOWLEDGMENTS

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Table 1. Summary of the four whale shark observations off the Galápagos Islands, 1985. Surface water temperatures are extrapolated from measurements made at 3 hour intervals (0600, 0900, 1200, etc.).

Observation Number	Date	Time	Latitude	Longitude	Surface Water Temperature (°C)	Depth (m)	Other Species
1	7 March	0655	1°21'S	91°12'W	23.5	3,000	*Neothunnus macropterus*
2	13 April	1010	1°08'S	91°12'W	26.0	2,000	*Galeocerdo cuvieri*
3	13 April	1140	1°10'S	91°11'W	26.5	2,000	Sphyrnidae *sp.* Escheneidae *sp.* Other small teleosts
4	13 April	1350	1°11'S	91°11'W	26.5	2,000	- - - -

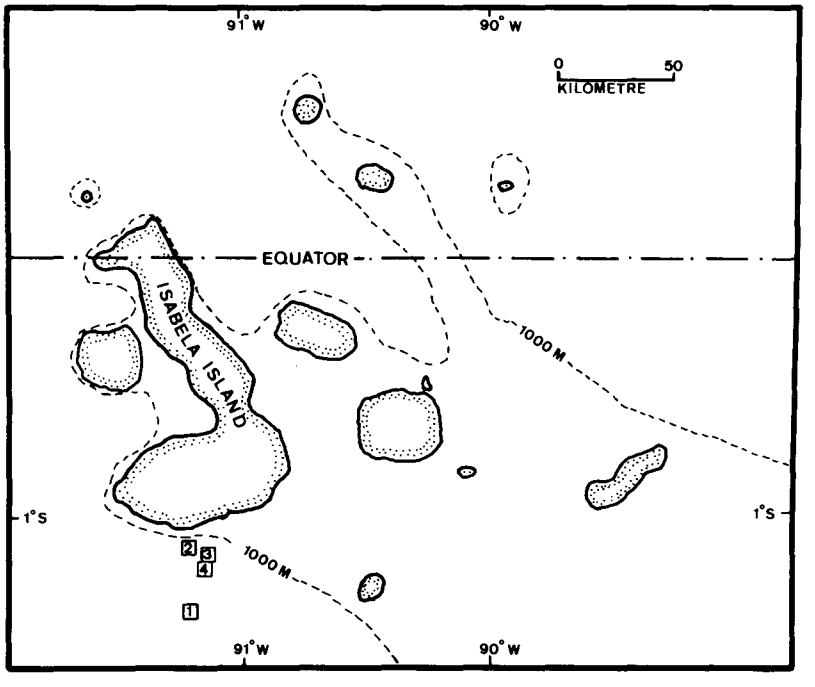

Figure 1. Isabela Island and surrounding waters where whale sharks were sighted. Numbers 1-4 indicate areas of sightings. A dashed line indicates the 1,000 m depth contour. Isla Isabela y el mar alrededor donde se vieron los tiburones ballena. Los números indican los sitios. La linea rayada representa la curva de nivel de 1,000 m profundidad.

WHERE HAVE ALL THE ALGAE GONE?

By: Gary Kendrick

The shores of Academy Bay are relatively bleak. The coastline consists of black blocks of lava devoid of life except for the equally dark marine iguanas barely visible against their background or the occasional yellow warbler feeding on insects attracted to the moisture of the sea spray at the edge of the ocean. Below the water, however, most rocky surfaces are pink with encrusting corallines, a group of red algae (Rhodophyta) which precipitates calcium carbonate ($CaCo_3$) from sea water and incorporates it into their thalli giving them a "coral-like" appearance. The pink pavement is broken by multicolored miniscule lawns or turfs of filamentous red (Rhodophyta) and green (Chlorophyta) algae. Many of these lawns are guarded by fearless black fish with a touch of yellow on their pectoral fins--the damselfish. Beware of the damselfish for they go white-faced with anger at your trespassing and may bite the unwary visitor.

Gerald Wellington described the same shore in 1975 and noted the predominance of a skirt of brown seaweeds, mainly *Blossevillea*, draping the lower tide level to a depth of 5-6 m into the subtidal. This olive band was intermixed with slashes of purple, red, brown, and pink (the red algae, *Grateloupia howeii*, *Prionitis hancocki*, and *Gracilaria subsecunda*, and the brown alga, *Padina durvilleai*). Apparently, in the period from 1975 to 1987, this characteristic band of macroscopic algae has disappeared. Wellington observed that the northernmost islands of the Archipelago (Islas Darwin, Wolf, and Genovesa) were depauperate in macroscopic algae over large areas, but these areas were characterized by encrusting corallines and algal turfs. Macroscopic algal communities were found to be restricted to southern shores of southern islands, the western shores of Isabela, and all of Fernandina. These are areas usually associated with upwelling of the Equatorial Undercurrent (Cromwell Current) during the "garúa" season. Could it be that the loss of the macroscopic algal community in Academy Bay is related to a shift in the oceanographic setting?

I noted several differences when I compared the marine flora of Academy Bay, Isla Santa Cruz, observed by Gerald Wellington during 1973 and 1974 (Wellington 1975) with my observations made in 1987 (Table 1). The number of species of bladed and macroscopically branched algae found by Gerald Wellington in 1973-74 (25 bladed and 17 branched) was double the number found in 1987 (10 bladed and 9 branched). But, three times as many species of filamentous algae were observed in 1987 as in Wellington's 1973-74 study (18 species versus 6 species, respectively). In 1987, the dominant fucoid (*Blossevillea*) had disappeared, bladed brown (*Padina spp.* and *Spatoglossum spp.*) and red algae (Cryptonemiales, Gigartinales, and Rhodonemiales) were rare; but filamentous green (*Cladophora spp.* and *Chaetomorpha spp.*), brown (*Giffordia sp.*), and red (e.g., *Ceramium spp.*, *Polysiphonia spp.*, *Audouinella spp.*) algae predominated the marine flora.

The marine benthic flora of Academy Bay in 1987 is more representative of floras found in the more tropically influenced northern islands of the Archipelago. Why is this so? Possibilities could range from human impact, long-term changes in the oceanographic setting, a result of the El Niño event of 1982-83, a reflection of the exceptionally wet and warm weather conditions of 1987, or a combination of all of the above. Where has the fucoid *Blossevillea* gone? Will it come back? In travels to Española, Floreana, and southern Isabela in 1987, no *Blossevillea* have been observed. This particular genus suffered greatly in the 1982-83 El Niño completely disappearing from many shores of the islands. That it has not recolonized infers either that Academy Bay was a transitional environment for this species before El Niño or that a change has occurred in the oceanographic conditions of Academy Bay in the extent and frequency of upwelling. Do not worry for the algae though. Such changes to the benthic flora occur seasonally in the higher temperate latitudes. As long as the more temperately-influenced benthic flora occurs somewhere on the islands (western Isabela and Fernandina), recolonization of Academy Bay will occur when the oceanographic setting shifts toward more temperate conditions.

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Table 1. Differences in the components of the marine flora of Academy Bay between 1973-74 and 1987. The predominant habit of the groups is given although there will be some overlap between bladed and branched. All orders and families are those used by Silva (1966).

Group	Habit	Number of species 1973-74	Number of species 1987
Chlorophyta			
Ulvales	bladed	2	4
Cladophorales	filament	1	3
Others	branched	3	2
Phaeophyta			
Sphacelariales	bladed	6	1
Fucales	branched	3	0
Ectocarpales	crusts and filament	0	2
Rhodophyta			
Nemaliales	branched	1	0
Gelidiales	branched	5	3
Cryptonemiales Corallinaceae	branched and crusts	5	3
Cryptonemiales other families	bladed	9	2
Gigartinales	bladed	6	3
Rhodomeniales	bladed	3	0
Ceramiales			
Dasyaceae	filament	0	1
Ceramiaceae	filament	2	9
Rhodomelaceae	filament	3	3

REVEGETATION OF THE BURNT AREA IN ISABELA

By: J. Bosco Nowak and Jonas E. Lawesson

By May 1985 after more than 3 months of intensive efforts, fire fighters were able to bring the large fire that had raged on the southern flanks of Volcán Sierra Negra on Isabela Island under control by encircling it with a firebreak more than 40 km long. Approximately 175 km^2 had been burned (Vanbeveren 1985) and isolated fires continued to smolder into June and July when they were finally extinguished naturally by rain. The fire was the largest ever registered in Galápagos and fire fighting efforts were the biggest in Ecuador's history (Adsersen and Lawesson 1985; Gara et al. 1986).

The national and international attention that was focused on the fire helped illustrate the worldwide interest in conservation of the unique Galápagos ecosystems (Anonymous 1985a, 1985b). The major preoccupation during the fire was the potential loss of the very symbol of successful conservation management in Galápagos, the giant tortoise. A number of tortoises were carried by Park wardens to areas outside the fire zone, although most Station and Park staff members considered the danger to be minimal for most of the giant tortoise populations (Márquez 1986). Nevertheless, on our regular monitoring visits to the burned area which we began shortly after the fire, we frequently found a few tortoises near the firebreak line, a clear indication that tortoise distribution and the burned area do overlap in at least a 3-5 km long line near Cerro Barahona. To date we have found no evidence that any tortoises were killed or injured by the fire.

Without a doubt, damage occurred on other ecological levels. Commencing in March 1985, multidisciplinary approaches were used to assess fire risks based on biomass and substrate (Huttel and Winckell 1985), and to assess fuel combustion rates, both qualitatively and quantitatively, in different forest types (Gara et al. 1986). Thanks to the generous help of the World Wildlife Fund, the Governments of West Germany and of Sweden, and the Danish National Science Council, it was possible to initiate three long-term studies shortly after the fire. Studies on vegetation and soil dynamics were undertaken by H. Adsersen and T. de Vries, on the invertebrate fauna by G. Onore, and on the avian fauna by M. Wilson. Under the auspices of the Charles Darwin Research Station, three students from the Catholic University of Ecuador (Pontífica Universidad Católica del Ecuador) in Quito--among them the senior author--were fortunate enough to have the opportunity of conducting research in this area for their final thesis studies. Detailed data analyses are underway and some preliminary results will be published soon (Nowak et al., in press). Only a general description of the vegetation status and dynamics during 2.5 years of post-fire regeneration can be given here.

The burned area ranges from the caldera floor of Sierra Negra (at an altitude of 900 m), over the southern rim of the caldera (at an altitude of 1,100 m), and down the flanks to an altitude of 80 m. Three main vegetation zones were affected by the fire: the Pampa Zone, the evergreen forest, and the semideciduous forest.

The uppermost zone is the treeless Pampa Zone, which extends from the summit down to 800 m altitude. Here, deep and slow-moving fires burned almost all vegetation, the organic litter, and into the soil, leaving only barren and loose reddish ash and gravel substrates. Two distinctive vegetation types distinguish this zone: the native ferns, which are presently restricted to inclined areas, and the secondary grass meadows, which were almost certainly produced by the long-term presence of introduced ungulates and previous fires and which extend onto flat areas. Reestablishment of grass meadows followed a definable pattern and occurred rather quickly. Most areas are again covered by grasses but are characterized by species not previously dominant. In the fern vegetation, the tree fern *Cyathea* and the deep-rooted bracken ferns were partially able to survive. Shortly after the fire, the bracken fern took over, due to resprouting and massive spore germination. Other ferns, however, in this naturally species-rich zone, needed more than 1 year to reappear. The time needed for complete reestablishment, particularly of endemic shrub species, is not yet known. Invasions of grasses and common guava (*Psidium guajava*), plants distributed by donkeys and cows, are severely threatening to change this vegetation type.

At middle elevations, between 250 and 800 m, the evergreen forest is mainly dominated by the introduced common guava, but also contains patches of native tree species such as *Scalesia cordata* and cat's claw (*Zanthoxylum*). Almost 90% of the guava trees were canopy-killed by the fire, but unfortunately most resprouted from the base or roots. Stimulated by heavy rains in the first part of 1987, a native climbing plant (*Ipomoea alba*) in the morning-glory family, formed a dense and suffocating carpet over large parts of the burned guava forest. Since this climber pulls down young trees, it is efficiently inhibiting guava reestablishment. During some future drought, *Ipomoea alba* will probably be killed, and the area will be as equally barren as it was after the fire, the main difference being that the guava might be

nearly eliminated. This suggests that even such "invincible" pest species as the guava have their weak points, which may be exploited in eradication efforts. Native forest species, sown or planted in an area free of introduced competition, certainly have good chances for development.

In the lower parts of the guava forest, *Trema micrantha*, a tree species which was probably introduced, proved its good pioneer capabilities in establishing a fast-growing forest in a belt over 3 km wide. Tree densities exceed 0.5 trees/m^2, with the largest specimens already 5.8 m tall having basal diameters close to 6 cm. Prior to the fire, there were only a few trees of *Trema* in this zone. Long-term studies will show if guava can survive or if it will be killed by shade under the closed canopy of *Trema*. And yet, *Trema* itself might become a severe pest species over large areas.

The status of *Scalesia cordata* changed rapidly. After an extremely successful germination and early development (seeds are probably stimulated by fire), plagues of snails and even worse plagues of butterfly and beetle larvae began in September 1986, killing trees that had attained a height of 3 m. In certain areas, mortality was complete. Thus, since almost no adult trees survived the fire, *S. cordata*, which is restricted to southern Isabela, has now lost many of its previous refuges.

The fires in the semideciduous forest within the Transition Zone were of two distinct types. In most sites, fast-running fires eliminated mainly the abundant accumulations of dry herbs and shrubs, generally permitting a high survival of the canopy. After an explosion of nitrate-stimulated herbs such as nettles, these areas recovered within 2 years. However, in forests with dense stands of the soapberry tree (*Sapindus*), there were scorching ground and crown fires. Those areas will probably not recover their majestic trees within a human's life span.

The frequency of fires has increased greatly since human colonization of southern Isabela, and fires are probably a main factor influencing long-term changes in native vegetation. Secondary grasslands are restored most rapidly, and fern vegetation is frequently invaded by grasses. Fire speeds the spread of introduced plant species, herbs and trees alike, and except for the examples noted above, fire has not significantly impeded previously established alien plants. The number of native species with specific fire adaptations is low, but the general pioneer characteristics of the Galápagos flora and vegetation highly favor their reestablishment. Nevertheless, a significant number of rare species, most of them ferns or lycopodiums, showed no or very slow regeneration during the first 2 years. Almost all burned vegetation had intermediate successional stages, with a high dominance of creeping or climbing plants. Vegetation in the process of regeneration has less stability, shows low tolerance to climatic stress, and is prone to disease.

Post-fire studies must be continued if we are to understand fully the long-term changes and the dynamics of regeneration. The data obtained should result in adequate and practical fire management strategies for Galápagos. To prevent the rapid and uncontrollable loss of natural, economic, and possibly human resources by wildfires, specialization in fire prediction, prevention, and control, as well as multi-institutional emergency plans and acquisition of fire control equipment are needed. Environmental education programs and the recent frightening experience of the Isabela fire are creating an awareness within the Galápagos population about the threat of uncontrolled fires.

This time it was probably luck that no endemic vascular plant or vertebrate species was eliminated by the fire. But, if we do not learn the lesson and act accordingly, irreplaceable losses could result in the future.

RESUMEN

El control del incendio en los flancos sur del Volcán Sierra Negra en la Isla Isabela se logró en mayo de 1985, pero quedó una área quemada de aproximadamente 175 km^2. Los daños a la población de tortugas gigantes, que eran una gran preocupación, fueron limitados. Varios efectos perjudiciales fueron analizados inmediatamente en investigaciones multidisciplinarias. Gracias a la ayuda del Fondo Mundial para la Naturaleza (WWF), de los Gobiernos de Alemania Federal y de Suecia, y del Consejo Científico de Dinamarca, pudieron financiarse tres investigaciones sobre la regeneración ecológica, realizadas por estudiantes de la Pontífica Universidad Católica del Ecuador, para la elaboración de tesis de grado.

El área quemada llega desde el fondo de la caldera de Sierra Negra (900 m), pasando por encima del borde (1,100 m), y bajando los flancos sur y oeste hasta una altitud de 80 m. Tres zonas principales fueron afectadas:

1) Los fuegos en la Zona de las Pampas (800-1,100 m) quemaron la mayor parte de la vegetación. Las Pampas de Gramineas siguieron un patrón definible de un rápido reestablecimiento. En las Pampas de Helechos, *Pteridium* alcanzó a poco tiempo del incendio alta dominancia, otros helechos colonizaron lentamente, y los arbustos faltan aun.

2) En la Zona del Bosque Siempre Verde (250-800 m), el introducido guayabo (*Psidium guajava*) mostró un 90% de mortalidad del dosel, pero una alta capacidad de retoñar de la base. La densa cobertura de la enredadera *Ipomoea alba* inhibe en grandes áreas efectivamente el reestablecimiento del guayabo, lo que podría beneficiar plantaciones de árboles nativos. En menores altitudes, la probablemente introducida *Trema micrantha* establece bosques densos (0.5 arboles/m^2) pudiendo posiblemente reprimir el guayabo, y/o volverse una nueva plaga. *Scalesia cordata* mostró una numerosa regeneración inicial, hasta que plagas produjeron una alta mortalidad.

3) En el Bosque Semideciduo (80-250 m), vegetaciones afectadas por fuegos rápidos limitados al sotobosque, regeneraron dentro de 2 años; pero áreas con alta abundancia de jaboncillo (*Sapindus*) quemaron completamente y la regeneración demorará muchos años.

Los incendios producen cambios vegetacionales a largo plazo y ayudan a la dispersión de plantas introducidas. Un alto número de plantas raras mostró ninguna o sólo baja regeneración dentro de 2 años.

Varias medidas para prevenir y controlar incendios son indispensables.

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DISTRIBUTION AND FLIGHT ACTIVITY OF CARABID BEETLES GENUS *TACHYS* IN THE GALAPAGOS ARCHIPELAGO

By: Konjev Desender, Leon Baert, and Jean-Pierre Maelfait

ABSTRACT

This preliminary report summarizes the results of recent studies of the carabid beetles belonging to the genus *Tachys* in Galápagos. In addition to the two species previously known to occur in the islands, we discovered a third as yet unidentified species on the islands of Santa Cruz and Rábida.

INTRODUCTION

Carabid beetles belong to a very species-rich beetle family, with worldwide occurrence. Recent estimates of as many as 50,000 species have been proposed (N. Stork, pers. comm.). Nevertheless, many carabids can be characterized by a more or less similar body form, whereas macromorphological adaptations would only have occurred to a lesser degree during their evolutionary history. Despite this similarity, carabids are found in virtually all terrestrial ecosystems. Many species show a very high degree of specialization in their habitat preference, which seems mainly a consequence of ecophysiological adaptations, i.e., adaptations to different microclimatological conditions. Most species are known to be carnivorous and show a pronounced soil surface activity, at least during their reproductive season. Ground beetles show much variation in their ability to disperse, making them an excellent group for evolutionary and biogegraphic studies.

Insects, and terrestrial invertebrates in general, are among the least studied organisms from the Galápagos Archipelago. The ecological knowledge of insects is especially sparse. The carabid beetles of the genus *Tachys* have been studied (Van Dyke 1953; Linsley and Usinger 1966; Reichardt 1976; Franz 1985), but few ecological data exist for these organisms (Reichardt 1976). The lack of ecological observations for these beetles may stem in part from

their small size. Adults attain a length of only 2-3 mm.

Until now only two species of *Tachys* have been recorded from the Archipelago. *Tachys beebei* Mutchler 1925 was described as a species endemic to the Galápagos, but was subsequently found to be synonymous with a previously named species, *T. vittiger* LeConte 1851, which is widespread along the western coast of the Americas (Erwin 1974). Within Galápagos, this species, now known as *T. vittiger*, has been collected using light traps on the islands of Baltra, Seymour, Santa Cruz, and Isabela (cf., Reichardt 1976). *Tachys erwini* Reichardt 1976 is endemic to the islands and is most closely related to *T. vittiger*. It is known from Fernandina and Volcán Darwin on Isabela. Little is known about the ecology of this species.

METHODS

During 1982 and subsequently in 1986, we visited the Galápagos to sample different islands for their beetle and spider faunas. Our main purpose was to contribute to the understanding of the distribution, adaptive radiation, and role of dispersal in the speciation of carabid beetles. As a preliminary step we had to consider problems of identification and taxonomy of these small organisms. During our visit in 1986, we noted abundant insect life at many sites, probably due to the heavy rains in previous months. Besides hand collecting in which we recorded capture success per unit time, we employed light traps which attracted insects to sampling stations. We also studied carabid beetles collected during previous expeditions (previously unpublished data: S. Jacquemart 1974; I. Schatz 1985).

Our samples were identified by means of the available scientific literature and reference material of the two species already known from Galápagos and especially using specimens from the Leleup Expedition deposited in the IRSNB, Brussels (Basilewsky 1968; Reichardt 1976). Table 1 summarizes all new data obtained in our study, including those from the Jacquemart and Schatz expeditions.

RESULTS

The Species and Their Distribution.-- *Tachys vittiger* and *T. erwini* are both easily recognized by the two large pale spots on both of the elytra (the hard winglike structures that cover the functional wings) and the microsculpture (pattern of sculpture only visible at higher magnification) of a very fine mesh on the elytra. The latter species is somewhat larger, and differs in the shape of midbody, especially by having less pronounced posterior angles of the pronotum.

A third species was encountered (Fig. 1) which can be distinguished from the other species by the following combination of characters: smaller in size than *T. vittiger* (mean total length of 2.015 mm versus 2.163 mm for males and 2.039 mm versus 2.282 mm for females), the presence of coarse isodiametric microsculpture evident on the elytra; head, pronotum, and elytra brownish-black without paler spots, the sides of pronotum and elytra only somewhat paler; appendages pale, except femora and penultimate segment of palp somewhat darker. We do not know yet whether this species is known from the continent or elsewhere. Further study is planned to determine if this species is new to science or is instead a species known from elsewhere but not previously known from Galápagos.

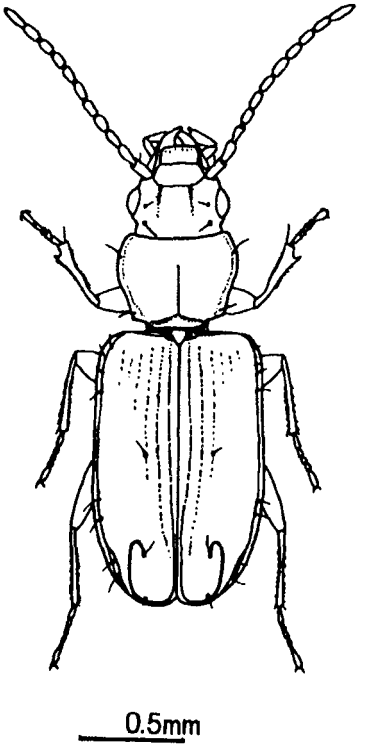

Figure 1. Dorsal view of *Tachys sp.*, an unidentified species only recently discovered in Galápagos. Vista dorsal de *Tachys sp.*, una especie recientemente descubierto en Galápagos y todavia no identifcada.

The distribution of the three species as presently known is summarized in Fig. 2. It is not clear if these beetles have not been adequately sampled in

southeastern islands or whether they are not present in this region. Perhaps preferred habitats are rare or absent on these islands. The only sites where we found *T. vittiger* and *Tachys sp.* to be abundant were near lagoons and small ponds with brackish or salty water especially in the coastal zones of the islands. On this basis we suspect that one or more species will be found in the future on Genovesa near the saline crater lake.

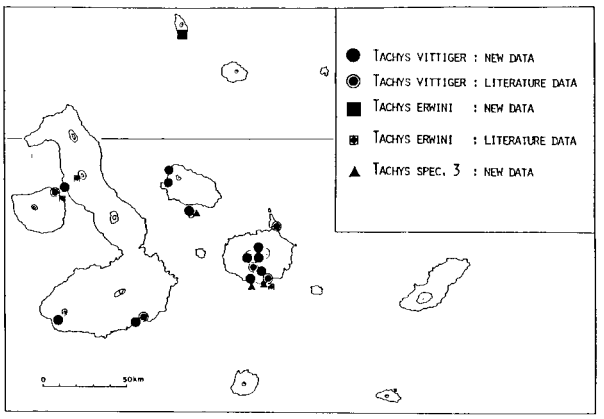

Figure 2. The distribution of *Tachys* species on the Galápagos Islands. La distribución de *Tachys* en las Islas Galápagos.

Flight Activity.--We have noted that all specimens of the three species examined to date by us have possessed large hind wings and had functional indirect flight muscles (these are the main necessary muscles involved in wing beating during flight; in other carabids these muscles can be absent or reduced to a high degree) indicating an ability to fly. We have observed each of the species in flight, but only during nighttime hours. Moreover, we observed that high numbers of beetles could be attracted to a light after heavy rain showers. At least during the warm season, beetles may avoid flight during the day due to the high temperatures and higher risk of water loss in warm dry air. On several occasions when flight was observed, temperatures were recorded to investigate possible threshold reactions of the flight activity (Table 2). Nights with temperatures around 20°C were most productive for capturing beetles in flight; nights with higher temperatures had fewer captures (Table 2). On 1 night the number of beetles caught at a light source in 30 minute intervals was simultaneously compared with the mean temperature of the air over the hours during which beetles were sampled (Fig. 3). On the basis of these data we suggest that flight activity occurs within a narrow range of temperatures at 21-24°C. This conclusion is tentative, because we do not have simultaneous data on humidity of the air, wind speed, and light levels which are other possible factors affecting flight activity of beetles. In any case the attraction of beetles to light proves their ability to orient their flight.

The tendency for insects to lose their flight ability and reduce the distances moved is well-known in island situations, and the flight ability in the diminutive carabid beetles which we found may seem paradoxical in this regard. We propose a simple explanation for this failure to lose flight. The *Tachys* beetles in Galápagos show a high degree of habitat preference for edges of brackish or saline water bodies. They were especially abundant at the borders of all salt marshes explored by us: the lagoon near Villamil and Beagle Crater on Isabela, the lagoons near Playa Espumilla and Mina de Sal on Santiago. and at Turtle Bay on Santa Cruz. The preference for such an unstable habitat that could dry out or be inundated could have serious consequences for the beetles inhabiting the Galápagos. The capacity to fly enables beetles to escape from adverse conditions. A by-product would be the potential for colonization of new areas. The ability to move over large distances by flying contributes to the possibility that one or more of these beetles is likely to occur on each Galápagos island wherever suitable habitats exist. During or after periods with optimal circumstances for flight, small numbers of beetles could be found in other habitats, not just those where the populations are most successful. This could account for observations of *T. vittiger* at higher altitudes in the Transition Zone with *Scalesia* and *Miconia* on Santa Cruz during February 1974 and Volcán Cerro Azul (at 700 m) on Isabela during February 1986. For these species, flight ability seems to be adapted to the instability of their preferred habitats.

CONCLUSIONS

As a consequence of their flight ability, populations of beetles on different islands are not completely isolated and a significant amount of gene flow may occur between relatively distant populations. Adaptive radiation into new or markedly different habitats may be less likely to occur in the face of frequent interisland movements. None of the *Tachys* species is restricted to a single volcano or island within Galápagos. This is in contrast to many other carabid beetles which have limited powers of dispersal and are quite restricted in their distributions within Galápagos (Desender et al., in prep.). Even though *T. vittiger* is the only *Tachys* species known from the South American mainland, the possibility exists that

the other two species also occur there.

ACKNOWLEDGMENTS

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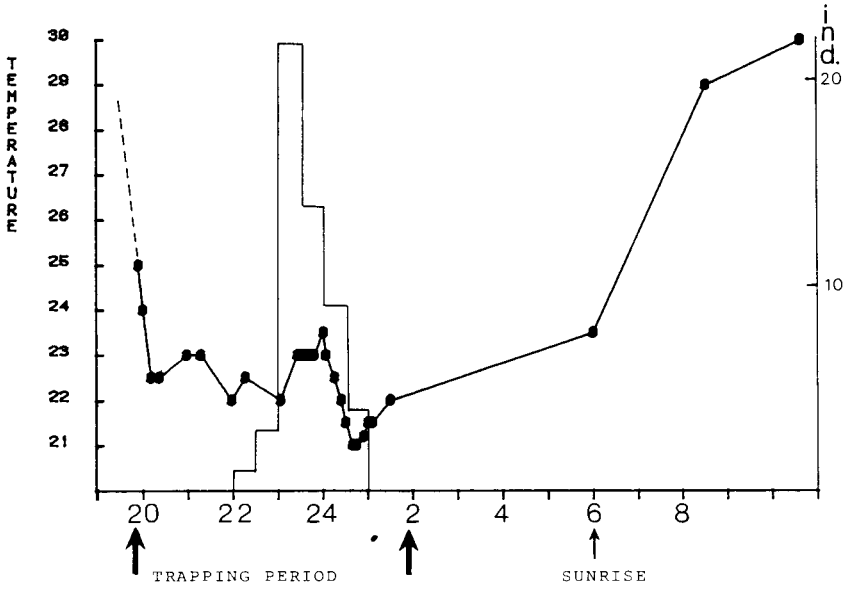

Figure 3. Observed flight activity (vertical bars) of *Tachys vittiger* in relation to mean air temperatures during 1 night in which sampling was conducted from 2000 to 0200. Note the decrease in captures when the air temperature rose above 23°C. Actividad de vuelo (baras verticales) de *Tachys vittiger* en relación al promedio de temperaturas del aire durante una noche entree 2000 y 0200. Se nota una disminución de capturas cuando la temperatura subió arriba de 23°C.

Table 1. New records of *Tachys* species in Galápagos.

Site	Date	Numbers Males/Females	Situation
T. erwini			
Pinta	03 Mar 86	0/ 1	beach zone, near light
T. vittiger			
Isabela	24 Feb 82	8/ 3	Beagle Crater
	21 Feb 86	4/ 4	lagoon, 4 km N Villamil
	21 Feb 86	18/19	lagoon, Villamil
	25 Feb 86	11/11	lagoon, Villamil
	23 Feb 86	0/ 1	Cerro Azul, 700 m
Rábida	09 Mar 86	1/ 2	lagoon
Santa Cruz	15 Jan 74	0/ 1	*Miconia* zone
	07 Feb 74	0/ 1	transition zone
	09 Feb 74	0/ 2	northern slope
	15 Feb 74	1/ 0	top of island
	20 Feb 85	1/ 0	Puerto Ayora
	28 Feb 86	1/12	Darwin Station, near light
	01 Mar 86	11/17	Darwin Station, near light
	02 Mar 86	0/ 1	Darwin Station, near light
	29 Mar 86	21/26	Darwin Station, near light
	14 Mar 86	18/27	Bahía Tortuga, near light
	15 Mar 86	14/20	Bahía Tortuga
Santiago	08 Mar 86	25/35	Mina de Sal
	08 Mar 86	18/16	Playa Espumilla lagoons
T. sp.			
Rábida	09 Mar 86	0/ 1	lagoon
Santa Cruz	15 Mar 86	5/ 5	Bahía Tortuga
	29 Mar 86	0/ 1	Darwin Station, near light

Konjev Desender and Jean-Pierre Maelfait, Laboratorium voor Oecologie, Zoogeografie en Natuurbehoud Ledeganckstraat 35, B-9000 Gent, Belgium; Leon Baert, Koninklijk Belgisch Instituut voor Natuurwetenschappen, Vautierstraat 29, B-1040 Brussels, Belgium.

Table 2. Details of flight activity observed relative to ambient air temperatures. *Specimens in this sample were not sexed.

Date	Site	Period	Temperature Range (°C)	Catch Success Males/Females
19 Mar 86	Pinta	1800-2200	23-30	*T. erwini*, 0/1
21 Mar 86	Pinta	2030-2215	24.5-27	none
28 Feb 86	Darwin Station	2200-2400	24	*T. vittiger*, 11/12
16 Mar 86	Darwin Station	1900-2230	27-28.5	none
29 Mar 86	Darwin Station	2000-0200	21-25	*T. vittiger*, 53*; *T. sp.*, 0/1
14 Mar 86	Bahía Tortuga	2030-2130	24.5-26	*T. vittiger*, 10/19
14 Mar 86	Bahía Tortuga	2130-2230	24.5-25.5	*T. vittiger*, 8/8

REVIEW: FUR SEALS, MATERNAL STRATEGIES ON LAND AND AT SEA

Edited By: Roger L. Gentry and Gerald L. Kooyman

Published 1986, 344 pages, with illustrations. Princeton University Press, 3175 Princeton Pike, Lawrenceville, New Jersey 08648, USA

Reviewed By: Hendrick N. Hoeck

In 1986 two outstanding books on Galápagos species were published by Princeton University Press. One is Peter Grant's *Ecology and Evolution of Darwin's Finches* (reviewed elsewhere in this issue) and the other, which is reviewed here, is *Fur Seals, Maternal Strategies on Land and at Sea* in which Fritz Trillmich and his associates present in five chapters the results of their 10 years of research on the behavioral ecology of Galápagos fur seals and sea lions.

In mammals, the females bear almost all the cost of rearing the young. The long gestation and postnatal period up to weaning is energetically very costly. The mother/offspring group is therefore the key unit for understanding the social organization in mammals.

The overall allocation of maternal energy resources can be divided into several categories such as foraging and travel costs, energy spent for avoiding predators, energy loss due to parasites and diseases, and finally milk production and maintenance metabolism. The pattern of energy allocation to these categories has evolved in response to environmental pressures balanced against physiological limitations.

The book tells the fascinating story of how females of six different species of Otariids, living in Galápagos under tropical conditions and in the Arctic and Antarctic under subpolar conditions, manage to raise a maximum number of offspring. Fourteen scientists (all experts and some with years of field experience) give a detailed account of the behavioral ecology of Northern, Antarctic, South African, South American, and Galápagos fur seals and Galápagos sea lions.

Of the 15 chapters, the first gives an overview of the evolutionary history of the species studied and a brief description of their systematics, distribution, and biology. The second chapter deals with methods. Chapters 3, 6, 8, 10, 11, and 13 describe the attendance behavior of each species, while Chapters 4, 5, 7, 9, 10, 12, and 14 describe the feeding and diving behavior of the six species and the free ranging energetics of the Northern fur seals. In the last and most important chapter, nine authors integrate the results and draw conclusions.

The Northern fur seal and the Antarctic fur seal occur in the subpolar regions where there are extreme cold temperatures but predictable seasonal changes. In contrast, the Galápagos fur seal and sea lion live on the Equator, where the seasonal changes are less profound but are highly unpredictable. Between these environmental extremes a fur seal mother has to adapt in order to produce a maximum number of young. The different options and strategies that fur seal females use are presented.

The authors not only applied conventional methods of data acquisition but successfully used new technologies as well. Isotopic tracers, for example, were used to measure the amount of energy flow from the lactating mother to the pup. Milk was analyzed during different lactation periods for protein, fat, and water content. A Time-Depth-Recorder (TDR) that was specifically developed to record parameters of diving physiology and feeding ecology of fur seals was effectively placed on individual females.

The results for the two subpolar and the two tropical species show the different strategies for raising pups. Northern and Antarctic fur seals have highly synchronous pupping seasons and short weaning periods of about 4 months. During lactation the mothers undertake relatively few feeding trips, each of medium to long duration and alternating with attendance periods of 2 days with the pups. In contrast, the Galápagos fur seal and sea lion show a long synchronization in pupping, and the rearing period is prolonged to such an extent that consecutive offspring are simultaneously nursed by the mother. The females' feeding trips and the periods spent attending pups are seldom longer than 1 day.

Despite these differences in the attendance patterns, the pup growth rates of all six species are similar. The median doubling time for birth weight is about 66 days, and the initial growth rates are similar too. Therefore, the major differences lie not in the pup growth but rather in the weaning time and in varying milk composition. The fat content in the Northern and the Antarctic fur seals is rich (47% and 40%, respectively) whereas in the Galápagos fur seal and sea lion it is lower (25% and 18%, respectively).

The pups of the subpolar species have a well-developed fat layer: they molt into their adult pelage at an age of 3 months, and a month later they are prepared for nutritional independence. In contrast, pups of the Galápagos fur seals have few fat reserves, start molting at 4 months, and begin independent feeding at an age of 10-12 months.

The fasting abilities of both Galápagos species are only 1.5-3 days between mothers' visits, whereas the pups of both subpolar species must fast for 4-7 days between feedings. At the weaning age of 18 months, they are as advanced in their development as a Northern fur seal pup at 4 months. At weaning, the pups of the subpolar species have additional fat reserves for the postweaning period, which help them while gaining feeding experience. In contrast, the Galápagos fur seal at weaning has a considerable amount of open-water feeding experience with few additional fat reserves.

The data obtained with the TDR were very interesting for behavioral and physiological conclusions. The diving behavior of all fur seal species is similar; diving occurs mainly during nighttime hours. Most diving is done to about 30 m; however, the animals can reach a depth of over 100 m. Calculations indicate that 200 m would be near the physiological limit for fur seals and sea lions because oxygen consumption would reduce arterial oxygen to a critical level.

Across species there is also a clear difference in the foraging ranges. The subpolar seals range over 200 km from shore whereas the tropical species forage within 75 km of shore. Unfortunately, it is difficult to interpret most diving patterns because the authors have very few data on the behavioral patterns of the prey exploited by fur seals and sea lions. Only for the Antarctic fur seal, a feeding specialist, is the behavior of the prey species known.

Another interesting comparison is developed in Chapter 14 which deals with the question of the ecological separation between the sympatrically occurring Galápagos fur seal and the sea lion. The Galápagos fur seal is the smallest fur seal and one of the smallest marine mammals. Adult males weigh 70 kg and females weigh about 35 kg. They feed during the night and most dives are in depths shallower than 30 m. This diving habit probably reflects the most common depths of squids, the fur seals' main food resource. The Galápagos sea lion primarily dives during the day, thus avoiding many thermoregulatory problems on land. The data show that the sea lion reaches greater depths than the fur seal, but both species are equally successful in capturing prey.

The most complete and substantiated information is available for the two tropical and subpolar species. The data on the attendance behavior and diving behavior of the South African (Chapters 8 and 9) and the South American (Chapter 10) fur seals are limited. The South African species, the largest of the fur seals, is very shy and only two females could be fitted with the TDR. The South American fur seal was studied during the strongest "El Niño/Southern Oscillation" (meteorological and oceanographic phenomena) in over 100 years and only one female was observed.

This book is one of the best and most complete comparative studies on the maternal behavior of species living under different environmental conditions. Because of its clarity, the application of new technologies in field studies, and the well-organized format, with each chapter having its own introduction and summary, this book is a must not only for biologists interested in mammals but also as an exemplary study for biology students and laymen interested in behavioral ecology, marine biology, and physiology.

This book and Peter Grant's book on finches show the importance of long-term field research. Such

research not only has academic value in understanding the evolution of the organisms' differing environments but, in addition, clearly presents the responses of individual species to environmental changes from year to year. The latter aspect is important for conservation. It is hoped that these and other long-term projects will continue in Galápagos.

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REVIEW: ECOLOGY AND EVOLUTION OF DARWIN'S FINCHES

Authored By: Peter R. Grant

Published 1986, xiv + 458 pages, 101 figures, 24 tables, 63 plates including 8 in color, US - $55.00 cloth, $22.50 paper; UK - £36.70 cloth, £15.10 paper. Princeton University Press, 3175 Princeton Pike, Lawrenceville, New Jersey 08648, USA

Reviewed By: Peter T. Boag

John Wiens (1984, Auk 101:202-203) commented recently on the importance of long-term studies of avian populations, concluding that for many purposes "a long-term approach that spans the periodicity of the normal dynamics of the system is essential." Peter Grant's sweeping synthesis of more than 12 years of fieldwork on Darwin's finches in the Galápagos provides us with an excellent illustration of the merits of extended field studies. This volume is a state-of-the-art synthesis of past and present research on a group of birds that has become a paradigm of the evolutionary process.

In 16 chapters, Grant not only summarizes his group's research on the ground finches (Genus *Geospiza*), but also provides up-to-date detail on the other, lesser known finches. Aspects of the Galápagos environment ranging from geology, climate, and vegetation to the history of scientific research in the islands are included. Complementing the text are plates, which include 117 black-and-white and 24 color photographs. The photographs not only illustrate inter- and intraspecific morphological variation in the finches, but also vividly describe study techniques, the effects of El Niño rains on vegetation, unusual feeding behaviors, and some of the important food plants for the birds.

The book begins with a description of how the project began and with a brief history of the study of Darwin's finches. Grant sets himself the task of explaining "why so many different types of species have arisen, and why they vary so much in form, function, and behavior." Two chapters then set the stage by summarizing first the general characteristics of the islands, and next, the general characteristics and distributions of the finches.

The meat of the book follows in six chapters which detail the data collected by Grant and his colleagues since 1973. The results of over 60 scientific papers produced by the group in this time are described and integrated, with many of the original figures and tables reproduced or elaborated upon. Two technical chapters provide an overview of morphological variation in the finches, as well as statistical methods for dealing with both adult morphological patterns and the ontogeny of morphology. Chapter 6 examines the relations between beak morphology and diet, as well as dietary differences within and between species. Chapter 7 follows with a detailed look at the links between food supplies and finch population dynamics, arguing that food is often a limiting resource, and hence a driving force behind the evolution of specific feeding structures and behaviors.

Chapter 8 presents the genetic data now available for Darwin's finches, with an emphasis on the quantitative genetics of morphological characters, and the relationship between heritabilities and the response to natural selection in times of food stress. A major theme is the search for reasons why many *Geospiza* populations are so variable. This chapter also attempts to unravel the mechanisms of natural and sexual selection which are responsible for the observed population means and levels of sexual dimorphism.

The final data chapter looks at mating behavior. There is good evidence that reproductive isolating mechanisms are based on both morphology and song. However, considerable flexibility in species-recognition behavior seems to exist, with some cases of hybridization known, and several instances of misimprinting during song development.

In the following four chapters, Grant turns his attention to interpretation of this wealth of data. He first examines various models for the evolution of finch species, and then compares the relative importance of allopatric divergence on ecologically diverse islands with competition in sympatric situations in the evolution of finch communities. The patterns are complex, and the paucity of fossils or other historical data complicates their interpretation. However, the main conclusion is that during speciation, the finches appear to have adapted both to direct changes in their physical environment and to indirect changes caused by competitors. The effects of competition are most evident in the large scale patterns seen at the community level. The evolution of reproductive isolating mechanisms is dealt with briefly. Two interesting findings emerge; first, the

evidence suggests that most reproductive character displacement probably occurred as a correlated response to ecological character displacement. However, there is also evidence that reproductive absorption of some immigrant populations may occur, and such effects may combine with ecological competition in the development of distinctive island finch communities.

After dealing with the adaptive evolution of features other than trophic morphology, Grant reconstructs the most likely scenario for the evolution of this monophyletic group. He then summarizes the key results of earlier chapters and presents a brief extension and comparison of the findings with other taxa. The main message is that "the allopatric model of gradual genetic change links Darwin's Finch evolution with the radiations of many other groups of organisms as the most probable, general mode of speciation." He concludes with a warning that understanding a complex evolutionary radiation requires knowledge in a broad range of areas. In the finches, as in other examples, there tends to be an uneven distribution of knowledge in areas such as morphology, behavior, ecology, and genetics. Scientists working on different evolutionary radiations are rarely able to cover all these facets of their species in depth and tend to emphasize the importance of those aspects they know best. In Darwin's finches for instance, there is obviously much to be learned about the ecology of the tree finches, and for all the species further paleontological and biochemical research may help describe the sequence and time-scale of divergence between populations.

The book is attractive and well produced, with few typographical errors. In addition to the general summary in the final chapter, each chapter contains a complete summary of its own. Couple this with a carefully constructed Table of Contents, an abundance of subheadings, and comprehensive author and subject indices, and the result is very easy and quick retrieval of information. The bibliography, with more than 300 references, is the most complete available on avian evolution, ecology, and behavior for the Galápagos.

The focus of the book is a complete summary of Darwin's finch biology. Grant has not belabored the theoretical or epistomological implications of his study. Indeed, the real strength of the work is that it brings together in one place what has grown to be an increasingly large and specialized literature. This clearly written overview will be of interest to a wide range of readers, including scientists specializing in avian and evolutionary biology, as well as amateur naturalists interested in learning more about this fascinating group of birds.

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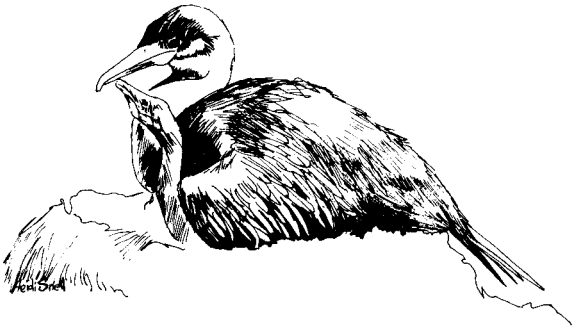

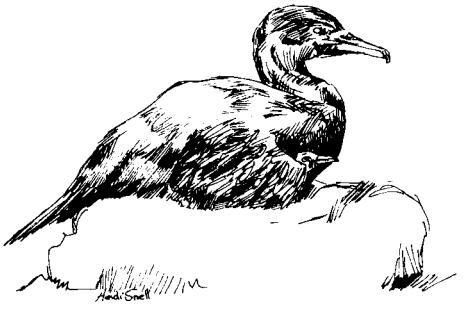

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