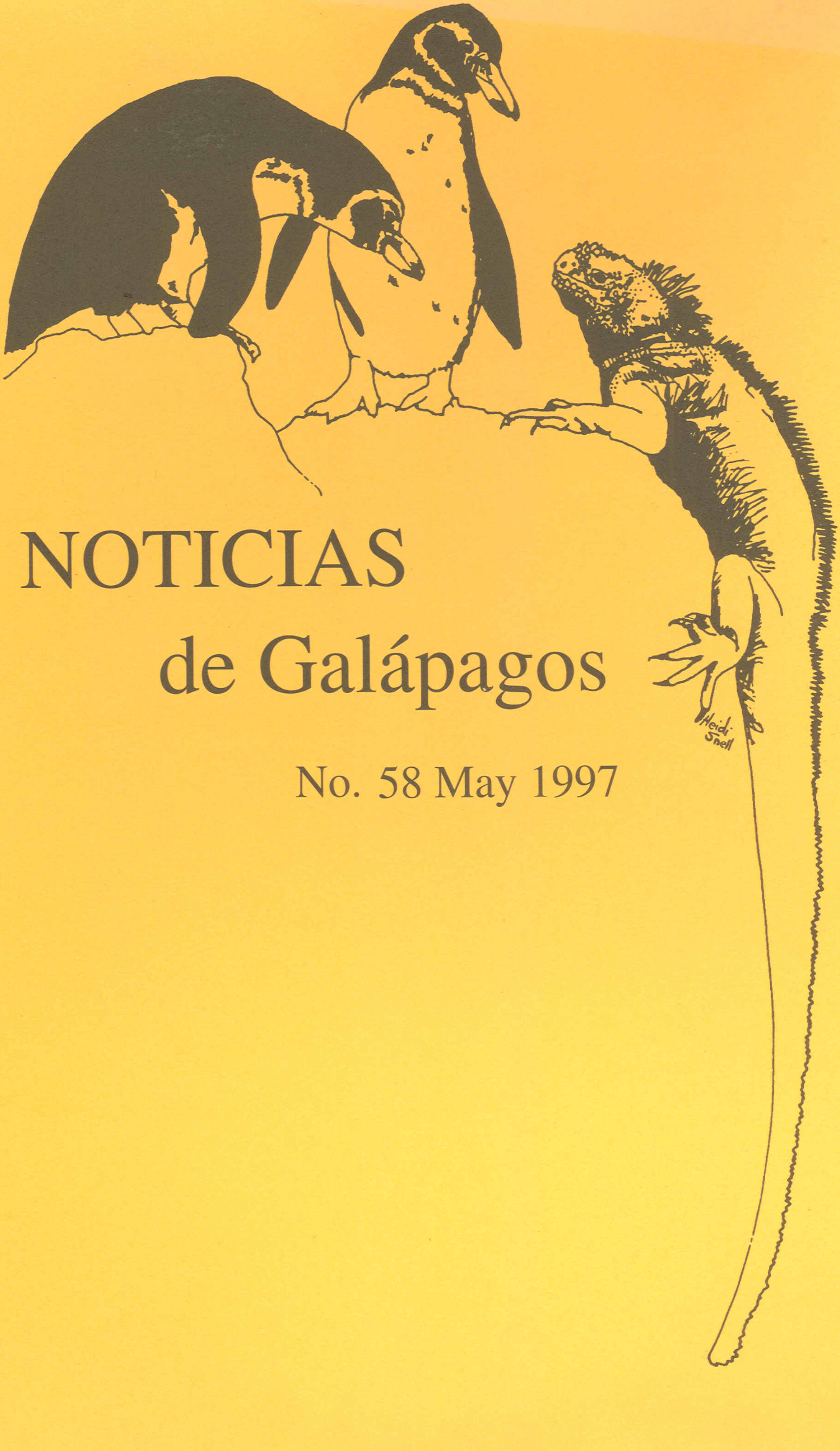

NOTICIAS de Galápagos

No. 58 May 1997

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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 state 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.

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We are grateful for your steadfast support and help.

NOTICIAS DE GALÁPAGOS

A Publication about Science and Conservation in the Galápagos Islands, the Galápagos National Park Service, and the Charles Darwin Foundation

No. 58 May 1997

Contents

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CHARLES DARWIN FOUNDATION for the Galápagos Islands

Editor: Howard L. Snell, Biology Department, University of New Mexico, Albuquerque, New Mexico 87131, USA; snell@mail.unm.edu; (505) 277-3411

Associate Editor: Thomas H. Fritts, Noticias de Galápagos, National Museum of Natural History, Washington, DC 20560, USA; 72370.1207@-compuserve.com; (202) 357-1930

Editorial Assistant: Heidi M. Snell, *R/V Prima*, c/o Estación Científica Charles Darwin, Puerto Ayora, Isla Santa Cruz, Galápagos, Ecuador; hsnell@fcdarwin.org.ec; (5) 526-147

NEWS FROM ACADEMY BAY

SEA CUCUMBER FISHING BOAT CAPTURED

A recent control operation within the Biological Reserve of Marine Resources of Galapágos was successful. On Sunday, 2 March 1997, an overflight was conducted by the Acting Director of the Galapágos National Park Service (GNPS), Edgar Vargas, confirmed the presence of an illegal camp on northern Isabela and several small boats carrying out suspicious activities.

With this background, and in coordination with the Port Captain of Puerto Ayora, the GNPS launch *Guadalupe River* left Puerto Ayora with Park and Navy personnel on board. On 4 March, a camp was found on western Isla Isabela with 5,000 dried sea cucumbers. Personnel proceeded to confiscate various elements that serve in the processing of sea cucumbers and also cleaned all the garbage that was found at the site. The people in the camp managed to escape upon hearing the sound of the launch *Guadalupe River*.

On 5 March, another camp, this one with 22,000 dried sea cucumbers, was found on the northwestern coast of Isla Fernandina, where the same procedure of confiscation and cleaning was carried out. On 6 March, at 15:30, during a voyage along the western coast of Isla Isabela, the launch *Guadalupe River* encountered the boat named *Magdalena*, with documentation number CN-02-0594, from Guayaquil. The boat was boarded by personnel from the Port Authority of Puerto Ayora, who found in the interior 25 sacks of dried sea cucumbers containing approximately 30,000 individuals. At present, this boat is detained by the Port Authority of Puerto Ayora, where it will receive the corresponding sanction. It is presumed that this is one of the boats that periodically makes clandestine trips between the continent and the Galapágos Islands to transport the illegally fished sea cucumbers.

It is worth mentioning that, since 1994, the exploitation of sea cucumbers in Galapágos has been prohibited, because this species is an integral part of the marine ecosystems and its exploitation could cause damage to the fragile insular biodiversity.

Edgar Vargas, translated by Gayle Davis-Merlen

PARK WARDEN WOUNDED BY BULLET IN CONFRONTATION BETWEEN ILLEGAL SEA CUCUMBER FISHERMEN AND PATROL PERSONNEL OF THE GALÁPAGOS NATIONAL PARK

Julio Lopez, crew member in the Galápagos National Park Service (GNPS), became the first victim in the fight against illegal fishing in the Archipelago. Julio was seriously wounded in the abdomen by shots fired from an illegal camp of sea cucumber fishermen on western Isla Isabela.

The incident occurred on Wednesday, 19 March 1997, at approximately 3:00 in the afternoon (15:00), when a group of crew members and park wardens from the GNPS patrol boat *Belle Vie*, went to inspect an illegal camp detected during an aerial reconnaissance of the zone around Bahía Urvina, on the western coast of Isla Isabela. Upon attempting to disembark, the group was surprised by approximately 20 heavily armed men who were involved in processing sea cucumbers, which is prohibited by law, and who opened fire on the members of the Park Service, wounding one crew member in the abdomen. The wounded man was picked up by a helicopter belonging to a boat that was nearby and was taken to the hospital in the Second Naval Zone on Isla San Cristóbal.

Additionally, during the same aerial reconnaissance, various illegal camps of fishermen taking sea cucumbers and shark fins were detected, which prompted the dispatch of the GNPS patrol launch *Guadalupe River* to dismantle these camps. Once informed of the incident, the Second Naval Zone immediately dispatched a coast guard launch to help in the work of the Park's patrol boats.

The GNPS emphatically denounces this violent escalation against the actions to protect the resources of the Archipelago, and it announces that it will not tolerate any type of intimidation or aggression against its functionaries. Similarly, it makes an emphatic appeal to the National Government to offer the help necessary to protect the integrity of those who undertake the work of control and surveillance in the Archipelago.

Eliecer Cruz, translated by Gayle Davis-Merlen

PEACEFUL DEMONSTRATION TO REJECT VIOLENCE IN GALÁPAGOS

In rejection of the recent acts of vandalism that have occurred in the Archipelago, performed by a group of people dedicated to illegal fishing, the Galápagos National Park Service conducted a march to demonstrate solidarity with the park wardens who are in charge of controlling illegal fishing and, in particular, the park warden who was wounded by a gunshot during a recent patrol made to the western side of Isla Isabela.

More than 300 people joined the march, including representatives of the civilian society and of distinct unions and Galápagos institutions such as the Municipality of Santa Cruz, the Fishing Cooperative, I.E.S.S. (Ecuadorian Social Security Institution), Tourism Operators, the Charles Darwin Research Station, and Agriculture Department, among others.

For the Galápagos National Park, the support given by the entire Galápagos community through their participation in this demonstration is important. Of particular importance was the participation by the fishing cooperative, whose members expressed their backing of this institution and condemnation of the violent acts perpetrated by certain groups on Isla Isabela. They stated that those responsible do not belong to any of the three fishing cooperatives in the Archipelago. In addition, placards were carried during the march that expressed support for the injured park warden, Julio Lopez, and indicated that the entire community is concerned for the health of this galapagueño.

Park warden Julio Lopez has undergone two operations and he is on the road to a prompt recovery. He was transported and cared for in a clinic in Guayaquil and, after his complete recovery, will return to Galápagos to take up once again the work of protecting the insular ecosystems.

The Galápagos National Park Service, through its Office of the Director, has already initiated contact with the maximum governmental authorities in order to receive the protection necessary to continue the work of controlling the illegal fishery and to prevent, by this means, the occurrence of new acts of violence that endanger the lives of park wardens.

Eliecer Cruz, translated by Gayle Davis-Merlen

CONFLICT IN THE GALÁPAGOS BIOLOGICAL RESERVE FOR MARINE RESOURCES, A STATEMENT BY THE PRESIDENT OF THE CHARLES DARWIN FOUNDATION

The Charles Darwin Foundation for the Galápagos Islands wishes to comment on the serious incidents that have taken place in the Biological Reserve of Marine Resources of Galápagos. The Galápagos National Park Service has issued several press bulletins in which these incidents have been reported. The incidents culminated in an armed attack on officials of the Galápagos National Park by illegal fishermen, resulting in one park warden seriously injured, as well as threats of retaliation against Park personnel for the capture of the boat *Magdalena*, which was transporting products from illegal fisheries.

The Charles Darwin Foundation supports the actions of the National Park Service and condemns the armed attack and the threats against that institution and its personnel. The Foundation calls upon the Ecuadorian Government to take a strong position in defense of the Biological Reserve of Marine Resources with regard to the types of fishing that are prohibited in the Reserve, above all industrial fishing, fishing for sea cucumbers, and fishing for sharks.

The Charles Darwin Foundation also joins the Park in its position that the aggressive actions of this month have been provoked by a minority of citizens, who are dedicated to illegal fishing, many of whom have come to the Islands in recent years specifically to fish for sea cucumbers. The Foundation wishes to point out that it is aware that the great majority of the local fishermen and the population of Galápagos reject these violent actions and support the efforts of the National Park to conserve the Biological Reserve. The fishing cooperatives of Galápagos have often shown their respect and constant cooperation with the authorities of the National Park.

The Charles Darwin Foundation will not permit these problems to deflect it and its operative arm, the Charles Darwin Research Station, from positive actions to achieve better cooperation with the people of Galápagos on behalf of the conservation of the Islands.

The conservation of the ecosystem of Galápagos depends on the protection of the Biological Reserve of Marine Resources. In the face of serious threats from industrial fishing and fishing for sea cucumbers and sharks, it is indispensable that the Galápagos National Park be supported strongly by all authorities. The Charles Darwin Foundation requests urgent action to control the present situation, as well as long-term strengthening of the National Park, to guarantee the future of the Archipelago.

Jorge Anhalzer, translated by Gayle Davis-Merlen

REDISCOVERY OF AN "EXTINCT" ENDEMIC PLANT - THE FLOREANA FLAX *LINUM CRATERICOLA*

On 16 April 1997, two scientists from the Charles Darwin Research Station (CDRS) discovered a tiny population of the Floreana Flax *Linum cratericola*, after 16 years with no recorded observation of the species.

The plant was first discovered in two neighboring extinct volcanic craters on Floreana Island by the botanist Uno Eliasson, in December 1966. It was found again, in one of the same sites, in 1981. It has not been found anywhere else on Floreana, and there is no record of it on any other island in the Galápagos. Neither had it ever been seen since, despite repeated searches of the original localities and similar sites on Floreana, by botanists of the CDRS during the 1990s. Some considered that, given the effort that had been spent searching for it, the species must have gone extinct: the areas where it occurred have been badly damaged by introduced feral donkeys and goats, and one of the two known sites has been heavily invaded by the introduced pest bush "Curse of India" *Lantana camara*.

On the fifth search by CDRS botanists, and equipped with detailed notes supplied by Eliasson, the original sites of discovery were visited again by Alan Tye and Sarah Wilkinson. Even though both sites had been searched fruitlessly several times before, there was still the faint hope that the plant might survive.

In the first site described by Eliasson, where the species was still present in 1981, the crater rim was now found to be almost covered by a dense growth of *Lantana*, and in the few suitable remaining spots, no trace of the *Linum* was found. There was evidence there too of the presence of the introduced herbivores.

The team then visited the second crater, where Eliasson last saw the species in 1966, and searched the area described by him, as thoroughly as the difficult terrain permitted. As they were transiting in parallel along the crater wall, Alan Tye spotted a small, bright green plant that was immediately obvious as matching the specimens in the CDRS Herbarium. A closer examination of the area by the two researchers revealed thirteen plants of the Floreana Flax, only eight of them adult, in a tiny area of two square meters (18 square feet). Searches of similar habitat patches nearby revealed no additional plants.

The excitement of this discovery was tinged with worry. The plant, although not yet extinct, is obviously on the brink. The single site was by a pathway used by introduced animals, and the largest Flax plant was hidden within the stems of a bush, suggesting that the goats and donkeys eat the unprotected individuals. There are also *Lantana* bushes at the site, as well as other introduced plants. The two researchers left the crater, after making a thorough description, with the depressing thought that they could be the last people to see the species alive.

In conjunction with the Galápagos National Park Service, the CDRS is now formulating plans for the protection of this tiny population, and for its eventual reintroduction to other former sites. With rapid concerted action, the species might yet be saved.

Alan Tye

THE ARRIVAL OF MAREK'S DISEASE TO GALÁPAGOS

During the end of 1995 and the beginning of 1996 a breakout of an avian plague called Marek's Disease was reported for the first time in the Galápagos archipelago, specifically on Isla San Cristóbal. Immediate precautions were taken to diminish the dispersion of the sickness to other islands. Intially the precautions appeared successful and the disease was not reported anywhere else in the archipelago. Unfortunately, in October of 1996, the same disease was reported for the first time on Isla Santa Cruz. During October and November approximately 800 chickens from various farms died in the highland agriculture zone of Isla Santa Cruz.

Figure 1. Chicken with Marek's Diease. The right leg is paralyzed. Photograph by Heranán Vargas.

An analysis of two of the sick chickens collected from a farm in Bellavista and sent to Quito by the Dirección Provincial Agropecuaria (DPA) proved positive for Marek's Disease. The analysis was done by the Ecuadorian Animal Health Service (Servicio Ecuatoriano de Sanidad Animal - SESA). The analysis of the samples also indicated the presence of other diseases, *Salmonella pollorum*, *Mycoplasma gallisepticum* and parasites (ascarids and eggs of *Heterakis* [pinworms]). Of these diseases the most dangerous is Marek's, which has caused the loss of millions of dollars for the poultry industry worldwide.

Marek's Disease is caused by a herpes virus and is highly contagious and easily transmitted among chickens. The virus can live in the feathers of the fowl where it produces a type of feather dandruff that can disperse by wind and air currents. The disease is also spread by direct contact and through contaminated food.

Fowl which have contracted Marek's Disease will often demonstrate the following symptoms: paralysis of a foot or wing (Figure 1), poor vision to total blindness, enlarged feather follicles, and trembling. Sometimes these symptoms may not be obvious and affected birds may only show depression prior to death. Marek's Disease, as well as the other diseases registered, possibly arrived from continental Ecuador on fighting cocks and/or eggs for incubation and human consumption.

Apparently a vaccine would not help in this case to control the spread of the disease because the vaccinated fowl still remains a carrier for the virus. The immune fowl could continue to pass the infectious virus on to other birds even though it would not suffer symptoms of the disease.

Because of the intensity of the outbreak on Isla Santa Cruz, the Charles Darwin Research Station (CDRS) has begun an investigation to determine the state of health of the native birds and the potential impact of introduced avian plagues. Preliminary observations indicate that two of the endemic species of ground finches (*Geospiza fortis* and *Geospiza fuliginosa*) are possibly the most susceptible to introduced avian diseases since they are the birds most often seen feeding alongside chickens and other introduced fowl. There has been one report by a farmer who observed some weak finches, but there has not been any positive evidence that the finches or other native birds have been fatally infected, although one rancher informed authorities of the death of four anis (*Crotophaga ani*), an introduced bird, in an area where there were diseased chickens, but the cause of death is uncertain.

The member institutions of the Quarantine Committee of Galápagos have taken various measures to prevent the dispersion of the disease to other islands such as Isla Isabela and Isla Floreana, where humans live and maintain populations of introduced fowl, but no sign of the disease has been reported. The Committee has made the following recommendations to avoid the further spread of the disease and possibly eradicate it where it exists:

1. Advise the ranchers of the quarantine methods. Quarantine Committee members have visited the farms and members of the DPA have remained in frequent contact with the farmers. It has been recommended to the farmers that once Marek's Disease is detected they should immediately sacrifice all the chickens, then burn or bury them and disinfect the area thoroughly.
2. Make the local community conscientious of the immediate necessity to implement a quarantine system in Galápagos. The CDRS, Servicio Parque Nacional Galápagos (SPNG) and the DPA have informed communities, by each of their respective radio programs, about the diseases which are being brought in and spread. It was also recommended that a video be made about Marek's Disease for community viewing.
3. Mandate ordinances associated with the quarantine. The Municipality of Santa Cruz is drawing up an ordinance to control and prohibit the keeping of domestic animals in the town of Puerto Ayora. This ordinance will permit the control of diseases by the eradication of chickens, fighting cocks, domestic pigeons, and other introduced animals which are a reservoir of diseases.

Unfortunately politics played a role contrary to conservation, and the largest flock of diseased chickens was never destroyed as recommended. This action demonstrates to us that much must be done to convince people about the mechanisms for disease control for the sake of economics and conservation.

The following is a summary of the avian diseases which have now been noted in Galápagos: Marek's, *Salmonella pollorum*, *Mycoplasma gallisepticum*, Newcastle's, Gumburo (or infectious bursal disease), infectious bronchitis, *Trichomonas gallinae* and avian pox. *T. gallinae* has been detected in native doves and the avian pox has affected various species of native terrestrial birds, most notably the endemic mockingbirds and Darwin's finches.

Avian diseases do not solely affect the economics of the farmers, but threaten the very biological diversity of the entire archipelago. We must join forces and implement a quarantine system for Galápagos and curtail these disastrous introductions.

Hernan Vargas and Heidi M. Snell

MORTALITY OF GIANT TORTOISES AT EL CHATO, ISLA SANTA CRUZ

The Government of Ecuador, through the Galápagos National Park Service (GNPS), in conjunction with the Charles Darwin Foundation (CDF), have undertaken research and management over the past thirty years to protect the giant tortoises of Galápagos. These efforts have been successful and, through the Program of Captive Rearing and Repatriation, have saved ten of the eleven threatened populations of giant tortoises; the exception is the race from Isla Pinta, from which the only remaining individual is the famous Lonesome George. Nevertheless, there are very serious new problems facing certain populations.

At the end of July and beginning of August 1996, reports were received of dead tortoises in the area of "El Chato," a visitor site in the Galápagos National Park (GNP) near the farms of Salasaca in the highlands of Isla Santa Cruz. Immediately, personnel of the GNPS, the Charles Darwin Research Station (CDRS), and the Provincial Agriculture Department (DPA) made trips to the site to perform an exhaustive search for dead or sick tortoises. During the first month of work, nine dead and eleven sick tortoises were found. Although individual dead tortoises have been observed over the years on all the islands, this is the first time that so many have been found in such a small area.

Unfortunately, nowhere in the world is there the necessary knowledge to resolve the problem within a short time. In general, there are very few studies on wild tortoises related to problems of health, nutrition, or of mortality due to unknown causes. The available information about the evaluation and diagnosis of reptile diseases is principally the result of work with animals in captivity.

To ensure that the efforts to study and manage the situation would be successful, immediate contact was made with two veterinarians in the United States who have considerable experience with tortoises and who have collaborated with the GNPS and the CDF in the past. Dr. Elliott Jacobson, of the University of Florida in Gainesville, is the world expert on tortoise diseases. Dr. Joseph Flanagan is the head veterinarian of the Houston Zoo in Texas.

A team was assembled to study and manage the problem *in situ*, directed by Dr. Linda Cayot, Head of Research for the Protection of Native Animals of the Charles Darwin Research Station (CDRS), Agronomist Sixto Naranjo, Head of Protection of the GNPS, and Dr. Edison Encalada, veterinarian. El Chato and adjacent areas were searched to determine the distribution of dead, ailing, and healthy tortoises. After an intensive search in various zones with different ecological conditions, dead and sick tortoises were found only in El Chato and further work focused on that area.

In El Chato, nine dead and eleven sick tortoises were found. During that period more than fifty healthy tortoises were also in the area. Samples were taken of blood and, whenever possible, of feces from sick and healthy tortoises from there and from tortoises found in other parts of Isla Santa Cruz. Necropsies were conducted on two dead tortoises and tissue samples were collected from all the principle organs. All the samples were sent to Dr. Jacobson for analysis in Florida.

Environmental conditions in the area are being studied. Samples were taken of the water in the main pond of El Chato. The results of toxicological analyses were negative; the results of bacteriological analyses indicated the presence of coliform bacteria, of anaerobic bacteria, and of fungus. Studies of the area and of tortoise feces indicated that the diet of the tortoises has changed. Some are feeding almost entirely on the fruit of an introduced plant "maracuya," a passionfruit (*Passiflora edulis*). An experiment is planned to study the effect of this change in diet.

To eliminate the possibility of transferring the problem to other areas, the GNPS closed the El Chato visitor site. As of 19 August 1996 only authorized personnel were allowed to enter the area. This was particularly important since the majority of visitors to that site are tourists who also visit the Rearing Center at the Darwin Research Station during the same day. A system of disinfection was established for those who enter the area with the aim of avoiding dispersal of a possible disease. Personnel who work in El Chato are different from those who work in the Rearing Center. Park wardens began a daily monitoring of the area to check on the sickest tortoises, to ensure that no unauthorized person entered the area, and to prevent the entrance of cattle or other animals from the nearby farms.

Based on the condition of the tortoises and the environment of El Chato, a list has been drawn up of factors that could be part of the problem. The cause of death could be a combination of several factors; the exact identification of the cause of death may be impossible. Potential factors in the poor condition of the tortoises include:

- Unbalanced nutrition related to the high consumption of passionfruit.
- Poisoning by passionfruit.
- Poisoning by herbicides, pesticides, or fertilizers.
- Abnormal increase in the quantity of intestinal parasites.
- Unknown bacterial or viral disease.
- Infection of the pond in El Chato due to the death of a tortoise within it.

To date, the preliminary analyses do not allow us to determine the cause of death.

Due to the ever-accelerating increase in changes in the insular ecosystems of Galápagos and the potential impact of these changes on the native fauna, it is imperative to initiate a system to monitor the health status of various species. The lack of basic information acts as a barrier to action when these types of problems arise. It is suggested that a system be established first with the tortoises, then be extended to other reptiles and to birds. The outbreak of Marek's disease in the chickens of Isla San Cristóbal in 1995 shows that, without a good quarantine system, new diseases will arrive with potentially severe impacts on these vulnerable ecosystems. The continued loss of integrity in these ecosystems, especially on populated islands, can affect the health of all native species and makes them even more vulnerable to diseases and changes in diet and habitat.

The fact that mortality of tortoises has not been recorded on this level in the past suggests that the mortality detected may be related to changes in the integrity of the ecosystems. The future protection of the Galápagos flora and fauna depends not only on efforts of research and management, but also on the establishment, continued operation, and maintenance of an effective quarantine system.

Linda J. Cayot and Eliecer Cruz

THE DARWIN STATION BEGINS A MONTHLY PROGRAM ON LOCAL TELEVISION

Part of the objectives of the Communication and Education Department of the CDRS is to spread information about activities at the Station to the local community. This includes information about internal Station programs, projects by visiting scientists, as well as activities which are shared by the Station and other institutions. In Galápagos, there is an ever-increasing audience which is in need of information about where they live and the activities of local organizations. The Communication and

Education Department is presently including local mass-media in it's strategy to communicate more effectively to the residents of the islands.

Within this parameter, a decision was made to produce a monthly television program. Before the first program could be completed however, an audiovisual production studio had to be finished and the existing personnel in the Department had to be reorganized for working in this new area. After the formation of the working group and the establishment of information objectives for television media, the first program of "A Mil Kilometers" (At a Thousand Kilometers) was aired in March of 1997. The Station's new local television program has a pleasant and personal format whose objectives are to entertain and inform the local populace about the continuous activities of the CDRS.

Rita Spadafora, translated by H. M. Snell

ACCOUNT OF A HISTORICAL CROSSING OF ISTHMUS PERRY

This letter was submitted by Galápagos Naturalist Guide Cynthia Manning for people who have an interest in past historical events and to bring to light a letter she was given by a fellow guide, Henk Kastelen. The letter was written by David M. Payne who revisited the islands in 1985 on the *M/V Santa Cruz* after serving in the military in the Galápagos during 1942. He wrote the following about a memorable crossing of the Isthmus Perry with several other adventurous crewmen. The following is an extract from that letter:

> *At the time I was a Naval Reserve Officer, captain of one of the PT boats of Motor Torpedo Squadron 5. In November 1942, six of our boats went to the Galápagos from Panama, our purpose being to patrol the islands against a possible attack on the airfield being constructed on Seymour Island and to search the islands for traces of enemy occupation.*
>
> *On a sunny day my boat and another were cruising down the coast of Albermarle. We anchored in a strong onshore wind in the bight to the east of Perry Isthmus. Someone (it may have been me), had the idea that it would be profitable or at least gratifying if a shore party were to cross the isthmus on foot, while the boats went around to the other side to pick the party up. On our ancient and inadequate map, the distance across looked negligible, perhaps three or four miles, and with their high speed the boats could easily round the island in a few hours. So a half a dozen of us were put ashore, rather ill-equipped. We had no idea what we were getting into.*
>
> *At first the going was good, part lava and still the breeze, and no trouble finding our way towards the saddle of the isthmus, although occasionally we would go up a deep dead-end gully. The going deteriorated. The lava was sheeted, thin sheets like giant crisp oatmeal cookies. A foot placed for an ordinary step might crash through the sheet, with one, two, or ten feet of emptiness below. There were many scarred legs, trousers in shreds and luckily no broken bones. It was the worst going I have ever known or imagined, and I doubt if our forward progress was anything like half-a-mile an hour. By this time the lava felt as hot to touch as a pot on a stove, and I suppose the air temperature (mid-afternoon) at ground level was 130 degrees F, perhaps more. Thirst was passing the point of irritation and becoming serious. We got late in the day to a series of lava ridges rising to the crest; each ridge was sure to be the top of the saddle, but never was. When night came we built a small fire of deadwood; we could not go on in the dark in that terrain. Our canteens were now empty, in spite of careful husbanding; a couple cans of tomatoes I had luckily brought were like elixir. One gulp per person was it.*
>
> *In the morning on we went, more ridges and heat. By mid-day we were so feeble and dehydrated that our rate of progress was extremely slow and halting and our tongues and lips were swollen and black. We had been holding pebbles in our mouths, and we had tried chewing and sucking the fleshy part of cacti, with indifferent results. My last few drops of urine were like ink. Eventually the sea appeared. The boats had assumed we had turned back and were gone, but at least the trip was over. All of us plodded straight into the sea, and I shall never forget the wonderful coolness. We stayed submerged for some time, soaking and washing our mouths out. I believe some of the party actually drank sea-water (which seemed relatively non-saline) and suffered no ill-effects. We were all wearing comparatively new Marine combat boots, with thick composition soles, and in some cases the soles were completely worn through, with nothing left but the ragged uppers. Soon after dark one of the boats returned on the chance we had not turned back. We were ferried aboard on the dinghy, I can remember the infinite luxury of lying on a mattress and drinking can after can of grapefruit concentrate.*
>
> *We all recovered very quickly but I wouldn't want to try it again unless the water supply was pretty well organized.*

As far as we know, Isthmus Perry has been crossed at least two subsequent times. Roger Perry and Rolf Seivers crossed while Roger was the Director of the CDRS and Hendrik Hoeck and Howard Snell crossed in 1978. All of these individuals recall that there are nicer places to wander about!

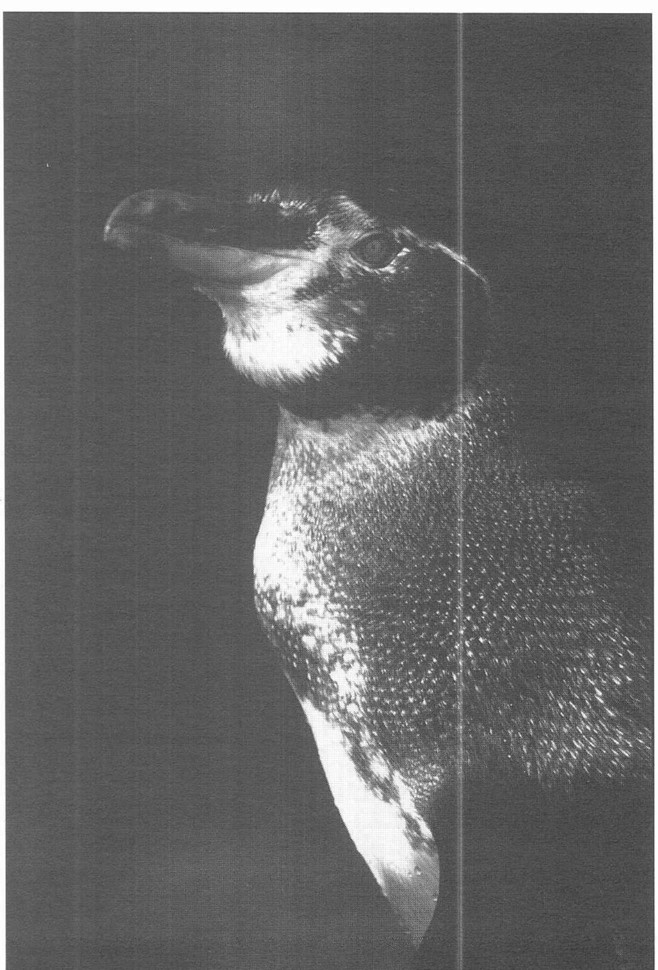
Cynthia Manning and Heidi M. Snell

CURRENT STATUS, ANALYSIS OF CENSUS METHODOLOGY, AND CONSERVATION OF THE GALÁPAGOS PENGUIN, *SPHENISCUS MENDICULUS*

By: Kyra L. Mills and Hernán Vargas

INTRODUCTION

The Galápagos penguin, *Spheniscus mendiculus*, is a threatened species endemic to the Galápagos Islands, and one of the least studied penguins in the world. Approximately 90 percent of the population of Galápagos penguins inhabits the two western-most central islands of Fernandina and Isabela, which coincide with the main path of the Cromwell Current. This eastward-flowing undercurrent upwells as it meets the western edge of the archipelago, lowering the surface temperature by several degrees and increasing the productivity in the surrounding waters (Houvenaghel 1978). Since 1970 the population of Galápagos penguins has been monitored via partial and total censuses as a result of the joint efforts of the Charles Darwin Research Station (CDRS) and the Galápagos National Park Service (GNPS). Data from these censuses reveal a fluctuating population that experienced a sharp decline during the El Niño event of 1982-83, and a slow increase since. The intent of this paper is to summarize the results of censuses from 1970 to 1995, and to discuss the methodologies used to estimate the total population of Galápagos penguins. In addition, we present novel data on the expansion of the breeding range of this species of penguin and implications for its preservation.



Galapagos Penguin - Bahía Sullivan, Isla Santiago

There are several factors that contribute to the low reproductive rate of the Galápagos penguin, which may explain the slow recovery from declines caused by events such as an El Niño. Apparently the Galápagos penguin is an opportunistic breeder, breeding when food is plentiful (Boersma 1974). However, once breeding has started the period is long, lasting approximately three months from the incubation of eggs through fledging of young. Furthermore, the mortality of juveniles is high (Boersma 1974). Past censuses indicate that the present population of penguins is still 50 percent smaller than before the 1982-83 El Niño, which caused a 77 percent decline (Valle 1983). Regular monitoring of the population of penguins is of vital importance for the preservation of this species due to its restricted distribution, the effects caused by El Niño events, the threat of introduced animals, and the potential impacts of human activities such as tourism and fishing.

The CDRS and the GNPS are attempting to conduct annual censuses of penguins and to standardize the methods used. Standardized methods for censuses can decrease inconsistencies caused by varying personnel, and/or the timing of censuses. Furthermore, standardized methods facilitate the analysis and monitoring of population trends from one year to the next. A manual that presents methodology for censuses of penguins and flightless cormorants was written in 1989 and has been reviewed and updated in 1993, 1994, and 1995 (Castro *et al.* 1995).

CENSUS METHODOLOGY

Because the flightless cormorant (*Campsohaelius [Nannopterum] harrisi*) and the Galápagos penguin have similar breeding distributions, both species are censused simultaneously. This decreases the time and eliminates the extra costs of conducting a separate census for each species. Even though both species are censused during a single trip, this paper will mainly focus on the census methodologies for Galápagos penguins.

In conducting a census, several considerations are important, such as the particular behaviors and habits of the species involved, the time of the year, the time of day to conduct the census, and the personnel involved. Each of these factors may introduce error in the results if not planned carefully.

Personnel involved in conducting any of these censuses are two wardens from the GNPS and two scientists from the CDRS. All four people search for penguins both on land and in the water, although one park warden and one scientist are the principal observers. The second park warden is in charge of managing the dinghy, and the second scientist keeps a written record of general weather conditions and the number of penguins counted. The censuses are conducted from a small dinghy, approaching the coast as closely as possible. Counting begins in the early morning, between 5:30 and 5:45, and ends between 17:30 and 18:00, with an hour off at noon. Binoculars (7x25 and 8x40) are used to count penguins that are in the water and on land, and penguins are identified, when possible, as juveniles or adults. The presence of molting penguins is also noted. Atmospheric and oceanographic conditions, including cloud cover, air and sea-surface temperatures and water clarity (measured with a Secchi disc) are recorded from the support vessel at regular intervals.

Despite efforts to standardize counting methods, one of the factors that may contribute to annual variability in efficiency is that each person searches for penguins in a slightly different manner, thereby introducing error when personnel are changed. Annual variations in the apparent numbers of penguins counted often correlate with changes in personnel, and may be due to individual differences and abilities in spotting penguins. During the last three censuses (1993, 1994 and 1995), two individuals participated in two out of the three censuses. Also of great importance is the person who helms the dinghy. Skillful and safe handling of the dinghy combined with knowledge of the census work and the character of the coastline greatly increases the numbers of penguins encountered.

The actual size of a population may be very different from the number of individuals counted in a census. Breeding birds may be more sedentary while actively foraging birds are more conspicuous. Flightless cormorants breed in small colonies on top of the lava. This makes them fairly conspicuous and relatively easy to count. Their breeding activity is also obvious and easily recorded. On the other hand, Galápagos penguins nest in crevices in the lava. This makes them difficult to observe when they are breeding, and the extent of breeding activities is rarely determined during a census. Furthermore, during the times when a census is conducted, most penguins are foraging at sea, and are very easily missed by observers. The most conspicuous penguins are those on land at the water's edge.

Conducting censuses at the same time every year reduces errors caused by comparing reproductive and non-reproductive periods. When Galápagos penguins breed, one member of a breeding pair remains at the nest in the cave during the incubation period and the first few weeks after the chick hatches (Boersma 1974). Those penguins are not observed in a census. Past censuses have occurred during different times of the year, varying from one in January, two in August, two in late August/early September, two in September, two in late September/early October, and three in October. Since 1993, personnel from the CDRS and the GNPS have set the date for the censuses in the period between late August and early September, given that the majority of past censuses were conducted during those two months.

ESTIMATING POPULATION SIZE

Because cormorants are more apparent, a greater percentage of their populations are counted in a census. Thus a census may more directly reflect the actual size of their population compared to a census of penguins. Boersma (1974) attempted to account for this error in estimating the actual size of penguin populations by tagging individuals from two specific populations and then conducting censuses.

She established a method of estimating the total population size of penguins based on those mark-recapture experiments in 1970 and 1971. By comparing the number of banded penguins sighted at two different periods (between January and March, and between June and October 1972), she concluded that penguins counted in a census represent between 10 and 20 percent of the actual number of penguins in the population. She then estimated a total population size between 11,000 and 23,000 penguins in 1971. Using the same method, the range of estimates for the population size in 1983 (the year when the El Niño occurred) is from 2,000 to 4,000 individuals, and that for 1995 (the most recent census) from 4,000 to 8,500.

Currently this method of estimation is questionable because of two potentially important differences in the methods that Boersma used in her analysis and those used recently. Boersma based the maximum and minimum limits of her estimation on counts of penguins done between 15:00 and 18:00, times when the penguins are most likely to be found on land. Current censuses are done between 5:30 and 18:00. Therefore, in addition to the times that Boersma included in her estimates, current censuses cover additional hours when many penguins are at sea foraging (between about 6:00 and 16:30). Thus, recent censuses probably count a lower percentage of the total population of penguins than the 10 to 20 percent documented by Boersma (Vargas 1995*b*).

A second factor that should be taken into account when interpreting estimates of the total population based on Boersma's method, is that her counts of penguins were done in two protected areas, Elizabeth Bay (Isla Isabela)

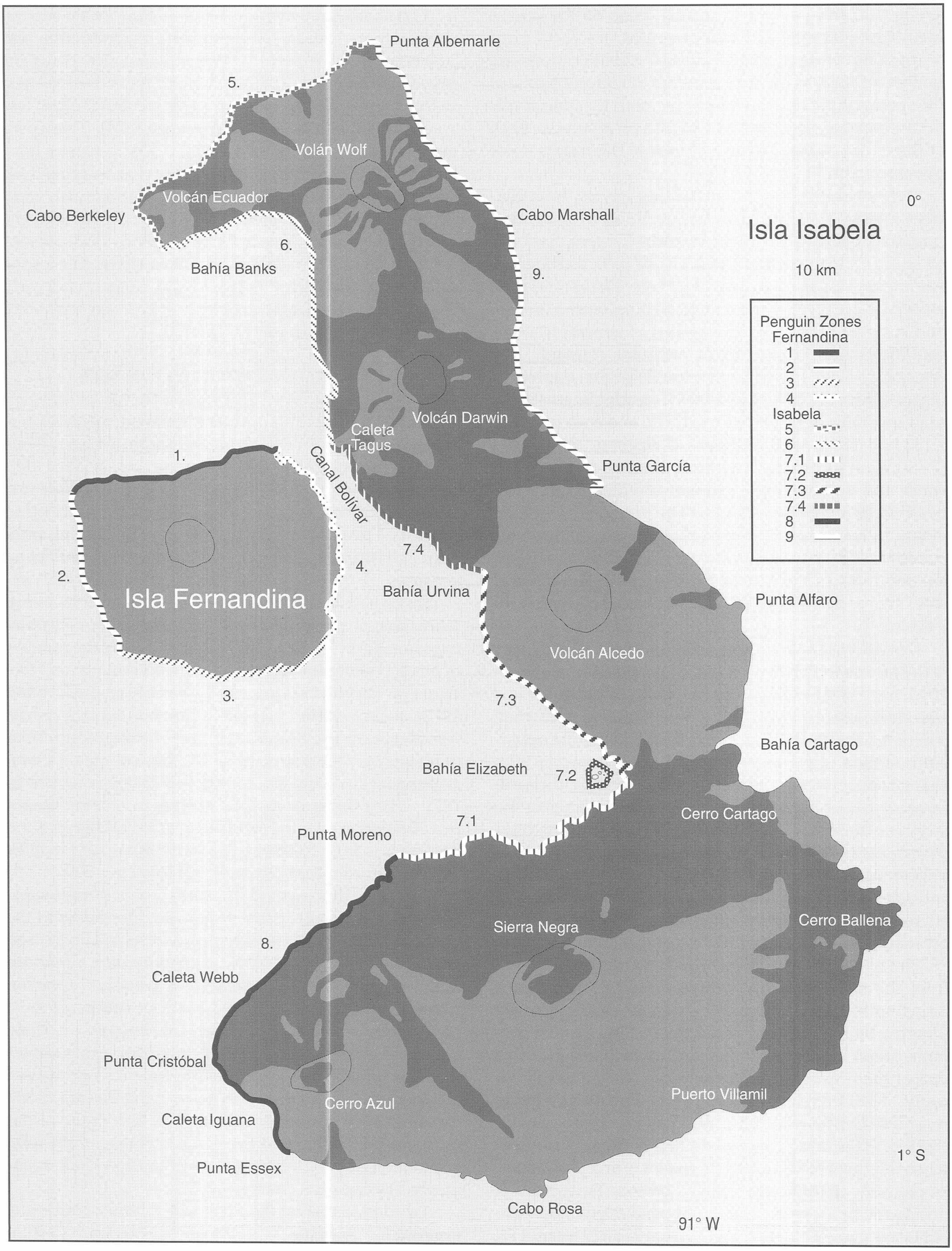


Figure 1. Zones used for dividing the census efforts on Islas Fernandina and Isabela. On Isla Isabela the darker regions indicate relatively barren lava flows. Lava flows are not indicated on Isla Fernandina.

and Punta Espinosa (Isla Fernandina). Current censuses include many areas that are exposed to waves, which make it more difficult to spot penguins both on land and in the water (Vargas 1995*b*). These factors, along with the longer period of the day used for censusing, reduce the success in spotting penguins. Hence, using Boersma's 10 to 20 percent as an index for estimating total population sizes may not be accurate. If current censuses record a lower percentage of actual birds, then using Boersma's indices would under-estimate the total population. To estimate the number of penguins present in the Galápagos more accurately, devising a new set of indices based on multiple censuses of marked individuals will be necessary.

Because limited funds make conducting a total census every year difficult, Rosenberg *et al.* (1990) used analyses of multiple regression to determine the best areas in the archipelago for predicting the total population size. Hence, a partial census could potentially be conducted at a reduced cost, and still be an accurate estimate of the total number of penguins. Islas Isabela and Fernandina were divided into nine zones (Figure 1), which had originally been established by Boersma in 1970-71. Rosenberg *et al.* used data from censuses in 1970 through 1986 to determine which zone or zones were the most reliable predictors, in other words, which zones had the greatest correlation with the total number of penguins observed in a census. They concluded that Zone 7 (on Isla Isabela) was the overall best predictor of the total penguin population, although Zone 1 (on Isla Fernandina) was also a good predictor. Both zones had the greatest abundance of penguins in the censuses. In years when funds are limited, therefore, a census could be conducted in Zone 7, and Zone 1 could be included for more accuracy. Due to the relatively large area that Zone 7 encompasses, Vargas (1995*a*) further divided Zone 7 into four subzones (Figure 1).

RESULTS

To date, 12 total and three partial censuses have been conducted. The first systematic census of this species was carried out in 1970 by P. D. Boersma, who reported a total count of 1584 individuals, and estimated a total population size between 6,000 and 15,000 (Boersma 1974). Further censuses were conducted in 1971 (Boersma 1977), 1980 (Harcourt 1980*a*, 1980*b*), 1983 (Valle 1983), in January 1984 (Valle 1984), in September 1984 (Valle and Coulter 1984), 1985 (Valle 1985), 1986 (Rosenberg and Harcourt 1987), 1989 (Castro 1989), 1993 (Mills 1993), 1994 (Soria *et al.* 1994), and 1995 (Vargas 1995*a*). Partial censuses were carried out in 1988 (Vargas 1988), 1990 (Paton and Valle 1990), and 1991 (Palacios 1991). The most dramatic population fluctuation was recorded in the census of 1983, immediately following the warm-water event known as an El Niño. This census revealed a total count of 398 individuals, or a 77 percent reduction in the population from 1980 (Valle 1983). Population counts since then suggest that the penguin population is still about 50 percent below its original numbers before the El Niño of 1982-83 (Figure 2).

Since the decrease of 77 percent that occurred in 1982-83, a small but steady increase in numbers can be seen, with the 1994 census having the greatest number of penguins in thirteen years (Figure 2). One must keep in mind, however, that there is error between the counts that makes comparing these absolute numbers potentially misleading. Nevertheless, given the similar methodology used in conducting the censuses, the margin of error is possibly small. The two major populations of Islas Isabela and Fernadina are monitored separately because Isla Isabela has introduced predators such as rats, cats, and dogs, which can have serious effects on penguin populations while Isla Fernadina lacks them (Harcourt 1980*b*, Valle 1986, Rosenberg and Harcourt 1987). Isla Isabela had a larger population count before 1980, after which Isla Fernandina had slightly greater numbers until 1993 when, once again, Isla Isabela had a larger population (Figure 2). Variation in the numbers of penguins counted among the census zones appears to reflect the overall pattern of fluctuations at the population level (Table 1).

One indication of a recovering population is an increasing number of young or juveniles observed, indicating successful breeding. Before the 1980 census, adults and juveniles were not counted separately and therefore numbers of juvenile are only known since 1980. Figure 3 shows the percentage of the total population that were juveniles since the 1980 census. Before the 1982-83 El Niño the number of juveniles was low (1.8 percent in 1980), and it remained below 10 percent until 1989. The year that shows the highest reproduction is 1993, with 35.8 percent juveniles. The 1994 census showed a high production (23.6 percent juveniles), although somewhat lower than the previous year, and in 1995 juveniles comprised 17.2 percent of the population.

DISCUSSION

It is not surprising that the censuses of penguins have revealed a slow recovery since the 1982-83 El Niño event, given their high mortality of juveniles, low reproductive rate, and long breeding period. Another limiting factor is a fluctuating food supply, caused by the spatial and temporal variation in the ocean currents that are directly responsible for the availability and abundance of penguins' prey. In addition to these factors, it is possible that human activity may have adverse effects, especially in those areas where it is great.

Contrary to many other species of Galápagos animals, penguins are wary of humans and easily disturbed. Therefore, high levels of tourist and/or fishing activity may pose serious threats to penguins, given their already low numbers. Fortunately, most penguins inhabit the coasts of Islas Fernandina and Isabela, areas where tourism is restricted to a few sites, although illegal fishermen have

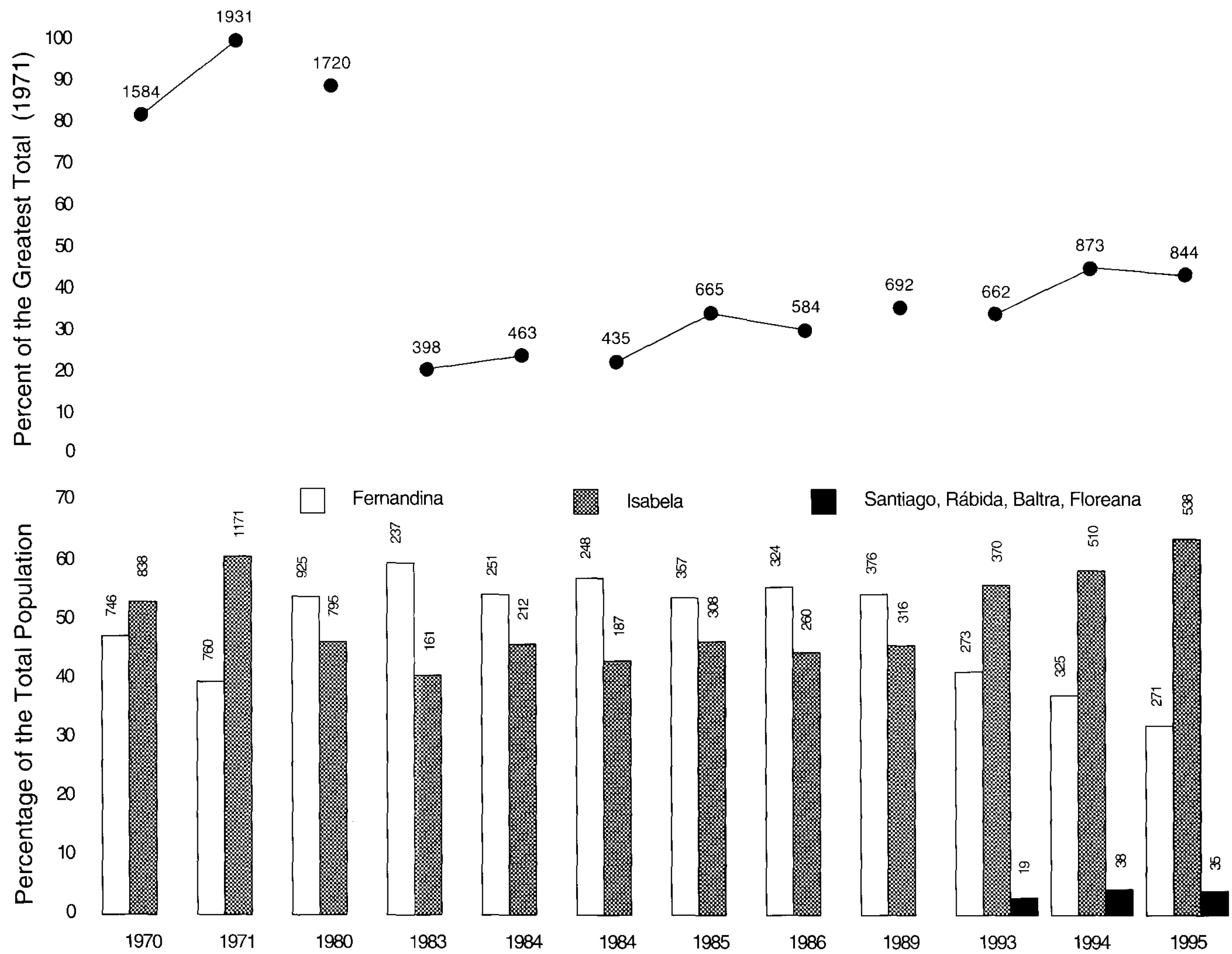


Figure 2. Variation in the numbers of penguins censused. The bars represent the percentages of the total number counted in a year that were found in different areas. The dots represent the totals counted in different years as a percentage of the year with the greatest population (1971). Dots from adjacent years are connected to indicate trends. The numbers above bars and dots are the actual numbers of penguins counted that formed the percentages. Because there are missing years it is important to be cautious in visualizing growth or declines of the population of Galápagos penguins.

been found camping on these remote coasts in recent years. Nevertheless, the most highly visited areas in the archipelago are also areas where small numbers of penguins exist. Even though these populations are small, they may be important for recruitment to the general population (Mills 1994).

Past studies (e. g., Boersma 1974, Harris 1982, and references therein) found the breeding range of the Galápagos penguin restricted to the coasts of the westernmost central islands (Fernandina and Isabela), adjacent to areas where the deep Cromwell Current upwells. Boersma and Harris did not find penguins breeding in the central islands, which are surrounded by warmer waters, although they did report the presence of juveniles and non-breeding adults in several of the central islands and Isla Floreana, a southern island. Recently, breeding was confirmed on Isla Bartolomé in 1993, 1994 and 1995 when chicks were found (Mills 1993, Soria *et al.* 1994, Vargas 1995*a*), and reports from scientists and naturalist guides suggest that breeding may also be occurring on several other islands as well (Isla Floreana [see Vargas *et al.* this issue), Islas Sombrero Chino and Rábida), although there has been no conclusive evidence of breeding found on these islands in the past three censuses. Prior to 1993, the central and southern islands were not included in penguin censuses, but since 1993 the total censuses have been organized to include these islands where the numbers of penguins may be increasing (Figure 2).

Isla Bartolomé is one of the most visited sites in the archipelago and therefore the potential for disturbance of it's population of penguins is great. Small dinghies with groups of tourists approach penguins in the water as well as on land. It appears that these penguins are somewhat accustomed to this level of tourist activity, and allow a

Table 1. Counts of penguins per census zone by year.

Zone[1]	Yearly Total Counted												Average	%
	1970	1971	1980	1983	1984[2]	1984[3]	1985	1986	1989	1993	1994	1995		
Fernandina														
1	41	381	373	86	50	102	134	123	132	92	163	84	147	16
2	36	66	144	11	21	56	41	23	65	40	17	30	46	5
3	83	32	151	73	6	22	17	17	28	32	3	19	40	4
4	586	281	257	67	174	68	165	161	151	109	142	138	192	21
Isabela														
5	75	15	75	5	10	8	18	37	46	35	96	38	38	4
6	144	239	197	45	34	59	38	21	20	36	37	33	75	8
7	568	619	456	93	154	79	232	175	212	212	178	246	269	30
8	51	298	63	18	14	41	20	27	38	87	199	220	90	10
9	0	0	4	0	0	0	0	0	0	0	0	1	0.42	0.05
Others														
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	19	38	35	31	3
TOTAL	**1584**	**1931**	**1720**	**398**	**463**	**435**	**665**	**584**	**692**	**662**	**873**	**844**	**904**	

[1] See Figure 1 for definition of zones.
[2] This 1984 census was in January
[3] This 1984 census was in September.

closer approach than penguins do on Isla Fernandina or Isla Isabela. However, many penguins on Isla Bartolomé show signs of being disturbed because they enter the water upon approach, or they swim away, if already in the water (Mills, personal observation). Even though GNPS regulations prohibit chasing or touching the animals, these rules are not always respected. At the moment, there is no restriction on how close tourists can approach penguins. In the past, the potential disturbance of penguins caused by visitation on the central islands was not considered detrimental to the population because it was believed that these penguins were immature and therefore non-breeders. However, because breeding penguins are more easily disturbed, and we now know that penguins are breeding in the central islands, new tourist regulations may need to be applied in these areas.

Introduced animals may pose serious threats to the population of penguins on islands such as Isla Isabela. The potentially most damaging introduced animals appear to be rats, cats and dogs, which can eat penguin eggs, juveniles, or adults. Because these introduced animals pose serious threats to penguins and other endemic species, the CDRS and GNPS hope to control their populations. Nevertheless, funding for these programs is scarce and eradication is difficult on some of the larger islands. However, localized control of populations of introduced animals is feasible, and could be implemented in areas that have the highest densities of breeding penguins and cormorants. Of particular concern in the past few years has been the possibility of introducing alien animals to Isla Fernandina, the largest remaining island in the archipelago with no introduced vertebrates. Because of the recent illegal fishing camps on this island, the likelihood for the introduction of animals has increased, although so far there has been no confirmation of any introductions. Because Isla Fernandina has high densities of breeding flightless cormorants and Galápagos penguins, the introduction of animals such as rats, cats, or dogs would be devastating to these endemic seabirds. In addition, human disturbances such as fishing offshore and camping

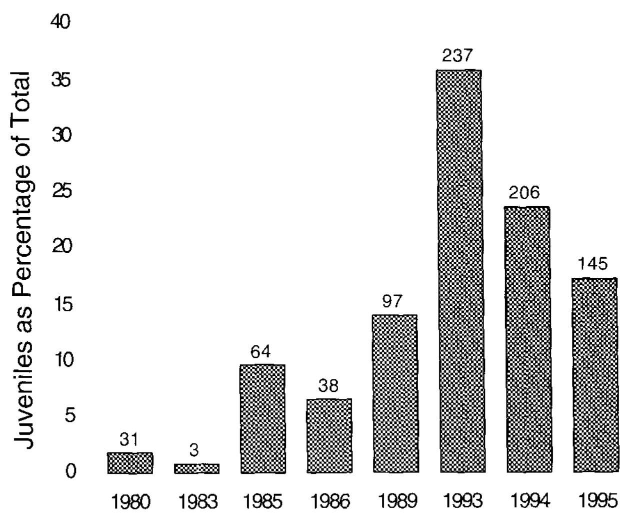


Figure 3. The population of juveniles as a percentage of the total population. The bars represent percentages and the numbers above the bars are the numbers of juveniles counted.

could have contributed to the decline in numbers of penguins that has been observed on Isla Fernandina since 1993.

Since the 1982-83 El Niño there have been six El Niño events of weaker intensity. The 1982-83 El Niño appears to be one of the most severe ever observed (Barber and Chávez 1986). El Niño events in Galápagos are characterized by increases in sea-surface temperatures and the suppression of marine primary productivity (phytoplankton). This decrease in primary productivity creates a cascade effect on the higher trophic levels, including the top level of marine mammals and seabirds (Barber and Chávez 1983, Cane 1983). Hence, in El Niño years there is a reduction in the availability of prey for penguins. Now that penguins are known to be breeding on the central islands and because El Niño events may be more frequent, the small, central island populations may be crucial for the maintenance of penguins in Galápagos.

Results from recent censuses have given us a reason to be optimistic about the recovery of the population of Galápagos penguins. The high percentage of juveniles and the highest numbers of birds counted since the dramatic decline following the 1982-83 El Niño, suggest that the penguin population is recovering, although slowly. As with any other population of animals, there will always be natural fluctuations in the numbers of Galápagos penguins, but it is within our capacity to diminish the negative effects of human activity. When natural fluctuations caused by events such as an El Niño are combined with fluctuations caused by human activity, the results can be devastating. Therefore, if we are successful in eliminating the negative human effects, then this rare species of penguin will have a better chance at survival. The regular monitoring of these populations through annual censuses will foster the early observation of potential declines.

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Kyra L. Mills, Department of Ecology and Evolutionary Biology, University of California, Irvine, CA 92717-2525 USA (klmills@uci.edu). Hernán Vargas, Charles Darwin Research Station, Puerto Ayora, Isla Santa Cruz, Galápagos, Ecuador (hernanv@fcdarwin.org.ec).

MONOECY IN THE DIOECIOUS *CROTON SCOULERI*, ENDEMIC TO GALÁPAGOS

By: André Mauchamp

INTRODUCTION

Establishment on islands is a challenge for propagules arriving with the winds, the marine currents or borne by animals. Survival capacities of the first individual plants determine their fate in the short term. Whether they can form a viable population depends on a complex array of traits, among which are the characteristics of the breeding system. It is generally considered that hermaphroditic self-compatible species have a better chance to establish on an island, since a single propagule can be sufficient to build up a population (Baker 1955). On the other hand, this may lead to low genetic variability, possibly negative in the long term. The contrasting proportions of different breeding systems on islands, about twenty percent dioecious in Hawaii and New Zealand (Bawa 1982) to less than three percent in Galápagos (Baker and Cox 1984), shows that a complex array of selective pressures determine the reproductive traits of plants on islands. These observations led to a considerable interest in the evolution of breeding systems, particularly on islands (Baker 1955, Carlquist 1966, Bawa 1980, 1982, Givnish 1982, Baker and Cox 1984).

Studies of the flora of the Galápagos Islands started with the very first scientific journeys to the archipelago (Hooker 1847, Stewart 1902) and culminated with the publication of the *Flora of the Galápagos Islands* (Wiggins and Porter 1971). However, relatively few studies focused on the processes of population dynamics or the reproductive biology of the Galápagos plants. The main studies of breeding systems show that self-compatibility is highly represented in the islands (Rick 1966; Grant and Grant 1981; and McMullen 1985, 1986, 1987). The dioecious species were described in Wiggins and Porter (1971) but never specifically studied. I present three cases of "leakage" in the breeding system of the dioecious *Croton* on three of the Galápagos islands.

THE SPECIES

Croton scouleri Hook f. (Euphorbiaceae) is an endemic species of the Galápagos Archipelago. It is a highly variable taxa usually divided into four varieties, *brevifolius* Muell Arg., *darwinii* Webster, *grandifolius* Muell Arg. and *scouleri*, according to the size of the leaves and a few other morphological traits (Wiggins and Porter 1971, Lawesson *et al*. 1987). It is present on most of the islands of the archipelago (45 of a sample of 77 islands, Snell *et al*. 1995). Species of the genus *Croton* are dioecious or monoecious (Mabberley 1987). *Croton scouleri* was considered exclusively dioecious (Wiggins and Porter 1971). However, monoecy was recently observed in a few specimens by C. Huttel on Isla Española and nearby islets.

RESULTS AND DISCUSSION

Monoecy was observed in three areas. Charles Huttel collected monoecious specimens in the southern archipelago: on Isla Osborn (specimen Huttel # 2283), Isla Gardner (Huttel # 2290) and on Isla Española (Huttel # 2440). One monoecious population was found on Isla Isabela, on the southeastern slope of Volcán Alcedo, about 850 m elevation, and another on southern Isla Genovesa, a low, dry island in the north of the archipelago. The pattern was the same for all three populations. Three types of plants could be found: female trees with only female inflorescences of ten to thirty flowers; male trees that bear male inflorescences with a similar number of

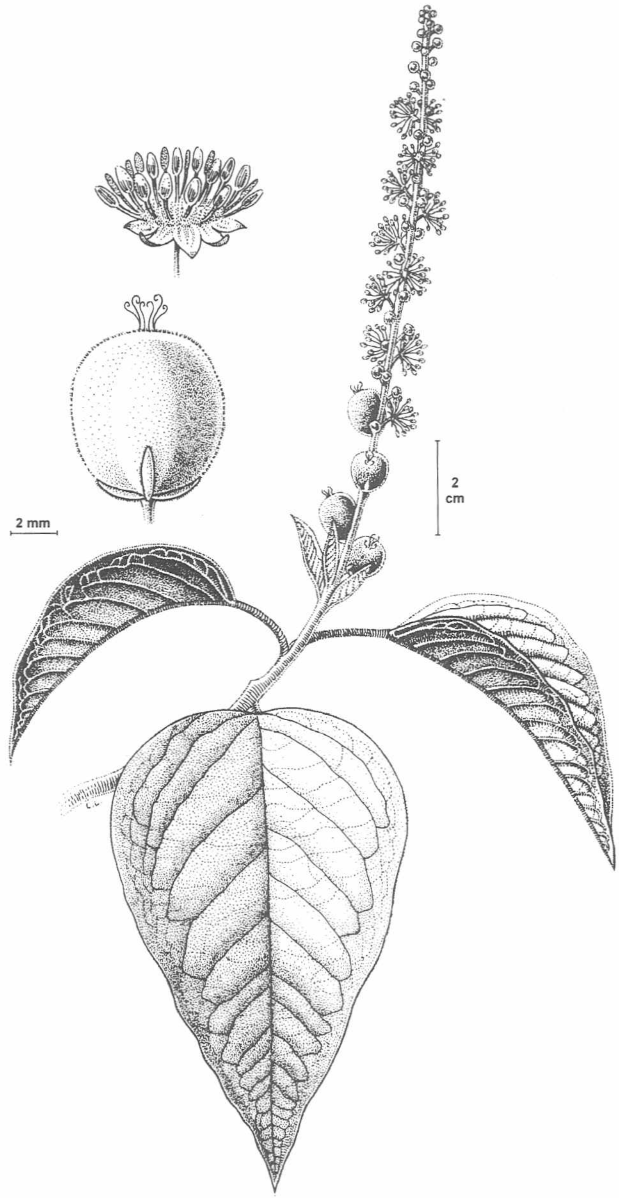

Figure 1. Monoecious inflorescence of *Croton scouleri*. The photograph is from Islote Osborn, Bahía Gardner, Isla Española. The drawing is from a specimen collected on Volcán Alcedo, Isla Isabela. On Alcedo the trees were 4 to 6 m high and formed patches of *Croton* forest. The fruits are below the male flowers on the central stem.

flowers; and monoecious trees. The monoecious trees are mainly male, but about one to five percent of their inflorescences have two to five female flowers, always the most basal (Figure 1). I counted 100 plants randomly selected in both the Volcán Alcedo and Isla Genovesa populations and the proportions of sexes are shown in Table 1. The proportion for the Española population could not be determined because the plants were never sufficiently flowered when visited. In all three cases, the female flowers of the monoecious inflorescences developed and produced seeds. On Isla Gardner, seeds produced by a monoecious plant were collected. Of fourteen seeds, two germinated and grew; both were male plants. However, they were young and bore only a few inflorescences each.

Only three percent of the native and endemic plant species of the Galápagos Islands are dioecious (Baker and Cox 1984). Among the thirteen dioecious species, five are endemic and eight native (Table 2). This low proportion is similar to the only available figure for the flora of continental Ecuador, three percent (Gilmartin 1968). Two dioecious genera from the Galápagos, *Baccharis* and *Bursera*, have an endemic and a native species. It is likely that the majority of the dioecious species of the Galápagos were already dioecious when they colonized the islands. Although the information on seed set and seed viability of the monoecious inflorescences is still very scarce, *Croton scouleri* is probably an example of "leaky dioecism," a

Table 1. Proportions of sexes among 100 individuals of *Croton scouleri* in two Galápagos populations.

Site	Male	Female	Monoecious
Alcedo	41	44	15
Genovesa	45	47	8

Table 2. Dioecious species of the Galápagos islands.

Family	Genus	Species[1]	Origin[2]
BURSERACEAE	*Bursera*	*malacophyla*	E
COMPOSITAE	*Baccharis*	*steetzii*	E
EUPHORBIACEAE	*Croton*	*scouleri*	E
NYCTAGINACEAE	*Pisonia*	*floribunda*	E
SIMAROUBACEAE	*Castela*	*galapageia*	E
BATIDACEAE	*Batis*	*maritima*	N
BURSERACEAE	*Bursera*	*graveolens*	N
CHENOPODIACEAE	*Atriplex*	*peruviana*	N
COMPOSITAE	*Baccharis*	*gnidiifolia*	N
MENISPERMACEAE	*Cissampelos*	*pareira*	N
MENISPERMACEAE	*Cissampelos*	*glaberrima*	N
RUTACEAE	*Zanthoxylum*	*fagara*	N
URTICACEAE	*Urera*	*caracasana*	N

[1] Nomenclature follows Wiggins and Porter (1971).
[2] E = endemic and N = native.

phenomenon that is not rare in island floras (Baker and Cox 1984). The occasional production of female flowers and possibly seeds by a male plant could favor the establishment of a new population on an island and species with such a breeding system might persist on more islands than those that are strictly dioecious.

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André Mauchamp, Former Head of the Botany Department, CDRS. Station Biologique de la Tour du Valat, Le Sambuc, 13200 Arles, France.
E-mail: a.mauchamp@sansouire-tourduvalat.fr

THE SPECIES-SCAPE OF GALÁPAGOS ORGANISMS

By: Stewart B. Peck

INTRODUCTION

I have long been interested in the comparative diversity of organisms inhabiting the Galápagos Islands. One way to visually show the relative species diversity of different groups is to present the data as a species-scape. This shows the relative sizes of representative organisms in a landscape in proportion to the number of species in each main group. I thought it might be useful to construct a species-scape for terrestrial and marine organisms known from the Galápagos.

METHODS

To make a species-scape, I surveyed the literature on numbers of species that have been reported from the Archipelago. The literature is extensive. Most Galápagos studies have focused on the plants and vertebrate animals. Recent overviews are Berry (1984), Bowman *et al.* (1983), Grant (1986), Jackson (1985), and Perry (1984). The latest summary of data on invertebrates is James (1991).

In constructing the comparative diversity lists presented here my intention is to provide numbers only for naturally occurring species (native and endemic), and not to include numbers of species that have been accidentally or intentionally introduced by human activity. However, these are not always distinguished as such in the literature from which I have drawn the data. I also limit the data to multicellular organisms. Of course, I can not give numbers for taxa for which we know of no data. I have also consulted the primary literature for the Galápagos and give references to it. The numbers reported here are minimal and based on actual data, rather than my estimates or extrapolations of total diversity. The actual figures are viewed as not being as important as the known diversity relative to other groups. Numbers of endemics for the marine fauna are also relative to the level of knowledge of the difficult-to-sample deep-water and pelagic faunas, and various author's operational definitions of the term endemic. The lists presented here do include the available data on the deep-water as well as for the shallow-water faunas.

Comparative data on species diversity of Galápagos multicellular plants and vertebrates are in Table 1. Comparative data on marine invertebrates and on terrestrial (plus freshwater) invertebrates are given in Table 2. Figure 1 shows this data as a species-scape.

I recognize that I am employing the methodology of an accountant in this approach. That is, I am simply counting up entities, without regard for their biological properties and what these mean for the structure and function of the ecosystems they inhabit. This is undesirable, but appears unavoidable in the circumstances.

From the data and illustration, one can draw one's own conclusions. One obvious conclusion is that there seem to be many gaps in knowledge of the diversity of many invertebrate groups, especially in marine habitats.

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Table 1. Summary of species diversity of major groups of indigenous (native and endemic) multicellular "plants", and vertebrate animals of the Galápagos Archipelago.

Organismal Group	Indigenous species[1]	Endemic species[2]	Reference
"Plants"			
Macro fungi	59	0	Bonar 1939
Marine algae	333	116	Silva 1966
Lichens	213	11	Weber 1986
Liverworts & mosses	204	22	Gradstein and Weber 1982, Weber and Gradstein 1984
Ferns and allies	108	8	Porter 1984
Flowering plants	550	193	Jackson 1985
Total	**1467**	**350 (24%)**	
Vertebrates			
Fishes, marine	306	44	Brusca 1987
freshwater	0	0	
Reptiles, marine	2		Jackson 1985
terrestrial	21	21	Jackson 1985
Birds, sea birds	21	4	Jackson 1985
land birds	46	23	Jackson 1985
Mammals, marine	26	1	Day 1994; Jackson 1985
terrestrial	9	10	Key and Muñoz 1995; Jackson 1985
Total	**431**	**103 (24%)**	

[1] Total indigenous species diversity will probably increase in some groups as research continues. Indigenous species naturally occur within the Galápagos.

[2] Endemism may decrease as the island biotas are more accurately related to continental source biotas. Endemic species are those indigenous species occuring only within the Galápagos

Table 2. Species richness of multicellular indigenous invertebrates in marine and terrestrial (including fresh water) habitats of the Galápagos.

Organismal Group	Indigenous species	Endemic species	Reference
I. Marine Invertebrates			
Placozoa	?	?	
Porifera	?	?	
Cnidara			
Hydrozoa	?	?	
Scyphozoa	?	?	
Anthozoa, Octocorallia	?	?	
Zoantharia	?	?	
Antipatharia	?	?	
Scleractinia	44	11	Wells 1983
Ctenophora	?	?	
Platyhelminthes	95	85?	Westheide 1991
Nemertinea	8	2	Westheide 1991
Nematoda	33	19	Westheide 1991
Other Aschelminthes	15	12	Westheide 1991
Gnathostomulida	4	4	Westheide 1991
Priapulida	?	?	
Bryozoa	184	34	Banta 1991
Brachiopoda	?	?	
Phoronida	?	?	
Sipunculida	?	?	
Echiura	?	?	
Annelida			
Polycheta	192	50	Blake 1991, Westheide 1991
Oligochaeta	7	7	Westheide 1991
Hirudinea	0	0	
Tardigrada	10	5	Westheide 1991
Mollusca			
Gastropoda	530	126	Kay 1991, Finet 1991
Bivalvia	100	11	Kay 1991
Polyplacophora	13	9	Kay 1991
Cephalopoda	4	2	Kay 1991
Scaphopoda	5	0	Kay 1991
Arthropoda			
Acari	42	35	Westheide 1991
Pycnogonida	12	9	Brusca 1987
Crustacea, Ostracoda	72+	25	Westheide 1991
Copepoda	61	44	Westheide 1991
Cirripedia	18	4	Zullo 1991
Stomatopoda	?	?	
Isopoda	26	17	Brusca 1987
Amphipoda	50	19	Barnard 1991
Natantia	65	6	Wicksten 1991
Macrura	?	?	
Anomura	20?	1?	Harvey 1991
Brachyura	120	27	Garth 1991
Insecta	3	0	Peck unpubl.
Chaetognatha	?	?	
Echinodermata			
Crinoida	1	0	Maluf 1991
Asteroida	23	2	Maluf 1991
Echinoida	31	5	Maluf 1991
Holothuroidea	24	2	Maluf 1991
Ophiuroidea	47	7	Maluf 1991
Hemichordata	?	?	
Cephalochordata	?	?	
Tunicata	?	?	
Total	**1859+**	**580+(>31%)**	

Table 2 continued:

II. Terrestrial (and Freshwater) Invertebrates			
Platyhelminthes	1	?	Peck, unpubl.
Nematoda	100+	5?	P. DeLey 1992
Annelida, Oligochaeta	?	0	
Tardigrada	14	2	Schuster & Grigarick 1966, Van Rompu *et al.* 1995
Mollusca (land snails)	83	80	Chambers 1991
Arthropoda			
Arachnids			
Spiders	80	55	Baert *et al.* 1989, unpubl.
Mites	≈ 400	≈ 275	Schatz and Schatz 1988; Schatz 1996, unpubl.
Other Arachnids	21	15	Peck 1991
Crustacea	20?	8	Peck 1991, 1994
Centipedes & Millipeds	8	6	Shear and Peck 1987, 1992
Insects	1530	712	Peck 1991 and unpubl.
Total	**2257**	**1158 (51%)**	

Research Station, G. Reck, Dan Evans, and Chantal Blanton, Directors, aided in logistics of field work. Field work was partially supported by the Natural Sciences and Engineering Research Council of Canada. TAME provided reduced airfares.

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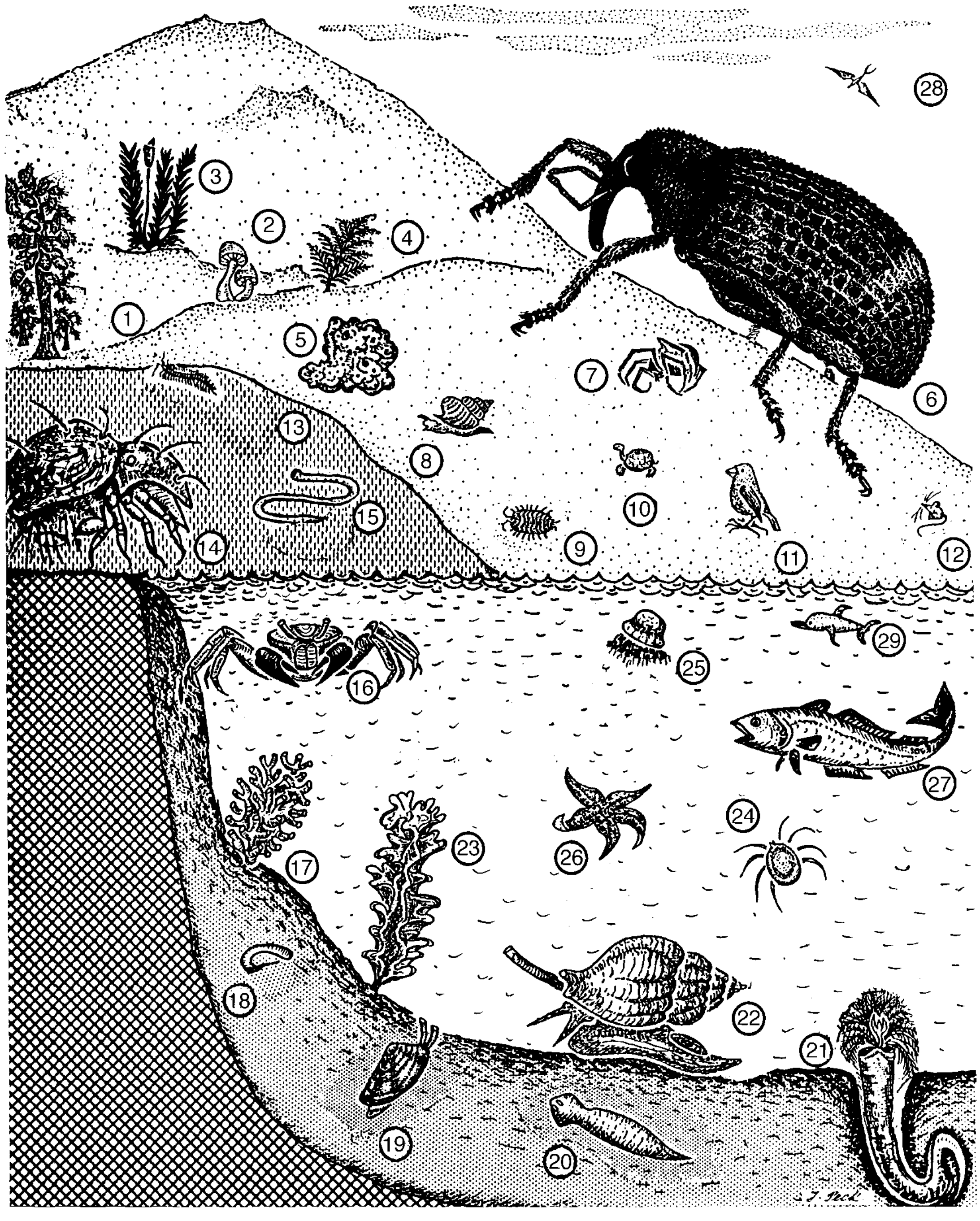

Figure 1. A "species-scape" of the major groups of multicellular naturally occurring terrestrial and marine organisms of the Galápagos Islands. Size of organism is shown proportional to the relative known species diversity in the major group. Major taxa with 10 or fewer species are not indicated. Diversity data from Tables 1 and 2. Key to taxa: 1. Angiosperm plants. 2. Fungi. 3. Mosses. 4. Ferns. 5. Lichens and liverworts. 6. Insecta (insects). 7. Aranea (spiders). 8. Mollusca (land snails). 9. Crustacea (terrestrial isopods). 10. Reptiles. 11. Land birds. 12. Land mammals. 13. Centipeds and millipeds. 14. Acari (terrestrial mites). 15. Nematoda. 16. Marine Crustacea. 17. Bryozoa. 18. Nematoda. 19. Mollusca (Bivalvia; clams). 20. Platyhelminthes. 21. Annelida (polychaete worms). 22. Mollusca (Gastropoda; snails). 23. Macroscopic "Algae". 24. Acari (marine mites). 25. Cnidaria (corals). 26. Echinoderms (starfish, sea urchins, brittle stars, etc.). 27. Fishes. 28. Sea birds. 29. Marine mammals.

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Stewart B. Peck, Department of Biology, Carleton University, Ottawa K1S 5B6, Canada.

DEEPSLOPE FISHES COLLECTED DURING THE 1995 ERUPTION OF ISLA FERNANDINA, GALÁPAGOS

By: John E. McCosker, Godfrey Merlen, Douglas J. Long, R. Grant Gilmore and Carlos Villon

INTRODUCTION

The volcanic nature and steep terrain of much of the Galápagos Archipelago has made collecting deep shorefish nearly impossible by traditional oceanographic methods. The majority of deepwater fishes collected at or near the Galápagos were the result of the 1891 voyage of the U. S. Fish Commission Steamer *Albatross* (Garman 1899). Thirteen stations, the deepest at 1740 fathoms, were made along a southerly transect from north of Isla Darwin to the central Galápagos plateau, then to the east from northern Isla Floreana (Charles) to Isla San Cristóbal (Chatham) and across to the mainland. The western, southern, and eastern margins of the archipelago were not sampled. The sampling methodology, primarily benthic trawling, was hindered by the volcanic submarine terrain, and as a result most of the fishes that were captured are associated with sand and mud bottoms. The collections were remarkable, however, and resulted in many new taxa several of which were not seen again for 104 years. Two extraordinary events occurred in 1995 which allowed us an opportunity to contribute to the knowledge of Galápagos fishes. First was the eruption and lava flow from a fissure on the slope of Isla Fernandina during January and February 1995 that provided an exceptional ichthyological sampling opportunity rivaling the efforts of most collectors since the *Albatross*. Similar serendipitous fish kills associated with volcanic eruptions in Hawaii have occurred in the past (Jordan 1922, Gosline *et al.* 1954). Just off Isla Fernandina, hundreds of fish died at Cabo Hammond (00° 28'S, 91° 37'W) when copious amounts of lava plunged into the water forming a new coastline

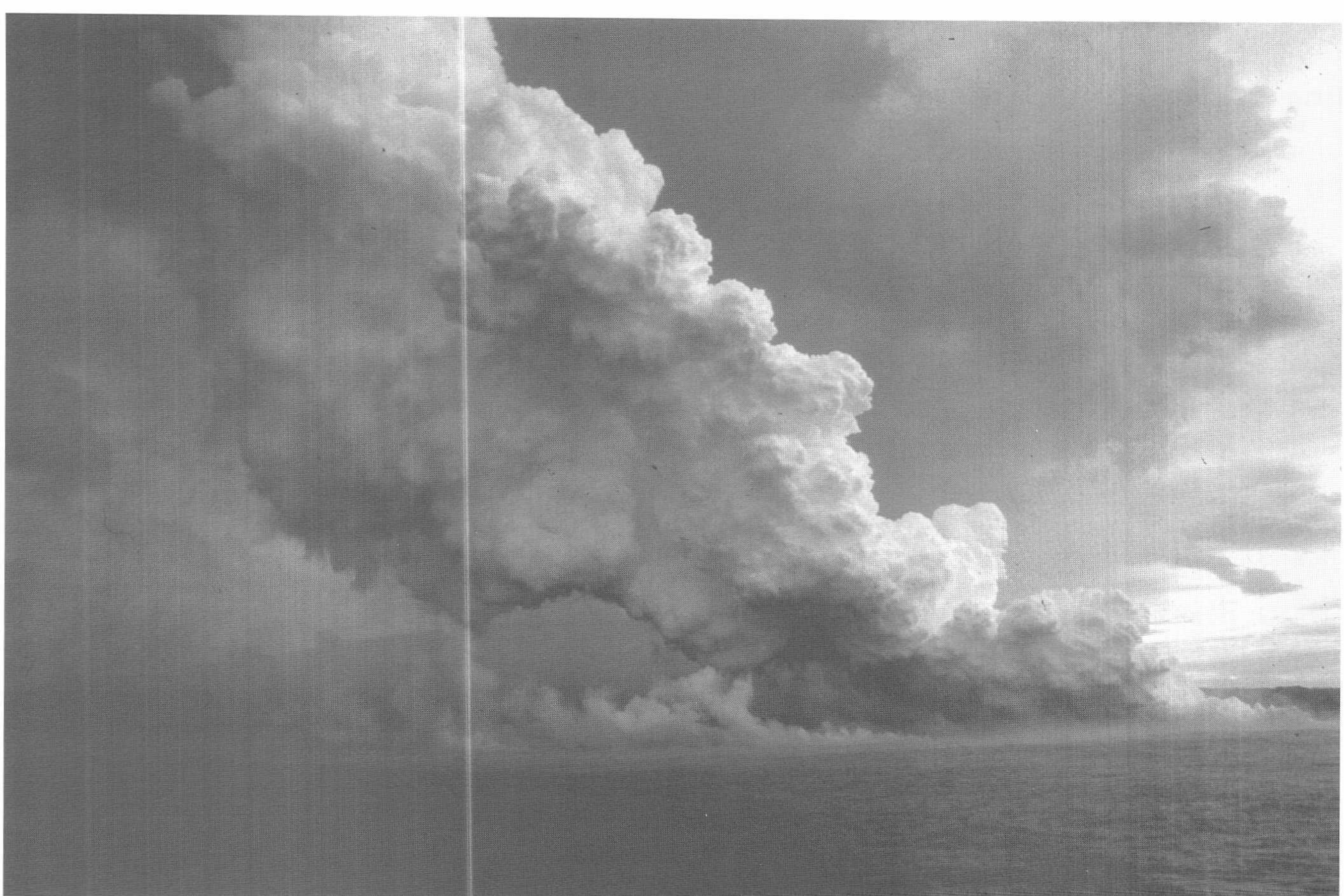

Figure 1. Steam and smoke from volcanic materials entering the ocean at Cabo Hammond, Isla Fernandina on 29 January 1996. Photograph by Godfrey Merlen.

(Merlen 1995, Figures 1 and 2). Low-frequency, echoing explosions could be heard through hydrophones, miles offshore. The sea temperature near the coast rose to the boiling point. Several marine iguanas and brown pelicans died, and the coastal algal beds were destroyed. The submarine topography offshore of Cabo Hammond drops off to depths of 550 m and 914 m at one and two kilometers from shore, respectively.

During 6-7 February 1995 Merlen, in virile competition with feeding seabirds, was able to capture a small sample of the fishes found dead and dying at the surface, but it was not adequate to provide either a complete qualitative or quantitative sample of the fishes that live along the submarine slope of Isla Fernandina. Even though incomplete, this sample, resulted in some interesting discoveries, particularly of deepwater species which appear to have been brought to the surface by violent upwelling of cold water associated with lava entering the sea, and included new records and two new species of fishes.

The second extraordinary event was the Harbor Branch Oceanographic Institute/California Academy of Sciences (HBOI/CAS) Expedition during November 1995 aboard the *R/V Seward Johnson*. During that trip the research submersible *Johnson Sea-Link* (*JSL*), allowed the first opportunity to observe, film, and capture deepwater Galápagos fishes to the submarine's limit of 1000 m depth. In this report we describe the fishes which were captured and photographed by Godfrey Merlen while Isla Fernandina erupted and combine information about the habitat and depth distribution of those species as observed from the submersible. Further results from the HBOI/CAS Expedition are forthcoming.

MATERIALS AND METHODS

Specimens and 35 mm transparencies are deposited in the ichthyological collections of the CAS in San Francisco and at the Charles Darwin Research Station (CDRS). Additional Galápagos specimens were deposited with the Instituto Nacional de Pesca (INP) in Guayaquil. Institutional abbreviations follow the Standard Symbolic Codes for Institutional Research Collections in Herpetology and Ichthyology (Leviton *et al.* 1985). Our other abbreviations are SL, standard length; and HL, head length. English and Spanish common names are based on FAO documents, Humann (1993), Merlen (1988), common usage by Galápagos residents, and some were created with the assistance of William Bussing.

ACCOUNTS

An adult dogface witch eel (anguila cariperro), *Faciolella gilberti* (Garman 1899), was found floating (CAS 86454, 380 mm SL). This species is widespread in the eastern Pacific, from Point Conception, California, to Panama. We are unaware of any previous records from Galápagos for this species. It was commonly observed from the *JSL* at or near the bottom on slopes from 600-1000 m depth.

Figure 2. Coastline at Cabo Hammond, Isla Fernandina on 15 November 1996. Photograph by John E. McCosker.

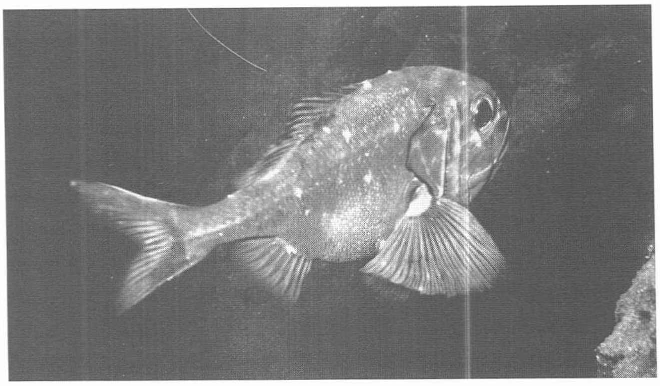

Figure 3. Adult Galápagos slimehead, *Hoplostethus pacificus*, photographed from *JSL* submersible at 600 m depth off of Cabo Hammond.

Many specimens of silver hatchetfish (hacha plateada), *Argylopelecus lychnus* (Garman 1899) were found floating (CAS 86456, 49-62 mm SL). These are midwater fishes, typically "concentrated between 300 m and 400 m off California by day, with the highest concentration near 400 m; by night major concentrations occur from 200 m to 350 m, with no marked indication of geographical variation in depth" (Baird 1971: 66). They are primarily restricted to the tropical Pacific; found in abundance in the eastern Pacific between 35° N and 35° S and across the Pacific as far as 160° W (Baird 1971). They were observed but not captured from the *JSL* during its ascent and descent.

Several slender hatchetfishes (hacha fina), *Maurolicus breviculus*, recently described from the equatorial Pacific between 84° W and 105° W, including the Galápagos Islands (Parin and Kobyliansky 1993), were found floating (CAS 86498, 33-36 mm SL). The type series was captured by midwater trawl between the surface and 1200 m. They were probably observed but were not recognized by divers in the submersible.

An adult Galápagos slimehead (guadaña del Pacífico), *Hoplostethus pacificus* (Garman 1899), was found floating (CAS 86499, 88 mm SL). Slimeheads were observed to aggregate along the deep volcanic slopes, approximately 3-5 m above the substrate (Figure 3). From our observations aboard *JSL*, it appeared that the juvenile and adult specimens occupied slightly different depths, the younger fish between 400-600 m, and the adults between 600-750 m. Other species of slimeheads are fished commercially elsewhere, however based on our observations it seems that there is far too small a biomass to allow a significantly commercial fishery.

An adult specimen of Panamic soldierfish (soldado panámico), *Myripristis leiognathos* (Valenciennes 1855), was collected (CDRS V-1230, 157 mm SL). Soldierfishes are nocturnally-active reef associates that live throughout the archipelago and from Baja California to Ecuador at depths of 3-25 m.

An immature male deepwater cardinalfish (cardenal de profundidad) represents the first of the genus *Epigonus* from the Galápagos and a new species as well (McCosker and Long, in prep., CAS 86581, 146 mm SL). Species of *Epigonus* are found in all tropical oceans and seas, and live between 200-1000 m depth. Other specimens of *Epigonus*, presumably of this species, were seen and videotaped but not captured by the senior author and R. Grant Gilmore during *JSL* dives on two occasions along the southwest shore of Isla Fernandina, off Cabo Douglas (0°14.6'S, 91°26.6'W). The fish were approximately the size of the floating specimen and were inactive or swimming slowly about 2-3 m above a steeply sloping sediment-coated volcanic bottom which fell off rapidly from 740 m into deeper water.

Four species of seabasses were found dead in the area where the lava flowed into the sea. Not surprisingly, specimens of creole fish (gringo), *Paranthias colonus* (Valenciennes 1855) were observed and collected (CDRS V-1228, 157 mm SL). *P. colonus* is widespread in the eastern Pacific, from the Gulf of California to Perú, and at all offshore islands (Revillagigedos, Cocos, Clipperton, and Malpelo). From our scuba and submersible observations, it appears to be the most abundant fish in Galápagos, occupying reef and near-reef habitats from the surface to 100 m depth. A subadult flag cabrilla (cabrilla), *Epinephelus labriformis* (Jenyns 1842), was found floating, photographed, and discarded. It is a common species from the Gulf of California to Perú and Galápagos, and occupies nearshore rock reefs to a depth of 50 m. An adult wrasseass bass (cabrilla rayada), *Liopropoma fasciatum* (Bussing 1980) was photographed and collected (CDRS V-1227, 90 mm SL). It is unmistakable in appearance (see photos in Humann 1993: 83, and Allen and Robertson 1994: 117), and also known from deep reef habitats at Cabo San Lucas, Baja California, and off Costa Rica. It is an associate of deepwater reefs, and like the scythmarked butterflyfish and the oval damselfish, it is occasionally found in the Galápagos in caves and reef cracks beneath the thermocline. It was observed during *JSL* dives to a depth of 130 m, beneath which it appeared to be replaced by its congener, *L. liolepis* (Garman 1899), which was associated with reefs between 120-250 m depth. Several threadfin bass (plumero), *Pronotogrammus multifasciatus* (Gill 1863), were observed floating and two specimens were preserved (CAS 86501, 105-165 mm SL). It is a widespread species in the eastern Pacific (including its synonyms *Anthias gordensis* [Wade 1946], and *Holanthias sechurae* [Barton 1947]) from the outer coast and Gulf of California to Perú, and lives between 40-200 m depth. From the *JSL* we observed it to be very abundant along rock reefs to depths of 150-300 m.

An adult Peruvian grunt (roncador peruano), *Anisotremus scapularis* (Tschudi 1845) was found floating, photographed, and discarded. Peruvian grunts are common in Galápagos and Perú, and form large schools above rocky reefs in about 5-20 m depth (Allen and Robertson 1994).

An adult little barracuda (barracuda chica), *Sphyraena idiastes* (Heller and Snodgrass 1903), was found floating, photographed, and discarded. This species forms abundant nearshore schools throughout the archipelago, between the surface and approximately 25 m, and is also found in Perú.

A intermediate scabbardfish (pez daga), *Aphanopus intermedius* (Parin 1983), represents the first known Galápagos record (CAS 86497, 520 mm SL). The species is widely distributed in tropical and subtropical seas; in the northeastern Pacific it is known from British Columbia to California, and in the southeastern Pacific from Perú. Adults are benthopelagic from 800-1350 m depth, and juveniles are mesopelagic from 300-1000 m. It reaches approximately 1 m in length, and is not commercially fished (Nakamura and Parin 1993).

Two specimens of Galápagos drum (gungo de Galápagos), *Pareques perissa* (Heller and Snodgrass 1903), including a large and badly-damaged adult were collected (CAS 86808, ~230 mm SL, and CDRS V-1226, 183 mm SL). Endemic to Galápagos, this species is very secretive and normally found in reef crevices between 3-40 m depth. The maximum size of this species is 250 mm.

Several specimens of the deepwater oval damselfish (castañuela gorda), *Chromis alta* (Greenfield and Woods 1980), were observed and collected (CDRS V-1210, 1215-1219, 1221-1222, 1225, 100-120 mm SL). It is also known from the Gulf of California, between approximately 30-150 m depth, and from Cocos Island. This is the deepest-living damselfish in the Galápagos, and was observed below the thermocline by divers as shallow as 15 m, and observed from the *JSL* to be abundant along reefs to 200 m depth.

Three adult scythemarked butterflyfishes (mariposa guadaña), *Prognathodes falcifer* (Hubbs and Rechnitzer 1958), were photographed and preserved CDRS V-1229, 71-100 mm SL). It is an associate of deep reefs, and like the oval damselfish, is found in the Galápagos beneath the thermocline. It is also known from islands off Southern California and deepwater off Baja California and Costa Rica. In Galápagos we found it in water as shallow as 10 m, and observed it from the *JSL* to depths of 270 m off Isla Baltra.

Several specimens of two species of deepwater scorpionfish, genus *Pontinus*, were found dead and floating. The large gas bladder which extends from the mouth of rapidly ascending scorpionfishes insures that they will float to the surface after traumatic death. The mottled scorpionfish (pez brujo), *P. clemensi* (Fitch 1955), is a rock associate previously known from the type specimen, captured at 91 m off the coast of Colombia (Poss 1995). We observed specimens from the *JSL* at various locations in the Galápagos. The striped scorpionfish (brujo listado), *P. strigatus* (Heller and Snodgrass 1903), is a Galápagos endemic, first known from the holotype found within the stomach of a shark captured near Isla Wolf (Wenman). We observed individuals of *P. strigatus*, along with four other congeners, from the *JSL* at various locations, however we were unable at that time to identify each species with certainty.

Three species of morid cods were collected. The charcoal mora (carbonero de fango), *Physiculus nematopus* (Gilbert 1891) (and its synonym, *P. longipes* Garman 1899), reaches a length of 290 mm, is known from depths of 18-330 m, and is not a commercial species. It was previously known from Baja California to Panama (Paulin 1989), and we report it for the first time from the Galápagos (CAS 87927, 290 mm SL). Popeye mora (mora ojóna), *Laemonema gracillipes* (Garman 1899), were also captured (CAS 86548, 270-325 mm SL); it is known from waters off Panama and the Galápagos, between depths of 332-637 m. The third morid discovered represented a small new species of *Gadella* (Long and McCosker in prep.). Other specimens were observed and captured by the *JSL* at 485-580 m depth from a seamount SE of Isla San Cristóbal and from Cabo Hammond, Isla Fernandina.

An adult spotted brotula (brótula pintada), *Brotula ordwayi* (Hildebrand and Barton 1949) was collected (CAS 86500, 340 mm SL). It is generally found in shallow water, inhabiting crevices of rocky reefs, and is known from the Galápagos Islands and Perú.

Table 1 summarizes the specimens found floating during the eruption.

Table 1. Fishes collected by Godfrey Merlen during the eruption on Isla Fernadina, February 1995.

Collection/ Photo	Species	Family
CAS	*Faciolella gilberti*	Nettastomatidae
CAS	*Argyropelecus lychnus*	Sternoptychidae
CAS	*Maurolicus breviculus*	Sternoptychidae
CAS	*Hoplostethus pacificus*	Trachichthyidae
CDRS	*Myripristis leigonathus*	Holocentridae
CAS	*Epigonus sp.*	Epigonidae
CDRS	*Liopropoma fasciatum*	Serranidae
photo	*Epinephelus labriformis*	Serranidae
CDRS	*Paranthias colonus*	Serranidae
CAS	*Pronotogrammus multifasciatus*	Serranidae
photo	*Anisotremus scapularis*	Haemulidae
photo	*Sphyraena idiastes*	Sphyraenidae
CAS	*Aphanopus intermedius*	Trichiuridae
CAS	*Prognathodes falcifer*	Chaetodontidae
CAS, CDRS	*Pareques perissa*	Sciaenidae
CDRS	*Chromis alta*	Pomacentridae
photo	*Pontinus clemensi*	Scorpaenidae
photo	*Pontinus strigatus*	Scorpaenidae
CAS	*Brotula ordwayi*	Bythitidae
CAS	*Physiculus nematopus*	Moridae
CAS	*Laemonema gracillipes*	Moridae
CAS	*Gadella sp.*	Moridae

CONCLUSIONS

We feel that the species-composition of our samples was an incomplete reflection of the total species comprising the Galápagos deepshore ichthyofuana. Several of the specimens were so intact that we surmise that causes other than thermal elevation may have killed many of the fishes. Other potential causes of mortality include acoustic shock, dissolved chemicals, suspended sedimentation, and embolism associated with rapid ascents. Most of the fishes that possessed gas bladders exhibited such organs distended from their mouths.

During the November 1995 HBOI/CAS Expedition, two scuba dives and two *JSL* submersible dives were made to assess the subsequent condition of the submarine lava flow. After ten months, little algal or invertebrate growth was seen over the new bottom. From the surface to 20 m, the primary fish observed was the coquito damselfish, *Nexilosus latifrons* (Tschudi 1845). From the submersible, few fishes, invertebrates or algae were observed at deeper depths. In conclusion, we thank the volcanic activity of Isla Fernandina for providing biologists with interesting specimens as well as an opportunity to follow the colonization of shallow and deep-slope Galápagos reefs.

ACKNOWLEDGMENTS

Many individuals have assisted us in this project, as well as with the operation of the Harbor Branch vessel *Seward Johnson* and its submersible, the *Johnson Sea-Link*, and the *R/V Ratty*. For assistance and permission to study in Ecuador, we sincerely thank: Ing. Oscar Aguirre, Subdirector de Pesca de Galápagos; Biól. Harold Müller and Dr. Franklin Ormaza-González, Instituto Nacional de Pesca; Lic. Arturo Izurieta Valery and Biól. Eduardo Amador, Servico Parque Nacional Galápagos; Teniente Alejandro Villacis, Capitan de Puerto, Puerto Ayora, Santa Cruz; and Dr. Chantal Blanton, Director of the Charles Darwin Research Station. Bill Bussing assisted with common names. Robert Lavenberg read an earlier version of this manuscript and provided advice on scorpaenids. Richard Rosenblatt, Scripps Institution of Oceanography, and William Eschmeyer and Tomio Iwamoto of the California Academy of Sciences permitted us to examine specimens in their care. We also thank the David and Lucile Packard Foundation and the Discovery Channel for grants and other assistance. TAME airline provided reduced air fare to and from the islands. Special thanks are due to the crew of *R/V Ratty* who skeptically sailed into boiling seas.

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John E. McCosker, California Academy of Sciences, San Francisco, California 94118, USA (e-mail: JMcCosker@casmail.calacademy.org). Godfrey Merlen, Charles Darwin Research Station, Isla Santa Cruz, Galápagos, Ecuador. Douglas J. Long, California Academy of Sciences. R. Grant Gilmore, Harbor Branch Oceanographic Institution, Fort Pierce, Florida 34946, USA. Carlos Villon Zambrano, Instituto Nacional de Pesca, Guayaquil, Ecuador.

THE CDRS HERBARIUM, AN OLD NEW RESEARCH TOOL FOR GALÁPAGOS

By: André Mauchamp and Iván Aldáz

"Where can I find *Sisyrinchium galapagense*?" "What is the variability of this particular species of *Scalesia*?" These are examples of common questions a herbarium curator is used to hearing. Many of the answers can be found affixed to the piles of paper stored in the shelves of this dark, strange-smelling room.

Many institutions have herbaria, but with the development of more highly technological sciences, their utility has recently been questioned. Are they necessary? Aren't they old remnants of another era of science, when Linnaeus and subsequent taxonomists were frequently describing new species?

Yes they are, and no they are not. We are again appreciating herbaria, collections and museums, realizing that our environment is changing rapidly and that these collections are often the only accurate "memories" that remain. Many fascinating studies on evolution and ecology were made measuring skulls in a museum or counting the stomatal density on centuries-old leaves taken from a herbarium (e.g., Penuelas & Matamala 1990). There is a qualification for the success of these "memories", they have to be representative, complete, kept in good condition, and easily available. Otherwise, the potential user will find more frustration than success and will join the army of detractors of collections of specimens.

The Herbarium of the Charles Darwin Research Station (CDRS) has gone through all these high and low stages and successive reports in the files of the Botany Department are witness to the difficulties of maintaining a good herbarium at the CDRS. However, since 1994 major efforts have been made to rehabilitate what is, in fact, the largest collection of specimens of Galápagos plants in the world.

In 1993, Eugene Moll remarked on the state of the herbarium in a report to the CDRS, "...it was not too good then [in 1990], and it is much worse now. In fact, it is a disgrace". We are pleased to announce that Eugene's comments were taken seriously and we wish he could return to see the results. Many of the necessary improvements made were suggestions accumulated over the years by successive visitors and users of the Herbarium. The first step was moving the collections to the new Fisher Science Building (March 1994) where they were isolated in a dehumidified room where no sunlight could enter to damage the specimens (Figure 1). Computerizing the collection records began and Iván Aldáz was hired as a permanent staff member responsible for the collections (April 1994). That was followed by acquiring two new specimen cabinets (September 1994) and a computer (June 1995), installing an air conditioner (July 1995), and recently changing the data-base to Access, more user-friendly than dBase IV. Moving the Herbarium was also a good change for the other Museum collections, which then expanded into the space vacated by the Herbarium, and are presently undergoing general improvements. In September of 1995 we began to collaborate with the Herbario Nacional de Ecuador for identifications (mainly of introduced species) and to exchange information and samples. Our Herbarium now deserves the international recognition it had since 1975, called CDS in the *Index Herbarium* (anonymous 1975).

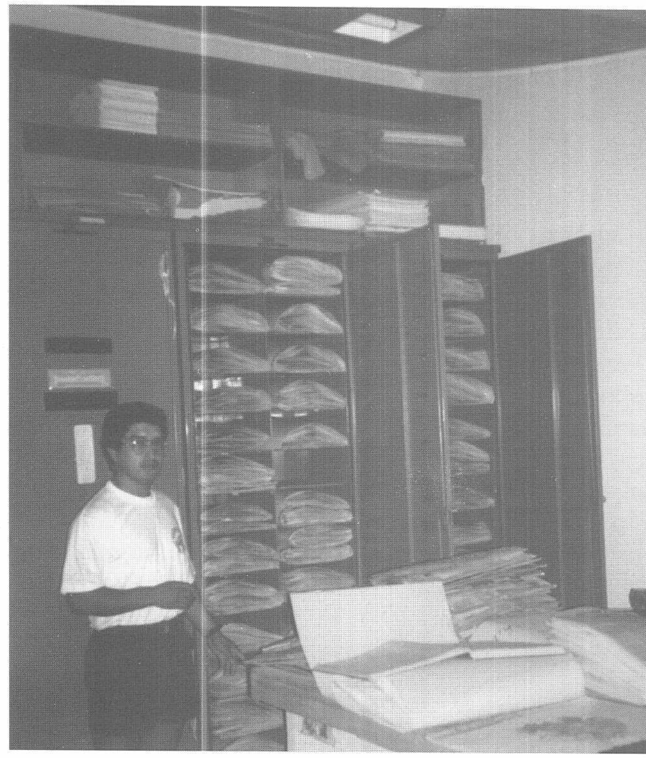

Figure 1. Iván Aldáz in the climatically controlled collection room of the CDRS Herbarium.

In 1995, the main users of the Herbarium were Drs. Conley McMullen, Yoshikazu Shimizu, Syuzo Itow and David Porter, all of whom came to Galápagos as visiting scientists. Several identifications were provided in particular to the program studying the nutrition of tortoises at the CDRS. Two students (Gioconda Villacis from the Universidad Técnica de Ambato and Sabina Estupiñán from the Universidad Estatal de Guayaquil) volunteered in the Herbarium and assisted in studies of endemic plants. Later, Ondina Landázuri of the Universidad Central de Quito and at least six students from local Galápagos schools have worked in the Herbarium for their studies.

Table 1. The main contributors to the collections of the CDRS Herbarium.

Collectors	Samples
Henning Adsersen	1,464
Charles Huttel	1,083
Jonas Lawesson	888
T. Loung	573

Table 2. Number of samples per island presently in the Darwin Station Herbarium.

Island	Samples
Darwin/Culpepper	14
Wolf/Wenman	28
Marchena	40
Genovesa	43
Santa Fé	91
Española	260
Floreana	329
Fernandina	372
Pinta	467
San Cristóbal	560
Santiago	623
Isabela	1,157
Santa Cruz	1,855

The data-base allows us to calculate a few statistics and point out interesting features of the collection. We have catalogued over 7,200 specimens and are growing quickly. The oldest specimen was collected by Peter Kramer in January 1963 it is a *Tribulus cistoides* from Isla Darwin (Culpepper). However, it is not sample #1 of the collection. CDRS #1 is a *Tournefortia pubescens* from Isla Santa Cruz collected by David Snow in February 1963 and was the first of a series of 300 samples. Ira Wiggins first collected plants in Galápagos in January 1964.

Henning Adsersen collected from March 1973 to January 1985, from a *Scalesia villosa* on Isla Floreana to an *Opuntia helleri* on Isla Genovesa, and Charles Huttel from January 1984 to July 1992, from a *Peperomia petiolata* on Isla Santiago to a *Cyperus andersonii* on an small islet near Santa Fé (Table 1). Charles Huttel was the main contributor for small islets through his participation in Howard Snell's Biological Diversity Program. A total of 84 collectors have provided samples to the Herbarium and some of these collectors include non-botanists and non-scientists.

Of course, not all the collections made in Galápagos are housed at the CDRS. Botanists began to collect in the 19th century (Porter 1822, Petit Thouars 1841, Hooker 1847) and these early collections are spread all around the world (California Academy of Sciences, Cambridge, etc.). Even more recently, some scientists have preferred to send their collections abroad. We only have twelve samples by Uno Eliasson (one of them being very important since it is our only sample of *Linum cratericola*, a nearly extinct species), and only one collected by Henk van der Werff (in 1974). Many of these collections were deposited away from Galápagos because there was no assurance that specimens would be well maintained at the CDRS.

Two genera are very highly represented. *Scalesia* has 214 specimens, and *Alternanthera* 200. Both have many taxa and attract attention. The distribution of the samples per island underlines one of our most difficult problems, the disparities of sampling effort (Table 2).

The almost scandalous dominance of samples from Isla Santa Cruz is obvious. On Isla Isabela, we can observe the same differences with 85 samples from Volcán Cerro Azul vs. 505 from Volcán Sierra Negra (and 17 from Volcán Ecuador). The small islands which were included in the Biological Diversity Project were systematically sampled and the numbers of specimens better reflect the biological diversity (e. g., Isla Darwin and Isla Wolf, or even Isla Gardner near Española with more samples than Isla Marchena). On the contrary, if Isla Pinta has more than ten times as many samples as Isla Marchena, it is probably because a botanist has worked there over many years (McMullen). This highlights a suggestion by Huttel in a CDRS report that will keep us busy for years to come, which is to identify the poorly sampled areas and ... go there!

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André Mauchamp, Former Head of the Botany Department, CDRS. Station Biologique de la Tour du Valat, Le Sambuc, 13200 Arles, France.
E-mail: a.mauchamp@sansouire-tourduvalat.fr.
Iván Aldáz, Botany Department, Charles Darwin Research Station, Puerto Ayora, Galápagos.

HEMIARGUS RAMON (DOGNIN, 1887) (LYCAENIDAE: POLYOMMATINAE) A NEW RESIDENT BUTTERFLY OF THE GALÁPAGOS ISLANDS

By: Lázaro Roque Albelo, Valentina Cruz Bedón, and Gerardo Lamas

The butterfly species *Hemiargus ramon* is distributed from southwestern Ecuador to northwestern Chile (Tarapaca); however, until now it has not been collected in the Galápagos Islands (Linsley and Usinger 1966; Linsley 1977).

Between January 1995 and August 1996 two authors (LRA and VCB) collected a series of specimens of this tiny species on the islands of Baltra, Española, Floreana, Isabela, San Cristóbal, Santa Cruz and Santiago (Figure 1).

The butterflies of the family Lycaenidae from the genus *Hemiargus* have slow flight and are generally associated with areas of human habitation. In Galápagos, we have observed oviposition of this species on the following plants: *Cucumis dispsaceus* (Cucurbitaceae), *Cassia hirsuta* (Leguminosae), *Prosopis juliflora* (Leguminosae), *Neptunia plena* (Leguminosae), *Rhynchosia minima* (Leguminosae) and *Phaseolus atropurpureus* (Leguminosae). Another lycaenid species occurs in the archipelago, *Leptotes parrhasioides* (Williams 1911), which is similar in external appearance to *H. ramon*,. Both species form small metapopulations closely associated with their specific host plants.

Roque (in press) recognized three mechanisms by which the butterflies can arrive to the Galápagos Islands: a) on natural rafts; b) by air, flying actively or passively; or finally, c) transported intentionally or accidentally by humans. It is difficult to determine which of the three mechanisms could have been responsible for the arrival of *H. ramon* to the Galápagos Islands but it's accidental introduction by man seems the most likely. Upon arrival the establishment of this species would not have been difficult since it could utilize many host plants, mainly from the Leguminosae family which is well represented in Galápagos.

Voucher specimens of *H. ramon* have been deposited in the entomological collection of the Charles Darwin Research Station Museum on Isla Santa Cruz , Galápagos and the Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Lima, Perú.

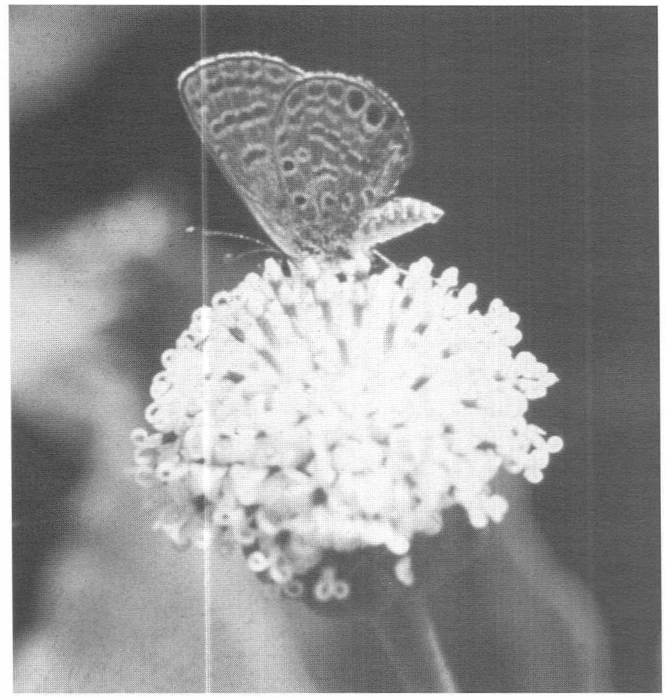

Figure 1. *H. ramon* on flowers of the endemic Galápagos plant *Scalesia affinis*.

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Lázaro Roque Albelo, Charles Darwin Research Station, Puerto Ayora, Galápagos. Valentina Cruz Bedón, Puerto Ayora, Galápagos. Gerardo Lamas, Museo de Historia Natural, Universidad Nacional Mayor de San Marcos, Apartado 14-0434, Lima-14, Perú.

FIRST REPORT OF PENGUINS NESTING ON ISLA FLOREANA

By: Hernán Vargas, Heidi M. Snell, Howard L. Snell,
Gary Miller, Rob Miller and Hector Serrano

During late 1996 we found two penguin nests on Isla Floreana where there has been no previous record of penguin reproduction. The first nest was found while most of the authors were collecting blood samples from the penguin populations within Galápagos. The second nest was found in August, 1996 during the annual penguin census in the archipelago (Mills and Vargas, *this issue*).

THE DISCOVERY OF THE FIRST NEST

The "Penguin Expedition" set out for five weeks during May and June of 1996. The goal was to collect sufficient blood samples to determine the genetic variability within different populations of Galápagos penguins as well as the relationship of this species to other species of penguins worldwide. On the first of June we began working on the northwest coast of Isla Floreana, the area from Post Office Bay to Black Beach (Figure 1). At the base of Cerro Daylight we found one pair of penguins. Continuing our search along the coast, just in front of a tiny islet known as Piedra Dura (Hard Rock), 1° 14'18"S, 90° 28'42"W, we found another adult penguin resting on the rocky shoreline. We attempted to capture it, but it outmaneuvered the land team and moved further inland instead of into the sea as these penguins often do. The team searched in the cracks and amid piles of basalt until they located it. Samples from penguins of Floreana were too few to give up without a thorough search. Our success was extra sweet since not only did we find the penguin in its cave, but it had joined its mate which was incubating two eggs on the first nest known from Isla Floreana (Vargas 1996).

THE 1996 PENGUIN CENSUS AND THE SECOND NEST

During the census on 23 August 1996, a second nest was found at the base of Cerro Daylight in a small cove, 1° 13'43" S, 90° 28'10" W. This nest had a single chick which was estimated to be approximately thirty days old. To our great joy, the two eggs we found in June had become feathered and robust chicks by the time that nest was checked in August. The distance between the two nests (1.5 kilometers) was determined with the help of a GPS (Global Positioning System) receiver that provided accurate latitude and longitude coordinates (Figure 1).

PENGUIN CENSUSES OF FLOREANA

The past censuses made by Charles Darwin Research Station (CDRS) and Galápagos National Park (GNP) personnel have included Isla Floreana as a census site since 1993 and during those times have registered between four and eight penguins (Table 1 and Mills and Vargas *this issue*).

The data also indicate that no more than three juveniles have been reported in any year. The presence of the juveniles indicates that the penguins from the Isla Floreana population may have been reproducing since 1993, but we can not discount the possibility that the juveniles seen previously could have been migrants from other islands such as Isabela, Fernandina, Santiago or Bartolomé, although that seems unlikely.

THE HISTORY OF PENGUINS ON FLOREANA

How long have penguins been living on Isla Floreana? Charles Darwin did not record penguins in Galápagos after his visit to Isla Floreana in 1835. Dr. Kingbird visited the island in 1852 and also did not mention observing penguins there even though the expedition collected specimens from Isla Santiago (those specimens were used in the original description of the species, Sundevall 1871).

It is possible that the naturalist Theodore Wolf was the first person who observed or at least report his observations of penguins on Isla Floreana, in Post Office Bay, in 1875 (Ridgeway 1896).

Members of the California Academy of Sciences (CAS) spent 33 days in repetitive visits to Isla Floreana during their 1905-1906 Expedition and noted, "Several were seen at each of the following places, viz.: Cormorant Bay, Post Office Bay and Black Beach Roads, Charles Island " (Gifford 1913, Swarth 1931). The CAS Expedition also

Table 1. Number of penguins observed on Isla Floreana from 1993 to 1996. The censuses have included the coast from Punta Cormorant to Piedra Dura.

Adults	Juveniles	Total	Year
4	1	5	1993 Penguin census
6	0	6	1994 Penguin census
3	1	4	1995 Penguin census
5	1	6	1996, June: *Prima* Expedition
5	3	8[1]	1996, August: Penguin census

[1] The total number of birds for August, 1996, does not include the three chicks found in the nests.

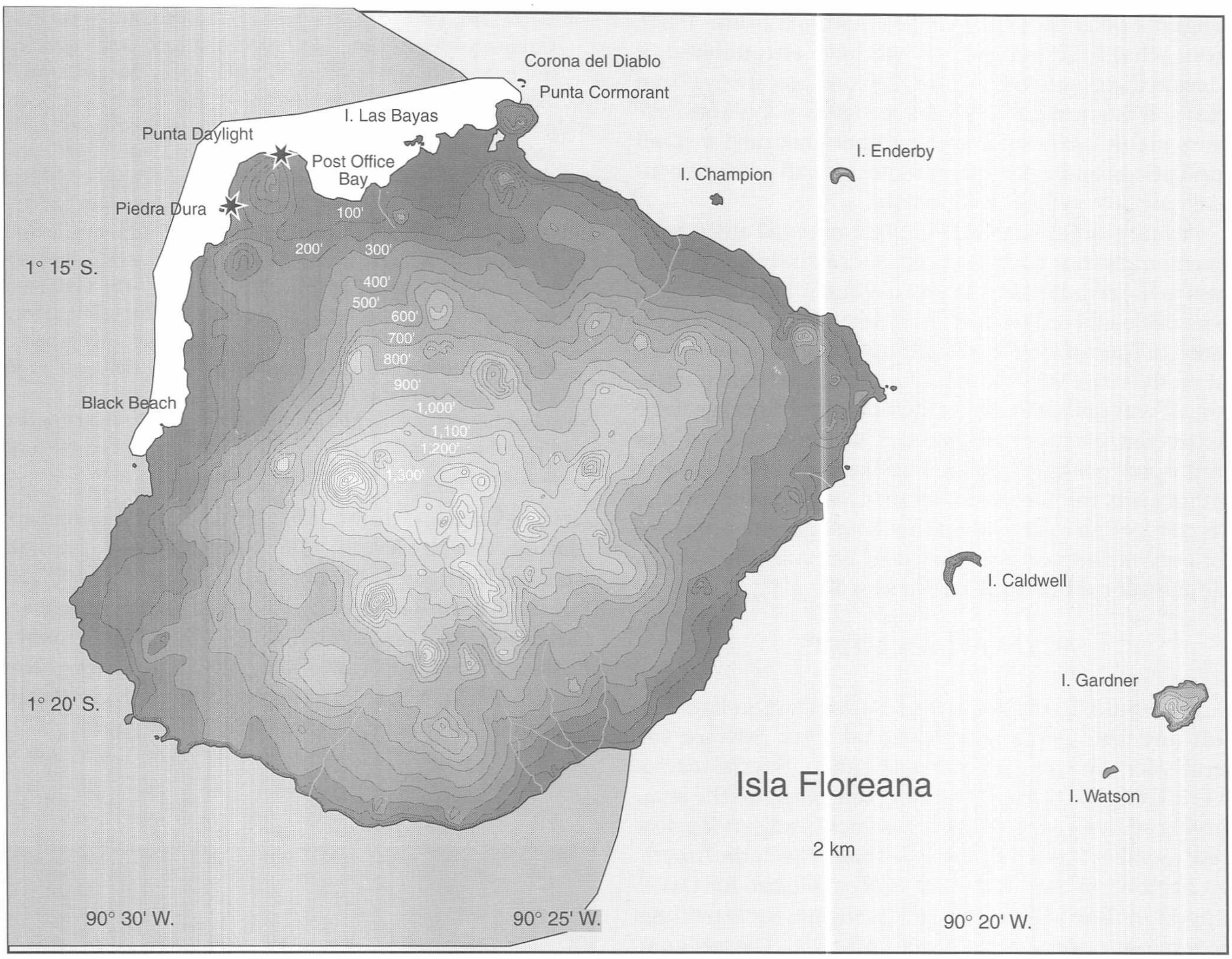

Figure 1. The two nest sites, the known distribution of penguins, and the areas of ocean-current upwelling around Isla Floreana. Nests are indicated by stars at the northwest corner of the island. The white region encompasses the known distribution and the darker grey area corresponds with the upwelling zone.

collected one penguin from Punta Cormorant, Isla Floreana.

Rolf Wittmer, a long-time resident of Black Beach, Isla Floreana, assured us that he has observed a small population (no greater than ten) of penguins since 1951. According to him, the penguins are always found in the coastal section between Punta Cormorant and the Lobería near Black Beach. His observations coincide with those of Gifford (1913) and those of the fisherman, Iván Escarabay (personal communication) who is a resident of Black Beach. By comparing old data with that of the present, we conclude that the penguin distribution on Isla Floreana has been maintained without obvious changes.

What is the limiting factor of this population? Is the population increasing, declining, or relatively stable? According to the data, the small range of fluctuation (4 to 8 birds) suggests that the population is relatively stable, but small. Such stability could indicate that a population is regulated by density-dependent factors, such as competition for food. If we assume that negative effects of introduced animals are absent, it is possible that the population is regulated by food abundance in the area of upwelling on the north and west coasts (Houvenaghel 1978, Figure 1).

This hypothesis would help to explain the absence of penguins on the east side of Isla Floreana, though it is difficult to understand the absence of the birds along the south coast which has a great deal of upwelling. Part of the uncertainty for these last two areas could be because the southern and eastern coastlines are very rough and dangerous regions where there has been little travel or exploration throughout the history of Galápagos. Since it is a little known area, it is conceivable that a few penguins may live along the rugged coast and have thus far escaped detection.

Unfortunately we do not know about the status of penguins on Isla Floreana before its colonization by humans in 1832. We are equally unaware of their exact numbers before the strong El Niño event of 1982-1983, where there was a 77 percent decline in the populations of penguins on Islas Isabela and Fernandina (Valle 1983). From what little information we have encountered, it appears the population of Isla Floreana has always been small. It is surprising that the penguin population appears stable with such low numbers because a small population can be especially vulnerable to environmental changes or catastrophic events.

Future studies should help determine the answers to several questions such as the rate of recruitment of juveniles to the population, the loss of genetic variability due to possible inbreeding and the impact of introduced animals. In June of 1996 we found a herd of six goats and a cat on the coast very close to the site of the first penguin nest. It was ominous that at the same time the eggs were discovered, a cat was also seen. We don't know if cats prey upon penguin chicks, but the nests are certainly within areas frequented by them. Despite these threats, it is comforting to know that the Galápagos penguins are not only nesting on the islands of Fernandina, Isabela, and Bartolomé but on Floreana as well.

ACKNOWLEDGMENTS

We would like to thank the Charles Darwin Foundation and the Galapagos National Park Service for permission to carry out this investigation. Special thanks to Eric Craig for tirelessly fending the panga off the lava, helping with all aspects of the research, and serving as a crew member aboard *Prima*. We thank the Latin American Institute of the University of New Mexico for travel support for Rob Miller, and TAME airlines for providing air travel for everyone at a reduced rate. The penguin census was financed by the GNPS and the Penguin Fund of Japan. And lastly, thanks to *R/V Prima*, who graciously tolerated her decks and interior littered with molted penguin feathers during that trip and for many months thereafter.

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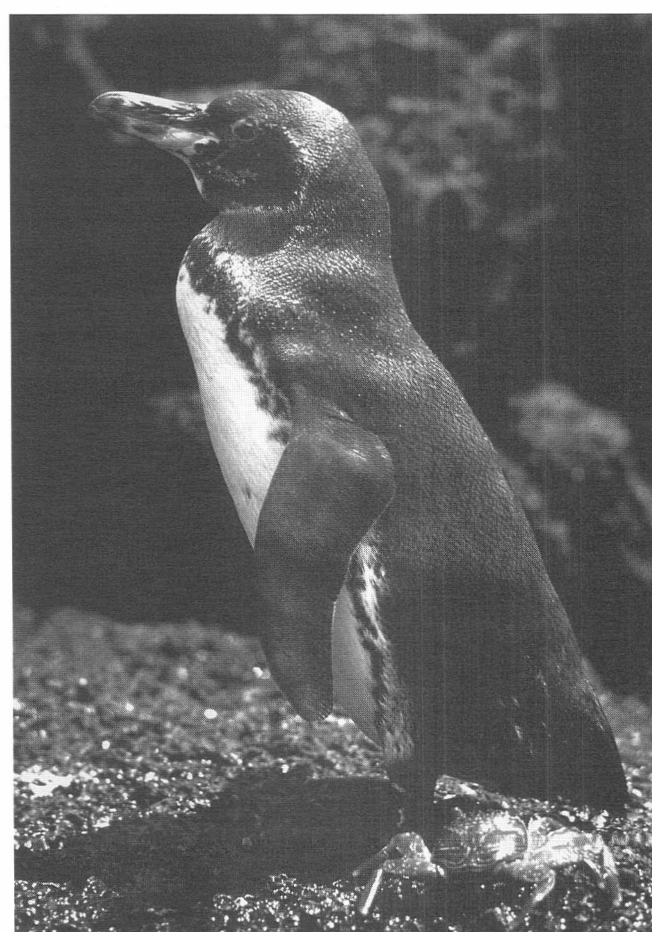
Hernán Vargas, Ornithologist, Charles Darwin Research Station, Puerto Ayora, Galápagos (E-mail: hernanv @fcdarwin.org.ec). Heidi Snell, R/V *Prima*, CDRS, Puerto Ayora, Galápagos (hsnell@fcdarwin.org.ec.). Howard Snell, Gary Miller, Rob Miller, Department of Biology, Univ. of New Mexico, Albuquerque, New Mexico 87131, USA. Hector Serrano, Servicio Parque Nacional Galápagos, Puerto Ayora, Galápagos.



HUMPTY-DUMPTY

By: Scott Shouse

No one said a word, we just looked up, trying to see the object we could hear crashing through the brush towards us. André, Iván and I were standing a few meters above a thundering steam vent inside the crater of Volcán Alcedo, the steam itself emitting from a smaller crater. With the steam cloud the size of a building behind us, occasionally engulfing us in sulfur smelling puffs of white, we tilted our heads back to look up the 100 m high, 50 m wide, slope of bare soil to the rim of the crater. It took only a second to identify the source of the disturbance, it was as big as a living room reclining chair and headed right for us. I am not sure if the words were spoken or only thought, but I'll never forget the instant I realized what it was. "It's a tortoise", I said (or thought). I could summon no more emotion than that as I was mesmerized by the spectacle, as I believe we all were. The giant tortoise crashed and rolled down the 30 degree slope as if he were doing cartwheels, his legs and neck extended, in what I assume was a vain attempt to slow his downward progress. He finally came to rest 15 m above us, stomach down, legs and neck extended, broken and bleeding. The three of us hustled up the steep slope to help the old man down from his teetering position. We managed to ease his estimated 140 kg down to a more level surface where he was less likely to further hurt himself in his confused state. His large shell was broken in three different places, the crack above his right rear leg steadily trickling blood. He had also received a bloody cut on his right tympanum and a blow that closed his left eye. As we sat on the ground just a meter or so uphill, slowly realizing how little we could do, a smaller tortoise happened by the scene of the accident while making his way towards the volcano rim from the crater floor. The smaller, younger tortoise moved in close to the battered veteran and began sniffing wildly as if he were greatly disturbed. The elder tortoise appeared to make an effort to respond in kind but lacked the strength to move very much. I am usually not prone to see human characteristics in animals but in this instance I agreed with André. There was an eerie human quality to the exchange and it gave me goose bumps all over. After the smaller tortoise decided it was time to be on his way, a Galápagos hawk swooped down and landed on the downhill side of the tortoise, about three meters from us, and began drinking from the stream of blood flowing from the giant reptile. While the warm clouds of steam continued to waft around us the hawk hopped onto the tortoise's shell, appetite whetted, and raised one leg in a position of rest. It appeared to be waiting for the probable death.

André Mauchamp, Head of the Terrestrial Plants Group of the Charles Darwin Research Station, Iván Aldáz, Herbarium Manager, and I had come to Volcán Alcedo to establish sampling areas for a long term study monitoring the plants of the volcano. The fourteen permanently installed plots lay scattered on the southern facing slopes of the outer volcano, not coincidentally in the area with the highest goat population. The idea is to observe long term changes in the vegetation in the area most visited by the voracious goats. When we finished installing the plots we found ourselves with an extra day or so to look around and so came to be witnesses to the unfortunate mishap. After collecting our thoughts we decided we should write down what information was available to give to the tortoise census group who had come with us to Alcedo. We found that the tortoise had a number (1180) on the rear of his shell indicating that he had already been measured by the census takers (we later found that 1180 had a long curve measurement, the top of the shell from head to tail, of 140.3 cm or 55 inches). We wrote down the number and made a sketch of the shell and wounds and, feeling just a little guilty left our wounded friend, to make our way back to camp two and a half hours away. The following day we were to break camp and walk the eight kilometers to the beach where the *Beagle* would be waiting to pick us up to return to the Darwin Station. Despite the long walk down to the beach, André and I decided to return to the fumarole early the next morning. It would add five and a half hours of walking to our day, but it would have weighed heavily on our conscience to leave without checking. The next day the old man was alive but apparently disoriented and still bleeding slightly. We didn't find out much but we both agree that it was worth the trip (and blisters).

Six months later we returned to Volcán Alcedo to do the scheduled collection on the fourteen plots and, if time allowed, to look for our behemoth friend. We finished the data collection with just enough time to walk down the inside of the crater to the place we had left the tortoise. The giant column of steam had abated to a few barely visible wisps and a boiling pond of black mud while the barren area above the fumarole remained without vegetation like a giant brown thumbprint on the lush green hillside. We found the bicentenarian (possibly tricentenarian?) just where we had left him, now nearly completely decomposed. The giant shell was empty except for a meandering trail of digested grasses that were once surrounded by intestines. He was easy to identify by the broken places on his shell we had sketched before.

Up to this incident I had never considered causes of tortoise mortality to be anything but old age or hungry seamen of earlier times. I had seen many empty, sun-bleached shells in various places around the volcano and had even seen a smaller tortoise climbing into a vacant shell, much larger than his own, looking for shade. But looking around the hot barren soil above the fumarole, I noticed several empty shells scattered about in various degrees of decay. This gave me cause to rethink the idea that tortoises have nothing to fear but old age. It occurred to me then that we had seen several living tortoises with damaged shells that had healed in a not so attractive manner. We had wondered aloud at the possible causes. I suppose it would be a great understatement to say that the movements of a giant tortoise are somewhat less than cat-like. And even though I am quite fond of the large reptiles it would be less than honest to deny their clumsiness. Having their own lack of agility against them in an environment as harsh as Galápagos can be, I can't imagine that they could stand too much competition from a bunch of smelly goats or braying burros. It is like having someone bully your slightly muddled younger brother who doesn't have the wherewithal to defend himself. You feel you need to protect them knowing they cannot defend themselves and they do not need any additional problems in the struggle to survive.

Scott Shouse, U. S. Peace Corps Volunteer, Terrestrial Plants, Charles Darwin Research Station, Isla Santa Cruz, Galápagos, Ecuador.

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