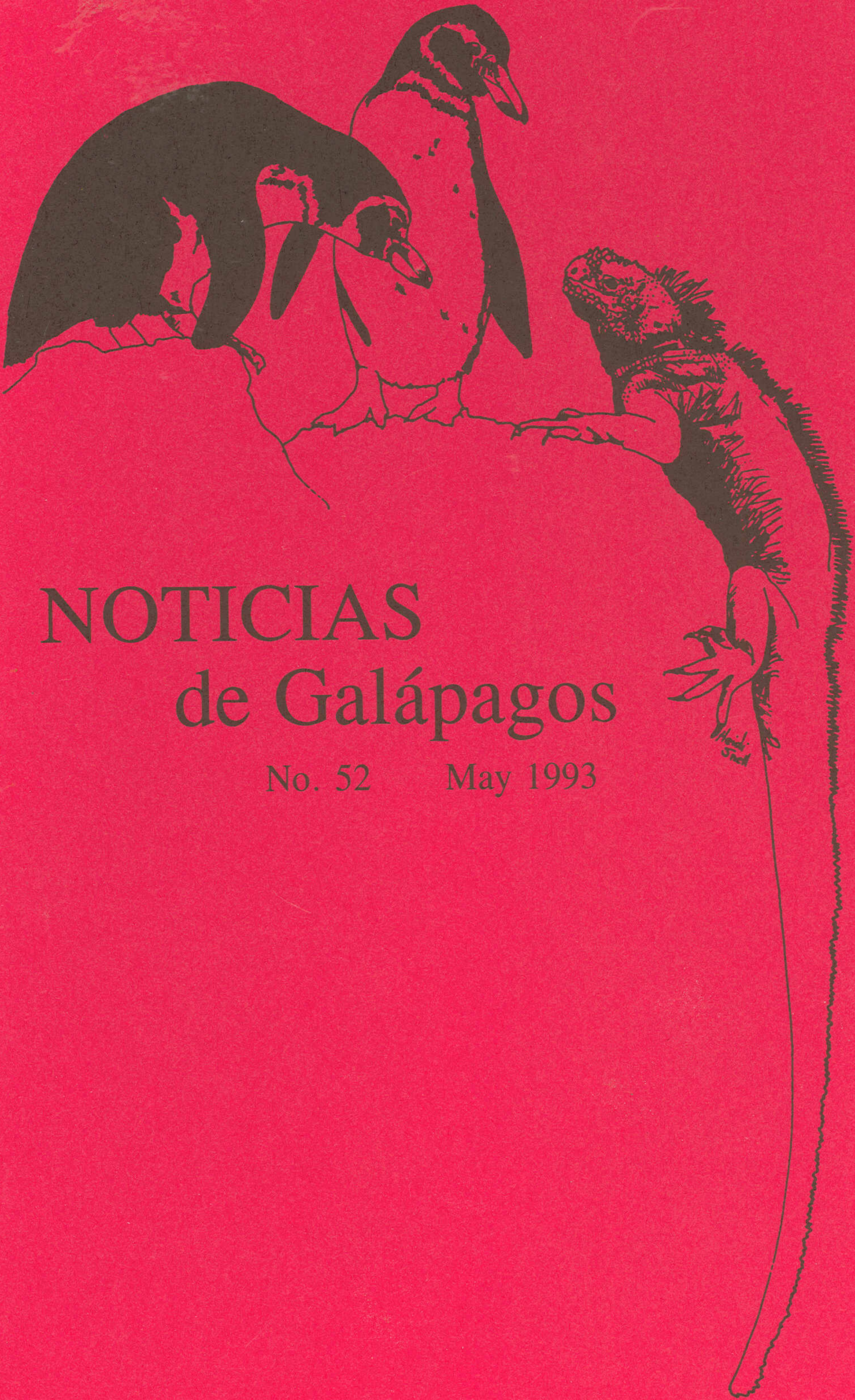

NOTICIAS de Galápagos

No. 52 May 1993

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We are grateful for your steadfast support and help.

NOTICIAS DE GALAPAGOS

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

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Published by The Charles Darwin Foundation for the Galápagos Islands

An International Organization created under the auspices of the Government of Ecuador, UNESCO, and the International Union for the Conservation of Nature & Natural Resources

Partial Financial Assistance from the Tinker Foundation, Inc.

Printed by the University of New Mexico Printing Services

CHARLES DARWIN FOUNDATION FOR THE GALAPAGOS ISLANDS

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NEWS FROM ACADEMY BAY

Ecología de los Chivos Ferales (*Capra hircus*) en el Volcán Alcedo.—En la Isla Isabela hasta hace 12 años, la distribución de los chivos ferales se restringía sólo al Volcán Sierra Negra. Sin embargo, en los últimos 4 años la migración y colonización se incrementó rápidamente hacia el norte de la Isla. Actualmente los chivos están ocupando diversas áreas del Volcán Alcedo. Consecuentemente, los efectos ecológicos que pueden ocasionar estos herbívoros pueden ser extremadamente devastadores con la inminente destrucción de la cobertura vegetal, erosión del suelo, probable extinción de especies de plantas nativas y endémicas y la eventual competencia por alimento y hábitat con la mayor población de tortugas terrestres (*Geochelone elephantopus vandenburghi*) del Archipiélago (3 a 4,000 individuos). Con estos antecedentes y buscando información que permite especializar los métodos de control, manejo, y erradicación de chivos se realizó durante 1991 un estudio sobre la distribución, estructura poblacional, área de vida, ciclo reproductivo, y comportamiento alimenticio entre otros de los chivos.

Los chivos en el Volcán Alcedo están distribuidos en el Sur, lados Este, y Suroeste del mismo. Grupos esporádicos se localizan en las costas con tendencia general de migrar y ocupar la parte norte del Volcán. Las migraciones más representativas de las poblaciones de chivos se dan en la época de garúa o de frío, debido principalmente a la falta de agua y de alimento. Existen solamente tres grupos de chivos en el cráter y uno en el Suroeste del Volcán, con un promedio de 18.2 individuos/rebaño. El tamaño y composición de los rebaños no varia con las estaciones climáticas. El área de vida de los chivos en el Volcán fue de 1.3 km^2, el área ocupada por las hembras fue mayor que la de los machos pero no difieren significativamente en ninguna época del año. Los chivos se reproducen durante todo el año, con picos de reproducción en la época de calor. Solamente de cinco especies de plantas se alimentan los chivos, siendo la más frecuente *Blainvillea dichotoma* (Compositae). Existe competencia por la disponibilidad alimento y espacio entre los chivos y tortugas, especialmente en la época de frío. Se incrementó grandemente el rendimiento, eficacia de la cacería con el uso de radiotelemetría y con la información obtenida. Esto permite planificar estrategias de diferentes niveles para el control y el posible exterminio de esta especie en el Volcán. **Edgar Muñoz, Estación Científica Charles Darwin, Isla Santa Cruz, Galápagos, Ecuador.**

Ecology of Feral Goats *(Capra hircus)* on Alcedo Volcano.—Twelve years ago, on Isla Isabela the distribution of feral goats was restricted to Sierra Negra Volcano. However, within the last 4 years, migration to and colonization of areas to the north increased rapidly and goats are now found on Alcedo Volcano. The ecological effects that these herbivores can cause could be devastating, with destruction of the vegetative cover, soil erosion, possible extinction of native and endemic plant species, and competition for food and space with the largest population of giant tortoise (*Geochelone elephantopus vandenburghi)* in the Archipelago, numbering 3,000-4,000 individuals.

Given this background and a literature search that allowed specialization in the methods of control, management, and eradication of goats, a study was conducted in 1991 on the distribution, population structure, home range, reproductive cycle, and feeding behavior of the goats.

The goats on Alcedo Volcano are distributed in the southern, eastern, and southwestern flanks. Sporadic groups are found on the coasts and have a general tendency to migrate towards and occupy the northern part of the volcano. The most representative migrations of the goat population occur in the garúa or cold season, due principally to the lack of water and food at this time. Only three groups of goats occur in the caldera and one in the southwest of the volcano, with an average of 18.2 individuals per herd. The size and composition of the herds do not vary with the seasons. The home range of the goats on the volcano averaged 1.3 km^2. Females averaged larger home ranges than males although the difference was not significant in either season of the year. Reproduction occurred throughout the year, with peaks in the hot season.

Only five species of plants were recorded as being consumed by goats, with *Blainvillea dichotoma* (Compositae) being the most frequently eaten. There is competition for food and space between goats and tortoises, especially during the cold season.

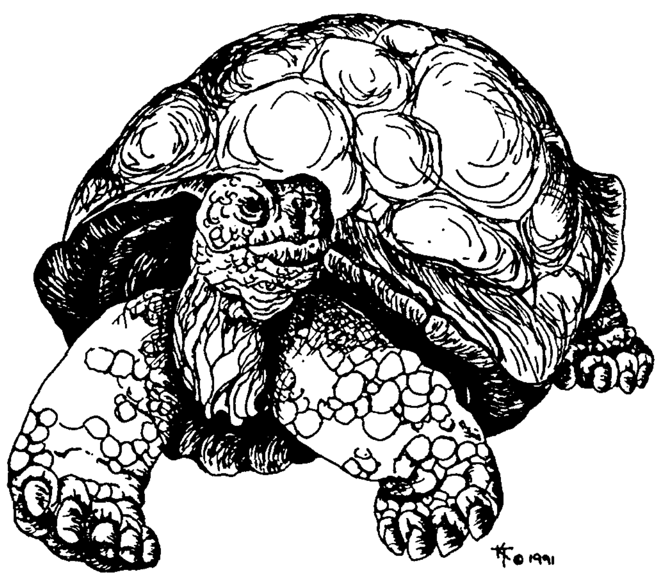
The yield and efficiency of hunting efforts increased greatly with the use of data obtained with radiotelemetry. The information gained from the study will permit the planning of strategies for the control and possible elimination of goats from Alcedo Volcano. **Edgar Muñoz, Charles Darwin Research Station, Isla Santa Cruz, Galápagos, Ecuador. (Translated by Gayle Davis-Merlen.)**

Pepino War, 1992.—If I had been born in the Guasmo of Guayaquil, into the abject poverty that occurs there, into a world of harsh survival, into a world without trinkets and fancy toys such as television, Betamax, and gaudy clothes, I would jump with glee to be offered ten thousand sucres a day to pick animals from the sea floor, to be able to join the wealthy elite gaining the power to buy my own baubles and vodka and Nike® shoes.

Thus it was that people were drawn to the black shores of the western islands of Galápagos in search of a fortune lining the floor of the ocean, their pathetic camps gaining a toehold on the harsh shoreline under a brilliant sun. It sparked a war between the conservationists, most of whom probably had their vodka and Nike shoes, and the entrepreneurs and employees of the ill-conceived plan to rashly overexploit a resource, sea cucumbers, or "pepinos del mar," in one of the world's most famous archipelagos.

It was, in the end, after accusations, threats, and anger, a victory for the conservationists. Stumps of cut mangroves will now be healing. Endemic rice rats on Fernandina will hop, kangaroo-fashion, during the dawn and dusk under the brooding volcano, temporarily free from the imminent threat of extinction by the accidental introduction of exotic rats by people unaware of the damages rats cause. The treasure seekers have returned, bankrupt, to the Guasmo. And we will sit down to sip our vodka and remove our new Nike shoes from our tired feet. **Godfrey Merlen, Isla Santa Cruz, Galápagos, Ecuador.**

Editor's Note.—Godfrey Merlen's graphic prose refers to one of the most recent face-offs between commercial pressures to allow unlimited harvest of natural resources and the desire to conserve Galápagos ecosystems. The conflict comes from economic desires to exploit resources in Galápagos risking major ecological perturbations versus the goal of preserving Galápagos for all of Ecuador and humanity by limiting commercial exploitation of resources to levels and uses that are sustainable and compatible with conservation of the terrestrial and marine ecosystems. In contrast to the long-term, ongoing management studies conducted in the terrestrial environment by the Servicio Parque Nacional Galápagos and the Charles Darwin Research Station, little is known about the potential sensitivity of Galápagos marine communities to commercial exploitation. While the battles between entrepreneurial and conservation interests will continue, clearly more scientific studies are needed in this environment before commercial activities can be safely permitted. [THF]



FLOTSAM AND JETSAM

By: Godfrey Merlen

On the evening of 24 November 1992, I was walking homeward when a motorcycle pulled up beside me. Astride it was Oswaldo Sarango, Chief Naturalist of the Servicio Parque Nacional Galápagos. He excitedly told me a guide had reported that a large marine mammal was washed up on the beach at Punta Núñez, 4 miles to the east of Puerto Ayora. By the size of its teeth, it was rumored as being a "morsa" (walrus). Since dark was coming on and the trail rough, I decided to leave at daybreak to resolve this issue.

Thus, at 0520, whilst the village slumbered on, I set out. Two hours later, having ascended and descended the coastal cliffs, I was walking upon the beachhead just short of Punta Núñez. To this point, I had not seen anything along the way that might justify the rumor, but I was kept amused by marine iguanas, who were using the various remains of wrecked boats as their dormitories. It was also clear that man had, and still was, making use of the same remains for his occasional abode.

Then I spied the remains, a brownish-yellow object draped over the rounded black boulders near the high tide mark. Coming closer, I was disappointed to see that the head was absent. Even so, it was obviously a large pinniped of some kind. Casting around, I was rewarded by the discovery of a massive cranium some 10 m from the body. A little more searching uncovered the mandibles. From these remains, I was well satisfied that what was in front of me was a South American sea lion *Otaria flavescens* formerly *byronia*. The skull was far too massive for any pinniped resident in Galápagos (*Zalophus californianus* or *Arctocephalus galapagoensis)* and certainly this was no "morsa," whose skull shape I had become familiar with in Alaska.

Thus, for only the second time, the remains of a South American sea lion had been identified from Galápagos. The first was reported by Wellington and de Vries (1976) on 10 October 1973 from Isla Pinta (the skeletal remains reside at the Darwin Station). This was, as in the present case, an adult male. This species has a marked sexual dimorphism with males being enormously larger than females.

Until that time, the northernmost record was from 4°S latitude (reported by Verrill in Scheffer 1958). This southern hemisphere pinniped has its range from Brazil, Uruguay, and Argentina to the Straits of Magellan, Chile, and Perú. Before the report of Wellington and de Vries, earlier reports had been dismissed as being unsubstantiated by specimens or proper descriptions, and misidentification with resident pinnipeds may have occurred.

It is interesting that the publication *El Observador Informativo* of the Fundación Ecuatoriana para el Estudio de Mamíferos Marinos first reported *Otaria byronia* in continental Ecuadorian waters. In the March-April 1992 issue, a photograph of two dead animals (which were later identified as *O. byronia)* from a beach at Salinas appeared and in the May-June issue there is a photograph of a live animal at Posorja, a fishing town at the entrance to the Guayas River. Apparently, this animal had become a mascot to the local fishermen who gave it food, although first reports stated that some fishermen wished to kill it because it was robbing fish from nets. Its fate is not known.

The animal at Punta Núñez was decomposing and had lost some of its extremities (phalanges plus right arm as far as the scapula). It lay draped on the rocks. Even so, I estimate it to have a length of about 2 m or more. Some photographs will be available; also, the cranium and mandibles, at least, will be preserved. The displacement of the head from the body can be explained, I believe, by the fact that no teeth were in the jaws. This area is visited by many people and the fact that the lower jaws had both been damaged suggests that the teeth had been forcibly removed by ivory hunters, which is a pity.

Although the Islands have been successfully colonized by two pinniped species, there does indeed seem to be some physical, thermal, or ecological barrier that has prevented this southern species from entering the Island habitat. There is no evidence to suggest that this animal ever cast his weary, sanguineous eyes over the black shoreline of Galápagos. The state of the body offers evidence that the creature had been dead for at least several weeks.

Note: Whilst defleshing the head, which luckily was largely clean, I was pleased to note a large number of endemic four-eyed blennies (*Dialommus fuscus*) skittering from rock to rock.

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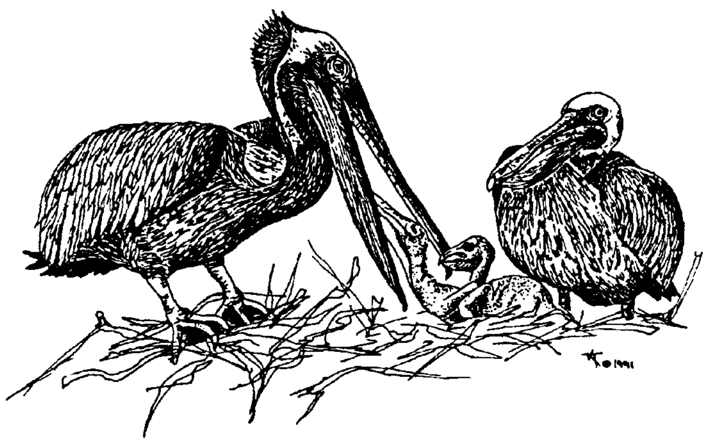
Godfrey Merlen, Isla Santa Cruz, Galápagos, Ecuador.



APPARENT POLLINATION OF *PORTULACA HOWELLI* BY RUDDY TURNSTONES (*ARENARIA INTERPRES* L.) ON ISLA PLAZA SUR

By: Francis E. Putz and Lisa C. Naughton

Bird pollination is a well-known phenomenon observed among a diverse range of birds including hummingbirds, blackbirds, sunbirds, and even woodpeckers. Within ecosystems with depauparate faunas, such as on isolated islands, plants may encounter a reduced set of potential pollinators. On 3 April 1991 we were surprised to observe Ruddy Turnstones visiting the large yellow flowers of *Portulaca howelli* in the *Sessuvium* dominated vegetation about 100 m from the shoreline on Isla Plaza Sur. More than 10 birds were observed visiting the flowers of this low-growing succulent. Each bird was observed to probe the usually single flower on a plant for 2 to 3 seconds, and then walk to the next plant and repeat the behavior. Each bird visited 12-15 flowers per minute during the course of our 2-hour visit. Bright yellow pollen was visible on the beaks of the flower-visiting birds. There was no obvious nectar in the flowers we observed but about half had small (1-2 mm), dark-bodied insects, including small flies (Diptera) and beetles (Coleoptera). We suspect that the turnstones were attracted to the flowers because of the presence of insects, but whatever the reason for their behavior, they appeared to be functioning as effective pollinators. **Francis E. Putz, Department of Botany, University of Florida, Gainesville, Florida 32611,**

THE VEGETATION OF ISLA SANTIAGO—PAST AND PRESENT

By: Ole Hamann

In October 1991, the Charles Darwin Research Station (CDRS) and the Servicio Parque Nacional Galápagos (SPNG) participated in a special visit to the Galápagos by H.R.H. Prince Henri of Luxembourg. The visit included field excursions to Islas North Seymour and Santiago, and on Isla Santa Cruz, so that the Prince could see conservation projects in action and get a firsthand impression of the problems facing the SPNG in safeguarding the flora and fauna of the Galápagos (Evans 1992).

Together with Rodrigo Crespo, Vice-President (Ecuador) of the Charles Darwin Foundation; Oswaldo Sarango, Acting Head of the SPNG; Edgar Muñoz of the CDRS; and Gabriel Almeida of the SPNG, I had the fortune to participate in the excursions. On Santiago we camped in the highland with the hunters and park wardens who spend long periods in the field hunting feral pigs and goats. During the few days available, park personnel demonstrated how the pig control program is carried out, and how this successfully has protected the nests of giant tortoises (*Geochelone*) and Dark-rumped Petrels (*Pterodroma phaeopygia*). We met with CDRS botanists Hugo Valdebenito and Lenin Prado, who were doing botanical research in the highlands, and we saw some of the fenced vegetation quadrats, established to protect small remnants of native vegetation.

It was a great experience to see conservation in action, and we were all impressed by the dedication and efficiency of the CDRS and SPNG teams. They clearly demonstrated that conservation in the field is hard work, carried out under very difficult conditions.

This visit, although short, also gave me the opportunity to compare the present state of Santiago with that of 19 years before, when I made my first visit to the Island. Obviously, the feral pigs and goats have had a very destructive impact on the Santiago ecosystems during this period, so the current major efforts by the CDRS and the SPNG towards eradicating these introduced mammals are not only justified but also very urgent.

THE VEGETATION OF SANTIAGO WAS GREEN AND FLOURISHING

During his famous visit to the Galápagos with HMS *Beagle*, Charles Darwin visited Isla Santiago (James) in October 1835. Darwin camped on shore for a week with the ship's surgeon, Benjamin Bynoe, and three sailors, and was particularly fascinated by the animal life. Of the land iguanas (*Conolophus subcristatus*) he noted "I cannot give a more forcible proof of their numbers than by stating that when we were left at James Island we could not for some time find a spot free from their burrows on which to pitch our single tent." On the plants and vegetation he noted, "As in the other islands, the lower region was covered by nearly leafless bushes, but the trees were here of larger growth than elsewhere.... The upper region, being kept damp by the clouds, supports a green and flourishing vegetation" (Darwin 1845).

Since Darwin's time, much has changed on Santiago. The land iguanas, then so numerous, have disappeared. When the California Academy of Sciences' 1905-06 expedition visited the Island, they only found a few bones, and no live land iguana has been recorded since. However, the vegetation was apparently in comparatively good shape at that time, according to the botanist of the Academy expedition, Alban Stewart. Although goats were introduced to Santiago for the first time already in 1813 by the U.S. frigate *Essex*, and then again in 1906 by Rollo Beck of the Academy expedition (Hoeck 1984), Stewart made no reference to the occurrence of goats on Santiago. If there were any on the Island by then, they must have been very few in number.

Stewart wrote the first extensive description of the vegetation zones of the Island, and it is worthwhile quoting his observations on the highland vegetation: "The rolling plateau ... is covered with forests of *Pisonia floribunda*, *Psidium galapageium*, *Scalesia pedunculata*, and *Zanthoxylum fagara*. The *Scalesia* trees are the most abundant in this region, and form true *Scalesia* forests, as on some of the other larger and higher islands of the group.... The *Scalesia* forests extend nearly to the top of the main crater on the leeward side, but on the windward side, which is bathed almost constantly by the strong southeast trade winds for several months of the year, the trees begin to thin out a short distance above the base of the crater and there are none at the top, although *Zanthoxylum* persists here as small gnarled bushes. Bushes of *Psychotria rufipes* are very common on this side and around the top" (Stewart 1915).

THE DESTRUCTIVE INFLUENCE OF GOATS AND PIGS

In August 1972 my wife and I spent a week in the Santiago highland together with Fausto Llerena, Galo Torres, and Angel Sanchez of the SPNG. While they checked tortoise nests and hunted goats and pigs, my wife and I investigated the plant communities. At that time it was still possible to discern the vegetation zones described by Stewart, but the Island had obviously suffered from the presence of large numbers of feral goats and pigs. In general, closed forest had been changed into steppe forest with large open areas devoid of trees in between. The *S. pedunculata* forests had almost completely disappeared; only small groups of old trees were found, mostly on cliffsides that were inaccessible even to goats. No regeneration of *Scalesia* trees was recorded. Large areas were covered with dense scrubby vegetation dominated by the shrubs *P. rufipes* and *Cordia scouleri*, and groves of tree ferns, *Cyathea weatherbyana*, were common on the steeper slopes of the many small craters. *Zanthoxylum fagara* was the most common tree all the way to the top of the Island; being long-lived and spiny, adult individuals were apparently not grazed or browsed by goats. However, the regeneration was very poor, and in many places the *Zanthoxylum* trees formed very open stands composed of old individuals only (Figs. 1 and 2), some of which had started to die off (Hamann 1981).

Several thousands of pigs and perhaps more than 100,000 goats were estimated to be present on Santiago by the early 1970s, and regular hunting expeditions became a prominent part of the work program of the SPNG, with the main focus on protection of the nests and nesting areas of the giant tortoises. In 1974-75 Lucho Calvopiña and Tjitte de Vries took the initiative to establish a series of seven fenced vegetation quadrants in order to study and preserve small remnants of the different vegetation types of Santiago (Calvopiña and de Vries 1975, de Vries and Calvopiña 1977). Since then, these fenced quadrants have been maintained and they have served a comparative study of plants in fenced enclosures and nearby open plots, thereby providing quantitative data on the impact of introduced grazers on the native vegetation. The results of this long-term comparative study were recently evaluated by Valdebenito and Prado, who found a striking difference in vegetation within the enclosures compared with the open areas where goats have access. Inside the enclosures, endemic and native species such as *Opuntia galapageia*, *Z. fagara*, *S. pedunculata*, and *P. galapageium* are all increasing in abundance, while outside the enclosures several species, including *Zanthoxylum* and *Scalesia*, are disappearing completely from the vegetation. Valdebenito and Prado concluded by recommending that several additional fenced enclosures should be established on those areas where the vegetation is vulnerable. Such fenced enclosures have three important objectives: they provide accurate data on the impact of the vegetation by introduced grazers, they provide protection against grazers for the native plant species, and they are "living seed banks" that in the future may serve as the nuclei from which the plants can start recolonizing the Island, once the introduced mammals have been eliminated (Hamann 1975, Valdebenito 1991, Valdebenito and Prado 1991).

ARE THE PLANTS ON THE VERGE OF EXTINCTION?

The deterioration of the vegetation on Santiago has clearly continued rapidly during the last decades, which is illustrated by the sets of photographs taken in 1972 and in 1991 (Figs. 1 and 2). During many years, the natural regeneration of numerous plant species has been almost totally prevented by grazing mammals, and whole vegetation zones have almost completely disappeared.

In general, seeds deposited in the soil seed bank may survive for a number of years, but eventually they germinate or die; if all emerging seedlings get eaten by goats, the remaining soil seed bank is gradually emptied. The only source for natural regeneration is, then, the seed production of the surviving, mature individuals, which on Santiago, however, are becoming fewer and fewer in number as

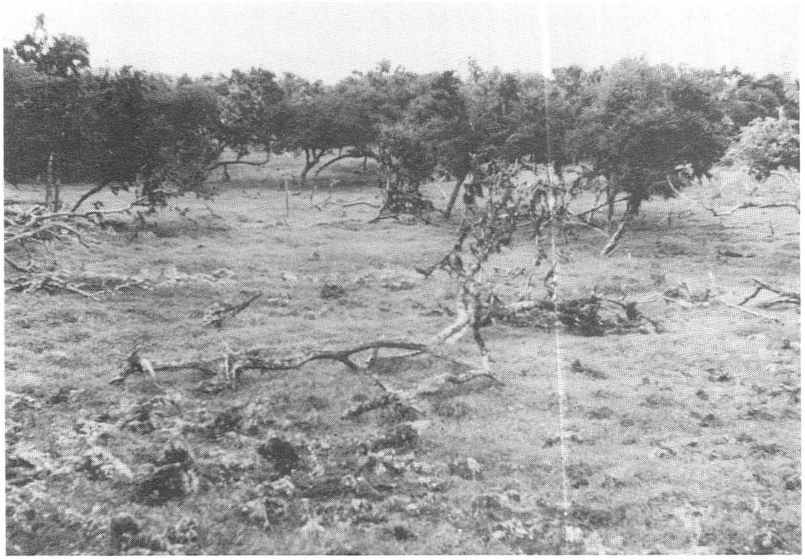


Figure 1 a. Highland area of Isla Santiago in 1972. The *Zanthoxylum fagara* trees obviously endured the intensive goat grazing longer than most other plant species. But in many places, only old individuals could be found, many were dying off, and almost all natural regeneration was prevented by the goats (above). *Zona alta de la Isla Santiago en 1972. Los árboles de* Zanthoxylum fagara *han soportado más el intenso pastoreo que otras especies de plantas. Sin embargo, en muchos lugares, sólo se han podido encontrar ejemplares viejos, muchos muriendo, y casi toda la regeneración natural ha sido impedida por los chivos (arriba).*

b. Dead *Zanthoxylum* trees in 1991. Large areas looked like this, being completely without any living trees or seedlings of woody plants (below). *Arboles* Zanthoxylum *muertos en 1991. Grandes áreas sin árboles o plántulas (abajo).*

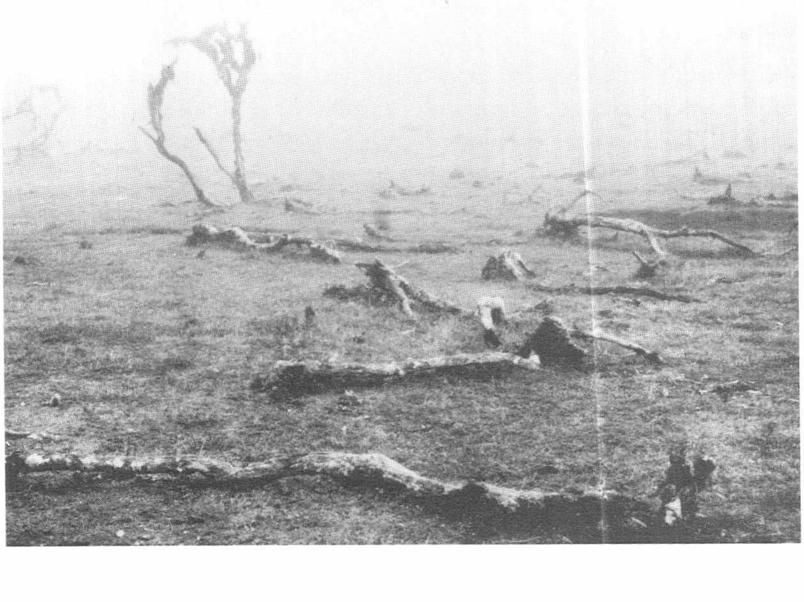


Figure 2 a. View from the highland towards north in 1972. In the foreground open steppe forest vegetation composed of dark *Zanthoxylum fagara* trees (above). *Vista de la zona alta hacia el norte en 1972. En el frente, el bosque abierto con la vegetación compuesta por árboles oscuros de* Zanthoxylum fagara *(arriba).*
b. View of the same general area in 1991 (note the two small hills in the center). The *Zanthoxylum* vegetation has almost completely disappeared, and only a few old trees are left (below). *Vista general de la misma área en 1991 (nótense las dos mismas pequeñas lomas en el centro). Los* Zanthoxylum *casi han desaparecido con excepción de unos pocos ejemplares viejos (abajo).*

they die of old age or are being destroyed by goats and pigs.

It is not known exactly how long the seeds of native Galápagos plants are able to survive under natural conditions. But for many species it is probably several years. Experiments carried out in the Botanic Garden, University of Copenhagen, have shown, for example, that seeds of the genus *Scalesia* are able to germinate after several years of dry storage (Hamann, in press), and that both arid zone and humid zone species of *Scalesia* keep their viability after years of dry storage. This means that the species probably are able to persist as seeds for some years in nature, in situ; it also means that it is possible to conserve the *Scalesia* species ex situ, outside their natural environment.

The native flora of Galápagos comprises some 596 taxa, of which 224 are endemic. Of these native taxa, 2 appear to be Extinct, 20 are considered Endangered, and 16 Vulnerable on an archipelago scale, according to the International Union for the Conservation of Nature and Natural Resources classification for threatened species (Lawesson 1990). One of the presumed extinct species, *Blutepharon rigidum* (of the Amaranth family), was only known from Santiago, from where it was collected twice, first by Baur in August 1891 and later by Stewart during the Academy expedition in 1905-06. Since then *Blutepharon* has never been found despite several searches, but it is impossible to say whether its extinction has been caused by the goats or by volcanic activity (Lawesson 1990).

However, other species are clearly close to extinction because of the goats. One is *Scalesia atractyloides*, a pretty shrub with narrow leaves and relatively large flowerheads. It only occurs in the arid zone on Santiago, and it is classified as an Endangered species. In the mid-1980s, the species was known to survive in very small populations at Buccaneer Cove and James Bay in the western part of Santiago and at one locality on the northeastern coast (Lawesson 1990; H. Adsersen, pers. comm.). One of these populations was reported as surviving some 3-4 years ago by Henning Adsersen, but during the last couple of years botanists from the CDRS have been unable to find any living bushes of this *Scalesia* in the western part of the Island (H. Valdebenito, pers. comm.). It may well be that *S. atractyloides* now is extinct in the wild.

Other Santiago plants threatened on an archipelago scale are the fern *Doryopteris concolor*, *Scalesia stewartii*, and *Mollugo crockeri*. However, many more species are very much threatened on Santiago although they are common on other Islands and therefore are not categorized as threatened on an archipelago scale. One such example is *S. pedunculata*, which is still abundant on Isla Santa Cruz. Consequently, if we consider the conservation status of the plants and the vegetation on Isla Santiago only, the picture is grim. Without doubt, several plant species are very close to disappearing from Santiago, and unique plant communities have, to a large extent, been destroyed by feral goats and pigs. It is not even certain, for example, that the *S. pedunculata* forests with all their many component species—forests which formerly were so abundant—will be able to regenerate at all, even when (or if) goats and pigs are removed. In the lower, arid parts of the Island, the land iguanas that lived there when Darwin visited in 1835 are long gone. But we do not know if other "key species," e.g., invertebrates that are vital for pollination or seed dispersal of plants in the highland, have disappeared by now; nor do we know whether soil erosion has reached a level that will prevent the original vegetation types to regenerate, even if the "right" species are still present in small numbers.

HOPE FOR THE FUTURE?

The general conclusion that has to be drawn on the basis of botanical observations and investigations during the last decades is that it is high time to act if the unique ecosystems of Isla Santiago, with their many plant and animal species, are to be saved.

This is realized by the CDRS and the SPNG, so the conservation of the flora and fauna of Isla Santiago is accorded top priority. Major programs are now underway for eliminating first the pigs and then, afterwards, the goats, and for protecting the vegetation. The reason for attacking the pig problem first is twofold. The pigs are a direct threat to such native animals as giant tortoises, Dark-rumped Petrels, and even marine turtles, simply because the pigs dig out nests and eat the eggs or the young. But since the vegetation now is very open because of goat grazing, it is possible to find and hunt the pigs. If goats were eliminated first, the vegetation would presumably become closer again and it would be extremely difficult to find and eliminate all pigs. So the first task is to get rid of the pigs, and then afterwards a large campaign against the goats can be mounted.

At the same time, the efforts towards protecting the vegetation are now being reinforced. One very important element in this is the ongoing establishment and maintenance of fenced enclosures in different types of vegetation, which can serve as nuclei for the future regeneration of the natural vegetation. Another important element yet to be carried out is to take out the last insurance against extinctions, viz. make sure that acutely endangered plants are conserved ex situ, either in seed banks or in conservation stands outside their natural environment. Ex situ conservation of endangered plant species may serve several purposes, but one very important one is to safeguard material that eventually can be used for reintroducing the species into their natural habitats once the conditions for their survival have improved. Ex situ conservation measures seem now to be justified for such plants as the threatened species of *Scalesia* on Santiago.

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WIND POLLINATION IN THE GALAPAGOS ISLANDS

By: Conley K. McMullen and David D. Close

Pollination, the movement of pollen from an anther to a stigma, is a requirement for the reproductive success of most flowering plants. This transfer, resulting in either cross- or self-pollination, may be accomplished by a variety of vectors such as insects, birds, bats, and wind. In addition, many flowers are capable of automatic self-pollination, and rely on none of the aforementioned vectors for this transferral. In these cases, pollen grains simply come in contact with the stigma at some point during the development and maturation of the flower. With some plants, this happens while the flowers are closed. In others, the mature anthers shed their pollen directly onto the receptive stigma with the opening of the petals.

Instances of insect and bird pollination among plants of the Galápagos Islands have been studied and documented (Rick 1963, 1966; Linsley 1966; Linsley et al. 1966; Grant and Grant 1981; McMullen 1985, 1986, 1989a, 1990; Elisens 1989). Briefly, the Galápagos carpenter bee (*Xylocopa darwini* Cockerell) is the most obvious insect pollinator on the Islands it inhabits, although the Galápagos sulfur butterfly (*Phoebis sennae* L.) and Galápagos blue butterfly (*Leptotes parrhasioides* Wallengren) are quite active as well. Birds, such as finches and mockingbirds, have also been observed at the flowers of many different Galápagos plants. These birds may be visiting the flowers for nectar, pollen, or even insects. Regardless of the reason, many of these visits are regular, and no doubt account for the pollination of some plants. This may be especially true on Islands where the carpenter bee is absent (Grant and Grant 1981). On the other hand, the bat species that inhabit the Galápagos are insectivorous and not known to visit flowers. They are thought to have no role in the pollination events taking place within the Archipelago (Gary McCracken, pers. comm.).

Fifty-three Galápagos Islands angiosperms are known to exhibit some degree of self-compatibility (Rick 1966; Grant and Grant 1981; Aide 1986; McMullen 1987, 1989b, 1990; Elisens 1989). Of these, 50 have demonstrated automatic self-pollination. This breeding strategy is thought to be especially valuable to plants when first colonizing an oceanic island. Theoretically, only one individual would be necessary to start a sexually reproducing population.

The role played by wind pollination in the breeding systems of Galápagos Islands angiosperms is still relatively unknown. Characteristically wind-pollinated plants, such as grasses and euphorbs, are well represented in the Archipelago (Rick 1983). However, morphological adaptations typical of wind-pollinated flowers, such as protruding stamens and feathery stigmas, seem largely to be missing from the flora (Rick 1966, McMullen 1987).

Colinvaux and Schofield (1976) found that members of the grass family contributed little to the contemporary pollen rain of Isla San Cristóbal. This information was based on core samples taken from El Junco Lake. What's more, their studies of surface pollen spectra suggested that pollen production in other typically wind-pollinated groups, including Cyperaceae and Amaranthaceae, is very low. They concluded that Galápagos plants produce so little pollen that selection against anemophily is strongly suggested. One explanation of this was that low pollen production would reduce the waste of energy that results when a plant produces copious pollen, only to have the majority blown out to sea and lost. This would certainly seem to be an important factor when one considers the limited resources available to the initial colonizers of many insular environments.

Further studies on wind pollination were performed by McMullen during the summer of 1990. These observations were part of a larger study dealing with angiosperm breeding systems and pollination ecology on Isla Pinta and Isla Santa Cruz. On 23 June 1990, McMullen arrived at Isla Pinta along with his assistant, Sandra Naranjo, a student at Universidad Central in Quito. During this stay, which lasted 34 days, tests and observations were performed on members of six angiosperm species. Plants chosen for study included *Justicia galapagana* Lindau (Acanthaceae), *Darwiniothamnus tenuifolius* (Hook. f.) Harling (Asteraceae), *Scalesia baurii* Robins. & Greenm. ssp. *hopkinsii* (Robins.) Eliass. (Asteraceae), *Tournefortia rufo-sericea* Hook. f. (Boraginaceae), *Plumbago scandens* L. (Plumbaginaceae), and *Lycopersicon cheesmanii* Riley var. *minor* (Hook. f.) Porter (Solanaceae). Study sites were established at a variety of locations on the southern slope of Pinta ranging from approximately 15 m to 580 m in elevation. Pollen collection slides were placed near each group of plants for approximately 3 to 5 days as a simple test to sample the local pollen rain. An area of each slide, the size of a typical microscope cover slip (22 × 22 mm), was coated with silica gel to trap airborne pollen grains. After each slide was collected, a cover slip was placed over the gel and made semipermanent. These slides were later studied, and the coordinates of all pollen and spores recorded. Voucher specimens of all plant species studied were collected and deposited in the herbarium of the Charles Darwin Research Station.

Similar research was undertaken on Isla Santa Cruz from 31 July to 10 August 1990. Study sites on the southern slope ranged from approximately 90 m to 632 m in elevation, but centered around the area near Los Gemelos (632 m). Plants chosen for investigation on this Island included *Justicia galapagana*, *Darwiniothamnus tenuifolius*, *Tournefortia rufo-sericea*, *Plumbago scandens*, and *Lycopersicon cheesmanii* Riley var. *cheesmanii*.

Table 1 shows the results of these tests. A total of 65 slides was placed in the field. Of these, 18 collected pollen belonging to either *Darwiniothamnus tenuifolius*, *Scalesia baurii* var. *hopkinsii*, or *Lyco-*

Table 1. Summary of wind pollination experiments on Isla Pinta (PI) and Isla Santa Cruz (SC).

Plant Name, Location, and Dates	Slide Number and (# of Pollen Grains Trapped)				
ACANTHACEAE					
Justicia galapagana					
PI - 580 m elevation	1(0)	2(0)	3(0)	4(0)	5(0)
21-24 Jul 1990	6(0)	7(0)[1]			
SC - 632 m elevation					
31 Jul-3 Aug 1990	1(0)	2(0)	3(0)	4(0)	5(0)
ASTERACEAE					
Scalesia baurii ssp. *hopkinsii*					
PI - 15-67 m elevation	1(0)	2(1)	3(16)	4(0)	5(280)[2]
9-14 Jul 1990	6(0)	7(38)	8(15)	9(0)	10(80)
	11(0)	12(0)	13(1)	14(13)	15(102)
Darwiniothamnus tenuifolius					
PI - 518 m elevation	1(0)	2(0)	3(1)	4(1)	5(0)
16-19 Jul 1990	6(28)	7(1)	8(90)[2]	9(0)	10(0)
SC - 632 m elevation					
31 Jul - 3 Aug 1990	1(0)	2(0)	3(0)	4(6)	5(0)
BORAGINACEAE					
Tournefortia rufo-sericea					
PI - 580 m elevation	1(0)	2(0)	3(0)	4(0)	5(0)
21-24 Jul 1990	6(0)	7(0)			
SC - 632 m elevation					
31 Jul - 3 Aug 1990	1(0)	2(0)	3(0)		
SC - 91 m elevation					
6-10 Aug1990	1(0)	2(0)			

Table 1. Continued from page 13.

Plant Name, Location, and Dates	Slide Number and (# of Pollen Grains Trapped)				
PLUMBAGINACEAE					
Plumbago scandens					
PI - 213 m elevation 11-14 Jul 1990	1(0)	2(0)	3(0)	4(0)	
PI - 533 m elevation 16-19 Jul 1990	1(0)	2(0)[3]			
SC - 91 m elevation 6-10 Aug 1990	1(0)	2(0)	3(0)	4(0)	5(0)
SOLANACEAE					
Lycopersicon cheesmanii var. minor					
PI - 213 m elevation 11-14 Jul 1990	1(0)	2(0)[4]			
Lycopersicon cheesmanii var. cheesmanii					
SC - 632 m elevation 31 Jul - 3 Aug 1990	1(0)	2(0)			
SC - 91 m elevation 6-10 Aug 1990	1(162)[2]	2(0)	3(0)		

[1] These seven slides were also used for the *Tournefortia rufo-sericea* plants at the same location.
[2] These pollen numbers are an approximation due to the fact that the pollen was layered.
[3] Slide contained approximately 74 pollen grains of *Darwiniothamnus tenuifolius* attached to a stamen.
[4] Slide contained 1 pollen grain of *Darwiniothamnus tenuifolius*.

persicon cheesmanii var. *cheesmanii* (Fig. 1). In no instance was the amount of pollen trapped of a magnitude normally associated with wind-pollinated species. In addition, the pollen was often grouped together in bunches, whereas pollen adapted to wind pollination is usually dispersed singly or in groups of twos or threes (Proctor and Yeo 1972).

Several of the slides contained spores from plants other than those being studied. However, only pollen grains of the species listed above are recorded in Table 1. For example, many of the slides from Isla Pinta contain what appear to be fern spores, but these are not pertinent to the present discussion and are not considered here. In addition, seven grains of pine pollen were collected on Isla Pinta. This is of interest since these grains must have either blown in from the mainland, or arrived from Isla Santa Cruz or Isla San Cristóbal where *Pinus radiata* D. Don. (Pinaceae) is found. This represents a distance of at least 100 km if the pollen originated on Isla Santa Cruz.

Overall, relatively little pollen of any type was present in the air currents. These findings add support to the hypothesis that selection has not favored wind pollination in the Galápagos Islands. What remains to be addressed is an adequate explanation for this phenomenon. As mentioned earlier, Colinvaux and Schofield (1976) suggested that low pollen production would reduce the amount blown out to sea. Although this seems a reasonable answer, it proves inadequate when one considers that wind-pollinated species form a large part of certain other island floras. For example, Thornton (1971) estimated that 32.4% of the Hawaiian flora, 29% of the New Zealand flora, and 34% of the Juan Fernandez flora is wind-pollinated. Apparently the explanation lies elsewhere.

According to Whitehead (1983), wind pollination will be most effective only if certain criteria are met. The first of these is that large amounts of pollen must be produced and released by the species. Second, individuals belonging to the same species must be located near each other. Third, pollen release must be timed so that: a) there is little downwind dispersion (low air turbulence), b) little filtration of pollen by the vegetation occurs (leafless season), c) humidity is low (so that the pollen may dry quickly), and d) there is little rainfall.

It is difficult to say whether the low pollen production typical of most Galápagos plants is the cause or effect of selection against wind pollination. However, considering which of Whitehead's other criteria are met on the Galápagos Islands might prove instructive. The requirement that conspecifics be located near each other is indeed fulfilled by some members of the Galápagos flora. Species in which this is pronounced include *Scalesia pedunculata* Hook. f., *Bursera graveolens* Trian. & Planch. (Burseraceae), *Opuntia echios* Howell (Cactaceae), *Parkinsonia aculeata* L. (Caesalpiniaceae), *Miconia robinsoniana* Cogn. (Melastomataceae), and *Zanthoxylum fagara* (L.) Sarg. (Rutaceae) as well as various grasses and sedges. In fact, this is so obvious that certain of these species have lent their names to particular vegetation zones on the larger islands such as the *Zanthoxylum* zone, *Scalesia* zone, *Miconia* zone, and

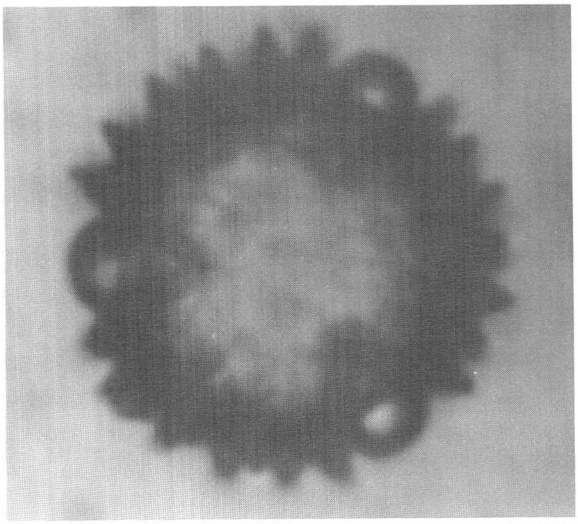

Figure 1. *Darwiniothamnus tenuifolius* pollen grain (1,000× magnification). *Grano de polen,* Darwiniothamnus tenuifolius *por 1,000×.*

fern-sedge or pampa zone. On first glance, this would seem to suggest that wind pollination might be favored in the Archipelago. However, other factors must be considered before drawing conclusions. For example, each of the above mentioned species, except for *Zanthoxylum fagara* and the grasses and sedges, is known to be visited frequently by the Galápagos carpenter bee. *Opuntia echios* is pollinated by finches as well. What's more, the close proximity of individuals in the above-mentioned species is not the norm when considering the flora as a whole.

Whitehead's third criterion deals with the appropriate timing of pollen release. The fact that the Galápagos Islands lie under an inversion layer during much of the year increases the possibility of pollen being released when downwind dispersion is minimized. Under such conditions, pollen concentration decreases less with distance from the plant and the efficiency of wind pollination is increased.

Wind pollination is also favored when the chance of pollen being filtered out of the air by vegetation is minimal. In the temperate regions of the world this occurs in the spring when leaves have not yet reappeared on the trees. In the Galápagos there are also seasons when certain species are leafless. One such plant is *Bursera graveolens*. However, this plant often does not flower until after its leaves have appeared. In addition, *Bursera*, as well as many other trees of the highlands, are covered with lichens, mosses, and ferns year round (Fig. 2). This vegetation no doubt would have a tremendous filtering effect on any pollen being borne by the wind.

Two other factors that promote wind pollination are low humidity and little rainfall. This is because a high relative humidity can cause pollen grains to clump together. Moisture can also keep pollen grains from germinating, and rain as well as mist can purge the atmosphere of pollen. Although the humidity is rarely low, reduced rainfall is a reality for much of the Archipelago throughout the year.

From the above discussion, it would appear that close proximity of conspecifics, little downwind dispersion of pollen, and reduced rainfall are the conditions that should favor wind pollination in the Galápagos Islands. However, what must be remembered is that most flowering in the lowlands takes place during the warm rainy season, and many highland flowers are produced during the cool garúa

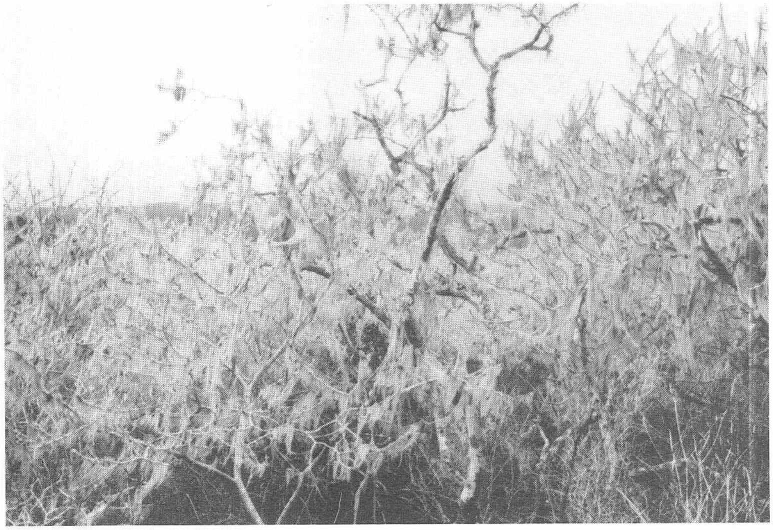

Figure 2. Lichen-covered trees of Isla Pinta highlands. *Arboles cubiertos por líquenes en la zona alta de la Isla Pinta.*

season. This means that most Galápagos plants flower during a time of year when it is likely that much of the pollen will be washed out of the atmosphere. Thus, only a very few plants can benefit from the advantage that reduced rainfall offers wind pollination.

Zanthoxylum fagara demonstrates this situation quite well. Not only are the members of this tree species dioecious and closely spaced, but also no pollinators have been recorded as visiting its flowers. It would seem a likely candidate for wind pollination until one considers the fact that it is normally a component of the highlands, and as such is subject to the pollen filtering effects of garúa and rainfall. In addition, it normally flowers after its leaves have appeared. This foliage, as well as the typical covering of lichens and mosses, must present a formidable obstacle for passage of wind-borne pollen grains. Regal (1982) has also pointed out that air movement in the understory of forests with a dense canopy may be restricted. This might prevent wind pollination among the herbaceous plants growing within these forests. This would also be true of other Galápagos species, such as *Bursera graveolens*, that are covered with lichens and mosses.

In summary, this study supports the hypothesis that wind pollination is not highly represented in the Galápagos Islands. This is largely due to the fact that the same abiotic factors that stimulate flowering (i.e., rainfall and garúa) are those that are unsuitable for efficient wind pollination. A light shower with fine droplets is more effective at ridding pollen from the air than a thunderstorm with large droplets, and a moderate shower will clean the atmosphere of almost all pollen grains (Whitehead 1983). These are exactly the circumstances under which many of the Galápagos flowers begin to appear.

Faegri and van der Pijl (1971) stated that it would be difficult for wind pollination to be successful in small populations due to the need for massive pollen production. This, of course, would be another problem for anemophilous species when colonizing an island. If only a few plants arrive and grow at one time, then insect pollination or automatic self-pollination will be much more likely to produce a successful pollination event. As mentioned earlier, most of the species studied are capable of automatic self-pollination. Additionally, several of them take advantage of the few insect pollinators that are available. This is no doubt why many of the plants produce small flowers that are not pollinator specific.

Proctor and Yeo (1972) pointed out that most insect-pollinated species probably shed pollen into the air occasionally, and this local wind pollination may be effective. In fact, a combination of two or more pollination syndromes might be common in plants. *Helianthemum* (Cistaceae) is an example of a species pollinated by both insects and the wind. Perhaps *Darwiniothamnus tenuifolius*, *Scalesia baurii* var. *hopkinsii*, and *Lycopersicon cheesmanii* var. *cheesmanii* are other examples of this phenomenon. These species are often visited by insects, and they are all capable of automatic self-pollination (McMullen 1990; unpubl. data). However, a small amount of wind pollination might also take place. Particularly on an island, this would seem the ultimate strategy for initial as well as long-term survival.

Thornton (1971) stated that the Galápagos Islands should have a similar percentage of wind-pollinated species as that found in Hawaii, New Zealand, and the Juan Fernandez flora. This does not appear to be the case. It would be interesting to study the flora of these other island systems more closely to determine if they actually do possess a high percentage of wind-pollinated species, or if that claim has been based entirely on the assumption that these plants are wind-pollinated since that is their pollination syndrome elsewhere.

ACKNOWLEDGMENTS

The following individuals deserve many thanks for their assistance in this study: Gayle Davis-Merlen, Bryan E. Dutton, Daniel Evans, Aracelly Fajardo, Gary McCracken, Godfrey Merlen, Cecilia Solis, Hugo Valdebenito, and Fionnuala Walsh. Special appreciation goes to Sandra Naranjo, an excellent field assistant and companion while on Isla Pinta. This study was supported by National Geographic Grant #4327-90.

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GALAPAGOS SPECIES DIVERSITY: IS IT ON THE LAND OR IN THE SEA?

By: Stewart B. Peck

In the past 10 years at least five important scientific books have been published on the biota of the Galápagos (e.g., Bowman et al. 1983, Berry 1984, Perry 1984, Grant 1986, Grant and Grant 1989). These books, or their included chapters, have usually (but not always) focused on one or a few species of terrestrial plants or vertebrates. A new book, edited by Matthew J. James (1991) is a much-needed summary of many groups of shallow-water benthic marine invertebrates of Galápagos. James noted (1991) that he had compiled a list of over 600 references on Galápagos marine invertebrates, and that copies of the list are available from him on request. This is an astonishing amount of scientific literature.

I was asked to write a review of James' book for the *Quarterly Review of Biology.* While doing this I got to thinking about the comparative diversity of organisms in both terrestrial and marine environments of the Galápagos. Some students and visiting scientists at the Charles Darwin Research Station will know that I have a distinct bias in favor of terrestrial organisms, and that I believe most biodiversity is terrestrial and not in the sea. This is based on the fact that 1.8 million species of all animals and plants have been described; and of these described species, 55% are insects (Stork 1988). We know that this is a low estimate of the true number of species which may be somewhere between 10 and 30 million for insects alone. However, the number of described species can serve as a frame of reference.

Insects are virtually exclusively terrestrial (but a few do live in freshwater). When we add to the insects the other terrestrial organisms such as mites, spiders, some nonflowering and most flowering plants, and a few others, we have a total of about 65% of all species of life as inhabitants of terrestrial (and freshwater) habitats. Now consider that only 30% of the earth's surface is land. We can then quickly calculate that global species diversity (based only on described species) is about six times richer per unit area on land than in the ocean.

With that background, I wondered about the proportions of species in Galápagos marine and terrestrial habitats. Jackson (1985) suggested that there are about 550 species of naturally occurring plants, and about 270 species of fish, and smaller numbers of other organisms. However, here I am most interested in the relative proportions of invertebrate animals. I compiled the available information summarized in James (1991), Peck (1991), and my unpublished data on insects and other invertebrates. These are presented in Table 1. After examining the table, I think that several interesting generalizations emerge.

1) Undoubtedly far more invertebrate species occur in the Galápagos, both on the land and in the sea, than we would have probably imagined.

2) Very little is known about what lives in freshwater on the Galápagos, partly because this is a very rare habitat.

3) Even if the other known Galápagos organisms such as fish, vascular plants, lower plants, land vertebrates, and algae were added to the above figures, there would still be only a somewhat higher number of organisms known from terrestrial habitats than from marine habitats.

4) Some marine invertebrates have not been summarized, such as the non-coral coelenterates, sponges and some crustacea (especially zooplankton), and unstudied groups such as rotifers, sipunculids, echiurids, etc., that will be added to the list of insects and mites and unstudied terrestrial and freshwater groups such as nematods, tardigrads, copepods, and oligochaetes that will increase the numbers of terrestrial and freshwater species.

5) Thus, the dominance of Galápagos terrestrial diversity over that in marine habitats certainly seems to be not as great as the global average. Why would this be? An obvious partial explanation is that the sea is a dispersal highway for many (but not all) marine organisms, but that the sea is a formidable barrier to terrestrial organisms. Dispersal for terrestrial organisms must be through the air or on the surface of the sea. Another explanation is that, upon arrival, the habitat must be suitable for the colonists, and they are

Table 1. Species diversity in invertebrates in marine and terrestrial (plus freshwater) habitats in the Galápagos. Correction and additions are appreciated.

Marine Invertebrates of the Galápagos	Number of Species	Number of Endemics
Meiofauna in marine beach sands (9 phyla) (Westheide 1991)	390	?
Coelenterata, Scleractinian corals (Wells 1983)	44	11
Annelida, Polycheta (Blake 1991)	192	50
Anthropoda		
Crustacea, Brachyura (Garth 1991)	120	27
Crustacea, Caridean and Stenopodid shrimps (Wicksten 1991)	65	6 ?
Crustacea, Porcelain crabs (Harvey 1991)	12	1
Crustacea, Cirripedia (Zullo 1991)	18	4
Crustacea, Amphipoda (Barnard 1991)	50	19
Crustacea, marine caves (Iliffe 1991)	20	16
Mullusca (Finet 1991, Kay 1991)	652	148
Bryozoa (Bamta 1991)	184	34
Echinodermata (Maluf 1991)	198	33
Total	1,945	349 (= 18%)
Terrestrial (and Freshwater) Invertebrates of the Galápagos		
Mollusca, land snails (Chambers 1991)	83	80
Spiders (Baert et al. 1989, unpubl.)	80	55
Mites (Schatz and Schatz 1988, Schatz 1991)	155	?
Other Arachnids (Peck 1991)	21	15
Crustacea (Peck 1991, and unpubl. data)	21	5
Centipedes and Millipeds (Shear and Peck 1987, 1992)	19	6
Insects (Peck 1991 and unpubl. data)	1,616	900 ?
Total	1,995	1,061 (= 53%)

more likely to be optimal in the sea than in the suboptimal and seasonally intensely arid conditions on land. Lastly, islands are generally known to have a smaller subset of species because of their decreased habitat diversity. While the marine habitat diversity of the Islands may be equivalent to that available in continental Ecuador, it is certainly not so for terrestrial habitats.

6) We can also see that many more of the terrestrial invertebrate species are endemics than are the marine invertebrate species. This means that once the ancestral colonists reached the Islands they were much more likely to be isolated and to evolve species differences. This strengthens the theoretical basis for understanding the reasons for isolation of the terrestrial invertebrates in item 5 above.

We are now beginning to learn about the true diversity of Galápagos life. Researchers should get on with learning more about this diversity: where it came from and how it got the way it is. After all, the Galápagos are the world's best preserved and protected tropical oceanic Archipelago. These Islands have much more to tell us than we have learned from them already. The book by James and his contributors is a good start. It is a pity we do not yet have a research base of 600 references on the terrestrial invertebrate fauna to draw from.

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THE UNNATURAL COLONIZATION OF GALAPAGOS BY SMOOTH-BILLED ANIS (*CROTOPHAGA ANI*)

By: Peter R. Grant and Tjitte de Vries

The Galápagos are the most isolated Islands in the eastern Pacific that have a clearly and wholly American terrestrial bird fauna. Smooth-billed Anis (*Crotophaga ani*) were first recorded on the Islands in 1962. This was surprising since they fly so weakly. Single individuals were seen on Isabela that year, on Santa Cruz 4 years later, and on Santiago in 1967 (Harris 1973). None were seen again until 1980-81, when some appeared in the farmland of Santa Cruz (Harris 1982). Since then a breeding population has become established on this Island, where at one time numbers were estimated to be well over 5,000 birds (Rosenberg 1987), and individuals have been seen on many other islands in the Archipelago. How did these cuckoo relatives reach the Galápagos?

Possibly they flew across the 1,000 km of open water from continental Ecuador. Harris (1973, 1982) suggested an alternative, that the anis were introduced by farmers in the belief they would remove tics from cattle. He pointed to their basically sedentary nature, weak flight, and association with cattle as reasons for thinking they were introduced, while acknowledging that individuals do sometimes wander outside the normal range of a population. We have made a survey of bird faunas on other eastern Pacific islands, and it supports Harris' suggestion that their journey to Galápagos was not accomplished without human help.

Crotophaga ani, or its close relative *C. sulcirostris* (the Groove-billed Ani), is found on the continent from Chile north to México, but neither occurs on

México's Revilla Gigedo Islands off Columbia. All these islands are well isolated, being more than 300 km from the continent. Similarly, neither species of anis has been recorded on the much less isolated Tres Marías Islands, 80 km off western México, even though a complete list of breeding bird species has been established and a long list of migrants and vagrants has been thoroughly documented for these islands (Grant and Cowan 1964).

The island in the eastern Pacific most isolated from main source populations on which anis (*C. ani*) are known to occur is Isla Gorgona, 55 km from the coast of Colombia (F. Köster, pers. comm.). The next most isolated island with anis is Isla Coiba. It is only 25 km from the mainland of Panamá. Anis are restricted to open cultivated land and low thickets in the middle of cleared land on the island (Wetmore 1957). On the mainland of Panamá the spread of this species from east to west was slow, and apparently it was made possible by forest clearance and the artificial creation of savannahs (Wetmore 1968).

Despite flying short distances and slowly over cultivated land, anis are capable of flight over water. In the Galápagos they have reached several well isolated Islands including Genovesa, which is about 90 km from the central Islands of Santa Cruz and Santiago. They have done so apparently unaided although possibly boats have given them inadvertent help.

In the Atlantic their presence on many islands in the West Indies (Voous 1957, Lack 1976) and on offshore islands of central America (Monroe 1968) certainly suggests they are capable of flying moderately long distances over water. Furthermore they have colonized Florida recently, and, unless they were introduced, they must have flown a minimum distance of 100 km from the Bahamas to get there (Lack 1976). Only one among the numerous islands of the West Indies, Jamaica, is more isolated (150 km), and only one other pair of islands in the Atlantic with anis, the Swan Islands (Monroe 1968), is more isolated (200 km) than Jamaica. In all colonized areas, however, anis are almost entirely restricted to cultivated land.

It is well known that the absence of a species from an island can be attributed to one of two causes: either failure to reach the island, or failure to colonize it by establishing a breeding population once it has got there. In the case of the ani, absence from most Pacific islands can be explained in either way. For example, the habitats on the Revilla Gigedo Islands and on Cocos Island are very different from each other, and both might be unsuitable for anis even if they were able to reach the islands naturally. However, some of the islands lacking anis do have some agricultural land, or at least some cultivation of land associated with human settlement, so for these islands colonization would appear not to be a problem. Anis may never have reached them.

Facts such as these lead us to conclude that the presence of anis on the Galápagos cannot reasonably be attributed to natural colonization following unaided immigration from the continent. There is no evidence that anis are capable of flying the enormous distance across water which would be required to reach the Islands. We do not claim this is impossible, only that it is highly unlikely. The alternative explanation for the presence of anis on the Galápagos, that they were introduced by humans, is much more likely. And from all that is known about the biology of the anis elsewhere, the success of the introduction (or introductions) was due to the clearing and cultivation of land on Isla Santa Cruz.

It may be interesting to compare the ani with the Cattle Egret (*Bubulcus ibis*). Like the ani, this species was first recorded on the Galápagos in the early 1960s (Harris 1982) and became common and widespread in the 1980s. Harris (1982) refers to it as a regular visitor. A breeding site on southern Isabela was discovered in 1986 (Perez and Nowak 1987), and confirmed in 1987 (Vargas 1990). Also, like the ani, it takes advantage of cultivated land and highland pampas with free-roaming cattle, particularly on southern Isabela and Santa Cruz. Unlike the ani, however, it almost certainly arrived unaided. There is no incentive to introduce it since it does not have the reputation of removing ticks from cattle. Moreover, it has undergone a recent expansion globally and not just in the eastern Pacific, and its distribution is now virtually worldwide. It has the powers of long-distance flight that the ani lacks.

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UPDATE FROM ISLA DE LA PLATA

By: Robert L. Curry

Isla de La Plata is a small island lying about 30 km off the coast of mainland Ecuador. The Island is not associated geologically with the Galápagos, but it shares many of the Archipelago's plant and animal species. Eight years ago, J. Bosco Nowak visited the Island and published a disturbing description of threats to the Island's wildlife (Nowak 1986). On 20 June 1991, I had an opportunity to visit Isla de La Plata for a few hours. Here I report my own observations, and my impressions concerning the Island's current conservation status, from the perspective of an ornithologist with extensive research experience in the Galápagos.

Isla de La Plata, along with smaller Isla Salango and a few other islets, forms one of four sectors of the 35,000 ha Machalilla National Park. The Park, with headquarters situated in the fishing village of Puerto Lopez, Manabí Province, was established in 1979. La Plata, which is nearly 5 km long, roughly 2 km wide, and 167 m in elevation, consists of eroded sedimentary deposits overlying older basaltic lava now exposed at sea level. The Island's vegetation, dominated by xeric shrubs (including *Cordia* and *Croton*) and scattered palo santo trees (*Bursera graveolens*), resembles that of both the mainland coast and the arid lowland zone in the Galápagos. Much of La Plata's woody vegetation, however, has been destroyed through a combination of grazing by goats and cutting by humans, presumably for fuelwood. I was surprised to observe many candelabra cacti (*Cereus* spp.) but no prickly pears (*Opuntia* spp.) though the latter occur along the mainland beaches and scrublands. My visit to La Plata followed the annual wet season, and much of the Island's loose soil was carpeted with recent growth of grasses and some vines.

National Park staff have been active in working towards eradication of goats from La Plata. Vargas, the Guardaparque who accompanied me on the Island, reported that about 30 goats remain on the Island, a dramatic decrease from the 300 estimated by Nowak in 1985; I saw none during my 6-hour visit. Vargas also believes that only a few introduced black rats (*Rattus rattus*), which have caused much devastation in the Galápagos (e.g., Curry 1985), are present on La Plata. The remaining rats may be held in check by the Island's few feral cats although the several cat scats I examined all seemed to contain eggshell fragments, rather than mammalian hair. I believe eradication of these cats should be considered, but only if the rat population can be controlled by some other means.

For naturalists with experience in the Galápagos, many of La Plata's marine organisms are familiar and intriguing. The Island's small colony of Waved Albatrosses (*Diomedea irrorata*) is particularly notable, because this is the only known breeding locality outside of Galápagos where the breeding is confined to Isla Española. I observed only four albatrosses on La Plata, including one bird incubating an egg and three others occupying likely nesting sites. The Island also supports breeding populations of all three species of boobies native to the Galápagos. During my visit, Blue-footed Boobies (*Sula nebouxii*) were most abundant, with most involved in courtship and a few on nests with eggs. I was surprised to see at least two adult blue-foots perched, as Red-footed Boobies (*S. sula*) often do, above the ground on low branches! Masked Boobies (*S. dactylatra*) were less numerous than blue-foots and were clustered near nesting colonies at both ends of the Island. Most were incubating eggs though many fledged juveniles from the previous breeding period were also present. The Guardaparques told me more than 30 birds were nesting at the Island's east end, but I did not observe any Red-footed Boobies in this area. Complementing the Galapagean scene were a colony of nesting Magnificent Frigatebirds (*Fregata magnificens*), three resting Galápagos sea lions (*Zalophus californianus wollebaeki*), whose presence on La Plata was noted by Nowak (1986), and many sally lightfoot crabs (*Grapsus grapsus*) dotting the wave-washed lava.

My own primary reason for visiting the Island was to observe its resident Long-tailed Mockingbirds (*Mimus longicaudatus platensis*). I was pleased to find a thriving mockingbird population on La Plata. The birds I saw all appeared to be in adult plumage—

though I am not certain if the race endemic to La Plata retains small breast spots until the first post-juvenile molt as do all four species of Galápagos mockingbirds (*Nesomimus* spp.; Curry and Grant 1990) and most other mimids. The La Plata mockingbirds appeared to be living in territorial groups of four to five individuals. Such observations are consistent with data collected on the mainland where apparently two or more females sometimes lay their eggs jointly in a single nest (Marchant 1960). This aggregation of eggs happens in *Nesomimus*, on both Genovesa and Champion, but only when two or more females live together in the same cooperatively breeding social group (Curry and Grant 1990). Therefore, it appears that Long-tailed Mockingbirds are also group-territorial cooperative breeders. The La Plata birds also seem to engage in an inordinate amount of singing. Their songs have a liquid quality that differs from those of any of the species of *Nesomimus*. To my ear, the La Plata songs also seem to include phrases that may be copied from other species on the Island.

The Island supports only a few other landbirds. I was surprised to find that the most abundant species was the Collared Warbling-finch (*Poospiza hispaniolensis*), a bird I had not encountered previously during two trips to nearby coastal areas of the Ecuadorean mainland. The black-and-white males and brown-and-white females of this species seem to fill the niche occupied by the Small or Medium Ground Finches (*Geospiza fuliginosa* and *G. fortis*) on most Islands in the Galápagos. At the time of my visit, they were feeding in flocks of up to about 20 individuals in open, grassy areas and under shrubs and brush. Might not this population exhibit the extreme degree of morphological and behavioral variation typical of landbirds on depauperate islands? I suspect the species would be an excellent subject of further study. Other landbirds I observed included many Black and Turkey Vultures (*Coragyps atratus* and *Cathares aura*), about a dozen Eared Doves (*Zenaida auriculata*), one pair of Vermilion Flycatchers (*Pyrocephalus rubinus*), two Grey-and-white Tyrannulets (*Phaeomyias leucospodia*), and several Southern Beardless-Tyrannulets (*Camptostoma obsoletum*).

Isla de La Plata is an interesting and special component of one of Ecuador's unique National Parks. I am encouraged that the Island's conservation status seems to have improved since Nowak's visit in 1985. Plans are underway to establish a scientific research station, through renovation of an abandoned fishing lodge, on the north side of the Island. Such a facility will serve as an excellent base for future protection and research activities, to be conducted by the Park staff and by a group of young conservation ecologists based in Guayaquil known as "Semilla de la Vida."

ACKNOWLEDGMENTS

I thank Niki Gaibor of the Instituto Nacional de Pesca for arranging my visit to Isla de La Plata and for accompanying me. I also thank the Intendente of Machalilla National Park for permission to visit the Island and for transportation on the Park's boat.

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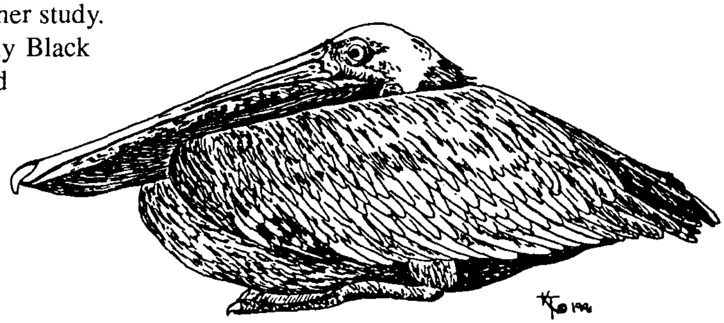


REVIEW: DARWIN MULTIMEDIA CD-ROM FOR MACs AND PCs

Produced By: Peter Goldie and Michael T. Ghiselin 1992
US—$99.95. Lightbinders, Inc., 2325 Third Street,
Suite 320, San Francisco, California 94107, USA,
(415) 621-5746, (800) 43-CDROM.

Reviewed By: John M. Woram

Darwinian scholarship has just gotten a bit easier—actually, megabits easier. Drs. Peter Goldie and Michael T. Ghiselin have produced Darwin Multimedia CD-ROM on disc; a digital database which contains the following works by the indicated authors:

Charles Darwin (unless otherwise noted, complete text and illustrations) *Voyage of the Beagle, Origin of Species, The Descent of Man,* and *The Zoology of the Voyage of the HMS* Beagle (plates only, no text).

Darwin and Alfred Russel Wallace: Joint paper *On the Tendency of Species to Form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection.*

P. Parker King and Robert FitzRoy: Survey maps of *H.M.S. Adventure* and *H.M.S. Beagle*, from *Narrative of the Surveying Voyages of His Majesty's Ships* Adventure *and* Beagle....

Peter Goldie and Michael T. Ghiselin: *Introduction to the Study of Darwin: A Guide to Darwin Studies.*

Michael T. Ghiselin: *Triumph of the Darwinian Method—A Guide to the Study of Darwin, The Darwin Timeline—A Chronology of Significant Events in His Lifetime, The Darwin Bibliography, Publications of Charles Darwin, Darwin Manuscripts, Letters, and Miscellaneous Sources,* and *Darwin Secondary Sources.*

Cornell Laboratory of Ornithology: *Library of Natural Sounds* (audio accompanying some screen images).

As you might expect, this impressive Darwin database resides on a single CD-ROM disc. Superficially resembling the now-familiar compact disc, such a disc may contain text, audio, video (photographs, illustrations, other static images), and/or video animation. The Darwin disc contains all but the latter. To play it, you'll need a suitably equipped IBM-compatible or Macintosh computer, a CD-ROM drive, and a VGA or better monitor. To hear the audio segments, add a sound card and stereo playback system. Or, if your CD-ROM drive has an earphone jack on its front panel, this can be used in the absence of a sound card. The same disc plays on either type of computer; an IBM-compatible (Dell 486) was used for this review. To read Darwin, or anyone else, on a computer screen is no doubt a temptation many will find quite easy to resist. For all but the most dedicated computer maven, a good book usually remains the medium of choice. However, if you have ever tried to find something in a book (good, or otherwise) which you remember reading but can't locate in the index, you're more than ready for a Darwin on disc. The disc's main screen presents four options,Contents, Search, Browse, and Database, which are briefly described below.

THE TABLE OF CONTENTS

The Contents screen displays the above-cited works in chronological order, between introductory and concluding essays by the editors. Select the first entry by the master himself to open the Table of Contents for *The Voyage of the Beagle* (1838). Select the chapter of interest ("Galápagos Archipelago" for example) and the complete text for that chapter is displayed. A bar at the bottom of the screen lists the function keys that may be used to perform various functions (next chapter, print, copy, display list of figures, etc.).

A DARWINIAN SEARCH

The Search option allows the user to search the entire disc for a word (or words or a phrase), or for an author, subject, or title. To illustrate the power of a computer search, where did the great man use the "E" word? A CD-ROM search for "evolution" on the disc takes about 1 second (search time will vary according to computer speed). The computer screen reports 34 occurrences of that word, the first of which is in Chapter VII, "Miscellaneous Objections to the Theory of Natural Selection." Chapter VII of what is not yet revealed. To dig deeper, press function key F10 to open the chapter; and the screen shows that it is in *Origin of Species*, and the first few paragraphs are seen. Press F10 again to jump directly to the word "evolution," which is highlighted in red. Press the same key again to jump to the next occurrence, and so on through all 34 locations. But perhaps you were looking for something more specific. For example, Darwin mentioned an acquaintance who was a "strong disbeliever in evolution." Now then, where did Darwin make this remark, and who was the nonbeliever? Add "strong disbeliever" to the search and the phrase "Mr. Hudson is a strong disbeliever in evolution" is found in about another second (VII, *Origin of Species*). But who was Mr. Hudson? A search for "Mr. Hudson" won't work: in the interests of efficiency (read, speed) the search mechanism does not recognize common words, such as a, be, it, of, the, to, and in this case, Mr. If you enter a phrase containing such common words, the search process fails and you'll need to try again. Some searching software does allow one to force a search for a phrase with a common word in it, by enclosing the phrase in quotation marks. But not this time, so you'll need to search for "Hudson" alone, and he turns up in two chapters. We learn that he is "an excellent observer" but that's all. Here the fault is not in the medium but in the message. Darwin was not always scrupulous in identifying his sources, as anyone who has encountered his "mystery of mysteries" may already know.

More sophisticated searching is possible, up to a point. You may recall that Darwin commented on a person's woe and weal, or *was* it woe or weal? Or did weal come first? Instead of making four searches, or fewer if you guess the right combination before exhausting all possibilities, simply search for "woe [2] weal" to find either word within two words of the other. A single entry "It is not the weal or woe of any one individual ...." is found almost immediately. For a different type of search, enter "civil*" to find any word beginning with those letters, of which there are 36 entries (for civil, civility, civilize, civilization, and so on). Unfortunately, a bracketed number/asterisk combination cannot be used simultaneously. Sometimes the search engine sputters a bit: one of the above-mentioned searches (mystery [2] mysteries) turned up four occurrences: one in the Galápagos chapter of *Voyage* ..., a second in the introduction to *Origin* ....("as it has been called by one of our greatest [but here unnamed] philosophers"), with the latter entry appearing again in Dr. Ghiselin's "Darwinian Method" essay. The fourth was a searching artifact, in which "mysteries" and "mystery" were found—separated by some 50+ words.

BROWSING THROUGH DARWIN

The Browse option displays a list of key words (aa to zygomas), authors (16, listed alphabetically by first name), subjects (aborigines to zorillo), and titles (abbreviated to zealand). That last category in fact tabulates all the words which appear in chapter and heading titles, along with a count for each one. Thus we learn there are nine titles which include the word "affinities." For whatever it's worth, the word "and" graces 49 titles, and "Chapter" is the winner with 138 occurrences. Ignoring such minor distractions, the browse list might be helpful in tracking down the titles (all 26 of them) which include variation, or for a similar search on some other significant word.

DATABASE

If the CD-ROM disc contained more than one database, this option would list them. But for the moment at least, Darwin on disc is the only database listed. And so the option is not yet needed.

THE LIGHT AND SOUND SHOW

Moving now into the audio/video realm, select any chapter and press function key F9 to read the list of illustrations which accompany that chapter. For example, the Galápagos Archipelago (XVII, in *Voyage*) contains 38 charts and maps (FitzRoy), drawings (*Zoology of the* Beagle and others), and photographs—some in color, others not. A "+" symbol in the left margin indicates that a sound recording accompanies the illustration. In the cited chapter there are 11 audio samples (7 finch, 2 owl, 1 flycatcher, 1 mockingbird). Alas, the boobies and frigates didn't make it into the recording studio. Scroll through the list, highlight the desired entry, and press the Enter key to view the illustration. If sound is available, it will be heard automatically (assuming your computer is suitably equipped of course).

OTHER FEATURES

Any chapter can be printed in its entirety by pressing function key F7 while that chapter is on the screen. To print an excerpt, you'll need to use your favorite word processor to select the paragraph or section of interest. However, there is no guide to finding what you want to print, so you'll have to do a bit of snooping. Although Darwin's Galápagos Archipelago is Chapter XVII in *The Voyage of the Beagle*, it becomes document 00018.TXT on the disc (the preface is 00001.TXT). Since subsequent chapter files are numbered sequentially, and placed in directories of 10 files each, Chapter I of *Origin* becomes \DP\0003\00039.TXT. None of this is of any consequence to the reader who uses the product as intended, nor will it discourage the knowledgeable computer user from finding what's needed. However, it might be enough to deter the casual researcher from printing out an excerpt or two.

Darwin on disc provides a great deal of literature in a small package, and at a modest price compared with purchasing the books. The power of Darwin on disc obviously lies in its search capabilities, which should make it a valuable tool for anyone whose needs are not entirely satisfied by the usual book index. But once the phrase is found, you'll probably want to return to the bookshelf for a more leisurely look at the subject. The CD-ROM disc may save you many minutes, or even many hours, for doing just that. Of course there is a risk: once you've found what you're looking for, you'll no doubt think of something else that needs discovering. And then, something else. So much for saving time. Although Darwin on Disc is accompanied by very little documentation (two loose sheets of paper), installation is reasonably straightforward and on-line help is available by pressing function key F1. Nevertheless, a printed User's Guide would make this excellent research tool even better.

John M. Woram, 45 Lakeside Drive, Rockville Centre, New York 11570, USA.

VISITORS AND EVENTS

March 1992-September 1992

March 1992

—Homero Almeida resigned from his position as CDRS Accountant.

—Peter W. Glynn and Joshua Feingold, University of Miami, Richard W. Grigg, University of Hawaii, and assistant Jorge Gómez-Jurado; recuperation of coral reef communities.

—Pádraig Whelan and Fionnuala Walsh met with the Ministry of Agriculture and Livestock in Quito about the quarantine program.

—Gila von Hegel and the field assistants of Martin Wikelski returned to Germany.

—Sergio Mora resigned from his position as Captain of the *Beagle*.

—Jacinto Gordillo began work as CDRS Representative on Isla Isabela; Arnaldo Tupiza continues as Logistical Coordinator.

—Gonzalo Vargas joined the CDRS as Stockroom Assistant.

—María del Pilar Solís, University of Guayaquil; volunteer in the Area of Terrestrial Plants.

—Arturo Ortiz, new CDRS Accountant, arrived from Quito.

—Mauricio Vallejo and William Guamba, Quito; installed a new computerized accounting system.

—Jaime Navas, scholarship student from Galápagos; volunteer in the Area of Introduced Mammals.

—Peter W. Glynn and Richard W. Grigg returned to the USA.

—Jorge Palacios, Central University; lagoon bird censuses on Islas San Cristóbal and Isabela; accompanied by Jorge Sotomayor, photographer and assistant.

—Amada Altamirano, student of the National Galápagos High School, finished her practical work in the CDRS.

—Gustavo Santos joined the CDRS as new Watchman-Concierge.

—Charles Huttel, ORSTOM; botanical studies as part of the Biodiversity project.

—Lenin Prado travelled to the continent to contact personnel of the Ministry of Agriculture about the Agroforestry Program.

—Noralma Palacios, Mirelly Vera, and Daniel García, OFSERCON, Guayaquil; 1991 CDRS accounting review.

—María Teresa Lasso, scholarship student in the Area of Invertebrates from the Central University in Quito; distribution, ecology, and impact of the introduced wasp *Polistes versicolor* on Islas Santa Cruz and Floreana.

—Cecilia Ponce, also from the Central University; volunteer in the Area of Invertebrates.

—The heads of Peace Corps in Ecuador visited to discuss the Agroforestry Program.

—Christian Bausch, Ambassador from Sweden to Ecuador, visited the CDRS.

—A group from Channel 10 of Quito interviewed Arturo Izurieta, Superintendent, SPNG, and Cynthia Jaramillo, Head of Institutional Promotion, CDRS.

—Fabrizio Barahona, Eduardo Espinoza, and Martha León, assistants in the study of marine iguanas on Santa Fe, left the Station.

—Luis Paredes resigned as Electrician at the Station.

April 1992

—Sheila McKenna and Laurie Flebotte, USA; assistants to Joshua Feingold in the study of coral communities.

—Lucía de Yánez, temporary Assistant in Accounting, left the Station.

—Pablo Larrea travelled to Quito and participated in the 59th Meeting of the Executive Council of the CDF in San Diego.

—Hugo Valdebenito travelled to the continent to visit the universities in Quito, Ibarra, and Riobamba.

—Auditor Carlos Falconí, Quito; 1991 CDRS accounts.

—Pedro Ponce travelled to Quito to coordinate the transfer of funds from the Fund for the Development of Childhood (FODINFA) for Club Renacer.

—Martha Romoleroux resigned as Assistant in Public Relations.

—Cecilia Machado, Ambato; Environmental Education teacher.

—Dr. and Mrs. Flemming, Cambridge University, England; discussed possibilities of scholarships.

—Charles Huttel returned to Quito after finishing his botanical studies.

—Mao Ortuño began temporary work as Assistant in Public Relations.
—Martin Wikelski and his group returned to Germany.
—The Princess of Thailand and her entourage visited the Station.
—Joshua Feingold, Sheila McKenna, and Laurie Flebotte returned to the USA and Jorge Gómez-Jurado returned to Guayaquil after finishing studies on coral communities.
—Pádraig Whelan and Juan Ruiz went to Quito for discussions with the director of Juan's thesis in the Central University.
—Jorge Palacios, Central University in Quito, scholarship student in the Area of Natural Resource Management; impact of *Cinchona* on the *Miconia* community.
—Rosemary Andrade completed her volunteership and left the Station.
—Various activities to celebrate Earth Day on 22 April were conducted in the community.
—Charles Huttel, ORSTOM, and Fernando Hurtado; Biodiversity Program.

May 1992

—Jack Grove, Los Angeles Museum of Natural History, with assistant, Jorge Gómez-Jurado; 2-week study of endemic fishes of Galápagos.
—Thelma Estrella, University of Guayaquil; volunteer in the Area of Herpetology.
—Edwin Ortiz, Central University, scholarship student in the Area of Terrestrial Plants; distribution of threatened endemic plants.
—Terry Finston and Rick Perry, of Stewart Peck's group, arrived from Canada.
—Pedro Castañeda finished his volunteership and returned to Guayaquil. He was replaced by Eduardo Espinoza, University of Guayaquil, as volunteer for the Marine Laboratory.
—Rafael Menoscal finished his volunteership in the Area of Herpetology and left the Station.
—Ron Sjostedt, volunteer from the Peace Corps, replaced John Kolbe, who returned to the USA.
—Jeanne Dodeman, journalist from the French magazine *Marie Claire*.
—A group of marines from the ship *Hualcopo* visited the Station.
—Heidi Snell and Paul Stone, University of New Mexico; land iguanas and lava lizards.
—Cecilia Betancourt finished her volunteership in the Area of Terrestrial Plants and left the Station.
—Joshua Feingold, USA; 2-week study of coral communities.
—Chantal Blanton, the new CDRS Director, arrived, accompanied by Craig MacFarland, President of the CDF, and Alfredo Carrasco, CDF Secretary General.
—Charles Huttel and Fernando Hurtado returned to Quito.
—Gonzalo Cerón, CDRS Representative in Quito, and Mario Hurtado, CDF Representative in Guayaquil.
—Robert Malott, Chairman of the Board, National Museum of Natural History in Washington, DC, and his wife.

June 1992

—Jorge Gómez-Jurado returned to Guayaquil.
—Stewart Peck, Bernard Landry, Joyce Cook, and Elvia Inca finished their field work and left the Station.
—Jacinto Gordillo, CDRS Representative on Isla Isabela.
—An internal workshop was held for CDRS personnel, together with the heads of the CDF.
—Gonzalo Cerón returned to Quito.
—Aracelly Fajardo resigned her position as Assistant in Publications and left the Station.
—Howard Snell, University of New Mexico, and assistant Carlos Carrera; land iguanas and lava lizards.
—Craig MacFarland, Alfredo Carrasco, and Mario Hurtado returned to the continent.
—Carlos Valle and field assistants Joanne Avery and Marcín Jakubowski, Princeton University; reproductive and feeding ecology of Flightless Cormorants on Fernandina.
—Sandra Abedrabbo travelled to Quito to give talks about the CDRS to universities on the continent.
—Alfonso Calles, Bayer Company; discussed support for the CDRS Area of Introduced Mammals.
—Cecilia Amaluiza, Ecuadorian Center for Popular Promotion; teachers' course on Methodology of Environmental Education.
—Linda Cayot travelled to Quito to present a paper at the Symposium on Research for the Conservation of Biological Diversity in Ecuador. Lenin Prado and Sandra Abedrabbo also attended the symposium.

—Carlos Caiza finished his volunteership in the Area of Introduced Mammals and returned to Ambato.
—Dr. Roger Conant, University of New Mexico; visited the Area of Herpetology.
—Edgar Muñoz travelled to Quito to present talks about the CDRS to universities on the continent.
—Representatives of the group Technical Cooperation of Spain, accompanied by Alfredo Carrasco, discussed donations for information centers.
—Representatives of US AID discussed donations for the programs of quarantine, agroforestry, and native and endemic plants.
—Pedro Ponce went to Quito to give talks about the CDRS to universities on the continent and to work with the FODINFA project.
—A short course on radio production was given in San Cristóbal, directed by Marcelo Mantilla, volunteer in the Area of Education.
—Craig MacFarland and family on their vacation.
—Yashuhira Kobayashi, journalist for the *Asahi Shimbun* in Japan; to learn about Galápagos and to interview Chantal Blanton and Arturo Izurieta.
—Mr. Wada, Mitsubishi Company of Japan.
—Digvijay Sinh, former Minister of the Environment of India.
—Germán Morillo went to Quito to defend his thesis at the Pontifical Catholic University of Ecuador.
—The continuation of the workshop of Ecuadorian Foundation for Conservation and Sustainable Development (FECODES), which began in Quito, was held in Galápagos.
—Francisco Dalmier and N. Ishuaran, UNESCO; FECODES Workshop and discussed past and future donations.
—Auditor Alex Jara, Price-Waterhouse, Quito.
—Orfa Rodríguez, Central University in Quito, volunteer in the Area of Introduced Mammals, Dark-rumped Petrel protection.

July 1992

—Jim Pinson, husband of the new CDRS Director, arrived.
—Hal Whitehead, Linda Weilgart, and their assistants aboard the yacht *Balena*; studying whales across the Pacific Ocean.
—Robert Reynolds, Kerry Wepner, and David Kammer, University of Idaho, and assistant Alvaro Sánchez; geological studies on Sierra Negra.
—Antonio Portacarrero, Technical University of Esmeraldas, volunteer in the Area of Terrestrial Plants.
—Alfredo Carrasco and a group of journalists for a press conference in the CDRS.
—President-elect Sixto Durán and his family.
—Indira Rivadeneira, Pontifical Catholic University of Ecuador; volunteer in the Area of Environmental Education.
—Folmer Arnklipt, and his wife and daughter, Botanical Garden in Copenhagen, Denmark.
—Carlos Valle notified the CDRS and the SPNG that black rats may have been introduced to Fernandina by fishermen.
—Juan Ruiz left the Station after finishing his thesis on the introduced plants *Lantana* and *Rubus*.
—Bernd Reichelt of the German Parliament.
—David Kammer returned to the USA.
—Television producer Freddy Ehlers with his son Fernando and his assistant Elena Almeida.
—Chantal Blanton, the group of Freddy Ehlers, and Felipe Cruz and Oswaldo Sarango, SPNG, filmed the sea cucumber fishermen on Fernandina and Isabela.
—For the first time, Lonesome George is observed attempting to copulate.
—Carlos Valle and assistants Marcín Jakubowski and Joanne Avery left after finishing their field work studying Flightless Cormorants.
—A ceremony was held to publicly present the books *¿Dónde Vivo Yo?* and *AEIOU*.
—The commander and crew of the *Lae 27 de Febrero*.

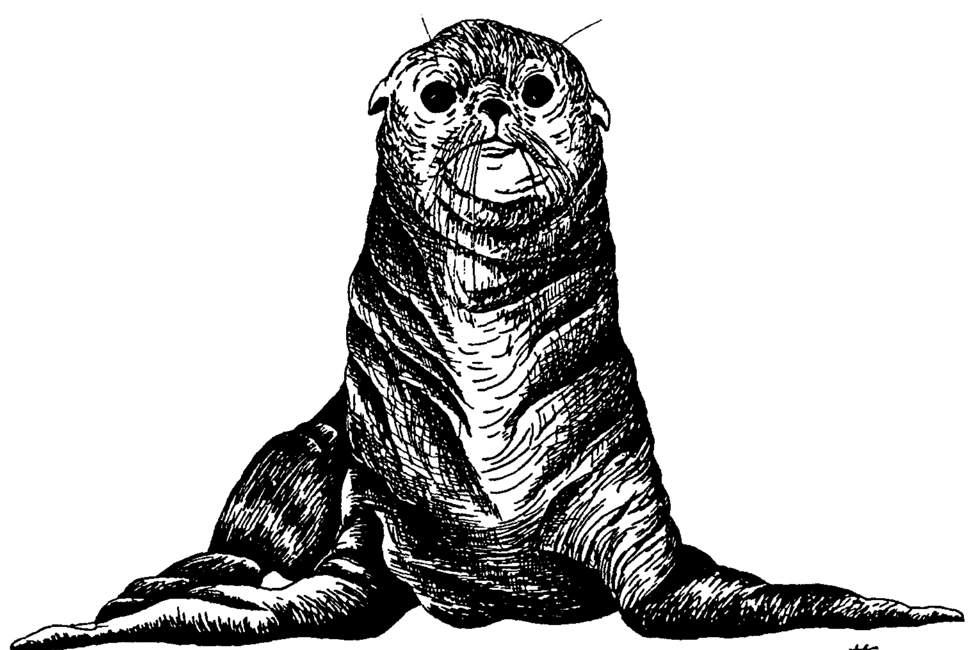
August 1992

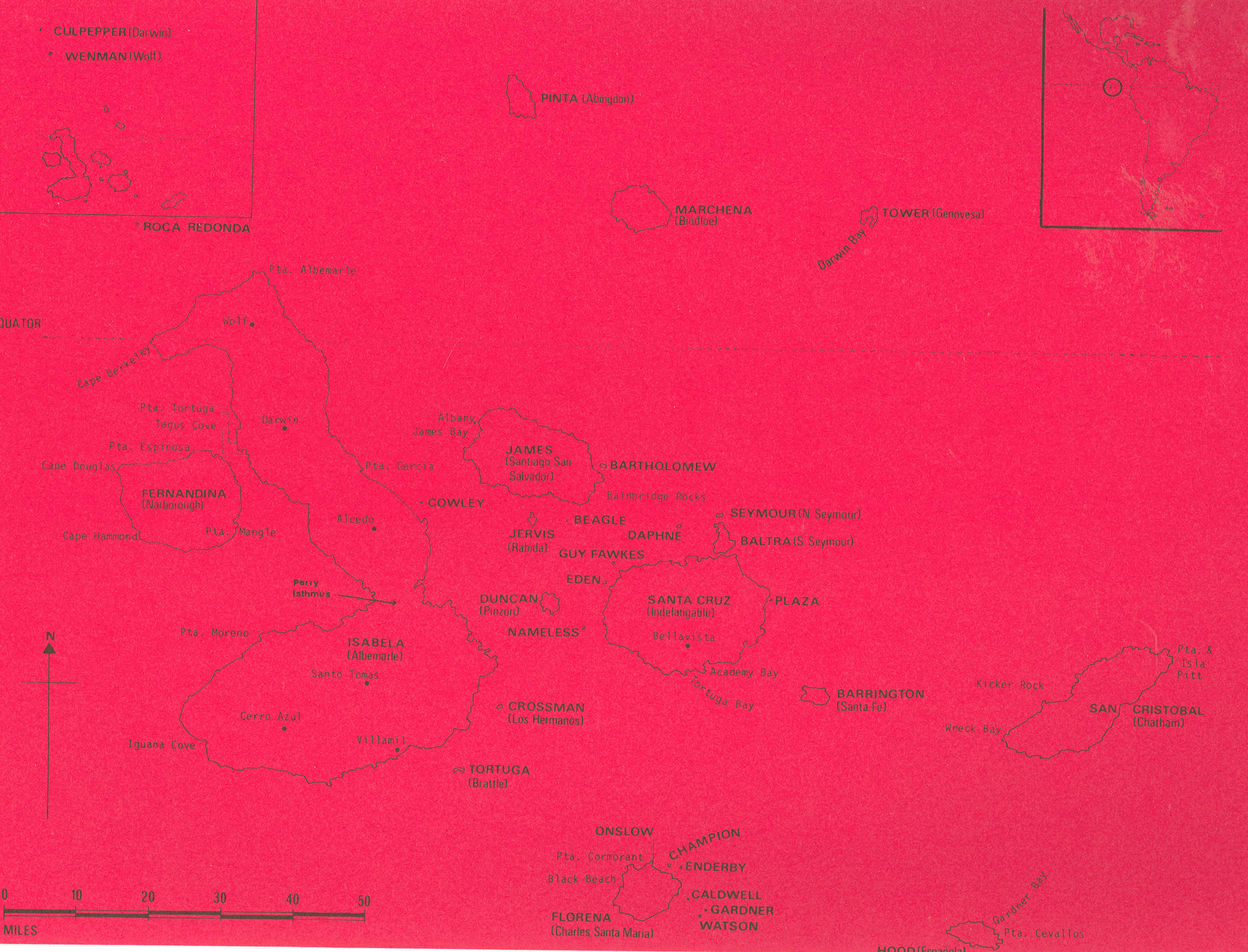
—Howard and Heidi Snell and their assistants Paul Stone and Carlos Carrera left the Station.
—Reporters from Channel 13 of Buenos Aires, Argentina, interviewed Germán Morillo, CDRS Area of Herpetology.
—Volunteers Sylvia Gavilánez, Marcelo Mantilla, and Beatriz Guarnizo left the Station after finishing their volunteerships.
—Adelaida Herrera, University of Guayaquil; volunteer in the Marine Laboratory.
—Paola Buitrón, Galapagueña studying at the University of Azuay; volunteer in the Areas of Herpetology and Invertebrates.
—Chris Reed, World Wide Fund for Nature International.
—Chantal Blanton attended the inauguration of the

new Municipal Council of Puerto Ayora.
—Kay Dodge, President of the Center for Environmental Studies, USA.
—Joseph Reed, Undersecretary of the United Nations, and Mario Salzmann, United Nations Development Program; various aspects of conservation in Galápagos.
—Robert Reynolds, Kerry Wepner, and Alvaro Sánchez left after finishing their geological studies on Sierra Negra.
—Alfredo Carrasco and Blas Luje, CDF, Quito, and Jorge Sotomayor, Representative of the CDRS on Isla San Cristóbal; Workshop of Evaluation and Operation Plan.
—CDRS personnel assisted in the search for a foreign tourist lost in the Tortoise Reserve on Santa Cruz.
—Mario Hurtado and the new Undersecretary of Fisheries, Alberto Loor, visited the Station. Mario also participated in the Operation Plan Workshop.
—Washington Tapia, Galapagueño scholarship student, University of Ibarra; volunteer in the Area of Herpetology.
—Noralma Palacios and Mirelly Vera, OFSERCON, left the Station after auditing the 1991 CDRS accounts.

September 1992

—Chantal Blanton and Arturo Izurieta attended the ceremony for the 25th anniversary of the Republic of Ecuador Hospital in Puerto Ayora.
—Luis Maldonado of Metropolitan Touring and a group of new guide candidates.
—The Courses for Naturalist Guides II and III began.
—Fernando Arcos; cooperative studies between the CDRS and Oceanographic Institute of the Ecuadorian Navy.
—Sara Santacruz, volunteer artist in the Area of Interpretation.
—The Permanent Commission on Galápagos visited Islas San Cristóbal, Santa Cruz, Isabela, and Floreana, for meetings with local authorities.
—Gerald Ackers, fundraiser for CDRS projects with the European Campaign.
—Victor Carrillo, University of Guayaquil and University of Bielefeld; marine iguanas on Santa Fe; accompanied by his assistants Raúl Menoscal, Polytechnical School of Guayaquil, and Jorge Bermeo and Fabricio Pesantes, University of Guayaquil.
—María Eugenia Jara, Pontifical Catholic University of Ecuador; anis.




CULPEPPER (Darwin)
WENMAN (Wolf)
ROCA REDONDA
PINTA (Abingdon)
MARCHENA (Bindloe)
TOWER (Genovesa)
Darwin Bay
Pta. Albemarle
EQUATOR
Wolf
Cape Berkeley
Pta. Tortuga
Tagus Cove
Darwin
Pta. Espinosa
Cape Douglas
FERNANDINA (Narborough)
Cape Hammond
Pta. Mangle
Pta. Garcia
Alcedo
Perry Isthmus
Pta. Moreno
ISABELA (Albemarle)
Santo Tomas
Cerro Azul
Iguana Cove
Villamil
Albany
James Bay
JAMES (Santiago San Salvador)
BARTHOLOMEW
Bainbridge Rocks
COWLEY
JERVIS (Rabida)
BEAGLE
DAPHNE
GUY FAWKES
EDEN
DUNCAN (Pinzon)
NAMELESS
SEYMOUR (N Seymour)
BALTRA (S Seymour)
SANTA CRUZ (Indefatigable)
Bellavista
PLAZA
Academy Bay
Tortuga Bay
CROSSMAN (Los Hermanos)
TORTUGA (Brattle)
BARRINGTON (Santa Fe)
Kicker Rock
Wreck Bay
SAN CRISTOBAL (Chatham)
Pta. & Isla Pitt
ONSLOW
CHAMPION
Pta. Cormorant
ENDERBY
Black Beach
CALDWELL
GARDNER
WATSON
FLORENA (Charles Santa Maria)
Gardner Bay
Pta. Cevallos
HOOD
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MILES