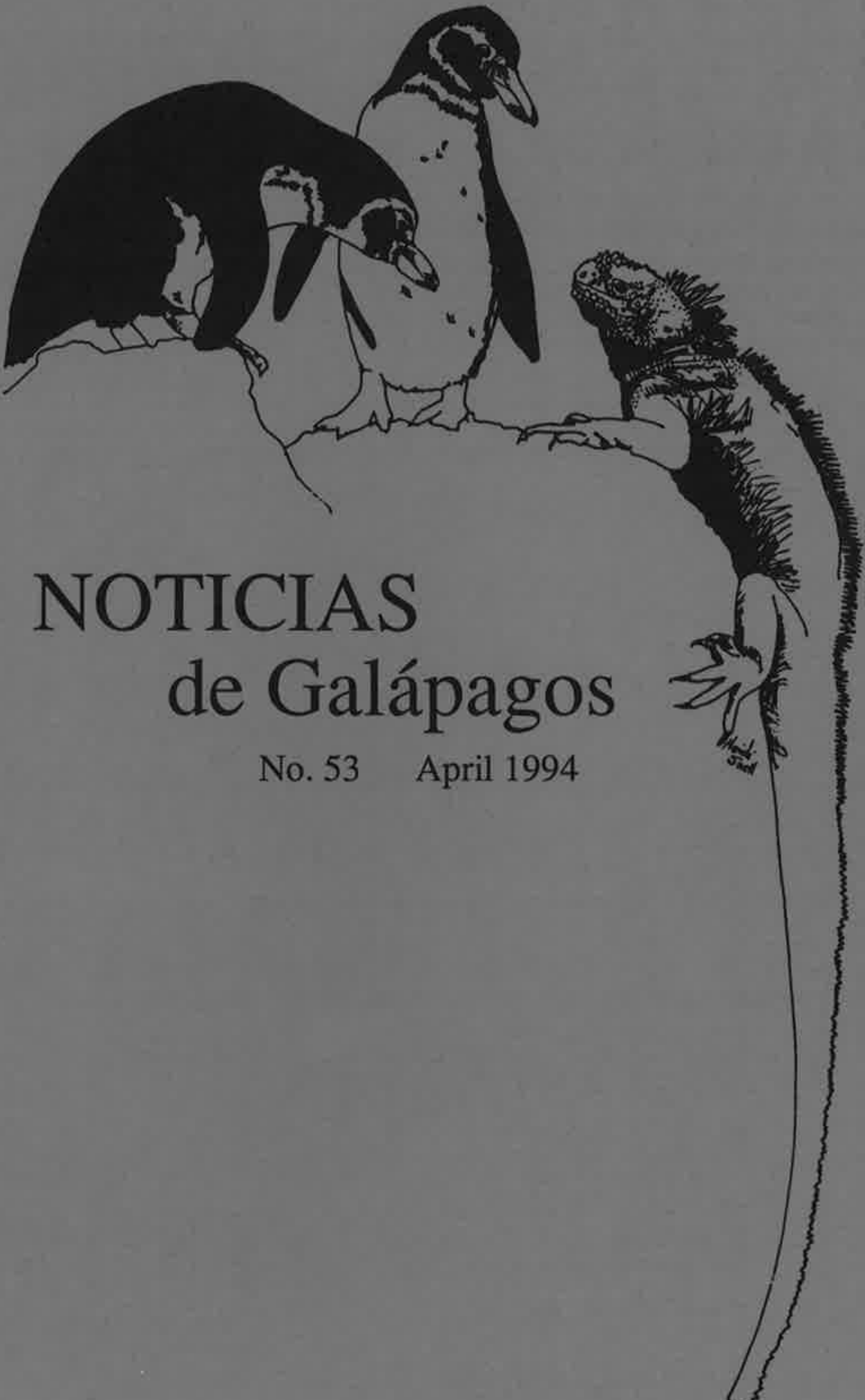

NOTICIAS de Galápagos

No. 53 April 1994

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NOTICIAS DE GALÁPAGOS

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

No. 53 April 1994

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'PEPINO WAR, 1992' — IS CONSERVATION JUST A MATTER FOR THE ELITE? A GALAPAGUENO'S VIEWPOINT.

By: Carlos A. Valle

Poverty was the common link of all the first 'colonos' that came to the Galápagos islands with the wish of fulfilling the simple dream of getting enough food to the table of their starving families. At that time, the 'patriotic' philosophy was, "go there, and ... haga Patria, clean up the land, get rid of the weeds, plant whatever you want, and... that will be your land". Why can't that philosophy hold any more? Simply because, apart from the patriotic attitude, everything about it is wrong.

To understand this we have to realize that the Galápagos, like the rest of Ecuador, has an economy based on its natural resources, and that an intelligent use of them is our only way of ensuring our future as a country, as a community, and as a family. Therefore, there is no need for a complicated model of the economy to convince one that it is unwise to allow the predatory exploitations of natural resources that have been made in the Galápagos Islands in the last decades.

For example, continued exploitations of sharks, and more recently, of sea cucumbers (pepinos del mar), can have only one outcome, and nobody has to be a prophet to foresee it: unjustified destruction and even more poverty. Hundreds, and perhaps thousands, of Ecuadorians could get a glimpse of an ephemeral paradise brought by a sudden short-lived economic opportunity and illusory prosperity, but at the price of tomorrow's misery. That is the most likely story, the sorry story for the poor, but by that time the entrepreneur who promoted it will be gone, his pockets full, and here we will still be, even poorer than before. We would have undermined our own future, a future that we could achieve by protecting our resources and demanding an ecologically sustainable use. That is the reason why conservationists, including myself, have been fighting a 'war' apparently against our own people, instead of adopting the easier position of jumping into a political arena to defend the galapaguenos' rights to destroy their own future.

Therefore, the 'victory for the conservationists' as recently described by Godfrey Merlen (Noticias de Galápagos 1993), means not only that endemic rice rats have been protected once again — although they have an inherent right to survive — it means the only future for Galapaguenos and other Ecuadorians has been ensured once again. We also have avoided the shame of an irresponsible action, which internationally can harm the Country's political and economic trust. Thus, rather than an endeavor of an 'eccentric elite' (Merlen 1993), we should understand that an ecological protection of the Galápagos Islands may be our only hope for the future.

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[Editors Note: Carlos was born in the Galápagos and worked within the National Park as a tourist guide and a researcher at the Charles Darwin Research Station. He recently received his Ph.D. degree in Peter Grant's laboratory at Princeton.]

A LOT MORE THAN JUST *MONTE*!

By: David Sutherland

Maria Lourdes surveyed the scrubby transition-zone forest behind the high school, looking puzzled. Finally she asked, "Where are we going to build this nature trail? There's nothing out there but *monte*." *Monte* is a Spanish word refering to worthless brush and weeds, a term often used to disparage uncleared land.

The question caught me off guard. I was standing on an ancient flow of aa lava with a group of about a dozen students, looking across 2.4 hectares owned by the Miguel Angel Cazares High School of Puerto Ayora. The property was located within the township, but shared a border with Galápagos National Park. It was virgin forest: no signs of tree-felling, construction or introduced plants. We could see Palo Santo and Matazarno trees, and huge *Opuntia* and *Jasminocereus* cacti, from our vantage point. To me it was not just *monte*. It seemed the perfect place to build a nature trail. Over the next few months, I hoped to see this trail take shape as the result of careful planning and hot, sweaty labor.

The high school's original plan was to clear the brush and trees to make way for students' vegetable gardens. This seemed like a sad waste of such a valuable teaching resource, and could also encourage the spread of introduced plants within the community close to the National Park boundary. It was easy to convince the high school's director to save the forest and build a nature trail instead of a cabbage patch.

Besides acting as a buffer zone and protecting habitat, the forest would preserve an incomparable laboratory for natural science classes and student projects. "Imagine," I told the director, "Biology students around the world read about Galápagos in books and would give their molars to visit what you have out behind the administration building. This will be a fun place to study science." Many of the high school students had hopes of someday taking the Naturalist Guide Training Course offered by the Galápagos National Park Service. They could practice their guiding with children from other schools on their own private teaching trail while providing an educational service for the town. They could also learn how to communicate with visitors by preparing self-guiding pamphlets and signs to interpret the trail. As Head of Interpretation at the Charles Darwin Research Station, I agreed to work with the high school staff, to show the kids how to construct their own nature trail.

But it turned out to be a lot more than just cutting a trail through the brush. A group of high school students armed with enthusiasm and machetes but lacking a plan can wreak havoc on a natural area. So before attacking the *monte*, we practiced defining and writing objectives, a new skill for most of them. Once they had agreed among themselves to a common set of objectives, we conducted a careful study of the terrain to identify potential sites of interest as well as sites to avoid. They produced a detailed map of the area and with this in hand, were able to identify a route for the trail. They agreed that the trail would detour around all trees and large cacti.

This planning process was in some ways the most interesting phase. Some of the students, especially a few the teachers had warned me about, developed into real leaders on the project. A core group of about fifteen would stay late into the afternoons or come on weekends. I took the students on a series of nature walks on the school's land so they would become familiar with the forest and its mysteries. Once we quietly watched a Woodpecker Finch rip apart dead branches in search of wood-boring insects. We found a hidden glade of tall *Opuntia* tree cacti where a tiny black and yellow spider spun a delicate web between the tips of cactus spines. I showed them how to call in Yellow Warblers and Darwin's finches, and how to smell the Palo Santo tree's distinctive odor without damaging the bark.

One weekend morning, we flagged the route and were finally ready to begin the actual construction. Most of the students showed up that day, equipped with shovels, saws, picks and machetes; those who had demonstrated the most interest and leadership each took a work crew and started construction at different points. It was astonishing how quickly the trail was cleared. We moved rocks to the edges, making an easier walking surface while building up a border.

When it was finally finished, the loop trail measured just under half a kilometer, curves and all. The construction had taken two weekends, and cost virtually nothing since it relied on volunteer labor of students. Finishing touches, such as an interpretive pamphlet, signs and gravel for a few rough spots will require an investment. The nature trail was a big hit during the Cazares High School open house in September. Students who participated in the planning and construction guided the guests, proud to show off their achievement. I was delighted to see professors from the other high school enviously noting details: they have an even larger tract of untouched transition forest along the National Park boundary. Perhaps they were realizing that they have something extremely valuable on their hands.

On that long-ago morning, Maria Lourdes' question had caught me off guard. Sighing inwardly, I had prepared to explain again, but one of the other students beat me to it. "That is where we'll build the nature trail. And it's not just *monte*, it's a forest. That's what people are going to want to see." I felt an uncontrollable grin slowly spread across my face.

WHAT IS INTERPRETATION? *Interpretation is a communication strategy for teaching people who are not required to pay attention to the teacher. Visitors to parks and museums cannot be forced to read exhibits, attend campfire programs or watch educational videos. Interpreters are professional educators who specialize in making the learning process enjoyable and personal, and "interpreting" technical content, so that people will choose to learn in spite of competing stimuli.*

The CDRS has employed various interpreters over the years. These professionals have used their talents to create exhibits and nature trails; to develop educational audiovisual programs; and to design publications for visitors and people in the communities of Galápagos. Interpreters have worked with school groups, presented slide talks to visitors and trained Naturalist guides in the art of communication.

David Sutherland, Charles Darwin Research Station, Puerto Ayora, Galápagos, Ecuador.

LIST OF CETACEANS SEEN IN GALÁPAGOS

By: David Day

This list is mainly based on personal observations, records from other qualified observers, and from collected specimens preserved in the islands. Only fairly recently (10-15 years) has there been more than a casual interest in observations of whales; thus, there are anomalies in previous records, e.g. formerly the larger baleen whales were nearly always identified as fin whales (*Balaenoptera physalus*), but recently these are correctly identified as Bryde's (*B. edeni*), or occasionally Sei (*B. borealis*) whales. Tui de Roy, a Galápagos resident and very experienced naturalist, was uncertain of their identification for many years, until she observed fin whales in Baja California. She has since corrected many previous identifications.

Another dilemma is with the common (*Delphinus delphis*) and stenellid dolphins (*Stenella* spp.); in all my years here I have never seen a spinner (*Stenella longirostris*), but some people report them regularly. When the other species leap, and gyrate their tails, as the striped (*S. coeruleoalba*) does, it looks like they are spinning. Spinners certainly are present in the waters around the Islands. To differentiate between these species at distance can be very difficult.

Two other species that are almost impossible to tell apart are the melon headed (*Peponocephala electra*) and the pygmy killer whale (*Feresa attenuata*). The mesoplodont beaked whales are almost impossible to tell apart as well; for many species there is very little data, and new species have been described in the last few years.

A demonstration of our limited knowledge at sea of these creatures is that the Fraser's dolphin (*Lagenodelphis hosei*), a relatively common tropical species, was not described to science until 1956. The most recent case is that of the blue whale (*Balaenoptera musculus*), a species common to other areas of the eastern tropical and south Pacific. It was never reported for the Galápagos until 1993 when they were sighted on four different occasions in western and southern Isabela and Fernandina Islands, within a few miles from the coast. The southern bottlenose whale (*Hyperoodon planifrons*) could be a potential candidate, as there are records from along the equator.

The following list of 24 species should be regarded as a minimum number rather than a complete list. My taxonomic organization follows Leatherwood and Reeves (1983). Abundance is classified as frequent (F), present (P), occasional (O), rare (R). Range is described as outer, normally in waters deeper than 1000 fathoms (O), mid, waters between 1000 and 100 fathoms deep (M), inner, waters less than 100 fathoms (I), all areas (A).

Note: This describes the normal range from present knowledge, and does not mean that some species from deep water will not make incursions into shallower water, especially where deeper water is close to the coast.

Other classification marks are: ? = lack of data, owing to the animals being shy or rare, or because of identification difficulties and ( ) = in range category that they are occasionally seen there; in abundance category that they are probably more common than sightings suggest. * = probable sighting just off NE coast of Santa Cruz Island. ** = skull and skeleton remains found in 1964 by members of the Galapagos International Scientific Project expedition, buried in sand along the beach at Tortuga Bay, Santa Cruz Island. The skull is deposited in the collection of the California Academy of Sciences (Orr 1965).

LIST OF CETACEANS SEEN IN GALÁPAGOS.

SCIENTIFIC NAME	COMMON NAME	ABUNDANCE	RANGE
A. Suborder Mysticeti			
1. *Balaenoptera musculus*	Blue whale	R	M, O
2. *Balaenoptera borealis*	Sei whale	R, ?	M, O
3. *Balaenoptera edeni*	Bryde's whale	F	A
4. *Balaenoptera acutorostrata*	Minke whale	R	?
5. *Megaptera novaeangliae*	Humpback whale	O	I, M (O)
B. Suborder Odontoceti			
6. *Physeter macrocephalus*	Sperm whale	F	O, (M)
7. *Kogia breviceps*	Pygmy sperm whale	R, ?	O, (M)
8. *Kogia simus*	Dwarf Sperm whale	O, ?	A
9. *Berardius* sp.	Beaked whales*	--	--
10. *Ziphius cavirostris*	Cuvier's beaked whale	P	M, O
11. *Mesoplodon* spp.	Beaked whales	O	M, O
12. *Peponocephala electra*	Melon headed whale	R	O, (I)
13. *Feresa attenuata*	Pygmy killer whale	R	O
14. *Pseudorca crassidens*	False killer whale	P	I, M, (O)
15. *Orcinus orca*	Killer whale	P	A
16. *Globicephala macrorhynchus*	Short finned pilot whale	P	A, (M, O)
17. *Steno bredanensis*	Rough-toothed dolphin**	--	--
18. *Lagenodelphis hosei*	Fraser's dolphin	R, (P)	O
19. *Delphinus delphis*	Common dolphin	F	M, O
20. *Tursiops truncatus*	Bottlenose dolphin	F	I, M, (O)
21. *Grampus griseus*	Risso's dolphin	P	M, O
22. *Stenella attenuata*	Pantropical spotted dolphin	P, R, ?	O
23. *Stenella coeruleoalba*	Striped dolphin	P	O
24. *Stenella longirostris*	Spinner dolphin	?	O

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David Day, Puerto Ayora, Isla Santa Cruz, Galápagos, Ecuador.

INTRODUCED GECKOS IN THE TOWNS OF SANTA CRUZ, SAN CRISTÓBAL AND ISABELA

By: Janeth Olmedo and Linda J. Cayot

INTRODUCTION

Introduced organisms often negatively affect island ecosystems (MacDonald et al. 1989, Loope and Mueller-Dombois 1989). While most examples of these negative effects involve organisms other than reptiles, there are cases where introduced reptiles, such as the brown tree snake (*Boiga irregularis*), have had disastrous effects on native fauna (Marshall 1985). The impact of introduced organisms in Galápagos is well documented (Hamann 1984, Hoeck 1984). However, little is known about the impact of the introduced reptiles.

The only introduced reptiles that have established reproductive populations in Galápagos are in the family Gekkonidae. The status of introduced gecko species was reviewed in 1989 (Hoogmoed 1989). The large introduced gecko in Puerto Ayora, Santa Cruz, *Phyllodactylus reissi*, was seen first in the mid 1970s and was probably brought to the Islands via the regular cargo boat service from Guayaquil. *Lepidodactylus lugubris* was also introduced to Santa Cruz (Wright 1983a, 1983b). *Gonatodes caudiscutatus*, the third introduced species of gecko in Galápagos, is found only on San Cristóbal and was first recorded there in 1892 (Van Denburgh 1912). In addition, *Phyllodactylus leei*, a species endemic to San Cristóbal, was reported in Puerto Villamil on Isabela (Wood 1939), but no further observations of this species on Isabela have been made. Hoogmoed (1989) recommended regular monitoring of the introduced gecko populations and that a decision be made as soon as possible whether the eradication of the introduced geckos is of high priority.

In Galápagos there are six endemic species of geckos, all of the genus *Phyllodactylus*. All are relatively small and are generally restricted to the Arid Zone. Of the introduced species, only *P. reissi* has habitat requirements similar to the endemic species, restricted to arid coastal areas. *Gonatodes caudiscutatus* requires relatively wet areas; it is found in the wet highlands of San Cristóbal and in artificially wet gardens in the coastal town of Puerto Baquerizo Moreno (Hoogmoed 1989). *Lepidodactylus lugubris* is generally associated with humans throughout the coastal areas of the southern and central Pacific. In Galápagos it appears to be restricted to coastal areas. All of the endemic species lay only one egg, except for *P. darwini*, which can lay 1-2 eggs, while all of the introduced species lay two eggs. In addition, *Lepidodactylus lugubris* is parthenogenic.

In 1992-93, a study of the introduced and endemic species of geckos in the populated areas of the five inhabited islands was completed. The primary objective was to determine the distribution of the various species and the impact and potential threat of the introduced species on the endemic species.

METHODS

This study was carried out on Santa Cruz, San Cristóbal, Isabela, Floreana and Baltra. Lowland areas with human habitations were monitored on all islands, while highland areas were monitored only on the first three. Monitoring was done in both the hot and garua seasons (Table 1). Each inhabited area was divided into sectors. A monitoring period consisted of observations in one sector per night (15 houses randomly selected per sector), on consecutive nights until all sectors had been completed. In addition, in each of the three main ports (Puerto Ayora, Puerto Baquerizo Moreno and Puerto Villamil), eight 50-m transects into the natural habitat surrounding the developed areas were checked (two transects in each

Table 1. Dates of sampling periods in each of the five populated islands.

SEASON	MONTH	SANTA CRUZ	SAN CRISTÓBAL	ISABELA	BALTRA	FLOREANA
HOT	May/92	X				
	June/92					
GARUA	July/92	X				
	Aug/92		X			
	Sept/92	X				
	Oct/92			X		
	Nov/92	X				
HOT	Dec/92				X	
	Jan/93					
	Feb/93	X				
	March/93		X			
	April/93	X				X
	May/93					
	June/93			X		
GARUA	July/93				X	
	Aug/93					
	Sept/93					
	Oct/93					X

of the cardinal directions).

When possible, geckos were captured, measured and their sex and age group determined. Total number of observations include both captured and non-captured animals.

RESULTS

Gecko distribution on the inhabited islands is as follows: Santa Cruz -- *Phyllodactylus galapagoensis* (endemic), *Phyllodactylus reissi* (introduced), *Lepidodactylus lugubris* (introduced); San Cristóbal -- *Phyllodactylus darwini* (endemic), *Phyllodactylus leei* (endemic), *Gonatodes caudiscutatus* (introduced), *Lepidodactylus lugubris* (introduced); Isabela -- *Phyllodactylus galapagoensis* (endemic), *Lepidodactylus lugubris* (introduced); Floreana -- *Phyllodactylus bauri* (endemic); Baltra -- *Phyllodactylus galapagoensis* (endemic).

The introduced species *Lepidodactylus lugubris* was reported for the first time on both San Cristóbal and Isabela. Both Floreana and Baltra are apparently still free of introduced geckos.

P. darwini, one of the endemic species on San Cristóbal, and *P. reissi*, one of the introduced species on Santa Cruz, are the largest of the geckos studied (Table 2).

In Santa Cruz, introduced geckos were found only in Puerto Ayora, not in the highlands. In the six sampling periods, the total number of observations of the endemic species (n = 2950) was more than three times greater than the total number of observations of the two introduced geckos (*P. reiss*, n = 657; *L. lugubris*, n = 193). *P. reissi* was observed in nearly all sectors of town, but, based on numbers of observations, it is dominant only in the three sectors surrounding the dock (Fig. 1). *Lepidodactylus lugubris* was only observed in four coastal sectors, generally in areas with mangroves. Only one observation of an introduced gecko (*P. reissi*) was made in the natural habitat transects surrounding Puerto Ayora, while there were 34 observations of the endemic species. The one observation of *P. reissi* was in a transect adjacent to the Ninfas neighborhood, which had the second highest number of observations of that species.

In San Cristóbal, the two endemic species were found in all sectors of Puerto Baquerizo Moreno (Fig. 2). Both of the introduced species, *G. caudiscutatus* and *L. lugubris*, were present in few sectors, generally close to the town dock. Both appear to be restricted to fairly humid habitats. Only the endemic species, *P. leei*, was observed in the natural habitat transects (n = 4). *G. caudiscutatus* was much more abundant in the highlands and was found not only in the village El Progreso (Fig. 2), but also in the farmlands (5 observations in a sample of two houses and 29 in the farm area surrounding the houses) and in the Galápagos National Park (GNP) (1 observation).

In Isabela, the endemic species was observed in all sectors of Puerto Villamil, while the introduced species, *Lepidodactylus lugubris*, was observed in only two sectors (Fig. 3). Only the endemic species was observed in the natural habitat transects (n = 4).

Table 2. Snout-vent length (SVL, mean and standard deviation) of gecko species in the populated islands.

		MALE		FEMALE	
SPECIES	ISLAND	N	SVL	N	SVL
Endemic					
P. galapagoensis	Santa Cruz	611	41.4 + 4.7	700	40.9 + 5.5
	Isabela	89	43.1 + 4.4	130	42.4 + 5.4
	Baltra	17	43.5 + 3.5	19	44.7 + 4.4
P. bauri	Floreana	27	46.6 + 5.8	38	43.4 + 5.8
P. leei	San Cristóbal	39	41.9 + 3.2	43	42.0 + 3.8
P. darwini	San Cristóbal	22	65.6 + 9.0	39	58.7 + 10.7
Introduced					
P. reissi	Santa Cruz	103	62.2 + 14.3	139	56.3 + 13.8
L. lugubris	Santa Cruz	2	40.1 + 4.1	53	39.4 + 4.1
	Isabela	-	-	6	41.2 + 2.5
	San Cristóbal	-	-	21	41.5 + 2.5
G. caudiscutatus	San Cristóbal	7	40.1 + 2.1	24	38.4 + 3.2

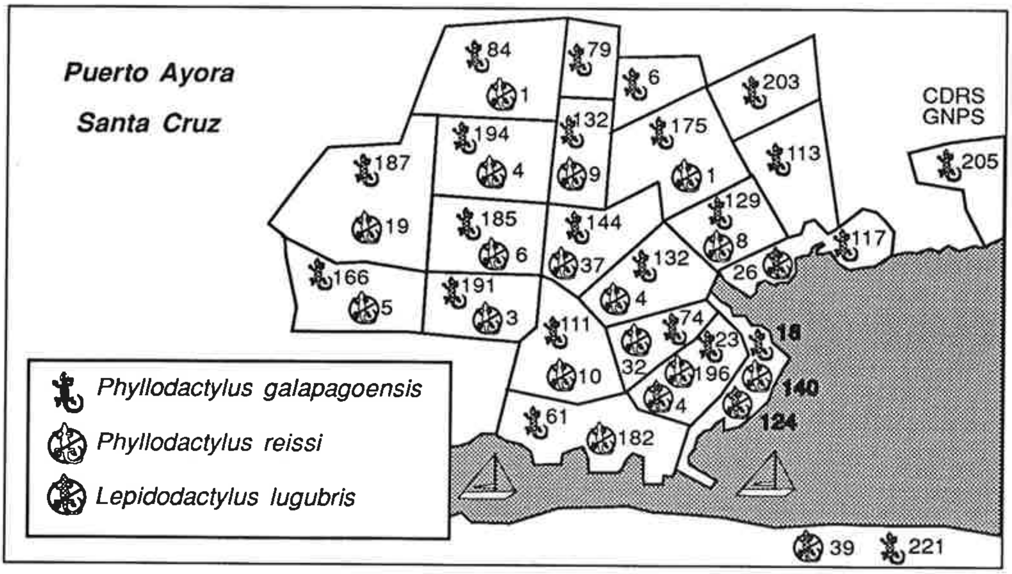

Figure 1. Total number of observations of gecko species in the 23 sectors of Puerto Ayora, Santa Cruz; includes data from six sampling periods (May 1992 - April 1993).

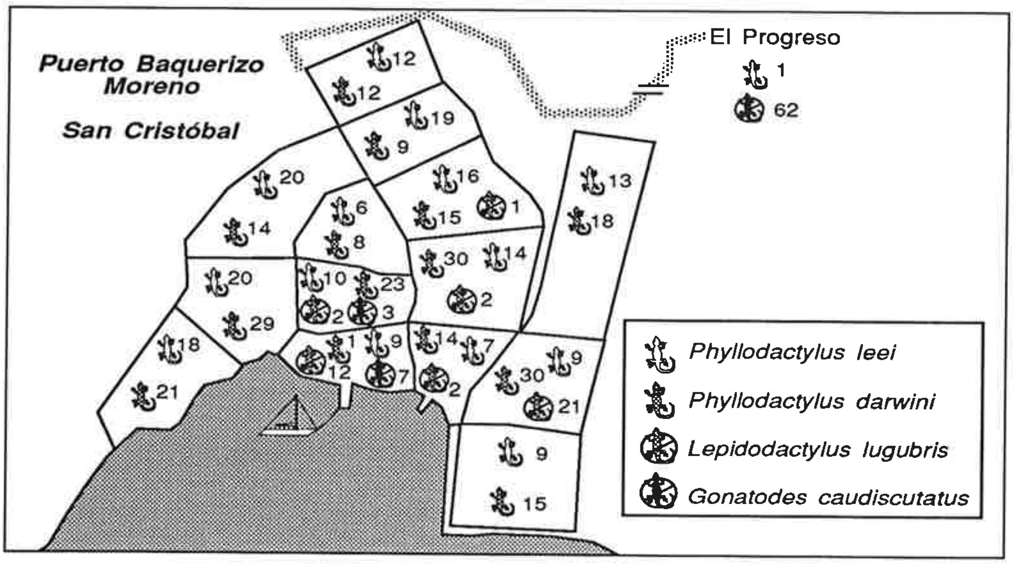

Figure 2. Total number of observations of gecko species in the 14 sectors of Puerto Baquerizo Moreno and in El Progreso, San Cristóbal; includes data from two sampling periods (August 1992 and March 1993).

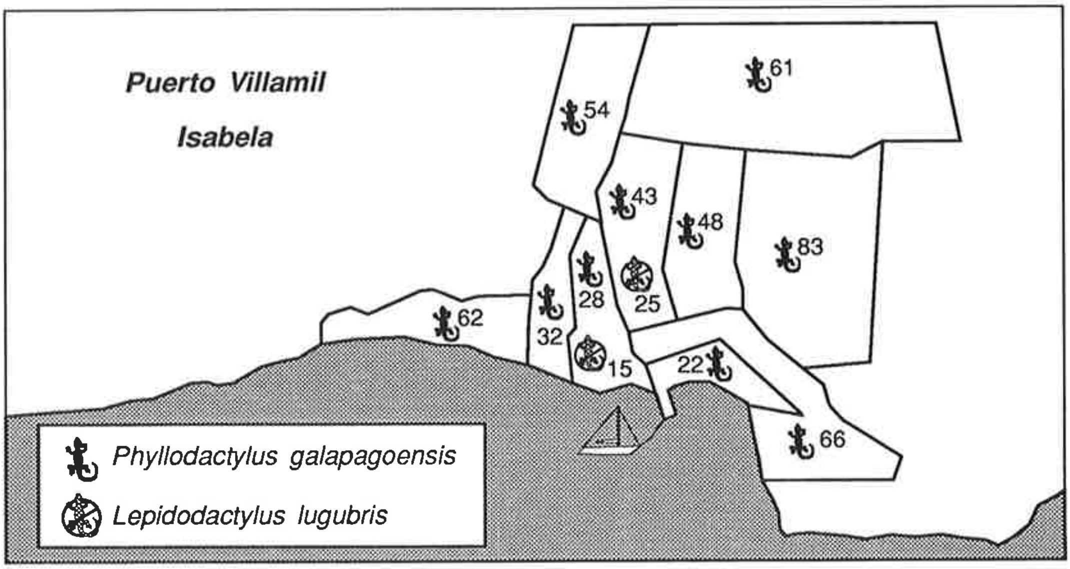

Figure 3. Total number of observations of gecko species in the 10 sectors of Puerto Villamil, Isabela; includes data from two sampling periods (October 1992 and June 1993).

DISCUSSION

In summary, results from this study indicate that introduced geckos have resident populations on the three islands with greater human populations (Santa Cruz, San Cristóbal and Isabela), but not on Floreana or Baltra. The dispersion of the introduced species appears to be from the dock of each port, where cargo arrives from ships, presumably carrying the introduced organisms. Since the distribution of each species depends not only on the point of arrival, but also on their preferred habitat, the potential threat of the introduced geckos to the endemic geckos depends primarily on the preferred habitat of each species.

The dispersion of *Phyllodactylus reissi* in Puerto Ayora appears to be from the dock area towards the center of the town. Where it exists in greater numbers, it appears to have displaced the endemic species. In only a few cases are both species seen together on the same wall. While the distribution of *P. reissi* remains limited to the town, it does not present a major threat to the endemic species in the GNP. However, it could become a threat if it spreads into the GNP (Hoogmoed 1989). A campaign to reduce numbers or eliminate *P. reissi* in Puerto Ayora, especially in the areas close to the GNP boundary, would be warranted, possibly enlisting the aid of high school students in coordination with educational programs on the problems of introduced species.

Lepidodactylus lugubris is apparently restricted to the coastal zone where there is adequate humidity, often areas with mangroves. It therefore does not present a major threat to the endemic geckos, which are restricted to the Arid Zone. However, it is more likely to successfully disperse throughout the Archipelago than the other species due to its distribution along the coast and the fact that it is parthenogenic.

Of the three species, *G. caudiscutatus* was the only one found outside the inhabited areas. Individuals were observed primarily in the highlands (in El Progreso, in farmlands and in the GNP). The generally humid habitat of this species does not support the endemic geckos, which occur only in xeric habitats. Therefore, the direct impact of *G. caudiscutatus* on the endemic species of gecko in San Cristóbal is minimal.

Unlike the impact of many other organisms introduced to the Galápagos Islands (including plants, insects, mammals, etc.), the introduced geckos do not present a serious threat to the endemic species. We consider that conservation efforts, which depend on limited funds and personnel, should be directed at the more aggressive and dangerous introduced species rather than the geckos. However, periodic monitoring of all introduced species and low-cost control efforts of *P. reissi* in Puerto Ayora should be carried out.

ACKNOWLEDGMENTS

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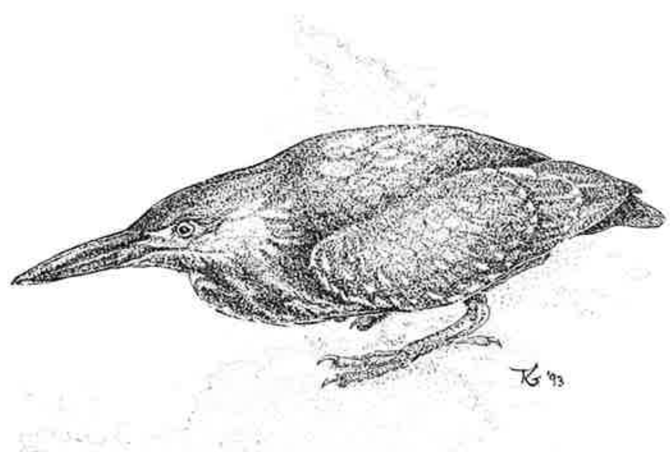

ARE MARINE IGUANAS ENDANGERED ON ISLANDS WITH INTRODUCED PREDATORS?

By: Linda J. Cayot, Kornelia Rassmann, and Fritz Trillmich

To visitors of Galápagos, marine iguanas (*Amblyrhynchus cristatus*) are the most obvious large reptile, inhabiting nearly all islands. They occur most abundantly on southern coastlines exposed to the prevailing winds, currents, and wave patterns (Laurie 1983). However, this superficial impression of widespread, healthy and very abundant populations may be in need of careful revision. While it has been known for a long time that introduced mammals prey upon marine iguanas (feral dogs attack adults (Kruuk and Snell 1981); feral cats attack young (Konecny 1983, Laurie 1983)), recent observations indicate a potentially alarming lack of recruitment, i.e., survival and growth to reproductive age, in some populations.

Laurie (1983) described an apparent lack of recruitment in populations of marine iguanas on some islands where cats and rats are abundant and where cats, at least, demonstrably prey heavily on hatchling and juvenile marine iguanas (his Fig. 2 shows cats as a predator on Santiago, where they apparently no longer occur). In his survey of most of the coastline of the Archipelago, Laurie noted this lack of recruitment of hatchlings in a number of colonies on Isabela (see also Jacome 1989), Floreana, San Cristóbal, and Santa Cruz, all islands with abundant cat and rat populations. A comparison of a population from Santa Fe, an island without introduced predators, with a population from Punta Nuñez on Santa Cruz, shows great differences. On Santa Fe, 53% of 650 hatchlings marked in May 1981 still survived in November, whereas at Punta Nuñez less than 1% of over 1000 marked hatchlings were still alive in November (Laurie 1983; Rauch, pers. comm. in Laurie 1983).

On a recent trip to collect blood samples of marine iguanas throughout the Archipelago (February/March 1993, Fig. 1), we were impressed by the conspicuous absence of juveniles in the populations on Isabela, Floreana, San Cristóbal, and Santa Cruz. These are the only islands, other than Baltra, with feral cat populations. There was evidence of iguana nesting on all islands visited, but only on islands without introduced predators was an abundance of juveniles observed.

Marine iguana populations seem to be much lower today than described for 1981 by Laurie (1983), particularly at Caleta Negra and Punta Albermarle on Isabela. Laurie indicated that many of the populations, particularly those on Isabela, were in severe danger of extermination once the adults presently comprising most of the populations die. Unlike for other populations on Isabela, at Punta Vicente Roca, Laurie found substantial recruitment and suggested that the steep cliffs protected marine iguanas from cat predation. However, Jacome (1989) observed in 1987 and 1988, that feral cats had preyed on hatchlings and that recruitment was nearly zero. The causes for such differences should be investigated as they may be due to factors not directly related to cat predation.

The iguana population on Pinzon, where Laurie also noticed a lack of recruitment, may present a special case. Unlike the other four islands mentioned, where cats appear to be the dominant predator of marine iguanas, the only introduced predator on Pinzon is the black rat. While black rats do not appear to have a major impact on marine iguana populations on other islands, they may be particularly food-stressed on Pinzon and, as in the case of giant tortoises (MacFarland et al., 1974), prey on the recent hatchling marine iguanas, thus limiting recruitment. Only in 1989, when the rat population was near zero following the rat eradication campaign

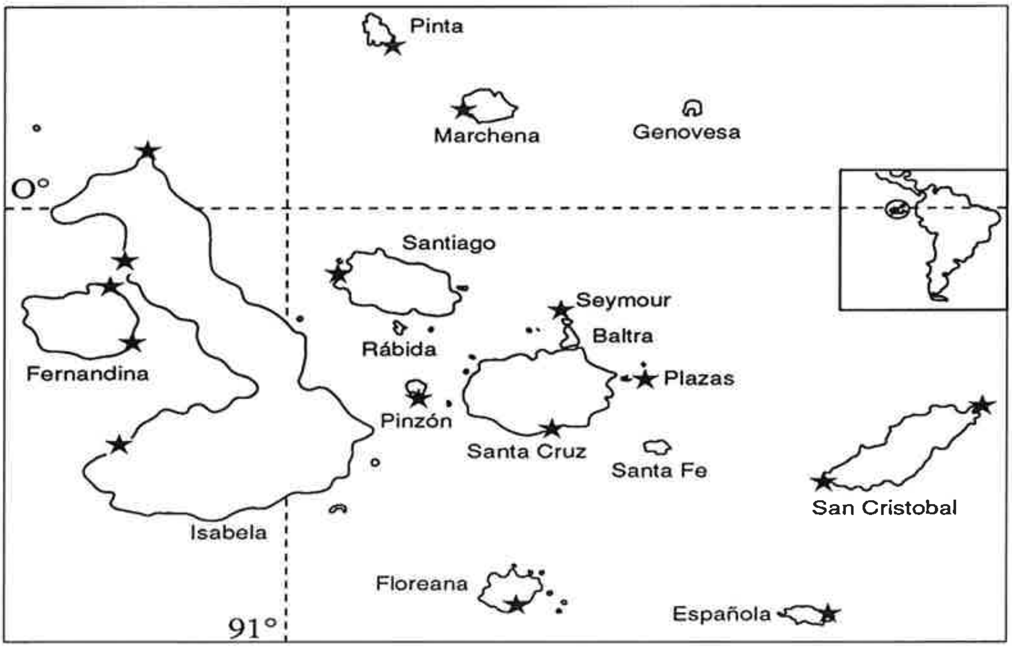

Figure 1. Marine iguana sites visited in February/March 1993.

in 1988 (Cayot and Calvopiña 1989), were more marine iguana hatchlings observed than normally. During our brief stay, we observed few adults and even fewer young. The combination of a coastline that does not provide the ideal habitat for marine iguanas and an abundance of black rats may result in a small marine iguana population.

It is probable that the current status of marine iguana populations on the cat-infested islands is due to the combined effect of high mortality during El Niño 1982-83 (Laurie and Brown 1990) and continued cat predation of hatchlings resulting in low recruitment. We recommend the development of a careful monitoring program to determine the dynamics of the apparently threatened iguana populations and the level of threat due to feral cats. This would involve periodic censusing using mark/recapture at specific sites, on islands with and without cats.

In addition, we recommend a study testing the feasibility of improving hatchling recruitment by reducing cat numbers in iguana nesting zones. This could be done by comparing survivorship of hatchling iguanas on Caamaño, a small islet without feral cats off the southern coast of Santa Cruz, with survivorship of hatchlings in 4-6 nesting areas on the southern coast of Santa Cruz, where cats are abundant. No reduction in cat numbers would be done at one of the Santa Cruz sites (control), while various levels of cat reduction would be carried out in the remaining sites. A goal of this study should be the development of techniques that will ensure an increase in hatchling survival and eventual recruitment to the breeding population. The results of the proposed study will provide the necessary data to establish both the need for and the means of a pilot management program for marine iguana populations. This program may need to be implemented almost immediately for certain populations; otherwise some marine iguana populations may become severely threatened in the near future if they are not already.

Both a long-term monitoring program and a pilot study on increasing survivorship of hatchling marine iguanas by reducing cat numbers may help maintain the teeming abundance of marine iguanas throughout the Galápagos Archipelago.

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THE STORY OF THE DISCOVERY OF THE TORTOISE "LONESOME GEORGE" ON PINTA ISLAND

By: Dr. Manuel Cruz P. (Translated by Heidi M. Snell)

THE BEGINNING

In the beginning of 1972, during the last year of our studies in the Department of Natural Sciences of the University of Guayaquil, Hipolito Ronquillo and myself were asked to become the first scholarship students to represent INP and the University at the Darwin Station. This began a long term agreement between the Instituto Nacional de Pesca (INP), the Department of Natural Sciences of the University of Guayaquil and the Charles Darwin Research Station.

GUAYAQUIL TO GALÁPAGOS

In 1972, TAME made twice weekly flights between Guayaquil and Galápagos. Hipolito told me that this was the first time he would be away from his family for so long. We were scheduled to be in Galápagos for three months. After the three hour flight we arrived at Baltra and then to the dock. We went aboard a small boat and traveled four hours around Santa Cruz until we arrived at Puerto Ayora where we were met by the director of the Darwin Station, Dr. Peter Kramer.

I joined the "Introduced Animals" program and my counselor was Dr. Ole Hamann, who taught me to recognize many of the plants of Galápagos. The main part of my project was to learn which plants were being eaten by the goats who were destroying the native vegetation. Another part was to learn about the pigs which were eating the eggs in the nests of the tortoises, both introduced animals endangering the insular ecosystems.

Since I needed to examine the stomach contents of the goats and pigs to identify the species of plants these animals preferred, I worked closely with wardens from the Parque Nacional Galápagos. With them I visited the 'Caseta" (part of the reserve in the highland area of Santa Cruz), the pampas of Santiago, and also the islands of Pinta, Marchena, Genovesa and Santa Fe.

We made a trip to hunt goats in April 1972. The following persons were on the trip: Camilo Calapucha, Pedro Cartagena, Francisco Castañada, Carlos Cedeño, Oswaldo Chapi, Cesar Doaz, Fausto Llerena, Basilio Toro, Galo Torres, Luis Torres, Arnaldo Tupiza, and myself. The purpose of the trip was to hunt goats and my study was to look at stomach contents and learn the species of plants which were most likely to disappear under the influence of the goats.

When we were on Pinta I remember one of the Park wardens telling me there had been feces of a tortoise found the year before but no one had seen a live tortoise in many years. [Editor's note: A report was filed at the station and park by Joseph Vagvolgyi who was on Pinta studying snails in November of 1971, he reported finding a tortoise but was unaware of its significance.]

THE DISCOVERY

In order to do the stomach content analysis in the field I carried many items such as a rifle, knife, canteen, plant press, scales, altimeter, and books. I was assigned a Park warden, Francisco Castañada, to help me complete the work.

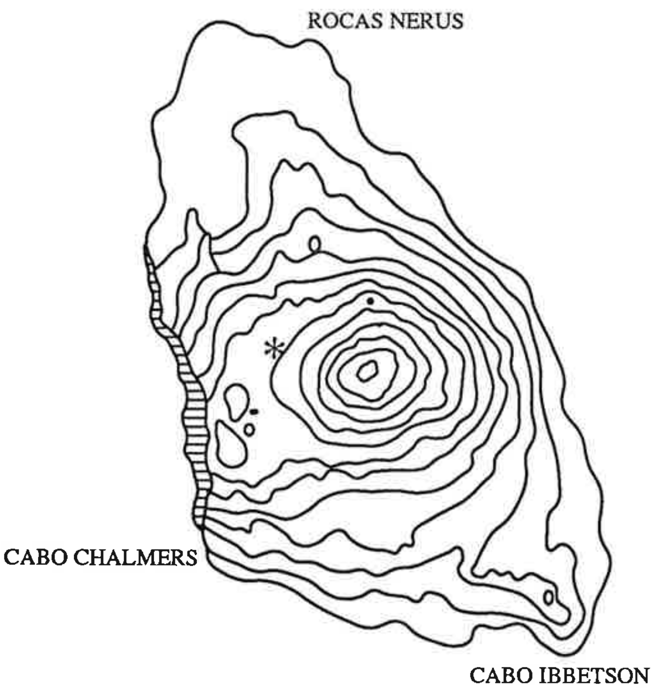

Figure 1. Location on Pinta Island where the Galápagos tortoise *Geochetone elephantopus abingdoni*, "Lonesome George", was found in March 1972.

Figure 2. First photograph of "Lonesome George", taken with Manuel Cruz at the moment of capture on Pinta Island, March 1972.

One day we were at about 300 meters altitude and we observed something moving about 60 to 70 meters distant (Fig. 1). We both thought it was a goat and taking aim with our rifles we walked closer until we saw that it was actually a tortoise! The tortoise was under a palo santo tree (*Bursera graveolens*) and surrounded by large rocks which appeared to enclose the area. I asked Francisco if he would photograph me with the camera I had (Fig. 2).

In order to relocate the area, I took off my shirt and left it hanging like a flag, then I asked Francisco if he would stay with the tortoise while I went back to camp with news of the discovery. At first no one in camp believed me so Camilo returned to the tortoise with me to verify the discovery. When we returned to camp he confirmed the existence of the tortoise.

THE RESCUE

A group of us returned to the tortoise equipped with machetes, ropes and a camera. Before moving the tortoise Oswaldo Chapi took a few photos. The wardens proceeded to cut several branches, and tied the tortoise to these so we could carry it down to shore suspended. On two occasions the branch holding the tortoise broke and in general the swinging of the tortoise made it very difficult for us to walk over the lava while carrying the tortoise. On many occasions we had to carry it between four people, two in front and two in back; it was a horrible trip! [Editors note: A boat chartered by Ole Hamann and Peter Pritchard arrived on Pinta the following day to leave their group for five days, and take the Park personnel to work on Marchena. Peter and Ole both photographed the tortoise before it was loaded on the boat. It seems certain this boat then took the tortoise back to the Darwin Station. Peter and an assistant walked to the highlands one of the days, but were unable to find anything except bones of a male tortoise and the intact carapace of what Peter believes to have been a mature female. The female had been killed by a machete some few years earlier he estimated. Peter collected this specimen and took photos (personnel communication, Hamann; Pritchard 1977 & 1984).]

Almost no one is certain who named "Lonesome George" and for what reason. I questioned Julio Cesar Sanmiguel (who is one of the oldest employees of the National Park) and he couldn't remember who named the tortoise. It is almost certain that the name "Lonesome" is because is the only surviving example of a Pinta tortoise. According to Gayle Davis-Merlen, a long-time Station employee, the name "George" came from the U.S. actor George Goebel who called himself "Lonesome George" in a television program.

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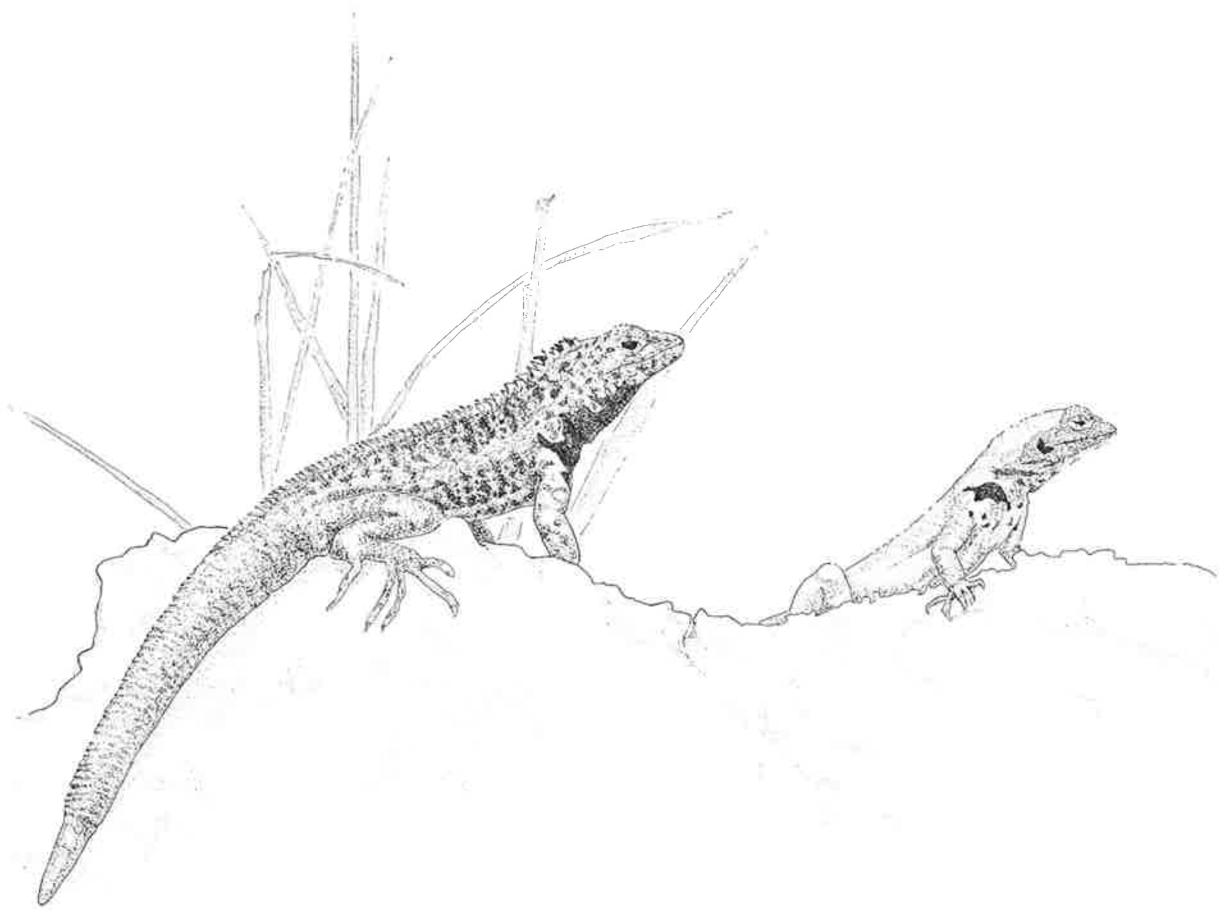

ACCELERATED MORTALITY OF *OPUNTIA* ON ISLA PLAZA SUR: ANOTHER THREAT FROM AN INTRODUCED VERTEBRATE?

By: Howard L. Snell, Heidi M. Snell, and Paul Stone

In 1979 and 1980, as part of our research on the Land Iguanas of Plaza Sur, we made a complete vegetation map of the island. Since that time we have monitored the mortality and recruitment of the *Opuntia* there. The results are striking (Fig. 1). From 1980 to 1982 we saw little mortality. Then during the 1982-83 El Niño a tremendous number of individuals died (Snell and Snell 1988). The proximate cause of death was apparently a combination of loading the trunks and pads with water absorbed from the ground and then toppling by wind. We initially thought that this was a natural situation caused by the extremely wet conditions of El Niño. We prepared a manuscript dealing with it as a natural selective event and proposed an alternative hypothesis for the low growing cacti of small islands (Snell and Snell 1988). However, the mortality has continued. It has continued to be greatest in wetter years (Fig. 1), although the per-

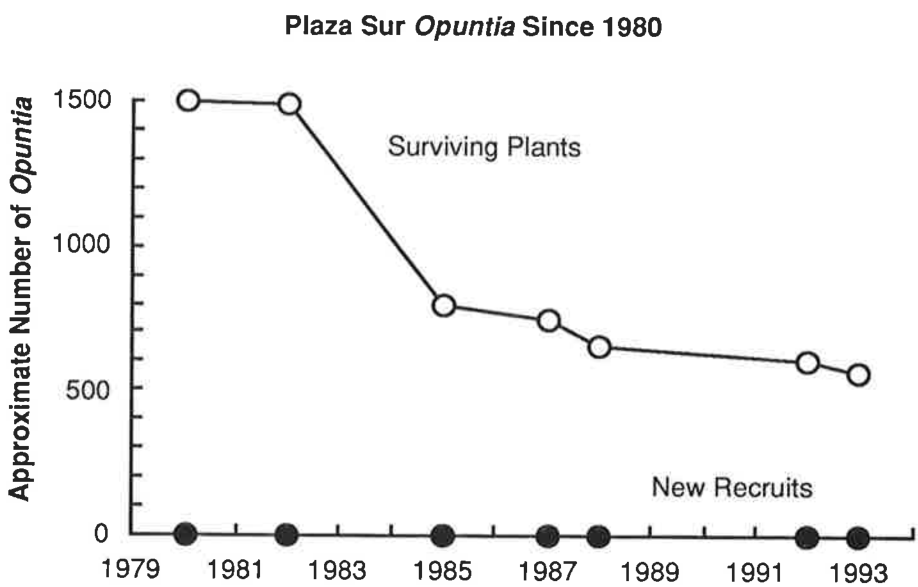

Figure 1. The status of *Opuntia* on Isla Plaza Sur since 1980. Population estimates come from the total counts and vegetation maps. Mortality has been monitored by c ounting dead individuals.

centage of the population dying in any year has increased. Several things have bothered us about this pattern for a number of years. First: if the wet years act as selective events, and the taller cacti are selected against, then in the next wet year shouldn't the percentage of the population that dies be less? In other words, if the selection in 1982-83 killed the tall cacti which were susceptible, then why were even relatively more killed in the next wet year? The cacti did not measurably grow, so if they weren't susceptible in 1982-83, what changed?

One thing that changed was the colonization of Plazas Sur and Norte by mice in the 1982-83 El Niño, probably from boats or by being swept into the sea from Santa Cruz. The mice reproduced extremely rapidly and were already numerous when Heidi discovered them in 1984. We've tried to hypothesize a mechanism for the mice to affect the *Opuntia* for several years without success. However, this year we made several observations that we feel are significant. First many *Opuntia* have small piles of disturbed soil from mouse burrows at their bases. The burrowing could weaken the hold of the roots on the soil, allowing the toppling mortality to occur. We also saw where mice had burrowed into the roots of *Opuntia*, hollowed out the central tissue, and left the root bark along the walls. That directly destroys the roots, and must weaken the cactus' hold on the ground. These could both be mechanisms by which the mice have played a role in the increased mortality.

An apparently logical test of this idea is provided by other islands with mice and *Opuntia*. If the effect is serious then why do *Opuntia* remain on other islands with mice? Possibly because most islands lack the final component of the situation, land iguanas. On most islands a fallen *Opuntia* isn't really a dead plant, it simply sprouts vegetatively from the fallen trunk or pads. However, on Plaza Sur the land iguanas quickly converge on fallen *Opuntia* and rapidly eat all of the pads and any fresh sprouts that appear. We've compared the success of vegetative regeneration of fallen *Opuntia* on Plazas Sur and Norte from 1982-83 to 1985 and 1987. On Plaza Norte 75% of cacti that fell in the 1982-83 El Niño had living sprouts in 1985. On Plaza Sur only 3% had sprouts in 1985! By 1987 the situation was worse. Seventy percent were successfully sprouted on Plaza Norte and 0% on Plaza Sur! The iguanas are effective. This is also true with recruitment into the population. We've seen no successful recruitment of new individuals into the Plaza Sur population in 15 years (Fig. 1)!

The *Opuntia* population of Plaza Sur has decreased by roughly two thirds without recruitment since the arrival of mice onto the island in 1983. The connection is not definite, but suggestive enough to warrant further attention. We suggest two courses of action. First to try and strengthen the mouse/mortality hypothesis. This could be done by carefully surveying surviving *Opuntia* for the presence of mouse burrows. Then in 1994, do a chi-square analysis of the ratios of infested to non-infested *Opuntia* that died and that survived. If a significantly higher percentage of the cacti that died were mouse infected we'd have as strong a conclusion as we're going to get. Unfortunately, the cacti must be surveyed before they die. The soil around a fallen *Opuntia* is disturbed by the upheaval of roots, and the presence or absence of mouse burrows is impossible to determine.

At the same time we recommend trying to find all information possible about potentially applicable eradication techniques for mice. There is a tricky problem with poisoning on Plaza Sur. The land iguanas will eat anything presented. However, since the mice are small we're sure that some sort of a system of bait delivery via containers with small holes would be successful. The paired nature of Plazas Norte and Sur provides an opportunity to perfect techniques on Plaza Norte in the absence of iguanas and them move the effort to Plaza Sur.

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DISTRIBUTION AND CURRENT STATUS OF RODENTS IN THE GALÁPAGOS

By: Gillian Key and Edgar Muñoz Heredia.

INTRODUCTION

The uniqueness and scientific importance of the Galápagos Islands has long been recognized, although the creation of the National Park in 1959 came after several centuries of sporadic use and colonization by man. Undoubtedly, the lack of water in the islands has been their savior by limiting the extent and duration of many early attempts to colonize. Even so the impact of man has been severe in the Archipelago, and the biggest problems for conservation today are the introduced species of plants and animals. These introduced species are frequently pests to the human inhabitants as well as to the native flora and fauna, to the former by damaging crops and goods, and to the latter by competition, predation and transmission of disease.

The feral mammals in particular constitute a major problem, principally due to their size and numbers. The destructive capacity of goats, pigs, dogs and cats has been proved enormous in the islands. The introduced commensal rodents have contributed to the loss and endangered status of one race of giant tortoise (MacFarland 1974), and of the dark-rumped petrel (Cruz & Cruz 1987). The native rats have also suffered from the introduced species, but mostly before the risk was realized, as seven species had been reduced to three before the Park was even created. Modern methods of pest control bring the possibility of eradication nearer, but it is important to know the extent and relative abundance of the existing populations, both native and introduced. This article summarizes the knowledge of the present status of the rodent species in the Galápagos Archipelago as an aid to the Galápagos National Park Service (GPNS) and the Charles Darwin Research Station (CDRS) in their continuing efforts to protect the unique wildlife of the islands.

ENDEMIC RODENTS

Seven species of endemic rice rats are known from the Archipelago, of which the seventh was only relatively recently discovered from owl pellets on Fernandina island (Hutterer & Hirsch 1979). Brosset (1963) and Niethammer (1964) have summarized the available information on the six species known at that time, including last sightings and probable dates of extinction. Galápagos rice rats belong to two closely related genera of *oryzomys* rodents and were distributed among the six islands (Table 1).

Patton and Hafner (1983) concluded that rats of the genus *Nesoryzomys* arrived in the Archipelago first, and that the four larger species (excluding *N. fernandinae* which was not considered in their study) may be considered races of a single species differing only in pelage color. *Oryzomys* rats arrived much later and the two known species may also be conspecific, and closely related to *O. xantheolus*, an extant species of coastal Peru. Of the four extinct species, nothing is known of their biology and ecology and the arrival of the commensal ship rat, *Rattus rattus*, has been implicated in their subsequent extinction (Brosset 1963).

The extant species are only slightly better known and work has been done on *O. bauri* (Clark 1978; 1980) and to a much lesser extent *N. narboroughi* (Eshelman 1978). The present status of *O. bauri* is apparently thriving on Santa Fe, with high population levels at least along the coast. Brosset estimated

Table 1. Distribution of rats in the Galápagos Archipelago.

GENUS	SPECIES	ISLAND
Oryzomys		
	O. galapagoensis	San Cristóbal (extinct)
	O. bauri	Santa Fe
Nesoryzomys		
	N. indefessus	Santa Cruz and Baltra (extinct)
	N. darwini	Santa Cruz (extinct)
	N. narboroughi	Fernandina
	N. fernandinae	Fernandina
	N. swarthi	Santiago (extinct)

the total population in 1963 at 1000 - 2000 animals, distributed primarily in the littoral zone, and very sparsely in the central plain. Clark (1978) estimated numbers between 10,000 and 100,000 individuals in varying densities over the island, and he also noted stability of *O. bauri* populations over the study period. On Fernandina the population levels of the two species are not known. There is some evidence that the smaller *N. fernandinae* occurs inland on the lava beds, at least in the vicinity of Cape Hammond, while *N. narboroughi* is common along the coast (Adsersen 1987). Certainly there is abundant evidence of small rodents in the mangroves around Punta Espinosa in the form of nibbled fruits of white and black mangrove (Key and Muñoz 1992, pers. obs.). There remains the slight chance that small populations of *Nesoryzomys* species still exist in the highlands of Santa Cruz, and possibly even in Santiago (Peterson 1966); in 1980 Steadman found the remains of a small species of *Nesoryzomys* on Isabela (Steadman & Ray 1982) but no more is known of this discovery.

The giant rat, *Megaoryzomys curioi*, represents a third endemic rodent group which arrived independently and probably early on (Steadman & Ray 1982). This species is known only from subfossil remains on Santa Cruz and Isabela and appears to have become extinct within the last few centuries, possibly due to the introduction of feral mammals. Giant rats have never been seen alive and nothing is known of their biology.

INTRODUCED RODENTS

The three pan-global commensal rodents, *Rattus rattus*, *R. norvegicus* and *Mus musculus* are now all in the Archipelago. *Rattus rattus* was probably the first species of rat to arrive on whaling boats and pirate ships in the late 1600's to James Bay on Santiago and then spread to Bartolomé. A second introduction occurred during the 1800's on Floreana, and then to San Cristóbal and Isabela by the spread of the human colonies. The third and most recent introduction occurred on Santa Cruz and Baltra islands around the time of World War II (Patton et al. 1975). Pinzon was used by whaling ships extensively in the 1800's and was either a fourth point of introduction, or was infested with rats from the Floreana-San Cristóbal-Isabela group (Patton et al. 1975). The exact dates of arrival for most of the islands are not known, but ship rats were present on Santiago when Darwin arrived in 1835, were first found on Pinzon in the 1890s, on Santa Cruz after 1934, and on Seymour

Norte, Islote Pitt and Isla Mosquera in 1983 (Anon. 1985; Calvopia 1984; Clark 1978). There are three races present in the Archipelago, the so-called subspecies *rattus*, *alexandrinus* and *frugivorous*, but coat color is actually considerably more varied and Patton et al. (1975) recognized seven color phenotypes. The ship rat is now on 10 islands and is a major pest, not only in settlements and farms but also in the National Park where it attacks tortoise eggs and emergent young, and the eggs and chicks of ground nesting sea birds, such as the dark-rumped petrel (e.g., Harris 1967; Kramer 1974; Snow 1964). A lot of effort has been expended by the GNPS and the CDRS towards eradication on some infested islands, with success on Islote Pitt (Muñoz 1993), but failure on the larger Pinzon. The policy is now for seasonal rat control on Floreana and Santa Cruz around the dark-rumped petrel colonies during the nesting season. Populations of the ship rat in the Archipelago are apparently thriving; Clark (1978) considered that Santa Cruz has some of the highest densities of rats in the world, increasing the risk of further spread by tourist and fishing boats, especially during El Niño years when population densities peak and rats are frequently seen swimming off shore.

Mus musculus was probably not far behind *R. rattus* in arrival to the Archipelago, because they are typically brought in produce to inhabited islands, including Santiago (now no longer inhabited), Floreana, San Cristóbal, Isabela and Santa Cruz (Muñoz, pers. obs.). On Santa Cruz mice were first seen in the 1940's, and quickly became abundant (Kastdalen 1982). In 1982-3 they arrived on Plazas Norte and Sur (Calvopia 1986) and in 1989 they were also found on Seymour Norte and Islote Mosquera. They are now found on seven islands and are a major nuisance in houses, especially during rainy years when they are very abundant. Mice also occur in the National Park, but nothing is known of the ecology of feral populations and they are not implicated as major pests as is *R. rattus*. They may contribute to cactus mortality on Plazas since their introduction during the 1982-83 El Niño event (Snell et al. 1993). Present status is thriving, with some risk of further introductions to other islands via boats.

Rattus norvegicus is the largest of the three commensal species and the most aggressive. It was first identified on Santa Cruz in 1984, and probably arrived one to two years earlier from an unknown source (Fiedler 1984). It is also reported to occur on San Cristóbal (Sivinta 1988). A study done in 1988 on Santa Cruz found that their distribution had expanded from Puerto Ayora to Bellavista, but that brown rats were confined to the houses and were not found along the road between the villages (Sivinta 1988). The ship rat was still the dominant species, even in houses. A second study in 1993 sampled the road from Puerto Ayora to the canal of Itabaca, and several sites in the agricultural zone; *R. norvegicus* had increased its range up the south side of the island to the *Scalesia* zone (Los Gemelos) and just above the *Miconia* zone at Media Luna (Key et al., in preparation). The brown rat had not displaced *R. rattus* but had become the dominant species in Puerto Ayora and Bellavista and could be found in the National Park as well as in the villages. It is not clear whether in the future *R. norvegicus* will displace *R. rattus* or whether the two species will continue to co-exist.

DISCUSSION

The relatively recent arrival of *R. norvegicus* is important, indicating that new species are still arriving in the Archipelago, and that the GNPS needs to give serious consideration to the creation of a quarantine center and adherence to rigid regulations. If enough individuals of an animal this size can arrive to become established, how many other species of potentially harmful invertebrates and plants may also be colonizing the islands? It is alarming to note that Patton et al. (1975) found relatively high levels of heterozygosity in ship rats from Wreck Bay, Academy Bay and, especially, Baltra island from which they concluded that constant immigration was occurring. The implications for conservation, of the arrival of the brown rat are serious; as it is a larger, more aggressive species, young tortoises and petrel chicks will need to be protected for longer, with a concomitant increase in the costs of rat control and in the captive breeding programs. As this species is also a better digger than the ship rat, tortoise eggs in the nesting sites may also require protection.

The CDRS and the GNPS are very concerned with the threat of the accidental introduction of commensal rodents on Santa Fe and Fernandina (the apparent cause of extinction of other endemic rice rats). The CDRS is considering starting captive breeding programs with all three species so as to be ready with an emergency response in the event of a commensal invasion (Trillmich 1986). The current lack of knowledge of the biology and ecology of the rice rats, especially on Fernandina, poses serious limitations to the intention.

More basic research needs to be done, on both introduced and native rodents. Regular and systematic monitoring of the main islands is needed to check the distribution and relative abundance of the commensal species, and the status of endemics. The emergency recovery of the endemics should be considered now, and ecological studies should be initiated on the Fernandina rice rats. The ecology of house mice in the field is unknown, and in view of the hypothesis of Snell et al. (1993) should be investigated; in addition to their potential status as pests these small rodents may be filling the ecological niche left by the extinction of the native rats and their loss may have unforeseen ecological effect.

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POLLINATION OF *SCALESIA BAURII* SSP. *HOPKINSII* (ASTERACEAE) ON PINTA ISLAND

By: Conley K. McMullen and Sandra J. Naranjo

Previous studies in the genus *Scalesia* have shown that *S. affinis* Hooker f., *S. helleri* Robinson, *S. pedunculata* Hooker f., and *S. aspera* Andersson can reproduce by autogamy (automatic self-pollination) (Rick 1966; McMullen 1987, 1990). In addition, the first three of these, as well as an unidentified species thought to be *S. retroflexa* Hemsley, are known to be pollinated by the endemic carpenter bee *Xylocopa darwini* Cockerell (Hymenoptera: Apidae) (Linsley et al. 1966; Rick 1966; Eliasson 1974; McMullen 1985). The flowers of *S. pedunculata* on Santa Cruz Island are also visited by the Galápagos fritillary butterfly *Agraulis vanillae galapagensis* Holland (Lepidoptera: Nymphalidae) (personal observation).

Pollination studies on an additional member of this genus, *Scalesia baurii* Robinson & Greenman ssp. *hopkinsii* (Robinson) Eliasson, were conducted on Pinta Island from 28 June - 20 July 1990 (Fig. 1). Pinta is one of the northern islands in the archipelago that the carpenter bee does not inhabit. Fifteen individuals, located between 15-67 m altitude on Pinta's southern slope, were selected for this study. One hundred inflorescences were bagged before their flowers had opened to determine if the plants could reproduce autogamously. One hundred open-pollinated inflorescences were marked as well, and then covered after being exposed for one week. All pollination bags were collected on the last day of the study and fruit counts were made. Flower observations were conducted to discover what insects made visits

Figure 1. Inflorescence and leaves of *Scalesia baurii* ssp. *hopkinsii* on Pinta Island.

to these plants and might act as pollinators. These visits were timed and recorded. The maximum stay listed for any one insect was 15 minutes. After this, the insect was either captured, or another observation was begun so as not to spend an excessive amount of time watching one individual.

Table 1 shows the results of the bagging studies. Flower counts were not made, so an actual percentage of fruit set cannot be given. Eliasson (1974) mentions that approximately 50 bisexual disc-flowers are typically found in an inflorescence, although as many as 100 or more may be present. Ray-flowers are also present, but these are sterile. In any case, both treatments produced numerous fruits. The mean number for bagged inflorescences was 45.2, while that for open-pollinated inflorescences was 38.2. The reason for the latter having a lower fruit set is probably because of their exposure to predators before being bagged. Finches were often seen at these plants, and one inflorescence was actually observed being eaten. Ten of the bags were not recovered after this study. One explanation for this might be that they were overlooked during the final collection. However, another possibility is that these bags were destroyed by the Galápagos hawk (*Buteo galapagoensis*). This hawk removed and tore apart pollination bags from other plant species that were being studied during the same period.

The primary insect visitors to these plants are noted in Table 2. A species of *Mythenteles* (Diptera: Bombyliidae) was most frequently observed, with 51 visits and a total of 28,494 seconds spent on inflorescences. These bee flies would often visit more than one flower per inflorescence, and appeared to be probing for nectar. In fact, one was observed trying to force its way down into a corolla tube. Pollen was clearly visible on its wings and thorax during this visit. Second in occurrence was *Lepidanthrax tinctus* Thomas

Table 1. Bagging experiment results, in number of fruits produced per inflorescence.

	MEAN	RANGE	SD	N
Bagged Inflorescences	45.20	0-76	18.06	99
Open-Pollinated Inflorescences	38.18	0-67	16.78	91

Table 2. Insect visitation times, in seconds, based on 24 hours of observation (6:00 A.M. - 6:00 P.M, 9 & 10 July 1990).

	TOTAL	MEAN	RANGE	SD	N
DIPTERA					
Mythenteles sp. (Bombyliidae)	28,494	558.71	30-900	349.26	51
Lepidanthrax tinctus (Bombyliidae)	1,061	32.15	2-139	31.63	33
LEPIDOPTERA					
Atteva hysginiella (Yponomeutidae)	1,664	208.00	12-405	155.68	8
Pyralid Moth (Pyralidae)	568	189.33	60-274	113.78	3

(Diptera: Bombyliidae) with 33 visits, and a total time of 1,061 seconds. A moth, *Atteva hysginiella* Wallengren (Lepidoptera: Yponomeutidae), was the third most common insect with eight visits. However, its total visitation time was 1,664 seconds. Thus, its mean stay (208 seconds) was approximately 6.5 times longer than that of *L. tinctus*. Both of these insects appeared to probe for nectar just as the species of *Mythenteles*. The least frequent visitor recorded during the observation studies was a pyralid moth (Lepidoptera: Pyralidae). This single individual visited inflorescences three times, for a total of 568 seconds. In addition, two untimed visits were made by a species of *Rhinacloa* (Hemiptera: Miridae).

Most of the insects made their visits throughout the day, although the pyralid moth did not appear until after 4:00 P.M. Only *Mythenteles* individuals were observed spending more than 15 minutes on an inflorescence during the timed studies.

Insufficient nectar was produced by the flowers for micropipet collection. However, the fact that all of the insect visitors had mouthparts adapted for sucking rather than chewing suggests that a small nectar reward presumably is present.

These results indicate that *S. baurii* ssp. *hopkinsii* is capable of autogamous reproduction, just as the other members of this genus that have been studied. In addition, even though the carpenter bee is absent on Pinta, there are other visitors that may promote self- or cross-pollination. Insects spending longer periods of time on each inflorescence are probably more important for selfing, since this behavior results in fewer visits to other plants. If this scenario is correct, then *L. tinctus* may be more important in the cross-pollination of this plant than the other visitors listed in Table 2.

The breeding strategy of *S. baurii* ssp. *hopkinsii* appears reasonable for a plant inhabiting an oceanic island. Autogamy would promote initial establishment, while visits by available insects might lead to outcrossing. The flowers of this species are well suited to the small generalist insects found on Pinta Island. Wind pollination, which demands profuse pollen production, would be of little value, especially during the colonization period when only a few individuals presumably would be present (McMullen and Close 1993).

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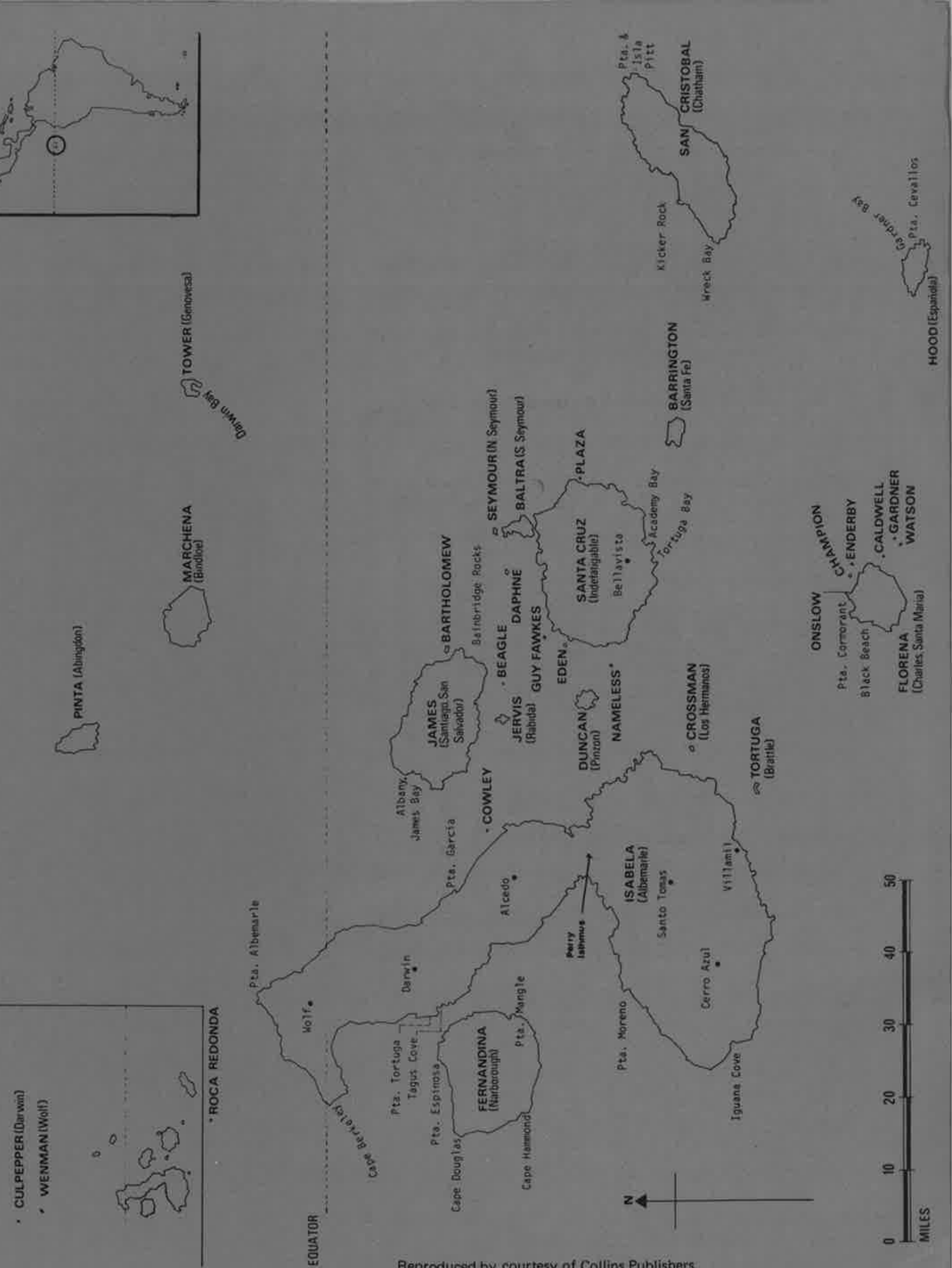

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