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AMPHIBIAN & REPTILE CONSERVATION

THE INTERNATIONAL JOURNAL DEVOTED TO THE WORLDWIDE PRESERVATION AND MANAGEMENT OF AMPHIBIAN AND REPTILIAN DIVERSITY

ISLANDS

Madagascar
Radiated tortoises
Herpetofauna extinction

New Caledonia
***Rhacodactylus* geckos**

The Caribbean
***Anolis Lizards of the Caribbean* (Book review)**

Herpetofauna and Humanity (New Column)
The trade in live reptiles and amphibians

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DISCLOSURE: Until 2000, ARC was published irregularly with one issue being printed (premiere) and referenced as volume 1, number 1. ARC is now publishing two issues per year (semi-annually). This issue marks number two in the serial and is listed as volume 2, number 1 (2000). With the support that ARC continues to receive we plan to progress into a quarterly serial sometime in the future. Presently, all subscribers receive four consecutively distributed issues at a minimum of two per year.

Editorial

MARLENE MIHELL

WORDS FROM THE EDITOR—With the completion and publication of this issue, *Amphibian and Reptile Conservation* (ARC) is now publishing semiannually, from our previously irregular publishing schedule. We still have not given up our original plans of being published as a quarterly serial, and hope to be able to do so in the near future. We will continue to pick up the pace, and add more pages to each volume (when possible), as well as report on some of the most exciting topics in the world, from a balanced geographic perspective. ARC will continue its focus on publishing research in the field of herpetology, and specifically herpetological conservation. We will try our best to publish cutting edge herpetological conservation research, but in a way that makes the subject matter accessible and enjoyable to professional herpetologists, conservation managers, naturalists, and nonprofessionals. This often requires an extra effort on part of reviewers, authors, and others involved. It is to these unselfish individuals that deserve most of the credit for the success of the journal.

This issue begins with an additional four pages (two in full-color) being added from that of the previous issue and volume (volume 1, number 1—premiere issue). It also adds new standardized graphic design throughout, important article contributions, full-color illustrated maps, country sidebars, a new column titled "Herpetofauna and Humanity," book review(s), world news, glossary, and abbreviations used. All these new improvements are implemented to make this science journal as accessible and interesting to as broad an audience as possible. Many of these journal elements will continue to be developed, as well as others that come to my attention, with each successive volume. I am very pleased to exhibit our latest effort and hope that you all will continue your great enthusiasm for the journal, as we work hard to establish what we think will become an important serial, specifically for the conservation and preservation of amphibians, reptiles, and their habitats worldwide.

Craig Hassapakis
Editor and Publisher

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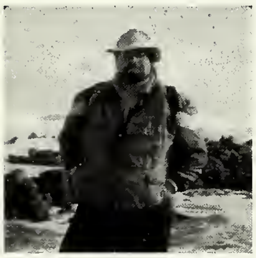

TRIP LAMB

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AARON BAUER

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Cover

Standing's day gecko *Phelsuma standingi*, at Zombitsy Forest, Southwest Madagascar. This species is restricted to deciduous dry forest, a habitat that is declining due to clearing for cattle grazing and agriculture. Uncontrolled grassland fires which, every year, burn the forest edge have scorched the tree stump. These day geckos have also had dramatic population declines due to overcollecting for the pet trade in some areas of its limited distribution. *Photo: C. J. Raxworthy.*

Background screen photograph (see in color on page 18): Some of the last known surviving *Mantella bernhardi* forest habitat cleared for cultivation between 1993-4. *Photo: C. J. Raxworthy.*

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Plate 1. Adult radiated tortoise (*Geochelone radiata*) [*sokatra*]. *Photo courtesy of R. D. Bartlett.*

Amphibian and Reptile Conservation **2(1):6-14.**

Commentary on conservation of "*Sokatra*," the radiated tortoise (*Geochelone radiata*) of Madagascar

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Abstract.—**The radiated tortoise *Geochelone radiata* of the desert regions of Southwestern Madagascar, known as "*sokatra*" among most Malagasy, has gained much attention recently as a result of increasing and highly publicized smuggling of this commercially valuable species. *Sokatra* have been protected by Malagasy law since 1960 and have been classified as a Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I species since 1975. *Sokatra* also are protected to some extent in the four reserves where they are known to occur. In the central part of their range, on the Mahafaly and Karimbola Plateaux, *sokatra* are considered *fady* (taboo) by the Antandroy and Mahafaly people who live in this area, and they generally are not killed for food in this region. They are, however, killed and eaten by the Vezo and Antanosy people who largely occupy the northwestern and southeastern limits of the species' range. It has been suggested that this taboo is largely responsible for the survival of the species, and there is worry that the taboo may be breaking down as a result of human famine and intermingling of tribal peoples, many of whom do not consider the flesh of *sokatra* to be forbidden. In addition to the possible erosion of taboo barriers, there is strong evidence of increased illegal trade in *sokatra*, increased deterioration of its habitat, and increased local consumption of them for food, all of which are reasons for concern. Given the conspicuousness of this species in nature, its popularity among tortoise fanciers, and concern for *sokatra* among conservationists, there is surprisingly little published information about them in their natural environment that would allow for objective evaluation of their status. Especially needed are intensive studies of the life history and ecology of *sokatra*, with special attention paid to determining their limiting environmental requirements. It will also be important to examine the degree to which *zebu* (cattle) and goats compete with *sokatra* for food and to determine the intensity of *zebu* and goat grazing that can be tolerated without causing local extinction of *sokatra*. We have no reason to believe that the *sokatra* is threatened with extinction over the next 20 years, just as it obviously was not threatened over the past 23 years, although classified as Appendix I during that period. We recommend that downgrading the *sokatra* to CITES Appendix II might be beneficial to the survival of the species if certain conditions are met, such as careful controls on the number of legally exported animals. We also strongly recommend the establishment of additional nature reserves on the Mahafaly and Karimbola Plateaux in the central part of the range of the *sokatra*, both for survival insurance for this species and for other rare and endemic species that occur in this area.**

Key words. *Radiated tortoises,* Geochelone radiata, *Madagascar, conservation,* sokatra, *protection, CITES, pet trade, education, captive breeding, repatriation, monitored legal trade program*

Introduction

The radiated tortoise, *Geochelone radiata* (Plate 1), is one of the most spectacular of the larger tortoise species. It grows to a maximum size of about 40 cm carapace length and may weigh up to 14 kg. Radiated tortoises are readily identified by their color pattern of bright yellow lines radiating from the center of each dorsal scute and their yellow legs and throat. Because of their beauty, and perhaps because they are members of the high profile Madagascan fauna, radiated tortoises are highly coveted by pet keepers. A large breeding pair may be valued up to $25,000 in the pet trade, and prices in the range of $5,000 for a single, not necessarily mature, radiated tortoise are not uncommon. Because of their commercial value, and because they are killed for food by local Malagasy and served as a delicacy in some Malagasy restaurants, radiated tortoises have received considerable attention from conservationists. Recently, awareness of radiated tortoises reached new heights as a result of a highly publicized smuggling bust in Orlando, Florida that resulted in the confiscation of about $250,000 worth of radiated tortoises, spider tortoises, and Madagascan boas and in the conviction on 10 January 1997 of two smuggling partners, a German and a South African. This headline news was followed by an article (Webster 1997) in a major news magazine that described the business of smuggling rare animals and featured a color photograph of a radiated tortoise on the cover.

Considering the great interest in radiated tortoises, it is astounding that so little of scientific merit has been published about them. Most of the sparse literature consists of anecdotal and repeated observations. Not a single in-depth study of this species in nature exists, and we are unaware of any ongoing or planned research. The most recent field survey of the species was sponsored by the World Wide Fund for Nature (WWF) and was done by Richard Lewis, whose report (1995) to WWF-

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Aires Protégées, Madagascar, is unpublished. Juvik (1975) reviewed the literature and presented some limited new information on radiated tortoises. Durrell et al. (1989) commented on captive breeding programs and the status of the species. Goodman et al. (1994) reported road count data for a single trip along one segment of road in the center of the range of the species. Razafindrakoto (1987) provided the only information available on food habits and other autecological[a] aspects of the species in its natural environment at Beza-Mahafaly Réserve Spéciale. Unfortunately, the population at Beza-Mahafaly has subsequently been genetically polluted and otherwise influenced by the release of numerous confiscated tortoises (Lewis 1995), so that follow-up studies would be of limited value.

Distribution and habitat

"*Sokatra*,"[1] or radiated tortoises, are restricted to the xeric[b] region of Southwestern Madagascar (Fig. 1), where they occur in a variety of habitats ranging from brushy spiny desert dominated by endemic Didieriaceae and euphorbs to gallery forests dominated by deciduous species such as "kily," or the tamarind tree, *Tamarindus indica*. In this region, annual rainfall is low (< 400 mm) and highly unpredictable, and temperatures are very high, especially during sunny summer (November-February) days. It has been claimed that *sokatra* hibernate during the winter, but, while there are undoubtedly periods of inactivity, we have seen them active during every month of the year. Within their range, *sokatra* are absent from open savannahs and from forests with no understory vegetation, probably because of their need for low vegetation for grazing and for frequent shady areas to escape overheating from insolation. Historically, the eastern limit of their range was probably determined by the dense, low elevation rain forests near Tôlañaro. There are no records of the species north of the Manombo River along the western seaboard, although it is highly unlikely that the river itself poses a barrier (they occur on both sides of much larger rivers). Their restriction to a wide coastal band is somewhat mysterious, but it may be that higher inland elevations limit them to the coastal band. Before human occupation of Madagascar, the species probably occurred somewhat further inland.

Status and protection

Theoretically, *sokatra* have been protected since 1960 by national Malagasy law (Decree no. 60-126), which provides for fines and/or imprisonment for unauthorized collecting. Since 1975, *sokatra* have been classified as Appendix I species according to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which regulates international commercial trade. The species is further protected in limited parts of its range that are set aside as nature reserves. These protected areas are Tsimanampetsotsa Réserve Naturelle Intégrale (43,200 ha), Cap Sainte Marie Réserve Spéciale (1,750 ha), Beza-Mahafaly Réserve Spéciale (580 ha), and Parcel II of Andohahela Réserve Naturelle Intégrale (12,420 ha). Two of these reserves, Beza-Mahafaly and Parcel II of Andohahela, are at the limits of the species' range in areas where *sokatra* are uncommon (Andohahela) or consist of populations genetically polluted by release of confiscated animals (Beza-Mahafaly). Tsimanampetsotsa and Cap Sainte Marie are in the center of the species' range and are potentially important for conservation of *sokatra*. Both of these reserves are overgrazed by *zebu* (cattle) and goats and are subjected to limited woodcutting, but *sokatra* seem to be abundant in both reserves (pers. obs.). There are no large, undisturbed reserves on the Mahafaly and Karimbola Plateaux in the region of prime *sokatra* habitat. A large reserve in this area is badly needed, not only for *sokatra*, but also for protection of many other rare species of plants and animals that occur in this unique and spectacular environment. These two plateaux have not been adequately surveyed for biodiversity. A brief survey done by us at the edge of the Mahafaly Plateau at Lac Tsimanampetsotsa yielded several rare reptiles, including two undescribed geckos of the genera *Ebenavia* (Malagasy leaf-toed geckos) and *Paroedura* (Malagasy casque-headed geckos) [Nussbaum and Raxworthy 1998].

The Antandroy and Mahafaly people of Southwestern Madagascar regard *sokatra* as *fady* (taboo), and eating *sokatra* flesh is forbidden. In some areas, especially where they are associated with tombs, *sokatra* are believed to contain spirits of ancestors and are, therefore, sacred as well as *fady*. It has frequently been suggested (e.g., Juvik 1975) that their status as forbidden and sacred animals is the best protection *sokatra* currently has, and without it they might already be extinct. It is believed (Juvik 1975; Lewis 1995) that the range of *sokatra* is shrinking and the populations diminishing at the northwestern and southeastern limits of its range (Fig. 1). This may result largely from exploitation for food by the Vezo and Antanosy tribes to the northwest and southeast, respectively. *Sokatra* have no taboo status among the members of these two tribes, and these people eagerly seek *sokatra* for food. In addition to exploitation for food, habitat destruction in these two areas is advanced, especially east of Ambondro, and this undoubtedly has a negative impact on local *sokatra* populations.

Sokatra are classified as "threatened/vulnerable" by the World Conservation Organization (IUCN) [1996 Red List of Threatened Animals], which seems justified, given the conspicuousness of *sokatra* in their habitat, their ease of capture, their popularity for food and pets, and the ongoing degradation of their habitat. However, their classification as a CITES Appendix I species is highly questionable. Originally (1973), this classification was reserved for species that are threatened with extinction, or could be threatened with extinction within a five-year period, or have a very limited range. This has been revised so that now Appendix I species are those "threatened with extinction which are or may be affected by trade." Because "threatened with extinction" can be interpreted very broadly (there are no guidelines), the current criterion reduces the question of status to a matter of opinion, so that almost any species of commercial value arguably could be classified as Appendix I. In our view, there is no evidence, published or otherwise, that indicates *sokatra* currently are threatened with extinction, although there are reasons for concern. There is not even any strong evidence that *sokatra* are less abundant or more restricted geographically now than they were in 1975 when placed on Appendix I. Clearly, more objective criteria for CITES classifications are needed, and, most of all, in the case of *sokatra* and many other threatened/vulnerable species, intensive research is needed to determine the distribution and abundance of the species and to identify environmental factors important for maintaining viable populations.

Population densities

Most information on population densities of *sokatra* is anecdotal or involves estimates from road counts and other rapid survey methods. There are no data that would provide for meaningful comparisons of past and present population densities. Juvik (1975) reported that after a rain storm in 1974, *sokatra* were encountered at a rate of about one per km along Route National 10 between Tôlañaro and Toliara, presumably in the area around Beloha. Goodman et al. (1994) recorded road counts of about 3 *sokatra* per km on 30 December 1992 after heavy rain along 42.8 km of road between Ankororoka and Beloha. These counts, however, included both living and many dead *sokatra*, so that it is necessary to adjust for the accumulation of dead animals. When that is done, the encounter rate is closer to one *sokatra* per km. A count of *sokatra* in January/February, 1995, along 15 km of road in the region of the Menarandra River, yielded 30 individuals for a rate of two *sokatra* per km (Lewis 1995).

We have traveled extensively, logging many thousands of kilometers, over roads in this region every year and in every season since 1989, and we can confirm observations of others that *sokatra* activity is greatest during warm weather shortly after rain. Not a single *sokatra* was observed during long periods of drought along the Route National between Tsiombe and Ampanihy, but, during warm and wet weather, numerous *sokatra* can be observed, especially between 40 km south to 30 km north of Beloha. Normally, *sokatra* will not be seen during the dry, cool winters, but on 6 July 1995 we counted 0.36 *sokatra*/km along this stretch of road. There had been rain the day before, and the day of the count was partially cloudy with light sprinkle, and the temperature was unseasonably warm.

Other than road counts, there are only two reports of densities. Razafindrakoto (1987) indicated a density of 1.3 *sokatra* per ha in Parcel I of Beza-Mahafaly Réserve Spéciale, based on a mark-recapture study. Lewis (1995) estimated densities from five transect counts in a variety of prime habitats from well within the core of the species' distributional area. Lewis's density estimates ranged from 262 to 1,077 *sokatra* per km^2. Using these data, Lewis gave "conservative" total population estimates of 1.6 to 4.0 million *sokatra* for the core area on the Mahafaly and Karimbola Plateaux, an area of about 10,000 km^2.

Juvik (1975) and Lewis (1995) believed the range of *sokatra* was contacting and fragmenting at the northern and eastern ends of the distributional area. While this is probably true, the historical records that could confirm this unequivocally do not exist. If humans are the main threat to *sokatra*, and if the range of *sokatra* has been accurately identified, then *sokatra* have done remarkably well over the past 2,000 years since humans colonized Madagascar. Most of the negative impact on *sokatra* populations has probably occurred over that past 500 years, coincident with the arrival of Europeans, and more recently with the explosion of the Malagasy population. There are reliable reports of large numbers of *sokatra* being shipped to the Mascarenes for food during the 18th and 19th centuries (Juvik 1975). Passing ships in the Western Indian Ocean regularly took on large quantities of the larger tortoises from Southern Madagascar and the Mascarene and Seychelles Islands for ship's stores. This activity is thought to be responsible for the extinction of the giant tortoise (*Geochelone gigantea*) on the granitic Seychelles Islands.

Prospect

Based on his limited survey taken in 1974, Juvik (1975:145) believed that "the outlook for the radiated tortoise in Southern Madagascar is not entirely gloomy, thanks to traditional taboos on eating its flesh, improved government controls on exports, and import restrictions in other countries. Its future depends on the survival of some natural habitat; at the same time... modern agricultural developments may be indirectly beneficial." Now, 22 years after Juvik's optimistic report, the outlook for *sokatra* is still not "gloomy," but there have been significant changes that are worrisome. Increasing human population pressures in recent years have resulted in a marked increase in habitat destruction, harvesting of *sokatra* for food and pets is clearly on the rise, and there is no evidence that the Malagasy government has been able to do anything about it. We agree entirely with Richard Lewis (1995) who writes, "One is left with the conclusion that there is a lack of political will to enforce the law."

Our evidence for increased habitat destruction and harvesting of *sokatra* stems mainly from our field observations, which began in the southwest in 1989. Habitat destruction is of four kinds. First, land is being cleared to establish many new agricultural plots, especially noticeable in the eastern part the range of *sokatra*, near Ambovombe and Amboasary. These new fields include small family-owned subsistence plots of corn, cassava, sweet potato, and peanuts, but also larger plots for the commercial growing of sisal[c]. Second, every year during the dry season, much of Southern Madagascar is deliberately burned, as it is widely believed that burning increases the growth of plants needed for grazing of *zebu* and goats. Burning grasslands inevitably leads to burning of spiny forest and brush, as the grass fires are not controlled. A significant but unknown amount of *sokatra* habitat is lost through uncontrolled burning every year, and it is our impression that the intensity of burning has increased over the past eight years. Furthermore, *sokatra* travel over terrain slowly compared to most animals and can easily be overcome by fire, and we suspect that large numbers are killed each year in this manner. That some tortoises are killed in this way is certain, as we have seen charred tortoise shells in several burned areas. Third, the number of *zebu* and goats grazed is increasing with human populations, and the intensity of grazing is exacerbated. At the same time *zebu* and goat populations are increasing, the amount of land available for grazing them is diminishing as a result of conversion of land to agricultural use. It seems certain that *zebu*, and especially goats, consume food necessary for the survival of *sokatra*, but the intensity of competition is unstudied. There is a critical need to study the effects of *zebu* and goats on *sokatra*, because virtually every square meter of *sokatra* range is subject to cattle and goat grazing, even in the reserves and sacred forests of the Mahafaly. Fourth, and equally worrisome, is the dramatic increase in woodcutting for firewood, charcoal making, and construction of houses. Increased woodcutting is proportional to population growth, and there is a direct effect of increased agricultural clearing on woodcutting. For example, now that the town of Amboasary is completely surrounded by sisal plantations, woodcutters who supply the cooking fires for that large village range out as far as 30 km to cut wood. Every day, a steady stream of woodcutters with bundles of firewood on their backs or in push carts can be seen along the Route National east of Amboasary, and similar scenes can be seen along the Route National east of the seaport of Toliara. Along these same two stretches of national highways, entire villages based on charcoal making and selling have sprung up. The charcoal is made deep in the bush and transported to the villages mainly on the backs of humans.

Madagascar is the world's fourth-largest island with a total area of 587,040 square km (about twice the size of Arizona) located off the southeast coast of Africa (Geographic Coordinates 20°00' S, 47°00' E) in the Indian Ocean. Madagascar is one of the seven major world centers of biodiversity and has been called the number one conservation priority in the world. Endemism is extremely high, with as much as 75 percent of all animal and plant species on the island found nowhere else in the world. Plant species number 8,000, birds 102, mammals 77, and reptiles and amphibians 450 species. Madagascar's human population numbers 14,061,627 (July 1997 estimate) with a roughly 3% annual growth. Climate varies from tropical along the east coast, temperate inland, and arid in the south. The diversity of its climate, soils, and geographical features provides a variety of ecosystems from deserts to high-montane rain forests. Madagascar's people suffer from malnutrition and underfunded health and education facilities. The World Bank, in a significant departure from its normal strictly developmental role, has targeted Madagascar in a pilot cooperative venture to integrate conservation and economic growth. Environmental and social problems include deforestation (the principal agent of destruction is "tavy" [slash-and-burn] cultivation, carried out by subsistence farmers for farm land and charcoal production but also exacerbated by overgrazing by live stock), erosion (caused primarily by the previous factor), poverty, economic underdevelopment, political instability, fire (bush fires set by subsistence farmers), desertification, habitat lose (as a result of all the factors above), poaching, and surface water contaminated with raw sewage and other organic wastes; also traditional conservation measures are becoming weaker. At least 80% (and probably 85%) of the land surface of the island no longer has significant native woody plant cover. Currently, less than 2% of the country is included within 37 protected area systems (excluding forest reserves), and Malagasy biodiversity is not fully represented. There is an extreme lack of needed equipment and personnel to sufficiently monitor protected areas. Among all these pressing problems, one can do something to help protect Madagascar's unique plant and animal life. Take an ecotour to this fascinating place and learn of its people, land, and local issues. DO NOT buy native plants or animals that are protected. If interested in captive breeding, learn about such programs as the American Zoo and Aquarium Association's Species Survival Plan, or other similar programs, and help out. Learn about other such activities by reading, traveling, and participating in projects, which help this unique part of the world. Furthermore, teach others about what you experience and learn in the process.[2] *Maps courtesy of John W. Megahan, Senior Graphic Artist, Museum of Zoology, University of Michigan at Ann Arbor.*

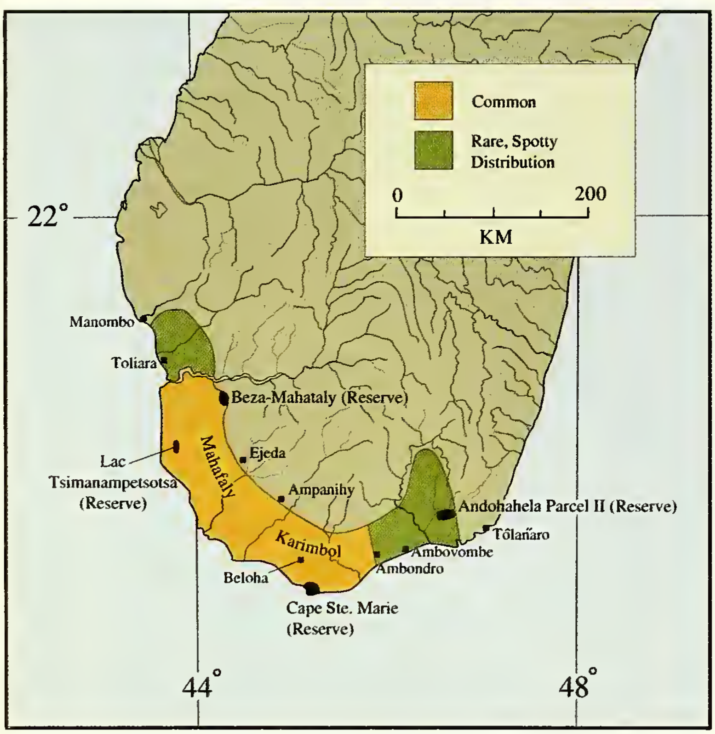

Fig. 1. Distribution of *sokatra* in Southeastern Madagascar.

Evidence for increased harvesting of *sokatra* for local consumption and illegal export is everywhere. Throughout coastal Southwestern Madagascar, campsites very often are cluttered with the remains of one to several *sokatra* that were killed and eaten (Plate 2). Sometimes these campsites are outside the range of *sokatra*, which means the animals were transported there for the purpose of providing meals. Remains of *sokatra* are also found within villages. For example, Beloha is in the heart of Antandroy country where *sokatra* are supposedly *fady*, yet hundreds of discarded shells of eaten *sokatra* can be seen only partially hidden in the sisal plants along the roads in the village. It is not known whether these *sokatra* are being eaten by less traditional Antandroy who no longer consider *sokatra* to be *fady* or whether the significant harvest is done by the many non-Antandroy who live in these regions. Increasingly, except in the most remote areas of the southwest, there is a mixing of the various Malagasy tribes, and this may be one of the greatest threats to *sokatra* survival, as *sokatra* are neither *fady* nor sacred to tribes other than the Antandroy and Mahafaly.

Sokatra are sold openly in restaurants in Southern Madagascar, and neither federal law nor local taboo influences this commerce. The Antandroy and the Mahafaly apparently place no pressure on visitors to their lands to respect the *fady* status of tortoises although they do insist that sacred tortoises be left alone. Seated in a small hotely (Malagasy restaurant) on a winter day, 1995, in Ejeda, a large village dominated by Mahafaly tribespeople, one of us (RAN) overheard two soldiers and a policeman inquiring about *sokatra* on the menu. It was available, but they declined it because the price 2,500 Francs Malagasy (FMG) was too high, choosing instead hena kisoa (pork), which was only FMG 1,500 per plate. At that time, FMG 2,500 was worth about US$0.55. The restaurant owners made no attempt to hide their *sokatra* and the soldiers and policeman obviously weren't interested in enforcing the law. Nor, evidently, were the local Mahafaly opposed to selling *sokatra* for food.

On several occasions, we witnessed buses and other vehicles stopping along Routes National within the range of *sokatra*, so that occupants could debark to collect a hapless *sokatra* observed near the road. RAN once followed a bus for about 15 kilometers on the road south of Beloha, which stopped no less than eleven times to collect *sokatra*... not one was passed up. Some of these *sokatra* may have been destined to become pets, but most were probably eaten. Some of the passengers of these buses must have been Antandroy and Mahafaly, and yet there was a festive atmosphere about collecting the tortoises and no objections from any passengers.

Plate 2. Remains of a killed and eaten *sokatra* near a campsite in Southeastern Madagascar.

In addition to local consumption, *sokatra* are harvested for sale in the markets and restaurants in bigger cities, and at least limited numbers of them are killed and exported for food from the port of Toliara (Lewis 1995; pers. obs.). On 9 October 1995, about 20 km east of Ampanihy, one of us (RAN) came across five large oxcarts filled with 500-800 *sokatra* being transported in disturbingly inhumane conditions. The *sokatra* were piled on top of one another, fully exposed to the blazing sun, and were bouncing up and down on the extremely rough road. The oxcart drivers didn't want to talk to us, but they didn't seem worried about exposure of their illegal cargo. We were informed in Ampanihy that these tortoises were on their way to market in Toliara. We have observed, and Lewis (1995) has reported, dumpsites for *sokatra* shells numbering up to 300 shells per dump near Toliara.

Droughts in Southern Madagascar between 1991 and the present, which caused crop failures and human starvation and death, resulted in increased killing of *sokatra* for food. During the drought of 1992/93, numerous small *sokatra* appeared in Tôlañaro where they were being sold to (mainly) the local Antanosy for food. Inquiries led one of us (RAN) to the discovery that nearly 3,000 *sokatra* were being sold openly in the markets at Ambovombe, the Antandroy capital city. The 3,000 were present on a single market day; the rate of flow of *sokatra* through the market is unknown. RAN was informed by many local Malagasy of both Antandroy and Antanosy nationality that during times of food shortages, nontraditional Antandroy eat *sokatra* regardless of the *fady* (some Malagasy have ceremonies for temporary lifting of various *fadys*), and of course the Antanosy openly eat *sokatra* with great gusto any time they are fortunate enough to have them. The danger now is that those who were forced to eat *sokatra* during this unprecedented famine will continue to consume them after the famine.

Holidays in Madagascar are especially hard times for *sokatra*. Poor families who can't afford meat everyday will usually find a way to provide their families with a special holiday treat. This might be a fowl, but *sokatra* are often available for nothing and may be more desirable than fowl for special occasions.

Two other problems, perhaps of less concern, for *sokatra* conservation are the killing of these animals as pests in agricultural areas and for selling as stuffed curios to tourists, mainly in Antananarivo and Toliara (Plate 3). As land is converted to crops, *sokatra* are increasing obliged to forage in fields, and many *sokatra* are now killed because of the damage they do in fields. Many Antandroy who won't eat them nevertheless do not hesitate to kill them if their crops are threatened.

A surprising number of Malagasy citizens keep *sokatra* for pets, in some cases for pleasure, and in others because they believe their presence protects their poultry against diseases, especially louse infestation. Keeping *sokatra* as pets is not restricted to the south; families in the capital city (Antananarivo) and other northern villages keep numerous *sokatra*. In one small village near Antananarivo, about 30 *sokatra* are being kept by a small group of Malagasy villagers (O. Pronk, pers. comm.).

The illegal harvesting and exportation of *sokatra* for pets is obviously on the increase, as is indicated by the numerous recent reports of arrests of smugglers and confiscation of these animals (e.g., Webster 1997). It is easy for tourists to purchase live *sokatra* in the larger cities, and customs officials confiscate significant numbers. On two occasions, we witnessed *sokatra* taken from the baggage of Japanese tourists at Ivato International Airport in Madagascar, and there are regular reports of *sokatra* confiscated from European (mainly German) travelers in the Malagasy newspapers distributed in Antananarivo. The most recent report of which we are aware is in the 25 March 1997 issue of "Midi Madagasikara," which told the story of 78 *sokatra* taken from the backpacks of two Japanese tourists at Ivato International Airport.

Such is the current situation with the *sokatra*. Their habitat is being degraded and destroyed at an increasing rate, they are being harvested by the thousands every year, and local law enforcement does little to mitigate the situation or stop such activities. The laws protecting *sokatra* are well known to the Malagasy, but they have learned that these laws can be completely ignored.

It is equally clear that laws to prevent international trade in radiated tortoises are not working very well. Perversely, it appears that laws restricting export of radiated tortoises may do more harm than good. Banning exportation increases the value of the tortoises, both in the legal and black market trades (see Lamar 1997, for other species), which increases the determination of smugglers to find ways to get the tortoises out and inevitably leads to more corruption of officials charged with enforcing the laws. With higher values, smugglers can afford to pay for illegal transport and lay out more money for bribes. Evidence that embargoes on shipments of pet trade animals from Madagascar don't work can be seen in regard to the recent CITES embargo on most species of day geckos (*Phelsuma*) and chameleons from Madagascar. Since this embargo went into effect 20 January 1995, the banned species have continued to arrive in Europe and the United States in large numbers, and at least in Europe the prices have declined suggesting they are arriving in greater numbers than before (O. Pronk, pers. comm.). Economically, this may be because the smaller day geckos and chameleons can be smuggled in greater numbers than tortoises, and because smugglers do not have to pay the export tax that is levied by the Malagasy government against legal animal exporters.

Plate 3. C. J. Raxworthy examines a stuffed *sokatra* for sale to tourists in the Analakely market in Antananarivo, Madagascar.

An additional negative effect of banning export of radiated tortoises (and other species) is the inhumane treatment of the exported animals. Smugglers do not have to comply with International Air Transport Association (IATA) rules regarding humane packing and shipment of commercial animals and, indeed, probably cannot comply with these conditions because of the need to hide the animals and use circuitous and prolonged routes for their movement. Undoubtedly, the percentage of dead, injured, and unhealthy animals arriving at their destinations is higher in illegal shipments than in legal shipments.

It seems certain that local traditions have had more impact than federal and international laws in conserving the *sokatra*. But it also seems certain that the forbidden status of *sokatra* among the Mahafaly and Antandroy will erode as human populations and the need for protein and money increases and as people from other tribes without *fady* constraints continue to immigrate into the range of the tortoise. Much serious thought, research, and considerable effort will be needed to insure the survival of this increasingly vulnerable species.

Solutions

It has repeatedly been argued that education of the Malagasy is the key to the survival of the *sokatra*. This seems unlikely. Many well-educated Malagasy, who are well aware of conservation issues, keep *sokatra* as pets and regularly eat them because they taste good. Poorly educated Malagasy, those who live in the bush and survive off the land and eat tortoises because they need food, are largely immune to education, and, in any case, all the education in the world will not stop them from doing what is necessary to survive. The dilemma these poor Malagasy face is dramatically demonstrated in Webster's (1997) article.

Education, especially in regard to resource management, may be of some value if directed at land managers and guardians of the Reserves. During a visit to Cap Sainte Marie, RAN was proudly informed by the guardians of the Reserve that they regularly collected tortoises observed on the limestone plateaux and placed them in one of the steep-sided canyons where the tortoise could not get out, find more food, and were protected from poachers. It apparently hadn't occurred to these guardians that the tortoises were numerous on the plateaux because the conditions there are good for them and that taking the tortoises from their familiar home ranges might be disastrous for them. Furthermore, the guardians had not considered the negative effects of artificially concentrating tortoises in a habitat which they should have realized was suboptimal for the tortoise, otherwise there would have been more tortoises there naturally. Finally, the guardians should have realized that concentrating the tortoises in a canyon might actually make it easier for poachers to collect them. Education might also help to stop the genetic pollution caused by the irresponsible release of confiscated animals.

It has also been suggested that captive breeding programs are a way to ensure survival of the species. Such a program is the American Zoo and Aquarium Association's Species Survival Plan (AZA/SSP) for the radiated tortoise, underway through a consortium of zoos, in which tortoises would ultimately be repatriated, to the natural environment under the auspices of Malagasy guardianship. There are obvious problems with this approach, not the least of which is that it will do no good to repatriate captive-bred tortoises to an environment that will not sustain them. If the ecosystem no longer supports wild-bred tortoises, then why should we expect captive-bred tortoises to do any better? If the natural environment will not support *sokatra*, then captive-bred animals are best kept where they are... in zoos. If natural populations still exist, then they should not be genetically polluted by release of captive-bred animals. Captive-bred animals should be used to establish populations in nature only if natural populations no longer exist and only if conditions that insure protection of the released animals are in place.

Aside from educating resource managers and guardians, what are the solutions to conservation of *sokatra*? Something should be done to (1) curtail habitat degradation, (2) reduce harvesting of *sokatra* for local consumption, and (3) control the exportation of *sokatra* in the pet trade.

It seems highly unlikely, given the inexorable human population growth and the Malagasy local traditions, that much can be done to slow habitat degradation. The best that can be done is to establish one or more large nature reserves on the Mahafaly and Karimbola Plateaux in areas that are not currently being converted to agricultural plots and have little value for agricul-

Hatchling radiated tortoise *Geochelone radiata*. *Photo courtesy of R. D. Bartlett.*

ture. This might be done in conjunction with the large and relatively undisturbed sacred forests where Mahafaly kings are buried. These sacred forests are not immune to cattle grazing, and neither are the reserves. Therefore, studies are needed to learn the impact of grazing on tortoise populations and to determine the maximum allowable grazing within reserves. Control of grazing and poaching of tortoises on the reserves would be impossible without the cooperation of local and federal authorities and, more importantly, without some reward for local support of law enforcement. This would have to include compensation for lost income from reduced grazing of cattle and harvesting of tortoises. Threats of punishment alone won't work.

Reduction of local consumption of *sokatra* will be difficult, especially in areas outside of the Mahafaly and Antandroy homelands. Antanosy and other Malagasy connoisseurs of *sokatra* will always eat them, regardless of the law. Malagasy law regarding the *sokatra* has been widely ignored for so long that any attempt to enact strict enforcement locally would lead to serious problems with which the Malagasy authorities are not adapted to cope. However, we note that although lemurs (family Lemuridae) are still consumed for food in Madagascar, the law protecting lemurs is both more widely enforced and respected than are the laws protecting *sokatra*, perhaps as a result of more intense public scrutiny related to the economy of tourism and because of greater international involvement.

If the international community, through agencies such as United States Agency for International Development (US AID), can be persuaded to act more responsibly by promoting meaningful projects in Southern Madagascar that increase the food supply (relative to human population density) and by reacting more swiftly to drought and famine, then desperation consumption of *sokatra* might be reduced. This would mean providing food rich in protein, and not just surplus corn and bulger wheat, during times of famine. In the area around Tôlañaro, much of the surplus food given to Malagasy by aid agencies during the recent drought, especially the dried corn, was either fed to livestock or sold for pittance so that the puzzled owners could buy real food. The problem of consumption of *sokatra* is probably intractable in peripheral areas, but creation of additional reserves and strong rewards for respecting the boundaries of the reserves would help to insure the survival of *sokatra* in the core area of their distribution.

There are two options for reducing the impact of the illegal commercial pet trade on natural populations of *sokatra*. The first is to enact a monitored legal trade program that strictly limits the number of wild-caught *sokatra* that could be exported and would generate some income for the Malagasy government through taxation on exports of *sokatra*. This would be especially desirable if the generated income were used to support monitoring programs and research on the tortoise. Such a solution would require downgrading of the *sokatra* from Appendix I to Appendix II, which theoretically shouldn't be a problem, because it is clear that the *sokatra* is currently misclassified by CITES, as it is not currently "threatened with extinction." If the species was downgraded to Appendix II, then a limited number of both wild-caught and first generation, captive-bred *sokatra* could be legally exported as could confiscated animals (under the monitored program), a better solution than genetic adulteration of natural populations through random release into the environment. Limited legal export (with controls such as internal pas-

Plate 4. Confiscated *sokatra* at a Malagasy government station in Ivoloina (September 1985).

sive integrated transponder [PIT] tag markers) would destroy or greatly reduce the market for smuggled animals and prevent inhumane shipping methods.

Realistically, downgrading to CITES II might be politically impossible, so a second solution would be to encourage captive breeding programs in Madagascar that would eventually yield second generation, registered, captive-bred tortoises that could be legally exported under a monitored program. This could be done under a partnership with the Malagasy government and captive breeders in which the Malagasy government retains ownership of the tortoises and in which some of the income would be returned to the Malagasy to support tortoise conservation. Perhaps third-party monitoring agencies would be required to insure against corruption. The nucleus for a monitored, legal export program for *sokatra* already exists in Madagascar at Ivoloina (Plate 4), where the Malagasy government (Eaux et Forêts) keeps confiscated tortoises. Under either program, it might be possible to supply tourists with legal tortoises, under the same kind of regulation used for exporting semiprecious stones and other valued objects from Madagascar. Such programs would not entirely eliminate illegal trade but might reduce it considerably, as profit from illegal activity would be greatly diminished.

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Footnotes

[1]*The Malagasy name for the radiated tortoise varies regionally in Madagascar.* "Sokatra" *(Merino),* "sokaka" *(Antandroy and Antanosy), and* "kotroky" *(Mohafaly) are commonly used. These words are pronounced* "sookol," "sookock," *and* "kootrook," *respectively.*

[2]*For more information on protected areas (policy and legislation, international activities, odministration and management, system reviews, addresses, protected area information, definitions of protected orea designations, as legislated, together with authorities responsible for their administration, maps, and the 1993 United Nations list of national parks and protected areas), travel, health information, global biodiversity hotspots, and country information consult the following sources which were used to write this country summary:* **Protected Areas:** *World Conservation Monitoring Centre's Protected Areas website location: www.unep-wcmc.org/parks/index.html and the IUCN, 1992.* Protected Areas of the World: a review of national systems. *IUCN, Gland, Switzerland and Cambridge, United Kingdom. Xx + 352 p. Also, available via the Internet at: www.unep-wcmc.org/protected_areas/data/pa_world_text.html;* **Travel:** *United States State Department, Bureau of Cansular Affairs website: travel.state.gov;* **Health:** *Shoreland's Travel Health Online: www.tripprep.com;* **Global Biodiversity Hotspots:** *www.conservation.org/hotspots/default.htm; and* **Country information:** United States Central Intelligence Agency's (CIA) World Factbook, *CIA, Washington, D.C. Also, available via the Internet at: www.odci.gov/cia/publications/factbook*

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Extinction and extinction vulnerability of amphibians and reptiles in Madagascar

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Abstract.—**In Madagascar, only two herpetofaunal extinction events are well documented. Both are extinctions of subfossil giant tortoises, which coexisted with humans for more than 1,000 years. Modern extinctions of amphibians and reptiles are also likely, but researchers and conservationists are probably overlooking these extinction events, because the most vulnerable species, with small relict populations, are easily missed during regional surveys. To date, conservation programs in Madagascar have largely ignored many relict distribution species, restricted to transitional or rare habitat types. We provide four examples of species with relict distributions that we consider vulnerable to extinction. Based on ongoing surveys and systematic revisions, many new herpetofaunal species will be described in the future, some of which may require rapid conservation efforts to prevent extinction.**

Conservationists frequently measure extinction vulnerability using the World Conservation Union (IUCN) Red Lists, and fifteen endemic Malagasy amphibians and reptiles are included in the IUCN Threatened List. However, this list appears to reflect a historical bias towards conserving turtles and boas in Madagascar, listing eight species in these groups, although they represent just 2 percent of the island's actual endemic herpetofauna. Ironically, this taxonomic bias may hinder attempts to prevent herpetofaunal extinctions, by promoting some species for conservation activities that are not vulnerable (e.g., tolerant of human habitat modification, or widespread) and ignoring many species that are soon to be lost. For Malagasy amphibians and reptiles, biogeographic data appear to provide more objective criteria with which to assess extinction threats rather than suspected rates of population decline.

Key words. *Extinction, conservation, Madagascar, herpetology, biogeography, reptiles, amphibians*

Introduction

Despite the considerable interest in the amphibian and reptile faunas of Madagascar and the widely held view that the island represents one of the world's top conservation priorities (e.g., Wright 1997), it is surprising that there has been so little discussion regarding the patterns of extinctions (past, present, or future) for these two highly diverse and largely endemic groups. This is of special concern because the objective of most conservation programs in Madagascar is to maintain biodiversity. Therefore these programs should prevent, or at least minimize, future extinctions.

The purpose of this paper is to provide a summary of herpetofaunal extinctions and extinction vulnerability in Madagascar: first by reviewing the evidence of extinction; second by providing examples of species we believe are at imminent threat of extinction; and third by evaluating and summarizing methods used to measure risks of extinctions by the conservation community using the World Conservation Union (IUCN) Red List criteria.

Subfossil extinctions

The only well documented cases of herpetofaunal extinctions in Madagascar are for the two species of giant tortoises, *Dispsochelys grandidieri* and *Dispsochelys abrupta*, which once occupied a large area of the central and western region of the island (Bour 1984). Both species went extinct during Madagascar's "megafauna" extinction event that occurred during the past two thousand years (Dewar 1984). The reasons for their extinctions are unknown, but it is certain that they coexisted with humans on the island between 2000 Before Present (B.P.), the date of earliest human occupation of the island (MacPhee and Burney 1991) and 750 B.P., the youngest carbon date for giant tortoise subfossils in Madagascar (Burleigh and Arnold 1986). Raxworthy and Nussbaum (1996) have suggested that the modern day practice of regular (typically annual) burning of grassland and its peripheral forests, over much of the island, was responsible for destroying the original habitats of grazing animals such as giant tortoises, while MacPhee and Marx (1997) consider their extinction may be due to the human introduction of exotic pathogens that caused hyperdisease.

The former distribution of both species of giant tortoises was vast, and their remains frequently represent the most common subfossil material recovered by paleontological excavations (Dewar 1984). Because of their former large distribution and fact that much of island of Madagascar has still been poorly surveyed, there remains a chance that either species may survive as a small population in one of the remoter regions, although this possibility must now be considered extremely unlikely.

No other extinct reptile or amphibian subfossil material is known from Madagascar, and there are no historically documented cases of species going to extinction.

Possible extinctions

One possible extinction claimed in the literature (IUCN/UNEP/WWF 1987) is the colubrid snake *Liophidium apperti*. This

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Plate 1

Plate 2

Plate 3

Plate 4

Plate 5

Plate 6

Plate 7

Plate 8

Plate captions: **1**. Antanosy day gecko *Phelsuma antanosy*, from a Petriky relict forest fragment that has now been lost. **2**. *Chamaeleo belalandaensis*, at Belalanda. One of Madagascar's rarest chameleons. **3**. Angonoka tortoise *Geochelone yniphora*, photographed at Ampijoroa. **4**. Adult big headed Madagascar side-necked turtle *Erymnochelys madagascariensis*, photographed at the Andranomiditra River, Bevazaha village, Ankarafantsika Reserve. *Photo: Gerardo Garcia Herrero.* **5**. Tomato frog *Dyscophus antongili*, Antongil's Bay. **6**. Dumeril boa *Boa dumerili*. *Photo courtesy of Kevin and Sue Hanley*. **7**. Madagascar boa *Boa madagascariensis*. *Photo: R. D. Bartlett.* **8**. Sanzinia tree boa *Boa manditra*. *Photo by Peter Stafford, courtesy of The Natural History Museum, London. Photos 1 and 2: C. J. Raxworthy. Photos 3 and 5 courtesy of Franco Andreone, Museo Regionale di Scienze Naturali, Torino, Italy.*


Plate 9


Plate 10


Plate 11


Plate 12


Plate 13


Plate 14


Plate 15


Plate 16

Plate captions: **9**. Campan's chameleon *Furcifer campani*. **10**. Labord's chameleon *Furcifer labordi* (female), Kirindy. **11**. Minor chameleon *Furcifer minor* (female), photographed at "Mandraka Breeding Centre." **12**. Standing's day gecko *Phelsuma standingi*. **13**. Golden mantella *Mantella aurantiaca*, from Andasibe. *Photo: C. J. Raxworthy.* **14**. *Pyxis planicauda*, photographed at Ampijoroa. **15**. Radiated tortoise *Geochelone radiata*. **16**. Armored chameleon *Brookesia peramata*. *Photos 9 and 12 courtesy of R. D. Bartlett. Photos 10, 11, and 14 courtesy of Franco Andreone, Museo Regionale di Scienze Naturali, Torino, Italy. Photos 15 and 16 courtesy of Kevin and Sue Hanley.*

species was described from a single specimen collected from a forest 7 km north of Befandrina-sud in 1968 (Domergue 1983). Domergue reported that the forest had been subsequently cleared, which prompted IUCN/UNEP/WWF (1987) to consider that "the survival of this snake must now be in question." We think it is premature to consider this species to be extinct, because this region remains so poorly studied, and it appears that similar forest types still survive in nearby sites in the Morombe region. We have collected *Liophidium* c.f. *apperti* at several localities in southern Madagascar, and although these specimens require further taxonomic study, this also suggests this species is not confined to Befandrina-sud.

Possibly the best candidate we have for an extinction event occurring during the past 100 years is for the colubrid snake *Pseudoxyrhopus ankafinaensis*, which was not described until 1994. This very large species is represented by just a single specimen collected in 1880 from montane forest of the High Plateau. Forest of this type is now almost completely degraded in this region (Raxworthy and Nussbaum 1994), and the absence of observations of *P. ankafinaensis* from surviving forest of lower elevation, or other montane forest sites suggests it was endemic to this high elevational region of the High Plateau.

Dubious extinctions

Other species have not been found for more than one hundred years, and, therefore, could also be considered extinct. However, before this conclusion can be made with any certainty, it is important to confirm that the species were collected in Madagascar. During the 1800's, specimen localities were sometimes confused or lost, frequently because museums were receiving collections from throughout the world during this period. An example is the colubrid snake *Pseudoxyrphopus punctatus*, which was thought for a period of more than 50 years to have been collected in Madagascar. Subsequently, this was identified as a Brazilian snake in the genus *Sordellina* (see Raxworthy and Nussbaum 1994).

Another possible example of a species that may not ever have been collected in Madagascar is *Ailuronyx trachygaster*. This giant gecko, known only from a single specimen MNHP 6679 (Muséum National d'Histoire Naturelle, Paris) was collected by an unknown person from a locality listed in the Paris Museum as Madagascar. Interestingly, the two specimens catalogued before *A. trachygaster*: MNHP 6677-8, are both *Ailuronyx seychellensis* collected in the Seychelles (6677 was collected by Péron and Lesueur). Possibly *A. trachygaster* was also collected on the same voyage. *A. trachygaster* is a valid species, with very different characters compared to *A. seychellensis*. Despite some uncertainty about the geographic origin, we suspect *A. trachygaster* is extinct because no new specimens (of what should be a very conspicuous gecko) have been found in more than 140 years.

As a result of recent surveying in Madagascar, most of the rarer species in collections have been rediscovered, such as *Zonosaurus boettgeri*, *Phyllodactylus brevipes*, *Paragehyra petiti*, *Uroplatus alluaudi*, and *Pseudoxyrhopus ambreensis*, but a few notable exceptions remain, especially among the most cryptic groups. For example, among the skinks, the following species have not been collected since their original description: *Mabuya betsileana* (possibly African), *Cryptoscincus minimus*, *Pseudoacontias madagascariensis*, and *Paracontias rothschildi*. Their exact distributions remain unknown at present (in Madagascar or elsewhere) but we consider it premature to consider any of them to be extinct.

Vulnerable to extinction

We consider species in the category "Vulnerable to Extinction" to have populations that are sufficiently small that near-future extinction in the wild can be considered highly likely (without conservation action). These species are restricted to primary habitat that has declined so dramatically, that they now survive only in tiny isolated patches, which are continuing to decline. As a result, the species dependent on this primary habitat are now endemic to a very small region of the island. To illustrate this type of extinction vulnerability, we have selected four species to serve as examples. However, many other herpetofaunal species exhibit similar extinction vulnerability in Madagascar.

Bernard's mantella frog *Mantella bernhardi* (Plate 18A and B). During a survey of Tolongoina made by Nussbaum in 1993, *M. bernhardi* was first discovered, in a single patch of relict forest. Within months, commercial collectors visited the locality and supplied André Peyrieras, a commercial exporter, with animals to be sold into the pet trade. Vences et al. (1994) described this species based on animals they obtained from commercial collectors working for Peyrieras. They provided no data on the exact locality, habitat requirements, or conservation concerns of this species, because they never saw this species in the wild.

A subsequent visit to the Tolongoina region by Raxworthy in 1994 discovered that the only known *M. bernhardi* habitat had been further cleared, so that no more than 20 ha of forest survived (Plate 17). No other populations were discovered during this visit, and almost all other primary rain forest had been cleared from the area. Deforestation of primary forest has been so extensive in this region that almost no fragments now survive east of the Faraony River. Topographic maps indicate that this forest was almost entire during aerial photography made of the region between 1950 and 1965 (FTM 1974).

Although it is likely that *M. bernhardi* once had a more widespread distribution, the deforestation pattern of low elevation rain forest (below 800 m elevation) in this region suggests that little forest of this type now survives. The closest protected forest of this type occurs in the lowest elevational areas of the Ranomafana National Park (the southern boundary limit is 18 km to the northwest). It is not known if this species occurs there, or even if the habitat is similar to that at Tolongoina. The low elevation rain forest at Manombo Reserve (140 km to the south) does not appear to have populations of *M. bernhardi* based on a survey by Raxworthy in 1991.

Because no known populations of *M. bernhardi* occur within a protected area and its habitat appears to have been almost completely destroyed, we consider this species extremely vulnerable to extinction.

Antanosy day gecko *Phelsuma antanosy* (Plate 1). This day gecko is restricted to coastal fragments of forest in the Tolagnaro region of southeastern Madagascar. Raxworthy and Nussbaum (1993) described three sites (forest fragments) in the description of this species at Petriky, Ste. Luce, and Tapera. Since then, one new site has been discovered near Manambaro, and one site (the Petriky fragment, area 81 ha in 1989) has been completely destroyed. None of the three surviving forest fragments is greater than 191 ha, and the Manambaro site is decreasing in area rapidly as a result of annual burning.

Unlike some *Phelsuma* species, *P. antanosy* does not survive in degraded or heavily modified habitats and appears to be entirely dependent on the transitional dry-humid forests that are restricted to a small region of the southeast. This habitat has now been almost completely lost from the region, having been degraded and cleared for charcoal production and agricultural land. None of the forest fragments where *P. antanosy* occurs is within a protected area.

The surviving populations are now so small that we consider this species to be extremely vulnerable to extinction. Conservation efforts are required if the last fragments of habitat are to be saved.

Belalanda chameleon *Chamaeleo belalandaensis* (Plate 2). Very little information exists on either the distribution or habitat requirements of this chameleon. However, all data to date suggest it is endemic to a tiny region of Madagascar. The only locality is Belalanda, Southwestern Madagascar, where Raxworthy has recorded individuals as recently as 1995. However, we were unable to find this species at other sites, despite intensive herpetofaunal surveys within 10-50 km of Belalanda. The habitat where this chameleon was recorded is degraded gallery forest, which has now been almost completely cleared. Because *C. belalandaensis* was not found in the other surviving primary forest habitats of the region, we suspect it is restricted to gallery forest.

This chameleon is an example of a species for which biogeographic data are urgently needed. It would be valuable to record the exact distribution limits for this chameleon, so that conservation efforts could be directed at those populations, which appear to be most viable. The species has already been subject to some commercial collecting, but the impact on the population is not known. The very localized distribution of *C. belalandaensis*, in part confirmed by our survey efforts in surrounding areas, suggests that this species is vulnerable to extinction because of the apparently tiny surviving populations.

Angonoka tortoise *Geochelone yniphora* (Plate 3). This tortoise is restricted to an area of less than 1,000 km^2 in the Baly Bay area of Western Madagascar. The distribution appears to be relict, because the species is now confined to two isolated areas, one to the east of the Baly Bay (Cap Sada), and the other to the west (Belambo). Dispersal across the bay is likely to be very limited or impossible. Therefore, the eastern and western populations appear to be genetically isolated. Only five sites are known or suspected to have *G. yniphora* populations (Durrell et al. 1994). The suspected sites are based on interviews with local people and the occurrence of suitable habitat. The wild populations are thought to have declined recently due to habitat loss, predation of eggs, and juveniles by African bush pig (*Potamochoerus larvatus*), and collecting by people (Durrell et al. 1994). At Cap Sada the first detailed population study is now underway.

The isolated eastern and western populations of *G. yniphora* suggest this species was previously distributed to the south of Baly Bay and that the distribution range has contracted since this time. The habitat of this tortoise is a mosaic of deciduous forest and bamboo scrub, which appears to be replaced by a palm savanna as a result of frequent burning. Between 1949-1973, Curl et al. (1985) reported only minor change in tortoise habitat distribution, and suggested this habitat is no longer declining. However, it should be noted that during this same period, the setting of fires was both illegal and frequently enforced by local communities.

The tiny isolated populations and the restricted area of surviving habitat clearly indicate that *G. yniphora* is vulnerable to extinction if further habitat decline continues. A major conservation program (Project Angonoka) coordinated by the Malagasy Water and Forests Authority and Jersey Wildlife Preservation Trust is now underway in the Cap Sada region to protect this population.

IUCN Threatened species

This section includes those species listed with a threatened category (Critically Endangered, Endangered, or Vulnerable) in the most recent IUCN Red List (IUCN 1996). Threatened species, as recognized by IUCN, refers specifically to the level of risk of extinction. Fifteen endemic Malagasy amphibians and reptiles are currently listed as threatened in the Red List; three species are classified as Endangered, and another 12 as Vulnerable. A significant advance with the new IUCN categories is that threats are presented in a quantified format. A summary of these endemic species, as well as their perceived risks of extinction, is given in Table 1.

IUCN Endangered species

Big headed Madagascar side-necked turtle *Erymnochelys madagascariensis* (Plate 4). The criteria used for considering this turtle as endangered is based on a 50 percent population decline in 10 years or three generations. The generation time (average age of parents in the population, as used by IUCN) for this turtle is unknown, but without doubt will be greater than 10 years. For long-lived species IUCN suggests a cap of 75 years (IUCN 1996). Even working with this time span, however, the problem is a lack of population data for this species, both modern and historical.

There is no doubt that populations are being exploited by fishing practices, and Kuchling and Mittermeier (1993) have presented evidence that two populations have gone extinct out of a sample of nine lakes. Nevertheless, these authors recognized that the status of river populations have not been estimated because of an almost complete lack of surveys within the rivers of Western Madagascar. In addition, we still lack modern data on either lake or river populations throughout much of the species' distribution range, especially the many remote regions of the west.

Because our knowledge of the populations of *E. madagascariensis* is so incomplete, it is questionable if we can claim even a suspected population reduction of 50 percent. The large historical distribution area of this turtle, with an extent of occurrence of approximately 100,000 km^2, does not suggest to us that this species is yet at high risk to extinction, although clearly more field work is required to determine the current distribution of this species.

Angonoka tortoise *Geochelone yniphora*. Like *E. madagascariensis*, the three-generation time for *G. yniphora* will be greater than 10 years. We are unaware of data to support a 50 percent population decline over either 10 years or three generations. However, this tortoise does qualify for Endangered status based

Plate 17. Some of the last known surviving *Mantella bernhardi* forest habitat cleared for cultivation between 1993-4. *Photo: C. J. Raxworthy.*

Plate 18A. Bernard's mantella frog *Mantella bernhardi*. Probably the rarest Mantella species. *Photo courtesy of Franco Andreone, Museo Regionale di Scienze Naturali, Torino, Italy.*

Plate 18B. *Mantella bernhardi* (belly pattern). *Photo courtesy of Franco Andreone, Museo Regionale di Scienze Naturali, Torino, Italy.*

on the criteria of an extent of occurrence less than 5,000 km^2, and less than 5 isolated populations (see earlier).

Madagascar flat tailed tortoise *Pyxis planicauda* (Plate 14). Adult wild *P. planicauda* are reported to have 10-30 growth rings (Kuchling and Bloxam 1988), which appear to reflect the growth between each period of annual aestivation[d]. Using a mean generation time of 20 years, three generations would represent 60 years. The Endangered category given to this tortoise is based on a 50 percent decline in the population during this period.

Without question, populations of this tortoise are declining due to habitat destruction for cultivation (Kuchling and Bloxam 1988; Bloxam et al. 1993; Raxworthy, pers. obs.). However, our knowledge of the species distribution is actually improving. New localities are being discovered, including important range extensions further to the north (Behler et al. 1993; Bloxam et al. 1993). The extent of occurrence for *P. planicauda* is currently about 500 km^2 (based on the localities given in Fig. 1, Behler et al. 1993), with the species endemic to a small region of coastal, western, deciduous forest between the Morondava and Tsiribihina Rivers. This justifies *P. planicauda* being considered Endangered (the extent of occurrence is significantly less than 5,000 km^2) based on its small distribution, rather than the criteria of rate of population decline. The localized distribution of this species, and its dependence on native forest, suggests this species is vulnerable to extinction.

IUCN Vulnerable species

Of the 12 species classified as Vulnerable, 11 are so classification based on a criteria of a 20 percent reduction in population over 10 years or three generations. The mean wild generation time is unknown for any of these species, although a study of radiated tortoise *Geochelone radiata* at one site has yielded some data on the population age structure (Razafindrakoto 1987). The population size and rate of decline have never been measured for these species, although populations of some species restricted to primary habitats are declining in areas subjected to habitat loss. For those species restricted to primary habitats, it may be reasonable to positively correlate rates of habitat loss (e.g., based on satellite images) to rates of population decline.

Four of the Vulnerable species: the tomato frog *Dyscophus antongili* (Plate 5), the Dumeril boa *Boa dumerili* (Plate 6), the Madagascar boa *Boa madagascariensis* (Plate 7), and the Sanzinia tree boa *Boa manditra* (Plate 8), are not restricted to primary vegetation. *D. antongili* is found in secondary habitats, such as around villages and in areas of cultivation (Raxworthy 1991), and even in towns such as Maroantsetra (Glaw and Vences 1994). All three of the Malagasy *boas (B. dumerili, B. madagascariensis*, and *B. manditra*) are frequently found in heavily degraded habitats and cultivated areas, even including close proximity to villages where they are probably feeding on commensal rats. For these species, the loss of primary forest does not lead to local extinction, although their population changes (negative or positive), when primary forest is converted, are not known.

The most likely source of population decline for *D. antongili*, and the three species of boa, is commercial collecting, although now all four species are listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I, which prevents legal international trade. Malagasy boas are collected in regions such as Marovoay to supply a domestic leather trade. However, boas continue to be among the most common snakes found in Madagascar, and the scale of commercial collecting may be comparable to the number of road kills that can be seen throughout Madagascar during the rainy season. The approximate extent of occurrence of each species is: *D. antongili* 10,000 km^2, *B. dumerili*, 120,000 km^2, *B. madagascariensis* 40,000 km^2, and *B. manditra*, 100,000 km^2. Based on the large distribution area, and the broad tolerance to habitat degradation, none of these species appear at risk to extinction.

Of the other eight vulnerable species which are restricted to primary habitats, it is impossible for us to assess the criteria used for the following species: Campan's chameleon *Furcifer campani* (Plate 9), Labord's chameleon *Furcifer labordi* (Plate 10), the Minor chameleon *Furcifer minor* (Plate 11), Standing's day gecko *Phelsuma standingi* (Plate 12), and the golden mantella *Mantella aurantiaca* (Plate 13), because these are based on rates of population decline (observed or suspected) for which we have been unable to find obvious supporting data.

Table 1. IUCN threatened species of endemic amphibians and reptiles of Madagascar (IUCN 1996).

SPECIES	CATEGORY	SUMMARY OF CRITERIA
Erymnochelys madagascariensis	ENDANGERED	50% population decline in 10 years or 3 generations
Pyxis planicauda	ENDANGERED	50% population decline in 10 years or 3 generations
Geochelone yniphora	ENDANGERED	50% population decline in 10 years or 3 generations, < 5,000 km^2 extent of occurance and < 5 isolated populations
Dyscophus antongili	VULNERABLE	20% population decline in 10 years or 3 generations
Mantella aurantiaca	VULNERABLE	20% population decline in 10 years or 3 generations
Pyxis arachnoides	VULNERABLE	< 20,000 km^2 extent of occurance, < 10 isolated populations and decline in population
Geochelone radiata	VULNERABLE	20% population decline in 10 years or 3 generations < 20,000 km^2 extent of occurance, < 10 isolated populations
Phlesuma standingi	VULNERABLE	20% population decline in 10 years or 3 generations
Brookesia peramata	VULNERABLE	20% population decline in 10 years or 3 generations and < 100 km^2 area of occupancy or < 5 locations
Furcifer campani	VULNERABLE	20% population decline in 10 years or 3 generations
Furcifer labordi	VULNERABLE	20% population decline in 10 years or 3 generations
Furcifer minor	VULNERABLE	20% population decline in 10 years or 3 generations

These species have been commercially traded, but the impact of this trade on wild populations is unknown or only poorly known.

Two of these species have a very limited distribution: *M. aurantiaca* is restricted to eastern rain forest with an approximate extent of occurrence of 3,000 km^2 and *P. standingi* restricted to deciduous western forest in the Toliara region with an approximate extent of occurrence of 2,500 km^2 (although an unconfirmed report suggests this species may also occur further north).

In the case of *P. standingi* we have found this gecko is extremely rare (if not locally extinct) in forest within 5 km of major roads at Ifaty (none were seen during at least 60 man-days of searching). Commercial collecting has been occurring in this area for some time, and in many cases collecting poles could still can be found lying against baobab tree trunks, left by the local collectors in the hope of catching any remaining geckos. However, because the original population size and density in this region is unknown, the impact of commercial collecting cannot be measured.

The impact of collecting on *M. aurantiaca* is also unknown. Zimmermann and Zimmermann (1994) suggest that local population extinctions occurred in a swamp system between 1966 and 1993 as a result of habitat loss. They therefore propose that commercial collecting be prevented by placing *M. aurantiaca* on Appendix I of CITES.

For *M. aurantiaca* and *P. standingi*, their limited known distributions, primary habitat requirements, and commercial collecting pressures, all suggest that both species may be vulnerable to extinction.

Distribution data is used as criteria for Vulnerable status for three species: *Pyxis arachnoides*, *G. radiata* (Plate 15), and *Brookesia perarmata* (Plate 16). For the two tortoise species, *P. arachnoides* and *G. radiata*, the extent of occurrence is actually greater than 20,000 km^2 (we estimate both around 30,000 km^2), one of the criteria used to support the vulnerable status. In addition, although the populations of these species are also likely to becoming more fragmented, as a result of habitat loss, there are without doubt many more than 10 isolated populations (another criteria used to assign these species vulnerable status, see Table 1). Therefore, the only justification that can be made for considering these tortoises, as Vulnerable, using the IUCN criteria, is the rate of observed or suspected population decline, for which we currently have very little quantitative information. The large distributions of *P. arachnoides* and *G. radiata* do not suggest that either species is yet threatened by extinction.

B. perarmata is only known from one site: Bemaraha, in Western Madagascar. Although the surface area of the Bemaraha Reserve is large (152,000 ha), our survey of this protected area at three well separated sites, yielded this chameleon at just one locality indicating it is not continuously distributed throughout the reserve. This clearly supports the "less than five site" criteria for Vulnerable status.

Discussion

Despite the major environmental problems that have been developing for so long in Madagascar, it is perhaps surprising that we have no evidence of any herpetofaunal extinction events occurring on the island over the past 500 years. Although this suggests the island's species diversity has not declined during this period, we believe herpetofaunal extinctions have been occurring, and are occurring now, but that researchers and conservationists have overlooked these events.

Species most vulnerable to extinction will have small populations, and therefore tiny relict distributions. This makes them difficult to survey, and, therefore, easily missed. A modern example of this is *P. antanosy*, distributed in a region of Madagascar that has been subject to herpetological collecting for over 100 years. We suspect many more herpetofaunal species are on the verge of going extinct in transitional or rare habitat types. Regions that experience highly localized climatic conditions frequently have unusual transitional habitats in Madagascar. In many cases these localized habitats have been further reduced to small relict patches as a result of human exploitation and have attracted little research attention because of their small size or isolated locality. Examples of major sites we have surveyed, which offer these conditions, include Analavelona, Isalo, Bemaraha, Kelifely, Ambohijanahary, Namoroka, and Ankarana. We are in the process of describing new species from all of these sites, most of which are likely to be locally endemic, but active conservation programs are now underway in just three sites (Isalo, Bemaraha, and Ankarana). Many of these new species are reduced to such small population sizes that they are obviously some of the most vulnerable herpetofaunal species in Madagascar. Other potentially vulnerable species include *Phelsuma masohoala*, *Uroplatus malahelo*, *Pseudoxyrhopus kely*, and *Alluaudina mocquardi*.

Of the 15 endemic Malagasy amphibians and reptiles considered Threatened by the IUCN Red List, we consider (based on distribution and habitat requirements) just three species to be obviously vulnerable to extinction: *P. planicauda*, *G. yniphora*, and *B. perarmata*. Another two species, *M. aurantiaca* and *P. standingi*, appear to also have small distributions, but further fieldwork is required to confirm this. The other 10 species do not appear to be vulnerable to extinction because of their much larger distributions, and in some cases, broad tolerance to human modification of primary habitats.

In part, the IUCN Threatened List actually reflects a historical bias towards conserving turtles and boas in Madagascar, rather than actual risks to extinction. It is worth noting that 8 of the 15 Red List species are boas or turtles (53 percent), although this group represents just 2 percent of the island's actual endemic herpetofauna. Ironically, this conservation bias is actually hindering attempts to prevent herpetofaunal extinctions in Madagascar, by promoting some species for conservation activities that are not vulnerable and by ignoring many species that are about to be lost.

Rates of past, present, or future population decline (observed, estimated, inferred, or suspected) are used as IUCN criteria for all but one of the 15 threatened species. This surprises us, as we are unsure what types of evidence were used to support or estimate these rates of population decline. For the herpetofauna of Madagascar, we think that it would be far more effective to base vulnerability to extinction on biogeographic data, rather than estimated population declines. The advantage is that biogeographic data is available for most species, and these data can be compared between different taxa to determine conservation priorities. Of course, biogeographic data are never complete for any species, but it can be obtained with far less effort than undertaking population studies throughout a species distribution range.

Table 2 includes four biogeographic criteria that we consider to be the most important in determining vulnerability to extinction for amphibians and reptiles in Madagascar. Other population factors will also influence the risk of extinction (e.g., population density, generation time, reproductive output, predation, and human collecting), but since it is unlikely we will ever have detailed information of this type over the entire distributional range on any herpetofaunal species, we think the most objective data set available to us is biogeographic.

Table 2. Measuring extinction vulnerability with biogeographic criteria.

BIOGEOGRAPHIC CRITERIA	EXTINCTION RISK	
	HIGH	LOW
EXTENT OF OCCURANCE	Small	Large
NUMBER OF KNOWN SITES	Few	Many
DISTRIBUTION STRUCTURE	Fragmented	Continuous
HABITS	Specialist of a declining habitat	Specialist of a stable habitat

Provided that taxonomic biases are avoided, we believe that the analysis of biogeographic data has the potential to reveal a much more realistic picture of extinction threats to the amphibians and reptiles in Madagascar, compared to the criteria currently being employed. This will identify those species of greatest concern, which could then become the focus of conservation programs aimed at maintaining existing levels of biodiversity in Madagascar.

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New data on the distribution, status, and biology of the New Caledonian giant geckos (Squamata: Diplodactylidae: *Rhacodactylus* spp.)

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Abstract.—**Recent collections and observations of the New Caledonian giant geckos (*Rhacodactylus*) result in range extensions and new information regarding the biology of these lizards. Significant range extensions are reported for the rough-snouted giant gecko (*R. trachyrhynchus*) and for the recently rediscovered Guichenot's giant gecko (*R. ciliatus*). Field observations confirm the association of the knob-headed giant gecko (*R. auriculatus*) with plants of the family Cunoniaceae and that Leach's giant gecko (*R. leachianus*) feeds on fruit. Range extension of some species, and data on local abundance allows a reassessment of their conservation status. Despite implied increases in giant gecko density and range, significant threats from habitat loss, introduced predators, and illegal trade leave all species at risk.**

Key words. Rhacodactylus, *geckos, New Caledonia, distribution, diet, conservation status*

Introduction

Rhacodactylus is one of three carphodactyline[e] gecko genera occurring in New Caledonia. The genus includes the largest living species of gecko, *R. leachianus* (> 250 mm snout-vent length; Russell and Bauer 1986) and has attracted scientific attention because of unusual characteristics such as viviparity[f] (in *R. trachyrhynchus*; Bartmann and Minuth 1979), the possession of and specialized dentition (in *R. auriculatus*; Bauer and Russell 1990; Bauer and Sadlier 1994b), and prehensile tails (all species; Bauer 1990; Bauer and Russell 1994). Species of this genus have also attracted much popular attention, especially among terrarium keepers, because most species thrive and reproduce well in captivity (Henkel 1987, 1991, 1993; Henkel and Schmidt 1991; Tytle 1992).

The systematics and morphology of *Rhacodactylus* have recently been the focus of significant investigation (Bauer 1990; Bauer and Russell 1990; Bauer et al. 1993; Seipp and Klemmer 1994; Good et al. 1997). However, knowledge of the distribution and biology of these geckos remains largely incomplete (Bauer and Sadlier 1993). Aside from brief reports of various aspects of natural history (e.g., Mertens 1964; Meier 1979; Sameit 1985; Bauer 1990; Bauer and Vindum 1990; Henkel 1991), field-based data are limited to a few investigations of diet (Bauer and DeVaney 1987; Bauer and Sadlier 1994b) and general accounts of behavior and ecology in nontechnical works (de Vosjoli 1995; de Vosjoli and Fast 1995). However, increasing awareness of the uniqueness of the flora and terrestrial fauna of New Caledonia (Myers 1988; Mittermeier et al. 1996) has given new impetus to the collection of basic distributional and biological data for all members of the New Caledonian herpetofauna, and previously understudied areas are being surveyed more systematically (e.g., Isle of Pines, Bauer and Sadlier 1994a). Observations made by the authors during several recent expeditions to New Caledonia have yielded new distributional and/or dietary information for all six of the recognized species of *Rhacodactylus*. In addition, preliminary assessments of genetic variation within certain species (reported more fully in Good et al. 1997) were made on the basis of tissue samples accumulated over a series of trips since the mid-1980's. We present these data here as they help to provide a more accurate picture of the geographic ranges and biological requirements of the geckos and may be useful in establishing the conservation status of *Rhacodactylus* species.

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Materials and methods

Herpetological collections and observations were made on mainland New Caledonia during trips in 1994 and 1995. Specimens were collected under a series of permits issued by the conservation authorities of the Province Sud (Marcel Boulet) and Province Nord (Christian Papineau) of New Caledonia to the authors. Preliminary estimates of genetic divergence between populations were based on results derived from allozymic[g] data. Details of the electrophoretic methodology employed are presented in Good et al. 1997. Specimens cited are housed in the collections of the Australian Museum (Sydney)-AMS, the Natural History Museum (London)-BMNH, and the California Academy of Sciences (San Francisco)-CAS.

Results and discussion

Knob-headed giant gecko (*Rhacodactylus auriculatus*)

[Plate 1]. Böhme and Henkel (1985) reported a striped color phase of *R. auriculatus*, now known to be common. Although polymorphisms were noted within a single population of this species, there were no fixed differences among population samples from four different localities and no suggestion of significant intraspecific genetic variation. This tends to corroborate morphological observations that this species is generally polymorphic[h] throughout its range but that there are no geographically related trends in character variation (Bauer 1990).

Plate 1

Plate 2

Plate 3A

Plate 3B

Plate 4

Plate 5A

Plate 5B

Plate 6

Plate captions: **1.** Knob-headed giant gecko, *Rhacodactylus auriculatus*, from Rivière Bleue. **2**. Bavay's giant gecko *Rhacodactylus chahoua*. *Photo courtesy of R. D. Bartlett*. **3A**. Guichenot's giant gecko, *Rhacodactylus ciliatus*, from Rivière Bleue (adult with autotomized tail). **3B**. *Rhacodactylus ciliatus*, from Rivière Bleue (subadult with complete original tail and complex body patterning). **4**. Leach's giant gecko, *Rhacodactylus leachianus*, from Mt. Koghis. **5A**. Roux's giant gecko, *Rhacodactylus sarasinorum*, from Kwa Néie (adult retaining bold white dorsal markings). **5B**. *Rhacodactylus sarasinorum*, from Rivière Bleue (adult with mottled dorsal pattern). **6**. Rough-snouted giant gecko *Rhacodactylus trachyrhynchus*, from Mt. Aoupinié. *Photos 1, 3A and B, 4, 5A and B, and 6: Ross A. Sadlier.*

Plate 7. *Geissois* sp. from Mt. Do, southern New Caledonia. This plant is apparently utilized as a food source by *Rhacodactylus auriculatus*.

Bavay (1869) first reported on the diet of this species, indicating that it eats the flowers of *Geissois* (Cunoniaceae). This was verified by the recovery of anthers, stamens, and (possibly) pollen belonging to either a member of this family (or the Myrtaceae) from the stomach of one specimen (Bauer and Sadlier 1994b). On 9 January 1995 further evidence of the specific association between *R. auriculatus* and *Geissois* was obtained when geckos were found active on flowering specimens of *Geissois* spp. (Plate 7) 1.3-2.6 km from the summit of Mount (Mt.) Do (21°45' S, 166°00' E) in south central New Caledonia.

Bavay's giant gecko (*Rhacodactylus chahoua*) [Plate 2]. The known distribution of this species in central and southern mainland New Caledonia has been expanded by the capture of a specimen from Sarraméa (AMS R144171) and by specimens from unstated localities on the Isle of Pines (de Vosjoli 1995; de Vosjoli and Fast 1995) [Fig. 1]. This species is rather polymorphic with respect to coloration (Bavay 1869; Böhme and Henkel 1985; Bauer 1985), but the comparison of allozymes from individuals separated by more than 100 km suggests relative genetic uniformity.

Guichenot's giant gecko (*Rhacodactylus ciliatus*) [Plate 3A and 3B]. This species was numerous for the first 20 years after its description (e.g., Bavay 1869) and then was not seen again for over 100 years, despite extensive searches by several researchers. It was regarded as extinct (see Bauer and Sadlier 1993). In 1994, the species was rediscovered and has since been found at a variety of localities on the Isle of Pines (Seipp and Klemmer 1994; Kullmann 1995) and several smaller offshore islands (de Vosjoli 1995). De Vosjoli (1995) and de Vosjoli and Fast (1995) recorded this species as common on the Isle of Pines but stated that it was not present on the mainland of New Caledonia. Despite their claims, Bavay (1869), whose data have proved to be very accurate (see Bauer and Sadlier 1994b), reported collecting seven specimens of this species at several (unspecified) localities on the mainland, and the type locality given by Guichenot (1866) was at Canala (21°35' S, 165°56' E), also on the mainland. The persistence of this species on the mainland was verified by two specimens (AMS 146594-5) collected by R. A. Sadlier near Pont German, Rivière Bleue (22°06' S, 166°38' E) in the extreme south of New Caledonia (Fig. 1). It has subsequently been taken at other localities on the mainland (Girard and Heuclin 1998; Bauer and Sadlier 2000), suggesting that it may be relatively widespread.

Leach's giant gecko (*Rhacodactylus leachianus*) [Plate 4]. This species has a broad distribution in the wetter areas of the New Caledonian mainland, especially along the east coast (Bauer 1990). Boulenger (1885) first recorded the species from the Isle of Pines (BMNH 53.8.16.13). Bauer and Sadlier (1994a) confirmed the presence of this species on the island with a 194 mm female (CAS 182197). Subsequently, the species has been recorded as fairly common on the Isle of Pines and nearby offshore islands (de Vosjoli 1995; de Vosjoli and Fast 1995). Although most known mainland New Caledonian localities are in low- to middle-elevation forests (Bauer 1990), specimens have been recorded from up to 1100 m (Mertens 1964). Sight observations in January 1995 at 540 m on Mt. Mandjélia (20°24'15" S, 164°31'18" E) extend the confirmed distribution of the species to the northwest, almost to the limit of the humid forest on the main island of New Caledonia.

The Isle of Pines population has recently been described by Seipp and Obst (1994) as a distinctive subspecies, *Rhacodactylus leachianus henkeli*. The validity of this form is challenged on the basis of morphological and allozyme characters by Good et al. 1997. They found the *henkeli* color pattern to occur among geckos in at least two regions of the New Caledonian mainland and regarded behavioral differences as attributable to reduced predation pressure on the insular form. Because genetic distance data[i] indicated no long separation of Isle of Pines *R. leachianus* from mainland populations Good et al. 1997 regarded the split of the insular population to be very recent. Indeed sea level minima of 100 m or more would have connected New Caledonia to the Isle of Pines as recently as 16,000-20,000 years ago (Stevens 1973; Holloway 1979).

Although the diet in captivity of *Rhacodactylus leachianus* has been well documented (Mertens 1964; Bauer and DeVaney 1987; Henkel and Schmidt 1991), and a few stomach contents have been reported (Roux 1913), the natural diet remains poorly documented. At Mt. Aoupinié, in January 1995, we observed individuals feeding on fruit in humid forest trees. Examination of feces of freshly captured individuals revealed only fig seeds and partially digested fig fruit. It appears likely that this, and perhaps other *Rhacodactylus* species, take advantage of seasonal and local availability of figs and may play a role in seed dispersal.

Roux's giant gecko (*Rhacodactylus sarasinorum*) [Plate 5A and 5B]. Bauer (1990) figured the type of *R. sarasinorum*

NEW CALEDONIA

New Caledonia is a French overseas territory, consisting of the large island of New Caledonia and the Loyalty Islands. Its location is approximately 1,200 km east of Australia (Geographic Coordinates 21°30' S, 165°30' E) in the South Pacific Ocean. These islands have an extraordinary diversity of fauna and flora with an extreme level of endemism in many taxa including birds and reptiles. Naturally occurring plant species number 3,380 (vascular plants), birds 116, mammals 9, and reptiles 87 (71 terrestrial and 16 marine). No naturally occurring amphibian species exist on New Caledonia though a nonnative species has been introduced from Australia (green and golden bell frog *Litoria aurea*). Total area is 19,060 square (sq) km (land 18,575 sq km and water 485 sq km) comparatively, slightly smaller than New Jersey. The terrain is west coastal plains with interior mountains (highest point Mont Panie 1,628 m) making up two-thirds of the island. The climate is subtropical (warm and humid) modified by southeast trade winds. There is little temperature change throughout the year, averaging between 71°F and 75°F (22°C and 24°C). The natural vegetation comprises tropical evergreen rain forest up to 1,000 m and tropical montane rain forest above 1,000 m. Mangroves occur along western coasts. The major vegetation types are dense evergreen forest (22.8% of total land area), Niaouli savanna woodland (13.8%), maquis vegetation in mining areas (25.1%), savanna grassland (21.7%), and scrub (8.3%). New Caledonia's human population numbers 191,003 (July 1997 estimate) with a 1.68% (1997 estimate) annual growth rate. New Caledonia's moderately developed economy is based on mining and has more than 20% of the world's known nickel resources as well as other natural resources as chrome, iron, cobalt, manganese, silver, gold, lead, and copper (thus mining is an important environmental issue). Only a negligible amount of the land is suitable for cultivation and food accounts for about 25% of imports. In addition to nickel, financial support from France and tourism are key to the health of the economy. The principal threats to the natural flora and fauna are mining, logging, and bushfires, reducing the forest cover from an estimated 90% cover to just 20%.[1]

and noted variation in color pattern and body proportions in this species but did not elaborate. At least two color morphs have been illustrated and described by Henkel (Böhme and Henkel 1985; Henkel 1987, 1988), but there has been no suggestion of subspecific or specific distinction between these forms. Bauer's (1990) and Bauer and Vindum's (1990) concept of *R. sarasinorum* was based in part on typical specimens and in part on an individual from Touaourou that is larger, darker, and differs from other specimens in a number of scale counts. Allozyme analysis (Good et al. 1997) revealed that this specimen differed from a typical *R. sarasinorum* from Rivière Bleue (AMS R 146596) by four fixed differences. This is a greater genetic difference than that between *R. ciliatus* and *R. chahoua*. Both allozyme and morphological data thus suggest significant variation and are being analyzed separately, which may result in the recognition of a new *Rhacodactylus sarasinorum*-like species.

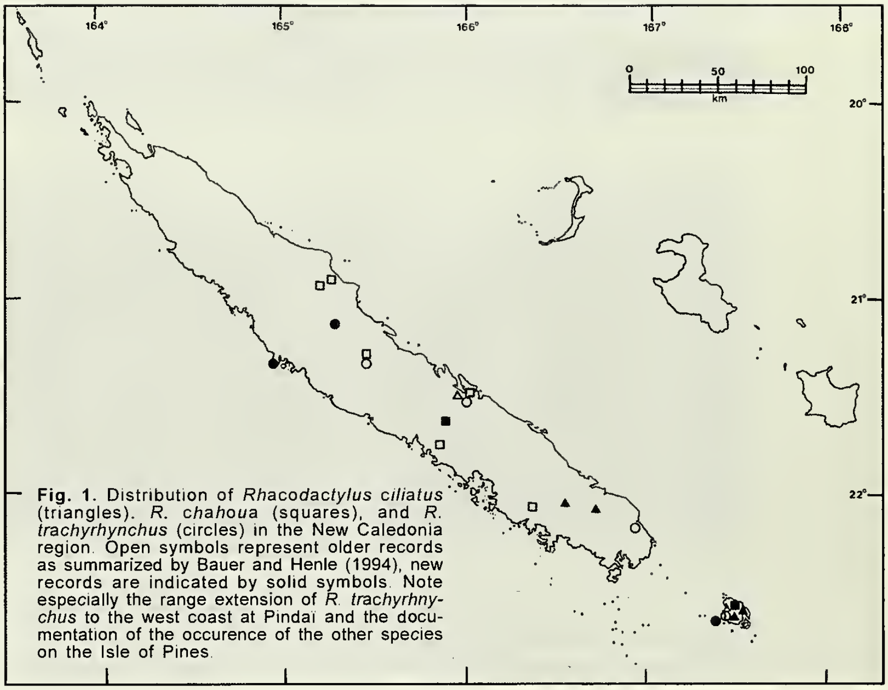

Fig. 1. Distribution of *Rhacodactylus ciliatus* (triangles). *R. chahoua* (squares), and *R. trachyrhynchus* (circles) in the New Caledonia region. Open symbols represent older records as summarized by Bauer and Henle (1994), new records are indicated by solid symbols. Note especially the range extension of *R. trachyrhynchus* to the west coast at Pindaï and the documentation of the occurence of the other species on the Isle of Pines.

Rough-snouted giant gecko (*Rhacodactylus trachyrhynchus*) [Plate 6]. Bauer (1990) recorded five mainland New Caledonian localities for *R. trachyrhynchus*. Several of these, Coula-Borearé, Ciu, and Mt. Gouemba are in the eastern humid forest region of the island. The other two localities, La Foa and near Nouméa are imprecise but probably are also humid forest localities. All localities are at middle to low elevation. As briefly noted by Bauer (1995), recent censuses have expanded the known range of the species, both elevationally and geographically (Fig. 1). Five specimens (AMS R146417-9, CAS 200266-8) were found during rainstorms in humid forest (Fig. 2A) at approximately 520 m on Mt. Aoupinié in Central New Caledonia (21°09'19" S, 165°19'12" E), 27 km north and west of the previously documented range of the species. A single specimen, CAS 200269, was obtained in sclerophyll forest[l] at Pindaï (21°20'02" S, 164°58'21" E) at approximately 20 m elevation (Fig. 2B). This locality is also somewhat further north than earlier records, but it is unique in that it is a west coastal locality in an area of low rainfall. The local vegetation is dominated by largely endemic dry forest plants and is regarded as the most threatened terrestrial habitat in New Caledonia (Jafrré et al. 1993; Bouchet et al. 1995). The only other reptiles collected sympatrically with *R. trachyrhynchus* at Pindaï were Vieillard's prehensile-tailed gecko (*Eurydactylodes vieillardi*), Günther's New Caledonian gecko (*Bavayia cyclura*), sclerophyll forest gecko (*Bavayia exsuccida*), festive New Caledonian skink (*Caledoniscincus festivus*), New Caledonian skink (*Caledoniscincus austrocaledonicus*), and a new species of elf skink (*Nannoscincus* sp.). All previous records of *Rhacodactylus* spp. from the New Caledonian mainland have originated from the wetter eastern portions of the island, or from rainforest or maquis vegetation[k] in the south (Bauer 1990; Henkel 1991, 1993; Bauer and Henle 1994). The occurrence of *R. trachyrhynchus* at this site is thus intriguing and suggests a much broader habitat tolerance range than previously suspected for this species. Although normally associated with large, mature rainforest trees (Meier 1979), at Pindaï, this gecko was collected less than five meters from the ground in the branches of a small tree. A very low genetic distance from this specimen to specimens from Mt. Gouemba and Mt. Aoupinié (Good et al. 1997) suggests no significant differentiation in the dry forest population, and the specimen is typical for the species in regard to morphology. Henkel (1991) suggested that there are two morphs in the species, one with a short, wide, robust snout, the other less so, but because these features were noted in captive born specimens of uncertain locality he did not imply any subspecific distinction. Our data, from three widely scattered localities, do not support the recognition of any specific or subspecific subdivisions within *R. trachyrhynchus*.

Fig. 2. Habitat of *Rhacodactylus trachyrhynchus*.

A. Overview of humid forest habitat at middle elevation on Mt. Aoupinié.

B. Sclerophyll forest habitat at Pindaï on the west central coast of New Caledonia.

The presence of this species on the Isle of Pines remains problematic. Boulenger (1878) recorded the species (as *Chamaeleonurus trachycephalus*) from this locality. Subsequent collecting activity on this island, however (Bauer and Sadlier 1994a; de Vosjoli 1995) has not verified this occurrence. The unexpected findings of this and other *Rhacodactylus* after many years of extensive and intensive searching, however, argue against dismissal of this early record. Bauer and Sadlier (1994a) identified appropriate habitat for the species on the island.

Conclusions

The new dietary observations confirm earlier reports of herbivory by *Rhacodactylus* species. It is especially noteworthy that *R. auriculatus* was found active on flowering heads of plants of the same genus on which Bavay observed them over 130 years ago. The significance of reptiles as seed dispersers and as possible pollinators was recognized by Borzi (1911) but remains largely unexplored. Its recent documentation for the closely related carphodactyline geckos of New Zealand (Whitaker 1987) suggests that at least some species of giant geckos are important in this regard. The importance of plant material in the diets of *Rhacodactylus* sp. and the significance of geckos as dispersers of pollen or seeds, however, can only be adequately addressed by a seasonal dietary study at a single site.

Bauer and Sadlier (1993) reviewed the conservation status of all New Caledonian lizards on the basis of data then available. They summarized both the extent of the geographic range of the species and their apparent abundance within the appropriate habitat types. The data reported on here necessitate a re-evaluation of that status report. *Rhacodactylus ciliatus*, previously considered possibly extinct, is now known to be common on islands of the south coast of New Caledonia and present, if somewhat less common, on the mainland. Using the terminology of Bauer and Sadlier (1993), its distribution is now regarded as restricted and its status as locally common. With the extension of its known range to the north and to the west coast sclerophyll forest, the distribution of *Rhacodactylus trachyrhynchus* can now be upgraded from restricted to moderately widespread and its status to locally common. The presence of this species, as well as a regionally endemic *Bavayia* (*B. exsuccida*) and a new, apparently endemic, *Nannoscincus* in the sclerophyll forest in west coastal New Caldeonia (Bauer et al. 1998) adds impetus to efforts to protect the small remaining tracts of this habitat. *Rhacodactylus leachianus* was previously regarded as widespread and uncommon. The extension of the east coast range to the limit of humid forest underscores the fact that this is the most widely distributed of all *Rhacodactylus* species and observations of individuals under ideal weather conditions (warm and wet) suggest that the species may best be categorized as common in appropriate habitats. The status of the remaining species is unchanged by the new records.

Although at least several species of *Rhacodactylus* do appear to be locally abundant, even the most widely ranging species is endemic to the New Caledonian mainland and adjacent satellite islands, an area about the size of Connecticut. Further, no species is known to be present in all native habitat types and all are excluded from agricultural or urban environments (although they may be present at the periphery of human-modified areas). Habitat destruction and the impact of introduced predators were cited as the primary threats to the herpetofauna of New Caledonia by Bauer and Sadlier in 1993. These factors remain the most significant conservation concerns, but the illegal pet trade in *Rhacodactylus* has increased significantly in the 1990's and has become a potential threat to wild populations.

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Footnote

[1]*The research sources used in writing the country sidebar an page 10 (Madagascar), of this valume, and footnoted on page 14 (faatnate [2]), were also used in writing the New Caledania summary.*

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Amphibian and Reptile Conservation 2(1):30-31.

Column

The United States role in the international live reptile trade

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***Abstract.*—In the 1990's, the trade in live reptiles has grown substantially, and the United States (U.S.) is the world's most significant player in the international trade in live reptiles, both as an importer of exotic species, and as an exporter of native and exotic species. In 1995, more than 2.5 million reptiles were imported into the U.S., primarily to supply the pet trade. In 1996, over 9.5 million reptiles were exported or reexported from the U.S., primarily to Europe and Asia, to supply the demand for reptiles as pets and food. Despite the large and apparently growing number of reptiles and amphibians in trade, we have yet to quantify the impacts of this trade on the conservation of these species in the wild.**

Key words. *Herpetofauna, import, export, reexport, live reptile, international trade*

By way of introduction, I would like to give you some background information about myself, TRAFFIC, and this new column in *Amphibian and Reptile Conservation* titled, *Herpetofauna and Humanity*. Presently, I am a Senior Program Officer for TRAFFIC North America. As a Senior Program Officer, I am responsible for the development and oversight of wildlife trade studies and the implementation of their findings and recommendations. TRAFFIC North America is a part of the worldwide TRAFFIC Network, a program of World Wildlife Fund (WWF) and The World Conservation Union (IUCN). TRAFFIC is the world's largest wildlife trade monitoring program with 21 offices covering most regions of the globe. TRAFFIC produces reports and papers documenting the findings of its studies and recommending measures necessary to help ensure that the trade in wildlife and wildlife products are conducted in a sustainable and legal manner. This work is done by collecting trade data via government agencies such as the United States Fish and Wildlife Service (USFWS), customs agencies, and international bodies, carrying out market surveys, conducting literature reviews and website searches, and other means. In the three years that I have been with TRAFFIC, much of my time has been devoted to investigating various aspects of reptile and amphibian trade.

Prior to coming to TRAFFIC North America, I was a wildlife inspector for the USFWS in Los Angeles, where for over four years I was able to see firsthand the scope of the trade in reptiles and amphibians. Equally important, I gained valuable knowledge of the laws that govern the trade, and the means by which these laws are implemented and enforced in the United States (U.S.).

Ball python (*Python regius*). *Photo: World Wildlife Fund.*

This background, along with an education in natural resources and law, will influence the areas to be covered in this column. Among the subjects I intend to tackle in this space are reptile and amphibian trade and its implications for conservation; the use of reptiles and amphibians as clothing, food and medicine; the enactment, implementation and effectiveness of wildlife trade laws; illegal trade and the threat posed to reptiles and amphibians in the wild; captive breeding and the private breeder's role in conservation; and the current events that shape the relationship between herpetofauna and humankind. As an introduction to this new column, *Herpetofauna and Humanity*, it would be useful to provide an overview of the U.S. role in the international live reptile trade. The following information summarizes a report released by TRAFFIC in August, 1998, entitled *The U.S. Role in the International Live Reptile Trade: Amazon tree boas to Zululand dwarf chameleons* (Hoover 1998).

The international trade in live reptiles has grown dramatically in the last decade. The import, export, and reexport of live reptiles supplies a number of markets, including zoos and aquariums, breeding facilities, research centers, private breeders and keepers, and even food markets in some segments of society. By far the most significant market for the live reptile trade is the pet market (private breeders and keepers of amphibians and reptiles).

The causes of the substantial rise in the international trade in live reptiles are difficult to quantify but may include an increase in the availability and variety of species; improved reptile husbandry practices due to advances in technology and scientific knowledge; increased restrictions on other wildlife trade; changing lifestyles that make reptiles more suitable pets than other fauna; or simply an increased popularity that has made reptiles today's fashionable pets. Whatever the reason, and there may be some truth to all of these explanations, there can be no denying that the live reptile industry has expanded dramatically.

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In 1970, prior to the passage of laws such as the U.S. Endangered Species Act and adoption of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), U.S. imports of live reptiles approached 2 million animals. Nearly 80 percent of this import volume consisted of turtles, primarily red-eared slider turtles (*Trachemys scripta elegans*), with 12 percent lizards, 6.5 percent crocodilians, and less than 2 percent snakes (Busack 1974).

Based on analysis of USFWS trade data for a number of reptile species, it is clear that the trade subsequently declined significantly and remained relatively low throughout the 1980s. However, imports increased again in the early 1990s, and in 1995 more than 2.5 million live reptiles were imported to the U.S. Yet the content of this trade differed significantly from the reptiles imported in 1970. By far the most commonly imported species was the green iguana (*Iguana iguana*), which made up more than 45 percent of the total trade in 1995, and only 8 percent of imports in 1970. Snakes and lizards played a far more significant role in current import levels than they did in 1970, with 1995 turtle volumes greatly reduced and crocodilian imports virtually nonexistent. In fact, the dramatic increase in the total number of live reptiles imported is primarily due to fluctuations in the number of iguanas imported.

However, the U.S. is not only a consumer in the international live reptile trade, but also a significant supplier. In fact, the U.S. presently exports or reexports more live reptiles than it imports, due largely to the export of farm-raised hatchling red-eared slider turtles, a species even more influential on overall trade volumes than the iguana. For example, in 1996, the U.S. exported or reexported over 9.5 million reptiles, primarily to Europe, East and Southeast Asia, yet over 88 percent of this trade consisted of the red-eared slider, at a volume of nearly 8.4 million animals.

Setting aside the voluminous trade in red-eared sliders, there are more than one million reptiles of other species that are exported or reexported from the U.S. The North American taxa nearest to the red-eared slider in export volume are the map turtles (*Graptemys* spp.). According to USFWS data, map turtle exports have risen from less than 10,000 in 1990 to over 80,000 in both 1995 and 1996. Based on map turtle export data, just two of the twelve map turtle species make up 90 to 95 percent of the export trade: the common map turtle (*G. geographica*) and the false map turtle (*G pseudogeographica*) [Ventura 1997; data provided by Weissgold 1997].

The U.S. also plays a substantial and apparently expanding role as an exporter of previously imported reptiles. For example, the U.S. reexported less than 60,000 iguanas in 1993 and more than 270,000 imported iguanas in 1996. This role as a supplier of previously imported reptiles is influenced by a number of factors. Perhaps foremost is geography; for instance, U.S. dealers are well positioned to supply Asia and Europe with Latin American reptiles. Another significant factor may be that U.S. dealers have long-established connections with overseas suppliers that may provide a competitive advantage as new markets arise. For example, most of the live reptile trade in Canada, where the trade in reptiles is less established, appears to be supplied by U.S. traders (Chatel 1998).

U.S. trade in live reptiles also appears to make up a substantial portion of the world trade in live reptiles. A comparison of trade data for certain CITES-listed species indicates that U.S. trade constituted approximately 28 percent of the total world trade in 1983, but constituted more than 82 percent of the world trade by 1992. However, these numbers may be artificially high given the failure of many countries to accurately report such trade.

There appears to have been an increase in illegal as well as legal trade. Based on a review of press releases, wildlife trade journals, and other sources, from 1970 to 1990 there were only 11 reported investigations of international live reptile smuggling, while from 1991 to 1997 there were at least 23 such cases reported. However, there are a number of alternative explanations to these results, including increased enforcement effort and better reporting of prosecutions.

Of course, all of this information on the growth in the reptile trade raises the all-important "so what" question. The overview study that TRAFFIC conducted was not meant to answer that question, but to identify areas that needed further examination so that, in some respects, the "so what" question could be addressed. That, in large part, will be the role of this column as well. In future issues, we will look at several "so what" questions, such as:

What impact does the pet trade have on wild populations of reptiles and amphibians?

What is being done to monitor and protect native species found in trade?

What other forms of reptile and amphibian trade may be threatening species around the world, such as the skin, food, and medicine trades?

What is the impact of commercial captive breeding, farming, and ranching operations for iguanas, turtles, ball pythons, and other species on wild populations of reptiles and amphibians?

What is the threat posed by exotic species introductions that can occur with international trade, such as the red-eared slider turtle in Europe?

What is being done to more effectively enforce existing laws and regulations to ensure that trade is not detrimentally affecting wild reptiles and amphibians?

The U.S. is clearly the world's largest consumer of live reptiles for the pet trade, as well as a significant supplier and intermediary. Yet, this is only one piece of the puzzle. The growth in popularity of reptiles and amphibians as pets, along with the continued enormous demand for these species for skins, meat, and medicine, present us with a broad array of subjects for discussion and debate. In coming issues, we will explore these fascinating topics in an effort to gain a better understanding of the dynamic and complex relationship between herpetofauna and humanity.

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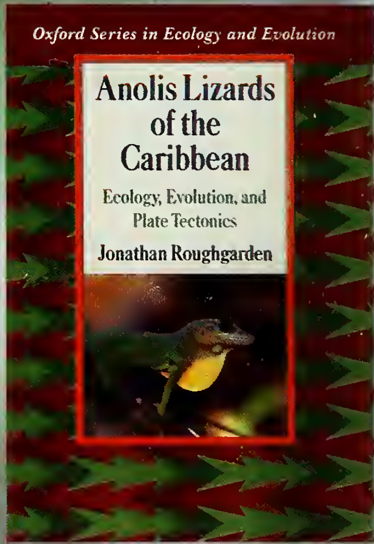
Weissgold, B. 1997 (May). Personal communication to Craig Hoover, TRAFFIC USA, Washington, D.C.

The background screen photo: red-eared slider turtles (*Trachemys scripta elegans*). *Photo: Wil Luijf.*

Book Reviews



Lizards in the stream

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Roughgarden, Jonathan. 1995. *Anolis Lizards of the Caribbean: ecology, evolution, and plate tectonics.* Oxford University Press, New York. 200 p. + xvi. (ISBN: 0-19-506731-2).

Key words. *Lizards,* Anolis, *Caribbean, ecology, evolution, plate tectonics, islands, history, foraging, coexistence, communities*

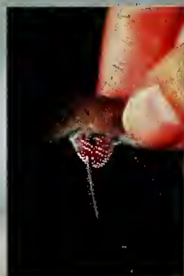
Ecologists most often study phenomena that occur within the lifetime of the observer. These phenomena are caused, however, by processes that span a huge range of scales, from the second by second behavior of individual animals to the processes of plate tectonics that span millions of years. How one goes about untangling such processes is a difficult problem for ecologists, but one, as Roughgarden shows, that is not unsurmountable. This monograph is a compilation of many years of study by Roughgarden and colleagues of the lizards in the genus *Anolis* that live in the Caribbean region.

Roughgarden begins by considering how an organism such as a lizard, with its ability to make decisions regarding its choice of prey items, can maximize its rate of energy intake when constrained by food abundances, body mass, and other important aspects of lizard biology. The ability of lizards to forage profitably is related to their fitness, which in turn, can be related to the presence of other species of lizards that use similar resources. Using empirically based estimates of foraging rates Roughgarden shows that it is not unreasonable to assume that much of lizard diversity, especially on small islands, is a consequence of constraints on foraging of different-sized species as they interact together. Roughgarden sketches out a reasonable picture of how these interactions vary spatially from one island to the next, and how one might begin to make predictions of which species should be found together on which islands. Covering the literature on pairs of lizard species found together in different combinations on different islands, Roughgarden builds a convincing case that resource-based competition between different species is likely to explain many aspects of *Anolis* ecology in the Caribbean.

Norops tropidonotus (male), Las Cuevas, Cayo District, Belize (*April 1998*). *Photo by Peter Stofford, courtesy of The Notural History Museum, London.*

But there is much more to the story, as Roughgarden goes on to show in later chapters. Lizards evolve at relatively slow rates, and Roughgarden shows how certain aspects of the history of the Caribbean basin can be traced by examining the relationships among different species of lizards within the Caribbean dwelling species. Many aspects of the distribution of *Anolis* species among islands cannot be explained by rare colonization events, but must be a consequence of the geological history of different islands. So on a longer time scale and larger spatial scale, patterns of distribution and ecology of these species reflect geological history, and these patterns are superimposed on the more local patterns of coexistence of species determined by their immediate ecology.

Thus, a fascinating story of history and ecology interacting emerges from Roughgarden's narrative that shows just how complex ecological systems like lizard communities can get. The underlying message of the monograph is that it is indeed possible to untangle many aspects of this complexity by taking a rigorous and multi-scaled approach to the patterns observed in nature. Although Roughgarden describes the results of several field experiments that help elucidate certain aspects of *Anolis* ecology, the real meat of the story lies in weaving together evidence from a wide variety of studies. So ecology without history is incomplete, while history without ecology is inexplicable. Melding together the two, however, yields deep insights in to the nature of species assemblages that cannot be had from investigations of limited scope. Herpetologists and ecologists alike have much to gain from examining Roughgarden's broad, sweeping approach.



Norops uniformis (male), Cuxta Bani, upper Raspaculo, Cayo District, Belize (*April 1997*). *Photo by Peter Stofford, courtesy of The Noturol History Museum, London.*

Further suggested readings:

Crother, Brian I. (editor). 1999. *Caribbean Amphibians and Reptiles*. Academic Press, San Diego, California. 495 p. (ISBN: 0-12-197955-5).

Powell, R. and Henderson, Robert W. (editors). 1996. *Contributions to West Indian Herpetology: a tribute to Albert Schwartz. contributions to herpetology, volume 12.* Society for the Study of Amphibians and Reptiles, Ithaca, New York. 457 p. (ISBN: 0-916984-37-0).

Rivero, Juan A. 1976. Los Anfibios y Reptiles de Puerto Rico. University of Puerto Rico Press. (ISBN: 0-8477-2317-8).

Schettino, Lourdes Rodriguez. (editor). 1999. *The Iguanid Lizards of Cuba*. University Press of Florida, Gainesville, Florida. 384 p. (ISBN: 0-8130-1647-9). Availability: see inside cover ad.

Schwartz, Albert and Henderson, Robert W. 1991. *Amphibians and Reptiles of the West Indies: descriptions, distributions, and natural history.* University Press of Florida, Gainesville, Florida. 736 p. (ISBN: 0-8130-1049-7). Availability: see inside cover ad.

Background screen photograph: *Anolis eremanni* (male), Ciales, Puerto Rico (24-August-1999). *Photo courtesy of Father Alejandro J. Sanchez Munoz, Pastor of Saint Anne's Parish, Saint Thomas, U.S. Virgin Islands.*

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Amphibian and Reptile Conservation 2(1):33-34.

News and Notes

WORLD NEWS

Amphibian declines: unraveling the mystery. The apparent mysterious declines of amphibian populations in protected or relatively undisturbed areas was discussed recently by university scientists, government biologists, federal administrators and representatives from non-government organizations at a workshop organized by Dr. James Collins, Dr. Elizabeth Davidson, and Dr. Andrew Storfer from Arizona State University and sponsored by the National Science Foundation in Arlington, Virginia on May 28-29, 1998. On Thursday morning, May 28, strong evidence for declines of amphibian populations in different geographic locations around the world was presented. The group consensus was that there is a global amphibian decline problem, but there is no single cause. Rather, multiple factors are implicated, including: habitat loss and alteration, global change, pathogens, parasites, toxic chemicals, ultraviolet radiation, and invasive species. The potential effects of four of these factors; UV, toxic chemicals, pathogens, and global change, were discussed in detail on Thursday afternoon. On Friday, participants outlined a research and management plan and passed a resolution (below) that summarizes the plan. Follow-up workshops on specific topics were outlined, and the National Science Foundation has already funded a workshop on disease in amphibians in late July 1998.

Resolution: declining amphibian populations. Whereas, there is compelling evidence that, over the last 15 years, there have been unusual and substantial declines in abundance and numbers of populations of various species of amphibians in globally distributed geographic regions, and Whereas, many of the declines are in protected areas or other places not affected by obvious degradation of habitats, and Whereas, these factors are symptomatic of a general decline in environmental quality, and Whereas, even where amphibian populations persist, there are factors that may place them at risk, and Whereas, some patterns of amphibian population decline appear to be linked by causative factors, and Whereas, declines can occur on multiple scales, in different phases of amphibian life cycles, and can impact species with differing ecology and behavior, and Whereas, there is no obvious single common cause of these declines, and Whereas, amphibian declines, including species extinctions can be caused by multiple environmental factors, including habitat loss and alteration, global change, pathogens, parasites, various chemicals, ultraviolet radiation, invasive species, and stochastic events, and Whereas, these factors may act alone, sequentially, or synergistically to impact amphibian populations, and Whereas, to understand, mitigate and preempt the impacts of these factors, a comprehensive, interdisciplinary research program must be undertaken, and Whereas, this research program must be conducted in several regions around the globe, both in areas of known declines, and in areas where declines have not been documented, and Whereas, this research must examine issues ranging from environmental quality of landscapes to the condition of individual animals. Now therefore be it resolved, the signatories hereto call for the establishment of an interdisciplinary and collaborative research program, which will specify and quantify the direct and indirect factors affecting amphibian population dynamics, and Be it further resolved, that this program will include basic research and monitoring that will test hypotheses of causative factors and examine patterns of change through historical records, field-based correlative data, and controlled, multi-factorial experiments, and Be it further resolved, that interdisciplinary, incident response teams should be assembled in "hot spots" of amphibian decline to identify causative factors to facilitate the mitigation of these sudden declines, and Be it further resolved, that the signatories hereto call upon both public and private agencies and institutions, to promote and support research, policies and conservation measures that will ameliorate losses and declines of amphibian populations, and Be it further resolved, that this broad-based approach to the study of amphibian population dynamics will serve as a model for study of the global biodiversity crisis. *Submitted by Andrew Storfer, Department of Biology, Arizona State University, Tempe, Arizona 85287-1501, USA. Tel: (602) 965-5857; fax: (602) 965-2519; email: astorfer@asu.edu*

ANNOUNCEMENTS

NARCAM. Since 1995, reports of malformed amphibians have increased in number, and public concern for the health of our environment has grown. The North American Reporting Center for Amphibian Malformations (NARCAM) was established as a central repository for information on this phenomenon. With the help of the public and scientists, NARCAM strives to convey an accurate account of the frequency and distribution of malformed amphibians. NARCAM is maintained by the Northern Prairie Wildlife Research Center in Jamestown, North Dakota, a facility of the United States Geological Survey, Biological Resources Division. The United States Environmental Protection Agency provides additional support. NARCAM's worldwide website contains maps on the geographic distribution of reports in North America, along with a description of the type of malformation present at each site. The site also has photos of the different types of malformations that may be encountered. For help in identification of species, NARCAM has a growing online guide to the amphibians of the United States and Canada that most frequently are reported with malformations. The public and researchers can submit information directly through the Web site (http://www.npwrc.usgs.gov/narcam) by using an online data reporting form. Individuals who do not have Web access can phone in reports toll-free at 1 (800) 238-9801. The public is urged to report sightings of malformed amphibians. If appropriate, a local biologist will visit the site to confirm the species identity and collect additional information. *Submitted by Jeff A. Jundt, Coordinator, North American Reporting Center for Amphibian Malformations, Northern Prairie Wildlife Research Center, United States Geological Service (USGS)/ Biological Resources Division, 8711 37th Street Southeast, Jamestown, North Dakota 58401, USA. Tel: (701) 253-*

5580; fax: (701) 253-5553; email: Jeffrey_Jundt@usgs.gov

MEETINGS

Society for the Study of Amphibians and Reptiles and the Herpetologists' League Annual Joint Meeting, 27-31 July 2000, Indiana University Purdue University at Indianapolis, Indianapolis, Indiana. Two symposiums: amphibian population declines (organized by David M. Green and Karen Lips) and a one-day symposium on herpetological research in zoos: the academic connection. *For further information contact Henry R. Mushinsky, Department of Biology, University of South Florida, Tampa, Florida 33620. Tel: (813) 974-5218; email: MUSHINSK@ CHUMA1.CAS. USF.EDU*

21st Annual Symposium on Sea Turtle Biology and Conservation Philadelphia, USA February 24-28, 2001. For more information reference: http://www. seaturtle.org/symposium/2001

WEBSITES

AmphibiaWeb
elib.cs.berkeley.edu/aw
Center for North American Amphibians and Reptiles
Eagle.cc.ukans.edu/~cnaar/CNAARHomePage.html
Conservation Breeding Specialist Group
www.cbsg.org
International Zoo News
www.quantum-conservation.org/IZN/294/IZN-294.html
Kansas Herpetological Society
eagle.cc.ukans.edu/~cnaar/khs/khsmain.html
Online Herpetologists Directory
www.smoky-hills.com/directory/search.asp
Species Survival Commission
www.iucn.org/themes/SSC
World Conservation Monitoring Centre
www.wcmc.org.uk
World Zoo Organization
www.wzo.org

NEW LITERATURE

Journal—*Advances in Amphibian Research in the Former Soviet Union* (AARFSU) [ISSN: 1310-8840]. Volume 1, Kuzmin, S. L. and Dodd, Jr., C. K. (editors). [ISBN: 954-642-017-4], vi + 233 p. (9 color photos). Volume 2 (ISBN: 954-642-019-0), vi + 189 p., 11 color photos. Format 165 x 235 mm, paperback, color photos, numerous black and white graphs, photos, drawings, figures, maps, and tables. Text in English. US$34. Kuzmin, S. L. and Wilkinson, J. 1998. Volume 3 (ISBN: 954-642-046-8), 165 x 245 mm, graphs, maps, black and white drawings, and ~ 60 color photographs. Text in English, 245 p. US$34. Tarkhnishvili, D. N. and Gokhelashvili, R. K. 1999. Volume 4, *The Amphibians of the Caucasus* (ISBN: 954-642-047-6). Format 165 x 235, graphs, color and black and white drawings, photos, tables, and bibliography. Text in English. 240 p. US$34. Discounts are possible for ordering all three volumes and subscribing to future issues. *Inquiries and ordering information can be obtained from PENSOFT Publishers (Sofia and Moscow-based scientific publishers and booksellers), Dr. Lyubomir D. Penev, Akad. G. Bonchev Street, Block 6, 1113 Sofia, Bulgaria. Tel: +359-2-716451; fax: +359-2-704508; email: pensoft@mbox.infotel.bg; website: www.pensoft.net*

Electronic Journal—*Contemporary Herpetology* (CH). CH is a peer-reviewed electronic journal devoted to herpetology on-line at URL: http://vmsweb.selu.edu/~pcsd4805. CH plans to publish articles covering all aspects of herpetology, including ecology, ethnology, systematics, conservation biology, and physiology. CH also plans to publish monographs, points-of-view, and faunistic surveys of poorly known areas but will not publish herpetocultural or anecdotal papers. *For more information contact the editor, Joe Slowinski, at tel:(415) 750-7041 (or) by email: jslowins@cas. calacademy.org*

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The Last Page

GLOSSARY

Definitions of words footnoted in journal articles.

P. 6-14 [a]*autoecological.*—Is the study of the relationship of individual organisms to their environment.

[b]*xeric.*—"Dry," of or pertaining to a habitat having a low or inadequate supply of moisture.

[c]*sisal.*—A species of agave grown for commercial production of fiber.

P. 15-23 [d]*aestivation.*—A state of inactivity occurring in some animals during prolonged periods of drought or heat.

P. 24-29 *Diplodactylidae* (In title).—Family of southwest Pacific geckos and pygopods, distributed in Australia, New Zealand, New Caledonia, and in the case of pygopods, New Guinea.

[e]*carphodactyline.*—Adjectival form of Carphodactylini, a tribe of the Diplodactylidae including *Rhacodactylus*.

[f]*viviparity.*—Reproductive mode in which development takes place within the mother and young are born live, as opposed to oviparity, in which eggs are laid.

[g]*allozymic.*—In reference to allozymes, the different forms of proteins that can be separated by electrophoresis to yield evidence about relationships or similarity of individuals within or between populations and species.

[h]*polymorphic.*—Having many forms, usually refers to the presence of more than one manifestation of particular characters within a single taxon.

[i]*genetic distance data.*—Measurements of the relative similarity between taxa or individuals being compared, based on direct or indirect genetic information. In this instance, genetic distance data were derived from the allozyme data obtained by electrophoresis.

[j]*sclerophyll forest.*—Critically endangered dry forest found only in isolated pockets on the west coast of New Caledonia.

[k]*maquis vegetation.*—The characteristic and highly endemic scrub vegetation of the mineral-rich soils of parts of New Caledonia, especially the south.

ABBREVIATION USAGE

New abbreviations appear herein. Past issues should be consulted for previous abbreviation usage.

W = West	N = North
E = East	S = South
et al. = and others	F = Fahrenheit
e.g. = for example	C = Celsius
cm = centimeter	tel = telephone
mm = millimeter	fax = fascimile
km = kilometer	email = electronic mail
kg = kilogram	ha = hectares
m = meter	U.S. and US = United States
UK = United Kingdom	USA = United States of America
p. = pages, page	pers. = personal
~ = approximately	obs. = observation(s)
fig. = figure	comm. = communication(s)

ERRATA

The following journal corrections should be noted in Volume 1, Number 1 (Premiere issue): Page 3. CONTENTS PAGE. The article under Next Issue: *Conservation of South African's Endemic Dwarf Chameleons* has been postponed indefinitely. MASTHEAD. The premiere issue (Volume 1, Number 1) is out-of-print and no longer available, although nicely reproduced photocopies are available for $10 plus shipping and handling. All back issues are available for $12 each while regular supplies last. PAGE 10. In the "Key words" section the word *Viridi_* should have been spelled *Viridis*. PAGE 16. Under the photo caption the word *Pletledon* should have been spelled *Plethodon*. PAGE 20. The third sentence of the body of the article should read "Inbreeding depression may adversely affect small populations by unmasking recessive deleterious alleles and reducing heterozygosity." Pages 24-26. COLUMN. 1). The personal communication on page 25 (Groombridge 1994) was not attributed to Dr. Brian Groombridge of the World Conservation Monitoring Centre (WCMC), Cambridge, England. 2). The WCMC database, referred to in the column, is in fact the CITES database of trade records. 3). By comparing export records and import records, and checking against known countries of origin, it is in fact possible to get some idea of the extent of misreporting (The updated commentary for this particular article was provided by Brian Groombridge on November 8, 1996). PAGE 27. Meetings. The meeting date for the conference *Conservation and Biodiversity of Amphibians and Reptiles of Tropical Rain Forests* was re-scheduled for June 1999 and was then subsequently cancelled.

NOTE.—The most up-to-date *Writer's Guidelines and Manuscript Preparation Instructions* can be located at the *Amphibian and Reptile Conservation* website at: *www.herpetofauna.com*

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DEDICATION

This issue is kindly dedicated to my family: my mother Frances, my dad Anthony, and both my brothers Steve, and Greg Hasspakis.

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