

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

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 Madagascar 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 Madagascar 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 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 Tôlaïaro. 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

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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 Tôlaiario 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 km². 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 km².

Juvik (1975) and Lewis (1995) believed the range of *sokatra* was contracting 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 sisal¹. 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

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 loss (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.

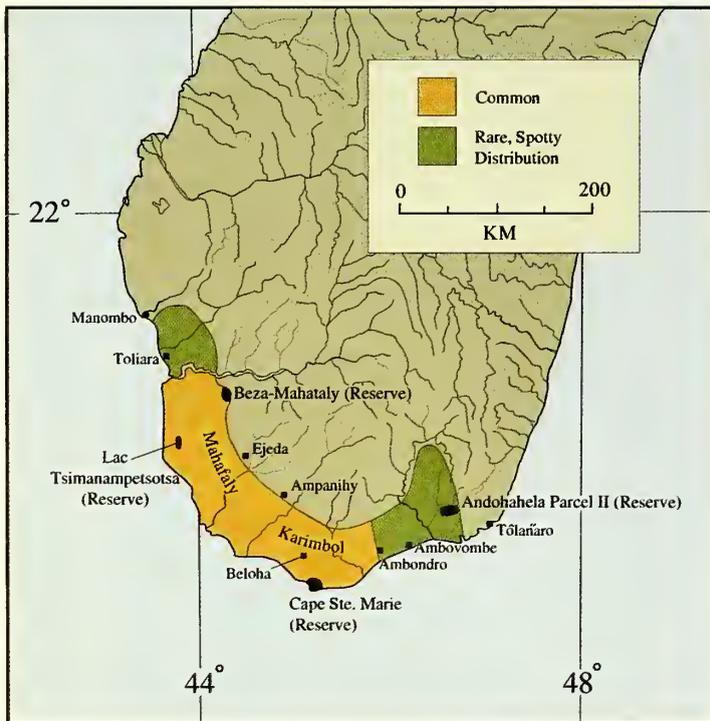


Fig. 1. Distribution of *sokatra* in Southeastern Madagascar.

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 hotel (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

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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 ox carts 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 ox cart 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 Tôlaiñaro 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 increasingly 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 Anakelky 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-

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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 Lemnridae) 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 Tôlaïïaro, 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

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

²For more information on protected areas (policy and legislation, international activities, administration and management, system reviews, addresses, protected area information, definitions of protected area 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. Xs + 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 Consular 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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