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An Assessment of the Effects of Commercial Exploitation on the Pancake Tortoise, *Malacochersus tornieri*, in Tanzania

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ABSTRACT. – **Pancake tortoises, flattened, rock-crevice dwelling testudinids of East Africa's Somalia-Masai floristic region, have been supplied to the commercial wildlife trade by exports from Tanzania since 1981. Collection and trade is concentrated between Arusha and Dodoma in north-central Tanzania. Compared to exploited habitats, unexploited habitats are characterized by significantly greater numbers of tortoises encountered per unit of search time, a larger proportion of multiple tortoise occupancies per crevice, and a higher proportion of adults. Isolation of suitable habitats coupled with this species' limited dispersal abilities and low recruitment rates make recovery of depleted populations unlikely. Commercial collecting is conducted through a well-organized, multi-tier system with minimal economic return for the actual collectors or local middlemen. No significant threats to survival of pancake tortoises other than commercial collecting were identified. We therefore recommend the severe curtailment of trade in pancake tortoises by Tanzania and recipient countries as the best method to halt further depletion.**

KEY WORDS. – **Reptilia; Testudines; Testudinidae; *Malacochersus tornieri*; tortoise; conservation; exploitation; trade; population status; habitat; Tanzania**

The bizarre flattened appearance of the pancake tortoise, *Malacochersus tornieri*, has made it a desirable species in the international wildlife trade. Since Kenya discontinued authorizing exports of this species in 1981, Tanzania has been the primary supplier of pancake tortoises, serving markets in North America, Asia, and until recently, Europe, by exporting thousands of specimens annually (Moll et al., 1991; WCMC and IUCN/SSC, 1991, 1992). In 1992 the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Animals Committee recommended a moratorium on exports of this species pending an evaluation of the results of a field assessment. Although Tanzanian authorities administratively instituted this moratorium through a zero-export quota system, there was evidence that collection and attempts to smuggle pancake tortoises out of the country were still occurring (Moll et al., 1993). In 1992 we initiated field surveys to determine the conservation status of the pancake tortoise, ascertain the levels, mechanisms, and effects of exploitation, as well as identify and evaluate other factors that potentially threaten populations within Tanzania. We hope these data will provide the impetus to develop an effective conservation and management strategy for this species.

METHODS

Field surveys were conducted between 3 June and 9 July 1992 in the Arusha and Dodoma regions of northern and central Tanzania. These surveys were supplemented by information collected in February and March 1992 in central and northwestern Tanzania. By examining topographic maps and interviewing individuals knowledgeable of the local terrain, flora, and fauna, we identified areas of potentially suitable habitat. As many of these areas as possible were visited. Appropriate microhabitats (i.e., deep crevices in rocks) were examined carefully with the aid of battery-powered flashlights to determine the presence of tortoises. The number of pancake tortoises found, the number of man-hours of search, habitat, and ecological data were recorded. The number of tortoises collected per man-hour of search as well as the ratio of juveniles to adults was calculated for each site. We compared the ratios of sites considered exploited with those considered unexploited (see Abundance Analysis). The magnitude and mechanisms of the pancake tortoise trade were gauged through interviews with individuals involved in the trade and local residents knowledgeable of collection activities.

RESULTS AND DISCUSSION

Distribution of Pancake Tortoise Populations

Populations of pancake tortoises are scattered discontinuously from central (possibly even northern) Kenya southward through central Tanzania. Within Tanzania, our surveys indicated that this species ranges from Mwanza on the southeastern shore of Lake Victoria eastward through central Tanzania and southward into Ruaha National Park. Specific locations of sites surveyed are tabulated (Table 1) and mapped (Fig. 1). Surveys were conducted in the Arusha, Dodoma, Hanang, Kondoa, Mbulu, and Mwanza districts, as well as Tarangire National Park, Yaedachini

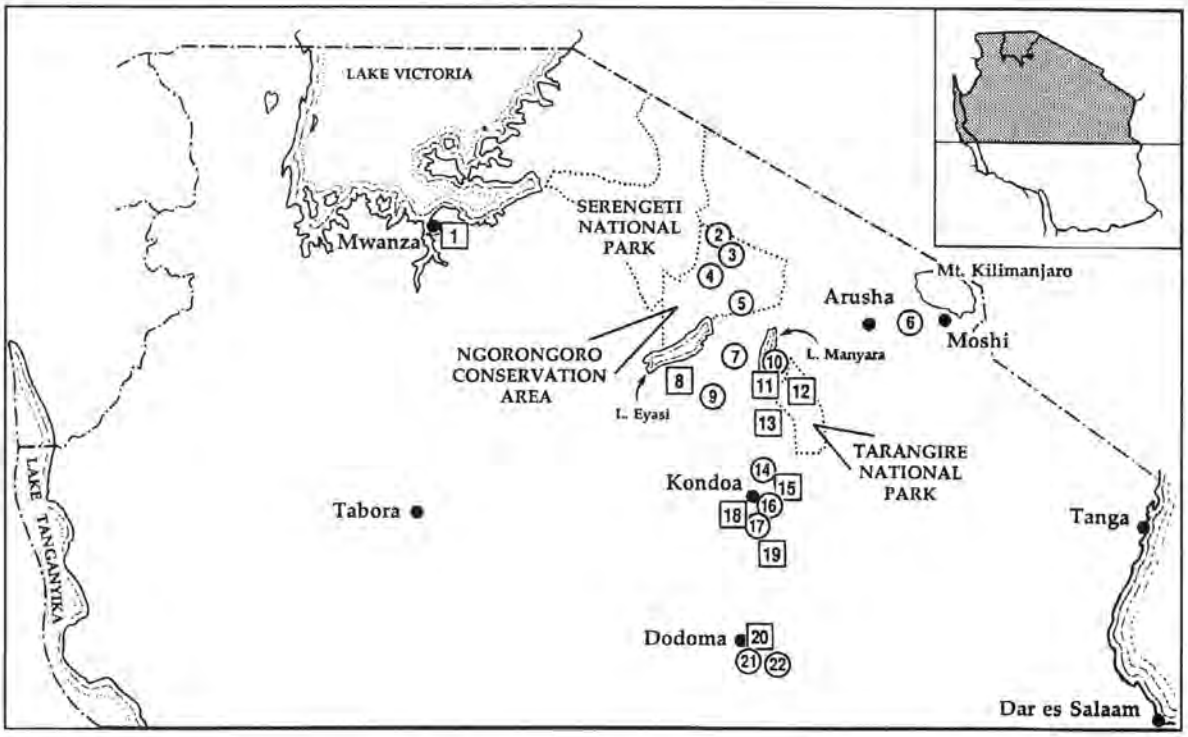

Figure 1. Map of northern Tanzania illustrating the sampling stations described in Table 1. Squares = confirmed pancake tortoise sites; circles = sites where tortoises were absent.

Game Controlled Area, and the Ngorongoro Conservation Area.

We were unable to verify the status of populations lying outside the areas surveyed, including several literature reports. Pancake tortoises were characterized by Broadley and Howell (1991) as a herpetofaunal component of arid semi-desert and grassland known as the Somalia-Masai floristic region (White, 1983). Most published records and the results of our surveys support this floristic region placement, although a few valid records are known from the Zambesian floristic region (White, 1983). We question the validity of Broadley's (1989) report from Lindi on Tanzania's southeast coast as representing a natural population. The habitat at Lindi is unsuitable and this site is far removed from the range of this species in Tanzania. Lindi was possibly the point of export rather than the actual site of collection. In summary, pancake tortoises may be expected to occur in areas of northern and central Tanzania lying within the Somalia-Masai floristic region (see Fig. 2). As it is highly secretive, this species could easily escape detection unless searches are conducted by experienced personnel. For example, we found large, previously unreported populations in areas of Tarangire National Park frequented by park personnel and tourists.

Pancake tortoises are distributed irregularly, confined to areas of optimal habitat lying below 1800 m. They require deep rock crevices that taper back from the entrance to heights of 5 cm or less and which allow relatively easy access to the ground below (Fig. 3). Appropriate crevice microhabitats are often a small proportion of the fissures in any given area. These pockets of optimal habitat often are widely separated from one another by large expanses of apparently unsuitable and unoccupied habitat. Detailed information concerning microhabitat characteristics and other ecological observations will be presented elsewhere (Moll and Klemens, in prep.).

Abundance Analysis of Exploited vs. Non-Exploited Populations

We compared the abundance of pancake tortoises in six unexploited habitats with that of five exploited habitats (Table 2). These comparisons were based upon the number of tortoises observed per man-hour of search effort. The following criteria were used to determine whether a pancake tortoise population had been exploited:

a) Proximity of the site to known collecting centers,

b) Degree of site-protection (e.g., its location in a well-guarded section of a national park or reserve),

c) Indications of site exploitation derived from interviews with tortoise collectors and local residents,

d) Physical evidence of site exploitation (e.g., in the Mawe Mbiti area of Tarangire National Park, a rock slab had been propped up by a stone of a different kind, apparently allowing freer access to the crevice underneath, as illustrated in Fig. 4).

In some cases, we were unable to verify that exploitation of tortoises had occurred. Absence of tortoises in apparently suitable habitats may be attributable to other factors. Therefore, we do not assume low numbers of tor-

Figure 2. Map of Tanzania illustrating the Somalia-Masai floristic region where almost all confirmed Tanzanian populations of *Malacochersus tornieri* have been found.

toises observed per man-hour to indicate that exploitation had occurred unless supported by reports of collection or physical evidence of habitat disturbance by collecting activities.

To ensure that the sites compared in these analyses actually contained pancake tortoises, we selected habitats that 1) contained at least one pancake tortoise and 2) were searched for at least one man-hour. We are reasonably certain that some apparently suitable habitats had been stripped of all pancake tortoises. Habitats of uncertain exploitation status (e.g., Paranga) were excluded. The six unexploited habitats used in these analyses are:

1. A grassy hillside with numerous granite outcrops near Iyoli village, which yielded the greatest number of tortoises per man-hour of search ($n = 8.5$). Although it was near Karema and Kondoa, well-known centers of the tortoise trade, we were told by villagers that this particular area had not been collected.

2–5. Four unexploited habitats within Tarangire National Park were located along the Ridge Road on rocky outcrops and in the "Buffalo Pool" area (two areas with $n = 1.5$ and $n = 0.5$ tortoises per man-hour respectively), near "Poacher's Hide" ($n = 1.07$ tortoises per man-hour), and near the Tarangire River in the Matete area ($n = 0.8$ tortoises per man-hour). The location of these habitats in the center of the park adjacent to roads regularly traveled by park personnel enhances their protection from poaching activities.

6. A very large area of rock outcrops in wooded (*Brachystegia*) hills in the vicinity of Kolo (the Mongomi, Mnenia, and Pahi samples in Table 1 are combined here as they are believed to represent a continuous population and habitat) in Kondoa District, Dodoma Region ($n = 2.15$ tortoises per man-hour). Because of the presence of rock paintings, this site is fairly well monitored by government personnel and has not been visited by collectors (Juma Mpore, *pers. comm.*).

The average number of pancake tortoises observed per man-hour in these six unexploited habitats was $n = 2.42$. In contrast, habitats that were considered exploited yielded fewer tortoises per man-hour of search effort (Table 2). These exploited habitats are:

1. The Sangaiwe Hills, a major area of collecting activity that was verified by direct observation and interviews with collectors from Magugu and local residents ($n = 0.25$ tortoises per man-hour).

2. The set of three hills (including the northernmost Wembe Hill) west of Lake Burungi, 1 km south of Mdori village and 22 km north of the tortoise-collecting center of Magugu along the main road to Dodoma ($n = 0.33$ tortoises per man-hour).

3–4. The Mawe Mbiti and Maweninga outcrops on the western edge of Tarangire National Park (these two sites were situated along the western boundary of Tarangire National Park, near the Sangaiwe Hills and the main road to Magugu and Dodoma, east of Lake Burungi). Mawe Mbiti had physical evidence of habitat manipulation, probably related to collecting activity (Fig. 4). Both sites yielded $n = 0.27$ tortoises per man-hour.

5. The Boundary Hill site on the eastern boundary of Tarangire National Park above the Silale Plain

Figure 3. Female pancake tortoise, *Malacochersus tornieri*, in entrance to crevice, Poacher's Hide, Tarangire National Park. Photo by M.W. Klemens.

yielded $n = 0.23$ tortoises per man-hour even though it offered large expanses of excellent habitat.

The average number of tortoises observed per man-hour in these five exploited sites was $n = 0.27$. The difference between exploited and unexploited sites of roughly comparable quality was analyzed using the Mann-Whitney U test and found to be highly significant at the 0.01 level ($U_s = 30$; $U_{c[0.01]} = 29$; $P < 0.01$).

Population Structure

During the dry season in June–July 1992, pancake tortoises observed were always in crevices. Single individuals were most common, less frequently two individuals were found, and rarely more than two tortoises inhabited a crevice (Table 3).

Exploited habitats were characterized by a single individual occupying each crevice, with the exception of Wembe Hill where a male/female pair was extracted from a crevice. As we were not always able or permitted to extract animals from crevices for examination, we were limited in our ability to assess the age/sex structure of populations. However, we were able to judge sexual maturity based upon size and could often distinguish males from females based upon morphological differences without extracting the tortoises from their crevices. We ascertained that an additional three observed pairs were male/female. Wood and MacKay (1993) reported a high proportion of male/female pairs in crevices near Nguni in the Kitui District of Kenya.

The ratio of adults to juveniles in exploited and unexploited habitats was compared (Table 2). In the six unexploited habitats, the number of juveniles ranged from 0–28.6% (mean 10.1%) of the individuals encountered. In the five exploited habitats, the number of juveniles ranged from 0–100% with a mean of 60.1%. The differences were compared with a Mann-Whitney U test and found to be highly significant ($U_s = 30$; $U_{c[0.01]} = 29$; $P < 0.01$). In three of the exploited habitats, a thorough search of available crevices revealed only one juvenile tortoise per site. We suggest that this a function of collectors' bias for larger individuals. Based upon our experience, adults are easier to find than juveniles, which hide in smaller crevices and "blind pockets." It may be more efficient and profitable (in terms of tortoises collected per unit time) to concentrate on finding and extracting adults. In addition, juvenile tortoises are more vulnerable to desiccation and other stress-induced mortalities, and therefore may not be as marketable. Observations of captive pancake tortoises obtained by collectors (e.g., a large group of over 200 confiscated tortoises held at the College of African Wildlife Management near Moshi and others seen in various holding areas near Magugu and Karema) were predominantly adults. When juveniles and adults are present in the same area, they usually occupy separate crevices. The large assemblage of 11 animals found in a single crevice at Iyoli was noteworthy, as three live juveniles (and one dead) were found with seven adults.

Based upon these analyses, suitable habitats that have been exploited may be identified by the following characteristics: unoccupied suitably configured crevices, low tortoise densities relative to the number of suitably configured crevices, low incidence of multiple tortoise assemblages in crevices, and a disproportionately high ratio of juveniles to adults.

Threats to Pancake Tortoise Populations

Collection of tortoises for the wildlife trade poses the only serious threat to the survival of pancake tortoises in Tanzania that we identified. We know of no other use made

Table 1. Locations and results of pancake tortoise (*Malacochersus tornieri*) field surveys in several Tanzanian districts from February to July 1992. See Fig. 1 for map showing corresponding location position numbers. Numbers of tortoises found are recorded as Alive or (Dead, in parentheses); N.R. = man-hours of search Not Recorded.

Date	Map Position (see Fig. 1)	Location	Number of Tortoises	Man-hours of Search	Tortoises/ Man-hour
Mwanza District:					
March 25–27	1	Sanane Island	(2)	N.R.	—
Ngorongoro Conservation Area:					
July 1	2	Southern Gol Mountains, Lemuta Hill/Nasera Rock	0	10.00	0
July 2	3	Oldoinyo Gol Mountain, W side of Malambo Road	0	4.00	0
July 1	4	Olduvai Gorge	0	4.00	0
July 1	5	Ngorongoro Crater	0	8.00	0
Arusha District:					
June 13	6	Arusha–Moshi Road, 32 km E Mt. Meru Hotel	0	1.00	0
Mbulu District:					
June 19	7	Mbulu–Karatu Road	0	1.00	0
June 17–18	8	Yaedachini Game Controlled Area	0 [a]	4.00	0
June 4	9	Mbulu–Dongobesh Road, 28 km S Mbulu	0	4.00	0
June 16	9	Mbulu–Dongobesh Road, 28 km S Mbulu	0	3.00	0
Hanang District:					
June 14	10	Minjinju, 105 km SW Arusha	0	3.00	0
June 14	11	W Lake Burungi, 13 km S Minjinju, 1 km S Mdori	3	4.50	0.67
June 21	11	W Lake Burungi, 13 km S Minjinju, 1 km S Mdori	2	9.00	0.22
July 6	13	Sangaiwe Hills, between Magugu and Babati	1	4.00	0.50
Tarangire National Park:					
June 23	12	Ridge Road near Buffalo Pool, site 1	12 (2)	8.00	1.50
June 23	12	Tarangire Hill	0	4.00	0
June 23	12	Ridge Road near Buffalo Pool, site 2	2 (1)	4.00	0.50
June 24	12	Ridge Road near Poacher's Hide	8 (1)	7.50	1.07
June 24	12	Mawe Mbiti	1	3.75	0.27
June 24	12	Maweninga	1	3.75	0.27
June 24	12	Matete near Tarangire River	2	2.50	0.80
June 25	12	Boundary Hill W of Silale Plain	2 (1)	8.75	0.23
Kondoa District:					
July 7	14	8 km N Kolo	0	2.00	0
July 7	15	Mongomi area near Kolo	2	0.50	4.00
July 7	15	near Mnenia by Kolo River	3	2.25	1.33
July 8	15	1 km SW Pahi on road to Haubi	2	0.50	4.00
July 8	15	near Keikei on the Busi–Pahi Road	1	1.00	1.00
July 8	16	2 km E Kondoa on road to Mondo	0	1.50	0
Feb 11–20	17	near Kingale	0	N.R.	—
Feb 11–20	18	near Iyoli	±35	N.R.	—
June 7–8	18	near Iyoli	17 (1)	2.00	8.50
Feb 11–20	19	near Piho	40	N.R.	—
Feb 11–20	19	near Mirambo	20–40	N.R.	—
Feb 11–20	19	near Chirimo	6	N.R.	—
June 8	19	near Paranga	3	2.50	1.20
Dodoma District:					
June 6	20	Dodoma, Simba Hill	0 [b]	3.00	0
June 6	21	on Dodoma–Iringa Road, 10 km S Dodoma	0	2.00	0
June 6	22	near Mvumi	0	3.00	0

[a] Pancake tortoises were known to the Hadza tribesmen in the hills above Lake Eyasi.
[b] Two pancake tortoises reported from the base of Simba Hill (J. DeGraaf, *pers. comm.*).

Figure 4. Physical evidence of site exploitation in the Mawe Mbiti area of Tarangire National Park. Note the rock slab propped up by a different kind of stone, allowing freer access to the crevice. Photo by M.W. Klemens.

of the pancake tortoise, except that Hadza women living in the Yaedachini Game Controlled Area above Lake Eyasi are reported to eat them (Klemens, 1992). Although over-grazing by cattle and goats occurs in many of the areas inhabited by pancake tortoises outside of the national parks, we know so little of the tortoise's food habits and ecological requirements that impacts of these activities upon pancake tortoises cannot yet be evaluated.

That large-scale collecting has been and is occurring is evident, both from reports received from local wildlife collectors as well as the seizure of several tortoise shipments in May 1992. These seizures, intercepted during an eight-day surveillance period at Dar es Salaam Airport by the Tanzanian Division of Wildlife, totalled nearly 1000 leopard and pancake tortoises (C. Mlay, *pers. comm.*). Several large collections of pancake tortoises were observed being held for export in February–March 1992 (A. Njalale, *pers. comm.*).

Healthy pancake tortoise populations still may exist in remote and inaccessible areas of Tanzania. Should intensive exploitation of pancake tortoises continue, these populations will be at risk, depending upon their geographic location and accessibility.

Mechanics of Pancake Tortoise Trade

Commercial collecting of pancake tortoises in Tanzania is well-organized and efficient. Based upon our interviews with traders, orders are initially placed with local animal dealers by overseas wildlife importers. The Tanzanian dealer, usually based in Arusha or Dar es Salaam, applies for the necessary government permits. The dealers then obtain their supply of tortoises by visiting collecting centers in villages such as Magugu (Hanang District) or Karema and Kondoa (Kondoa District), where an order is placed with a local middleman. These middlemen in turn employ local people, usually teenagers and young men, to collect the animals. The tortoises are held at the collecting center until the dealer returns to pick up the animals, although some dealers employ an assistant to accept and maintain the animals as they are brought in. In some cases, local people in these village collecting centers stockpile tortoises, keeping them in their homes in anticipation of an order. Ultimately, the animals are transported to export centers at Kilimanjaro Airport or Dar es Salaam.

Traders informed us that local collectors receive approximately TSh 20 (U.S. $0.05) per pancake tortoise from the village middleman, who in turn receives approximately TSh 150 (U.S. $0.38) from the animal dealer. Because of the limited monetary return and erratic nature of orders, tortoise collectors and middlemen cannot depend upon tortoise collecting as their sole source of income. Most appear to have other work and supplement their income when possible by collecting tortoises. There are some villages in which tortoise collecting is well-established, but in other villages in proximity to tortoise populations, collecting is not pursued. This may be due to a variety of factors, including a lack of interest in tortoise collecting because of the modest financial

returns or, more likely, the lack of a local marketing infrastructure. The latter may be a major factor in remote areas not visited by wildlife dealers. Collectors whom we interviewed considered pancake tortoises to be increasingly difficult to find because of intensive collecting activities. We were unable to obtain information regarding export prices of pancake tortoises.

The retail price in the United States, which has been the major importer of pancake tortoises since the European Economic Community import ban, according to CITES trade data, has steadily fallen from $300 to $40 per tortoise (Pritchard, 1987). In the early 1990s prices continued their downward spiral, and we have seen pancake tortoises offered for as low as $25. This recent flooding of the U.S. market with pancake tortoises has saturated the market far beyond the limited number of serious collectors and institutions willing to pay hundreds of dollars for a single tortoise, causing a subsequent reduction in price. Under these conditions the demand for pancake tortoises will continue unabated as the price is now within the range of many casual pet owners. This devalued market will consume as many pancake tortoises as can be supplied, while providing no financial incentive to breed the species in captivity. A previous example of a "bottomless tortoise market" was the insatiable post-World War II demand for inexpensive Mediterranean tortoises (*Testudo graeca* and *T. hermanni*) which continued until 1988 throughout western Europe. Although many populations of *Testudo* were severely damaged by collecting activities, the wide geographic range of these species prevented their extinction (Lambert, 1979). However, the pancake tortoise is much more vulnerable to this "bottomless market" type of exploitation because of its comparatively small geographic range, narrow habitat requirements, and localized populations.

Geographic Sources of Pancake Tortoises for Trade

In the areas surveyed in 1992, tortoise populations near collecting centers, including Karema, Kondoa, and Magugu, had been the most heavily exploited. Exact numbers captured were impossible to obtain but are believed to be significant. A collector in Sarame village (2.9 km east of Magugu) informed us he had collected 400 pancake tortoises in 1991 for a single Arusha dealer. In 1992 (prior to May) he collected another 150 pancake tortoises as well as 200 plated lizards (*Gerrhosaurus*) for the same dealer. The tortoises had all been collected in the nearby Sangaiwe Hills (possibly from within Tarangire National Park).

Residents in the vicinity of Karema reported that in May 1992 a trader from Dar es Salaam bought over 500 pancake tortoises from local collectors. In March 1992, A. Njalale (*pers. comm.*) observed 68 pancake tortoises in one house in Chelen (a small village near Karema), 32 tortoises in Sori village, and 115 tortoises stored in a house at Karema. These tortoises all reflected orders that had been filled and were awaiting pickup by dealers. While it is not possible to quantify trade levels, it appears reasonably certain that the trade in pancake tortoises has been of considerable magnitude and that intensive exploitation of natural populations has occurred within the last decade. Intermittent confiscations confirm that illegal trade continues and, despite some

Table 2. *Malacochersus tornieri* located per man-hour of search effort in unexploited and exploited habitats.

Unexploited Habitats	Tortoises/ Man-hour	No. Juveniles	Juveniles as % of Tortoises	Exploited Habitats	Tortoises/ Man-hour	No. Juveniles	Juveniles as % of Tortoises
Near Iyoli	8.50	4	23.5	W Lake Burungi, 13 km S Minjinju, 1 km S Mdori	0.33[b]	1	33
Kolo area	2.15[a]	2	28.6	Tarangire N.P. Mawe Mbiti	0.27	1	100
Tarangire N.P. Ridge Road near Buffalo Pool, site 1	1.50	1	8.3	Tarangire N.P. Maweninga	0.27	0	0
Tarangire N.P. Ridge Road near Poacher's Hide	1.07	0	0	Sangaiwe Hills	0.25	1	100
Tarangire N.P. Matete	0.80	0	0	Tarangire N.P Boundary Hill	0.23	1	100
Tarangire N.P Ridge Road near Buffalo Pool, site 2	0.50	0	0				
	$\bar{x} = 2.42$	$\bar{x} = 1.16$	$\bar{x} = 10.1$		$\bar{x} = 0.27$	$\bar{x} = 0.8$	$\bar{x} = 60.1$

[a] Mongomi and Mnenia data (July 7) and Pahi data (July 8) are combined as these sites are a continuous habitat.
[b] June 14 and June 21 data are combined as searches conducted over same habitat.

increase in enforcement, an unknown number of export shipments escape detection. The extent of current off-take is impossible to accurately assess.

Sustainability of Pancake Tortoise Trade

Although our knowledge of pancake tortoise population dynamics or actual trade levels is incomplete, as pancake tortoises have high adult survivorship and low reproductive output, there is no doubt that this species has been exploited at unsustainable levels in many areas we surveyed. However, as we have only a cursory understanding of the pancake tortoise's distribution in Tanzania, it is impossible to state accurately the percentage of its range evaluated during this field assessment.

Natural population sizes are limited by the availability of suitably configured crevices, which are often a small portion of the crevices in any given habitat. Furthermore, based upon what is known of captive animals (Darlington and Davis, 1990; Shaw, 1970) reproductive potential is very low with usually only one egg per clutch. Therefore, recruitment is low in the pancake tortoise, a characteristic of many testudinids (Swingland and Klemens, 1989). In addition, because of the distances between suitable habitat areas, dispersal between many sites is probably quite limited.

Observations made during our field survey strongly suggest that populations were depleted in many suitable habitats as a consequence of commercial exploitation. If trade continues at similar levels, it is likely that as easily accessible populations become depleted, collectors will be forced to go further afield to obtain tortoises, establishing new collecting centers, depleting previously untapped populations. Considering this scenario, all Tanzanian pancake tortoise populations could be considered vulnerable to exploitation, even those within protected areas, as demonstrated by our discovery of several apparently exploited populations within Tarangire National Park.

Management of Pancake Tortoise Populations

Historically, the only protection afforded pancake tortoise populations occurred when their habitat fell within the boundaries of protected areas. Even within such areas, their specific protection is not assured, as most park management regimes are focused on the vertebrate "megafauna." An added complication is that their cryptic behavior often precludes recognition of their presence by park personnel. Most Tanzanian pancake tortoise populations do not appear to be threatened by habitat deterioration, even when located in proximity to human settlements. However, tortoise populations nearest to collecting centers are among the first to be exploited.

The effective deployment of a tortoise export moratorium pending the results of a comprehensive status assessment (as per the 1992 CITES Animals Committee recommendation) would halt the large-scale, non-sustainable exploitation of pancake tortoises in Tanzania. The moratorium would be effective only if accompanied by increased enforcement at Tanzanian export sites (especially airports) and if reciprocated by increased efforts by importing countries to halt the flow of pancake tortoises. An import/re-export prohibition on pancake tortoises was instituted by the European Economic Community in March 1988, but no such restrictions have been contemplated in the United States, currently the major importer of pancake tortoises.

The reduction or complete curtailment of tortoise collection appears to be the most immediate management option to effectively conserve pancake tortoise populations. A strictly controlled harvest may provide both capital and incentive to manage pancake tortoises, although it may, in turn, encourage illegal take, and is not recommended at present.

Further research on the distribution and ecology of this species is required. Long-term ecological monitoring is needed to evaluate the effects of management efforts. The large-scale trade in pancake tortoises has brought negligible economic returns to Tanzania. Elimination of the bulk trade in pancake tortoises is essential to the survival of this species.

CONCLUSIONS

1. Pancake tortoises are distributed over an extensive range in northern and central Tanzania, but their habitat within this range is narrowly restricted to rocky outcrops with deeply incised crevices scattered throughout the semi-arid Somalia-Masai floristic region.

2. Pancake tortoises have very specific microhabitat requirements. The crevices they inhabit must be of suitable dimensions and configuration (i.e., deep crevices in rock

Table 3. Distribution of *Malacochersus tornieri* in single crevices.

Number of live tortoises in single crevice	Number of locations	Percentage of total number of tortoises found ($n = 55$)
1	23	41.8
2	8	29.1
3	2	10.9
10	1	18.2

which taper back from the entrance to heights of 5 cm or less, and which are positioned so as to allow relatively easy access to the ground below). Population sizes are limited by the number of such crevices.

3. Unexploited sites have significantly higher population densities (i.e., tortoises found per unit of search time), a greater proportion of multiple tortoise occupancies per crevice, and usually have a higher ratio of adult to juvenile tortoises, when compared to exploited habitats.

4. There is evidence of continued commercial collecting of the species despite a zero-export quota in place since 1992.

5. Commercial collecting is accomplished through a well-organized, multi-tier system that has reduced pancake tortoise populations in areas near collecting centers to extremely low levels, from which natural recovery to former densities is unlikely.

6. At the local level, commercial collecting provides very limited financial benefits for most participants in the trade.

7. Commercial collecting is the only significant threat to pancake tortoises in Tanzania that was identified in our surveys.

RECOMMENDATIONS

Based on our observations, we presented three management scenarios to the Tanzanian government: 1) uncontrolled trade, 2) strictly regulated trade, and 3) enactment of a trade moratorium pending the outcome of further field research.

Uncontrolled Trade. — Currently, trade has been greatly reduced, though not completely curtailed by the Tanzanian government. However, if trade resumes at pre-1992 levels (i.e., uncontrolled trade), it is quite likely that easily accessible populations of tortoises will become depleted. Collectors will be forced to go further afield to obtain tortoises, establishing new collecting centers and depleting hitherto untapped populations. In this scenario, all Tanzanian pancake tortoise populations could be considered vulnerable to exploitation, even those within protected areas. The national economic returns from this management regime will be quite low, especially at the local level.

Regulated Trade. — A very limited and strictly controlled harvest, coupled with a substantial export tariff, might provide the incentive and capital to manage and conserve this resource, while encouraging captive breeding efforts. However, enactment of substantial export tariffs may have detrimental side effects, such as creating an incentive for illicit trade.

Trade Moratorium. — The adoption of a legally-binding moratorium on collection and trade of pancake tortoises would be prudent, pending the results of further research. If this moratorium is adopted, the details should be communicated to the CITES Secretariat and CITES parties. Importing countries such as the United States should take measures to control and limit the import of pancake tortoises. Presently, the legal status of *Malacochersus tornieri* in Tanzania with regard to commercial collection and export is uncertain. A zero-export quota is reported (C. Mlay, *pers. comm.*) to have been instituted, yet it is not clear when or if this quota is in effect and enforced.

In addition, we have identified the following conservation needs:

1. International efforts should be increased to enhance the capability of Tanzania to manage and monitor nongame wildlife resources. This could be accomplished through a variety of formal and informal education and training programs and technology transfers.

2. This preliminary assessment should be followed by more detailed studies on the distribution and exploitation of the pancake tortoise in Tanzania, as well as the ecology and population dynamics of pancake tortoises. From these studies a management program should be developed.

3. Studies should be initiated to determine the feasibility of repatriating confiscated pancake tortoises into the wild. However, many serious issues must be addressed in order to develop a set of responsible repatriation protocols, not the least being the actual per-animal cost of repatriation viewed in a cost-benefit-analysis *vis à vis* other conservation priorities and needs for pancake tortoises. In fact, responsible scientific repatriation of tortoises will require a large amount of data that will be both expensive and labor intensive to assemble. Dodd and Seigel (1991) have reviewed this problem in detail. Questions that must be addressed include whether the tortoises proposed to be released are healthy (Karesh et al., 1993; Raphael et al., 1994) and genetically compatible with those at the release site, and whether the release site is able to absorb additional tortoises into the population. This requires knowledge of the carrying capacity of the release site as well as its existing demographic structure. All proposed repatriations must develop protocols and mechanisms to monitor the effects of repatriation over time.

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