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Reptiles as a food resource

MICHAEL W. KLEMENS and JOHN B. THORBJARNARSON
Wildlife Conservation Society, 185th Street and Southern Boulevard, Bronx, NY 10460, USA

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Reptiles have served as an important source of protein for human populations around the world. Exploitation for food is heaviest in the tropical and sub-tropical regions, but also occurs in temperate areas. Of all reptiles, turtles are the most heavily exploited for human consumption. High, unsustainable levels of exploitation for food are directly responsible for the precarious conservation status of many turtles. Crocodilians, snakes, and lizards may be locally important food sources, however, with the exception of a few lizard species, they are exploited in a less intense and generally non-commercial manner for human consumption. In comparison, the commercial skin trade poses a far greater threat to the survival of crocodilians as well as certain large snakes and lizards. Recent field reports have implicated the south east Asian medicinal trade as a growing threat to reptiles, especially turtles and snakes. There are few unequivocal examples of managed harvest programmes for reptiles that are economically and culturally viable, as well as biologically sustainable. Given the economic importance of reptiles as sources of protein and other highly valued commodities, it is imperative that more attention be focused on the development of sustainable use programmes for these species.

Keywords: sustainable use of reptiles; turtles as food for humans; crocodilians as food for humans; snakes as food for humans; lizards as food for humans

Introduction

> Those who are really concerned with the environment – concerned with the well-being of posterity – must give the carrying capacity of the environment precedence over discontinuous human needs, however much these needs may tug at our heartstrings (Hardin, 1994).

Because reptiles possess low energy requirements and tend to have high reproductive rates, they often occur at high densities and biomass levels (Pough, 1980). These life-history traits make them especially well-suited for management as a food resource, and indeed throughout the lowland tropics, many reptiles have served as an important source of protein for human communities (Mittermeier *et al.*, 1992). Nevertheless, in many areas reptiles represent an ephemeral resource that can be easily over-harvested, particularly when exploitation is commercially oriented.

The use of reptiles for food for humans has varied considerably among the principal reptilian groups: turtles, snakes, lizards, and crocodilians. Although many species of reptiles are eaten by humans, only in certain groups do we find extensive consumption and commercialization of meat. These include freshwater and riverine turtles, sea turtles, tortoises, and some of the larger species of lizards. For most species of snakes and crocodilians meat hunting is not a significant conservation problem as commercialization is usually minimal. Consumption of reptile meat is often intertwined with cultural or medicinal beliefs. In some instances meat consumption is a by-product of the commercial

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skin harvest of crocodilians, snakes, and lizards. Similarly, the effect that this exploitation has had on the conservation status of species has depended on a complex relationship among a suite of factors, including (but not limited to) preferred habitat type and availability, the food or commercial value of the species, the ease with which the species can be caught, as well as particular features of the species' life-history.

The purpose of this paper is to provide an overview of the worldwide use of reptiles as a food resource. We will present information on both the subsistence and commercial use of reptiles, although the distinction between these two is often blurred. We will identify those species, or groups of species, for which use as food has been a major contributing factor to population decline. Lastly, we will address the question of developing management programmes for reptiles based on their use as a food resource.

Turtles

Turtles serve as an important, often seasonal, source of protein for rural and urban human populations, especially in developing countries. Given the extent of turtle meat and egg consumption, this harvest is a major conservation concern. The primary groups consumed are riverine, freshwater, and sea turtles (meat and eggs) and land tortoises (meat). However, almost all species of turtles, both large and small, have at one time or another been used for food. For example, Klemens (1992) reported that the small, flattened pancake tortoise, *Malacochersus tornieri*, is eaten by hunter-gatherers in the Kidero Mountains of Tanzania. In addition, the literature contains numerous references to the remains of quite small species such as *Emys orbicularis* and *Terrapene carolina* being found in Paleolithic and Amerindian middens.

Riverine and freshwater turtles

The large-scale exploitation of river turtles (*Podocnemis expansa* and *P. unifilis*) as food in South America has received widespread attention (e.g., Mittermeier, 1975; Smith, 1979). In addition to these two Amazonian species, IUCN/SSC (1989) considers a number of large river turtles 'in trouble through overexploitation for eggs and meat, and some are particularly vulnerable at colonial nesting sites'. These are *Carettochelys insculpta* (New Guinea), *Erymnochelys madagascariensis* (Madagascar), *Dermatemys mawii* (Central America), and *Batagur baska*, *Callagur borneoensis*, *Kachuga kachuga*, and *K. trivittata* (Indo-Malayan Region). Although not included on the IUCN list, other large riverine species have been, and continue to be, used for food, including the alligator snapping turtle, *Macroclemys temminckii*, of the south eastern United States (Pritchard, 1989). The closely-related common snapping turtle, *Chelydra serpentina*, which occurs in a wide range of aquatic habitats, is a commercially important food species in North America (Klemens, 1993). Softshell turtles (Trionychidae) include large riverine forms as well as smaller species found in ponds and lakes. They are consumed throughout their range, which includes North America (Carr, 1952) and Africa (Loveridge and Williams, 1957), but are an especially important food resource in Asia (Das, 1991).

Historical accounts of river turtle abundance are very revealing in that they illuminate the extent of exploitation that has taken place for particular species. One of us (JBT) recently visited an area of Brazil and compared the current status of river turtles with Henry Walter Bates' vivid accounts which indicated that little more than a century ago this area was literally teeming with turtles (Bates, 1863). River turtles (genus *Podocnemis*)

played a vital role in the regional economy, and may have been a key component of the flood-plain ecosystem, particularly by consuming and dispersing seeds of certain trees.

Bates reported that in the mid-1800s residents of Tefé lived for most of the year on turtle meat. Every house in the village was reported to have a pen (*cural*) to stock turtles throughout the wet season when they were less available. When Bates could no longer eat turtle (as he could not bear the smell of it) he went hungry as 'nothing else was to be had'. During the dry season turtles were caught using seine nets and with bow and arrow in both inland lakes and rivers.

Podocnemis expansa nests colonially on elevated sand beaches during the dry season. In one of the first attempts to manage the exploitation of a species of turtle, the excavation of *P. expansa* eggs was controlled by Amazonian municipal councils, based on a system

a

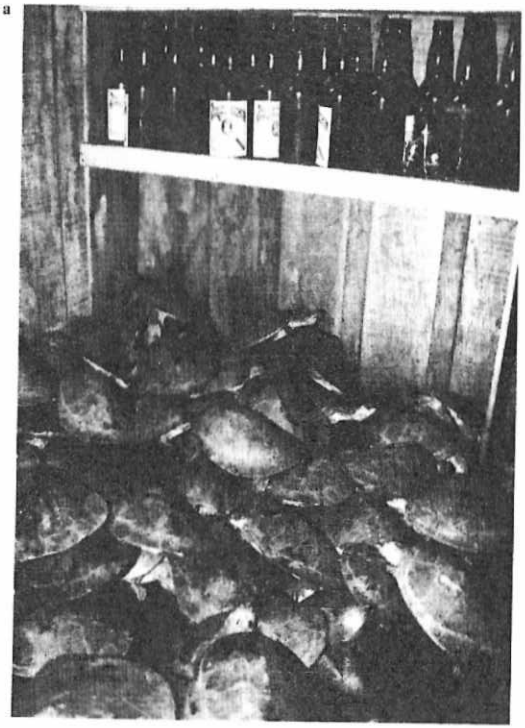
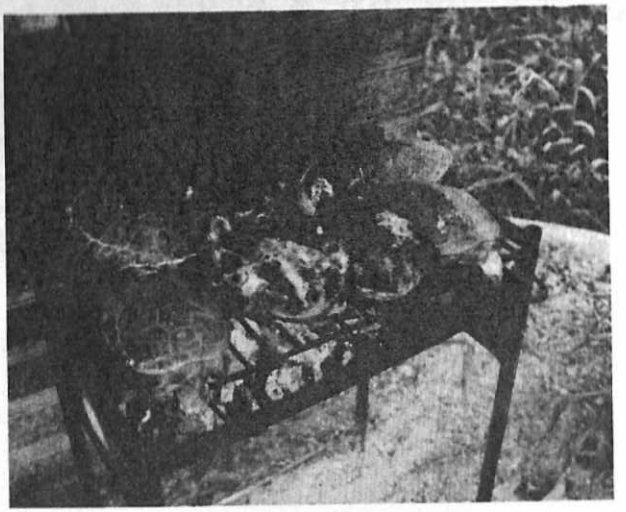


Figure 1(a, b). Hundreds of *Podocnemis sextuberculata* are collected each week, grilled, and offered for sale at Tefé in the Brazilian Amazon. (Photocredit – J.B. Thorbjarnarson/Wildlife Conservation Society.)

b



established by the Portuguese governors. Each year the council of Tefé would appoint a *commandante* to supervise the excavation of eggs at each of four *praia reales* located within 150 miles of the village. Sentries were posted in raised towers at each beach to monitor the nesting of the turtles and to protect the beaches from unauthorized egg harvesters. When the turtles had finished nesting, an announcement was made of the date for the excavation of eggs at the various nesting beaches. The *commandante* would record the names of the heads of households and collect a tax from each, the money being used to pay the beach sentinels. On a signal, all participants (Bates reported 400 at one beach) were permitted to begin digging up the eggs. These were tossed into canoes, mashed, and then allowed to sit in the sun until the oil rose to the surface. This oil was then skimmed off, purified in copper kettles, and stored in jars. The oil was used for a variety of purposes, the most important being for lamps. Bates estimated that 48 million eggs were destroyed annually in this fashion on the upper Amazon alone, representing the production of approximately 400 000 nesting females.

Bates reported that *P. unifilis* was exploited to a lesser degree, not only because of its smaller size, but also because it apparently did not live as long in captivity as *P. expansa* and it was more restricted to the main river, not using the forest lagoons as readily as *P. expansa*. Little mention was made of the consumption of a third *Podocnemis* species which was found at Tefé (*P. sextuberculata*). Even during the period when Bates lived in the Brazilian Amazon (1848–1859) he reported that turtles were becoming increasingly scarce and more expensive to purchase. Since that time continued exploitation has reduced populations of both *P. expansa* and *P. unifilis* near Tefé to small numbers. These species are now of little commercial importance. However, the relatively small *P. sextuberculata* is regularly captured in large numbers using long nets (*malhadeiras*) in bays along the rivers.

There is one shop in Tefé that sells roasted turtle. The owner reported that he sold 300 cooked turtles every 8–10 days (approximately 12 000 turtles a year).

Sea turtles

Sea turtles have been heavily exploited for food throughout their tropical, sub-tropical, and temperate near-shore habitats. Sea turtle meat, eggs, and oil are important dietary and economic resources for many peoples living in coastal areas (Lagueux, 1991). There is a tremendous body of literature documenting the exploitation of sea turtles from the subsistence level to large-scale commercial activities (Bjorndal, 1981). Throughout the world, sea turtles have been depleted by collection of adults and eggs (King, 1981; Ross, 1981). The species most heavily consumed for meat and eggs are the flatback, *Natator depressa*, green sea turtle, *Chelonia mydas*, loggerhead, *Caretta caretta*, and olive ridley, *Lepidochelys olivacea*. Kemp's ridley, *Lepidochelys kempii*, is now so rare that it has little economic importance, though historically its eggs and flesh were consumed. The hawksbill, *Eretmochelys imbricata*, is the major source of 'tortoiseshell', which is the primary cause of its decline. Its flesh, although consumed, is toxic in many areas. The flesh of the leatherback, *Dermochelys coriacea*, is very oily and its consumption is quite localized. However, its eggs are highly prized and harvested in large numbers, and its flesh is rendered for oil.

Tortoises

The land tortoises (Testudinidae) comprise approximately 40 species that are well adapted for terrestrial existence. They range in size from the giants of the Galapagos and Indian Ocean islands to the diminutive padlopers of southern Africa. As a group, tortoises are among the most endangered of all turtle species (Swingland and Klemens, 1989). The cumulative effects of collection for food, habitat loss and fragmentation, introduced predators and diseases, and the wildlife trade have reduced many species to dangerously low levels and have resulted in many local extirpations.

Consumption for food and oil have been major factors in the decline of the large oceanic island species. The large radiation of giant tortoises on the Indian Ocean islands and Madagascar have all but disappeared, with some extinctions occurring within the last centuries. Human predation was the major cause of these extinctions; only a single species, *Aldabrachelys elephantina*, still survives (Swingland, 1989). The giant tortoises (*Geochelone nigra* ssp.) of the Galapagos Islands have suffered a similar fate; several sub-species are considered extinct and populations of many others are at critically low levels.

The large-to-medium-sized mainland forms are also heavily consumed. In North America, the gopher tortoise, *Gopherus polyphemus*, has been exploited for food in Florida for over 4000 years and was a major food source for many families during the Depression of the 1930s (Diemer, 1989). Diemer reported that due to prohibitions and regulation of harvest, diminished tortoise populations, and an increase in private 'posted' lands, the collection of this species for consumption has declined, although illegal commercialization still occurs in some areas. The Bolson tortoise, *Gopherus flavomarginatus*, once ranged throughout the Chihuahuan grasslands. Human consumption has been the major cause of its decline (Morafka, *et al.*, 1989).

In Africa, the leopard tortoise, *Geochelone pardalis*, is widely consumed (Broadley, 1989a; Klemens, personal observations). The spurred tortoise, *Geochelone sulcata*, is the

Figure 2. Green sea turtles, *Chelonia mydas*, being butchered on the beach in Western District, Papua New Guinea. (Photocredit – J.L. Behler/Wildlife Conservation Society.)

Figure 3. Remains of radiated tortoises, *Geochelone radiata*, consumed in southwestern Madagascar. The meat is extracted through large holes smashed into the shells. (Photocredit – J.L. Behler/Wildlife Conservation Society.)

largest mainland tortoise, ranging throughout Africa's Sahel region. Traditionally, its consumption may have been minimal, as the inhabitants of this area are primarily Moslems who have a religious prohibition against the consumption of turtle flesh (Broadley, 1989b). Hingeback tortoises (*Kinixys*) range throughout sub-Saharan Africa and are locally consumed (Broadley, 1989c, d). Although often protected against local consumption by tribal taboos, the flesh of the Madagascan radiated tortoise, *Geochelone radiata*, is a delicacy which commands a good price in urban areas (Durrell *et al.*, 1989).

In Asia, all species of tortoises are consumed. The large Burmese brown tortoise, *Manouria emys*, has suffered a serious decline due to over-collection for food. It is now very scarce in many areas (Moll, 1989a). Consumption is the major cause for the near extinction of the Burmese starred tortoise, *Geochelone platynota*, and the widespread elongated tortoise, *Indotestudo elongata*, is consumed throughout southeast Asia (Moll, 1989b, c). Two species of tortoises inhabit the rainforests and savannas of South America, *Geochelone carbonaria* and *G. denticulata*, and serve as important local sources of protein. However, there is an increased commercialization of these species in urban areas. In Venezuela, large numbers of these species are collected and sent to urban centres for consumption. An upsurge in this trade occurs in the weeks before Easter, as during Holy Week devout Catholics may only consume fish. The Catholic Church classifies turtles as 'fish', creating a tremendous demand for tortoise meat in urban areas (Walker 1989a, b).

Crocodilians

Like turtles, crocodilians have been used worldwide as a source of protein for rural human communities throughout the lowland tropical and subtropical regions. Yet the consumption of crocodilians and their eggs is not as widespread or intense when compared to the exploitation of certain types of turtles. The consumption of crocodilian meat and eggs appears to be primarily a subsistence activity with minimal effects upon wild populations. Commercial hide hunting coupled with habitat loss are widely recognized as the principal factors responsible for the worldwide decline of crocodilians (Groombridge, 1982; Thorbjarnarson, 1992). Although there are scattered references to commercial and subsistence hunting for meat, virtually all literature accounts of crocodilian exploitation focus on the commercial skin trade.

The use of certain crocodilians for food, particularly small species, varies from culture to culture and from region to region. In some areas such as Haiti (Thorbjarnarson, 1988), there are cultural and religious taboos against the killing and eating of crocodiles. In other areas (e.g., Dominican Republic), crocodiles are used for the purported medicinal value of their fat, teeth, or penis. In Australia, the meat and eggs of crocodiles have been used by aboriginal peoples for 20 000–40 000 years (Webb *et al.*, 1987). Small species such as *Paleosuchus palpebrosus*, *P. trigonatus*, *Caiman crocodilus* (all South American) and *Osteolaemus tetraspis* (African) appear to be favoured as a source of protein.

In South America, crocodilians are widely consumed, but at low levels (Dourojeanni, 1985). There is some evidence suggesting that subsistence hunting of crocodilians can reduce population levels around human habitations (Ouboter, 1989). In the Venezuelan llanos, the meat of *Caiman* is consumed seasonally as part of a dry season managed harvest of adult males (Thorbjarnarson, 1991). Eggs are harvested illegally during the early wet season when *Caiman* begin to oviposit. The traditional use by Yaruro Indians of *Caiman* meat and eggs, as well as the eggs of the larger Orinoco crocodile, *Crocodylus intermedius*, was reported by Petrullo (1939). Today, Yaruros along the Capanaparo River in southwestern Venezuela maintain the same dietary pattern, consuming *Caiman* but avoiding the meat of the Orinoco crocodile, indicating that it tastes bad (Thorbjarnarson, personal observation). In these communities, the meat of river turtles (principally *Podocnemis unifilis*) and *Caiman* provide the most important sources of protein for the Yaruro during the dry season (Thorbjarnarson, personal observation). In the same region, Yaruro and Guahibo Indians will hunt *Paleosuchus palpebrosus* and their eggs. Hunting of *Caiman* and *Paleosuchus* does not appear to have any major impact on the populations of these crocodilians. However, the collection of Orinoco crocodile eggs may be a significant factor in retarding the population recovery of the depleted populations of this species (Thorbjarnarson and Hernández, 1992).

In the southern Venezuelan regions of Bolivar and Amazonas states, crocodilians are consumed by both indigenous groups and persons of European descent (Gorzula and Paolillo, 1986). Hames (1979) found that caimans comprise the most important prey of Ye'kwana Indians in the Rio Padamo (30% of total prey), but only 2% of the prey of Yanomamo at the same locality. In Colombia, Medem (1981) reported that archeological excavations in the Bajo Sinú region of Córdoba state dated at approximately 200 BC revealed that the remains of *Caiman crocodilus* were abundant while those of the American crocodile, *Crocodylus acutus*, were uncommon. In Guyana, Reese (1923) noted that crocodilians were not used much for food in the coastal lowlands, but Gorzula and Woolford (1990) found that both *Caiman* and *Paleosuchus* (not the larger *Melanosuchus*), were hunted for meat, but that consumption appeared to be negligible. Crocodilians are

Figure 4. Butchering spectacled caimans, *Caiman crocodilus*, for meat and hides in the Venezuelan llanos. (Photocredit – J.B. Thorbjarnarson/Wildlife Conservation Society.)

eaten by Macushi Amerindians, and by Wai-Wai Amerindians in the upper reaches of the Essiquibo River.

In Africa, the dwarf crocodile, *Osteolaemus tetraspis*, is widely hunted for food in West Africa (Groombridge, 1982). In the Congo, dwarf crocodiles are hunted in rural areas and transported on river boats to markets for sale (M. Fay, personal communication). In the Ituri Forest of Zaire *Osteolaemus* is consumed by the Mbuti (T. Hart, personal communication). However, in other areas such as Zimbabwe where only the larger Nile crocodile, *Crocodylus niloticus*, is found, there is no tradition of hunting for food (Child, 1987). In Papua New Guinea, a low level of exploitation of crocodiles (*Crocodylus novaeguineae* and *C. porosus*) for meat has existed for a long time, but it is unlikely that any serious impact on the populations occurred before commercial hunting for skins started (Hollands, 1987). In the southeastern United States, alligator (*Alligator mississippiensis*) meat is harvested through legal hunting, farming, and ranching programmes (Hines and Abercrombie, 1987). Joanen and McNease (1987) report that from 1979 to the mid-1980s approximately 45 000 kg of alligator meat was produced in the wild harvest from the state of Louisiana, with sales divided roughly in half between private individuals and restaurants and fish markets.

In summary, crocodilians and their eggs are widely used on a subsistence level for food by rural human communities. For a few species commercial sale of crocodile meat is conducted on a controlled, legal basis (e.g., Venezuela) or unmanaged basis (e.g., Congo, Zaire), but there is no direct evidence that this hunting has had significant negative effects on populations. In contrast, hunting crocodilians for the commercial value of their skins has been a major factor in the decline of many crocodilian species over the last 50 years.

Squamates

Like crocodilians, snakes are eaten on a subsistence basis in many parts of the world, but the commercial sale of snake meat is not common except in southeast Asia. Pope (1961) considered the southern Chinese city of Canton (Guanzhou) to have the greatest snake market. Irvine (1954) describes the snake markets of southern China and Hong Kong, listing the following species: *Naja naja* (common), *Ophiophagus hannah* (uncommon), *Bungarus fasciatus* (common), *Elaphe radiata* (common), *Ptyas mucosus* and *P. korros* (common), and *Python molurus* (uncommon). Certain restaurants were known to always serve snake, and during special banquets snake is sometimes the only meat served, up to five species comprising the menu. Pope (1961) mentions seeing cobras and other (non-venomous) snakes in the Canton market, and notes that the meat of the large pythons sells for a higher price than beef. Both Indian and reticulated pythons were said to be imported in large numbers to supply the market. Pope (1961) suggests that the consumption of snakes has been widely associated with the spread of the Cantonese culture in southeast Asia, but also cites Raven (1946), who indicated that native Dyaks also consume python meat. Quite recently investigations by TRAFFIC (J. Thomsen and J. Mills, personal communication) have revealed a large market for snake blood and bile, which is consumed as a health tonic in southeast Asia. One of us (MWK) examined photographs of 'health-tonic bars' in Taipei. Lines of customers were waiting to obtain a small glass of snake tonic. Snakes are selected, killed, and drained in assembly-line fashion, and the decanted tonic is immediately quaffed by the waiting customers.

Pope cited additional references on snake consumption, including sea snakes in the

Philippines (Herre and Rabor, 1929) and Zaire (Watts, 1925). He pointed out that religious beliefs prevent significant human consumption of snakes in some areas such as India, but not in others such as many regions of Africa. Large-bodied snakes such as pythons are particularly favoured for their flesh. In southwestern Cameroon, D. Lawson (personal communication) reported four species of large venomous snakes are consumed: *Bitis gabonica*, *Bitis nasicornis*, *Naja melanoleuca*, and *Dendroaspis jamesoni*. Lawson found that *Bitis nasicornis* was especially common in palm oil plantations where, during

Figure 5. Monitor lizard, *Varanus niloticus*, being ritually slaughtered for consumption in the Epulu River in Zaire's Ituri Forest. (Photocredit – J. Hart/Wildlife Conservation Society).

the rainy season, several of these large, heavy-bodied vipers were collected for consumption each day. Snakes figured prominently in the myths and legends of Australian aboriginal peoples (Shine, 1991), but certain snakes such as pythons and filesnakes also served as an important food source for particular groups. Irvine (1954) gives numerous other examples of the consumption of snakes by indigenous groups in Asia, Australia, Africa, and Latin America. In North America, rattlesnake (*Crotalus*) meat is consumed. The widespread popularity of southwestern US and Mexican cuisine has expanded the sale of rattlesnake meat into urban areas. For example, mesquite-broiled rattlesnake meat was recently offered at an upscale restaurant in Providence, Rhode Island (Klemens, personal observation).

Although snakes are used as a source of food for rural, and in some cases urban, human communities, over-exploitation for food does not appear to be a widespread cause of population decline, which is typically related to habitat loss, the introduction of exotic animals, and, in some cases, skin hunting (Dodd, 1987, 1993). Nevertheless, in some areas the commercial use of snakes may be having significant impacts (e.g., the Asian medicinal market) and studies are needed, particularly in southeast Asia, to determine the effect of commercial snake collecting on wild populations.

The use of lizards as food for humans can be traced back to the middle Pleistocene in Java (Auffenberg, 1988). Lizards were a protein source in the pre-Columbian Neotropics (Cooke, 1981; Fitch *et al.*, 1982). As with snakes, and to some degree crocodilians and turtles, the consumption of lizard meat is often related to the purported medicinal or cultural benefits derived from the flesh (Fitch *et al.*, 1982; Auffenberg, 1988). Also, in some instances, lizards hunted principally for their skins are also eaten (Fitzgerald, 1991).

Throughout Central America, iguanid lizards (*Iguana iguana* and *Ctenosaura similis*) are captured by professional lizard hunters (Fitch *et al.*, 1982). Dealers travel through the countryside purchasing live lizards and transporting them to local markets. Fitch and colleagues (1982) even report significant trade of lizards across borders (e.g., lizards caught in Honduras and Guatemala sold in El Salvador) and noted considerable regional variation in the use of iguanas and their eggs in Central and northern South America. Much of this variation in the use or non-use of lizards as food apparently stems from cultural beliefs concerning the medicinal or other benefits of their flesh. In some areas the eggs of iguanas are considered to be aphrodisiacs (Werner, 1991). The green iguana, *I. iguana*, has been managed on a sustained-yield basis in Panama, one of the few instances of a successful reptilian sustainable use programme that is conserving wild iguanas, protecting the iguana's forested habitat, as well as providing a dependable, sustainable source of protein for rural inhabitants (Werner, 1991).

In the Old World, the large monitor lizards (*Varanus*) are a frequently sought food item. Auffenberg (1988) notes that the monitor, *Varanus griseus*, is consumed for food by rural people in the Philippines, and most lizards are caught by general hunting parties looking for any type of game and are usually sold in local markets. In the miombo woodlands of Zambia, the consumption of monitor lizards is locally variable. Certain tribes regularly consume monitors while other tribes eschew their consumption (J. Hilty, personal communication). In Zambia's Luangwa Valley, a monitor was killed and then smoked to preserve the meat for future consumption (J. Hilty, personal communication). In Zaire's Ituri Forest, monitors are opportunistically collected by the Mbuti for food. According to tribal custom, these lizards are slaughtered in running water 'to protect the honey season' (T. Hart, personal communication).

In some areas, over-hunting lizards for meat markets combined with habitat destruction has had significant, negative effects on lizard populations (Werner, 1991). This is particularly true for large iguanids such as *Iguana* and *Ctenosaura* (Fitch *et al.*, 1982). Over-hunting in pre-Columbian times is suspected as the cause of extinctions of two terrestrial iguanas (*Cyclura mattea* and *C. portoricensis*) in the West Indies (Wiewandt, 1977). Hunting for meat is a major contributing factor to the endangered status of extant *Cyclura*, which face a multitude of threats including hunting, habitat loss, introduction of exotic predators such as cats and dogs, and competition with introduced livestock, particularly goats (Noble, 1923; Carey, 1975).

Sustainable use of reptiles for food

Over the last decade there has been an increasing focus on wildlife management programmes that promote both the economic development of human communities and the conservation of wildlife populations. Collectively referred to as sustainable use of wildlife programmes, these seek to impart an economic value to wildlife, thereby allowing it to compete in its own right for needed resources (such as habitat). The basic premise of assigning economic value to wildlife is that appropriately valued natural resources are not wasted. Sustainable use programmes can provide revenue for chronically underfunded and understaffed governmental wildlife management activities while addressing the economic needs of the rural poor.

Sustainable-use (SU) programmes are often considered to be a panacea – but they are not. Widespread and often indiscriminate promotion of SU programmes as a type of 'win-win scenario' has raised expectations often far in excess of biological realities. It is therefore imperative that groups of animals and plants be identified that are potentially suitable candidates for sustained use. Programmes to manage these resources must be devised and then rigorously tested to ensure that they are both biologically, economically, and culturally acceptable as well as sustainable.

Although SU management of reptiles holds much promise, there are relatively few examples of SU management benefiting reptile conservation. Many countries lack the resources to plan and implement wildlife management programmes, particularly those involving use. The existing policies regulating wildlife management in many developing countries are not conducive for the initiation of well-planned experimental sustainable use programmes. The start-up costs of many of these programmes are considered prohibitively high, especially when the tangible benefits are not clear. The desire for revenue often prompts the initiation of ill-conceived SU programmes which inadequately address the range of exploitation options, ranging from small-scale subsistence activities all the way to international commercial enterprises. The difficulties associated with programme enforcement frequently far exceed the control capacity of the responsible regulatory agencies. Illegal hunting and trade are not compatible with a successful SU programme and this has been the focus of much criticism for wildlife programmes based on managed harvests.

What is the potential for managing reptile populations for sustained meat production? For cultural reasons the most obvious groups to consider would be those which have historically been the most heavily exploited for food; freshwater and sea turtles, tortoises, and large lizards. In Central America a programme is underway to use iguanas as a food resource to promote the conservation of populations of wild and captive iguana, provide a

dependable supply of protein to rural inhabitants, and to provide incentives for reforestation (to improve iguana habitat) (Werner, 1991). Can similar programmes be developed for other species of reptiles? The most apparent candidate group would be turtles, the most frequently consumed group of reptiles.

Turtles are among the longest lived of vertebrates (Gibbons, 1987), but the survival of turtle populations is predicated upon the long adult reproductive life span, which offsets the high mortality of eggs and hatchlings. Congdon and colleagues (1993) analysed the life-history characteristics of a representative freshwater turtle (*Emydoidea blandingii*) and found that populations are very limited in their ability to compensate for long-term increases in juvenile, or especially adult mortality. They suggested that these results are applicable to other species such as sea turtles and desert tortoises as well. In many areas, the loss of adult turtles far exceeds recruitment, creating a conservation crisis (Klemens, 1989). Most conservation activities, as well as purported SU programmes, focus upon boosting the number of hatchling turtles, which are subsequently released into the wild, a process known as 'headstarting'. Frazer (1992) clearly underscored the flawed reasoning that undergirds headstarting programmes that do not simultaneously attempt to remedy the root cause of turtle population declines, i.e. the removal of large numbers of reproductively active adults. Large-scale collection of adult turtles is clearly not sustainable and further exacerbates the precarious conservation status of many species (IUCN/SSC, 1989; Swingland and Klemens, 1989). In the *IUCN Red Data Book*, Groombridge (1982) lists 41 species of turtles for which there are sufficient data to determine the cause(s) of their declines. Of these species, 46% list over-exploitation for food as the primary factor in their decline, while an additional 20% attribute use for food as a co-primary factor. However, controlled egg harvests (Anon., 1994) may offer some promise as may small-scale rearing of turtles and tortoises to augment protein needs of rural inhabitants. Whitaker (1993) proposed rearing a small species of softshell turtle, *Lissemys punctata*, in the tanks and ponds that are found on the outskirts of small villages in rural India.

Various strategies for commercialization of sea turtles by farming and/or ranching have been proposed. For example, 120 874 kg of 'farmed' *Chelonia mydas* meat were imported into the United States in 1978 (Mack *et al.*, 1981). However, serious concerns have been raised as to whether these activities benefit conservation or are in fact detrimental by removing additional individuals from the wild and creating new markets for turtle products (Dodd, 1981; Ehrenfeld, 1981; Reichart, 1981).

Can turtles be a managed food resource, and can programmes be developed which provide benefits both to human communities and turtle populations? The fact is that many populations are already being harvested on a subsistence and/or commercial basis, and that in many cases controlled utilization programmes may be the only realistic means of promoting conservation. Nevertheless these efforts must be cognizant of the limitations of the harvest potential of turtles due to their life-history characteristics. Perhaps one of the most viable options for turtle management is to encourage the managed use of species on a subsistence basis, but to limit commercial sale. Polisar and Horwich (1994) outlined a managed harvest scheme for *Dermatemys mawii* in Belize based on possession limits, the prohibition of selling turtles, and a short annual closed season when the turtles are nesting. The programme in Belize was greatly aided by the active involvement of the local communities that regularly harvested turtles.

It is apparent that much still needs to be done before we can accurately evaluate the potential of sustained use programmes for turtle conservation. Trial programmes are needed to devise alternative management models and to test their applicability in the field. As it is apparent that in most cases the large-scale commercial harvesting of wild turtle populations is not a viable alternative, programmes should be based on small, community-level projects that involve both cultural and biological components. Particular attention needs to be given to devising simple techniques to ensure adherence to harvest limits, and long-term population monitoring of the turtle populations. As management efforts should, to some degree, be tailored to the individual species being harvested, research on the ecology of these turtles should also be an important component of these trial programmes.

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