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REVIEW PAPER

Reptiles used in traditional folk medicine: conservation implications

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Abstract The present work provides an overview of the global use of reptiles in traditional folk medicine and the implications for conservation. The results demonstrate that at least 165 reptile species belonging to 104 genera and 30 families are used in traditional folk medicine around the world. Some species are used as sources of drugs for modern medical science. Of the reptiles recorded, 53% are included on lists of endangered species, demonstrating the importance of understanding such medicinal uses in the context of reptile conservation as well as the need for considering socio-cultural factors when establishing management plans directed towards the sustainable use of these reptiles.

Keywords Ethnozoology · Reptiles · Traditional medicines · Zootherapy · Wildlife conservation

Introduction

People have relied on medicinal products derived from natural sources for millennia, and animals have long been an important part of that repertoire (Adeola 1992; Anageletti 1992; Lev 2003; Alves and Rosa 2005; Alves et al. 2007a). The pharmacopoeia of folk societies as well as of traditional (such as those of the Chinese, Ayurvedic, Unani) and western medical systems contain thousands of uses for medicines made from leaves, herbs, roots, bark, animals, mineral substances and other materials found in nature (Good 1980; Gesler 1992). Ingredients derived from wild plants and animals are not only widely used in traditional

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remedies, but are also increasingly valued as raw materials in the preparation of modern medicines and herbal preparations. Increased demand and the growth of human populations have led to increased and often unsustainable rates of exploitation of natural resources, and some wild species are already threatened with extinction for this reason (Lee et al. 1998).

Discussions concerning the links between traditional medicine and biodiversity are therefore becoming imperative (Alves and Rosa 2007a), particularly in view of the fact that folk medicine is the source of primary health care for 80% of the world's population (Alves and Rosa 2005). Reptiles are among the animal species most frequently used in traditional folk medicine, and their role in folk practices related to the healing and/or prevention of illnesses has been recorded in different social-cultural contexts throughout the world (Zhou and Jiang 2004; Alves and Rosa 2006, 2007b, c; Mahawar and Jaroli 2006; Vazquez et al. 2006; Alves et al. 2007a; Alves and Pereira-Filho 2007).

Despite the intensive use of reptiles for medicinal purposes, there is a general lack of detailed information concerning the magnitude of this harvesting and its impact on the species involved (Alves and Pereira-Filho 2007). Demands on the wild sources of traditional medicinal products are increasing as human populations grow inexorably and poorer countries are forced to decrease spending per capita on western health systems, while western populations are turning to more traditional and homeopathic products and the demand for natural remedies is increasing among them (IUCN 2000). Additionally, some species are in danger of extinction due to a combination of factors independent of the growing global demand for traditional medicines and other natural products.

The goal of the present work was to provide an overview of the global use of reptiles in traditional medicine, identify those reptile species used as folk remedies, and discuss the implications of their harvesting. In this context, we address the following questions: (1) which reptile species are used in folk medicine; (2) which medicinal species are endangered; and (3) what are the implications of the use of zootherapics for reptile conservation? This study represents the first global review of folk zootherapy and we hope to further stimulate further discussions about this use of biodiversity and its implications for wildlife conservation.

Methods

In order to examine the diversity of reptiles used in traditional medicine, all available references or reports of folk remedies based on reptile sources were examined. Only taxa that could be identified to species level were included in the database. Scientific names provided in publications were updated according to the ITIS Catalogue of Life: 2007 Annual Checklist (http://www.catalogueoflife.org/search.php). The conservation status of the reptile species follows IUCN (2007) (http://www.iucnredlist.org/) and CITES (2007) (http://www.cites.org/eng/resources/species.html).

The sources analyzed were: Branch and Silva (1983), Begossi (1992), Begossi and Braga (1992), Donadio and Gallardo (1984), Figueiredo (1994), China National Corporation of Traditional and Herbal Medicine (1995), Marques (1995), Freire (1996), Costa-Neto (1996, 1999a, b, c, d, 2000a, b, c, 2001, 2005), SEMARNAP-PROFEPA (1998), Begossi et al. (1999), Sodeinde and Soewu (1999), Chen et al. (2000), El-Kamali (2000), Seixas and Begossi (2001), Almeida and Albuquerque (2002), CITES (2002), Kakati and Doulo (2002), Apaza et al. (2003), Lev (2003), Fitzgerald et al. (2004), Silva et al. (2004), Almeida (2005), Andrade and Costa-Neto (2005), Costa-Neto and Pacheco (2005), Smart et al. (2005), Walston (2005), Alakbarli (2006), Alves (2006), Alves and Rosa (2006, 2007b, c),

Alves et al. (2007a, b), Ives (2006), Kakati et al. (2006), Mahawar and Jaroli (2006), Vázquez et al. (2006), Alves and Pereira-Filho (2007), Barzyk (2007), Dharmananda (2007a,b), El Din (2007), Negi and Palyal (2007), Fretey et al. (2007), Highfield and Bayley (2007), Highfield and Slimani (2007), IFAW (2007) and Indian Traditional Medicinal Knowledgebase (2007).

Results and discussion

Medicinal reptiles

Our review revealed that a total of 165 species of reptiles belonging to 104 genera and 30 families are used in traditional folk medicine. The groups with the largest numbers of species used were snakes (60 species), followed by lizards (51), turtles and tortoises (43), and crocodilians (11) (Table 1). The high taxonomic diversity observed among reptiles used in traditional medicine is not surprising, as numerous workers have pointed out that reptiles are among the animals most frequently used in folk medicine (e.g., Branch and Silva 1983; Begossi 1992; Sodeinde and Soewu 1999; El-Kamali 2000; Seixas and Begossi 2001; Almeida and Albuquerque 2002; Kakati and Doulo 2002; Apaza et al. 2003; Silva et al. 2004; Alves and Rosa 2007b, c; Alves et al. 2007a). However, considering the relatively small number of published studies on the subject, we presume that the true number of medicinal reptile species used is greater than that recorded here.

Some widespread species are used in different countries, such as *Crotalus durissus* and *Kinosternon scorpioides* (in Mexico and Brazil), *Varanus niloticus* (in India, Sudan, and China), *V. bengalensis* (in India and China), and *Dermochelys coriacea* (in Brazil, Mexico, Benin, Cameroon, and Togo). A given reptile often has multiple medicinal uses and can be employed to treat more than one ailment, while different reptiles can likewise be used to treat the same illnesses. Products derived from *Tupinambis merianae* and *T. teguixin*, for instance, were indicated for treating 8 and 18 conditions, respectively, in Brazil (Alves and Rosa 2007b); in India, products derived from the Land Monitor (*Varanus bengalensis)* are used to treat hemorrhoids, rheumatism, body pain and burns, as well as spider and snake bites (Kakati et al. 2006); in Mexico, rattlesnake pills have been indicated for curing a wide variety of ailments, including: skin blotches, cancer, sores, rashes, pimples, welts, itching, rheumatism, varicose veins, face blotches, acne, blackheads, stress, heart disease, diabetes, hemorrhoids, and sexual impotence (Rubio 1998).

Despite the fact that technical studies recording the use of reptiles in traditional medicine are all relatively recent, an analysis of historical documents indicated that reptiles have been used in traditional medicines since ancient times (see Silva et al. 2004; Almeida 2005; Alakbarli 2006; Alves et al 2007a). In Brazil, for example, animal species (including reptiles) have been used medicinally by indigenous societies for millennia. During his voyage through the interior of Brazil in the nineteenth century, Von Martius (1939) recorded many natural medicines used by the Amerindian tribes he encountered, such as fresh caiman fat applied to alleviate rheumatism (Costa Neto 2005). Even today, caiman fat (*Cayman latirostris, Melanosuchus niger* and *Paleosuchus palpebrosus*) is used in rural and urban communities to treat rheumatism (Alves and Rosa 2006, 2007b, c). Some examples of reptiles that have been used in Brazil since colonial times include: *Iguana iguana* (Iguanidae), *Caiman latirostris*, *Crotalus durissus*, and *Micrurus ibiboboca*. Similarly, a historical revision of the therapeutic uses of animals as described in medieval manuscripts from Azerbaijan (Alakbarli 2006) revealed a total of 12 species of reptiles with medicinal uses. According to these medieval manuscripts, these reptiles were successfully used to treat ailments that

Table 1 Reptiles used in traditional folk medicine and conservation status according to IUCN (2007) and CITES Appendix (2007)

Family/species

Turtles and tortoises

Cheloniidae (5 spp.): *Chelonia mydas* (Linnaeus, 1758)[VU/I], *Eretmochelys imbricata* (Linnaeus 1766)[EN/I], *Caretta caretta* (Linnaeus 1758)[VU/I], *Lepidochelys olivacea* (Eschscholtz 1829)[EM/I], *Natator depressus* Garman 1880[DD//I]

Dermochelyidae (1 sp.): *Dermochelys coriacea* (Vandelli 1761)[CR/I],

Chelidae (2 spp.): *Phrynops geoffroanus* (Schweigger 1812), *Mesoclemmys tuberculata* (Luederwaldt 1926)

Trionychidae (4 spp.): *Lissemys punctata* Bonnaterre 1789[LR/II], *Pelochelys bibroni* Owen 1853[VU/II], *Pelodiscus sinensis* Wiegmann 1835[VU], *Palea steindachneri* Siebenrock 1906[EN/III]

Chelydridae (1 sp.): *Platysternon megacephalum* Gray 1831[EN/II]

Testudinidae (11 spp.): *Testudo horsfieldii* Gray 1844[VU/II], *T. graeca* Linnaeus 1758[II], *T. kleinmanni* Lortet 1883[CR/I], *Chelonoidis carbonaria* (Spix 1824)[DD/II], *C. denticulata* (Linnaeus 1766)[VU/II], *Geochelone elegans* Schoepff 1795[LR], *Psammobates pardalis* Bell 1828, *Kinixys belliana* Gray 1831, *Indotestudo elongata* Blyth 1854[EN], *I. forstenii* Schlegel and Müller 1844[EN/II], *Manouria impressa* Günther 1882[VU]

Kinosternidae (4 spp.): *Kinosternon scorpioides* Linnaeus 1766, *Kachuga tentoria* Gray 1834[LR], *Kachuga tecta* Gray 1831[LR], *Malaclemys terrapin* Schoepff 1793[LR]

Podocnemididae (4 spp.): *Podocnemis expansa* (Schweiger1812)[LR/II], *P. unifilis* (Troschel 1848)[VU/II], *P. sextuberculata* Cornalia 1849[VU/II], *Peltocephalus dumeriliana* Schweigger 1812[VU/II]

Geoemydidae (11 spp.): *Rhinoclemmys punctularia* (Daudin 1802), *Chinemys reevesii* Gray 1831[EN], *Cuora amboinensis* Daudin 1802[VU], *C. flavomarginata* Gray 1863[EN], *C. trifasciata* Bell 1825[CR], *Leucocephalon yuwonoi* Mccord, Iverson and Boeadi 1995[CR/II], *Sacalia bealei* Gray 1831[EN], *Mauremys mutica* Cantor 1842[EN], *Ocadia sinensis* Gray 1834[EN], *Morenia ocellata* DumÉril and Bibron 1835[VU/I], *Pyxidea mouhotii* (Gray 1862)[EN/II]

Lizards

Phrynosomatidae (5 spp.): *Sceloporus serrifer* Cope 1866, *S. taeniocnemis* Cope 1885, *Phrynosoma cornutum* Harlan 1825, *P. modestum* Girard 1852, *P. orbiculare* Linnaeus 1789

Anguidae (3 spp.): *Abronia lythrochila* Smith and Alvarez Del Toro 1963, *Mesaspis moreletii* Bocourt 1871, *Ophisaurus harti* Boulenger 1899

Scincidae (2 spp.): *Mabuya carinata* Schneider 1801, *Scincus scincus* Linnaeus 1758

Cordylidae (3 spp.): *Cordylus giganteus* Smith 1844[VU/II], *C. tropidosternum* Cope 1869[II], *C. warreni* Boulenger 1908[II]

Helodermatidae (1 sp.): *Heloderma horridum* Wiegmann 1829[VU/II]

Agamidae (8 spp.): *Uromastyx hardwickii* Gray 1827[II], *U. dispar* Heyden 1827[II], *U. aegyptia* Forskal 1775[II], *Agama agama* Linnaeus 1758, *A. impalearis* Boettger 1874, *Calotis versicolor* Daudim 1802, *Laudakia nupta* De Filippi 1843, *Trapelus mutabilis* Merrem 1820

Lacertidae (2 spp.): *Lacerta agilis* Linnaeus 1758, *Zootoca vivipara* Von Jacquin 1787[LR]

Varanidae (5 spp.): *Varanus niloticus* Linnaeus 1758[II], *V. bengalensis* Daudin 1758[I], *V. salvator* Laurenti 1768[II], *V. griseus* Daudin 1803[I], *V. albigularis* Daudin 1802[II]

Teiidae (5 spp.): *Tupinambis merianae* (Duméril and Bibron 1839)[II], *T. teguixin* (Linnaeus 1758)[II], *T. rufescens* (Günther1871)[II], *Ameiva ameiva* (Linnaeus 1758), *Cnemidophorus ocellifer* (Spix 1825)

Iguanidae (1 sp.): *Iguana iguana* (Linnaeus 1758)[II]

Tropiduridae (4 spp.): *Tropidurus semitaeniatus* (Spix 1825), *T. torquatus* (Wied 1820), *T. hispidus* (Spix 1825), *Uranoscodon superciliosus* (Linnaeus 1758)

Table 1 continued

Family/species
Gekkonidae (5 spp.): *Hemidactylus mabouia* (Moreau de Jonnes 1818), *H. frenatus* Schlegel 1836, *Gekko gecko* Linnaeus 1758^{NT}, *G. subpalmatus* Günther 1864, *Tarentola mauritanica* Linnaeus 1758^{LC}
Chamaeleonidae (7 spp.): *Chamaeleo senegalensis* Daudin 1802^{II}, *C. chamaeleon* Linnaeus 1758^{II}, *Furcifer lateralis* (Gray 1831), *Bradypodion dracomontanum* Raw 1976^{II}, *B. nemorale* Raw 1978$^{LR/II}$, *B. setaroi* Raw 1976$^{EN/II}$, *B. thamnobates* Raw 1976$^{LR/II}$
Crocodilians
Alligatoridae (6 spp.): *Caiman latirostris* (Daudin 1801)$^{LR/II}$, *C. crocodilus* (Linnaeus 1758)$^{LR/II}$, *Paleosuchus palpebrosus* (Cuvier 1807)$^{LR/II}$, *P. trigonatus* (Schneider 1801)$^{DD/II}$, *Melanosuchus niger* (Spix 1825)$^{LR/II}$, *Alligator sinensis* Fauvel 1879$^{CR/I}$
Crocodylidae (4 spp.): *Crocodylus niloticus* Laurenti 1768$^{LR/I}$, *C. siamensis* Schneider 1801$^{CR/I}$, *C. porosus* (Schneider 1801), *C. palustris* Lesson 1831$^{VU/I}$
Gavialidae (1 sp.): *Gavialis gangeticus* Gmelin 1789$^{EN/I}$
Snakes
Boidae (11 spp.): *Boa constrictor* Linnaeus 1758^{II}, *Corallus caninus* (Linnaeus 1758)$^{DD/II}$, *C. hortolanus* (Linnaeus 1758)$^{DD/II}$, *Epicrates cenchria* (Linnaeus 1758)^{II}, *Eunectes murinus* (Linnaeus 1758)^{II}, *Python sebae* Gmelin 1789^{II}, *P. regius* Shaw 1802^{II}, *P. molurus* Linnaeus 1758$^{LR/I}$, *P. reticulatus* Schneider 1801^{II}, *Python natalensis* Smith 1840^{II}, *Eryx johnii* Russell 1801^{II}
Viperidae (24 spp.): *Lachesis muta* (Linnaeus 1766), *Crotalus durissus* (Linnaeus 1758)$^{DD/III}$, *C. horridus* Linnaeus 1758, *C. atrox* Baird and Girard 1853, *C. lepidus* (Kennicott 1861), *C. molossus* Baird and Girard 1853, *C. pricei* Van Denburgh 1895, *C. scutulatus* (Kennicott 1861), *C. viridis* Rafinesque 1818, *C. willardi* Meek 1905, *Deinagkistrodon acutus* Günther 1888, *Atropoides nummifer* Rüppell 1845, *Cerrophidion tzotzilorum* Campbell 1985, *Protobothrops mucrosquamatus* Cantor 1839, *Bothrops asper* Garman 1883, *B. leucurus* Wagler 1824, *B. lanceolatus* Lacépède 1789, *Bitis gabonica* Duméril, Bibron and Duméril 1854, *B. arietans* Merrem 1820, *Causus rhombeatus* Lichtenstein 1823, *Agkistrodon contortrix* (Linnaeus 1766), *Gloydius blomhoffi* Boie 1826, *Vipera russelli* (Shaw 1797), *Macrovipera lebetina* (Dwigubsky 1832)
Elapidae (7 spp.): *Bungarus multicinctus* Blyth 1861, *B. fasciatus* Schneider 1801, *Naja atra* Cantor 1842^{II}, *N. annulifera* (Peters 1854), *N. naja* Linnaeus 1758^{II}, *Echis coloratus* Günther 1878, *Ophiophagus hannah* Cantor 1836^{II}
Hydrophiidae (1 sp.): *Hydrophis cyanocinctus* Daudin 1803
Colubridae (17 spp.): *Spilotes pullatus* (Linnaeus 1758), *Ptyas dhumnades* Cantor 1842, *P. mucosus* (Linnaeus 1758)^{II}, *P. korros* Schlegel 1837, *Drymobius margaritiferus* Schlegel 1837, *Dinodon rufozonatum* Cantor 1842, *Lampropeltis triangulum* Lacépède 1789, *Leptophis ahetula* (Linnaeus 1758), *Mastigodryas bifossatus* (Raddi 1820), *Oxyrhopus trigeminus* Duméril, Bibron and Duméril 1854, *Gloydius himalayanus* Günther 1864, *Elaphe taeniura* Cope 1861, *Elaphe carinata* Günther 1864, *Elaphe moellendorffi* Boettger 1886, *E. radiata* Boie 1827, *Enhydris chinensis* Gray 1842, *E. plumbea* Boie 1827

Legends: Categories of IUCN red list: CR—critically andangered, EN—endangered, VU—vunerable, LR—lower risk, DD—deficient data and NE—note evaluated and CITES Appendix (I, II and III)

included sexual impotence and leprosy. Among the species mentioned were indigenous species still found in Azerbaijan, such as the Caucasian agama (*Agama caucasica*), the Levantine viper (*Vipera lebetina*), the Mediterranean tortoise (*Testudo graeca*), and the Moorish gecko (*Tarentola mauritanica*). Exotic reptiles mentioned included the chameleon (*Chameleo chameleo*), the monitor lizard (*Varanus griseus*), and the crocodile (*Crocodylus niloticus*). The medicines prepared from these reptiles were imported into Azerbaijan from distant countries.

Crocodilians, snakes, lizards, turtles, and tortoises serve as important sources protein for human populations around the world, and the consumption of reptile meat is often intertwined with cultural or medicinal beliefs (Klemens and Thorbjarnarson 1995). Likewise, various medicinal species of reptiles are also hunted as food and represent important protein sources for the inhabitants of rural areas (as well as in urban areas where they are often sold), and include *Podocnemis expansa*, *P. unifilis*, *Chelonia mydas*, *Chelonoides denticulata*, *C. carbonaria*, *T. merianae*, *Paleosuchus palpebrosus*, *P. trigonatus*, *Melanosuchus niger*, *Naja naja*, *Bungarus fasciatus*, *Ptyas mucosus*, *P. korros*, among others. Other studies have likewise recorded the use of animal species as foods/medicines (e.g., Alves and Rosa 2006, 2007b; Pieroni et al. 2002; Alves et al. 2007a).

Besides their role in healing, natural products often have magical-religious significance, reflecting the different views of health and disease that exist within different cultures. In this context, animal parts are used to prepare clinical remedies as well as to make amulets or charms used in magical/religious diagnoses. Popular beliefs usually affect the way species are used in zootherapy (Alves and Rosa 2006). One form of spiritual treatment involves the use of amulets containing reptile parts to protect the user from the "evil-eye" or from diseases (Alves and Pereira-Filho 2007). An example is caiman teeth (*C. latirostris*, *M. niger*, and *P. palpebrosus*) used as protection against snake bites.

Alves and Pereira-Filho (2007) reported that snakes are commercialized for medicinal and magic-religious purposes in many Brazilian cities. Various medicinal reptiles are also sold as pets or souvenirs. Large numbers of iguanas (*I. iguana*), for example, are imported to well-established businesses in the United States from El Salvador and other Central American countries and then re-exported for the pet market in Europe and Asia (Gibbons et al. 2000). These multiple uses (including medicinal) of reptiles and their impact on animal populations must be properly assessed (Alves and Rosa 2006, 2007a) and taken into consideration when implementing recovery plans for these species, especially those that are highly exploited.

Traditional drugs, and traditional medicine in general, will require more research and careful evaluations, and it is a well-established fact that many vegetable, animal, and mineral remedies used in traditional settings are capable of producing serious adverse reactions (De Smet 1991; Alves and Rosa 2005). At least 11 cases of serious extra-gastrointestinal infections by *Salmonella arizona* attributed to the ingestion of a rattlesnake folk remedy have been reported remedy (Fainstein et al. 1982; McIntyre et al. 1982; Anon 1983; Riley et al. 1988; Fleischman et al. 1989). As such, it is essential that traditional drug therapies be submitted to appropriate risk/benefit analyses (De Smet 1991).

Unfortunately, little research has been done so far to prove the claimed clinical efficacy of animal products for medicinal purposes (Still 2003). Nevertheless, as pointed out by Pieroni et al. (2002), the chemical constituents and pharmacological actions of certain animal products are known to some extent, but more ethnopharmacological studies focusing on animal remedies are needed in order to better define the eventual therapeutic usefulness of this class of biological remedies. Reptiles are used as sources of drugs for modern medical practices. Reptile venoms are complex mixtures of bioactive molecules (Chen et al. 2006),

and the venom of snakes belonging to the families Viperidae and Elapidae contain analgesic substances that are stronger than morphine and have been used to treat terminal cancer patients (Bisset 1991). These observations are corroborated by Brazil (1934) and Giorgi et al. (1993), who noted that analgesic drugs have been extracted from the venom of *Crotalus durissus*. Batroxobin, extracted from the venom of *Bothrops atrox*, has been found to have significant therapeutic effects on ischaemic-reperfused rats in vivo clinical trials, and batroxobin, as well as ancrod, are currently being commercially produced. Three other thrombin-like enzyme preparations are also commercially available: reptilase, crotalase, and an enzyme derived from *Agkistrodon contortrix* (Bell 1997). However, wider clinical use of thrombin-like enzymes has been impeded by immunologic reactions in patients, limited availability of snake venoms, as well as high production costs (Warkentin 1998). As pointed by Alves and Rosa (2006), further ethnopharmacological studies are necessary to increase our understanding of the links between traditional uses of faunistic resources, public health policies and sustainable management of natural resources.

It is important to note that behind the perceived efficacy by users, the popularity of animal-based remedies is influenced by cultural aspects, the relations between humans and biodiversity in the form of zootherapeutic practices are conditioned by the social and economic relations between humans themselves. The traditional medicine is widely available and affordable, even in remote areas, and generally accessible to most people. In many developing countries, a large part of the population, especially in rural areas, depends mainly on traditional medicine for their primary health care, because it is cheaper and more accessible than orthodox medicine (Sofowora 1993; Luoga et al. 2000; World Health Organization 2002; Alves et al. 2007a). Traditional medicine is also more acceptable because it blends readily into the peoples' socio-cultural life (Tabuti et al. 2003). Nazarea et al. (1998) highlight that social, economic and cultural factors play a large role in determining how individuals and communities use natural resources. Furthermore, it has been documented that people sometimes resort to traditional home remedies as a means of resisting urban modern medicine (Boltanski 1977) and of asserting their traditional culture (Ngokwey 1995).

The present review indicated that the medicinal use of reptiles is important to both urban and rural populations, and it is in agreement with Alves and Rosa (2007b, c) who reported the use of these animal resources in both rural and urban areas. These authors suggested that zootherapeutic practices may function as a social conduit that (in conjunction with other factors) helps rural populations that have migrated to cities to maintain connections with their traditional cultures and values. More specifically, the use of folk remedies indicates an exchange of materials and information on illnesses and treatments between remote rural areas and urban communities.

The commercialization of reptiles for medicinal purposes has been reported from many parts of the world (e.g., Franke and Telecky 2001; Fitzgerald et al. 2004; Zhou and Jiang 2004; Alves and Pereira-Filho 2007). In several Brazilian cities, for example, snakes are widely traded in outdoor markets (that can even have designated stalls for medicinal animals and plants) or in small stores specifically dedicated to this activity (Alves and Pereira-Filho 2007; Alves and Rosa 2007c; Alves et al. 2007a). In Mexico, natural and traditional remedies derived from reptiles (such as dried rattlesnakes, rattlesnake pills, and rattles) are frequently offered for sale (Fitzgerald et al. 2004). Turtles, snakes, and lizards (especially monitors and geckos lizards) are widely hunted and traded in Viet Nam for food and as traditional medicines (Compton and Le Hai Quang 1998; Hendrie 2000; Jenkins 1995; Le and Broad 1995; Lehr 1997; Li and Wang 1999; Martin 1992; Nash 1997; Ziegler 2002; Stuart 2004). He and Peng (1999) reported that the quantity of snakes consumed in the markets of

Guangzhou, Guangdong Province of China was about 1.4×10^7 kg each year. From 1990 to 1995, the annual demand for wild snakes from 13 factories producing traditional Chinese medicines (TCM) included 1,656.77 kg of *Zaocys dhumnades*, 234.75 kg of *Deinagkistrodon acutus*, and 20,300 heads and 32.1 kg of *Bungarus multicinctus* (Zheng and Zhang 2000). These examples illustrate the urgent need to increase our knowledge concerning the harvesting and trading of reptiles in traditional medicine and to assess the impacts caused by this commercial exploitation.

Implications for conservation

Reptile populations are being seriously reduced throughout the world. Factors responsible for these observed declines include the alteration, destruction, or fragmentation of habitat, climate change, disease, impacts from non-indigenous species, ultraviolet radiation, and xenobiotic chemicals (Gibbons et al. 2000). In addition, reptile populations are heavily harvested for human use. The observed population decreases due to human harvesting may be due to the direct physical removal of these animals or to collection techniques that destroy the habitats used by these reptiles.

The collection of individual animals from the wild for subsistence or commercial purposes has been invoked as a factor contributing to the decline of certain species (Gibbons et al. 2000), although there has not yet been a comprehensive evaluation of this potential link. However, the popularity of folk medicine certainly places pressure on these natural resources (Almeida and Albuquerque 2002).

Our results demonstrate that a substantial number of reptile species (165) are used in traditional medicine throughout the world and that the vast majority of these animals are collected from the wild. Of the reptiles used, 88 (53%) are already included on endangered species lists. The trade of medicinal reptiles in urban areas (Zheng and Zhang 2000; Franke and Telecky 2001; Fitzgerald et al. 2004; Zhou and Jiang 2004; Alves and Pereira-Filho 2007; Alves and Rosa 2007c) represents an important factor for their over-exploitation. Of the species catalogued in this study, 71 (43%) are included in on oh three CITES Appendices (see Table 1), although the reasons for their inclusion are not necessarily related to medicinal use. These results demonstrate the need to assess the implications of the trade of reptile used in traditional medicines on their wild populations, and the need for including such uses in discussions of reptile conservation.

The commercialization of animals for medicinal purposes is a widespread phenomenon, with significant implications for their conservation and sustainable use (Alves and Rosa 2005). The demand for live snakes (and their body parts) for use in traditional medicine appears to have led to significant reductions in their populations in certain parts of the world (Fitzgerald et al. 2004). Field reports have indicated the southeastern Asian medicinal trade as a growing threat to reptiles, especially turtles and snakes (Klemens and Thorbjarnarson 1995). More than one-half of all freshwater tortoise and turtle species from southeast and eastern Asia are currently endangered or critically endangered, largely because of over-collection by the food and traditional medicine industries (Jenkins 1995; Klemens and Thorbjarnarson 1995; Van Dijk et al. 2000; Turtle Conservation Fund 2002). The high demand for crocodile skins, meat, and body parts for traditional medicine have certainly contributed to the observed decline in their populations in Nigeria (Ita 1994), as has the demand for live rattlesnakes, skins, and body parts reduced the populations of these reptiles in Mexico (Fitzgerald et al. 2004).

It must be emphasized, however, that many factors affect reptilian populations in the world, and the use of these animals for medicinal purposes is only part of the problem.

As such, the medicinal use of reptiles must be considered together with other anthropogenic pressures, such as habitat loss. The depletion of medicinal resources not only poses a challenge for conservation but represents a serious threat to the health of many human communities, and that efforts to stabilize the status of these species are important not only to conservationists but to millions of people whose health depends of the use of traditional remedies.

Habitat loss and landscape alterations are potential treats to the survival of many potential valuable medicinal animals. Environmental degradation also affects users of traditional medicine, both by limiting their access to the resources traditionally used and by extirpating from their community the knowledge base upon which traditional medicine is constructed (Anyinam 1995). This calls for an urgent action to document and preserve the traditional medical knowledge before it disappears. Despite the importance of traditional medicine for public health in many parts of the world, like the current spasm of plant and animal species extinction, the practitioners of ethnomedicine (especially herbalists and cult healers) appear to be at a greater risk of extinction than even forests and other biomes. The destruction of tropical forests has meant, in many parts of the tropical region, increasing disappearance of native peoples who have been living in these areas and who have accumulated a compendium of folk knowledge about the usefulness of plants for curing various diseases (Anyinam 1995). Such documentation is necessary because old people are usually the only custodians of such information, and the fast disappearance of traditional culture and natural resources arising from urbanization and industrialization of such areas suggests that unrecorded information may be lost forever. And even prior to cultural extinction, the accompanying process of acculturation leads to significant changes and/or losses of culturally encoded information.

The therapeutic indications of wild animals and plants and domestic or cultived species also overlapped in many cases. This aspect opens the possibility of, where suitable, replacing the use of threatened species with others in traditional medicine recipes. Such replacement of products is of interest from a conservationist perspective, in the context of reducing the pressure on overexploited populations, or legally protected species (Alves and Rosa 2007a). However, replacement of ingredients in remedies should be done with caution, because as pointed by Sodeinde and Soewu (1999), substitutes may not always be feasible because recipes using different species may not have the same efficacy, nor may it be advisable without a thorough examination into the sustainability of utilizing substitute species to ensure the viability of any such exploitation. Additionally, consumers sometimes prefer wild versions. Precaution should also be taken when suggesting the replacement of animal products with plants to ensure the survival of the medicinal animal species (Alves and Rosa 2007a).

Various authors (Marques 1995; Almeida and Albuquerque 2002; Alves and Rosa 2005, 2006, 2007a, b, c; Alves et al. 2007a) have discussed the conservation implications of the use of medicinal products derived from wild animal species. However, many traditional medicinal systems, such as Chinese Traditional Medicine, are recognized by the World Health Organization (WHO) and are accepted and used by one-fourth of the world's population (Alves and Rosa 2005). As such, any reliance on traditional medicinal uses of animals must be addressed when designing biodiversity conservation strategies (Alves and Rosa 2006). Celso (1992) pointed out that natural medicine is one important use of biodiversity, while Begossi (1992) suggested that a certain degree of animal conservation might be occurring precisely because of their medicinal use by local populations.

The manner in which natural resources are used by human populations and cultural norms associated with that use are extremely relevant to the definition of possible conservation

strategies. Gibbons et al. (2000) have pointed out that the use of reptiles is an integral part of many cultures, and the present study has demonstrated that reptiles play an important role in healing practices throughout the world and that the implications of this use must be discussed when considering conservation efforts. As such, the medicinal use of threatened species should be further investigated and amply discussed by all relevant stakeholders, and the socio-cultural aspects of this use must respected when establishing management plans aimed at the sustainable use of medicinal reptiles.

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