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The Relations Among Threatened Species, Their Protection, and Taboos

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ABSTRACT

We analyzed the role of taboos for the protection of species listed as "threatened" by the World Conservation Union (IUCN), and also for species known to be endemic and keystone. The study was limited to taboos that totally avoid or prohibit any use of particular species and their populations. We call them *specific−species taboos* . Through a literature review, 70 currently existing examples of specific−species taboos were identified and analyzed. The species avoided were grouped into biological classes. Threat categories were determined for each species, based on the IUCN Red Data Book. We found that ~ 30% of the identified taboos prohibit any use of species listed as threatened by IUCN. Of the specific−species taboos, 60% are set on reptiles and mammals. In these two classes, ~ 50% of the species are threatened, representing all of the threatened species in our analysis, with the exception of one bird species. Both endemic and keystone species that are important for ecosystem functions are avoided by specific−species taboos. Specific−species taboos have important ecological ramifications for the protection of threatened and ecologically important populations of species. We do not suggest that specific−species taboos are placed on species because they are, or have been, endangered; instead, we emphasize that species are avoided for a variety of other reasons. It is urgent to identify and analyze resource practices and social mechanisms of traditional societies, such as taboos, and to investigate their possible ecological significance. Although it may provide insights of value for conservation, not only of species, but also of ecosystem processes and functions, such information is being lost rapidly.

KEY WORDS: endemic species; keystone species; nature conservation; taboos; threatened species; traditional societies.

INTRODUCTION

Taboos represent unwritten social rules that regulate human behavior. Such constraints not only may govern human social life, but also may affect, and sometimes even directly manage, many constituents of the local natural environment. Whatever the reason for such constraints, taboos may, at least locally, play a major role for the conservation of natural resources, species, and ecosystems (Johannes 1978, 1982, 1984 *a*, *b*, Chapman 1985,

1987, Gadgil 1987, Gadgil et al. 1993). There are critics who view the practice of taboos as irrational and a hindrance toward development (Edgerton 1992), who dismiss any ecological reasons behind them (Rea 1981), or who argue that the taboos may not be adhered to by some groups and, consequently, may be of no value in nature conservation (Alvard 1993, 1994).

In contrast, Berkes et al. (1995) describe social restraints, such as taboos, that lead to indigenous biological conservation. These restraints include providing total protection to some biological communities, habitat patches, and certain selected species, as well as protection of other species during critical stages of their life history.

Taboos related to the natural environment initially may not have been intended for nature conservation. For example, species may be avoided because of their behavioral patterns and morphological characteristics (Zann 1983), or in the belief that they are toxic (Begossi 1992, Begossi and de Souza Braga 1992). Human perception of, and relation to, species may govern which ones to avoid. Species may be avoided simply because they occur in creation myths, because they represent religious symbols, or because they are pet animals. For example, several species associated with different gods and godesses in the Hindu scripture are sacred among Hindus. Thus, world view and cosmology may explain why species are culturally avoided.

In many cases, nonintentional nature conservation may be the outcome of such an avoidance, which may be highly adaptive in ecological terms. Good examples are taboos associated with particular habitat patches, known as *sacred groves*. Sacred groves are smaller or larger ecosystems, set aside for religious purposes (Gadgil and Vartak 1974). These habitat patches, once widespread throughout India, Africa, and Europe (Frazer 1922), may be the only primary forests remaining locally (Gadgil and Vartak 1974, Dorm−Adzoby et al. 1991, Wilson 1993). The same type of sacred habitats can be found in South America, for example, among the Kunas of Panama (Chapin 1991), the Cocnucos and Yanaconas of Colombia (Redford and Maclean Stearman 1993), and the Tukanos of the Brazilian−Colombian border (Chernella 1987). Under current rates of deforestation and species loss, sacred groves are becoming ecologically important. They may buffer against the depletion of genetically adapted local variants and overall biodiversity in a region. They can serve as important recruitment areas to surrounding ecosystems. Hence, culturally defined taboos may play an increasingly important role for biodiversity conservation on a local and regional level.

Taboos resemble mechanisms for the protection of species and habitats in contemporary society, but they have other social rules and sanctions, rooted in the traditional belief systems. Ecologically oriented anthropologists have revealed the complex ecological adaptations behind taboos (Rappaport 1967, 1968, Harris 1979, Balée 1985). For example, Harris (1971) suggested that the taboo on the Indian cattle is ecologically adaptive, in that it increases rather than decreases the capacity of the present Indian system of food production to support human life, through the production of milk, dung, and bullocks.

Taboos have also been a social mechanism in the management of natural resources, as documented in several studies. Among traditional societies in Oceania, it was customary to impose taboos on the use of subsistence crops to prevent their being harvested at inappropriate times (Chapman 1985, Child and Child 1993). Taboos were also imposed on certain marine locations in order to avoid overexploitation of aquatic resources (Johannes 1978, Chapman 1985). These taboos were not always permanent in time and space, but could be removed when food resources were plentiful. Such taboos that directly manage nature are reportedly found among traditional groups from various parts of the world (Reichel−Dolmatoff 1971, 1976, Kwapena 1984, Sarkar 1984, Begossi 1992, Sankhala 1993). They may have been the outcome of a trial−and−error process of resource management strategy resembling the contemporary practice of adaptive management (see Holling 1978, Walters 1986). For example, Berkes (1997) argues that periods of mismanagement of North American caribou among the Cree in the 1900s resulted, in part, from a neglect of traditional hunting rules. After a change in Cree hunting behavior, the caribou population returned to previous levels. In the same manner, taboos may be employed as a social mechanism for the enforcement of ecologically adaptive behavior, even though different cultural contexts are attached to them.

In this paper, we focus on what role taboos may have for the protection of threatened species. Thus, we are concerned with taboos that are directly set on particular species for various reasons. Most anthropologists refer to

taboos on species as "food taboos" or "food avoidances," stressing the anthropocentric function of species as food. A division is often made between *general*;and *specific*;food taboos, where the former is observed by all members in a human group, and the latter by particular segments in the population at particular times (Rea 1981).

It is tempting to regard specific food taboos as mechanisms in a resource management strategy, since they regulate the exploitation of species to a greater or lesser extent (McDonald 1977). Certain food sources may be forbidden to women during childbirth, children under a particular age, or parents of newborns. Thus, strains on a target resource may be greatly reduced. There is probably no single theory explaining why people employ specific food taboos. Possible ecological relations behind specific food taboos are often neglected by anthropologists, but should not be ruled out. In a study among South American tropical groups, McDonald (1977) found a positive correlation between environmental conditions and the number of specific food taboos imposed on game animals by different human groups. The increase in such taboos among some groups could be explained by the increased need for conservation in less productive natural environments.

General food taboos, on the other hand, comprise a total prohibition of species as food at all times. Here, we call such taboos *specific−species taboos*, stressing that species may be avoided not only as foods, but also for a variety of other plausible reasons. Such taboos totally protect animals and plants, both in time and space, by prohibiting their killing and detrimental use by all members of a human community. At least in theory, this total prohibition may be of direct value in protecting threatened, and perhaps ecologically critical, species. In this study, we will analyze such a relationship using information from several different case studies. As far as we know, no previous study has provided a synthesis of the relations between threatened species, their protection, and taboos.

METHODS

Through an extensive literature search, we have gathered information on presently existing specific−species taboos. Many ethnographic accounts describe taboos among traditional peoples, but very few deal with taboos in an ecological context. Most accounts of taboos have been published in anthropology; many of these concern already extinct human populations (Frazer 1922), or groups that have lost their traditional practices through a loss of political autonomy. In general, ecological considerations of traditional societies are missing from most ethnographic accounts. Among the indigenous groups described in those studies, there may have been no relationships between taboos and species, or they may have escaped the eye of the observer.

We limited our selection of sources to those between 1978 and 1994. Because current scientific documentation of specific−species taboos is scarce, our samples could not be selected randomly. We had to select studies in which such data existed. Therefore, it is awkward to draw any general conclusions from results conveyed here. In this synthesis, we have only focused on particular threatened species. Although we found information on taboos that prohibit the use of whole phyla and families, we could not use it unless particular species were referred to in the sources.

Populations of particular species documented as being avoided by specific−species taboos were grouped in biological classes to determine what types of species are most widely abstained from. Species avoided by taboos were compared with species listed as threatened, according to the World Conservation Union. Sources used for this comparison were the *1994 IUCN Red List of Threatened Animals* (Groombridge 1993) and the *Encyclopedia of Endangered Species* (Emanoil 1994). The species were registered using their IUCN index status. The following threatened−species categories have been employed (see Groombridge 1993):

Extinct (Ex) . Species not definitely located in the wild during the past 50 years.

Endangered (E) . Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so

drastically reduced that they are deemed to be in immediate danger of extinction. Also included are taxa that may be extinct but have definitely been seen in the wild in the past 50 years.

Vulnerable (V) . Taxa believed likely to become "Endangered" in the near future if the causal factors continue operating. Included are taxa of which most or all populations are decreasing because of overexploitation, extensive habitat destruction, or other environmental disturbance; taxa with seriously depleted populations whose ultimate security has not yet been assured; and taxa with populations that are still abundant, but are under threat from severe, adverse factors throughout their range.

Rare (R) . Taxa with small world populations that are not at present "Endangered" or "Vulnerable," but are at risk. These taxa are usually localized within restricted geographical areas or habitats, or are thinly scattered over a more extensive range.

Indeterminate (I) . Taxa *known* to be "Endangered," "Vulnerable," or "Rare," but for which there is not enough information to assign the appropriate category.

Insufficiently known (K) . Taxa that are *suspected*, but not definitely known, to belong to any of the above categories, because of lack of information.

Threatened (T) . Threatened is a general term to denote species that are "Endangered," "Vulnerable," "Rare," "Indeterminate," or "Insufficiently Known." It should not be confused with the use of the same term by the U.S. Office of Endangered Species.

Commercially threatened (CT) . Taxa not currently threatened with extinction, but most or all of whose populations are threatened as a sustainable commercial resource, or will become so, unless their exploitation is regulated.

We estimated the proportion of threatened species avoided out of the total number of avoided species, and did additional research to determine whether specific−species taboos are set on endemic and keystone species.

RESULTS

We found 15 publications in which there were linkages between specific−species taboos and threatened species (for references, see Table 1). From this material, 70 specific−species taboos were identified. Table 1 presents our findings on what types of species are avoided, what human groups avoid them, and to which IUCN threat category each species belongs.

TABLE 1. A comparison between avoided and threatened species.

No.	Species	Popular name[a]	Cultural group/locality[b]	IUCN status[c]
PLANTS				
1	*Ficus religiosa*	peepal tree	Among Hindu castes, India (2)	−
2	*Aegle marmelos*	bel tree	Among Hindu castes, India (3)	−

3	*Curcurbita foetidissima*	wild gourd	Pima Bajo of Sonoran desert, USA/Mexico (4)	−
4	*Curcurbita digitata*	wild gourd	Pima Bajo of Sonoran desert, USA/Mexico (4)	−
5	*Prospis cinerarea*	khejri tree	Bisnois, Rajasthan, India (14)	−
MOLLUSCS				
6	*Tympanotonus fuscatus*		Inhabitants of Djange lagoon, Ghana (5)	−
FISHES				
7	*Gymnothorax* spp.	moray	Inhabitants of Buzios Island, Brazil (6)	−
8	*Raja cycclophora*	ray	Inhabitants of Buzios Island, Brazil (6)	−
9	*Myliobates* sp.	ray	Inhabitants of Buzios Island, Brazil (6)	−
10	*Dasyatis* sp.	ray	Inhabitants of Buzios Island, Brazil (6)	−
11	*Auxis* sp.	mackerel	Inhabitants of Buzios Island, Brazil (6)	−
12	*Euthynnus alleteratus*	tunny	Inhabitants of Buzios Island, Brazil (6)	−
13	*Adubefduf saxatilis*	sargeant major	Inhabitants of Buzios Island, Brazil (6)	−
14	*Practocephalus hemiliopterus*	sheat−fish pirara	Fishermen from Tocantins River, Brazil (7)	−
15	*Pomatotrygon motoro*	ray	Fishermen from Tocantins River, Brazil (7)	−
16	*Pomatotrygon hystrix*	ray	Fishermen from Tocantins River, Brazil (7)	−
17	*Disceus thayeri*	ray	Fishermen from Tocantins River, Brazil (7)	−
REPTILES				
18	*Tupinambis teguixin*		Inhabitants of Buzios Island, Brazil (6)	−
19	*Kinosternon oaxacae*	Oaxaco mud turtle	Pima Bajo, Papago, Yuman speakers (USA/Mexico) (4)	I
20	*Chelonia mydas*	green sea turtle	Inhabitants of Buzios Island, Brazil (6)	E
21	*Naja oxiana*	Oxus cobra	Receives local protection in vicinity of temples in India	K

			(2)	
22	*Melanosuchus niger*	black caiman	The Piro of Amazonian Peru (8)	V
23	*Heloderma suspectum*	Gila monster	Riverine Pima, Papago (USA/Mexico) (4)	V
24	*Dipsosaurus dorsalis*	desert iguana	Riverine Pima, Papago (USA/Mexico) (4)	−
25	*Sauromalus obesus*	chuckwalla	Papago (USA/Mexico) (4)	−
BIRDS				
26	*Egretta ardesiaca*	Black Heron	Inhabitants at the Sakumo lagoon, Ghana (5)	−
27	*Columba livia*	Blue Rock Pigeon	Rural parts of Bangladesh (2)	−
28	*Amblyornis macgregoriae*	MacGregor's Bowerbird	Kewabi−speaking people, Southern Highland Province, Papua New Guinea (9)	−
29	*Astrapia stephaniae*	Black Long−tailed Bird of Paradise	Among the Kumbebe people of Papua New Guniea (9)	−
30	*Paradise raggiana*	Raggiana Bird of Paradise	The Mailu people of Amazon Bay, Papua New Guinea (9)	−
31	*Meleagris gallopavo*	Turkey	Papago (USA/Mexico) (4)	−
32	*Geococcyx californianus*	Roadrunner	Riverine Pima, Papago, Seri (USA/Mexico) (4)	−
33	*Bubo virginianus*	Great Horned Owl	Riverine Pima, Papago, Western Apache (4)	−
34	*Corvus* spp.	Raven	Papago, Seri, Western Apache (4)	−
35	*Pavo muticus*	Green Peafowl	Talminadu, Rajasthan, Gujarath (India) (2)	V
36	*Pitylus grossus*	Slate−colored Grosbeak	Achuar of Ecuador/Peru (15)	−
MAMMALS				
37	*Gorilla gorilla*	gorilla	Edo state, Nigeria (13)	V
38	*Colobus polykomos*	black and white colobus	Inhabitants of Boabeng and Fiema, Ghana (12)	V
39	*Cercopithecus campbelli*	mona monkey	Inhabitants of Boabeng and Fiema, Ghana (12)	−
40	*Cebus capucinus*	spider monkey	Achuar of Ecuador (15)	−

41	*Pan troglodytes*	chimpanzee	Edo state, Nigeria (13)	V
42	*Papio* spp.	baboon	Edo state, Nigeria (13)	−
43	*Erythrcebus patas*	Patas monkey	Edo state, Nigeria (13)	−
44	*Citellus* spp.	ground squirrel	Riverine Pima, Maricopa, Western Apache (4)	−
45	*Thomomys umbrinus emotus*	southern pocket gopher	Riverine Pima, Papago, Maricopa (4)	R
46	*Perognathus alticola*	white−eared pocket mouse	Riverine Pima, Papago, Maricopa (4)	V
47	*Peromyscus* sp.		Riverine Pima, Papago, Maricopa (4)	−
48	*Dipodomys gravipes*	San Quintin kangaroo rat	Riverine Pima, Papago (4)	E
49	*Dipodomys microps leucotis*	houserock chisel−toothed kangaroo rat	Riverine Pima, Papago (4)	K
50	*Erethizon dorsatum*	porcupine	Riverine Pima, Maricopa, Yuman speakers (4)	−
51	*Hydrochoerus capybara*	capybara	Ka'apor Indians, Brazil (10), Achuar of Ecuador/Peru (15)	−
52	*Canis latrans*	coyote	Reverine Pima, Pima Bajo, Papago, Seri, Maricopa (4)	−
53	*Canis aureas*	jackal	Bisnois of the Thar desert, Rajasthan, India (14)	−
54	*Canis lupus*	grey wolf	Bisnois of the Thar desert, Rajasthan, India (14)	V
55	*Vulpes macrotes*	kit fox	Riverine Pima, Papago, Maricopa, Western Apache (4)	−
56	*Urocyon cinereoargentus*	North American fox	Riverine Pima, Papago, Maricopa, Western Apache (4)	−
57	*Ursus americanus*	black bear	Papago, Maricopa, Western Apache (4)	−
58	*Tremarctos ornatus*	spectacled bear	Achuar of Ecuador/Peru (15)	V
59	*Taxidea taxus*	badger	Papago, Maricopa (4)	−
60	*Mephitis* spp.	skunk	Riverine Pima, Papago, Seri, Maricopa, Yuman speakers (4)	−
61	*Panthera tigris*	tiger	Receives local protection in the vicinity of temples in India (2)	E
62	*Felis concolor*	puma	Maricopa, Yuman speakers (4)	E

63	*Lynx rufus*	bobcat	Maricopa, Yuman speakers (4)	−
64	*Pecari tajacu*	peccary	Yuman speakers, Western Apache (4)	−
65	*Tapirus bairidii*	Central American tapir	Coshiro−wa−teri of Brazil/Venezuela; Achuar of Ecuador (11)	V
66	*Myrmecophaga tridactyla*	giant anteater	Coshiro−wa−teri of Brazil/Venezuela; Achuar of Ecuador (11)	V
67	*Pridontes maximus*	giant armadillo	Achuar of Ecuador/Peru (15)	V
68	*Cholopeus hoffmani*	two−toed sloth	Achuar of Ecuador/Peru (15)	−
69	*Antilope cervicapra*	blackbuck	Bisnois of the Thar deser, Rajasthan, India (14)	V
70	*Mazama americana*	red brocket deer	Achuar of Ecuador/Peru (15)	−

[a] Blank cells indicate that no popular name in English is specified.

[b] Sources of information: 1, Chapman (1985); 2, Gadgil (1987); 3, Ramakrishnan and Patnaik (1992); 4, Rea (1981); 5, Ntiamoa−Baidu (1991); 6, Begossi (1992); 7, Begossi and de Souza Braga (1992); 8, Alvard (1993); 9, Kwapena (1984); 10, Balée (1985); 11, Ross (1978); 12, Fargey (1992); 13, Osemeobo (1994); 14, Sankhala (1993); 15, DeScola (1986).

[c] IUCN status: E, endangered; I, indeterminate; V, vulnerable; K, insufficiently known; R, rare; −, no threat.

As indicated in Table 2 , the major class most frequently avoided is mammals, representing about half of the total number of species avoided in this study. Birds, fishes, and reptiles are more frequently avoided than plants and molluscs, and a number of classes of species are not avoided at all.

TABLE 2. Class distribution of avoided and threatened species.

	Plants	Molluscs	Fishes	Reptiles	Birds	Mammals	Total
Number of particular species avoided in each class:	5	1	11	8	11	34	70
Number of species listed as threatened by the IUCN:	0	0	0	5	1	15	21
Proportion of avoided species that are threatened:	0	0	0	0.62	0.09	0.44	0.30

Out of the 70 examples of species avoided under specific−species taboos, 21 are found in the *1994 IUCN Red List of Threatened Animals* and the *Encyclopedia of Endangered Species* (Emanoil 1994). That is, 30% of the species avoided are listed as "threatened." The distribution falls into the following IUCN threat categories: four species are listed as *endangered (E)*, 13 as *vulnerable (V)*, one as *rare (R)*, one as *indeterminate (I)*, and two as

insufficiently known (K). Thus, the situation for many of these avoided species is indeed critical. Out of these 21 threatened species, we found that at least four are recognized by ecologists as *endemic* (nos. 19, 45, 48, and 49 in Table 1).

Furthermore, of the total number of avoided species in this study, five are considered *keystone* by ecologists (nos. 1, 45, 48, 49, and 62). Paine (1966, 1969) first used the term "keystone" for species that play a major role in the structure, dynamics, and stability of an ecosystem. He demonstrated how removal of a keystone predator (starfish) changed the species composition and lowered species richness. Although the concept's relevance is debated (e.g., Mills et al. 1993), such species or groups of species seem to play an important role in ecosystem processes and functions (Naeem et al. 1994, Tilman and Downing 1994, Holling et al. 1995). Of course, they need not be "rare," "endangered," or "threatened," but contribute to functional diversity and maintain habitats for species that are threatened (Folke et al. 1996).

In our samples, the estimated ratio of threatened species avoided to the total number of species avoided within each class reveals that reptiles constitute the class with the highest ratio (62%), followed by mammals (44%). In these two classes, ~ 48% of the total number of species are threatened. Among birds, only one species is listed as "threatened" (no. 35, Table 1). The threatened species in this study are confined to tropical and subtropical regions, mainly in Central and South America, Africa, and India (see Table 1). They represent ~ 1.6% of the threatened reptiles worldwide and ~ 2.6% of the world's threatened mammals.

DISCUSSION

We found 70 species that were avoided by different human groups through specific−species taboos. About 30% of these taboos prohibit the use of threatened species, predominantly threatened reptiles and mammals. Given the limited number of studies available on which to base this analysis, what can be said about the link between threatened species and taboos, and between taboos, traditional societies, and species conservation in general?

Threatened, endemic, and keystone species

This analysis indicates that many specific−species taboos have the ability to protect threatened species. All of the endemic species protected by specific−species taboos, and all except one keystone species in this study, are listed as threatened by IUCN (Table 1). Although it may be impossible to quantify to what extent taboos protect species, it must be recognized that many traditional human groups offer *temporal* and *spatial refugia* to threatened and ecologically viable species in different ways. Such species may hide, forage, and reproduce in the vicinity of the local groups that abstain from their utilization.

From this study it appears that avoidance of species occurs in two ways, either through (1) the belief system of culturally isolated human populations (local avoidance), or (2) the sharing of belief systems throughout larger cultural regions (regional avoidance). The taboo on the green sea turtle, *Chelonia mydas*, (no. 20, Table 1) constitutes an example of local avoidance, because the specific−species taboo is locally restricted to the people of Buzios Island in Brazil. The taboo on the oxus cobra, *Naja oxiana* (no. 21), is an example of avoidance in particular sites over a large region, in this case, India. The cobra is protected in or near small forest patches dedicated to serpent deities, located in the vicinity of temple sites.

Threatened species occupying a narrow geographical range or only one or a few specialized habitats benefit from taboos imposed by local groups. Threatened species occurring in small populations throughout a wide range may also benefit from local specific−species taboos. Such taboos may protect habitats that serves as important refugia and recruitment sites.

A precondition for successful protection of threatened species and their habitats is that local human groups have access and control over their local resource areas, with rights to exclude outsiders (Hanna et al. 1996). Many indigenous groups, despite having small populations, may indeed control very large resource areas. The Achuars of Ecuador and Peru, with a population density of only 0.17 persons/km ^{2}, have access to an area greater than Corsica, 9000 km ^{2} (DeScola 1986). Threatened species such as the spectacled bear *Tremarctos ornatus* (no. 58), the giant anteater *Myrmecophaga tridactyla* (no. 66), and the giant armadillo *Priodontes maximus* (no. 67 of Table 1) receive protection by taboos imposed by the Achuars within this area. Thus, a specific−species taboo may have greater than the immediately recognized local effect if species are protected throughout vast habitats.

Among the 21 threatened species, four are endemic, i.e., confined to a very small range or to one particular region, not occurring naturally elsewhere (Primack 1993). For example, the mud turtle *Kinosternon* (no. 19 in Table 1) is totally avoided by three Sonoran desert tribes (see Rea 1981). These tribes have access to one of the thinly scattered localities where this species thrives. Other endemic populations of threatened species avoided include the southern pocket gopher *Thomomys umbrinus emotus* (no. 45), endemic to New Mexico, United States; the San Quintin kangaroo rat *Dipodomys gravipes*(no. 48), only found in Mexico; and the houserock chiseltoothed kangaroo rat *Dipodomys microps leucotis* (no. 49), which is restricted to Arizona, United States (Groombridge 1993). We believe that the specific−species taboos set on these species are highly effective for their protection.

Taboos protect not only threatened and endemic species, but also keystone species. A closer look at Table 1 shows that at least five of the 70 avoided species are recognized by ecologists as keystone. For example, the peepal tree *Ficus religiosa* (no. 1) is classified as a "keystone mutualist" for the maintenance of tropical biological diversity (Gilbert 1980, Terborgh 1986). This species is widely protected all over India (Gadgil 1987). Among vertebrates, the southern pocket gopher *Thomomys umbrinus emotus* (no. 45) is classified as an "earth−mover" keystone by Huntly and Inouye (1988). "Earth−movers" are important in that they move large quantities of earth and they burrow, scrape, or otherwise create bare areas free of plants (Bond 1993). Also, the two species of *Dipodomys* included in this study (nos. 48 and 49), are regarded as effective "keystone predators" in the North American deserts. They affect composition of the plant community, thereby indirectly affecting ant and bird densities (Bond 1993). These rodent species prey on large−seeded plants that would otherwise competitively reduce the abundance of small−seeded plants (Brown et al. 1986, Brown and Heske 1990, Thompson et al. 1991). The threatened puma *Felis concolor* (no. 62) is considered a keystone predator. Being a carnivore, it preys upon vertebrates that feed on tree species with large seeds. Thus, pumas may control forest composition by favoring large−seeded tree species on behalf of small−seeded species (Terborgh 1988).

Taboos, indigenous groups, and species conservation

As many as 62% of the avoided reptiles and 44% of the mammals in our analysis are threatened, showing the important role that traditional peoples may play in their protection. Taboos may be an important factor for some vertebrates not yet extinct. In fact, no one knows how many of the world's species owe their survival to human groups that have avoided using them.

Although several specific−species taboos may be a consequence of the symbolical or mythological qualities that certain groups ascribe to animals (Rea 1981, Kent 1989, Child and Child 1993), conservation motives behind such taboos should not be ruled out. For example, Reichel−Dolmatoff (1976), studying the Tukanos of the Colombian northwestern Amazon, states that the shaman in this group may interfere directly with hunting, fishing, gathering, and most other harvesting activities, and may personally control the number of animals to be killed. He might even completely prohibit the killing of certain animals in a restricted area whenever he thinks that a certain species is too low in abundance. Thus, the shaman becomes a powerful agent in the control and management of resources. Among other ethnic groups, the medicine man, the elders, or other prominent figures may hold the same position with a similar responsibility (Ntiamoa−Baidu 1991, Wilson 1993). Such conservation ethics may be more subtle and less clearly stated than Western notions of conservation (Primack 1993, Berkes et

al. 1995). However, this does not at all imply that traditional societies live in harmony with nature. Members of such societies are no more superior or inferior as people than other groups of humans (Bodley 1994). Even though many such groups impose constraints on their use of species, natural resources, and ecosystems, we do not imply that they are "noble savages."

What is at core here is that species conservation exists in traditional societies as a means of human survival. Even though such practices may have been diluted or even lost in many traditional societies (Alvard 1993, 1994), or might not be expressed in conservation terms, species protection by taboos seems to have existed over millennia (Gadgil et al. 1993). Especially in parts of Oceania, there are practices that seem to have been deliberate and part of a nature management strategy (Johannes 1981). The Tikopian taboo in Polynesia on harvesting coconuts at inappropriate times is one example. There is a belief that if the taboo is violated, the chief can get animals in whom a god is incarnate (like the special bat and the eel) to prevent further loss (Child and Child 1993). Such traditional conservation practices may not be incidental (Gadgil and Berkes 1991), but may have come about as a result of *coevolution* between humans and their natural resources over long time horizons. Coevolution, described as the reciprocal evolutionary interactions of ecologically intimate organisms (Ehrlich and Raven 1964), is here interpreted as the process in which human groups have learned to adapt to their natural environment without seriously deteriorating it. They thus increase the chances for their own survival and, indirectly, that of other species. In this sense, coevolution refers to self−organization through mutual entrainment. It is a trial−and−error process, with the continued acceptance of practices that appear to secure the resource base, coupled with the elimination of those practices that appear to destroy it (Gadgil and Berkes 1991). Such a dynamic process is likely to lead to the development of a whole range of practices, some beneficial for species conservation (Folke et al.1997).

Some specific−species taboos may have been developed in the past in order to sustain natural resources when local human groups faced resource scarcity and crises of different kinds and durations (Gadgil and Berkes 1991). Thus, taboos may have evolved to increase the buffering capacity, or resilience, of local ecosystems (Holling et al. 1997). The theory that taboos may have resulted from overexploitation of a resource can be termed the "crisis−and−learning" hypothesis.

Why a specific−species taboo continues to exist in a culture is difficult to determine. It may be that the species is still low in numbers, or that the species is recognized, through traditional ecological knowledge, as keystone in the ecosystem. There may be institutional and cultural inertia to changing conditions. Taboos can also have the opposite, anticonservation effect by increasing the harvesting pressure away from abundant species and toward less abundant ones (Johannes 1994).

An alternative hypothesis is that species are protected through specific−species taboos because they play a role in religious and cultural belief systems (Douglas 1966, Rea 1981, Roe 1982, Ingold 1994). In reality, it may be almost impossible to separate the belief system from practices and traditional ecological knowledge systems. Knowledge, practices, and beliefs tend to intermingle among traditional peoples (Gadgil et al. 1993, Folke et al. 1997). No single theory can explain specific−species taboos; species may be avoided for many reasons, depending on regional conditions and the world view of different peoples. Nevertheless, many specific−species taboos existing in the real world seem to help protect species that are threatened, endemic, and keystone.

CONCLUSIONS

We have reason to believe that our samples of specific−species taboos represent but a small fraction of those existing among the world's traditional peoples. Such peoples, numbering ~ 300 x 10^6 individuals today, inhabit nearly one−fifth of Earth's surface (Martin 1993). Indigenous peoples inhabit > 85% of the total protected areas in Central America (Herlihy 1992) and > 80% of the protected areas in South America (Alcorn 1994). As has been suggested elsewhere, active involvement of these groups in the protection and conservation of species and biodiversity is extremely important (Hanks 1984, Nepal and Weber 1995). This is especially true for protected

areas, where problems have arisen when local groups have been denied access to their traditional resource areas. Such exclusion may mean, among other things, the loss of practices that may be of great significance for conservation.

Many indigenous groups have adapted to their natural environment in ways that conserve both their ecosystems and themselves as an integrated social−ecological system. Some studies clearly indicate that locally based human subsistence practices may enhance species richness (Gómez−Pompa and Kaus 1992, Pimentel et al. 1992, Sankhala 1993). Species, resources, and global biodiversity very well may be negatively affected by the decay of adaptive traditional resource practices and linked social mechanisms, such as taboos (Atran 1993, Becker and Ostrom 1995). This illuminates the importance of a deeper understanding of the resource conservation practices and social mechanisms of traditional societies (Folke et al. 1996). In this paper, we have analyzed the role of taboos set on species as representing one such social mechanism.

We have shown that some taboos totally protect threatened and ecologically important species, thus serving conservation ends. Although this analysis may be criticized for not representing randomly selected samples, its major contribution lies in conveying qualitative information, i.e., that adaptive social mechanisms and local institutions for species protection already exist. Parallels may be drawn between such integrated social−ecological systems and nature reserves. However, in contrast to many modern nature reserves, the local community is not excluded from the reserve, but is an integrated part of it, such that conservation is of self−interest.

We urge scientists with detailed knowledge of specific indigenous groups to make explicit the potential linkages between social mechanisms, like taboos, and practices of species conservation. We urge conservationists to support traditional peoples that conserve species and ecosystems, to adjust the handling of grants to their culture, and to conserve and make use of traditional ecological knowledge before it is lost.

RESPONSES TO THIS ARTICLE

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