

## Biological Prioritization of Asian Countries for Turtle Conservation

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**ABSTRACT.** – A recent conservation assessment by IUCN recognized half of the Asian tortoise and freshwater turtle species to be Endangered or Critically Endangered, primarily due to overexploitation for food and medicinal purposes. To prioritize where in Asia the most urgent attention toward conserving wild turtle populations may be needed, we used recently updated information to rank Asian countries according to the richness, endemism, and threat level of their turtle faunas. The results of this biological analysis ranked China, Vietnam, Myanmar, and Indonesia as the top four priority countries in Asia for turtle conservation activities. China ranked highest in all three categories of richness, endemism, and threat level.

**KEY WORDS.** – Reptilia; Testudines; turtle; tortoise; conservation; threatened status; prioritization; endemism; diversity; species richness; Asia; China; Vietnam; Myanmar; Indonesia

A turtle biodiversity crisis in Asia has emerged during the last decade as the result of a far-reaching commercial trade of turtles for food, medicine and, to a lesser extent, the international pet trade (Jenkins, 1995; Behler, 1997; van Dijk et al., 2000; Thorbjarnarson et al., 2000; Rhodin, 2000). In East Asia, eating turtle meat is widely believed to have a variety of health benefits, and turtle shell, used in traditional Chinese medicine preparations, is thought to cure ailments ranging from fevers to cancer (Jenkins, 1995; Lau and Shi, 2000; Thorbjarnarson et al., 2000). While turtles were traditionally harvested for subsistence or local markets, since the early 1990s levels of exploitation have changed dramatically in volume and scope. Turtle trade into China has increased owing to economic liberalization and convertibility of Chinese currency, increased affluence of the Chinese consumer market (Yiming and Dianmo, 1998), improved infrastructure and transport links with other Asian countries, and a northward spread in China of the habit of eating wildlife (Lau and Shi, 2000).

With the collapse of turtle populations in China from overharvesting, the Chinese markets sought new sources of turtles (van Dijk et al., 2000). Today turtles traded in China originate from most countries in South and Southeast Asia, where rural residents find it much more profitable to sell them to traders than to eat them (van Dijk et al., 2000). Trade routes for turtles extend to the remotest places in South and Southeast Asia, the first link in a complex network that ends in ethnic Chinese communities in Asia (Sharma, 1999) or especially in bulk shipments to China (Ades et al., 2000).

Numbers of turtles in trade are difficult to quantify because much is illegal or not recorded. Where data are available, the numbers are enormous. In 1998, 13,500 tons of live turtles were imported into Hong Kong, a 28-fold increase since 1992 (Lau et al., 2000). In 1999, a

minimum of 25 tons of live turtles were exported weekly from Sumatra to China and Singapore (Shepherd, 2000). Demand for turtles is not species-specific, and in recent years all but a few Asian species have been seen in trade in Chinese markets (Lau and Shi, 2000). This enormous commercial trade, accentuated by widespread habitat destruction that affects fauna in general, is having dramatic consequences for wild turtle populations. Forty-five of the 89 (50.5%) native species of Asian turtles are now listed by the 2000 IUCN Red List as Endangered or Critically Endangered (Hilton-Taylor, 2000).

Curbing the international trade of turtles, particularly trade into China, has been identified as the highest priority activity for conserving Asian turtles (van Dijk et al., 2000). However, priorities for protecting remaining populations of Asian turtles in the wild are less clear. The recent evaluation of the conservation status of Asian turtle species by IUCN/SSC Tortoise and Freshwater Turtle Specialist Group and Asian Turtle Trade Working Group (2000), which was adopted by the 2000 IUCN Red List (Hilton-Taylor, 2000), allows workers to prioritize Asian turtle species for conservation activities. However, the majority of Asian turtle species occur in more than one country, and the question of where in Asia the most urgent attention towards conserving wild turtle populations may be needed remains unevaluated.

Here we prioritize the importance of Asian countries for conserving tortoise and freshwater turtle diversity, based on the recently updated information on the distribution and conservation status of these species. Specifically, we rank Asian countries according to the richness, endemism, and threat levels of their turtle faunas. The analysis is performed at the species level, and does not incorporate subspecies or higher classification levels such as genera. It is important to recognize that this prioritization is based on biological data alone, and does

not account for the highly variable political wills of Asian countries to conserve their turtle faunas. The results do not necessarily infer that priority countries have the greatest opportunity or least impediments for turtle conservation, nor do the results provide information on where conservation efforts should be directed within the priority countries.

## METHODS

Our analysis included all 89 species of native Asian tortoises and freshwater turtles that were considered for evaluation by IUCN/SSC Tortoise and Freshwater Turtle Specialist Group and Asian Turtle Trade Working Group (2000). Nomenclature follows the same publication, including the decision to evaluate the *Cyclemys* species complex as a single taxon, *C. dentata*.

The conservation status of turtles was taken from the 2000 IUCN Red List (Hilton-Taylor, 2000). We analyzed those species listed by IUCN as Extinct (EX), Critically Endangered (CR), and Endangered (EN), but not those species listed as Vulnerable or lower levels of threat. The following Asian political areas, hereafter called countries, were included in the analysis: Bangladesh, Brunei, Cambodia, China, India, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Singapore, Taiwan, Thailand, and Vietnam. Australia, Korea, Maldives, and Sri Lanka were not included, even though they share some turtle species with those countries in the analysis.

Species were considered to be confirmed or unconfirmed (suspected) in each country based on distributions reported by IUCN/SSC Tortoise and Freshwater Turtle Specialist Group and Asian Turtle Trade Working Group (2000), with these amendments: *Manouria impressa* added confirmed to Cambodia (Lehr and Holloway, 2000), *Indotestudo elongata* added unconfirmed to Indonesia (Samedi and Iskandar, 2000), *Batagur baska* added confirmed to Cambodia (Platt et al., 2003) and Myanmar (Platt et al., 2000), *Cuora amboinensis* and *Cyclemys dentata* added confirmed to the Philippines (Gaulke and Fritz, 1998), *Geoclemys hamiltonii* removed from Indonesia and added confirmed to India (clearly a typographical error of the country codes IN and ID in IUCN/SSC Tortoise and Freshwater Turtle Specialist Group and Asian Turtle Trade Working Group [2000]), *Hardella thurjii* added unconfirmed to Myanmar (Platt et al., 2000), *Hieremys annandalii* and *Pelochelys cantorii* added confirmed to Laos (Stuart and Timmins, 2000), *Pyxidea mouhotii* added unconfirmed to Thailand (van Dijk and Palasuwan, 2000), *Siebenrockiella crassicollis* added unconfirmed to Laos (Stuart and Timmins, 2000), and *Platysternon megacephalum* added unconfirmed to Cambodia (Tana et al., 2000). Numerous discrepancies in species' ranges were found between IUCN/SSC Tortoise and Freshwater Turtle Specialist Group and Asian Turtle Trade Working Group (2000) and Hilton-Taylor

(2000). The ranges given in the former publication were considered to be more accurate and so chosen for use (with the above amendments).

Species richness of each country included the number of confirmed and unconfirmed species, but not introduced species. Species richness was ranked by country, where countries with higher species numbers were given priority ranking. Countries with tied values were given an average rank (Sokal and Rohlf, 2000).

Percentage of endemism was calculated by dividing the number of species endemic to a country by the species richness of that country. Species were considered endemic to a country even if that species is suspected (but unconfirmed) to occur in another country. For example, *Lissemys scutata* was treated as endemic to Myanmar, even though it is suspected (but unconfirmed) to occur in western Thailand (van Dijk and Palasuwan, 2000). Percentage of endemism was ranked by country, where countries with higher percentages of endemism were given priority ranking.

The percentages of Extinct (%EX), Critically Endangered (%CR), and Endangered (%EN) species were calculated for each country by dividing the number of species in each threat category by the species richness. A weighted sum of threat level (TL) for each country was then calculated by the formula:

$$TL = (\%EX \times 3) + (\%CR \times 2) + (\%EN \times 1).$$

This formula treats Endangered as the basic unit of threat, and weights Critically Endangered as two times, and Extinct as three times, the threat level of Endangered. This formula is arbitrary and based on the opinions of the authors. Weighted sum of threat level was ranked by country, where countries with higher weighted sums of threat level were given priority ranking.

The terms high, moderate, and low used to describe species richness, percentage of endemism, and threat level are relative measurements, based on comparing Asian countries against each other. A judgment of low threat level for an Asian country does not necessarily mean threat level is *absolutely* low, but rather that it is *relatively* low compared to other countries in the analysis.

## RESULTS

China has the highest species richness with 32 species of tortoises and freshwater turtles, while Brunei, Philippines, and Taiwan have the lowest species richness with only 5 species each. Ranking countries by species richness from highest to lowest results in the following country order (hyphen indicates countries are of same rank): China, India – Indonesia – Myanmar, Vietnam, Bangladesh, Thailand, Malaysia, Laos, Cambodia, Nepal – Papua New Guinea, Pakistan – Singapore, Japan, Brunei – Philippines – Taiwan (Table 1).

**Table 1.** Ranking of 18 Asian countries according to level of threat, species richness, and percentage of endemism of tortoises and freshwater turtles. A weighted sum of threat level for each country was calculated by the formula  $[(\%EX \times 3) + (\%CR \times 2) + (\%EN \times 1)]$ . The percentages of Extinct (%EX), Critically Endangered (%CR), and Endangered (%EN) species were calculated for each country by dividing the number of species in each category by the species richness. Tied values are given an average rank.

Country	Richness		Endemism			Threat Level		Sum of Ranks	Overall Rank
	No. Species	Rank	No. Species	% Endemic	Rank	Weighted Sum	Rank		
China	32	1	11	34.4%	1	1.00	1	3	1
Vietnam	23	5	1	4.3%	9	0.87	2	16	2
Myanmar	27	3	6	22.2%	3	0.59	11.5	17.5	3
Indonesia	27	3	4	14.8%	5	0.59	11.5	19.5	4
India	27	3	3	11.1%	6	0.44	14	23	5.5
Japan	6	15	2	33.3%	2	0.67	6	23	5.5
Philippines	5	17	1	20.0%	4	0.80	3.5	24.5	7
Bangladesh	22	6	1	4.5%	8	0.55	13	27	8
Malaysia	18	8	0	0%	14	0.67	6	28	9
Laos	15	9	0	0%	14	0.67	6	29	10.5
Thailand	20	7	0	0%	14	0.65	8	29	10.5
Cambodia	14	10	0	0%	14	0.64	9	33	12
Taiwan	5	17	0	0%	14	0.80	3.5	34.5	13
Papua New Guinea	10	11.5	1	10.0%	7	0.20	17	35.5	14
Nepal	10	11.5	0	0%	14	0.40	15	40.5	15
Brunei	5	17	0	0%	14	0.60	10	41	16
Singapore	8	13.5	0	0%	14	0.38	16	43.5	17
Pakistan	8	13.5	0	0%	14	0.13	18	45.5	18

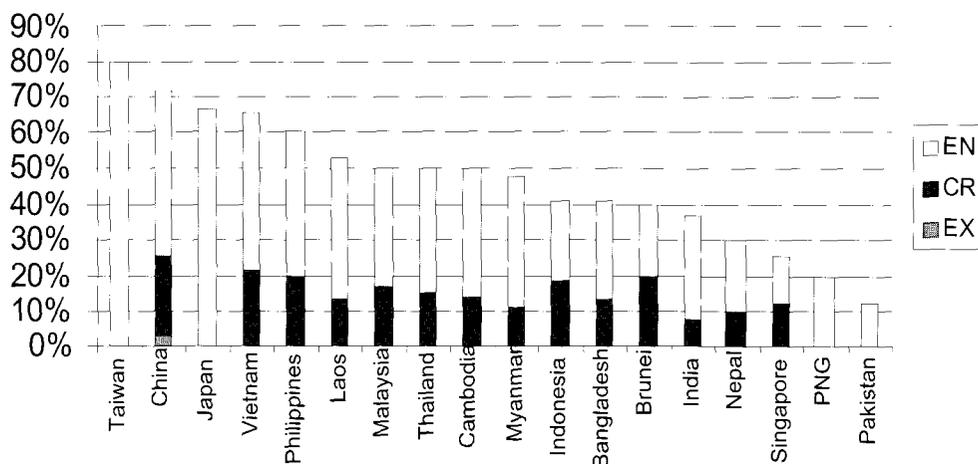
China has the highest number of endemics, with 11 species, while half of the countries in the analysis (9 of 18) have no endemic species. China also has the highest percentage of turtle endemism at 34.4%. Ranking by percentage of endemism from highest to lowest results in the following country order: China, Japan, Myanmar, Philippines, Indonesia, India, Papua New Guinea, Bangladesh, and Vietnam, followed by a tied ranking of all remaining countries with no endemics (Table 1).

Taiwan has the highest total percentage of threatened turtle species, with 80% of species at Endangered status or worse, while Pakistan has the lowest total percentage, with 12.5% of species at Endangered status or worse (Fig. 1). China and Vietnam have the highest percentages of Critically Endangered turtle species, with 21.9 and 21.7% of species, respectively.

Ranking by weighted sum of threat level from highest to lowest results in the following country order (hyphen indicates countries are of same rank): China, Vietnam, Philippines – Taiwan, Japan – Laos – Malaysia, Thailand, Cambodia, Brunei, Indonesia – Myanmar, Bangladesh, India, Nepal, Singapore, Papua New Guinea, and Pakistan (Table 1).

Summing the ranks of turtle species richness, percentage of endemism, and threat level results in the following overall country order: China, Vietnam, Myanmar, Indonesia, India – Japan, Philippines, Bangladesh, Malaysia, Laos – Thailand, Cambodia, Taiwan, Papua New Guinea, Nepal, Brunei, Singapore, and Pakistan (Table 1).

China is the only country with a turtle fauna that ranks high in all three categories of species richness,



**Figure 1.** Percentages of Extinct (%EX), Critically Endangered (%CR), and Endangered (%EN) species of tortoises and freshwater turtles in 18 Asian countries, calculated by dividing the number of species in each category by the species richness of each country.

endemism, and threat level. In fact, the Chinese turtle fauna ranks highest among countries in all three categories. The turtle faunas of Myanmar and Indonesia nearly rank high in all categories, with relatively high richness, high endemism, but moderate threat level.

The turtle faunas of a group of countries demonstrate nearly all possible score combinations by ranking high in at least one category but low in at least one other category. The turtle fauna of Vietnam has relatively high richness, low endemism, and high threat level. The turtle faunas of Bangladesh and India have relatively high richness, moderate to high endemism, but low threat level. The Philippines has relatively low richness, high endemism, and high threat level. The turtle fauna of Taiwan has relatively low richness, no endemism, and high threat level. Japan has relatively low richness, high endemism, and moderate to high threat level. The turtle faunas of Cambodia, Laos, Malaysia, and Thailand all have relatively moderate to high richness, no endemism, and moderate to high threat level.

The turtle faunas of two countries that rank moderate to low in all categories are Brunei, which has relatively low richness, no endemism, but moderate threat level, and Papua New Guinea, which has relatively moderate richness, moderate endemism, but low threat level.

Lastly, the turtle faunas of Nepal, Pakistan, and Singapore are generally unremarkable, with relatively low richness, no endemism, and low threat level.

## DISCUSSION

As a result of our ranking method, China, Vietnam, Myanmar, and Indonesia ranked in that order as the top four countries in Asia needing the most urgent attention for conserving wild turtle populations. Each of these countries scored high in at least two of the three measured categories of turtle species richness, endemism, and threat level. China was remarkable in scoring highest among countries in all three categories.

Particular attention for conserving turtles needs to be focused on China, which ranked overall as the highest priority country for turtle conservation in Asia. China has the highest richness with 32 species, and the highest percentage of endemism with 34.4% (but see below). This large turtle fauna with high endemism is also highly threatened, primarily as a result of domestic overexploitation for food and traditional medicine purposes (Lau and Shi, 2000). China is the major consumer country of turtles in Asia, which originate partially from within China and especially from other countries throughout South and Southeast Asia (Lau and Shi, 2000). Thus, solutions to curb turtle trade within and to China will benefit not only the Chinese turtle fauna, but also the Asian turtle fauna in general. Fortunately, China has recently implemented new legislation and enforcement actions to improve control measures on the trade of turtles (Meng et al., 2002).

Five species considered endemic to China that were included in the analysis, *Mauremys iversoni*, *M. pritchardi*, *Ocadia glyphistoma*, *O. philippeni*, and *Sacalia pseudocellata*, are currently known only from the pet trade and markets, and are suspected to be natural or farm-produced hybrids (Parham and Shi, 2001; Parham et al., 2001; Shi and Parham, 2001). A sixth taxon, *Cuora serrata*, was not included in the analysis because the evidence to suggest it is an intergeneric hybrid was strong at the time of evaluation by IUCN/SSC Tortoise and Freshwater Turtle Specialist Group and Asian Turtle Trade Working Group (2000). The exclusion of these five species from the analysis would drop richness in China from 32 to 27 species, and percentage of endemism from 34.4% to 22.2% (threat levels would not change because all five species are listed by IUCN as Data Deficient). This would reduce the turtle richness of China to equal that of Myanmar, Indonesia, and India at 27 species, would equate the percentage of endemism of China with that of Myanmar at 22.2%, and would raise Japan to the highest percentage of endemism among countries at 33.3%. In addition to changing these country rankings by species richness and endemism, removing the five suspected-hybrid species from the analysis would have one effect on the overall ranking of countries: Japan would become the fifth and India would become the sixth priority country, breaking their tied rankings. China remains the top priority country by overall ranking, even without the five suspected-hybrid species. Although relatively minor in impact on the overall country rankings, removing the five suspected-hybrid species from the analysis does change some country rankings according to species richness and endemism. This is a good example of how taxonomic studies can affect conservation priorities. Indeed, van Dijk et al. (2000) and Parham and Shi (2001) recommended that the taxonomic validity of these suspected hybrid species be investigated so that limited conservation resources are spent on legitimate taxa that are threatened in the wild.

Vietnam ranked overall as the second priority country for turtle conservation. The priority ranking of Vietnam was a result of a high richness of 23 turtle species largely composed of threatened species. Vietnam has devastated its own turtle fauna primarily by mass export to China, and also trans-ships turtles from Laos and Cambodia to China (Hendrie, 2000). Thus, curbing trade within Vietnam would benefit not only Vietnam's native turtle fauna, but also that of Laos and Cambodia.

The turtle faunas of both Myanmar and Indonesia ranked high in species richness with 27 species, and endemism of 22.2 and 14.8%, respectively. Species endemic to Myanmar are *Geochelone platynota*, *Heosemys depressa*, *Kachuga trivittata*, *Morenia ocellata*, *Lissemys scutata*, and *Nilssonina formosa*, and to Indonesia are *Elseya branderhorstii*, *Chelodina mccordi*, *Leucocephalon yuwonoi*, and *Indotestudo forstenii*. Like in Vietnam, the primary threat to the turtle fauna of

Myanmar (Platt et al., 2000; S.G. Platt and J. Thorbjarnarson, unpubl. data) and Indonesia (Samed and Iskandar, 2000) is overexploitation for international export to East Asia, particularly China.

Our method of prioritization was highly sensitive to small changes in the raw data, such as the addition or deletion of a single species from a country. This is expected, considering that richness values maximized at only 32 species. Thus the addition or deletion of a single species from a country's fauna can influence the ranking of countries according to species richness, percentage of endemism, and threat level. This effect is exemplified by how close some values are in Table 1, such as species richness of Vietnam and Bangladesh (23 vs. 22), percentage of endemism of China and Japan (34.4 vs. 33.3%), weighted sum of threat level of Thailand and Cambodia (0.65 vs. 0.64), and sum of ranks of Vietnam and Myanmar (16 vs. 17.5). Therefore, the prioritization that we present here is considered dynamic rather than static. Using the same methods, this prioritization will change in the future with improved resolution of species' distributions through additional field work, the synonymization or splitting of taxa through further taxonomic studies, and changes in the conservation status of species. Furthermore, we arbitrarily chose to weight Critically Endangered as two times, and Extinct as three times, the threat level of Endangered, and we chose to treat richness, endemism and threat level as equally important in contributing to an overall ranking of countries. Changes in these weighting schemes by other authors would undoubtedly change the prioritization rankings of countries.

Regardless of the ranking results of countries, conserving turtle diversity requires the immediate participation of all Asian countries. In most cases, this primarily entails curbing the largely uncontrolled international trade of turtles to East Asia. Other recommendations for conserving Asian turtles have been proposed by van Dijk et al. (2000), and include protecting natural habitats, properly dealing with turtles confiscated from the trade, and reducing demand for wild turtles by improving turtle farming techniques, finding alternative sources for traditional medicine, and public awareness campaigns.

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