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Conservation Implications of Rapid Shifts in the Trade of Wild African and Asian Pythons

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ABSTRACT

Pythons are harvested for the international leather industry and pet trade. We analyzed the CITES export records (1999–2008) of the most intensively commercialized wild pythons (*Python regius*, *Python sebae*, *Python reticulatus*, *Python molurus*, *Python curtus* species complex) from African and Asian countries where reliable data on trade rates and ecology are available. Mean declared annual numbers of exported pythons were 30,000 in five African countries and 164,000 in Indonesia. Trade intensity tripled in Indonesia over the last decade, but declined in Africa. African international trade is exclusively associated with the pet market (mainly United States and Europe), whereas Asian pythons are sold mostly for luxury leather, albeit more recently also for the pet trade. A negative correlation between the annual numbers of pythons traded in Africa vs. Asia suggests a rapid and recent shift of the pressure exerted on wild populations in the two main exporting continents. We also found a strong effect of the currency exchange rate (*i.e.*, U.S.$/€, the currencies used by the major importing countries) on African python exports: when the cost per African python increased, importers relied increasingly on Asian providers for pet trade. Overall, our data indicate that Asian pythons (especially *P. reticulatus*) might be threatened due to the rapidly increasing pressure, whereas the decreasing international trade in African pythons is likely more sustainable.

Key words: Africa; Asia; CITES; conservation; leather industry; pet trade; pythons.

PYTHONS ARE THOUGHT TO BE RELATIVELY RARE AS THEY ARE VERY LARGE ANIMALS POSITIONED AT THE TOP OF THE TROPHIC WEB (Luiselli *et al.* 2005). At least three species (*i.e.*, the African *Python sebae*, and the Asian *Python molurus* and *Python reticulatus*) reach 7 m in length (Starin & Burghardt 1992, Murphy & Henderson 1997). The largest pythons are traded for both their skin and the pet trade (Gorzula *et al.* 1997, WCS 2008). Whether the international python trade is sustainable is currently unknown.

We analyzed CITES annual wild python export data from the main python-trading countries in Africa and Asia to assess temporal and geographical patterns. Although less accurate in comparison to field population surveys, this approach is appropriate to obtain broad patterns over large spatial and temporal scales (Shine *et al.* 1999a, b). As we cannot afford to wait for certified reports of irreversible population declines, any evidence of serious threats on wild species should be considered.

Our goals were: (1) to examine trade trends over years and patterns between species (*e.g.*, pet trade vs. leather trade), countries, and continents; (2) to explore the influence of the main currencies involved in the international python trade, notably by examining the €/U.S.$ exchange rate on the temporal and geographical patterns (as the main African countries that export pythons are indexed to the Euro); and (3) to provide suggestions to better organize or to reduce the exploitation of wild pythons.

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MATERIALS AND METHODS

We focused on the most intensively traded species, the African *Python regius, P. sebae*, and the Asian *P. molurus, P. reticulatus, Python timorensis, Python curtus, Python brongesmai*, and *Python breitensteni* (see Keogh *et al.* 2001 for taxonomy updates). We analyzed data for Ghana, Togo, Benin, Nigeria, Cameroon (Africa), Cambodia, Indonesia, Thailand, and Vietnam (Asia) because (1) they represent the main python exporters in the respective continents (our unpublished CITES data analyses), and (2) results from intensive research on the field ecology of the pythons are available (*e.g.*, Shine *et al.* 1998, Luiselli *et al.* 2001, Reading *et al.* 2010).

We downloaded *Python* traded numbers from the CITES trade data base (http://www.unep-wcmc.org/citestrade/) by country and by year (1999–2008). We considered only the 'origin wild' specimens in the dataset, and used the 'imp quantity' data reported in the 'comparative tabulation reports' for each year in each country. We did not consider: (1) re-exports because these numbers are unrelated to the country of origin of the specimens; (2) illegal trade because these data are not reliable; (3) meat trades because they are for internal use and not reliably identified by CITES (Klemens & Thorbjarnarson 1995).

The United States, countries paying in U.S.$ (*e.g.*, Japan, China), and European countries that pay in Euro are the main python importers, either for the pet market and/or for the leather industry (our unpublished analyses of CITES dataset). Importantly, the main African countries involved in the python

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trade (Togo and Benin notably) exhibit strong and deeply rooted commercial relationships with Europe. For instance, their currency (Franc-CFA) is directly indexed to the Euro. Consequently, the €/U.S.$ exchange rates automatically influence the respective export capacity of African vs. Asiatic countries. Pythons (as pets or skin) are traded through the same systems as other goods, and their trade is similarly affected by changing currency exchange rates. To explore the effect of such relationships, we examined the €/U.S.$ exchange rates over time (obtained from Banque de France: http://www.banque-france.fr/economie-et-statistiques/changes-et-taux.html). We examined the influence of annual variations of mean currency exchange rates year on the *Python* exports per year by species.

Data variables were checked for normality and homoscedasticity prior to applying parametric tests; data were log-transformed when normality was not achieved; non-parametric tests were used otherwise. A parametric MANOVA model was used to analyze the effects of species, country, and year on the number of exported pythons. Pearson's correlation coefficient was used for assessing linear correlations. Means are expressed with ± 1 standard deviation.

RESULTS

African countries exported a lower number of pythons compared to Asian countries (mean annual numbers over 10 yr were respectively 30,495 ± 26,787 vs. 175,297 ± 25,573; one-way ANOVA, $F_{1,18} = 9.112$, $P < 0.0001$). Indonesia alone exported annually 164,585.2 ± 79,051 pythons, representing more than five times the African countries pooled (one-way ANOVA: $F_{1,18} = 25.804$, $P < 0.0001$). Other Asian countries exported lower numbers of pythons, peaking in 2005, 2007, and 2008 (Table 1). The number of annual exports increased rapidly in Indonesia over the recent years (Fig. 1), whereas it decreased in Africa (Fig. 1). Asian and African (log-transformed) exports were negatively correlated ($r = -0.691$; $P = 0.027$).

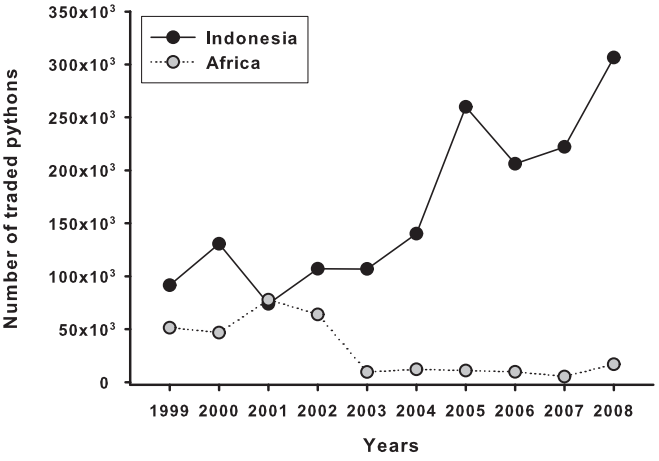

FIGURE 1. Annual exports of pythons in Indonesia (black circles, continuous line) and five countries in Africa (gray circles, dashed line) according to CITES trade database, 1999–2008 period. All species of pythons are pooled in this graphic.

In Indonesia, annual export trends revealed that the majority of specimens were *P. reticulatus*, with exports increasing from about 64,000 individuals in 1999 to over 257,000 in 2008 (Fig. 2A). The decrease in *P. curtus* exports after 2003 (Fig. 2A) was merely apparent, depending on *P. brongesmai* and *Python breitensteini* being recognized by CITES as distinct from *P. curtus* after that year. Cumulative *P. curtus* + *brongesmai* + *breitensteini* exports were significantly higher than *P. curtus* exports in the earlier years (Mann–Whitney *U*-test, $Z = -2.402$, $P < 0.016$).

In Africa, *P. regius* exports exceeded considerably those of *P. sebae* ($Z = 3.704$, $P < 0.0002$), with a significant annual decrease after 2002 ($Z = -1.984$, $P < 0.047$; Fig. 2B). Annual *P. regius* exports were independent from those of *P. sebae* ($r = 0.494$, $P = 0.078$). Country ($F_{4,220} = 2.881$, $P < 0.0235$) and species ($F_{1,220} = 13.38$, $P = 0.0003$), but not year ($F_{9,220} = 1.13$, $P = 0.344$), influenced the number of exported pythons.

TABLE 1. *Annual exports (1999–2008) of pythons from Cambodia, Thailand and Vietnam as reported in CITES database.*

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Vietnam										
Python sp.	200	0	0	0	0	0	0	6	2	0
Python reticulatus	1929	701	1058	120	6	0	6836	3689	11,662	22,464
Python molurus	4586	1334	6115	5236	2125	3444	2801	204	2032	301
Cambodia										
Python sp.	0	0	0	11	0	0	0	0	0	0
Python reticulatus	0	0	0	0	0	0	0	0	1	0
Python molurus	0	0	20,000	0	10,000	0	0	0	0	0
Thailand										
Python sp.	0	0	42	0	1	0	0	37	0	0
Python reticulatus	0	0	0	0	1	3	0	0	42	6
Python molurus	16	36	0	59	1	0	0	0	10	0
Python curtus	0	0	0	0	0	2	0	0	0	0

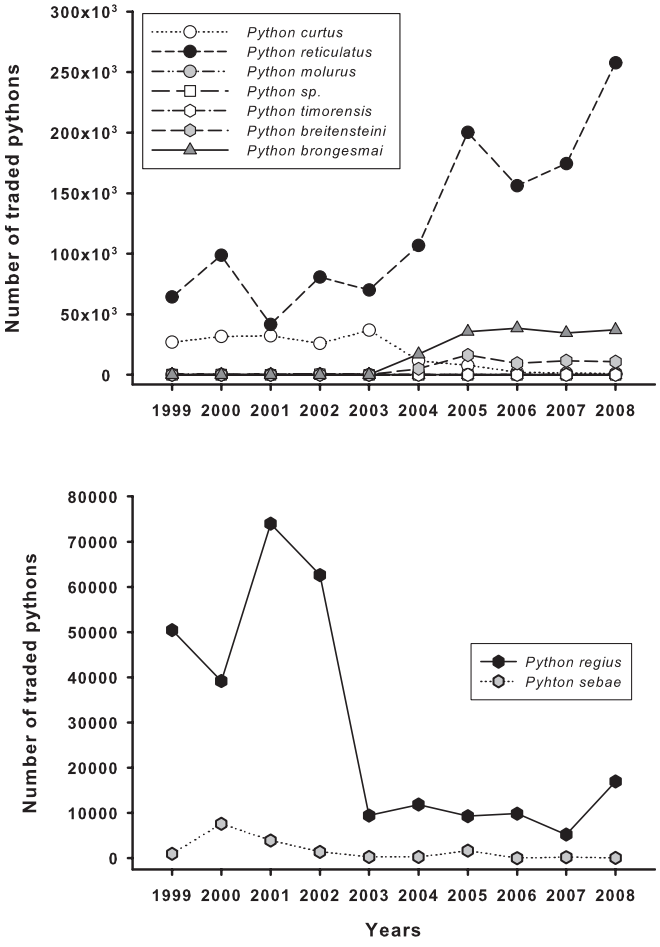

FIGURE 2. Annual exports of Indonesian (A) and African (B) pythons by species.

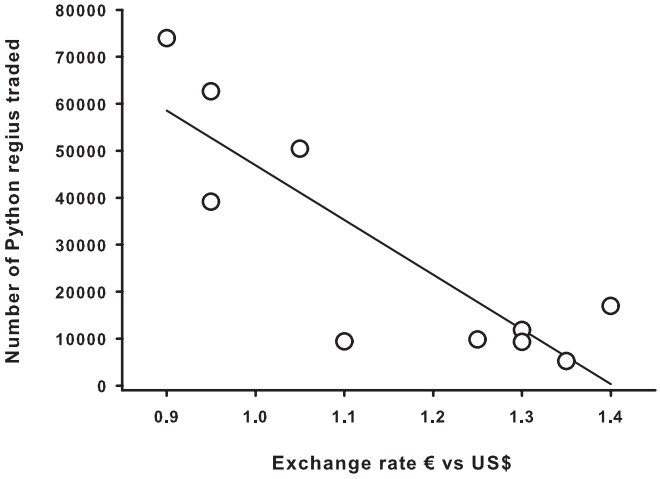

FIGURE 3. (A) Currency exchange rate (U.S.$/€) over time; and (B) relationship between mean annual *Python regius* trade and mean annual €/U.S.$ change rate between 1999 and 2008 ($r = -0.81$, $F_{1,8} = 15.78$, $P < 0.005$).

Mean annual exports and mean annual €/U.S.$ change rate were negatively correlated in Africa for *P. regius* ($r = -0.85$, $F_{1,8} = 20.88$, $P < 0.002$; Fig. 3), *P. sebae* ($r = -0.65$, $F_{1,8} = 5.81$, $P < 0.05$), or both pooled ($r = -0.87$, $F_{1,8} = 24.50$, $P < 0.002$); instead, there were positive trends in Asia (*P. reticulatus*: $r = 0.84$, $F_{1,8} = 20.23$, $P < 0.002$; other Indonesian pythons pooled: $r = 0.77$, $F_{1,8} = 11.47$, $P < 0.01$; all Indonesian species pooled: $r = 0.85$, $F_{1,8} = 21.29$, $P < 0.002$). Overall, a higher relative exchange rate of the Euro compared to the U.S.$ was associated with a lower trade in Africa and a more intensive trade in Asia.

DISCUSSION

Our estimates of traded pythons are likely conservative, because of under-reporting. First, we did not consider illegal non-official markets, indeed such data are by nature extremely imprecise (including snakes for meat and for medicine trades). Second, we confined our analyses to CITES 'wild' specimens, although many officially declared 'ranched' specimens in Africa (Harris 1999, TRAFFIC & IUCN 2004) and 'captive-breeding' specimens in Asia (WCS 2008, Nijman & Shepherd 2009) are instead wild-caught, or the progeny of wild-caught gravid females.

AFRICAN PYTHONS.—Annual python exports were much lower in African than in Asian countries. *Python regius*, a typical pet species, is still locally common with density estimates ranging from 0.839 to 2.77 individuals per ha in Togo (Harris 1999) and Ghana (Gorzula *et al.* 1997) to 6.6 individuals per ha in Nigeria (Luiselli *et al.* 2007). In these countries, both the gravid females and 10 percent of their neonates are released in the ranching system. Even in major export countries such as Togo the overall trade (wild plus ranched pythons) is systematically under the quotas due to an excess of the ranching production relative to the international demand. This system has been sustained for more than 35 yr without apparent negative impact on wild populations (Harris 1999). In addition, there are several sites where pythons are included in (or subject to) cultural taboos and cannot be harvested (Eniang *et al.* 2006). Some *P. regius* populations, however, exhibit worrying and unexplained declines in well-protected areas that are not subjected to international trade (Reading *et al.* 2010).

The mean population densities of *P. sebae* are about 0.2–0.4 individuals per km^2 in Nigeria (with mangrove swamps being the most suitable habitat; Luiselli & Akani 2002, Luiselli *et al.* 2007), and 0.1 individuals per km^2 in Cameroon (Van der Hoeven *et al.* 2004), Ghana (Gorzula *et al.* 1997), and Togo (Harris 1999). Wild *P. sebae* exports are low and decreasing. Current trade levels do not appear to constitute a major threat for this species, whereas rapid urbanization and intensive deforestation do (Luiselli *et al.* 2001).

African python species exports decreased since 2002. This is probably not directly due to political pressures exerted by the European Union or the United States on Togo and Benin governments to limit wild catches. Indeed, wild specimen exports decreased slightly (*e.g.*, annual quotas remained below 2000 in

Togo) in comparison to ranched specimens (that dropped from several tens of thousands per year; Amori *et al.*, unpubl. analysis of CITES data). More likely this negative trend is linked to change of the currency exchange rates between the main export and import countries as the currency (franc-CFA) of Togo and Benin (main exporters) is directly indexed to the Euro while the main import country is the United States where neonate *P. regius* are popular pets (McCurley 2005). In support of this we found a strong negative correlation between the annual €/U.S.$ exchange rate and the python trade intensity. When African pet-pythons become more expensive, American pet traders likely rely more massively on captive-bred animals. Wild pythons are considerably (four times) cheaper than captive-bred animals (X. Bonnet, unpubl. data) due to high breeding colony maintenance and labor costs combined with low reproductive rates, otherwise the international trade would have totally disappeared. Captive-bred pythons, however, are preferable for both ethical and sanitary reasons, easier to feed; thus the wild pythons can be less competitive under high €/U.S.$ exchange rates. Increasing numbers of captive-bred pythons in association to the increase of the €/U.S.$ exchange rate likely reduced the wild specimen exports. To our knowledge, our results revealed for the first time this currency effect on reptile trade. These results may be important in predictive terms, because we may better anticipate whether the trade of a given species may increase or decrease considering the fluctuations of currency exchange rates.

Asian pythons.—Indonesian exports dominate the Asian trade although Vietnam is becoming an increasingly important export country. Thus, we focus mainly on the Indonesian pythons. Auliya (2006) estimated a density of 4.31 individuals per km^2 for *P. reticulatus*, 0.07 individuals per km^2 for *P. breitensteini*, and 0.162 individuals per km^2 for *P. breitensteini*; these estimates are similar to densities of African pythons.

Asian pythons are forest-habitat generalists that also live in suburban areas (Riquier 1998, Stuart 1998). Annual wild python exports strongly increased in recent years, with more than 300,000 pythons exported in 2008. Is such a massive and rapidly increasing export sustainable? Tropical snakes display life history characteristics (rapid growth rates, early maturation, high fecundity, flexibility in diets and habitat use) compatible with meat and skin exploitation (Shine *et al.* 1999b). Groombridge and Luxmoore (1991) and Shine *et al.* (1999b) concluded that the commercial skin trade is unlikely to extirpate reticulated pythons from their Indonesian range, but might eliminate them from highly fragmented habitat sections. These studies, however, did not provide direct evidence that Asian python trade was sustainable, especially considering that before 1999 a total of 64,343 *P. reticulatus* were exported from Indonesia (Shine *et al.* 1999b), while in 2008 this number increased by about 400 percent (up to 257,658 animals). We suggest that it is very difficult to determine to what extent current harvesting levels are really sustainable (King 1995, Roberts 1997, Shine *et al.* 1999b), also because forest coverage has dramatically decreased in Indonesia (World Resource Institute 2005). Even accepting previous optimistic conclusions based on pre-1999 data (*e.g.*, Groombridge & Luxmoore 1991, Shine *et al.* 1999b), the rapid shifts we documented reveal a current worrying situation, and the very intensive Indonesian python harvesting rates urgently require careful investigations.

Overall comparisons.—

1. In Africa, pythons are exported mostly for pets, whereas in Asia for skin. In Africa, most adult females survive after egg-laying, whereas in Asia most individuals are killed or sold as adults on the pet market. Although African post-reproductive females may be occasionally killed after egg hatching (Harris 1999) and a small proportion of adults are exported, the abovementioned great differences make the African python trade much more sustainable than the Asian trade. Indeed, in Asia, large reproductive individuals (notably highly fecund females) are heavily targeted. In addition, ethically speaking, pet trade should be promoted over skin industry unless the meat of the snakes is effectively consumed. Therefore, strong international regulations against skin industry but not necessarily against pet trade are desired in order to support the activity of the snake hunters/farmers. Although long-term sustainable snake hunting is more likely under pet trade than skin industry regime, such fundamental distinction is not yet considered by any international committee.
2. Importantly, sustainable trade indirectly protects habitats. In Africa, python harvest is performed by local hunters in the vicinity of their villages (Harris 1999); villagers have interest to manage their environment in a traditional way (*i.e.*, mosaic of small fields) that also benefit to the pythons (and to many other species), and they actually protect the snakes (a key resource) from over hunting. Therefore, a reasonable level of international trade with relatively elevated prices should be promoted. The €/U.S.$ currency exchange fluctuations, however, represent a serious limitation. In terms of python conservation (and perhaps for other harvested species), balancing through quotas the impact of currency fluctuations might be important.
3. Quotas must be used with caution: they can produce deleterious effects locally (rarity on the market means value; Rivalan *et al.* 2007) and internationally (unbalanced trade between continents may favor overharvesting of vulnerable populations). There is probably no direct causality between the African (pet) and Asian (skin) trades; although we detected a significant correlation between them and despite they both react to currency exchange rate fluctuations. Pet trade is likely very sensitive to currency rates but the pressure on leather-pythons (large species: *P. reticulatus* in Asia vs. *P. sebae* in Africa) is not necessarily a currency related one, but rather an increase in demand for snake leather. Therefore, quotas must be considered separately within each continent, and mostly they should be oriented to favor pet trade over leather industry.
4. Currency exchange effect on reptile trade should be carefully monitored. Fluctuations in this index may strongly affect exploitation policies and hence resulting in cascade effects on biodiversity. Our study pioneered the discovery of these effects in reptiles.

We recommend that pet industry should be based and conform to a certification labeling system inspired from the international wood market. A label should accompany each pet for sale, indicating the origin (wild vs. captive bred) and if the associated trade is eventually sustainable. More constraining labeling and regulations are certainly required also for leather-manufactured goods. A simple ban may not solve this complex situation, as it may even cause the opposite effect than the desired one (Rivalan *et al.* 2007). Python ecotourism should also be promoted, with the skills of snake hunters being essential for this strategy.

LITERATURE CITED

Auliya, M. A. 2006. Taxonomy, life history and conservation of giant reptiles in West Kalimantan (Indonesian Borneo). Natur und Tier Verlag GMBH, Münster, Germany.

Eniang, E. A., E. Egwali, L. Luiselli, I. Ayodele, G. C. Akani, and N. Pacini. 2006. Snake bushmeat from the forest markets of south-eastern Nigeria. Natura (Milan) 95: 33–46.

Gorzula, S., W. O. Nsiah, W. Oduro, and W. 1997. Survey of the status and management of the royal python (*Python regius*) in Ghana. Unpublished report, Kumasi, Ghana.

Groombridge, B., and R. Luxmoore. 1991. Pythons in south-east Asia. A review of distribution, status and trade in three selected species. Report to CITES Secretariat, Laussane, Switzerland.

Harris, M. 1999. Assessment of the status of seven reptile species in Togo. Report to the Commission of the European Union, Ref EC 98/0072, Bruxelles.

Keogh, J. S., D. G. Barker, and R. Shine. 2001. Heavily exploited but poorly known: Systematics and biogeography of commercially harvested pythons (*Python curtus* group) in Southeast Asia. Biol. J. Linn. Soc. 73: 113–129.

King, M. 1995. Fisheries biology, assessment and management. Fishing News Books, Oxford.

Klemens, M. W., and J. B. Thorbjarnarson. 1995. Reptiles as a food resource. Biodivers. Conserv. 4: 281–298.

Luiselli, L., and G. C. Akani. 2002. An investigation into the composition, complexity and functioning of snake communities in the mangroves of south-eastern Nigeria. Afr. J. Ecol. 40: 220–227.

Luiselli, L., G. C. Akani, E. A. Eniang, and E. Politano. 2007. Comparative ecology and ecological modeling of sympatric pythons, *Python regius* and *P. sebae*. *In* R. W. Henderson, and R. Powell (Eds.). Biology of the boas and pythons, pp. 88–100. CPG/Biological Science Press, New York.

Luiselli, L., G. C. Akani, L. Rugiero, and E. Politano. 2005. Relationships between body size, population abundance and niche characteristics in the communities of snakes from three habitats in southern Nigeria. J. Zool. Lond. 265: 207–213.

Luiselli, L., F. M. Angelici, and G. C. Akani. 2001. Food habits of *Python sebae* in suburban and natural habitats. Afr. J. Ecol. 39: 116–118.

McCurley, K. 2005. Ball pythons in captivity. Livingart Publishing, Lansing, Missouri.

Murphy, J. C., and R. W. Henderson. 1997. Tales of Giant Snakes: a Historical Natural History of Anacondas and Pythons. Krieger Press, Malabar, Florida.

Nijman, V., and C. R. Shepherd. 2009. Wildlife trade from ASEAN to the EU: Issues with the trade in captive-bred reptiles from Indonesia. TRAFFIC Europe Report for the European Commission, Brussels, Belgium.

Reading, C. J., L. M. Luiselli, G. C. Akani, X. Bonnet, G. Amori, J. M. Ballouard, E. Filippi, G. Naulleau, D. Pearson, and L. Rugiero. 2010. Are snake populations in widespread decline? Biol. Lett. 6: 677–680.

Riquier, M. 1998. Status, population biology and conservation of the water monitor (*Varanus salvador*), the reticulated python (*Python reticulatus*) and the blood python (*Python curtus*) in Sumatra and Kalimantan, Indonesia. Mertensiella 9: 119–129.

Rivalan, P., A. M. Rosser, V. Delmas, E. Angulo, L. S. Bull, R. J. Hall, N. Leader-Williams, and F. Courchamp. 2007. Can bans stimulate wildlife trade? Nature 447: 529–530.

Roberts, C. 1997. Ecological advice for the global fisheries crisis. Trends Ecol. and Evol., 12: 35–38.

Shine, R., S. Ambariyanto, P. Harlow, and Mumpuni. 1999a. Ecological attributes of two commercially-harvested python species in northern Sumatra. J. Herpetol. 33: 249–257.

Shine, R., S. Ambariyanto, P. Harlow, and Mumpuni. 1999b. Reticulated pythons in Sumatra: Biology, harvesting and sustainability. Biol. Conserv. 87: 349–357.

Shine, R., P. Harlow, J. S. Keogh, and Boeadi. 1998. The influence of sex and body size on food habits of a giant tropical snake, *Python reticulatus*. Funct. Ecol. 12: 248–258.

Starin, E. D., and G. M. Burghardt. 1992. African rock pythons (*Python sebae*) in the Gambia: Observations on natural history and interactions with primates. Snake 24: 50–62.

Stuart, B. 1998. A survey of amphibians and reptiles at That Xay waterfall, Phou Xhao Khouay National Biodiversity Conservation Area, Bolikhamxay Province, Lao PDR. CPAWM/WCS, Vientiane, Laos.

TRAFFIC and IUCN. 2004. Taxa identified as possible candidates for inclusion in the review of significant trade in specimens of Appendix–II species. Traffic & IUCN, Johannesburg, South Africa.

Van der Hoeven, C. A., W. F. De Boer, and H. H. T. Prins. 2004. Pooling local expert opinions for estimating mammal densities in tropical rainforests. J. Nat. Conserv. 12: 193–204.

WCS. 2008. Commercial wildlife farms in Vietnam: A problem or solution for conservation? Technical Report, Wildlife Conservation Society, Hanoi, Vietnam.

World Resource Institute. 2005. World Resources 1998–99. Oxford University Press, New York.