Monitoring Monitors: A Biological Perspective on the Commercial Harvesting of Indonesian Reptiles

R. Shine, P. Harlow, Ambariyanto, Boeadi, Mumpuni & J. S. Keogh

Abstract

Although a few species of Indonesian snakes and lizards support large-scale harvests for both international and domestic use, the basic biology and natural history of the harvested taxa remain poorly known. We obtained extensive information on these topics by measuring and dissecting specimens of four species (*Acrochordus javanicus, Python curtus, P. reticulatus* and *Varanus salvator*) collected and killed for the commercial leather industry. Our data on greater than 2,000 specimens constitute the first quantitative information on the sizes, sexes and reproductive status of the harvested animals, as well as providing basic data on the food habits and reproductive biology of these giant tropical species. We discuss the implications of our results for the long-term sustainability of the commercial harvest, and comment on issues relevant to the management of these important natural resources.

Abstrak

MEMANTAU BIAWAK: SATU PANDANGAN BIOLOGI TERHADAP PENANGKAPAN KOMERSIAL BANGSA REPTIL INDONESIA

Meskipun beberapa spesies ular dan biawak di Indonesia ditangkap dalam jumlah besar untuk penggunaan di dalam dan luar negeri, biologi dasar dan sejarah alami dari taksa yang ditangkap itu masih belum banyak diketahui. Kami telah mendapatkan banyak informasi mengenai topik ini melalui pengukuran dan pembedahan terhadap empat spesies (*Acrochordus javanicus, Python curtus, P. reticulatus,* dan *Varanus salvator*) yang biasanya ditangkap dan dibunuh untuk industri kulit. Data kami mengenai lebih dari 2.000 spesimen merupakan informasi kuantitatif pertama untuk ukuran, jenis kelamin, dan status reproduktivitas hewan-hewan yang ditangkap itu. Selain itu data kami juga memberikan informasi dasar mengenai kebiasaan makan dan biologi reproduksi dari spesies-spesies tropis yang besar itu. Makalah ini membahas implikasi dari hasil penyelidikan kami terhadap keberlanjutan jangka panjang penangkapan komersial, serta mengulas isu-isu yang relevan dengan manajemen sumberdaya alam yang penting tersebut.

Zusammenfassung

Obwohl nur wenige der Schlangen- und Echsenarten Indonesiens im großen Maßstab national und international gehandelt werden, sind weder die Grundlagen der Biologie noch der Lebensgewohnheiten dieser Arten bekannt. Wir haben umfangreiche Informationen hierzu anhand von Messungen und Untersuchungen an vier Arten, die für den Lederhandel besonders wichtig sind, zusammengetragen. Es handelt sich dabei um *Acrochordus javanicus, Python curtus, P. reticulatus* und *Varanus salvator*. Unsere Daten, die an über 2000 Tieren erhoben wurden, liefern erstmals quantitative Informationen über Größe, Geschlecht und Reproduktionsstatus dieser Arten. Darüber hinaus wurden das Nahrungsspektrum und die Fortpflanzungsbiologie dieser durchwegs großwüchsigen tropischen Reptilienarten analysiert. Die Bedeutung unserer Ergebnisse für eine langfristig nachhaltige kommerzielle Nutzung dieser Arten und die Aspekte, die für das Management dieser wichtigen natürlichen Ressourcen relevant sind, werden diskutiert.

Conservation, Trade and Sustainable Use of Lizards and Snakes in Indonesia. – Mertensiella 9: 61-68
© 1998 Deutsche Gesellschaft für Herpetologie und Terrarienkunde (DGHT)

INTRODUCTION

The reptilian fauna of Indonesia is remarkable for its extraordinary diversity as well as for the spectacular nature of many of the component species. Several Indonesian reptile species attain very large body sizes, for example, Indonesia possesses both the world's largest lizard (*Varanus komodoensis*) and the world's longest snake (*Python reticulatus*). This large body size, together with the abundance of several such taxa, has meant that these animals constitute a significant resource for Indonesian people. Thus, many of the larger species have been harvested for domestic uses for a very long time. More recently, large-scale commercial harvesting has flourished, with a primary focus on the skins of snakes and lizards for use in the international luxury leather trade. Even more recently, a growing demand for reptile meat and for medicinally valuable body parts (such as the gall bladder) has stimulated a growing market in the export of live reptiles for human consumption.

Despite this intensive exploitation, remarkably little is known about the basic biology of the reptile species that are being harvested. Our ignorance in this respect does not reflect any specific attribute of Indonesian reptiles; instead, it simply reflects the general scarcity of information about the biology of any tropical reptiles anywhere in the world – or indeed, the biology of any reptile species other than those occurring in cold-temperate habitats in Europe and North America (*e.g.* Seigel 1993, Shine & Madsen 1996). This ignorance stimulated the study that forms the basis of the present report. Although our original intention was simply to document the basic biology of giant tropical reptiles, it soon became apparent that the debate on long-term sustainability of the Indonesian reptile harvest was being carried on in the absence of reliable ecological information. Hence, we have attempted to bring our data to bear on some of the relevant issues.

In this paper, we will review some of the main findings of our studies to date, with particular emphasis on the prospects for long-term sustainability of the commercial trade. Although our study is still in progress, some parts have been completed and have already appeared in the primary scientific literature (Shine et al. 1995, 1996). Other parts of the work have been submitted for publication. In order to reduce duplication, we will restrict the current paper to a broad overview of the relevant results, and focus on their implications for sustainability of the reptile harvest.

MATERIALS AND METHODS

The logistical problems associated with the ecological study of large secretive reptiles, especially snakes, have attracted considerable scientific attention (*e.g.* Turner 1977). The overwhelming conclusion of practitioners in this field is that population-ecology studies are likely to be feasible for only a small proportion of snake species – mostly, small animals that inhabit relatively open habitats, occur in high densities, and are relatively easy to find and capture. Even the most ardent advocates of field studies on snake ecology (*e.g.* Seigel 1993) would concede that it is virtually impossible to obtain reliable information on population densities of large snakes inhabiting complex tropical habitats, at least on a spatial scale large enough to permit generalizing to broader areas. The problems are several. First, most pythons are well-camouflaged ambush predators, lying in wait for passing prey items. The snakes are hence immobile for long periods, and are virtually impossible to find at these times. Second, the tropical climate removes any need for the snakes to bask to raise their body temperatures, so that another common reason for snakes to move about (and thus, become available for capture) is removed (*e.g.* SHINE & MADSEN 1996). Third, the population densities of such large animals are likely to be relatively low, and the distribution of animals among various habitat types is likely to vary strongly among seasons (*e.g.* SLIP & SHINE 1988, MADSEN & SHINE, 1995). Fourth, the animals are potentially capable of long-distance movements, so that it will be difficult or impossible to separate immigration and emigration from recruitment and mortality.

This is not to say that field studies on the Indonesian reptiles are impossible: simply that the appropriate techniques (such as radiotelemetry) will be those that provide insights into general ecology, behavior, movement patterns and habitat use, rather than population demography. In view of the almost insurmountable obstacles to demographic work on free-ranging snakes, we adopted a simpler and more direct approach. The large numbers of specimens collected and killed for the commercial trade, and the fact that many of these animals are brought alive to the skinning factories, provide an opportunity for researchers to gather detailed information on these animals immediately after they are killed. This kind of study is not a substitute for detailed field research, but it provides a cost-effective and time-effective technique for amassing a large quantity of information on important biological attributes of the harvested taxa. Clearly, information on the characteristics (sexes, sizes, etc.) of the harvested animals is also directly relevant to any evaluation of the sustainability of the industry.

Hence, we carried out a series of trips to two areas in Sumatra to examine the carcasses of freshly killed reptiles at skinning factories. The first three trips were to Palembang in southern Sumatra, and the fourth trip was to the Medan area in northern Sumatra. On all four trips, large numbers of specimens were examined (Tab. 1). Our procedures were very straightforward. We weighed and measured the reptile as soon as it was killed (or immediately beforehand), and then dissected it after it was skinned. Our measurements included head length, snout-vent length, and tail length. We scored sex and reproductive status by visual inspection of the gonads, and removed all prey items in the alimentary tract for later identification. In the case of mammalian prey, we sectioned fur samples and identified them by comparison with a reference collection from specimens at the Bogor Museum.

	Palembang area (3 trips)	Medan area (1 trip)
Acrochordus javanicus (Ular brot, karung, filesnake)	101	2
Python curtus (Sanca padi, gendang, blood python)	35	511
Python reticulatus (Sanca batik, sawah, reticulated python)	1,067	39
Varanus salvator (Biawak, water monitor)	166	125

Tab. 1. Sample sizes of reptiles examined at skinning premises in Sumatra over the period July 1993 to September 1996.

RESULTS

Table 2 provides a broad overview of relevant results from our work to date. The four harvested species that we examined differ in many traits, but some consistent trends were also evident.

(i) Sexual dimorphism in body size

Females grow much larger than males in *Acrochordus javanicus* and *Python reticulatus*, but not in *P. curtus*. Male *Varanus salvator* grow larger than females, although the sex difference appears to be smaller in this species than in many other varanids. This may be due to collectors discarding the largest males (Shine et al. 1996).

(ii) Sex ratios of harvested specimens

Relatively equal numbers of males and females are taken in most of the harvested species (Tab. 2). The minimum sizes of animals collected is similar for the two sexes within each of the species. However, many of the females are juvenile animals, whereas almost all of the males are adults. This bias reflects the fact that males attain maturity at smaller sizes than females in all of the species we studied (even in the varanids, where males ultimately attain larger sizes than females), with the result that most of the collected males are adult animals but many of the females have yet to attain maturity.

(iii) Reproductive output

Reproduction is highly seasonal in all of the snake species studied, but continues for most of the year in the varanid lizards. Clutch and litter sizes vary from an average of about 12 (*Python curtus* and *Varanus salvator*) to an average of about 30 (*Python reticulatus* and *Acrochordus javanicus*). However, clutch sizes vary considerably even within the same species, mostly depending on the body size of the female. Large reticulated pythons can produce up to 100 eggs in a single clutch. In both reticulated pythons and filesnakes, adult females do not reproduce every year after attaining maturity, as is indicated by the fact that a considerable proportion of adult females are nonreproductive when they are collected. In contrast, female *Varanus salvator* can produce at least three clutches within a single year.

(iv) Food habits

The harvested species differ considerably in dietary habits. File snakes eat fishes, whereas varanids eat many invertebrates as well as vertebrates. Pythons eat

	A. javanicus	*P. curtus*	*P. reticulatus*	*V. salvator*
Sexual size dimorphism	female larger	female=male	female larger	male larger
Sex ratio of collected specimens (% male)	34%	41%	52%	53%
% of adult specimens	96% in males 85% in females	84% in males 55% in females	89% in males 21% in females	93% in males 55% in females
Average clutch or litter size	29.3	approx. 12	23.8	13.0
% of adult females reproductive in any year	64%	unknown	38%	100%
Food habits	fishes	rats	diverse mammals	invertebrates plus vertebrates

Tab. 2. A summary of ecological traits of Indonesian reptile species used for the commercial leather industry. See text for methods, and original papers for full details.

mostly mammals, with rats being the major food source for smaller snakes (including virtually all *Python curtus*). Large reticulated pythons take a very diverse diet, including large mammals such as monkeys, pangolins, porcupines, mouse-deer and wild pigs.

DISCUSSION

What can these data tell us about the long-term sustainability of the commercial and domestic harvest of Indonesian reptiles? The issue is an enormously complex one, and involves a whole series of cultural, political and economic factors in addition to the straightforward biological questions. In an attempt to address the *biological* component of this issue, it may be useful to consider a variety of attributes that enhance a species' ability to withstand high rates of offtake (i.e. additional sources of mortality due to human activities).

(i) Geographic distribution

Clearly, species that occur over very large geographic areas are less vulnerable to extinction – regardless of the endangering process – than species that are restricted to smaller areas. All four of the species we studied are very widely distributed across Asia.

(ii) Population continuity

Species that occur as a series of relatively discrete populations (as in the case of island taxa, or forms that are restricted to habitat 'islands' by ecological specialization) are more vulnerable to local extinction, and the probability of recolonisation of suitable habitat pockets after such local extinction is greatly reduced. The Indonesian harvested reptile species tend to be habitat generalists, and are highly vagile. Although we lack detailed information on movement patterns, it seems likely that individuals of all of these taxa would be capable of long-distance dispersal. For example, water monitors arrived as some of the first colonizers of Krakatau after the island's famous volcanic eruption (SIMKIN & FISKE 1983).

(iii) Non-harvested areas

The incredible complexity and spatial heterogeneity of Indonesian habitats and societies (economies, religions, social systems) mean that collecting effort is highly heterogeneous. In many areas particular species are not common enough to warrant commercial collection, or the costs of transport to markets are too great. In other areas (*e.g.* northern Sumatra), traditional customs preclude harvesting of these animals. Thus, commercial harvesting does not occur uniformly over the species' ranges.

(iv) Exploitation of disturbed habitats

Human activities (notably, agriculture and urbanization) have substantially transformed large areas of Indonesia. In many cases, the end result of these activities has been to provide a vastly increased supply of potential prey items (especially rodents, in the case of the two harvested python species). The ability of the harvested taxa to persist even in highly disturbed habitats, and take advantage of anthropogenically-derived food sources, is probably a major contributor to the continued abundance of these reptiles in Indonesia. This ecological flexibility also means that extirpation of the harvested taxa is extremely unlikely. Indeed, in some areas the reptiles may be more common now than they were prior to human intervention. In particular, it seems likely that the construction of palm-oil plantations has substantially increased population densities of *Python curtus*.

(v) Reproductive rates

It is generally true that large-bodied species reproduce at lower rates than small-bodied species, and hence are less well-suited to sustaining high rates of mortality. The lower reproductive rate of larger species typically reflects both a delay in maturation and a reduction in reproductive frequency relative to smaller taxa (Peters 1983, Reiss 1989). Presumably, the generality of this effect may have contributed to international conservation concerns about the long-term viability of the commercial trade in giant Indonesian reptiles. However, this view is overly simplistic, because it does not take into account the extraordinary flexibility of life-history traits in reptiles; especially, the overwhelming influences of food supply and temperature (*e.g.* Madsen & Shine 1993). Our preliminary analyses, combined with extensive information on captive pythons and varanids, suggest that these taxa are actually fast-growing and early-maturing (Ross & Marzec 1990, Barker & Barker 1994). Hence, they are relatively well-suited to commercial exploitation; the low reproductive frequencies of female reticulated pythons (Tab. 2) would seem to offer the only cautionary tale in this respect.

(vi) Collecting techniques

The way in which reptiles are collected also has implications for the sustainability of the harvest. Techniques which potentially collect all of the animals in an area, or damage the habitat in the course of collecting specimens (*e.g.* poisoning or bombing coral reefs) have the potential to seriously deplete populations. In contrast, techniques which rely on the animal's activity (such that a high proportion of the population is essentially invulnerable for much of the time) are less likely to cause long-term conservation problems. In the case of the Indonesian reptiles, most collecting seems to be focused on actively moving animals. Radiotelemetric studies on other pythonid, varanid and acrochordid species suggest that these may constitute only a small proportion of the population at any point in time (*e.g.* Shine & Lambeck 1985, Slip & Shine 1988, Shine & Madsen 1996).

Similarly, collecting efforts are more likely to be sustainable if a significant proportion of the animals removed are males. This seems to be the case for most of the harvested Indonesian species (Tab. 2). Given the mating systems and high mobility of these animals, removal of males is unlikely to have any significant long-term impact on the viability of natural populations.

The end result of these considerations is to suggest that the four Indonesian reptile species that we have studied are well-suited to sustaining high levels of offtake. They are all widely-distributed ecological generalists, capable of persisting in disturbed habitats and able to take advantage of artificially-enhanced food supplies. Thus, it is difficult to believe that the current commercial and domestic harvest poses any conceivable threat to the long-term persistence of these taxa in Indonesia. There can be no doubt that intense harvesting can substantially reduce local populations, and may cause local extinctions in fragmented habitats (notably, on small islands). However, extinction of these taxa over their entire range is virtually unimaginable.

Although this conclusion suggests that harvesting is indeed sustainable, it tells us little about the levels of sustainable offtake. It also avoids the more complex issue of the meaning of 'sustainability' in this context. Different people discussing this issue often seem to employ different definitions, and it is worth exploring possible types of sustainability in more detail. One could imagine that the Indonesian reptile harvest might fail to be sustainable (i.e. be unable to continue long-term) for several different reasons:

(i) Extinction (either global or local): If the species ceases to exist in an area, the trade must obviously cease. This situation is highly improbable for the Indonesian harvested taxa, at least on the larger islands.

(ii) Ecological and/or economic disruption: Removal of large predators (especially pythons) might enable a significant increase in prey abundances. In the case of rodents (the primary prey for small *P. reticulatus*, and all size classes of *P. curtus*), such an increase could have significant implications economically (in terms of loss of agricultural production) as well as in terms of disruption to natural ecosystem function. This possibility is difficult to evaluate, but it seems likely that rodent reproductive rates are so high that predation by ectotherms is unlikely to exert significant control (*e.g.* MADSEN & SHINE, unpubl. data). Further investigation of this possibility would be of great value.

(iii) Commercial feasibility: Once population densities are reduced to very low levels, infrastructural costs may render continued harvesting of specimens economically unfeasible. Presumably, domestic consumption would continue under these circumstances, but at a reduced intensity. This scenario is a likely one, particularly in areas where human activities reduce usable habitats for the reptiles. For example, the currently low levels of offtake of reticulated pythons in Java presumably reflect the massive deforestation and habitat alteration over much of this island.

RECOMMENDATIONS FOR FUTURE WORK

The harvest of Indonesian reptiles confers significant economic benefits to many people, and our preliminary ecological data on the exploited species suggest that such a harvest has the potential to be sustainable in the long term. Nonetheless, it is very difficult to establish exactly what level of offtake offers the most efficient conservation strategy. In order to address this issue, we recommend two things: further research and regular monitoring.

(i) Research. Additional data from the skinning factories will be needed to establish biological attributes of the species being harvested, and particularly to quantify the degree and nature of spatial and temporal heterogeneity in important ecological traits. For example, a comparison of python and varanid populations from Kalimantan *versus* Sumatra would be very instructive. We also need more information on the genetic distinctiveness of local (especially, island) populations, and the detailed natural history (movement patterns, habitat use, etc.) of the harvested species.

(ii) Monitoring. The nature of the commercial trade (large numbers of animals brought in alive to central destinations for killing and skinning) makes the system ideally suited to monitoring. Additionally, the cooperation of the relevant industry (via IRATA and ACSUG) and the simplicity and cost-effectiveness of the techniques, means that it should be feasible to monitor the animals that are brought in for skinning. If this procedure proves difficult to implement, a simple recording of the numbers and sizes of skins of each species collected in a given area over a known timespan would be an even more straightforward approach. If Indonesian wildlife authorities initiated surveys at appropriate sites in Sumatra and Kalimantan, they would be able to obtain extensive and reliable sampling of the trade. With such data over several years, any substantial decrease in the wild populations should then be apparent from shifts in the body sizes and numbers of collected specimens.

ACKNOWLEDGMENTS

We thank the many people who have contributed to the success of our Indonesian studies. We particularly thank the representatives of IRATA, especially Mr. SAPUTRA, Mr. HASAN, Mr. ALIAN RUSWAN, Mr. SUDIRMAN and Mr. SUKOSO and their staff, for allowing us free access to their premises to examine reptiles. Permits for the work were given by LIPI and PHPA.

REFERENCES

BARKER, D.G. & T.M. BARKER 1994. Pythons of the World. Volume 1. Australia. Advanced Vivarium Systems, Lakeside, California.

MADSEN, T. & R. SHINE 1993. Phenotypic plasticity in body sizes and sexual size dimorphism in European grass snakes. Evolution 47: 321-325.

MADSEN, T. & R. SHINE 1995. Seasonal migration of predators and prey: pythons and rats in tropical Australia. Ecology 77: 149-156.

PETERS, R.H. 1983. The Ecological Implications of Body Size. Cambridge University Press, Cambridge.

REISS, M.J. 1989. The Allometry of Growth and Reproduction. Cambridge University Press, Cambridge.

ROSS, R.A. & G. MARZEC 1990. The Reproductive Biology of Pythons and Boas. Institute for Herpetological Research, Stanford, CA.

SEIGEL, R.A. 1993. Summary: Future research on snakes, or how to combat 'lizard envy'. In: Snakes: Ecology and Behavior (R.A. SEIGEL & J.T. COLLINS, eds.), 395-402. McGraw-Hill, Inc., New York.

SHINE, R. & P. HARLOW, J.S. KEOGH, BOEADI. 1995. Biology and commercial utilization of acrochordid snakes, with special reference to karung (*Acrochordus javanicus*). J. Herpetol. 29: 352-360.

SHINE, R. & P. HARLOW, J.S. KEOGH, BOEADI. 1996. Commercial harvesting of giant lizards: the biology of water monitors, *Varanus salvator*, in southern Sumatra. Biol. Conserv. 77: 125-134.

SHINE, R. & R. LAMBECK 1985. A radiotelemetric study of movements, thermoregulation and habitat utilization of Arafura filesnakes (Serpentes, Acrochordidae). Herpetologica 41: 351-361.

SHINE, R. & T. MADSEN 1996. Is thermoregulation unimportant for most reptiles? An example using water pythons (*Liasis fuscus*) in tropical Australia. Physiol. Zoology 69: 252-269.

SLIP, D.J. & R. SHINE 1988. Habitat use, movements and activity patterns of free-ranging diamond pythons, *Morelia s. spilota* (Serpentes: Boidae): a radiotelemetric study. Austral. Wildl. Res. 15: 515-531.

SIMKIN, T. & R.S. FISKE 1983. Krakatau 1883. The Volcanic Eruption and its Effects. Smithsonian Institution Press, Washington, D.C.

TURNER, F.B. 1977. The dynamics of populations of squamates, crocodilians and rhyncocephalians. In: Biology of the Reptilia (GANS, C. & D.W. TINKLE (eds.), 157-264. Academic Press, New York.

Authors: R. SHINE, P. HARLOW and J.S. KEOGH, University of Sydney, School of Biological Sciences, Building AO8. N.S.W. 2006, Australia; AMBARIYANTO, FPK-University of Diponegoro, Tembalang Campus, Semarang, Indonesia; BOEADI and MUMPUNI, Research and Development Centre for Biology - LIPI, Jl. Ir. H. Juanda No. 18, Bogor 16122, Indonesia.