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Conservation of amphibians and reptiles in Indonesia: issues and problems

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***Abstract.*—Indonesia is an archipelagic nation comprising some 17,000 islands of varying sizes and geological origins, as well as marked differences in composition of their floras and faunas. Indonesia is considered one of the megadiversity centers, both in terms of species numbers as well as endemism. According to the Biodiversity Action Plan for Indonesia, 16% of all amphibian and reptile species occur in Indonesia, a total of over 1,100 species. New research activities, launched in the last few years, indicate that these figures may be significantly higher than generally assumed. Indonesia is suspected to host the worldwide highest numbers of amphibian and reptile species. Herpetological research in Indonesia, however, has not progressed at a rate comparable to that of neighboring countries. As a result, the ratio of Indonesian species to the entirety of Southeast Asian and Malesian species has "declined" from about 60% in 1930 to about 50% in 2000, essentially a result of more taxa having been described from areas outside Indonesia. Many of these taxa were subsequently also found in Indonesia. In the last 70 years, 762 new taxa have been described from the Southeast Asia region of which only 262 were from Indonesia. In general, the herpetofauna of Indonesia is poorly understood compared to the herpetofauna of neighboring countries. This refers not only to the taxonomic status, but also to the basic biological and ecological characteristics of most of the species. Moreover, geographic distribution patterns for many species are only poorly known. In view of the alarming rate of forest loss, measures for more effective protection of the herpetofauna of Indonesia are urgently required. The status of virtually all of the Indonesian species, e.g. in terms of IUCN categories, remains unknown, and no action plans have been formulated to date. In addition, research results on Indonesia's amphibian and reptile fauna have often not been made available in the country itself. Finally, there is a clear need to organize research activities in such a way that a larger segment of the Indonesian population becomes aware of the importance of the herpetofauna as an essential component of the country's biodiversity. To address these issues, this paper (1) gives an overview of the herpetofauna as part of Indonesia's biodiversity, (2) outlines the history of herpetological research in the region, (3) identifies major gaps in our knowledge of the Indonesian herpetofauna, and (4) uses this framework for discussing issues and problems of the conservation of amphibians and reptiles in Indonesia. In particular, the contents and shortcomings of compilations of lists of protected or threatened species by national and international authorities are discussed, major threats to the Indonesian herpetofauna or certain components thereof are described, and a set of measures for better long-term conservation is proposed.**

***Abstrak.*—Indonesia adalah suatu negara kepulauan yang terdiri dari sekitar 17.000 pulau dengan ukuran bervariasi dan mempunyai asal usul geologi yang kompleks seperti yang terlihat dalam komposisi tumbuhan dan hewannya. Indonesia, sebagai salah satu pusat keanekaragaman yang terbesar di dunia, baik dari segi kekayaan alam jenisnya maupun dari segi tingkat endemisitasnya. Menurut Biodiversity Action Plan for Indonesia, 16% dari amfibi dan reptil dunia terdapat di sini, dengan jumlah lebih dari 1100 jenis. Kegiatan penelitian yang dilaksanakan pada masa yang baru lalu menunjukkan bahwa jumlah tersebut di atas masih jauh di bawah keadaan yang sebenarnya. Indonesia mungkin sekali sebuah negara yang mempunyai jumlah amfibi dan reptil terbesar di dunia. Yang patut menjadi pertimbangan ialah bahwa penelitian amfibi dan reptil di Indonesia jauh lebih lambat di bandingkan dengan kemajuan di negara tetangga. Sebagai gambaran, jumlah jenis di Indonesia apabila dibandingkan dengan jumlah jenis di seluruh Asia Tenggara dalam kurun waktu 70 tahun telah merosot dari 60% menjadi 50%. Hal ini terjadi karena jumlah taksa baru kebanyakan ditemukan di luar Indonesia. Banyak diantara jenis-jenis tersebut kemudian ditemukan di Indonesia. Dalam 70 tahun terakhir, 762 jenis taksa dipertelakan dari luar Indonesia dan hanya 262 pertelaan dari Indonesia.**

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Pada umumnya herpetofauna Indonesia tidak banyak dikenal, baik dari segi taksonomi, ciri-ciri biologi maupun ciri-ciri ekologinya. Daerah penyebaran suatu jenis sangat sedikit diketahui. Meninjau dari cepatnya penebangan dan pengalihan fungsi hutan, usaha untuk melindungi komponen biologi (dalam hal ini amfibi dan reptil) sangat diperlukan. Hampir semua status perlindungan baik secara nasional maupun dengan mengikuti kategori IUCN atau CITES tidak banyak diketahui atau dipahami. Kebanyakan informasi mengenai organisme Indonesia sulit diperoleh di dalam negeri. Sebagai akibat, maka diperlukan suatu mekanisme untuk mengatur kegiatan penelitian sedemikian rupa sehingga timbul kesadaran bahwa amfibi dan reptil merupakan salah satu komponen yang sangat berharga dari kekayaan keaneka-ragaman Indonesia. Makalah ini memberikan (1) gambaran komponen biodiversitas herpetofauna Indonesia, (2) memaparkan sejarah perkembangan herpetologi di Indonesia, (3) mengidentifikasi kekosongan dalam pengetahuan herpetologi di Indonesia, (4) memaparkan masalah dan jalan keluar dalam konseravsi keanekaragaman herpetofauna Indonesia. Daftar herpetofauna Indonesia yang dilindungi undang-undang, CITES dan IUCN dibahas, hewan-hewan yang mulai terancam dan kiat untuk melindunginya dibahas.

Key words. *Conservation, biodiversity, current knowledge, Indonesia, Amphibia, Reptilia, IUCN*

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Introduction

Indonesia, an archipelagic nation with a population of some 210 million people, comprises about 17,000 islands of varying sizes and geological origins, as well as marked differences in composition of their floras and faunas. Indonesia is one of the 17 megadiversity countries (Mittermeier and Mittermeier 1997) with two of the world's 25 hotspots for conservation priorities, viz. Sundaland and Wallacea (Mittermeier et al. 1999; Myers et al. 2000), important ecoregions and endemic bird areas. According to the biodiversity action plan for Indonesia (BAPPENAS 1993), 16% of the world's amphibian and reptile species occur in Indonesia, a total of over 1100 species.

One of the earliest comprehensive descriptions of the herpetofauna of Indonesia, formerly referred to as Dutch East India or the Dutch East Indies, is the two volume work by de Rooij (1915, 1917). The first volume covers the lizards, turtles, and crocodiles; 267 species of lizards, 35 chelonians, and four species of crocodilians are described. The second volume on snakes lists 84 genera and 318 species. De Rooij's nomenclature is based on the catalogues of the British Museum published in several volumes by Boulenger (see Das 1998, for references). The region covered in this work is the Indo-Australian Archipelago, stretching from Sumatra in the west to New Guinea and the Solomon Islands in the east. The next landmark publication on the herpetofauna of the Indo-Australian Archipelago was the work of van Kampen (1923) on amphibians. This work was an extension of his earlier work—he had published a list of 194 amphibian species for the same region in 1907—which brought the total number of amphibian species described to 254 species. In 1950, more than 30 years after de Rooij's publication (de Rooij 1917), de Haas published a checklist of the snakes of the Indo-Australian Archipelago (de Haas 1950). This checklist contained additions to the snake fauna and also some nomenclatorial changes. De Haas (1950) stressed the imperfect knowledge of the geographic distribution of many species, even from Java, where much of the early research had been carried out. This, to some extent, was covered by van Hoesel's work on the snakes of Java (van Hoesel 1959). Later work either focused on specific taxonomic groups or on parts of the Indonesian region or neighboring countries (Iskandar 1998, 2000). As a consequence, discussed in further detail below, much of our increasing knowledge of the Indonesian herpetofauna was a result of work performed outside of Indonesia itself. Only within the last decade new work on the Indonesian herpetofauna has appeared, e.g., on turtles and crocodiles (Iskandar 2000), the snakes of Sumatra (David and Vogel 1996), the snakes of Borneo (Stuebing and Inger 1999), the snakes of Sulawesi (de Lang and Vogel 2005), the amphibians of Java and Bali (Iskandar 1998), the lizards of Borneo (Das 2004), and the amphibians and reptiles of the Sunda region (Manthey and Grossmann 1997). Checklists of all amphibian and snake species of Southeast Asia and New Guinea have been compiled (Iskandar and Colijn 2000, 2002); the other reptile checklists are still in press. Other publications of regional relevance include work on Philippine amphibians (Alcala and Brown 1998), on the herpetofauna of Sabah (Inger and Stuebing 1989; Inger and Tan 1996), and publications focusing on Borneo (e.g., Inger and Stuebing 1997; ITTO 1998), peninsular Malaysia and Thailand (Chan-Ard et al. 1999; Cox et al. 1998), peninsular Malaysia and Borneo (Lim and Das 1999), and Singapore (Lim and Lim 1992).

Das (1998) and recently Iskandar and Colijn (2003), published a comprehensive bibliography of herpetological publications about Indonesia (excluding the Moluccas and New Guinea). These bibliographies clearly illustrate how difficult it is to compile the relevant published material for certain taxonomic groups. Moreover, updating of taxonomic and systematic relationships of certain amphibian and reptile species groups occurring in Indonesia faces a few other problems as well. Some of the most crucial points are discussed more in detail below. The fact that new amphibians and reptiles are still being described from Indonesia, not only from lesser known areas such as Papua (formerly known as Irian Jaya) and from more remote islands, but also from Java (examples for amphibians in Iskandar (1998) and a lizard in Iskandar (1994)), clearly underscores our fragmentary knowledge of the herpetofauna of Indonesia.

Concern about conservation of Indonesian species is quite a recent phenomenon. An exception may be early focus on the Komodo dragon (*Varanus komodoensis*), the first Indonesian reptile species for which protection and population management were considered vital for its survival (e.g., Hoogerwerf 1953). Conservation activities have always been biased toward better known and more showy bird and mammal species. Amphibians and reptiles have largely been ignored. This changed only recently, after it was noticed that some reptile species, particularly from Indonesia, were heavily exploited for their skins and other products such as meat, gall bladders, etc., and when evidence for a worldwide and poorly understood decline of amphibian species became available. To the general public in Indonesia, however, amphibians and reptiles are not considered groups that are in specific need of protection. As a result of the bias of conservation-related research in Indonesia, again toward larger mammal and particular bird species, our data on the herpetofauna of Indonesia are still poor. This applies despite the fact that Indonesia harbors the second-most, if not the most diverse herpetofauna worldwide. Our ignorance is not only limited to amphibians and reptiles. In the Agenda 21-Indonesia, it is estimated that 30% of the plant species and 90% of the animal species of Indonesia have not been adequately described and scientifically documented (State Ministry for Environment 1997). Trained herpetologists are virtually non-existent in Indonesia, and conservation and management activities only occasionally extend to amphibian and reptile species. More recent work on the ecology of certain islands or island groups within the Indonesian archipelago (e.g., Monk et al. 1997; Whitten et al. 1996) and work on amphibians and reptiles in trade (Erdelen 1998a; Erdelen 1998b), however, indicate that amphibians and reptiles are gaining momentum as groups that need to be considered important components of Indonesia's biodiversity.

This paper (1) gives an overview of the herpetofauna as part of Indonesia's biodiversity, (2) outlines the history of herpetological research in the region, (3) identifies major gaps in our knowledge of the Indonesian herpetofauna, and (4) uses this framework for discussing issues and problems of the conservation of amphibians and reptiles in Indonesia. In particular, the contents and shortcomings of compilations of lists of protected or threatened species by national and international authorities are discussed, major threats to the Indonesian herpetofauna or certain components thereof are described, and a set of measures for better long-term conservation is proposed.

Knowledge of amphibians and reptiles of Indonesia: a historical perspective

As already indicated above, with the publications of de Rooij (1915, 1917) and van Kampen (1923), for the first time, overviews of the herpetofauna of the Indo-Australian Archipelago were available. Therefore, our analysis starts with the year 1930 (Fig. 1-3). During the last 70 years, the number of Malesian (Insular Southeast Asia and New Guinea) reptile species, described principally from outside Indonesia, increased from 942 to 1238 species. During the same period comparatively few taxa were described from Indonesia. This discrepancy in species described is even more evident in the amphibians; whereas the Malesian and the whole Southeast Asian taxa show a marked increase, especially after 1955, the Indonesian "increment" in taxa is only between one-half and one-third of the Malesian and of the whole Southeast Asian figures (Fig. 1-3).

Comparatively little new information was added during World War II and during the periods of major political unrest in Indonesia, i.e., between 1940 and 1960 (Fig. 1-3: data points at the mid-intervals of 1945 and 1955). The decade 1960 to 1970 is characterized by the description of many new taxa from the Malesian region. Most of these taxa had been described from studies that were not carried out in Indonesia but in neighboring countries (especially from Malaysia, Philippines, Papua New Guinea and the Solomon Islands). This indirectly contributed to the increase in our knowledge of the Indonesian herpetofauna after many of these new forms were also found in Indonesia.

A closer look shows that not only new species of monitor lizards (Böhme et al. 2002; Böhme and Jacobs; 2001; Böhme and Ziegler 1997, 2005; Harvey and Barker 1998; Jacobs, 2003; Philipp et al. 1999; Sprackland 1999; Ziegler et al. 1999) but also new species of land and freshwater tortoises (McCord et al. 1995; McCord and Pritchard, 2002; van Dijk 2000; Rhodin 1994) were described from Indonesia. Figures for total species numbers will probably still increase (Rhodin and Genorupa 2000). For instance, some of the so-called better known species may comprise species complexes (e.g., *Limnonectes macrodon*), and quite a few new taxa are already known but still await their scientific description (Emerson et al. 2000; Evans et al. 2003).

Need for conservation of Indonesian amphibians and reptiles

Threatened species, CITES, and protected species, IUCN, CITES, and PKA lists: a comparison

Three major compilations give an outline of the present status of national and international conservation and protection measures. These are the 2000 IUCN Red List of Threatened Animals (Baillie and Groombridge 1996), into which the new IUCN categories and criteria are incorporated (as adopted by IUCN in 1994), the CITES lists of species listed in the appendices, and the list of Indonesian protected species (Ministry of Forestry 2004). The 1996 IUCN list comprises a total of 30 reptile species occurring in Indonesia (Table 1). Of these reptile species, 22 are considered threatened, i.e., belonging to the category "critically endangered," "endangered," or "vulnerable." The remaining eight species are either grouped under "data deficient" (five species) or "lower risk" (three species). These threat categories differ only in quantitative aspects, e.g., in population decline rates.

The 2000 IUCN Red List (IUCN 2000) shows a dramatic increase in the numbers of turtle species included (Table 1). This has largely been due to information and recommendations from a workshop on conservation and trade of freshwater turtles and tortoises in Asia (van Dijk et al. 2000). In the IUCN Red List (IUCN 2000), no turtle species is further listed as data deficient, and nearly all Indonesian and New Guinean species are included, in addition to a number of other Asian turtle and tortoise species. The pres-

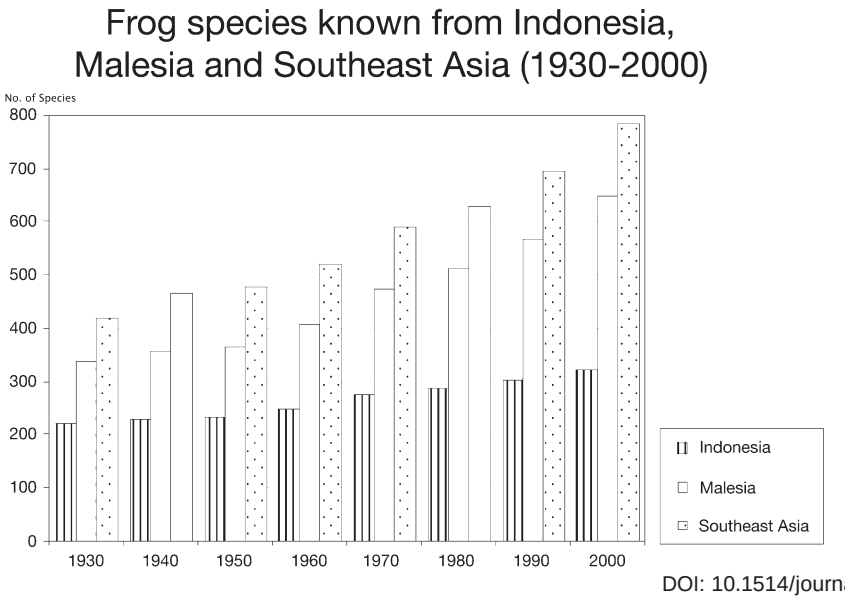

Figure 1. DOI: 10.1514/journal.arc.0040014g001

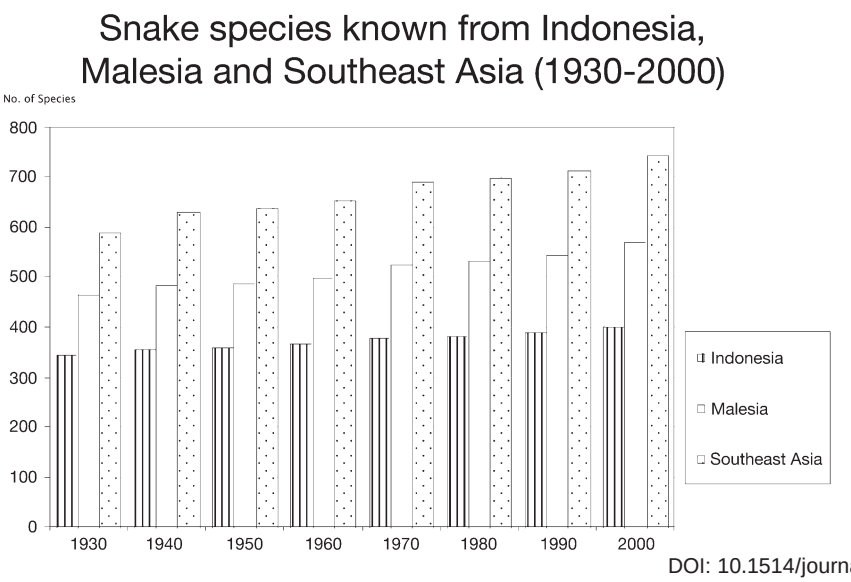

Figure 2. DOI: 10.1514/journal.arc.0040014g002

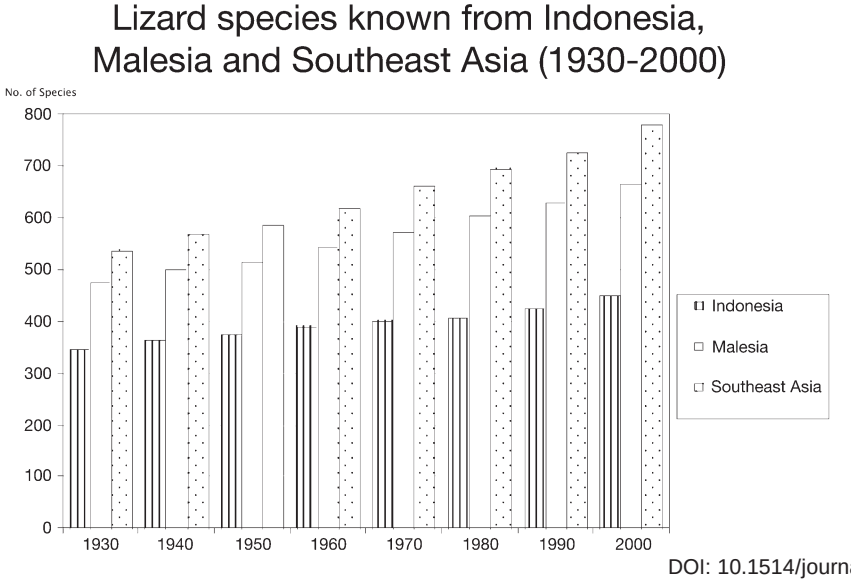

Figure 3. DOI: 10.1514/journal.arc.0040014g003

Table 1. Indonesian reptiles listed in the IUCN Red Lists of threatened animals (Baillie and Groombridge 1996; IUCN 2000), in the CITES Appendices I or II, and protection status in Indonesia. For comparison, threat proposals of the Asian turtle trade workshop (ATT 1999, see van Dijk et al. 2000) are included. IUCN categories of threat: CR = critically endangered, DD = data deficient, EN = endangered, LR = lower risk: near threatened, VU = vulnerable, — = not listed. CL = listed in CITES Appendices (I, II; - = not listed). PI = protection status of species in Indonesia (P = protected; - = not protected). Quota = Quota issued by PKA for skin trade (QS) and live export or pet trade (QL). Note: Quota categories given according to major use category. *) Including *Cyclemys oldhami*. **) Export stopped since 1994 (see text for details). Note: At least three new species of the chelid genus *Elseya*, none of them listed here, will be described from New Guinea. ***) The different subspecies of *Python curtus* are now in the process of being split into three distinct species. Note: Since this table was prepared several new species and subspecies have been described, including *Chitra vandjiki* and *Chitra chitra javanensis* (McCord and Pritchard 2002), *Varanus böhmei* (Jacobs 2003), *V. macraei* (Böhme and Jacobs 2001), *V. reisingeri* (Eidenmüller and Wicker 2005), and *V. zugorum* (Böhme and Ziegler 2005), *Pelochelys signifera* (Webb 2001), *Candoia paulsoni* and *Candoia superciliosa* (Smith et al. 2001)

Taxon	IUCN 1996	ATT 1999	IUCN 2000	CL	PI	Quota
Testudines - Turtles and Tortoises						
Carrettochelyidae						
Carrettochelys insculpta	VU	VU	VU	-	P	
Chelidae						
Chelodina mccordi	VU	CR	CR	-	-	
Chelodina novaeguineae	——	LR	——	-	P	
Chelodina parkeri	——	VU	VU	-	-	
Chelodina reimanni	DD	LR	LR	-	-	
Chelodina siebenrocki	——	LR	LR	-	-	
Elseya branderhorstii	——	VU	VU	-	-	
Elseya novaeguineae	——	LR	——	-	P	
Emydura subglobosa	——	LR	——	-	-	
Cheloniidae						
Caretta caretta	EN		EN	I	P	
Chelonia mydas	EN		EN	I	P	
Eretmochelys imbricata	CR		CR	I	P	
Lepidochelys olivacea	EN		EN	I	P	
Natator depressus	VU		VU	I	P	
Dermochelyidae						
Dermochelys coriacea	EN		CR	I	P	
Bataguridae						
Batagur baska	EN	CR	CR	I	P	
Callagur borneoensis	CR	CR	CR	II	-	QL
Cuora amboinensis	LR	VU	VU	-	-	
*Cyclemys dentata *)*	——	LR	LR	-	-	
Heosemys spinosa	VU	EN	EN	-	-	
Leucocephalon yuwonoi	DD	CR	CR	-	-	
Malayemys subtrijuga	——	VU	VU	-	-	
Notochelys platynota	DD	VU	VU	-	-	
Orlitia borneensis	LR	EN	EN	-	P	
Siebenrockiella crassicollis	——	VU	VU	-	-	
Testudinidae						
Indotestudo forstenii	VU	EN	EN	II	-	QL
"Indotestudo elongata"	VU	EN	EN	II	-	QL
Manouria emys	VU	EN	EN	II	-	QL
Trionychidae						
Amyda cartilaginea	VU	VU	VU	-	-	
Chitra chitra	CR	CR	CR	-	-	
Pelochelys bibroni	VU	VU	VU	-	-	
Pelochelys cantorii	VU	EN	EN	-	-	
Crocodylia - Crocodiles						
Crocodylidae						
Crocodylus mindorensis	CR		CR	I	-	
Crocodylus novaeguineae	——		——	II	P	QS

Continued on page 065.

Table 1. Continued.

Taxon	IUCN 1996	ATT 1999	IUCN 2000	CL	PI	Quota
Crocodylia - Crocodiles						
Crocodylidae						
Crocodylus porosus	——		——	II	P	QS
Crocodylus raninus	——		——	II	-	
Crocodylus siamensis	CR		CR	I	P	
Tomistoma schlegelii	DD		EN	I	P	
Sauria - Lizards						
Agamidae						
Chlamydosaurus kingii	——		——	-	P	
Hydrosaurus amboinensis	——		——	-	P	
Hypsilurus dilophus	——		——	-	P	
Lanthanotidae						
Lanthanotus borneensis	——		——	-	P	
Scincidae						
Tiliqua gigas	——		——	-	P	
Varanidae						
Varanus auffenbergi	——		——	II	-	
Varanus beccarii	——		——	II	-	QL
Varanus bengalensis nebulosus	——		——	I	P	
Varanus caerulivirens	——		——	II	-	
Varanus cerambonensis	——		——	II	-	
Varanus doreanus	——		——	II	-	QL
Varanus dumerilii	——		——	II	-	QLL
Varanus indicus	——		——	II	P	
Varanus jobiensis	——		——	II	-	QL
Varanus komodoensis	VU		VU	I	P	
Varanus melinus	——		——	II	-	
Varanus "panoptes" (gouldii)	——		——	II	P	
Varanus prasinus	——		——	II	P	
Varanus rudicollis	——		——	II	-	QL
Varanus salvadorii	——		——	II	-	QL
Varanus salvator	——		——	II	-	QS
Varanus salvator togianus	——		——	II	P	
Varanus timorensis	——		——	II	P	
Varanus yuwonoi	——		——	II	-	
Serpentes - Snakes						
Anomochilidae						
Anomochilus leonardi	DD		DD	-	-	
Boidae						
Candoia aspera	——		——	II	-	QL
Candoia carinata	——		——	II	-	QL
Colubridae						
Iguanognathus werneri	VU		VU	-	-	
Ptyas mucosa	——		——	II	-	(QS)**
Elapidae						
Naja sputatrix	——		——	II	-	QL
Naja sumatrana	——		——	II	-	
Ophiophagus hannah	——		——	II	-	QL
Pythonidae						
Apodora papuana	——		——	II	-	QL
Leiopython albertisii	——		——	II	-	QL
Liasis fuscus	——		——	II	-	QL
Liasis mackloti	——		——	II	-	QL

Continued on page 066.

Table 1. Continued.

Taxon	IUCN 1996	ATT 1999	IUCN 2000	CL	PI	Quota
Serpentes - Snakes						
Pythonidae						
Morelia amethistina	——		——	II	-	Q
Morelia boeleni	——		——	II	-	QL
Morelia clastolepis	——		——	II		
Morelia nauta	——		——	II		
Morelia spilota variegata	——		——	II	-	QL
Morelia tracyae	——		——	II		
Morelia viridis	——		——	II	P	
*Python curtus****)*	——		——	II	-	QS
Python molurus bivittatus	LR		LR	II	P	
Python reticulatus	——		——	II	-	QS
Python timoriensis	——		——	II	P	

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ent list contains 85 species, of which 31 species, including most turtles and crocodiles, are considered threatened. For other reptile groups such as varanid lizards and pythons, however, we urgently need assessment of their status. Except for highly localized knowledge of some of the most common species such as *Varanus salvator*, *Python curtus*, and *Python reticulatus*, we hardly know anything about the other Indonesian species.

None of the Indonesian amphibian species was listed in the 2000 IUCN Red List of Threatened Animals. However, by the 2004 Red List of Threatened Species, the status of amphibians had changed dramatically, and the report noted that they "are currently the most threatened class of vertebrates on the IUCN Red List" (Baillie et al. 2004, p. 11). This is reflected in the 2006 Red List, which lists 39 threatened amphibian species in Indonesia (IUCN 2006). All this new information on amphibians certainly requires further detailed analysis, which could not be carried out for this paper.

The IUCN criteria and subcriteria provide information on the underlying reasons why a species may be threatened. For the Indonesian taxa, most are given *criterion A*, i.e., populations are declining. *Subcriteria 1* and *2* (for *criterion A*) indicate that decline has been observed or suspected in the past (subcriterion 1) or will be in the future (subcriterion 2). *Subcriteria a* and *b* only point out the evidence available, i.e., direct observation or an index of abundance. More important is that *subcriteria c* and/or *d* are listed for virtually all of the

Plate 2. DOI: 10.1514/journal.arc.0040016g004

Plate 1. DOI: 10.1514/journal.arc.0040016g005

Plate 3. DOI: 10.1514/journal.arc.0040016g006

Plate captions: 1. *Ingerophrynus celebensis.* **2.** *Pelophryne signata.* **3.** *Litoria infrafrenata.*

Species plates 1–3 taken by Djoko T. Iskandar.

Plate 4. DOI: 10.1514/journal.arc.0040016g007

Plate 5. DOI: 10.1514/journal.arc.0040016g008

Plate 6. DOI: 10.1514/journal.arc.0040016g009

Plate 7. DOI: 10.1514/journal.arc.0040016g010

Plate 8. DOI: 10.1514/journal.arc.0040016g011

Plate 9. DOI: 10.1514/journal.arc.0040016g012

Plate 10. DOI: 10.1514/journal.arc.0040016g013

Plate 11. DOI: 10.1514/journal.arc.0040016g014

Plate captions: 4. *Litoria* sp. **5.** *Leptolalax hamidi.* **6.** *Leptobachium hasseltii.* **7.** *Limnonectes* sp. with a black tympanum. **8.** *Limnonectes* cf *modestus.* **9.** *Limnonectes* sp. that laid tadpoles. **10.** *Limnonectes shompenorum.* **11.** *Limnonectes modestus.*

Species plate 6–9 taken by Jim A. McGuire. Species plates 4–5, 10, & 11 taken by Djoko T. Iskandar.

threatened taxa; that is, either the area occupied by the species is shrinking or the habitat quality is decreasing (*subcriterion c*) or the species is heavily exploited (*subcriterion d*). In the case of the Komodo monitor, it is well-known that, except for Flores, the species is restricted only to a few smaller islands, Komodo being the most extensive, and that the Flores populations are threatened (for distributional details see Auffenberg 1981, Murphy et al. 2002; Ciofi and de Boer 2004). The species under *criterion D* and *subcriterion 2* all have susceptible populations. For instance, the chelid turtle *Chelodina mccordi* occurs only on Roti Island, south of Timor (Rhodin 1994), and *Chelodina parkeri* seems to have a very restricted distribution in Irian Jaya (Iskandar 2000; Samedi and Iskandar 2000). The colubrid snake *Iguanognathus werneri* is known only from a single specimen from Sumatra. *Leucocephalon* (formerly *Heosemys*) *yuwonoi* from northern Sulawesi, was only described within the last decade or so (McCord et al. 1995; McCord et al. 2000). The false gharial (*Tomistoma schlegelii*), in the 1996 IUCN list classified as DD is now (IUCN 2000) considered endangered. This change in threat status is supported by many studies in Sumatra, Borneo, and peninsular Malaysia (Bezujien et al., 1998; Ramono and Rahardjo 1993; Ross et al. 1996; Simpson et al. 1998; Stuebing et al. 1998).

In sum, as already indicated in the IUCN list (Baillie 1996), the overall conservation status of amphibians and reptiles cannot be assessed. As a consequence, this also applies to the lower national level of this analysis. The IUCN list largely reflects the fact that of the six orders of reptiles only the crocodiles (Crocodylia), the tuataras (Rhynchocephalia), and, at least in part, the turtles (Testudines) have been assessed. However, the majority of the reptile species, i.e., the lizards and snakes, do not fall into any of these groups. This bias in available assessment data is also clearly seen in the list for the Indonesian species. The majority of the species are turtles of which all of the species found in Indonesia are listed. Of the six crocodile species found in Indonesia, three appear in the IUCN list, all are listed in Appendix I or II of CITES (Table 1). Of the lizards, only the Komodo monitor, being the largest extant lizard species, is mentioned. As an endemic flagship species, it has the highest protection status among Indonesia's reptiles. The speciose group of snakes is only represented by a single python species (*Python molurus*) and a single colubrid snake species (*Iguanognathus werneri*).

By definition, CITES covers international trade issues. Therefore, the IUCN and CITES lists are not congruent but have only certain species in common (Table 1). For example, except for one species of monitor lizard (*Varanus bengalensis*), all species of CITES Appendix I are also listed as

Plate 12. DOI: 10.1514/journal.arc.0040016g015

Plate 13. DOI: 10.1514/journal.arc.0040016g016

Plate 14. DOI: 10.1514/journal.arc.0040016g017

Plate 15. DOI: 10.1514/journal.arc.0040016g018

Plate captions: **12.** *Limnonectes* cf. *grunniens.* **13.** *Occidozyga lima.* **14.** *Rhacophorus gauni.* **15.** *Nyctixalus pictus.*

Species plates 13 & 15 taken by Jim A. McGuire. Species plate 12 & 14 taken by Djoko T. Iskandar.

Plate 16. DOI: 10.1514/journal.arc.0040016g019

Plate 17. DOI: 10.1514/journal.arc.0040016g020

Plate 19. DOI: 10.1514/journal.arc.0040016g022

Plate 18. DOI: 10.1514/journal.arc.0040016g021

Plate captions: 16. *Nyctixalus margaritifer*. **17.** *Rhacophorus edentulus.* **18.** *Rhacophorus margaritifer.* **19.** *Staurois guttatus*.

Species plate 18 taken by Jim A. McGuire. Species plates 16 & 19 taken by Djoko T. Iskandar. Species plate 17 taken by Graeme Gillespie.

Plate 20. DOI: 10.1514/journal.arc.0040016g023

Plate 21. DOI: 10.1514/journal.arc.0040016g024

Plate 22. DOI: 10.1514/journal.arc.0040016g025

Plate 23. DOI: 10.1514/journal.arc.0040016g026

Plate 24. DOI: 10.1514/journal.arc.0040016g027

Plate 25. DOI: 10.1514/journal.arc.0040016g028

Plate 26. DOI: 10.1514/journal.arc.0040016g029

Plate 27. DOI: 10.1514/journal.arc.0040016g030

Plate captions: 20. *Sylvirana picturata.* **21.** *Hydrophylax chalconota.* **22.** *Odorrana hosii.* **23.** *Hydrophylax nicobariensis.* **24.** *Sylvirana celebensis*. **25.** *Kaloula baleata*. **26.** *Kaloula pulchra*. **27.** *Microhyla achatina.*

Species plate 20 taken by Djoko T. Iskandar. Species plates 21–27 taken by Jim A. McGuire.

Plate 28. DOI: 10.1514/journal.arc.0040016g031

Plate 29. DOI: 10.1514/journal.arc.0040016g032

Plate 30. DOI: 10.1514/journal.arc.0040016g033

Plate 31. DOI: 10.1514/journal.arc.0040016g034

Plate 32. DOI: 10.1514/journal.arc.0040016g035

Plate 33. DOI: 10.1514/journal.arc.0040016g036

Plate 34. DOI: 10.1514/journal.arc.0040016g037

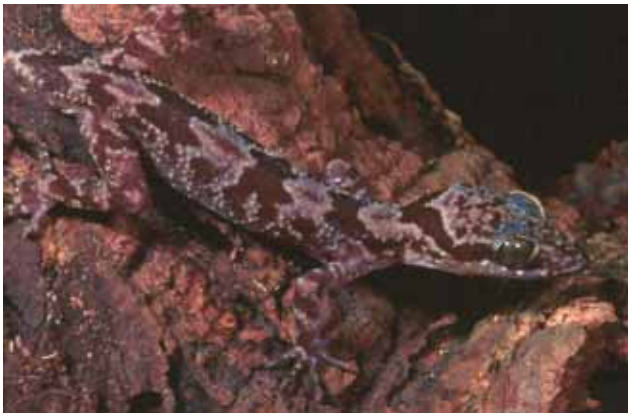

Plate 35. DOI: 10.1514/journal.arc.0040016g038

Plate captions: 28. *Oreophryne* sp. **29.** *Bronchocela jubata.* **30.** *Gonocephalus kuhlii.* **31.** *Gonocephalus grandis* (male). **32.** *Bronchocela cristatella.* **33.** *Draco bourouniensis*. **34.** *Draco haematopogon.* **35.** *Cyrtodactylus jellesmae.*

Species plate 31 taken by Djoko T. Iskandar. Species plates 29, 30, & 32–35 taken by Jim A. McGuire. Species plate 28 taken by Graeme Gillespie.

threatened by IUCN. For *Tomistoma schlegelii* this has applied only since the IUCN 2000 list was published (see Table 1). As shown in Table 1, except for species protected in Indonesia (P) and *Crocodylus raninus* and *C. mindorensis*, both species virtually unknown by Indonesian authorities to occur in Indonesia, all species listed under CITES are subject to quota that limit the annual catch. These may be quota referring to skin trade (QS) or quota for trade of live specimens (QL). In addition, a few species of reptiles are protected in Indonesia but appear neither in the IUCN list nor in the CITES appendices. These are two species of side-necked turtles (Chelidae), three showy and large species of agamid lizards, the monotypic genus *Lanthanotus*, and the scincid species *Tiliqua gigas*. The agamids belong to the genera *Chlamydosaurus*, *Hydrosaurus*, and *Hypsilurus*. These are either species with restricted ranges within Indonesia (*Hydrosaurus amboinensis*) or are elements of the Australian realm, found in Indonesia only in Papua and on small islands on the Sahul Shelf (*Chlamydosaurus kingii* and *Hypsilurus dilophus*).

Conclusions

Internationally protected species such as marine turtles may experience considerable exploitation in Indonesia. Species not adequately considered by any national or international regulations are exploited in enormous numbers in Indonesia. This presently particularly applies to freshwater turtles ("freshwater turtles" or "tortoises"—tortoises by definition do not occur in the water). The taxonomic status of many species is neither clear to scientists nor, as a consequence, to Indonesian conservation authorities. For instance, what is considered *Indotestudo elongata* is in fact *I. forsteni*, which shows intraspecific variation in presence or absence of nuchal scales, the major character by which the two species are distinguished by CITES. The species complex of *Crocodylus siamensis* and the taxonomic status of *C. raninus* are only poorly understood although recorded from Brunei Darussalam (Das and Charles 2000). In addition, varanid nomenclature is presently undergoing such rapid modification that the official authorities cannot keep pace with revisions published and new species described in the scientific literature (Pianka et al. 2004). Moreover, traders have identified the need for more taxonomic studies as specimens were collected that showed significant deviation from "classical" species descriptions (see, e.g., Yuwono 1998, for more specific information). In extreme cases, taxa later described as new species have already (under other names) been traded for some time before they were officially described in the literature. This, for instance, applies to virtually all recently described new species such as, among reptiles, the monitor lizards, pythons, and turtles.

Threats to Indonesian amphibians and reptiles

General remarks

Most of the information needed for conservation measures for the amphibians and reptiles of Indonesia is not available. In particular, habitat requirements are little known, population sizes are unknown for virtually all species, and, as a consequence, recent trends in population sizes also remain unknown. Generally, most of the fundamental data on species biology and ecology are lacking. Our knowledge, however, is not zero. We do know that certain species are typical forest dwellers and that habitat destruction and trade have affected species and local populations. Some of the potential threatening factors, however, we are only beginning to understand. These are, for instance, the questions as to what extent the global decline in amphibian species also applies for Indonesian species and to what extent extreme climatic fluctuations, mostly associated with El Niño Southern Oscillation (ENSO) events, cause disturbances in natural reproductive patterns in amphibians that may affect population sizes and densities in the long run. A study in Papua New Guinea, for instance, has shown that drought conditions affect frogs with terrestrial breeding modes and with direct development to such an extent that reproduction almost ceased (Bickford 1998). In addition, it was found that rare and uncommon arboreal species descend from their arboreal sites and frog densities seem to increase near streams. The effects of the latter two phenomena on the respective communities remain unknown. A similar situation may be expected for frogs in other parts of Indonesia, not only for the Indonesian part of New Guinea (Papua).

Studies in Kalimantan have shown that, as a result of the intense fires during the long drought in 1998 and the concomitant haze that affected the whole region, amphibian reproductive cycles normally triggered by the moon phases may have been completely out of synchronization with natural cues, and it is possible that reproduction may not have taken place (Iskandar et al. 1999). Similar observations have been made for other taxonomic groups such as birds and primates, which showed very limited activities and reduced vocalizations during such periods (Gurmaya et al. 1999, Raharjaningtrah and Prayogo 1999).

Habitat destruction

Habitat destruction and the resulting fragmentation of populations is the most important factor affecting the indigenous amphibian and reptile species of Indonesia. For instance, Sumatra has experienced a drastic loss of lowland forests during the past two decades. Many of the Indonesian endemics are species occurring in forests. We do not know to what extent these species can tolerate human impacts without severe population reductions. This situation is particularly acute in those parts of Indonesia where island sizes are small and, as a consequence, extension of natural vegetation and absolute numbers of individuals for most of the species are already low. This applies, for instance, to eastern Indonesia, e.g., the Lesser Sunda Islands and the Moluccas. But even on the larger islands such as Sumatra, Kalimantan, Sulawesi, and Irian Jaya, localized endemism and species with narrow geographical ranges are automatically prone to extinction. This applies to most of the New Guinean microhylid frogs such as the genera *Oreophryne* and *Xenobatrachus* and most tree frogs of the genus *Litoria*. In many cases, species are known only from the type specimen or species have not been found again for decades. Examples of such very poorly known species are the amphibians *Ichthyophis hypocyaneus*, *Rana debussyi*, *R. persimilis*, and

Plate 36. DOI: 10.1514/journal.arc.0040016g039

Plate 37. DOI: 10.1514/journal.arc.0040016g040

Plate 38. DOI: 10.1514/journal.arc.0040016g041

Plate 39. DOI: 10.1514/journal.arc.0040016g042

Plate 40. DOI: 10.1514/journal.arc.0040016g043

Plate 41. DOI: 10.1514/journal.arc.0040016g044

Plate 42. DOI: 10.1514/journal.arc.0040016g045

Plate 43. DOI: 10.1514/journal.arc.0040016g046

Plate captions: 36. *Cyrtodactylus* sp. **37.** *Gehyra mutilata.* **38.** *Gekko smithi.* **39.** *Gekko vittatus.* **40.** *Lepidodactylus lugubris*. **41.** *Cyrtodactylus* sp. **42.** *Ptychozoon kuhlii.* **43.** *Tribolonotus gracilis.*

Species plates 36–38, 40 & 42 taken by Jim A. McGuire. Species plate 39 taken by Alain Compost. Species plates 41 & 43 taken by Djoko T. Iskandar.

Philautus jacobsoni; the lizards *Harpesaurus tricinctus, H. modigliani*, and *Thaumatorhynchus brooksi*; and the snakes *Iguanognathus werneri* and *Anoplohydrus aemulans*.

The present rate of habitat destruction in Indonesia is alarming. In 1996, logging concessions covered an area of about 54 million hectares (Sunderlin and Resosudarmo 1996), and earlier reports by the United Nations Food and Agriculture Organisation and the World Bank estimated an increase in annual deforestation from 300,000 hectares in the 1970s to about 1 million hectares in 1990. In 1998, logging activities were still estimated to cover an area of some 51.5 million hectares, carried out by over 421 private companies, most of them operating under 33 leading business groups (Jakarta Post, 15 January 1999).

Agenda 21-Indonesia estimates that up to 1.3 million hectares of forest are cleared annually in Indonesia and that habitat loss in Java and Bali is about 91% (State Ministry for Environment 1997). Between 1985 and 1997 about 18 million hectares of forest have been lost in Indonesia, mostly lowland rain forests. It is estimated that by the year 2010 Kalimantan will have lost all of its lowland forests, as has largely occurred on Sumatra.

Studies in man-made habitats have shown that these contain only a small segment of the original diversity in amphibian and reptile species. Even in oil palm plantations which superficially resemble forests, i.e., in terms of shade conditions and microclimate, most of the amphibian and reptile taxa found are typical human commensals or species occurring in agricultural landscapes. For instance, no typical forest-dwelling species was found in oil palm plantations studied in north Sumatra (Gaulke et al. 1997, 1998). Accordingly, conversion of natural forest to agroecosystems or urban areas will result in the extermination of most of the species that formerly occurred in the given area.

Trade

General remarks on wildlife trade in Indonesia

Indonesia has a long history of wildlife trade, particularly in birds, live reptiles, reptile skins, and corals. Indonesia ranks among the world's leading nations in export of wildlife and wildlife products (Nash 1993). Early conservationists in Indonesia already saw a considerable danger for certain wild species through the largely uncontrolled export of wild animal species in those days, particularly the export of mammal and bird skins (e.g., Dammerman 1928). Trade in live plants and animals in Indonesia has received critical attention by the international community for many years. This particularly applies to trade in mammals, birds, and reptiles. For instance, enormous quantities of reptile skins were exported from Indonesia in the 1980s (see Jenkins and Broad 1994), and live export of birds and mammals had also reached new dimensions. The 1991 figures for Indonesian wildlife exports, as compiled by Nash (1993), list almost 80,000 parrots, 1.9 million reptiles including reptile skins, over 14,000 primates, and over 1 million pieces of coral. These figures certainly no longer apply, but nevertheless the question as to whether trade in certain species of Indonesian wild flora and fauna meets the criterion of sustainability still persists. In this section a few of the most important issues related to trade and conservation of amphibians and reptiles in Indonesia are discussed. A thorough analysis of the overall situation in wildlife trade in Indonesia is, in our opinion, long overdue.

Since 1978, Indonesia has been party to CITES, the Convention on International Trade in Endangered Species of Fauna and Flora. Indonesian CITES authorities are the Indonesian Institute of Sciences, the Scientific Authority (LIPI: Lembaga Ilmu Pengetahuan Indonesia); and the Directorate General of Protection and Nature Conservation (PKA: Direktorat Jenderal Perlindungan dan Konservasi Alam), the Management Authority.

CITES Appendix I species may be harvested for domestic use (see e.g., the non-protected CITES Appendix I species in Table 1). In international trade they are treated according to the rules and regulations in CITES. Appendix II species that are traded are subject to annual quota, i.e., PKA determines the number of specimens that may be caught for trade, both skin and live specimen trade (see Table 1 for species under the quota regulation). This "annual allowable catch" is determined newly for each calendar year. Quotas are then set on a provincial level. At present 30 reptile species are protected by Indonesian law, and, of these, quotas are issued for 27 species (Table 1).

Since Indonesia has been party to CITES, concern has been repeatedly stated over the implementation of Article IV of the Convention (Nash 1993). Article IV refers to Appendix II species and to the fact that export should not be detrimental to the survival of the respective species (paragraph 2a) and that export should "*be limited in order to maintain that species throughout its range at a level consistent with its role in the ecosystems in which it occurs and well above the level at which that species might become eligible for inclusion in Appendix I* ..." (paragraph 3). Subsequently, several reviews of the trade situation for particular species groups were carried out. For Indonesia, the most important ones were on Asian monitor lizards (Luxmoore and Groombridge 1990) and on Asian pythons (Groombridge and Luxmoore 1991). Information on trade in Indonesian lizards and snakes has been compiled documenting the many different facets of relevance for achieving sustainable harvests of the species in question (Erdelen 1998b). Still, the problem of setting appropriate quotas, as already discussed in Nash (1993), has not been solved for most of the taxa in trade in Indonesia. Confusion is also widespread over the term "non-detrimental" as given in the Convention (see above). This is underscored by the holding of an IUCN workshop to develop guidance for CITES scientific authorities on the making of "non-detriment findings".

Amphibian and reptile trade in Indonesia: conservation implications

As indicated above, an overall analysis of wildlife trade in Indonesia is not available. This also applies for the herpetofauna of Indonesia. As pointed out in an IUCN workshop on Asian turtles trade (van Dijk et al. 2000), determining trade levels for a species that should not have short-term or long-term negative effects on natural populations is a complex subject. This is exacerbated in amphibians and reptiles because of our lack of knowledge of their biology and ecolo-

Plate 44. DOI: 10.1514/journal.arc.0040016g047

Plate 45. DOI: 10.1514/journal.arc.0040016g048

Plate 46. DOI: 10.1514/journal.arc.0040016g049

Plate 47. DOI: 10.1514/journal.arc.0040016g050

Plate 48. DOI: 10.1514/journal.arc.0040016g051

Plate 49. DOI: 10.1514/journal.arc.0040016g052

Plate 50. DOI: 10.1514/journal.arc.0040016g053

Plate 51. DOI: 10.1514/journal.arc.0040016g054

Plate captions: **44.** *Cryptoblepharus balinensis.* **45.** *Emoia artrocostata.* **46.** *Emoia caeruleocauda.* **47.** *Lamprolepis smaragdinum.* **48.** *Eutropis multifasciata* (male). **49.** *Eutropix rudis.* **50.** *Glaphyromorphus nigricaudis*. **51.** *Papuascincus stanleyanus.*

Species plates 44–49 taken by Jim A. McGuire. Species plates 50 & 51 taken by Djoko T. Iskandar.

gy and the exploitation patterns, even in the so-called "better known" species (Erdelen 1998a). How difficult it is to collect the relevant field data to estimate sustainability was shown in a study of three of the most heavily exploited reptiles in Indonesia, the water monitor (*Varanus salvator*), the reticulated python (*Python reticulatus*), and the blood python (*Python curtus*) (Erdelen et al. 1997).

Reptile and amphibian trade is a comparatively recent phenomenon in Indonesia. Before the late 1980s, Indonesia had no professional collectors of live reptiles (Yuwono 1998). Generally, reptile trade may be subdivided into two major components, i.e., skin trade, including trade in other organs such as gall bladders, and pet trade. The former covers a few species harvested in large numbers, the latter about 30 species of amphibians, about 18 species of non-marine turtles, about 50 species of lizards, and about the same number of snake species (for details, see Yuwono 1998). Skin trade, on the other hand, essentially comprised five species in Indonesia, viz. the water monitor (*Varanus salvator*), two species of python (the reticulated python *Python reticulatus* and the blood python *P. curtus*), the rat snake (*Ptyas mucosa*), and the spitting cobra (*Naja sputatrix*). In the case of cobras, however, most specimens are caught for the food market, and skins are largely by-products (Saputra, pers. comm.). Since 1991, all quotas were reduced for these species, and international concern about the numbers of rat snakes harvested led to a total ban of trade in this species in Indonesia in 1994. In 1998, LIPI undertook a survey on *Ptyas mucosa*, and an EU project on this species is currently on its way to providing data on whether the international ban should be lifted or not. The latest (for the year 2000) quota for the remaining four species are 150,000 (*Naja sputatrix*), 46,400 (*Python curtus*), 176,000 (*Python reticulatus*), and 496,000 (*Varanus salvator*). One of the major questions arising from studies on the habitats from where specimens are collected is how to evaluate whether a species is collected from anthropogenic habitats such as paddy fields, rubber plantations or oil palm plantations, or from natural forest. Of these species, blood pythons are virtually exclusively collected from rubber and especially oil palm plantations (see e.g., Erdelen et al. 1997), and cobras and rat snakes are collected mostly from paddy field areas (Sugardjito et al. 1998). However, to what extent reticulated pythons are caught in forested areas or in open areas following deforestation remains unknown. Moreover, these pythons often are caught near human dwellings where they can easily find prey (Auliya, pers. comm. and own observations). The same applies for the water monitor, which may be caught in habitats ranging from urban areas to mangrove forests (e.g., Erdelen 1991). Surprisingly, these high harvest rates have obviously not led to large-scale extinctions of certain populations. This may be a result of high reproductive rates of species such as the water monitor and the reticulated python (Shine et al. 1998a, 1998b, 1998c, 1999a, 1999b).

This better understanding of the impact of harvesting on the populations of species in the skin trade is in no way matched by information available on the species used for live exports for the pet trade. To meet the demands of the pet market, however, rare species are captured only occasionally; mostly common species are traded to ensure a constant supply for the customers (see Yuwono 1998, for details). International customers are more interested in species from the Australian Realm rather than from the Southeast Asian Realm of Indonesia. This is possibly related to the fact that Australia and Papua New Guinea have rigorous export regulations for amphibians and reptiles, and so the limited availability increases the demand.

Toward improved conservation of amphibians and reptiles in Indonesia

Summary of the present situation

General issues

Amphibians and reptiles in Indonesia remain a poorly understood group. Although, in recent years, considerable effort has been put into obtaining a better understanding of the composition, taxonomic relationships, and geographic distribution of the amphibians and reptiles of Indonesia, we are still far from a complete knowledge of species numbers and the basic biogeographic patterns and their evolution. In particular, we need a better understanding of (1) the number of species occurring in Indonesia, (2) their relationships to closely related taxa found in the region, (3) the geographic distribution patterns within the Indonesian archipelago, (4) the closeness of association between certain species and specific vegetation or ecosystem types, and (5) the habitat and particularly microhabitat requirements for most of the Indonesian amphibian and reptile species.

These may appear as needs from a purely scientific perspective, but this information is also essential for approaching the problem of long-term conservation of Indonesian amphibians and reptiles. Conservation measures need to be launched now, despite the fact that our knowledge of the herpetofauna is still rather fragmentary. For instance, 71 amphibian species, 63 lizard species, 73 snake species, and one crocodilian; i.e., a total of 208 species of herpetofauna, are known from fewer than ten specimens. In most cases, these species are known only from the type specimens. How this translates into the conservation status of these taxa is difficult to assess. For instance, many species listed may be newly described taxa and not necessarily rare species. Others have questionable taxonomic status such as some of the species of the genus *Ichthyophis* and may also be naturally rare. Most species known only from the type specimen were collected from remote areas, and the status of these species remains unknown. Other species, particularly snakes, may be naturally rare but may have a wide geographic range within Indonesia or on the island(s) where they are found.

Local aspects

Studies carried out in Indonesia have been largely conducted by foreign scientists, in part due to the fact that there is a general lack of trained herpetologists in Indonesia, as well as a lack of funding facilities to conduct herpetological research. Both issues need to be addressed by Indonesian universities. Herpetology could, for instance, be much better represented in the curricula.

Plate 52. DOI: 10.1514/journal.arc.0040016g055

Plate 53. DOI: 10.1514/journal.arc.0040016g056

Plate 54. DOI: 10.1514/journal.arc.0040016g057

Plate 55. DOI: 10.1514/journal.arc.0040016g058

Plate 56. DOI: 10.1514/journal.arc.0040016g059

Plate 57. DOI: 10.1514/journal.arc.0040016g060

Plate 58. DOI: 10.1514/journal.arc.0040016g061

Plate 59. DOI: 10.1514/journal.arc.0040016g062

Plate captions: 52. *Sphenomorphus nigrilabris.* **53.** *Tropidophorus baconi.* **54.** *Varanus melinus.* **55.** *Varanus indicus*. **56.** *Typhlops lineatus.* **57.** *Cylindrophis melanotus.* **58.** *Xenopeltis unicolor.* **59.** *Chrysopelea rhodopleuron.*

Species plates 52, 53, 55, 58, & 59 taken by Jim A. McGuire. Species plate 54 taken by Djoko T. Iskandar. Species plate 58 taken by Graeme Gillespie. Species plate 56 taken by Alain Compost.

Only slowly are projects and studies planned and carried out that have amphibians and/or reptiles as the major target group. Up to now, these were groups only occasionally sampled within programs that were primarily aimed at broader conservation issues as, for example, conservation of natural forest ecosystems or wetlands in Indonesia. The only exception may have been trade-related surveys and studies and some work on marine turtles.

Most of the work carried out by local organizations involved species inventories. This work had to face problems of species identification and comparisons with reference collections. In this context, a strengthening of the role of the leading museum in Indonesia, the Museum Zoologicum Bogoriense, is urgently required. This refers to the setting up of reference collections for researchers, better infrastructure, and collection materials, and an increase in the number of highly qualified staff for the different taxonomic groups.

There is still a lack of basic information materials such as simple field guides or color guides for the most important taxa of Indonesian amphibians and reptiles. This information is urgently needed by various groups, especially the local communities and the official authorities (such as PKA and Customs Control). An internationally sponsored program for writing local language field guides is a promising step toward providing a better information basis for professionals, interested laymen, and the Indonesian authorities. Several agencies have taken up this issue, including EMDI, Fauna Malesiana, GEF Biodiversity, IUCN, and the World Bank. As a result, books about mammals, birds, reptiles, and amphibians have been published or are presently being prepared.

Taxa-specific issues

Amphibians

Most information about the status of amphibians in Indonesia is based on studies from neighboring areas, such as Sarawak, where Stuebing (1994, 1997) studied habitats and microhabitats of the herpetofauna, including the amphibian families Bufonidae, Megophryidae, Microhylidae, Ranidae, and Rhacophoridae. Stuebing's work is of particular relevance for Indonesia as it was carried out in a proposed connected protected area system in Sarawak and Kalimantan, jointly to be managed by Malaysian and Indonesian authorities (Lanjak-Entimau and Betung Kerihun, respectively; the latter until recently known as Bentuang Karimun). Moreover, Stuebing (1994, 1997) had developed a management plan that focused on the herpetofauna. Comparable work on the protected area management level is still lacking in Indonesia. A second example is the study on the effects of ENSO events on frog species in New Guinea (Bickford 1998), already discussed above. To date, we have only cursory information on the likely effects of prolonged droughts, fire, and haze on populations of Indonesian amphibians and, in particular, on impacts on reproductive cycles. For instance, Iskandar (1998) described the decline in the endemic toad *Leptophryne cruentata* (Bufonidae) from the slopes of Gede-Pangrango (West Java), most likely caused by the 1981 eruptions of the volcano Mt. Galunggung which lasted for about six months. Detailed longitudinal studies of population changes in Indonesian amphibian species have not been carried out yet. Accordingly, we do not know whether a general decline in amphibian numbers as observed elsewhere is also taking place in Indonesia. Because of our poor knowledge of the Indonesian amphibian species, we do not have any information against which to "calibrate" observed changes or trends. This database needs to be created, possibly as a joint venture between Indonesian universities and the Museum Zoologicum Bogoriense. Moreover, there is a strong need for more detailed taxonomic studies. This is best illustrated in the frog leg trade (mostly *Limnonectes macrodon* and *L. blythii*) for which actually many species are harvested; some of them have not even been described scientifically (for details see Emerson et al. 2000; Iskandar 1996).

Turtles and crocodiles

Although, among reptiles, sea turtles have received the most attention by international conservation organizations, the situation of the domestic trade in Indonesia and the smuggling of specimens or products from Indonesia still remain unknown. This particularly refers to the green turtle (*Chelonia mydas*), the species most commonly caught (Suwelo et al. 1995). In a study by Limpus (1995) it is stated that the "*largest slaughter of green turtles globally occurs within the Australasian region, including Indonesia*" ...., that "*near-total egg harvest still characterizes the green turtle nesting populations of Indonesia*", and that, for the hawksbill turtle (*Eretmochelys imbricata*), "*substantial harvest for domestic consumption of meat and scale continues in Cuba, Indonesia*" ... Mass collection of eggs of all marine turtle species still occurs throughout Indonesia (Tomascik et al. 1997). With the present economic situation in Indonesia these trends have been exacerbated and have been underscored in numerous articles that have appeared in the media. A national strategy and action plan for the conservation of marine turtles, already outlined in the early 1990s, has not been implemented, and current exploitation of marine turtles and their eggs in Indonesia is not sustainable (Tomascik et al. 1997). The conservation priority issues compiled by Tomascik et al. include, among others, improvement of fishing regulations and fishing techniques to the benefit of marine turtles, better planning of coastal development activities and avoidance of pollution in nesting areas, law enforcement, research on basic biology and ecology, production of education materials on conservation of marine turtles for the general public, and the launching of the relevant conservation programs by the Government of Indonesia.

Among turtles, least understood is the current situation of the live export of non-marine chelonians. Already in 1988, official export statistics for the Asiatic softshell turtle (*Amyda cartilaginea*) reached 66,500 kg for Sumatra only (details in Jenkins 1995; Shepherd 2000). During the past decade, volume in trade has reached enormous dimensions. The species affected, their relative percentages in the shipments, and their precise origin within Indonesia are virtually unknown. Moreover, to what extent protected or threatened species are exported as "by-catch" is not known either. For 1994, Jenkins (1995) listed quota for the Southeast Asian box turtle (*Cuora*

Plate 60. DOI: 10.1514/journal.arc.0040016g063

Plate 61. DOI: 10.1514/journal.arc.0040016g064

Plate 62. DOI: 10.1514/journal.arc.0040016g065

Plate 63. DOI: 10.1514/journal.arc.0040016g066

Plate 64. DOI: 10.1514/journal.arc.0040016g067

Plate 65. DOI: 10.1514/journal.arc.0040016g068

Plate 66. DOI: 10.1514/journal.arc.0040016g069

Plate 67. DOI: 10.1514/journal.arc.0040016g070

Plate captions: **60.** *Morelia tracyae.* **61.** *Morelia boeleni.* **62.** *Morelia viridis* (juvenile). **63.** *Morelia viridis.* **64.** *Python breitensteini.* **65.** *Boiga irregularis.* **66.** *Calamaria* sp. **67.** *Calamaria* sp.

Species plates 60, 62, & 65 taken by Djoko T. Iskandar. Species plates 66 & 67 taken by Graeme Gillespie. Species plates 61, 63, & 64 taken by Alain Compost.

amboinensis) of 10,000 specimens, and for *Amyda cartilaginea* of 50,000 specimens. However, other sources as quoted in Jenkins (1995) indicate that the real and actual figures may be much higher. Annual exports for *Cuora amboinensis* were estimated at 200,000 specimens or, more precisely, plastrons, which were exported from Sulawesi to Hong Kong as turtle paste (Samedi and Iskandar 2000).

The alarming trends in freshwater and marine turtle exploitation, particularly in Southeast Asia, have drawn attention to more rigorous protection measures and implementation of CITES, respectively. Although a first action plan for tortoises and freshwater turtles was already formulated more than a decade ago (IUCN/SSC Tortoise and Freshwater Turtle Specialist Group 1989), the situation has dramatically worsened. As pointed out by Jenkins (1995), exploitation patterns of non-marine chelonians have shifted from harvests for domestic consumption to large-scale international trade, mainly for meat consumption, covering hundreds of thousands of individuals annually. Imports by mainland China are increasing, including massive smuggling, and there are drastically increased exports from Indonesia, in particular from Sumatra, Kalimantan, and Sulawesi.

In his introductory remarks to the proceedings of the 1993 international conference on conservation, restoration, and management of tortoises and turtles, John Behler (1997), chairman of the respective IUCN/SSC specialist group, stated that "The great Asian river turtles (*Batagur baska*, *Callagur borneoensis*, and *Orlitia borneensis*) and the giant softshells (*Chitra* spp. and *Pelochelys bibroni*) are seriously depressed and will not long survive without heroic intervention" and that "Today, there is no more serious turtle crisis than that which is taking place in Southeast Asia and southern China. Some species are very likely being lost in nature before they can be described" (p. xix). Several of the papers in the same proceedings addressed questions of tortoise and non-marine turtle conservation in the Asian region, but not a single paper dealt with an analysis of the situation in Indonesia where populations are most heavily exploited for these turtle groups. In a workshop on trade of freshwater turtles and tortoises in Asia (van Dijk et al. 2000) a number of recommendations to lessen impacts on natural populations were formulated. The same appeal is addressed in the book about the turtles and crocodiles of insular Southeast Asia (Iskandar 2000). These are not repeated here, but it is hoped that they will be implemented in the respective countries of the region, thus reducing or eliminating collecting from the wild and curtailing demand in consumer countries. If this cannot be achieved in the near future, then the further existence of many of the species will be at stake.

Presently six species of crocodiles have been described from Indonesia, viz. the estuarine crocodile (*Crocodylus porosus*), the New Guinea crocodile (*C. novaeguineae*), the Bornean crocodile (*C. raninus*, Ross et al. 1998), the Siamese crocodile (*C. siamensis*), and the tomistoma or false gharial (*Tomistoma schlegelii*). The Philippine crocodile (*C. mindorensis*) has been sighted in East Sulawesi, and its occurrence in Indonesia has been confirmed through observation of specimens in a crocodile farm near Makassar (Iskandar 1998, 2000). *Crocodylus porosus* and *C. novaeguineae* are bred in captivity and caught from the wild for the skin trade. The status of their wild populations would need to be re-evaluated. Over ten years ago, Thorbjarnarson (1992) had already found that the estuarine crocodile had become rare in Java and Sumatra and that more information was needed about wild populations in Kalimantan and the smaller island groups (see Ross et al. 1996, for discussion). The status of *C. raninus* has been confirmed only recently, and it remains unclear whether this "species" consists of a species complex or not (for details see Ross et al. 1996). Moreover, the status of this species in the wild in Indonesia is unknown. The Siamese crocodile and *Tomistoma* were already listed as endangered in the Conservation Action Plan for crocodiles (Thorbjarnarson 1992). Next to Thailand, Indonesia was considered the highest priority for action regarding these two species. This is reflected in their protection status in Indonesia (Table 1). The fact that *Tomistoma schlegelii* is now considered endangered only indicates the need for further surveys on the status of this species, particularly with regard to its occurrence in Sulawesi. In addition, the status of *C. siamensis* in Indonesia – it was only reported from Kalimantan in the mid-1990s (Ross et al. 1996) – is unknown. According to Ross et al. (1996) the Siamese crocodile has not been "imported" to Kalimantan but occurs there naturally. In sum, more work on the systematic status of some of the Indonesian crocodilians as well as detailed studies of the status of their wild populations are urgently needed.

Lizards and snakes

Probably the least understood groups among Indonesian amphibians and reptiles are the lizards and snakes. Accordingly, for these groups only scanty information that was available was included into the lists compared here (Table 1). The reasons why, for instance, only some of the larger agamid species have been considered, remain unclear. For *Lanthanotus* no published evidence exists (yet) that this species occurs in Indonesia. To date, it has only been reported from Sarawak, in the East Malaysian state of Borneo, but according to information from traders and local people, it also occurs in West Kalimantan. Efforts are presently being undertaken to publish a series of guides with color photographs to facilitate identification of the most common amphibian and reptile species utilized in Indonesia. Long-term experience in the pet trade has shed light on taxonomic uncertainties, especially in taxa that are distributed in eastern Indonesia such as the *Tiliqua gigas* and *T. scincoides* species complex or species (see Yuwono 1998; Shea, 2000). *Candoia carinata* had been known as a very variable species, and is now split into three species. Two of them have two subspecies and the other has six subspecies (Smith et al. 2001). *Morelia amethistina* shows considerable morphological and color variation (Yuwono 1998) and was recently split into four species (Harvey et al. 2000). Most new monitor lizards from East Indonesia that were described after the year 1997 first appeared in trade under the identity of other species due to the lack of regulation to control undescribed species (i.e. Böhme et al. 2002; Böhme and Jacobs 2001; Böhme and Ziegler 1997; Eidenmüller and Wicker 2005; Harvey and Barker 1998; Jacobs, 2003; Philipp et al. 1999; Sprackland 1999; Ziegler et al. 1999). The criteria that led to the inclusion of *Iguanognathus werneri* and *Anomochilus leonardi* into the IUCN list remain unclear. There is virtually no information available on these species, and quite a number of similarly poorly known species should be included on the list if ignorance

Plate 68. DOI: 10.1514/journal.arc.0040016g071

Plate 69. DOI: 10.1514/journal.arc.0040016g072

Plate 70. DOI: 10.1514/journal.arc.0040016g073

Plate 71. DOI: 10.1514/journal.arc.0040016g074

Plate 72. DOI: 10.1514/journal.arc.0040016g075

Plate captions: 68. *Cerberus rynchops.* **69.** *Candoia carinata.* **70.** *Chrysopelea paradisii celebensis.* **71.** *Dendrelaphis caudalineatus.* **72.** *Dendrelaphis punctulatus.*

Species plates 68–70, & 72 taken by Jim A. McGuire. Species plate 69 & 71 taken by Djoko T. Iskandar.

Plate 73. DOI: 10.1514/journal.arc.0040016g076

Plate 74. DOI: 10.1514/journal.arc.0040016g077

Plate 75. DOI: 10.1514/journal.arc.0040016g078

Plate 76. DOI: 10.1514/journal.arc.0040016g079

Plate 77. DOI: 10.1514/journal.arc.0040016g080

Plate captions: 73. *Elaphe erythrura.* **74.** *Enhydris matannensis.* **75.** *Rhabdophis chrysargoides.* **76.** *Rhabdophis subminiatus.* **77.** *Acantophis praelongus.*

Species plates 74 & 76 taken by Djoko T. Iskandar. Species plates 73, 75, & 77 taken by Jim A. McGuire.

Plate 78. DOI: 10.1514/journal.arc.0040016g081

Plate 79. DOI: 10.1514/journal.arc.0040016g082

Plate 80. DOI: 10.1514/journal.arc.0040016g083

Plate 81. DOI: 10.1514/journal.arc.0040016g084

Plate 82. DOI: 10.1514/journal.arc.0040016g085

Plate 83. DOI: 10.1514/journal.arc.0040016g086

Plate captions: 78. *Stegonotus modestus.* **79.** *Aspidomorphus mulleri*. **80.** *Ophiophagus hannah.* **81.** *Tropidolaemus wagleri.* **82.** *Chelodina reimannii.* **83.** *Chelodina siebenrocki.*

Species plates 78, 79, 82, & 83 taken by Djoko T. Iskandar. Species plates 80 & 81 taken by Alain Compost.

about a taxon is a criterion for inclusion into IUCN Red Lists, particularly as a threatened species.

As far as skin trade is concerned, further studies on *Ptyas mucosa* are planned to eventually provide evidence that skin trade in this species could be resumed again after the ban in 1994. For skins that had been on stock for sometime, export permits have recently been issued by PKA. Another problem refers to the cobras. Whereas several species are listed as one taxon in the IUCN list, only for one species (*Naja sputatrix*) are quota issued by the Indonesian authorities. Although the greater number of specimens are certainly *N. sputatrix*, nevertheless an unknown number of other cobra species may be harvested from Sumatra and Kalimantan. In short, although surveys on harvest levels of cobras have already been undertaken (Boeadi et al. 1998; Sugardjito et al. 1998), we need more information for an overall assessment of harvest levels, especially for the island of Java, where most of the cobras are caught for the food market and skins are used as byproducts.

A set of measures for the future

Generally, much more research is needed to provide better information on which to base conservation measures for amphibians and reptiles in Indonesia. This should be carried out both by local and foreign scientists and should involve both basic and applied research components. The latter should place emphasis on conservation of herpetological diversity as part of ongoing and future programs in biodiversity conservation and sustainable use in Indonesia. The most pressing problems amphibians and reptiles in Indonesia are facing at the moment are, in our opinion, either related to their conservation and/or to their sustainable use. More specific recommendations regarding the trade situation have been made (Erdelen 1998b) and are not further discussed here.

A "research-coordinating" and "information-disseminating" body might be useful to identify research needs and ensure that information on ongoing research and published results are made available in Indonesia. This coordinating body should consist of representatives of the official Indonesian authorities such as LIPI and PKA, as well as representatives of universities, nongovernmental organizations, the trade community, and other interest groups (e.g., from the industrial sector).

For future research programs and the dissemination of information, as indicated above, an overview of project reports and other unpublished materials, so-called "gray literature," available from various Indonesian authorities, and an analysis of conservation-related results already reported in these sources might make further research more effective by avoiding duplication of work already carried out earlier in Indonesia. These efforts, however, would require the creation and management of a centralized database. Location of this database, combined with a library that contains other relevant published information, as well as staffing, would need funding, the greater part of which would naturally have to come from external sources. Several specific initiatives have been launched already, such as the LIPI database which contains information on plants and animals in its collections. In addition, Conservation International has launched a CD-ROM with comprehensive environmental information about Papua.

To develop necessary local expertise, Indonesian universities need to put more emphasis on teaching amphibian and reptile biology and systematics. This might require changes in the curriculum as well as good working groups in zoological systematics. The major aim should be to train more students in field techniques and methodology in zoological systematics for later degree work in herpetology. Teaching needs could be met either by Indonesian scientists only or in cooperation with visiting foreign scientists.

A basis for regular exchange of information among all people interested in herpetology in Indonesia is clearly needed. This may eventually lead to the development of public awareness programs aimed at making amphibians and reptiles a more "popular" group of animals in Indonesia. This exchange of information could be arranged by the formation of a herpetological working group and/or by providing and exchanging this information through the Internet.

Conclusions and outlook

Without doubt we need to put more efforts in improving our understanding of the composition, the geographic distribution, and habitat and microhabitat requirements of the herpetofauna of Indonesia. In addition, however, amphibians and reptiles need to be seen as an important component of the megadiversity of Indonesia and thus need to be more explicitly included into conservation measures such as setting aside protected areas or giving species a particular protection status. The more we learn about the herpetofauna, the more we will probably realize that many species comprise genetically different units, which should be the target of conservation genetic approaches to biodiversity conservation. Last, but certainly not least, amphibians and reptiles with their general low mobility and great evolutionary age may prove to be key groups toward an understanding of the biogeography of the world's largest archipelago.

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