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The **Herpetological Bulletin** is produced quarterly and publishes, in English, a range of articles concerned with herpetology. These include full-length papers of mostly a semi-technical nature, book reviews, letters from readers, society news, and other items of general herpetological interest. Emphasis is placed on natural history, conservation, captive breeding and husbandry, veterinary and behavioural aspects. Articles reporting the results of experimental research, descriptions of new taxa, or taxonomic revisions should be submitted to The Herpetological Journal (see inside back cover for Editor's address).

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All submissions and correspondence arising from the Bulletin should be sent to the Editor, Peter Stafford, c/o Dept. of Botany, The Natural History Museum, Cromwell Road, London, SW7 5BD. *E-mail: herpbulletin@thebhs.org*

Front cover illustration. Madagascar spider tortoise, *Pyxis arachnoides*. From an original lithographic plate in Vaillant, L. & Grandider, G. (1910). *Histoire de Madagascar. Vol. XVII. Reptiles (Part 1).* L'Imprinte Nacionale, Paris. Reproduction courtesy of the Natural History Museum, London. See article on page 2.

EDITORIAL

Colour photographs

In the previous two issues of *Herpetological Bulletin* (numbers 88 and 89), some of the colour images did not reproduce as well as hoped. In particular, several of those used in the articles by C. Gleed Owen (Lizards on Bournemouth cliffs) and R. Griffiths *et al.* (axolotls) were clearly pixelated and much poorer than the supplied originals. The editor would like to apologise for this, and also to the authors concerned. New software is now being used for processing scanned images, and there should consequently be no further problems of this nature.

Position of Librarian

David Bird, who for many years has been the BHS Librarian, has decided he would now like to step down from this post and pass it on to someone else. The library is currently held at his house in Dorset, so the new Librarian would have to be able to house the library as well as manage requests for information or the loan of books or journals from members. At present the library collection takes up the wall space in 1½ small rooms, or could otherwise probably be accommodated in one reasonably large room. A list of the number of books and journal holdings can be seen on the Yahoo members group, or can be obtained from David Bird. There are also a number of plastic box briefcases that have separates in that fit on shelves. This post may suit a member who is based at an institute such as museum or university with some spare space and where other workers or students could benefit from access to the publications in return for the space it takes up.

Anyone who thinks they would like the post and has room for the collection please contact David on 01258 857869 or by e-mail at: drbird.herp1@virgin.net.

Study on neonatal sea turtles

A new research project has recently been initiated on neonatal mortality in sea turtles, with special reference to the Leatherback (*Dermochelys coriacea*). This project is based at the School of Veterinary Medicine (SVM) of the University of the West Indies, but is in collaboration with a number of other institutions and organizations. These include WIDECAST (Dr. Scott Eckert, Duke University, USA), the Wildlife Section (Government of Trinidad and Tobago) and Nature Seekers, Matura, Trinidad.

The objective of the study is to investigate the causes of death and ill-health in unhatched and newly-hatched young turtles as well as to evaluate developmental abnormalities. The research will also provide an opportunity to learn more about the anatomy, histology and embryology of developing turtles and to provide training for students in investigative techniques.

After emergence, sea turtle nests will be excavated and their contents assessed for the number of hatchlings that emerged successfully from the nest (shell count), and the condition of all remaining eggs. Unhatched eggs will be opened, and dead embryos and hatchlings will be collected under the authority of a permit issued by Trinidad & Tobago Wildlife Section. The specimens will be examined for gross deformities, weighed, measured, radiographed and dissected. Histology and other laboratory tests will be carried out as appropriate. All material will be retained and form the basis of a reference collection for further study.

If you would like to know more about this project, or think you might be able to assist or provide advice, please contact the Acting Director of the School of Veterinary Medicine (e-mail: wharewood@fms.uwi.tt) or the Co-ordinator of the project, Professor John E. Cooper (e-mail: NGAGI@vetaid.net), address below.

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The export of the endangered Madagascar spider tortoise (*Pyxis arachnoides*) to support the exotic pet trade

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ABSTRACT — The endemic Madagascar spider tortoise *Pyxis arachnoides*, listed as 'Vulnerable' on the IUCN Red List and included on CITES Appendix II, faces threats of habitat destruction, hunting for human consumption and collection for the exotic pet market. This study reviews all available data and literature concerning the export of this species to supply the exotic pet market. CITES has recorded movements for 3984 individuals since 1980, with a considerable increases in movements since 1998. Ninety nine percent of individuals reported were recorded as being non-captive bred specimens and 97 % were listed for 'trade' purposes, with 74% of these exported specimens sent to USA or Japan. During 2000, Madagascar exceeded its CITES export quota for the species. Problems exist with CITES reporting for *P. arachnoides* by both importing and exporting nations, with 66.6% of individuals failing to be reported correctly. Seizures of illegally transported specimens are few with only 50 such specimens officially recorded by CITES, and none officially recorded by TRAFFIC. Smuggling, however, is believed to almost certainly occur. Madagascar's failure in the CITES reporting system is thought to be attributed to corruption and more recently, national political instability, but improvements and conservation initiatives in recent years have been made. Over-collection for the lucrative exotic pet trade could seriously threaten the long-term survival of this species, and education and capacity building are required at both the collection and consumption ends of the industry in order to increase its chances of long-term survival.

THE international trade in live reptiles has been ongoing for many years, with the pet trade component of this enterprise a significant end-user of live tortoises (Roth & Merz, 1997, Luiijf, 1997). In the United Sates alone there are estimated to be in the region of 4 million amateur herpetologists (Franke & Telecky, 2001). The herpetofuna of Madagascar includes four threatened species of endemic tortoises, including the endemic Madagascar spider tortoise *Pyxis arachnoides*, a favoured species of the exotic pet trade. This small, attractive and charismatic species' popularity has grown within the herpetological community in recent years. *Pyxis arachnoides* attains a carapace length of just 150 mm (Jesu & Schimmenti, 1995) and inhabits the narrow coastal strip (10–50 km inland) of south west Madagascar from Morombe to Amboasary. Endemism and limited range makes *P. arachnoides* important to global biodiversity. The species' range is largely dominated to the north by the Mikea forest, and spreads south of the Onilahy river through the southern dry forests, one of the most distinctive yet least protected ecosystems in Madagascar (Seddon *et al.*, 2000). This ecosystem supports characteristic coastal sandy soils covered with sparse thorny bushes of the families Euphoriaceae and Didieraceae. *Pyxis arachnoides* is divided into three subspecies, with the major distinguishing feature being the anterior plastral lobe. In the southern subspecies *P. a. matzi*, the lobe is highly mobile, but is less so (especially in adults) in the southwestern subspecies *P. a. arachnoides*, and rigid in the western form, *P. a. brygooi* (Durrell *et al.*, 1989). For the purpose of reporting, due to export and illicit seizure data not classifying specimens as far as subspecies level, all specimens reported in this work will be referred to as *P. arachnoides*.

The International Conservation Union (IUCN) Red List of Threatened Species, lists *P. arachnoides* as 'Vulnerable' (IUCN, 2002). The species is listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), implying that commercial trade is allowed provided a permit is obtained from the country of export. Currently CITES export quotas for *P. arachnoides* stand at 1000 live animals per year (CITES, 2000), but despite CITES and wildlife laws of treaty signatories, the world's exotic pet markets are in many cases poorly regulated (Behler, 1997). *Pyxis arachnoides* has been somewhat ignored by the scientific literature with the scarcer *P. planicauda* attracting much of the recent attention (Behler *et al.*, 1993; Bloxam *et al.*, 1993; Raxworthy & Nussbaum, 2000) since its recent re-listing from CITES Appendix II to Appendix I (Prop. 12.55; IWMC, 2002). As a result, *P. arachnoides* remains Madagascar's sole tortoise species to be subjected to legal trade.

The sparse literature on *Pyxis arachnoides* consistently states that the known status and biology of the species is very limited (Jesu & Schimmenti, 1995; Durrell *et al.*, 1989). Despite a relatively large potential distribution area, Durrell *et al.* (1989) state that populations are often fragmented, containing variable numbers of individuals. Only ten local populations are believed to remain (SSN, 2004). The reproductive potential of the species is thought to be low – individuals reach a reproductive state at 12 years of age and females will only produce a clutch of one egg (SSN, 2004). *Pyxis arachnoides* alongside Madagascar's three other species of endemic tortoises are under assault from habitat destruction (Seddon *et al.*, 2000), with large scale habitat loss reducing the area of distribution by 51–80% (SSN, 2004). Behler (2000) states that some areas ten years ago that held dense populations of *P. arachnoides* have been swept clean by collectors for food markets and exotic pet export. Tortoise collectors have even been known to harvest the species within protected areas such as the Tsimanampetsotsa National Park (Behler, 2002).

Information sources

This research reviewed the available literature and trade figures for *P. arachnoides*, with data collected from CITES databases for listed legal trade and trade infractions. Information was gained from TRAFFIC and WWF publications listing details on seizures, and web based searches collecting data and information on trade and trade prices for the species.

Trade analysis

Legal trade

Through analysis of CITES export data, trade infractions data for the species, plus reviews of the available literature regarding seizures, it was possible to establish annual figures of the legally exported, and some information on illegally exported numbers of *P. arachnoides* between 1980 and 2001 (with 2001 being the most recently available data). Table 1 shows that CITES has been recording *P. arachnoides* export movements since 1980, during these 21 years 3457 individuals had been reported by importers globally. Movements had been recorded for a total of 3984 individual specimens over this time, with 3314 specimens reported to have been exported from Madagascar (Table 1). A record of exports directly from Madagascar did not start until 1990, and between 1980 and 1989 only nine animals in total were recorded by CITES. Durrell *et al.* (1989) state that the species had yet to breed successfully in captivity before the time of their research, therefore the six animals traded between the

Year	Importer	Exporter	Origin	Quantity reported by importer: Quantity	Quantity reported by importer: Purpose	Quantity reported by importer: Source	Quantity reported by exporter: Quantity	Quantity reported by exporter: Purpose	Quantity reported by exporter: Source	Total animals traded for the year	Total animals exported from Madagascar for the year
1980	Switzerland	German D R	-	1	personal	-	-	-	-	1	0
1986	Germany	German D R	Madagascar	1	scientific		-	-	-	1	0
1988	USA	Netherlands	-	2	trade	captive-bred	2		captive-bred	2	0
1989	Japan	Netherlands	-	4	trade	captive-bred	4	trade	captive-bred		
1989	Germany	Soviet Union	Madagascar	1	scientific		1	zoo		5	0
1990	United Kingdom	Madagascar		6	-	-	-	-	-		
1990	Japan	Malaysia	-	3	trade	captive-bred	-	-	-		
1990	Germany	Soviet Union	Madagascar	1	scientific	-	-	-	-	10	6
1991	Madagascar	Germany	Madagascar	-	-	-	4	re-introduction	-		
1991	USA	Poland	-	1	trade	captive-bred	1	zoo	-	5	0
1995	USA	Madagascar	-	-	-	-	4	scientific	wild	4	4
1996	Madagascar	France	-	8	re-introduction	seized	-	-	-		
1996	USA	Madagascar	-	2	-	wild	-	-	-	10	2
1997	Italy	Madagascar	-	6	scientific	wild	6	scientific	wild		
1997	South Africa	Netherlands	-	4	zoo	captive-bred	-	-	-		
1997	Denmark	Sweden	-	7	trade	seized	-	-	-	17	6
1998	USA	Japan	Madagascar	32	trade	wild	36	trade	wild		
1998	Indonesia	Madagascar	-	4	trade	wild	4	breeding	wild		
1998	Japan	Madagascar	-	150	trade	wild	150	trade	wild		
1998	Netherlands	South Africa	-	1	-	seized	-	-	-	191	154
1999	Switzerland	Germany	-	4	personal	captive-bred	4	trade	captive-bred		
1999	Hong Kong	Indonesia	Madagascar	1	trade	wild	1	trade	wild		
1999	USA	Indonesia	Madagascar	2	trade	wild	2	trade	wild		
1999	Indonesia	Madagascar	-	-	-	-	1	trade	wild		
1999	Spain	Madagascar	-	-	-	-	10	trade	wild		
1999	USA	Madagascar	-	35	trade	wild	35	trade	wild	53	46
2000	Japan	Germany	-	-	-	-	8	trade	captive-bred		
2000	USA	Germany	-	5	trade	captive-bred	5	trade	captive-bred		
2000	Belgium	Madagascar	-	-	-	-	24	trade	wild		
2000	France	Madagascar	-	-	-	-	2	personal	wild		
2000	Hungary	Madagascar	-	-	-	-	2	trade	wild		
2000	Japan	Madagascar	-	-	-	-	1365	trade	wild		
2000	South Africa	Madagascar	-	300	trade	wild	308	trade	wild		
2000	South Africa	Madagascar	-	4	breeding	captive-bred	-	-	-		
2000	Switzerland	Madagascar	-	90	trade	wild	66	trade	wild		
2000	USA	Madagascar	-	577	trade	wild	865	trade	wild		
2000	France	Mauritius	Madagascar	-	-	-	110	trade	wild		
2000	Netherlands	Mauritius	Madagascar	-	-	-	90	trade	wild		
2000	Japan	South Africa	Madagascar	-	-	-	5	trade	wild		
2000	USA	South Africa	Madagascar	74	trade	wild	95	trade	wild		
2000	Hong Kong	USA	Madagascar	6	trade	wild	4	trade	wild		
2000	Japan	USA	Madagascar	-	-	-	6	trade	wild	2985	2651
2001	USA	Bulgaria	Madagascar	54	trade	wild	138	trade	wild		
2001	Hong Kong	Japan	Madagascar	8	trade	wild	-	-	-		
2001	Belgium	Madagascar	-	12	trade	captive-bred	-	-	-		
2001	Bulgaria	Madagascar	-	300	trade	wild	-	-	-		
2001	Czech Republic	Madagascar	-	100	trade	wild	-	-	-		
2001	Switzerland	Madagascar	-	21	trade	wild	-	-	-		
2001	USA	Madagascar	-	12	trade	wild	-	-	-		
2001	Czech Republic	South Africa	Madagascar	-	-	-	60	trade	wild		
2001	Japan	South Africa	Madagascar	-	-	-	8	trade	wild		
2001	Malta	South Africa	Madagascar	-	-	-	24	trade	wild		
2001	Hong Kong	USA	Madagascar	16	trade	wild	6	trade	wild		
2001	Switzerland	USA	Madagascar	1	trade	wild	1	trade	wild	700	445
	Total			1856			3457			3984	3314

Table 1. CITES recorded movements of *Pyxis arachnoides* between 1980–2001, highlighting the high number of gaps in the data.

Parties with discrepancies in CITES reported Imports	Parties with discrepancies in CITES reported exports
Madagascar (1)	German D.R. (2)
France (1)	Madagascar (10)
Netherlands (1)	Malaysia (1)
Japan (3)	Soviet Union (1)
Czech Republic (1)	Netherlands (1)
Malta (1)	Indonesia (1)
	Spain (1)
	Germany (1)
	Belgium (1)
	France (1)
	Hungary (1)
	Japan (2)
	USA (5)

Table 2. Parties showing discrepancies within CITES reported import / export data for *P. arachnoides*. Brackets show the number occasions of incidences of data inconstancies. Figures of <10% discrepancy between the exported figure and imported figure listed were ignored to allow for possible mortality in transit.

Netherlands and the USA, and Japan in 1988/9 listed as captive bred were probably amongst the first successfully captive bred specimens (Table 1). Pre-1998, only 18 individual tortoises were directly exported from Madagascar, according to CITES. This increased to 154 tortoises during 1998; exports dipped during 1999 with 46 tortoises, followed by 2651 animals exported during 2000. Export numbers were still high during 2001 with 445 animals recorded by CITES (Fig.2).

The CITES data revealed that 99.2% ($n = 3950$) of the tortoises recorded in global movements were either recorded as wild caught or not specifically recorded as captive bred. Of the 3314 recorded tortoises exported directly from Madagascar since 1980 (Table 1), only 0.7% (13 in 2000 and 12 in 2001), were recorded as captive bred, with the remaining animals therefore quite possibly all wild caught. Of the total numbers of animals involved in global movements recorded by CITES 97.2% ($n = 3842$) were listed as being used for trade purposes. Of the wild caught specimens exported directly from Madagascar, 98.6% ($n = 3842$) were recorded as being exported for trade purposes. Exports of the species for trade purposes from Madagascar increased between 1996–2001 (Fig. 1) ($p > 0.005$). A single consignment of 150 were exported to Japan in 1998, South Africa received 300 animals in 2000, and the USA imported a total of 865 in the same year (Table 1). During 2001, 300 and 100 animals were imported into Bulgaria and the Czech Republic respectively. The primary consumer nations were USA and Japan, with 74% ($n = 2780$) of the total number of *P. arachnoides* imports for trade purposes received by these two nations between 1990 and 2001 (Fig. 1).

In some cases the exporting nation, which in many cases is Madagascar, have not officially registered the exportation of a consignment or consignments of the animals with CITES. For example, during 2000 1365 wild caught specimens were recorded as imported to Japan for trade purposes in a single consignment from Madagascar, but failed to be reported by the exporting nation (Table 1). Similarly, in 2000, 577 wild caught individuals were reported as exported by the authorities in Madagascar for trade purposes in another consignment, but 865 animals were reported as received by the importing nation, in this case the USA. Again, during 2000, 90 wild caught specimens were exported from Madagascar for trade purposes to Switzerland, but only 66 specimens were recorded as being received by the Swiss authorities.

Illegal trade

During 1991, four tortoises were returned to Madagascar from Germany, the result of a possible customs seizure, and 1996 saw eight seized animals returned to Madagascar from France (Table 1). Seven illegally traded tortoises from Sweden imported to the Netherlands were seized in 1997, as was one animal seized between South Africa and Netherlands in 1998 (Table. 1).

Seizures of illegally traded *P. arachnoides* have not been officially recorded by TRAFFIC, the wildlife trade-monitoring network. However, on August 6th 1998 a key smuggling ring was

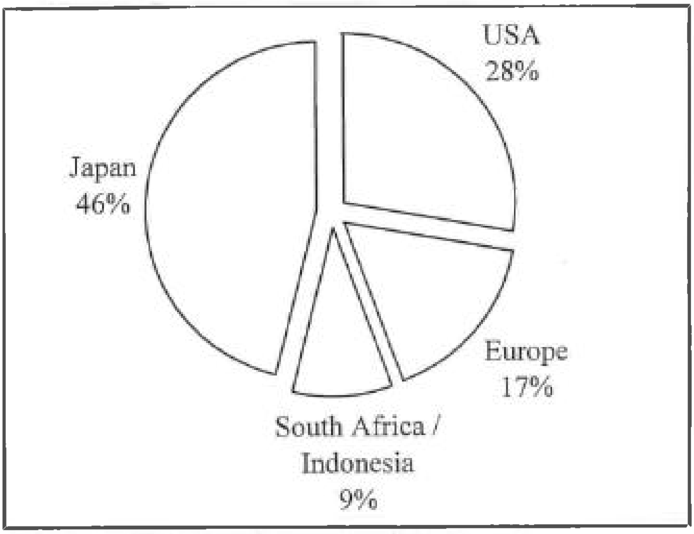

Figure 1. CITES reported imports from Madagascar for *P. arachnoides*, 1990–2001 including Europe and the four highest consuming nations.

intercepted, the result of a five year investigation into reptile smuggling, many of the animals seized were rare species from Madagascar including *P. arachnoides* (TRAFFIC, 1999). During 1998 one of the world's most successful smugglers was intercepted, with charges dating throughout most of the 1990s, the smuggler was known to be a regular illegal trafficker of *P. arachnoides* (WWF, 2001). CITES secretariat policy on information dissemination has changed in recent years. Rather than producing freely available reports on alleged infractions for the Conference of the Parties (CoP) (Reeve, 2002), in the interest of efficiency and confidentiality effort is now concentrated on a computerised intelligence and information system known as the Trade Infraction and Global Recording System (TIGERS). To date, one record has been listed on TIGERS for *P. arachnoides*, with 50 specimens seized in a European union Member State in 2000, smuggled from an eastern European country.

During Reeve's (2002) extensive work on the policing of international wildlife trade she concluded than in many cases Parties do not report all cases of illicit trade and the databases cannot be regarded as a complete record of illicit trade.

DISCUSSION

Clearly there are problems in the reporting and tracking of *P. arachnoides* due to discrepancies of individuals reported by the importers and those reported by the exporters (Table 1). Table 2 shows that 13 counties have discrepancies of >10% in consignments of CITES recorded *P. arachnoides* transport. Madagascar accounted for ten discrepancies in CITES reported exports of >10% between 1990 and 2001 and the two nations that support the greatest trade in the species, USA and Japan recorded five and two respectively. Discrepancies with CITES reported imports of the species is less, with six nations recording discrepancies of >10%, and Japan supporting three consignments of >10%. In total 2653 (66.6%) of all individuals traded have not been reported by either importing or exporting parties.

The high level of trade of *P. arachnoides* during 2000 resulted in 837 more specimens being exported from Madagascar than CITES regulations allow, and therefore constituting a 'serious overage' as described by CITES (2002), for exporting greater than 150% of the allowed quota of an Appendix II species. But in support for the system in place, 2000 was the only year that trade infractions were recorded as taking place in the form of over exportation. It is evident that mis-reporting and the incident of over exploitation of the species during 2000 by collectors and exporters can be attributed to certain problems with CITES implementation and enforcement in Madagascar as a whole (Reeve, 2002). The results of a field trip to research the reptile trade for the International Fund for Animal Welfare (IFAW) during December 2001 discovered the general circulation of blank permits and the uncontrolled export of species under restricted or zero quotas (Reeve, 2002). Despite claimed corruption at a national level by curtain authors (Behler, 1997; Reeve, 2002; CITES, 2003), problems have been identified by CITES and TRAFFIC and much work has been undertaken within the recent past to attempt to rectify the problem.

In response to this and the lax enforcement of CITES quotas, the 49th meeting of the CITES Standing Committee during April 2003 established the Intersessional Export Quota Working Group, with the goal of developing guidelines for Parties to establish, implement, monitor and report national export quotas for CITES-listed taxa (CITES, 2003). Particular issues addressed included the persistent serious overages of many reptile species, by many party signatories. During December 2001 the World Bank included improvement in CITES implementation as a condition for improving funding for the third phase of Madagascar's Environmental Action Plan (Reeve, 2002). Following this Madagascar descended into political chaos with the newly elected government refused power by the former party. The chaos resulted in confusion over legitimacy of wildlife exports, exacerbated by an unknown number of blank CITES permits in circulation signed under the previous administration.

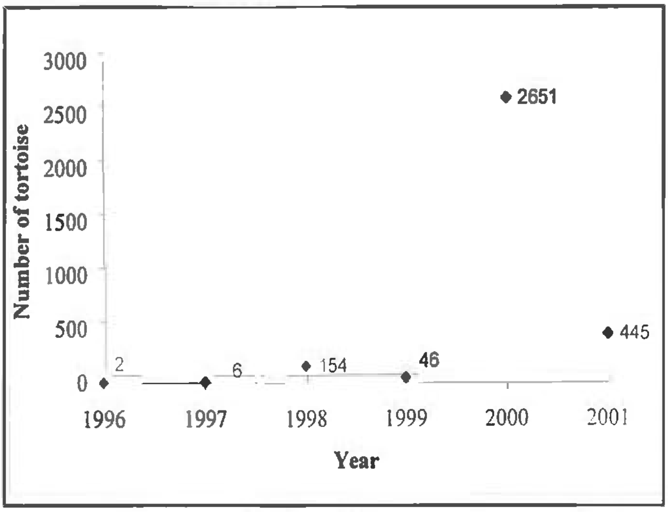

Figure 2. Number of *P. arachnoides* exported from Madagascar for trade purposes: 1996–2001.

Since Madagascar has stabilised politically even greater conservation initiatives have been implemented. At the 18th CITES Animal Committee meeting Madagascar's new administration announced a six month moratorium on CITES exports, a much needed move, but one that is impossible to enforce without corresponding action by importing countries. The USA immediately announced a suspension of imports of all species from Madagascar (lifted on the 20th September 2002), but the European Union decided against an import ban and no action was taken under CITES. More recently TRAFFIC is leading a new program in Madagascar aimed at helping the government authorities improve the countries wildlife trade, a new, comprehensive approach to CITES listed species management is being undertaken for the first time at a national level (TRAFFIC, 2003). A proposal has also been put forward to CITES (CoP13 – Prop. 15) to upgrade *P. arachnoides* from Appendix II to Appendix I within CITES listings as it has been considered that the illegal trade of the species would be easer to control if the species was listed on Appendix I (SSN, 2004). A much needed move highlighted by anecdotal evidence (such as the Cikananga Wildlife Rescue Center in Java reporting as recently as August 2004) that half the species of as many as 2300 individual turtles and tortoises on offer in a Jakarta pet market were comprised of rare species of tortoise from Madagascar (Vazquez, pers. comm.). However, *P. arachnoides* and Madagascar do not stand alone with problems of reporting and quota regulation for Appendix II species, as live reptiles have been responsible for almost 60% of the reported over quotas within CITES reports during 1999 (CITES, 2002). Madagascar is making positive steps towards conservation of endemic reptiles involved in the wildlife trade, with leaf tailed geckos *Uroplatus* spp., leaf-nosed snakes *Langaha* spp. and arboreal snakes *Stenophis citrinus* all under consideration for CITES Appendix II listing (CoP13 Prop. 27–29) (SSN, 2004).

The high exports to Japan and USA can be confirmed by high numbers of herpetological dealers advertising *P. arachnoides* for sale over the Internet in these respective countries. Specimens can fetch prices of up to US$1200 a pair. It appears that many wild caught animals are entering this lucrative pet trade and worryingly several dealers are openly providing questionable advice on the husbandry of these animals via their web sites. This may include stating that they require high levels of humidity when their natural habitat is arid with annual temperatures in the range of 21–37.5°C, mean annual rainfall of just 344 mm and relative humidity of 30% for most of the year (Jesu & Schimmenti, 1995). Well over 80% of live reptiles entering the herpetological trade die in the first year due to poor handling or husbandry (Franke & Telecky, 2001). High mortality due to poor handling, packing and failures in compliance with the International Air Transport Association (IATA) live animal regulations for the proper air transport of chelonians (Luiijf 1997; Franke & Telecky, 2001), could be another welfare issue. Despite specific documented cases by Luiijf (1997) on other similar pet species of tortoise no data is available on transportation mortality rates for *P. arachnoides*.

As well as the conservation and survival implications for the species itself from over collection of *P. arachnoides*, Simmons & Burbridge (2002) report that pest species have been associated with imported animals. Nineteen specimens, contained within a consignment of 125 *P. arachnoides* imported into Florida from Madagascar were infected by 23 ticks *Amblyomma chabaudi*. This is the first report of *A. chabaudi* outside of Madagascar; and Simmons & Burbridge (2002) state that all records of *A. chabaudi* are from *P. arachnoides*, except for one male on a Radiated tortoise *Geochelone radiata*. The tick's distribution is limited to the range of *P. arachnoides* in southern Madagascar, however *A. chabaudi* was able to be feed in the laboratory on rabbits. Thus, in the absence of its preferred host the tick could infest other species, as infested individuals are imported and become traded amongst herpetologists.

The long-term survival of *P. arachnoides* depends on the effectiveness of recent conservation strategies in Madagascar, the attitude and responsibility of the importing nations of the species and the influence of customs officials and authorities at both ends of the trade. CITES is examining ways of building capacity to implement and enforce CITES regulations within Madagascar, but a sense of responsibility needs to be installed at both ends of the trade with herpetologists within the consumer countries educated on the importance of only purchasing known captive bred stock. Collectors in Madagascar need to be targeted by Environmental NGOs with well-coordinated environmental education programs, and the provision of alterative livelihood generation needs to be considered in the impoverished and marginalised south west region of Madagascar.

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FOOTNOTE: After peer review of this manuscript and just prior to going to press the status of *P. arachnoides* within the CITES system was changed from Appendix II to Appendix I, during the CoP13, Bangkok 2–14th October, 2004. Appendix I status will ensure the movements of the species are easier to police, the new status ensures a total ban on trade of the species.

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The herpetofauna of Parque Nacional Cerro Azul, Honduras (Amphibia, Reptilia)

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ABSTRACT — Seventy-four species of amphibians and reptiles (4 salamanders, 24 anurans, 1 turtle, 15 lizards, and 30 snakes) are recorded from Parque Nacional Cerro Azul, located in the northwestern portion of the Honduran department of Copán. The park has an area of about 155 km^2 of mountainous terrain located in the Premontane Wet Forest and Lower Montane Wet Forest formations. Elevations in the park range from 770 to 2285 m. Lower elevations of the park are subject to the Intermediate Wet climate and the higher elevations to the Highland Wet climate. Population declines or disappearances of 23.0% of the herpetofaunal species are documented in the park. Only 21.6% of the entire Honduran mainland and insular herpetofauna, 36.9% of the species found in the Premontane Wet Forest formation, and 44.0% of the species found in the Lower Montane Wet Forest formation are afforded nominal protection in the park. Careful and continuing monitoring of the park's remaining herpetofaunal populations will be necessary, especially due to the severe habitat degradation resulting from continuing deforestation. *Lepidophyma mayae* is reported from Honduras for the first time.

RESUMEN — En el parque nacional Cerro Azul se han documentado un total de 74 especies de anfibios y reptiles (cuatro salamandras, 24 anuros, una tortuga, 15 largartijas y 30 culebras). Este parque esta ubicado al noroeste del Departamento de Copán y tienen un área de aproximadamente 155 $kilometros^2$ de terrenos montañosos comprendidos en la formaciones de Bosque Húmedo Premontano y Bosque Húmedo Montano Bajo. Las elevaciones en el parque tienen un rango que va desde 770 hasta 2285 m. Las partes bajas reciben influencia de un clima intermedio húmedo y las partes altas de un clima húmedo de altura. Se han documentado declines poblacionales de las 23.0% de las especies de la herpetofauna del parque. Solo el 21.6% de toda la herpetofauna de Honduras (continental y insular), el 36.9% de las especies encontradas de la formación Bosque Húmedo Premontano y 44.0% de las especies encontradas en la formación Bosque Húmedo Montano Bajo reciben protección nominal en este parque. Es necesario un cuidadoso y continuo monitoreo de la herpetofauna que aun existe en esta reserva, especialmente debido a una severa degradación del hábitat ocasionada por la deforestación. Se reporta *Lepidophyma mayae* por la primera vez en Honduras.

A series of publications was recently begun that have been concerned with the composition, distribution, and conservation status of the amphibians and reptiles occurring in various Honduran biotic reserves (Espinal *et al.*, 2001; Wilson & McCranie, 2004c). It has become increasingly clear that population declines are transpiring among the amphibian and reptile species inhabiting the biotic reserves, even in areas that remain relatively pristine. In this paper, I discuss the herpetofauna of Parque Nacional Cerro Azul, a park that has seen severe habitat destruction since I first visited the area in 1982, five years before it was declared a national park.

MATERIALS AND METHODS

I have made six trips for a total of 42 days collecting in the park (7-10th August 1982, 17th-21st July 1983, 4th–10th May 1988, 15th–21st July 1996, 17th–21st October 1998, and 17th–30st July 2004. The Coefficient of Biogeographic Resemblance algorithm (Duellman, 1990) was used to demonstrate herpetofaunal relationships between the two forest formations herein considered. The formula is CBR = 2C/(N1 + N2), where C is the number of species in common to both formations, N1 is the number of species in the first formation, and N2 is the number of species in the second formation.

Museum acronyms for the specimens listed in Appendix I follow those of Leviton *et al.* (1985).

Description of the Park

Parque Nacional Cerro Azul is located in the Sierra del Espíritu Santo in the northwestern portion of the Honduran department of Copán. The park encompasses an area of approximately 155 km^2, with a nuclear zone of about 9 km^2 and a buffer zone of about 146 km^2 (Wilson *et al.*, 2001). Elevations in the park range from 770 m at Laguna del Cerro to 2285 m at the highest elevation on Cerro Azul, with the nuclear zone occurring at elevations of 1600 m and above. The village of Quebrada Grande lies at the foot of Cerro Azul approximately between 1250 to 1370 m elevations. There is no visitor's centre in the park.

Physiography

Parque Nacional Cerro Azul is located within the largest physiographic area in Honduras, the *Serranía* (Wilson *et al.*, 2001). Moreover, it is found within the northwestern portion of the *Serranía*, called the Northern Cordillera. The park is situated within the Sierra del Espíritu Santo, which forms a portion of the border between Honduras and Guatemala. The range is bounded on the northeast by the Sierra de Omoa, on the east by the valley of the Río Chamelecón, on the west and north by the valley of the Río Motagua in Guatemala, and on the south by the valley of the Río Morjá (a tributary of the Río Motagua) and its tributaries.

Climate

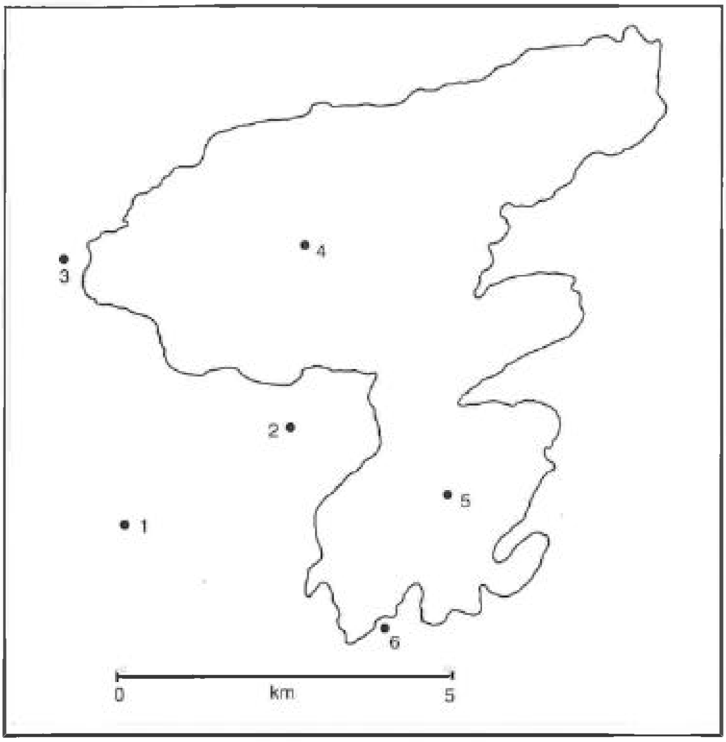
The park is subject to two climatic regimes. The lower elevations of the park are subject to the Intermediate Wet climate and the higher elevations to the Highland Wet climatic regime (Wilson & Meyer, 1985). The Intermediate Wet climate is characterized by an altitudinal range of 600 to 1500 m, a mean annual rainfall of 2000 mm or more, and a mean annual temperature of 18 to 24°C. The Highland Wet climate is characterized by an altitudinal range of 1500 to 2700 m, a mean annual rainfall of 1500 mm or more, and a mean annual temperature of 18°C or less.

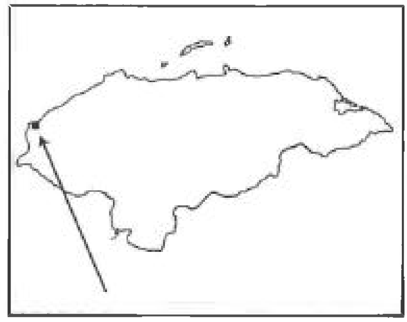
Vegetation

The vegetation of Parque Nacional El Cusuco is referable to the Premontane Wet Forest and Lower Montane Wet Forest formations, as slightly modified from Holdridge (1967). Premontane Wet Forest is found at elevations in the park from 770 to about 1350 m and is characterized by a mean annual precipitation range of 2000 to 4000 mm and a mean annual temperature range of 18° to 24°C. Lower Montane Wet Forest is found at elevations in the park above about 1350 m and is characterized by a mean annual precipitation range of 2000 to 4000 mm and a mean annual temperature range of 12° to 18°C (Wilson & Meyer, 1985).

Anonymous (1993) discussed the makeup of the vegetation of Lower Montane Wet Forest in Parque Nacional Cerro Azul. The undisturbed forest was described as consisting predominantly of broad-leafed trees and, to a lesser extent, conifers (including *Pinus oocarpa* or Ocote and *P. pseudostrobus* or Pinabete). The broad-leafed species include *Alchornea latifolia* (Amate), *Ardisia paschalis* (Uva), *Calophyllum* spp. (María), *Calatola mollis* (Nogal), *Cedrella oaxacensis* (Cedro), *Chamaedora pacaya* (Pacaya), *Gaultheria odorata* (Matapalo), *Liquidambar styraciflua* (Liquidambar), and *Quercus peduncularis* (Roble).

Premontane Wet Forest in the lower reaches of Parque Nacional Cerro Azul was described by Anonymous (1993) as a forest composed, at the upper stratum, of large trees growing to heights of more than 40 m and diameters of more than a meter. These trees are generally buttressed, with smooth trunks, and branches arising at a great height, and include such species as *Pterocarpus hayesii* and *P. officinalis* (both called Sangre blanco) and *Virola guatemalensis* and *V. koschayi* (both called Sangre colorada). Other species in the upper stratum include *Calophyllum brasiliense* (María), *Symphonia globulifera* (Varillo), and





Boundary of nuclear zone of Parque Nacional Cerro Azul (left) and an outline map of Honduras (above) showing the park's location. The park's buffer zone has not been adequately defined to show its limits. Localities are: (1) Laguna del Cerro; (2) Quebrada Grande; (3) San Isidro; (4) highest peak of Montaña del Cerro Azul; (5) Cerro Los Dantos; and (6) San Joaquín.

Vochysia hondurensis (San juan). A middle stratum consisting of shorter trees of the genera *Annona*, *Brosimun*, *Pithecolobium*, *Protium*, *Casearia*, and various laurels is present. The lower stratum is composed of members of the genera *Cupania*, *Psidium*, *Persea*, *Mabea*, *Cordia*, and *Casearia*. The floor of the forest is populated principally by *Swartzia simplex* (Yaya), *Carpotroche platyptera* (Jagua), and *Faramea occidentalis* (Cafecillo).

Microhabitats

Many microhabitats exist in the park. There are several streams and small rivers that provide habitat for streamside anurans of the genera *Duellmanohyla*, *Plectrohyla*, *Ptychohyla*, and *Rana*, and their larvae. A small, fishless lake occurs at 770 m elevation that provides ideal habitat for anurans of the genera *Agalychnis* and *Hyla* and turtles of the genus *Kinosternon*. However, the vegetation around all of these aquatic habitats has been removed almost completely since my first visit to the area in 1982. The epiphytic bromeliads, that were once numerous throughout forested areas, are utilized by several salamander species of the genus *Bolitoglossa* and the bromeliad frog *Hyla bromeliacia*. A few small temporary ponds are located in cleared areas in the vicinity of the village of Quebrada Grande. A small man made pond near San Isidro provides habitat for several species of pond breeding anurans. Numerous rock outcroppings occur on hillsides in the park.

RESULTS

Composition

The known herpetofauna of Parque Nacional Cerro Azul (Table 1) consists of 74 species, including four salamanders (5.4%), 24 anurans (32.4%), 1 turtle (1.4%), 15 lizards (20.3%), and 30 snakes (40.5%).

Broad patterns of geographical distribution

As did Wilson & Meyer (1985), Wilson *et al.* (2001), and McCranie & Wilson (2002), I placed the species occurring in the park into a set of distributional categories based on the entire extent of their geographic range (Table 1). Two of the categories used by Wilson *et al.* (2001) do not apply to this paper (marine species [category K], and insular and/or coastal species [category L]). The applicable categories are as follows:

A. Northern terminus of the range in the United States (or Canada) and southern terminus in South America;

B. Northern terminus of the range in the United States and southern terminus in Central America south of the Nicaraguan Depression;

C. Northern terminus of the range in the United States and southern terminus in Nuclear Middle America;

D. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and the southern terminus in South America;

E. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and southern terminus in Central America south of the Nicaraguan Depression;

F. Northern terminus of the range in Mexico north of the Isthmus of Tehuantepec and southern terminus in Nuclear Middle America;

G. Northern terminus of the range in Nuclear Middle America and southern terminus in South America;

H. Northern terminus of the range in Nuclear Middle America and southern terminus in Central America south of the Nicaraguan Depression;

I. Restricted to Nuclear Middle America (exclusive of Honduran endemics);

J. Endemic to Honduras.

The data on broad distributional patterns in Table 1 indicate that the largest number of species (22 or 29.7% of a combined total of 74 species) fall into the I category, i.e., that containing the Nuclear Middle American-restricted species (exclusive of the Honduran endemics). The next largest categories are F and E, with 14 (19.2%) and 13 (17.6%) species, respectively. Together, these three categories comprise 66.2% of the total for the park. The other eight categories contain from one to ten species each and harbour, as a group, 33.8% of the total number. Six (8.1%) Honduran endemics occur within the park.

Park distribution

I established three categories of distribution of the members of the herpetofauna within Parque Nacional Cerro Azul (Table 1). Species are considered to be widespread in the park, restricted to the park or its immediate environs (although, in some cases, species may be distributed otherwise outside of Honduras), and peripherally distributed in the park. Fifty-eight species (78.3% of total species) are categorized as widespread (four salamanders, 15 anurans, ten lizards, 29 snakes), seven (9.5%) as restricted (three anurans, four lizards), and nine (12.2%) as peripheral (six anurans, one turtle, one lizard, one snake).

Ecological distribution

Of the 74 species making up the known herpetofauna of Parque Nacional Cerro Azul, 12 (16.2%) are recorded only from Lower Montane Wet Forest, 30 (40.5%) only from Premontane Wet Forest, and 32 (43.2%) from both forest formations. The Coefficient of Biogeographic Resemblance (see Materials and Methods) for these two formations in the park is 0.60.

In terms of vertical positioning within the primary microhabitats in the park, 41 species (55.4%) were usually found only in terrestrial settings, 31 (41.9%) only in arboreal ones, and two (2.7%) in both terrestrial and arboreal situations (Table 1). With respect to occurrence in the three major habitats in the parks (forest proper, streamside, and lakeside or pond-side), 53 species (71.6%) were found only within the forest proper, nine (12.2%) only along streams, nine (12.2%) only around the lake or ponds, two (2.7%) in the forest and along streams, and one (1.4%) in the forest and around ponds (Table 1).

If the two sets of categories, vertical position within the primary microhabitat and the major habitats, are combined, then 19 species (25.7%) are arboreal forest inhabitants, seven (9.5%) are arboreal lakeside or pond-side inhabitants, five (6.8%) are arboreal streamside inhabitants, 32 (43.2%) are terrestrial forest inhabitants, two (2.7%) are terrestrial lakeside or pond-side inhabitants, four (5.4%) are terrestrial streamside inhabitants, two (2.7%) are terrestrial forest and

Species	Park Distribution	Elevational Range (m)	Forest Formation	Broad Distribution Pattern	Primary Microhabitat	Relative Abundance	Conservation Status
Bolitoglossa conanti	W	1250–1600	PWF, LMWF	I	A, F	C	D
Bolitoglossa dofleini	W	1040–1370	PWF, LMWF	I	A, T, F	C	S
Bolitoglossa dunni	W	1370–1600	LMWF	I	A, F	C	D
Bolitoglossa rufescens	W	1000–1370	PWF, LMWF	I	A, F	C	S
Bufo campbelli	P	770–1080	PWF	F	T, F	R	D
Bufo valliceps	W	770–1250	PWF	E	T, F, P	I	S
Hyalinobatrachium fleischmanni	P	770	PWF	D	A, S	R	D
Agalychnis callidryas	P	770	PWF	E	A, P	C	S
Agalychnis moreletii	W	770–1300	PWF	F	A, P	I	D
Duellmanohyla soralia	W	770–1370	PWF, LMWF	I	A, S	C	S
Hyla bromeliacia	W	1250–1600	PWF, LMWF	I	A, F	C	D
Hyla loquax	P	770	PWF	E	A, P	C	S
Hyla microcephala	P	770	PWF	D	A, P	C	S
Hyla picta	P	770	PWF	F	A, P	R	S
Hyla salvaje	R	1370	LMWF	I	A, F	R	D
Plectrohyla guatemalensis	W	1150–1480	PWF, LMWF	I	A, S	I	D
Plectrohyla matudai	W	770–1480	PWF, LMWF	I	T, S	C	S
Ptychohyla hypomykter	W	770–1600	PWF, LMWF	I	A, S	C	S
Scinax staufferi	W	1300	PWF	E	A, P	R	N
Smilisca baudinii	W	770–1370	PWF, LMWF	B	A, P	C	S
Eleutherodactylus charadra	W	770–1370	PWF, LMWF	I	T, F, S	C	S
Eleutherodactylus coffeus	R	900–1200	PWF	J	T, F	C	S
Eleutherodactylus laticeps	W	1040–1300	PWF	F	T, F	I	S
Eleutherodactylus milesi	W	1050–1400	PWF, LMWF	J	T, S	I	E
Eleutherodactylus rostralis	W	980–1370	PWF, LMWF	I	T, F	I	S
Eleutherodactylus sp.	R	900–1200	PWF	J	A, F	C	S
Rana brownorum	W	770–1370	PWF, LMWF	F	T, P	C	S
Rana maculata	W	770–1370	PWF, LMWF	I	T, S	I	D
Kinosternon leucostomum	P	770	PWF	D	T, P	R	S
Abronia montecristoi	R	1370	LMWF	I	T, F	R	N
Laemanctus longipes	W	1120	PWF	F	A, F	R	D
Sceloporus malachiticus	W	1250–1840	PWF, LMWF	H	A, F	C	S
Norops biporcatus	P	770	PWF	D	A, F	R	D
Norops capito	W	770–1040	PWF	H	A, F	I	S
Norops johnmeyeri	W	1370–1480	LMWF	J	A, F	I	S
Norops laeviventris	W	1250–1480	PWF, LMWF	E	A, F	I	S
Norops ocelloscapularis	R	1040–1370	PWF, LMWF	J	A, F	C	S
Norops petersii	R	1370–1400	LMWF	F	A, F	R	N
Norops rodriguezii	W	770–1250	PWF	F	A, F	I	S
Norops uniformis	W	770–1370	PWF, LMWF	F	T, F	C	S
Sphenomorphus cherriei	W	770–1300	PWF	E	T, F	I	S
Ameiva festiva	W	1300	PWF	G	T, F	R	N
Lepidophyma flavimaculatum	W	1040–1300	PWF	E	T, F	I	S
Lepidophyma mayae	R	1040	PWF	I	T, F	R	N
Typhlops stadelmani	W	1250–1370	PWF, LMWF	J	T, F	C	S
Boa constrictor	W	1370	LMWF	D	T, F	R	N
Adelphicos quadrivirgatum	W	1040–1370	PWF, LMWF	F	T, F	C	S
Clelia clelia	P	770	PWF	G	T, F	R	D
Coniophanes bipunctatus	W	1370	LMWF	E	T, S	R	N
Coniophanes fissidens	W	1040	PWF	D	T, F	R	S
Coniophanes imperialis	W	1040	PWF	C	T, F	R	S
Dryadophis dorsalis	W	1370–1600	LMWF	I	T, F	I	D
Dryadophis melanolomus	W	1040	PWF	E	T, F	R	S
Drymobius chloroticus	W	1370–1480	LMWF	F	T, F, S	I	D
Drymobius margaritiferus	W	860–1370	PWF, LMWF	A	T, F	I	S
Geophis fulvoguttatus	W	1680	LMWF	I	T, F	R	N
Imantodes cenchoa	W	1200–1370	PWF, LMWF	D	A, F	C	S
Lampropeltis triangulum	W	1040–1370	PWF, LMWF	A	T, F	C	S
Leptodeira septentrionalis	W	1250–1370	PWF, LMWF	A	A, F	I	S
Ninia diademata	W	1250–1370	PWF, LMWF	F	T, F	C	S
Ninia espinali	W	1040	PWF	I	T, F	I	N

Species	Park Distribution	Elevational Range (m)	Forest Formation	Broad Distribution Pattern	Primary Microhabitat	Relative Abundance	Conservation Status
Ninia sebae	W	1250	PWF	E	T, F	I	S
Pliocercus elapoides	W	1040–1370	PWF, LMWF	F	T, F	I	S
Rhadinaea kinkelini	W	900–1370	PWF, LMWF	I	A, T, F	I	S
Rhadinaea montecristi	W	1370–1600	LMWF	I	T, F	I	D
Sibon dimidiatus	W	1200–1400	PWF, LMWF	E	A, F	C	S
Sibon nebulatus	W	1250	PWF	D	A, F	I	S
Stenorrhina degenhardtii	W	1040–1370	PWF, LMWF	D	T, F	C	S
Tantilla impensa	W	1370–1600	LMWF	I	T, F	I	S
Tantilla schistosa	W	1040–1370	PWF, LMWF	E	T, F	I	S
Micrurus diastema	W	770–1680	PWF, LMWF	F	T, F	C	S
Atropoides mexicanus	W	1250–1300	PWF	E	T, F	C	S
Bothriechis thalassinus	W	1250–1600	PWF, LMWF	I	A, S	I	D
Bothrops asper	W	1300	PWF	D	T, F	R	N

Table 1. Distribution of the 74 species of amphibians and reptiles known from Parque Nacional Cerro Azul. Abbreviations include: Park Distribution-W = widespread in park, R = restricted to park or immediate environs (also includes species distributed outside of Honduras, but known from Honduras only in the park), P = peripherally distributed in park; Forest Formation-PWF = Premontane Wet Forest, LMWF = Lower Montane Wet Forest; Primary Microhabitat-A = arboreal, T = terrestrial, F = forest inhabitant, P = lakeside or pondside inhabitant; S = streamside inhabitant; Relative Abundance-C = common, I = infrequent, R = rare; Conservation Status-S = stable populations in Parque Nacional Cerro Azul, D = all Parque Nacional Cerro Azul populations declining, E = extirpated from park, N = no data on population status. See text for explanation of Broad Distribution Pattern abbreviations.

streamside inhabitants, two (2.7%) are arboreal and terrestrial forest inhabitants, and one (1.4%) is a terrestrial forest and pond-side inhabitant.

Relative abundance

The 74 species known from the park are classified as being common (found on a regular basis, many individuals can be found), infrequent (unpredictable, few individuals seen), and rare (rarely seen). These classifications are in part historical (i.e., based in part on earlier trips to the parks) and do not take into consideration the population declines taking place for several species (see next section). Twenty-eight species (37.8%) are classified as being common (four salamanders, 12 anurans, three lizards, nine snakes), 26 (35.1%) as being infrequent (seven anurans, six lizards, 13 snakes), and 20 (27.0%) as being rare (five anurans, one turtle, six lizards, eight snakes).

Population declines

Population declines, especially of amphibians, are proceeding in this national park, as is the case elsewhere in Honduras (McCranie & Wilson, 2002; Wilson & McCranie, 1998, 2004a). Of the 28 species of amphibians presently known from the park, ten (35.7%) have either all of their park populations apparently declining (9) or are apparently extirpated from the park (1). The latter (*Eleutherodactylus milesi*) is feared extinct. Those with declining populations are *Bolitoglossa conanti*, *B. dunni*, *Bufo campbelli*, *Hyalinobatrachium fleischmanni*, *Agalychnis moreletii*, *Hyla bromeliacia*, *H. salvaje*, *Plectrohyla guatemalensis*, and *Rana maculata*. Some of this decline appears to be part of a general pattern of disappearance of streamside *Eleutherodactylus* populations in the country occurring at about 900 m elevation and higher (McCranie & Wilson, 2002). However, the

Above: *Eleutherodactylus coffeus*. Below: *Micrurus diastema*. All photographs © J. R. McCranie.

in 2004 have deformed mouthparts. However, these populations are considered stable because of the large numbers of adults that could be seen in 2004.

Of the 46 species of reptiles recorded for the park, seven (15.2%) are thought to have all of their park populations declining, including *Laemanctus longipes*, *Norops biporcatus*, *Clelia clelia*, *Dryadophis dorsalis*, *Drymobius chloroticus*, *Rhadinaea montecristi*, and *Bothriechis thalassinus*. The primary reason for these declining populations is habitat destruction (see next section). Nine other reptile species are insufficiently known in the park to determine their conservation status. Also, numerous other species of amphibians and reptiles that have stable populations somewhere in the park have had other populations negatively impacted by the widespread habitat destruction.

Parque Nacional Cerro Azul contains six Honduran endemics, including *Eleutherodactylus coffeus*, *E. milesi*, *Eleutherodactylus* sp., *Norops johnmeyeri*, *N. ocelloscapularis*, and *Typhlops stadelmani*. Three of these Honduran endemics (*Eleutherodactylus coffeus*, *Eleutherodactylus* sp., and *Norops ocelloscapularis*) are not known outside of Parque Nacional Cerro Azul. One, *E. milesi*, is thought to be extinct.

greatest cause of these declines is habitat destruction (see next section). In addition, all tadpoles of *Plectrohyla matudai* collected from three localities (900–1480 m elevation) in the park

Given the above-indicated cases of decline or disappearance, it is critical that the populations of those species be carefully monitored for changes in their population status.

Eleutherodactylus rostralis

Lampropeltis triangulum

Pliocercus elapoides

Bothriechis thalassinus

IMPORTANCE OF THE PARK AS A HERPETOFAUNAL REFUGE

As currently understood, the herpetofauna of the mainland of Honduras, Bay Islands, Cayos Cochinos, Miskito Keys, Swan Islands, and territorial waters consists of 348 species (unpubl. data), including 121 amphibians and 227 reptiles (six of which are marine in distribution). The known herpetofauna of Parque Nacional Cerro Azul (74 species), thus, comprises 21.6% of the 342 species known from the mainland and insular environments in Honduras. The percentage of the various mainland and insular species afforded nominal protection in the park varies widely. Neither of the two species of caecilians nor of the two crocodilians is recorded from the park. The percentages of the other groups are as follows: salamanders (15.4% of 26 species); anurans (25.8% of 93 species); turtles (11.1% of 9 non-marine species); lizards (16.9% of 89 species); and snakes (24.8% of 121 non-marine species).

However, the above figures are misleading, inasmuch at Parque Nacional Cerro Azul harbours only two of the forest formations located in Honduras. Therefore, it is more useful to assess the park's importance by comparing the herpetofaunal composition of the two forest formations in the park with that of the same formations in the country as a whole. McCranie & Wilson (2002) and Wilson & McCranie (2004b) demonstrated the presence of 15 salamander species and 28 anuran species in Lower Montane Wet Forest in Honduras. With the addition of one salamander species to this forest formation (McCranie *et al.*, 2005), the park's four salamander species found in this formation make up 25.0% and its 12 anurans 42.9% of the whole. Wilson & McCranie (2004b) recorded 22 lizards and 33 snakes from this same forest formation. With the addition of one species of snake to this forest formation (McCranie & Castañeda, 2004), the park's seven lizard species found in this formation constitute 31.8% and its 21 snake species comprise 61.7% of the whole. With respect to Premontane Wet Forest, McCranie & Wilson (2002) listed nine salamander and 59 anuran species. The *Eleutherodactylus* sp. reported herein from Premontane Wet Forest is an addition to that formation; thus, there is a total of 60 anuran species now known from this formation. Therefore, the park's three salamander species found in this formation constitute 33.3% and its 23 anuran species 38.3% of the whole. Reptile species recorded from Premontane Wet Forest include three turtles, 35 lizards, and 61 snakes (unpubl. data). Thus, the park's one turtle species found in this formation comprises 33.3%, its 12 lizard species 34.3%, and its 23 snake species 37.7% of the whole.

During my visits to Parque Nacional Cerro Azul over the years, it has been obvious that the buffer zone has been subjected to increasing degradation, due to the conversion of the land to pastures and croplands, as has been noted in almost every other biotic reserve in Honduras (Wilson *et al.*, 2001; Wilson & McCranie, 2003, 2004a). On my first trip to the area in 1982, the entire region between Laguna del Cerro and the vicinity of Quebrada Grande was covered in primary forest. Presently, there is no primary forest left (or even secondary forest of any substance) within sight from the trails between Laguna del Cerro and Quebrada Grande, and a much larger area around Quebrada Grande has been denuded. Even the shade tolerant coffee farms prevalent between Laguna del Cerro and Quebrada Grande in 1988 had been converted to sun-resistant coffee fields by October 1998. Recent fieldwork along the southwestern portion of Montaña del Cerro Azul also demonstrated that no primary forests exist in that area as well, with the exception of some of the steeper slopes of the mountain. This habitat destruction and degradation, although serving to make available land for support of the local people, is disconcerting given the size and diversity of the documented herpetofauna, the number of endemic species supported by this biotic reserve, and the potential of the area to produce additional novelties for the country. Equally disconcerting is the lack of personnel and facilities in the park for its protection. Even many people living in this park apparently are unaware of its 'protected status'. Unless Parque Nacional Cerro Azul acquires such protection, it appears likely that the area will loose what remaining forests it has left.

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APPENDIX I - Specimen locality data

Bolitoglossa conanti.- Quebrada Grande, 1250-1600 m, KU 219840-91, MVZ 186762-63, 186767, 186769, 186772, 186777, UF 142380.

Bolitoglossa dofleini.- between Laguna del Cerro and Quebrada Grande, ca. 1300 m, SMF 78902; Quebrada Grande, 1250-1370 m, KU 202996, MVZ 221181-82, 225849-50, SMF 78901, UF 142389, 142393; San Isidro, 1040-1200 m, UF 142390.

Bolitoglossa dunni.- Quebrada Grande, 1370-1600 m, FMNH 236515-21, MVZ 186761, 186765-66, 186768, 186770-71.

Bolitoglossa rufescens.- between Laguna del Cerro and Quebrada Grande, 1000 m, SMF 78900; Quebrada Grande, 1250-1370 m, MVZ 186773, 186776, 225863, SMF 78891-94, 78896-99, UF 142381-82, USNM 333041-60, 343428-34; San Isidro, 1040 m, UF 142383-88.

Bufo campbelli.- Laguna del Cerro, 770 m, KU 209259; between Laguna del Cerro and Quebrada Grande, 810-1080 m, KU 209265-66.

Bufo valliceps.- Laguna del Cerro, 770 m, SMF 78500; between Laguna del Cerro and Quebrada Grande, 1250 m, SMF 78909; Quebrada Grande, 1250 m, UF 142406; San Isidro, 1040 m, UF 142410.

Hyalinobatrachium fleischmanni.- Laguna del Cerro, 770 m, KU 200525.

Agalychnis callidryas.- Laguna del Cerro, 770 m, UNAH 3776, USNM 514172-77.

Agalychnis moreletii.-Laguna del Cerro, 770 m, KU 200526-28; near Quebrada Grande, 1300 m, KU 200529-30.

Duellmanohyla soralia.- Quebrada Cañon Oscuro, 1050-1170 m, KU 195557-58 (both tadpoles), USNM 304991 (tadpoles), 514506-14, 514707-08 (both tadpoles); Laguna del Cerro, 770 m, USNM 508451 (tadpoles); Quebrada Grande, 1350-1370 m, KU 195554-55, SMF 78921, UNAH 3775, USNM 514515-20; San Isidro, 900-1060 m, UF 142532-33 (both tadpoles).

Hyla bromeliacia.- Cerro Los Dantos, 1600 m, USNM 523174-75; Quebrada Grande, 1250-1370 m, FMNH 236384, SMF 78920, UF 142376-77, USNM 304990 (tadpoles), 514710 (tadpoles), 523171-73, 523176-81, 523462 (tadpoles).

Hyla loquax.- Laguna del Cerro, 770 m, KU 200536, SMF 78914, UNAH 3778, USNM 514229.

Hyla microcephala.- Laguna del Cerro, 770 m, KU 200542, UNAH 3780, USNM 514245-51.

Hyla picta.- Laguna del Cerro, 770 m, USNM 514290-91.

Hyla salvaje.- Quebrada Grande, 1370 m, KU 195549-50, 195551-52 (both tadpoles).

Plectrohyla guatemalensis.- Quebrada Cañon Oscuro, 1150-1170 m, SMF 78770, USNM 514648 (tadpoles), 523190; Quebrada Grande, 1250-1370 m, KU 209685, 209706 (tadpoles), UF 142375, 142537 (tadpoles).

Plectrohyla matudai.- near Laguna del Cerro, 770 m, USNM 523484 (tadpole); Quebrada Grande, 1370-1480 m, KU 195447 (tadpoles), 195448-51, 195453-54, 209711, UF 142536 (tadpoles), USNM 514421-23; San Isidro, 900-1060 m, UF 142362-68, 142534-35 (last two both tadpoles).

Ptychohyla hypomykter.- Quebrada Cañon Oscuro, 1150-1170 m, USNM 319918-19, 319938 (tadpoles), 514296-97, 514691 (tadpoles); Laguna del Cerro, 770 m, USNM 508453-55 (all tadpoles), 514298-99; Quebrada Grande, 1250-1600 m, KU 204204-09, 204212 (cleared and stained adult), 209712 (tadpoles), SMF 78916, UF 142370, 142539 (tadpoles), UNAH 2873, USNM 304992-94 (all tadpoles), 319920-22, 319937 (tadpoles), 508452 (tadpoles), 514300, 514325, 514684 (tadpoles); San Isidro, 900-1060 m, UF 142371-74, 142540-41 (last two both tadpoles).

Scinax staufferi.- near Quebrada Grande, 1300 m, UNAH 2881.

Smilisca baudinii.- Laguna del Cerro, 770 m, UNAH 3773, USNM 508476-77 (both tadpoles), 514453; Quebrada Grande, 1250-1370 m, KU 202999-3001, SMF 78925, UF 142426, UNAH 3772, USNM 304995 (tadpoles), 508475 (tadpoles), 514457-63; San Isidro, 1040 m, UF 142427.

Eleutherodactylus charadra.- Laguna del Cerro, 770 m, KU 209136; Quebrada Grande, 1250-1370 m, KU 209132-35, 209137, UF 142428; San Isidro, 900-1200 m, UF 142429-38.

Eleutherodactylus coffeus.- between Laguna del Cerro and Quebrada Grande, 1000 m, SMF 78873; San Isidro, 900-1200 m (a series of 11 uncatalogued specimens is considered conspecific with the holotype of *E. coffeus*, even though they differ in having a longer head more typical of other species in the *E. gollmeri* group. They do agree, however, with *E. coffeus* in all other diagnostic characters).

Eleutherodactylus laticeps.- Quebrada Grande, 1250-1300 m, UF 142397, USNM 525573; San Isidro, 1040 m, UF 142396.

Eleutherodactylus milesi.- between Laguna del Cerro and Quebrada Grande, 1050-1100 m, KU 209076-77; Quebrada Grande, 1350-1400 m, KU 209078-79, 209097.

Eleutherodactylus rostralis.- between Laguna del Cerro and Quebrada Grande, 1050-1200 m, KU 209109-12; Quebrada Grande, 1370 m, KU 209113; San Isidro, 980-1200 m, UF 142439-40.

Eleutherodactylus sp.- San Isidro, 900-1200 m (a series of seven specimens represent an undescribed species of the *E. alfredi* group).

Rana brownorum.- Laguna del Cerro, 770 m, KU 200557, USNM 508486 (tadpoles). 523728; Quebrada Grande, 1370 m, KU 203005, USNM 523729-36; San Isidro, 1040 m, UF 142447-48.

Rana maculata.- Laguna del Cerro, 770 m, SMF 78918, USNM 508490 (tadpoles); Quebrada Grande, 1360-1370 m, KU 200547-48, 200500, USNM 514749 (tadpoles), 523255.

Kinosternon leucostomum.- Laguna del Cerro, 770 m, USNM 559563.

Abronia montecristoi.- Quebrada Grande, 1370 m, USNM 520001.

Laemanctus longipes.- between Laguna del Cerro and Quebrada Grande, 1120 m, USNM 549415.

Sceloporus malachiticus.-Cerro Los Dantos, 1840 m, KU 200576; Quebrada Grande, 1250-1370 m, KU 200570-71, 200575, 203006.

Norops biporcatus.- Laguna del Cerro, 770 m, SMF 79147.

Norops capito.- Laguna del Cerro, 770 m, UF 142454; San Isidro, 1040 m, UF 142455-57.

Norops johnmeyeri.- Quebrada Grande, 1370-1480 m, KU 192624-25.

Norops laeviventris.- Quebrada Grande, 1250-1480 m, FMNH 236388, SMF 79179, USNM 532569.

Norops ocelloscapularis.- Quebrada Cañon Oscuro, 1150-1170 m, SMF 79091, USNM 529976-77; between Laguna del Cerro and Quebrada Grande, 1200 m, SMF 78841, 79077-78; Quebrada Grande, 1250-1370 m, SMF 79090, 79092, USNM 529973-75; San Isidro, 1040-1200 m, UF 142458-59.

Norops petersii.- Quebrada Grande, 1370-1400 m, KU 195463, UF 142395.

Norops rodriguezii.- Laguna del Cerro, 770 m, SMF 79086; near Quebrada Grande, 1250 m, SMF 79085; San Isidro, 900-1040 m, UF 142546.

Norops uniformis.- Laguna del Cerro, 770 m, SMF 79150-51; between Laguna del Cerro and Quebrada Grande, 1100 m, USNM 330185; Quebrada Grande, 1370 m, UF 142460-61; San Isidro, 1040 m, UF 142462.

Sphenomorphus cherriei.- Laguna del Cerro, 770 m, UF 142463; near Quebrada Grande, 1300 m, SMF 79144.

Ameiva festiva.- near Quebrada Grande, 1300 m, SMF 79142.

Lepidophyma flavimaculatum.- Quebrada Grande, 1250-1300 m, SMF 79115, UF 142464-66; San Isidro, 1040 m, UF 142467.

Lepidophyma mayae.- San Isidro, 1040 m, UF 142392 (this specimen constitutes the first known record of this species from Honduras).

Typhlops stadelmani.- Quebrada Grande, 1250-1370 m, SMF 79113, UF 142468-74, USNM 539989-40000.

Boa constrictor.- Quebrada Grande, 1370 m, based on 2.5 m adult that was released at site of capture.

Adelphicos quadrivirgatum.- Quebrada Grande, 1250-1370 m, KU 203088, UF 142475-84, USNM 561009; San Isidro, 1040 m, UF 142485.

Clelia clelia.- Laguna del Cerro, 770 m, FMNH 236395 (hemipenis only; adult discarded).

Coniophanes bipunctatus.- Quebrada Grande, 1370 m, USNM 508405.

Coniophanes fissidens.- San Isidro, 1040 m, UF 142487.

Coniophanes imperialis.- San Isidro, 1040 m, UF 142488.

Dryadophis dorsalis.- Quebrada Grande, 1370 m, USNM 508409; near San Joaquín, 1600 m, SMF 79135.

Dryadophis melanolomus.- San Isidro, 1040 m, UF 142489.

Drymobius chloroticus.- Quebrada Grande, 1370-1480 m, KU 200600, 200602-04, UF 142490.

Drymobius margaritiferus.- near Laguna del Cerro, 860 m, KU 200606; Quebrada Grande, 1370 m, KU 203008, USNM 508412.

Geophis fulvoguttatus.- near Quebrada Grande, 1680 m, KU 214782.

Imantodes cenchoa.- Quebrada Grande, 1250-1370 m, KU 200607, ROM 19978-79, SMF 79121, UF 142491; San Isidro, 1200 m, UF 142492.

Lampropeltis triangulum.- Quebrada Grande, 1250-1370 m, ROM 19980-81, UF 141975, 142071, USNM 508417-18; San Isidro, 1040 m, UF 142072-73.

Leptodeira septentrionalis.- Quebrada Grande, 1250-1370 m, UF 142494, USNM 508420.

Ninia diademata.- Quebrada Grande, 1250-1370 m, SMF 79125, UF 142495-503, USNM 508422.

Ninia espinali.- San Isidro, 1040 m, UF 142504-05.

Ninia sebae.- Quebrada Grande, 1250 m, UF 142507-11.

Pliocercus elapoides.- Quebrada Grande, 1250-1370 m, FMNH 236406, UF 142512-13; San Isidro, 1040 m, UF 142514.

Rhadinaea kinkelini.- Quebrada Grande, 1250-1370 m, KU 203089, UF 142515; San Isidro, 900 m, UF 142516.

Rhadinaea montecristi.- Cerro Los Dantos, 1600 m, KU 203090; Quebrada Grande, 1370 m, KU 203091-92; near San Joaquín, 1600 m, USNM 508423.

Sibon dimidiatus.- Quebrada Grande, 1300-1400 m, KU 200612, ROM 19987-89, SMF 79119; San Isidro, 1200 m, UF 142077-79.

Sibon nebulatus.- Quebrada Grande, 1250 m, UF 142518.

Stenorrhina degenhardtii.- Quebrada Grande, 1250-1370 m, KU 200613, ROM 19990-94, UF 142520-21, USNM 508426-28; San Isidro, 1040 m, UF 142522-23.

Tantilla impensa.- Quebrada Grande, 1370-1600 m, FMNH 236413, SMF 79114, USNM 523955.

Tantilla schistosa.- Quebrada Grande, 1250-1370 m, KU 203093, ROM 19995, USNM 561062-63; San Isidro, 1040 m (this series may contain two species, as one of three uncatalogued specimens collected in 2004 and two of the three museum specimens listed have a head pattern similar to that of the closely related *T. alticola* of southern Central America).

Micrurus diastema.- near Laguna del Cerro, 830 m, KU 200628; Laguna del Cerro, 770 m, SMF 79108; Quebrada Grande, 1250-1680 m, KU 200629, ROM 20010, UF 142525-28, USNM 508431-32, 561075, 561123 (eggs); San Isidro, 1040 m, UF 142529.

Atropoides mexicanus.- Quebrada Grande, 1250-1300 m, KU 203011, SMF 79117, UF 141977, 142074.

Bothriechis thalassinus.- Quebrada Grande, 1250-1600 m, KU 203094, ROM 20015, UF 142530, USNM 561092.

Bothrops asper.- Quebrada Grande, 1300 m, KU 200621.

APPENDIX II - Gazetteer

Cañon Oscuro, Quebrada - a deep canyon stream that flows from Quebrada Grande southwestward into Laguna del Cerro; collections made from 1100 to 1250 m (15°05'N, 88°56'W).

Cerro, Laguna del - a small lake in SW portion of park; 770 m (15°05'N, 88°56'W).

Cerro Azul, Montaña del - highest peak in park, nuclear zone of park lies at 1600 m and above on slopes of this mountain; 2285 m (15°07'N, 88°55'W).

Dantos, Cerro Los - peak SE of Quebrada Grande near southeastern boundaries of nuclear zone; collections made from 1370 to 1840 m (15°05'N, 88°54'W).

Quebrada Grande - a village S of highest peak of Montaña del Cerro Azul; 1250 to 1370 m (15°05'N, 88°55'W).

San Isidro - a small village on W flank of Montaña del Cerro Azul; 1040 m (15°07'N, 88°56'W).

San Joaquín - a village SSE of Quebrada Grande, where foot trail to Quebrada Grande begins; 1500 m (15°04'N, 88°55'W).

Causes of mortality and bodily injury in Grass snakes (*Natrix natrix*) from the 'Stawy Milickie' nature reserve (SW Poland)

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FRAGMENTATION and pollution of the natural environment, together with the expansion of urban conurbations, are generally assumed to be among the major causes of population decline in various vertebrates (Dodd, 1987). Much attention has been paid to the threats posed to populations of small, seasonally migrating species by the ever increasing density of road traffic (Dodd, 1987; Bonnet *et al.*, 1999). In particular, many articles relate to the spring migrations of amphibians (e.g. Fahrig *et al.* 1995; Buchwald & Hels, 2001; Jędrzejczyk & Radwańska, 2002). However, the mortality of snakes on roads has not been so intensively studied (e.g. Spellerberg, 1975; Bernardino & Dalrymple, 1992; Rosen & Lowe, 1994; Tucker, 1995; Bonnet *et al.* 1999).

Apart from the dangers faced by reptiles – in particular snakes – associated with the development of road transport, there is also a danger of intentional killing, since these are the species which arouse the most negative feelings amongst humans (Dodd, 1987; Pupina & Pupinsh, 2002).

The Grass snake (*Natrix natrix* L.) is one of the most well known European reptiles. Although it is one of the most common European snakes, it has been in decline over a long period in many regions (Spellerberg, 1975; Zuiderwijk *et al.* 1998; Sura & Zamachowski, 2003). This article presents the results of research concerning the influence of potential predators and humans on the Grass snake population from the 'Stawy Milickie' nature reserve.

MATERIALS AND METHODS

Study area – The research was carried out on the terrain of the ornithological reserve 'Stawy Milickie' (51°31'51" N; 17°20'12" E). This area is made up of a complex of lakes separated by dykes, on which there is a road. The dykes are overgrown with grass and in some places by rushes and small trees. Rubble and stacks of dry branches and reeds, which are used to strengthen the dykes, provide additional cover. Intensive carp farming is carried out in the lakes; however, since this is a nature reserve, human activity is subject to various constraints (e.g. the felling of trees, lighting of bonfires and tourist access is prohibited). The reeds growing on the dykes are cut down systematically once every few years and this is carried out either in late autumn or winter. The reeds are never all cut down at once, due to the need to protect the local fauna, particularly birds.

Field studies were carried out in 2001 and 2002 from the end of April until the end of September. Snakes were captured between 08:00 and 11:00 hrs and between 16:00 and 18:00 hrs, since they were most active in these periods. Observations were carried out at least once every two weeks, commonly more often. The Grass snakes were captured, measured to the nearest millimetre and marked by clipping ventral scales (Borczyk, 2000). All visible scars and bodily injuries were noted and some photographed. Fisher's exact test was used to test whether there was an association between the appearance of scars or injuries and sex. The road mortality index for snakes was taken to be the number of snakes killed per day per kilometre of road (Tucker, 1995).

RESULTS

One hundred and four snakes were marked and additional 18 dead individuals were collected. In the cases of mortality that could be attributed to human action in the research area, the vast

Sex/age group	Cause of death	SVL (cm)
j	DOR	15.6
j	DOR	17
j	DOR	18.7
j	DOR	19
j	DOR	22
j	DOR	25
j	DOR	27.5
j	DOR	28
m	DOR	31
m	DOR	38.5
m	DOR	43
?	DOR	>50
m	DOR	54
m	Human activity (intentional)	57
f	Plugged eggs	59
f	Choked on fish	63
f	DOR	71
?	Animal predator	Tail and vertebrae fragment

Table 1. Causes of mortality in Grass snakes (*Natrix natrix*) from 'Stawy Milickie' reserve. DOR - dead on road, j - juvenile, m - male, f - female.

majority were road deaths heavily skewed towards small snakes (Tab. 1). The road mortality index in the investigated population was 0.27 snakes/km/day.

Most scars and injuries were visible in the region of the tail (11 individuals; fig. 1) and head (5 individuals). Only two individuals had injuries in other areas of the body.

No statistically significant difference between the sexes was observed in the appearance of scars and other injuries (p = 0.5426). Amongst those snakes, which had survived the attack of a predator, only one was a juvenile (25.8 cm). The remaining individuals were at least 48 cm long (Table 2).

DISCUSSION

On the basis of research carried out in Illinois, Tucker (1995) stated that the road mortality rate of snakes was 0.198 snakes/km/day. He suggested that such high mortality resulted from the floods, which at that time covered lower lying land and forced snakes to migrate. The road mortality rate I observed was even higher and amounted to 48,6 snakes/km/year on the assumption that the snakes are active for 180 days per year (6 months). This estimate is approximately twice the figure of 22.5 snakes/km/year reported by Rosen & Lowe (1994) and still could be an underestimate because some snakes were certainly removed from the road by predators or people before I found them (see Rosen & Lowe, 1994 for discussion of this issue).

The home ranges of Grass snakes are relatively large and can cover up to 30 ha (Madsen, 1984) and daily a snake can cover distances of up to 230 m (Nagy & Korsós, 1998). Thus, snakes migrating in search of food, a mate, or a place to lay eggs, often have to cross the roads running through their home range, which exposes them to the danger of death due to a road accident. Although there is relatively little traffic on the roads running through the nature reserve, the deaths of many Grass snakes are caused by road accidents. It may seem paradoxical, but it may be the case that more snakes die on roads where there is very little traffic. Possibly this is due to the fact that reptiles naturally steer clear of roads with heavy traffic, or that snake populations living near busy roads have significantly decreased. Moreover, snakes that are startled in open terrain sometimes do not flee at all, but remain fixed to the spot or take up a threatening pose (Borczyk, unpublished). In open areas, such as a road, snakes are visible to avian and other predators. The less they move the more cryptic they are, but the longer they are on the road, the higher the probability that they will be killed by vehicles. A common explanation of why snakes stop on the roads is thermoregulation (e.g. Rosen & Lowe, 1994), but the issue seems to be more complex (Shine *et al.*, 2004).

Forman & Alexander (1998) stated that at present far more vertebrates are killed by road accidents than by purposeful means (hunting, population control). They argue that mortality caused by road accidents may not have a significant influence on the populations of common species at a global level. They give the

Sex/age group	Injuries	SVL (cm)
j	Scars on whole body	25.8
m	Scars on head	48
m	Scars on head	50
m	Scars on head	53
m	Broken tail	54
m	Scars on tail and spine; deformed tail	55
m	Wound around the cloaca; broken tail	55.5
m	Scars on tail	55.7
m	Scars on belly	56.5
m	Scars on head	58.5
f	Broken tail	68
f	Wounded tail	70
f	Broken tail	73
f	Broken tail	75
f	Scars on head	75.5
f	Broken tail	75.5
f	Broken tail	77
f	Broken tail	80

Table 2. Bodily injuries of Grass snakes (*Natrix natrix*) from 'Stawy Milickie' reserve. j - juvenile, m - male, f - female.

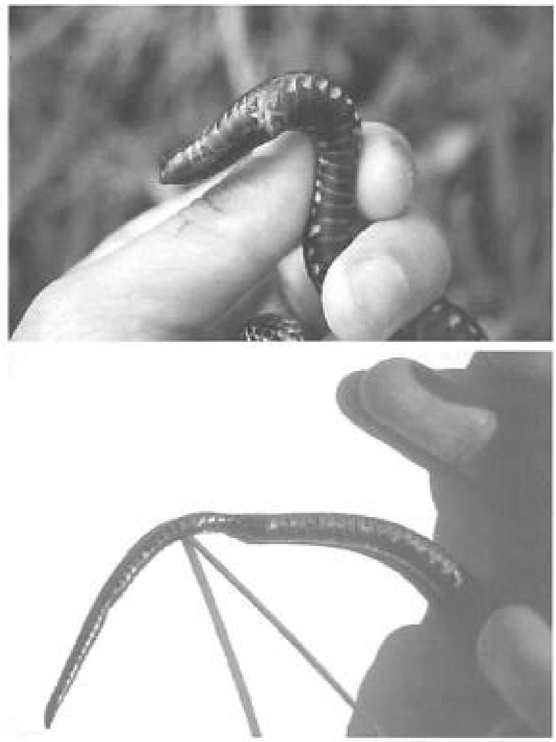

Figure 1. Examples of broken and deformed tails of Grass snakes (*Natrix natrix*) from 'Stawy Milickie' reserve.

example of the Sparrow (*Passer domesticus*), which is one of the most common victims of road accidents in the British Isles, but the population shows no sign of decreasing. This may be explained by a high birth rate, which compensates for mortality on the roads. New generations of birds migrate and inhabit the areas in which there is a high mortality rate. Mortality on the roads can have a significant impact on a population at a local level. This is an important observation, especially in the case of snakes, whose ability to migrate is far inferior to, for example, that of a bird. Thus the local effect on snakes can more readily translate into a global effect, unlike the case for vagile animals such a birds.

In their studies on the mortality of snakes, Bonnet *et al*. (1999) observed a significant relationship between the time of year and the sex/age group killed by road accidents. The most susceptible to such accidents are migrating individuals (individuals that have just hatched, males searching for females, and females looking for somewhere to lay eggs), while subadults are less likely to die in a road accident, since they do not roam to the same degree. These facts are important in relation to the local population, since females about to lay eggs are often victims of road accidents (Bonnet *et al*., 1999). It has been observed that the population investigated has two mating seasons, and eggs are laid over a very long period (Borczyk, unpublished). Combat between males has been observed in May (Borczyk, 2004) and at the end of August (verbal communication from employees of a fish farm). Gravid females, which are just about to lay eggs, have been observed from June to the end of August, so there is less seasonality to their road mortality.

Snakes occasionally eat prey items that are too large and subsequently die (e.g. Pauly & Benard, 2002; this study). Previous examples of this phenomenon involving Grass snakes are Gajewski (2000) who found a snake that had burst while swallowing a large Marsh frog (*Rana arvalis*) and Nagy (2001) who found snakes, whose oesophagus or lower section of the digestive system was punctured, due to swallowing an item of prey.

Also, infection or an egg of particularly large size may lead to the plugging of eggs in a female (Messonier, 1996). This may lead to a female being unable to lay her eggs. Infection and/or a prolonged pregnancy can lead to debilitation of a female and, as a result, its death.

It is difficult to estimate the impact of predator pressure on snake populations. During the present study I found only one small snake with scars suggesting that it survived a predator attack. Fitch (2003) found that females fall victims to predators more often than males. Mushinsky & Miller (1993) concluded that a higher wound rate in larger snakes suggests that they are either attacked more often or survive attempted predation better than smaller individuals. However, it can reflect the fact that older snakes live longer and therefore are subject to injuries for a longer time.

The negative effect of roads on snake population is two-fold. First, the high road mortality directly reduces the number of living and reproducing snakes. Second, habitat fragmentation by network of roads exerts a significant, negative effect on movements and mate location by snakes (Shine *et al.* 2004). There is clearly a need for more detailed studies of the impact of roads on the mobility and population dynamics of snakes, especially on the dispersal of young snakes, as well as on the strategies of conservation of snake populations that are affected by the expanding road network.

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A note on terrestrial activity and feeding in the Spectacled salamander, *Salamandrina terdigitata* (Urodela, Salamandridae)

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ABSTRACT — At a low elevation site (ca. 200 m a.s.l.) in central Italy, the Spectacled salamander was observed to be active mostly in the open ground between 18:00 and 24:00 hrs, while daytime activity was seldom recorded. Activity was positively correlated with air temperature, but the internal temperature of salamanders was correlated to substrate temperature. Thirteen taxa of terrestrial arthropods were recorded from faecal pellets, the greater part of which (36%) was represented by Acarina.

THE Spectacled salamander, *Salamandrina terdigitata*, is a terrestrial urodele endemic to Italy. Although described more than two centuries ago, very little information has so far been published on its ecology. The species is reported to be active by night, or sometimes during daylight on cool, humid or rainy days (Ramorino, 1863; Lessona, 1868; Lanza, 1983; Bruno, 1973, 1983; Zagaglioni, 1978; Vanni, 1980; Barbieri, 1994; Zuffi, 1999), but nothing is otherwise known of its daily activity cycle. Cherchi (1953) provided some information on internal temperatures, and notes on food consumption were published by Ramorino (1863) and Vanni (1980).

In the framework of an extensive investigation on the population ecology of *S. terdigitata* in central Italy, we collected some data on the terrestrial activity of several specimens, which in light of the deficient knowledge on the ecology of this species we believe are worth publishing.

MATERIALS AND METHODS

We carried out field observations during five nights between 4th November 1996 and 3rd January 1997, in open ground on clay-based soil near a shallow well. This was excavated in 1982 and has since recovered to semi-natural conditions. The well is located in the garden of a house on the outskirts of Terni, Umbria, central Italy, at about 200 m a.s.l., and was used by *S. terdigitata* as an oviposition site. Occasional observations were also carried out at some breeding sites in the Lepini mountains, Latium, central Italy.

We recorded the number of salamanders active in the open while covering a fixed 50-metre transect four times a night, between 18:00–21:00, 21:00–24:00, 24:00–03:00 and 03:00–06:00 hrs. In order to avoid disturbing the salamanders, we did not record their ventral patterns – which are unique to individuals – and therefore cannot state the precise number of individuals concerned.

Internal (cloacal) temperatures of salamanders as well as air temperatures were recorded by a digital thermocouple thermometer on 11th December 1996, between 22:30 and 23:40 hrs, with cloudy sky, discontinuous light rain and no wind. For internal temperature, a probe of 0.5 mm in diameter was used. The humidity variation was given by the Meteorological Station 'Federico Cesi', Terni.

A few individuals were kept singularly in small terrariums (without food) for a few days and their faecal pellets ($n = 24$) collected for the purposes of identifying food remains. These were preserved in 70% aethylether and examined subsequently with the aid of optical binoculars.

Taxa	This note	References
Annelida		Vanni, 1980; Bruno, 1973, 1983
Gastropoda		Vanni, 1980; Bruno, 1983
Copepoda		Bruno, 1973, 1983
Isopoda	+	Vanni, 1980; Bruno, 1973, 1983
Aracnida		Vanni, 1980; Bruno, 1973
Pseudoscorpiones	+	Vanni, 1980
Aranee	+	Bruno, 1983
Acarina	+	Vanni, 1980
Miriapoda		Vanni, 1980; Bruno, 1973, 1983
Juliformes	+	Vanni, 1980
Collembola	+	Vanni, 1980
Orthoptera		Ramorino, 1863; Vanni, 1980
Notonectidae		Ramorino, 1863
Coleoptera		Vanni, 1980; Bruno, 1973, 1983
Staphylinidae	+	
Carabidae	+	
Curculionidae	+	
Anthicidae	+	
various larvae	+	Ramorino, 1863
Diptera	+	Vanni, 1980; Bruno, 1973, 1983
Hymenoptera		Vanni, 1980
Formicidae	+	

Table 1. Taxa identified in faecal pellets of *S. terdigitata*.

Since no pattern characteristics are available to distinguish between males and females – although on average males are smaller and more slender than females and possess a relatively larger head (Vanni, 1980; Angelini *et al.*, 2001) – we did not attempt identification of the sexes, and herewith treat them collectively.

RESULTS

Night activity – At the oviposition sites in the Lepini Mountains, we occasionally found salamanders active on the ground between 11:00 and 15:00 hrs, with clear skies and an air temperature of 11°C. However, at the site in Umbria, except for ovipositing females – which spent one or more days submerged in water – salamanders were only active at night, and always on moist ground. In total we made 230 observation records. Salamanders were active mostly between 18:00–24:00 hrs and there was a positive correlation between time of activity and average air temperature (Spearman coefficient r_s = 1.00; p = 0.00), and a negative – but not significant correlation – between activity and average air humidity (r_s = -0.80; p = 0.20) (Fig. 1).

Internal temperature – The cloacal temperatures of 12 active salamanders ranged from 7.6°C to 9.8°C (mean ± SE = 8.8 ± 0.2°C). All salamanders showed an internal temperature lower than air temperature, which was constant at 10°C throughout the observation period (average Δt°± SE = -1.2 ± 0.2°C; range between -2.4 and -0.2°C), and was either slightly higher or lower than substrate temperature (average Δt° ± SE = -0.3 ± 0.2°C; range between -1.2 and 0.4°C), to which it was correlated ($r_{Spearman}$=0.66; p <0.02; n = 12) (Fig. 2). On one occasion in the Lepini Mountains we recorded a salamander walking on snow at 11°C, but we did not record its internal temperature.

Food – Among the undigested food from faecal pellets, we identified 13 taxa of terrestrial arthropods (Table 1). We also identified a fragment of a conch of a pulmonate mollusc, as

Taxa	*N*	%
Isopoda	2	10.5
Pseudoscorpiones	1	5.3
Aranee	3	15.8
Acarina	6	31.6
Juliformes	1	5.3
Staphylinidae	1	5.3
Anthicidae	1	5.3
Diptera	1	5.3
Formicidae	3	15.8
Total	**19**	100.2

Table 2. Diet composition of *S. terdigitata*, based on food remains from 14 faecal pellets.

well as various items alien to the salamander diet such as glass fragments, seeds, and small pieces of wood and grass, probably accidentally ingested together with prey. Some of the remaining materials, even though apparently of animal origin, could not be identified. Composition of the diet is presented in Table 2. Only once in the field did we observe a salamander quickly and repeatedly thrusting its tongue out and in as if feeding, but we were not able to identify any prey.

DISCUSSION

At the Umbria site, most salamanders were active during the first half of the night and only a very few individuals after midnight in the open ground. The usual increase of air humidity after sunset should be favourable to salamanders, while temperature decrease might cause the marked activity decline recorded between 24:00–06:00 hrs. However, it is possible that prey in the area was fairly abundant, and a few hours feeding were all that may have been necessary to sustain daily activity.

Cherchi (1953) conducted laboratory experiments to determine the maximum and minimum temperatures tolerated by *S. terdigitata* by keeping specimens at variable temperatures until their eventual death. He fixed at –17°C and 32–35°C, respectively, the minimum and maximum critical temperatures relative to the animals' survival. He also recorded daily cloacal and ambient (laboratory) temperatures, but not substrate temperature, of three specimens in the course of a month, and reported that the salamanders' internal temperature averaged lower than air temperature. Our findings (Fig. 2) agree to those of Cherchi (1953), but the significant, positive correlation between substrate and salamander cloacal temperatures suggests that substrate temperature most probably influences the salamanders' activity in the field.

With regard to diet, apparently only Ramorino (1863) and Vanni (1980) have provided original data based on the analysis of stomach content of adult salamanders. In the literature there are further reports of food records in *S. terdigitata* (Lessona, 1868; De Betta, 1874; Angel, 1949; Thorn, 1969; Hvass, 1972; Lanza, 1983, 1988; Bogliani & Barbieri, 1986; Di Tizio, 1986; Corsetti, 1994; Zuffi, 1999) but these probably refer to previous papers. Our data add some previously unreported items to the food spectrum of *S. terdigitata*, and this is particularly relevant because they were obtained from a very small sample (24 faecal pellets) using non-invasive methods. This suggests that the Spectacled salamander may feed on an even wider range of prey and that more information should be obtainable in the future from larger faecal samples and without sacrificing animals. The analysis of faecal pellets may preclude identification of prey species that typically leave behind only a few undigested fragments (e.g. earthworms and some insect larvae). However, unidentified prey remains have also been recorded from dissected stomachs (Vanni, 1980).

Ramorino (1863) and Bruno (1973, 1983) gave information on aquatic prey items (tab. 1), which considering the strictly terrestrial habits of *S.*

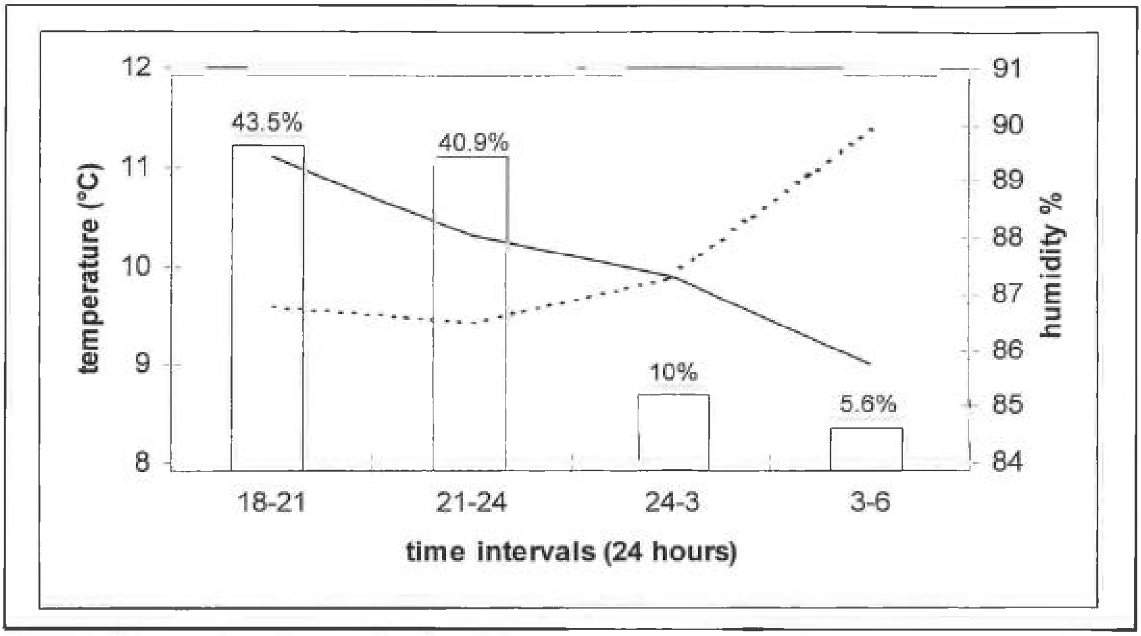

Figure 1. Relations of number of active *S. terdigitata* (n = 230) to air temperature (solid line) and humidity (broken line).

terdigitata is somewhat puzzling. Vanni (1980), Lanza (1983) and Zuffi (1999) state that only ovipositing females submerge, although Ramorino (1863) and Barbieri (pers. comm.) sometimes recorded males in water. In our experience, the female aquatic phase lasts no longer than the time needed to complete egg-laying. In fact the stomachs of Vanni's (1980) females, which he collected in water, were empty. Predation on aquatic organisms by this species would thus be usefully confirmed by further records.

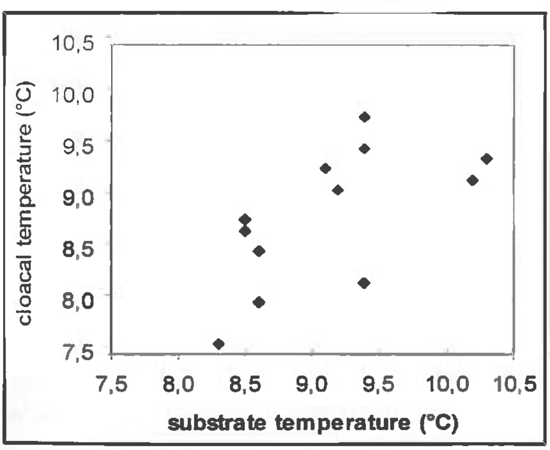

Figure 2. Correlation between internal temperature and substrate temperature of active *S. terdigitata* (r_{Spearman} = 0.66; $p < 0.02$; n = 12). Air temperature kept at 10°C all throughout the observation session.

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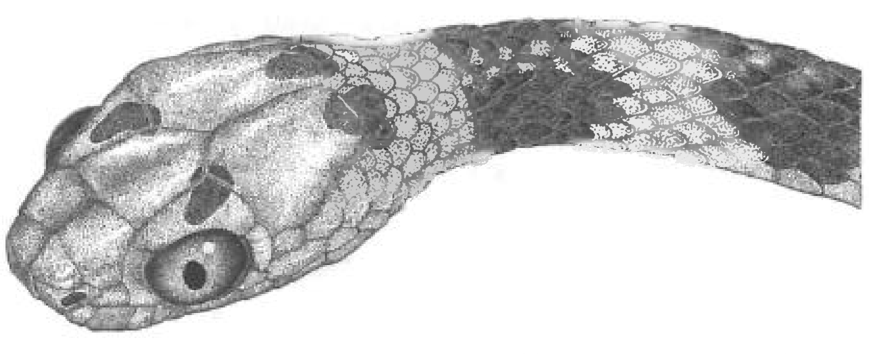

Head detail of *Imantodes tenuissimus*. Reproduced with kind permission of the artist/author, Julian C. Lee, from *The Amphibians and Reptiles of the Yucatán Peninsula* (Cornell University Press, 1996).

A photographic guide to snakes and other reptiles of Thailand and South-East Asia

Merel J. Cox, Peter Paul Van Dijk, Jarujin Nabhitabhata, and Kumthorn Thirakhupt

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As most readers will know, there is nothing worse than the prospect of a long-haul flight without a good book to read – except maybe the thought of trying to find one at the airport! Imagine my surprise then, when scouring the shelves of the bookstore in Bangkok International Airport I unearthed a copy of Cox *et al.*'s pocket field guide. Keen to be rid of my remaining Thai Baht I picked up a copy and settled down on the plane to peruse its pages.

Designed as a pocket guide to aid in the identification of the snakes and other reptiles of Thailand, Peninsular Malaysia and Singapore, emphasis is placed on the 'common, large, conspicuous, dangerous or biologically significant species'. Unlikely many 'pocket guides' this text does qualify for the name, measuring a mere 19cm by 10cm. As a result of this the 144 pages of the volume are only able to accommodate 222 of the 320 species and subspecies from the region that were described at the time of production. This should not be seen as a criticism however, since the 222 species chosen are each afforded at least one colour photograph, staged to highlight the reptile's characteristic features. It is just a shame that some of the impact of these beautiful photographs is lost due to their small size.

As the authors state this guide has been arranged by family, in 'more or less traditional taxonomic order' to aid field identification. The species accounts that accompany each photograph provide details of morphological characteristics that should aid identification of an animal in the field. A limited amount of information on a species' distribution and habitat preferences is also provided which may be useful when trying to identify two similar species in the field. One small criticism that I could make is the lack of dichotomous keys. To fulfil the role of a perfect field guide inclusion of identification keys is all-important. This is especially true of guides, which are limited in space such as this, and therefore cannot include every species present in the region.

The value of this guide for field scientists may be reduced by the lack of identification keys; however it is unlikely that this is the market the authors intended to supply. As a guide for holidaymakers and amateur herpetologists this book does its job perfectly. A short introductory chapter provides advice on how to find and photograph the reptiles of the region, including details on the pros and cons of different films, camera types and flash set ups and advice is provided on emergency first aid for snakebites, a section that one would hope never to need!

Engrossing enough to pass a twelve hour flight in relative ease, this small book contains a surprisingly large amount of information and as a result had me planning future trips to Thailand in order to see some of these amazing animals in the flesh. If you are planning a holiday to southeast Asia I would thoroughly recommend packing a copy, however if your trip is for research this book is unlikely to be sufficient to ensure the identification of all your study species and is better seen as a starting point for trawling the primary literature.

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