SALAMANDRA **47**(1) | 17–29 | 20 February 2011 | ISSN 0036–3375

The amphibians and reptiles of the Lore Lindu National Park area, Central Sulawesi, Indonesia

Thomas Cherico Wanger[1,2], Iris Motzke[2], Shahabuddin Saleh[3] & Djoko T. Iskandar[4]

[1)] Environment Institute and School of Earth and Environmental Sciences, University of Adelaide, SA 5095, Australia
[2)] Agroecology, University of Göttingen, 37073 Göttingen, Germany
[3)] Agrotechnology, Faculty of Agriculture, University of Tadulako Palu, Indonesia
[4)] School of Life Sciences and Technology, Institut Teknologi Bandung, 40132-Bandung, Indonesia

Corresponding author: Thomas Cherico Wanger, e-mail: thomas.wanger@adelaide.edu.au

Manuscript received: 03 April 2010

Abstract. While land-use change is rapid throughout Southeast Asia, the island of Sulawesi (Indonesia) is of pressing conservation concern because of its exceptional number of endemic species. However, a lack of good identification literature for certain taxa such as amphibians and reptiles (apart from snakes) substantially delays ecological research in this region. Here, we compile an illustrated species list based on three years of research in and around the Lore Lindu National Park (LLNP) area and supplement it with data from the literature. In total, our survey and the literature review revealed 25 amphibian and 54 reptile species in five and thirteen families, respectively. Our results highlight the LLNP area as an important herpetological endemism hotspot in the region. Appropriate utilization of species lists like this may facilitate capacity-building of local scientists and provide a knowledge base for local guides working in ecotourism.

Key words. Biodiversity, capacity-building, conservation, ecotourism, species list, Southeast Asia, Sulawesi.

Abstrak. Seiring dengan cepatnya konversi lahan di Asia Tenggara, Sulawesi (Indonesia) menjadi kawasan yang sangat penting untuk dikonservasi atas dasar tingginya keaneka-ragaman jenis, terutama untuk jenis yang endemik. Walaupun demikian, ketidak tersediaan kepustakaan yang mutakhir untuk pengenalan jenis (kecuali untuk jenis-jenis ular) menjadi penghambat utama dalam penelitian ekologi di daerah ini. Untuk tujuan tersebut, makalah ini dilengkapi dengan gambar yang dihasilkan dari penelitian selama tiga tahun di dalam kawasan Taman Nasional Lore Lindu maupun daerah sekitarnya dan ditambah dengan informasi dari kepustakaan yang ada. Berdasarkan informasi yang telah dihimpun, 25 jenis amfibi dan 54 jenis reptil dijumpai di dalam kawasan Taman Nasional Lore Lindu, mewakili lima famili katak dan 13 famili reptil. Hasil ini menunjukkan bahwa TNLL merupakan kawasan endemik yang penting untuk Sulawesi. Diharapkan makalah ini dapat bermanfaat untuk memberikan data dasar bagi masyarakat setempat dan juga berguna untuk kepentingan ekoturisme.

Introduction

Based on deforestation rates, climate change predictions, and the extent of current land-use change, Southeast Asia is a region of high conservation priority (Sodhi et al. 2010a, Brooks et al. 2006). However, ecological research efforts and suitable protection of species naturally depend on the knowledge of species occurrences in a particular area. This information in readily accessible form is lacking for several taxonomic groups and regions in Southeast Asia (Sodhi and Brook 2006). In order to facilitate arguments to policy makers for the protection and preservation of invaluable conservation areas and informed ecotourism (i.e., knowledgeable local guides), such accessible data is of crucial importance.

The island of Sulawesi (Indonesia) is a hotspot of endemism even on a global scale (Whitten et al. 2002), but knowledge about herpetological diversity and identification literature are both very limited (but see de Lang and Vogel 2005 for snakes). This is a worrying tendency as these two taxonomic groups contain many of the most threatened vertebrates on the planet (IUCN 2009, http://www.iucnredlist.org) and the ecological impacts of land-use change urgently need to be better understood (Sodhi et al. 2010b). Based on three years of collecting survey data and the available literature, we here provide the first herpetological species list with IUCN threat status and information on abundance, habitat use, and maximum elevation range, supplemented with pictures for most species encountered in the Lore Lindu National Park, LLNP, area in Central Sulawesi province. We discuss how studies like this may greatly benefit capacity-building of local scientists and tourism in the LLNP region, one of the largest rainforest national parks in Indonesia.

Material and methods

We collected our data in and around the LLNP, situated south of Palu, the capital of Central Sulawesi province (Fig.

1). The park covers 230,000 ha of mostly pristine tropical rainforest that partly covers mountain ranges with a maximum altitude of 2356 m above sea level (Mount Nokilalaki). The surroundings are dominated by agricultural land-use, mainly for cacao and coconut plantations, as well as rice cultivation. Native forest diversity is highly threatened by hunting activities and the land-use change of pristine forest into agricultural plantations.

We sampled amphibians and reptiles on 110 m transects with visual and acoustic encounter surveys (Heyer et al. 1994) and a 25-minute time constraint. More than 100 transects in six habitat types (primary and secondary rainforest, two cacao agroforest types, rice paddies, and open areas) were checked up to six times (three times during the day and night each). Our sampling from December 2007 until October 2009 covered wet and dry seasons and an elevational range from 400 to 2300 m above sea level (Mount Nokilalaki).

In addition to our sampling, the species list including abundance, habitat use, and elevation ranges was complemented with data from the literature (for references see Tabs. 1, 2). IUCN status was obtained from the IUCN RedList database (IUCN 2009, http://www.iucnredlist.org).

Nomenclature used here follows Frost (2009) for amphibians and McDiarmid et al. (1999) and de Lang and Vogel (2005) for snakes. For other reptiles, we used the literature sources cited in Table 2.

Results

We identified 25 amphibian species in five families and 54 reptile species in 13 families (Tab. 1). Reptiles comprised 22 snake, 28 lizard, and four turtle species (Tab. 2). While 32.0 % of all amphibian species found are not yet classified in the IUCN Red List, only four of the reptile species (the turtles) have been assessed until now. Our elevation data suggests that four of the new *Limnonectes* species are potentially high-elevation specialists and one rhacophorid is

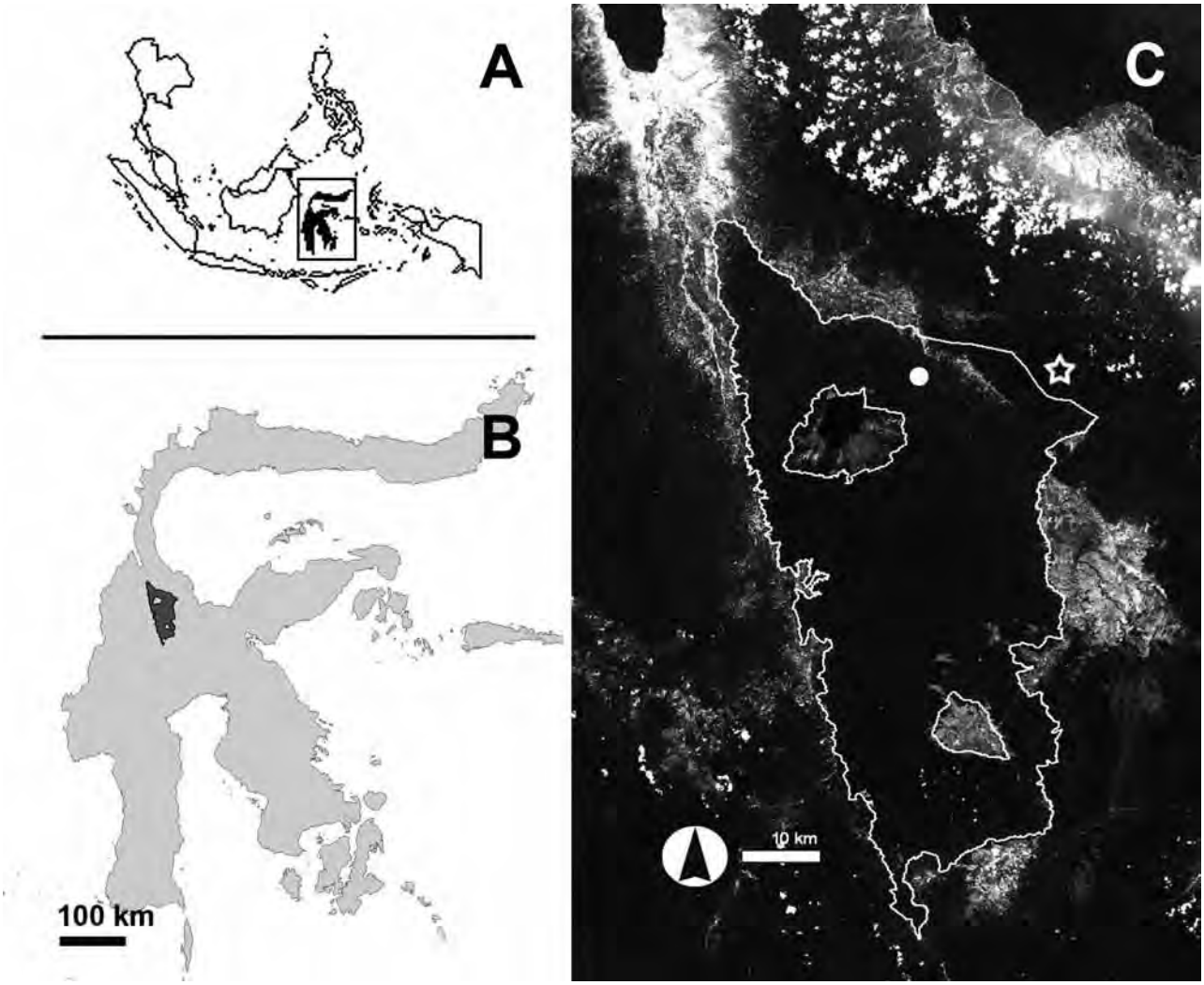


Figure 1. Map of the Lore Lindu National Park (LLNP) area in Sulawesi at three different scales: within Southeast Asia (A); in Sulawesi (B); in Central Sulawesi (C). The map shows the mountainous terrain of Central Sulawesi with the two highest peaks, both inside (Mount Nokilalaki, 2357 m, indicated by a white dot) and outside the LLNP (Mount Rore Katimbu 2610 m, indicted by a star). Land-use change from pristine forest into agricultural areas is evident all around the park, but most prominently in the northern and eastern sections. The park boundary is indicated by a white line; the arrow in (C) indicates north for (A) to (C).

Table 1. Amphibian species of the Lore Lindu National Park. Red List classifications follow the criteria of IUCN (IUCN 2009, http://www.iucnredlist.org): CE = Critically Endangered; E = Endangered; V = Vulnerable; NT = Near Threatened; LC = Least Concern; DD = Data Deficient; NE = not evaluated by the IUCN; Specialist [Y/N/?] = species considered a pristine-forest specialist/disturbance-tolerant species/not known; Habitat encountered = habitat where we encountered the species during the three-year survey; abbreviations used: PF = Rainforest; SF = secondary forest; AF = Cacao agroforest; CP = Cacao plantation; OA = Open area; RF = Rice paddy. Abundance was classified as C = commonly encountered; R = rare (as mentioned in the literature). Source LLNP = literature source that lists the species for Central Sulawesi Province/Lore Lindu National Park. Note that the studies by Wanger et al. (2009, 2010a) employed the same sampling methods and were conducted over the same time period as this study. Data from Amphibia Web (2009, http://amphibiaweb.org/). Elevation = maximum elevation range in metres above sea level given in the Source El reference. If no elevation data could be found in the literature, we present the elevation at which we found the species (indicated with "F" before the figure). The symbols < and > denote occurrence below or above the elevation given, respectively. The word "lowland" is used when it was mentioned that the species would occur in the lowland without giving an elevation in metres. NA = information on the elevation range is not available.

Amphibian species	IUCN Red List	Specialist	Habitat encountered	Abundance	Source LLNP	Elevation	Source El
Bufonidae							
Ingerophrynus biporcatus	LC	N		O	Iskandar & Tjan 1996	<1000	Sodhi et al. 2008
Duttaphrynus melanosticus	LC	N	AF, CP, HS	C	Wanger et al. 2009, This study	<1800	Sodhi et al. 2008
Ingerophrynus celebensis	LC	N	PF, SF, AF, CP, OA	O	Wanger et al. 2010a, Wanger et al. 2009	<1000	Sodhi et al. 2008
Microhylidae							
Callulops sp.	NE	Y	PF	R	This study	F1200	This study
Kaloula baleata	LC	N		C	Amphibia Web 2009	<800	Sodhi et al. 2008; updated from our study
Kaloula pulchra	LC	N	PF	C	Wanger et al. 2010a	F800	This study
Oreophryne sp. 1	NE	N	PF, SF	R	Wanger et al. 2010a	F800	This study
Oreophryne sp. 2	NE	Y	PF	R	This study	F800	This study
Ranidae							
Hylarana celebensis	LC	N	PF, SF	C	Wanger et al. 2010a, Wanger et al. 2009	<800	Sodhi et al. 2008; updated from our study
Hylarana erythraea	LC	N		C	Amphibia Web 2009	<1200	Sodhi et al. 2008
Hylarana macrops	NT	Y	PF, SF	R	Amphibia Web 2009, This study	<1000	Sodhi et al. 2008
Hylarana mocquardii	LC	N	PF, SF, AF, CP, OA	C	Inger et al. 2009, This study	<1000	Sodhi et al. 2008
Dicroglossidae							
Fejervarya cancrivora	LC	N	PF, SF, AF, CP, OA, RF	C	This study	<400	Sodhi et al. 2008; updated from our study
Fejervarya limnocharis	LC	N	PF, SF, AF, CP, OA, RF	C	This study	<2000	Sodhi et al. 2008
Limnonectes modestus	LC	N		C	Amphibia Web 2009	<1550	Sodhi et al. 2008; updated from our study
Limnonectes cf. *arathooni*	NE	Y	PF	R	Wanger et al. 2010a, Wanger et al. 2009	F2300	This study
Limnonectes cf. *modestus*	NE	N	PF, SF	R	Wanger et al. 2010a, Wanger et al. 2009	F1400	This study
Limnonectes cf. *heinrichi*	NE	Y	AF	R	Wanger et al. 2010a	F1600	This study
Limnonectes sp. (medium 3)	NE	Y	PF	R	Wanger et al. 2009	F1550	This study
Occidozyga celebensis	LC	N		C	Amphibia Web 2009	<1550	Sodhi et al. 2008; updated from our study
Occidozyga semipalmata	LC	Y	PF	C	This study	<1550	Sodhi et al. 2008; updated from our study
Rhacophoridae							
Polypedates leucomystax	LC	N	PF, SF, AF, CP, OA	C	Amphibia Web 2009, This study	<1550	Sodhi et al. 2008
Rhacophorus edentulus	DD	?		?	Iskandar & Tjan 1996	<1000	Iskandar & Tjan 1996
Rhacophorus monticola	NT	Y		C	Amphibia Web 2009	>1000	Sodhi et al. 2008
Rhacophorus sp.	NE	?	PF, SF	C	J.A. McGuire, pers. comm.	<300	Iskandar & Tjan 1996; this study

Table 2. Reptile species of the Lore Lindu National Park. For a detailed column header and explanation of abbreviations used see legend of Tab.1. Further abbreviations: + D.T. Iskandar noted that *Rhabdophis chrysargoides* does not occur in Sulawesi, despite the record in de Lang & Vogel (2005); ++ we noted indications that shops were selling specimens collected in the Lore Lindu area; this was confirmed by locals. Note that the works by Wanger et al. (2009, 2010a) were also based on this three-year sampling survey and consequently employed the same sampling methods. $: contains a key to the *Cyrtodactylus* species of Sulawesi.

	IUCN Red List	Specialist	Habitat encountered	Abundance	Source LLNP	Elevation	Source El
Snake species							
Colubridae							
Ahaetulla prasina	NE	N	SF, AF, CP	C	Wanger et al. 2009	< 1300	deLang & Vogel 2005
Boiga dendrophila gemmicincta	NE	Y		C	deLang & Vogel 2005	Lowland	de Rooij 1917
Boiga irregularis	NE	N	AF	C	Wanger et al. 2010a	< 1400	deLang & Vogel 2005
Calamaria nuchalis	NE	N		C	deLang & Vogel 2005	< 610	de Rooij 1917
Calamaria sp.	NE	N	SF	C	This study	F800	This study
Calamaria virgulata	NE	N		C	deLang & Vogel 2005	NA	deLang & Vogel 2005
Chrysopelea paradisi celebensis	NE	N		C	deLang & Vogel 2005	< 1300	deLang & Vogel 2005
Dendrelaphis pictus pictus	NE	N	AF, CP	C	Wanger et al. 2009	< 1400	deLang & Vogel 2005
Elaphe erythrura celebensis	NE	N		C	deLang & Vogel 2005	< 1100	deLang & Vogel 2005
Gonyosoma jansenii	NE	N		R	deLang & Vogel 2005	< 1000	deLang & Vogel 2005
Lycodon stormi	NE	Y	PF, SF, AF	R	This study	F820	This study
Oligodon waandersi	NE	Y		C	deLang & Vogel 2005	< 1200	deLang & Vogel 2005
Rabdion forsteni	NE	N	SF	C	This study	< 1830	deLang & Vogel 2005
Rhabdophis callistus	NE	N	SF	R	Wanger et al. 2009, Wanger et al. 2010a, +	< 1200	This study
Psammodynastes pulverulentus pulverulentus	NE	N	SF	C	Wanger et al. 2010a	< 2000	deLang & Vogel 2005
Ptyas dipsas	NE	N	PF, SF, AF, CP, OA	R	This study	< 1100	deLang & Vogel 2005
Xenochrophis trianguligerus	NE	N	PF, SF, AF, CP, OA, RF	C	This study	< 1400	deLang & Vogel 2005
Cylindrophiidae							
Cylindrophis melanotus	NE	Y		C	deLang & Vogel 2005	< 1200	deLang & Vogel 2005
Elapidae							
Ophiophagus hannah	NE	N	PF, SF, AF, CP, OA, RF	R	This study; ++	< 1800	deLang & Vogel 2005
Pythonidae							
Python reticulatus reticulatus	NE	N		C	deLang & Vogel 2005	< 1300	deLang & Vogel 2005
Viperidae							
Tropidolaemus subannulatus	NE	N		C	deLang & Vogel 2005; Vogel et al. 2007	< 1300	deLang & Vogel 2005
Xenopeltidae							
Xenopeltis unicolor	NE	N	AF, CP	C	Wanger et al. 2009, Wanger et al. 2010a	< 1300	deLang & Vogel 2005
Lizard species							
Agamidae							
Bronchocela celebensis	NE	N	PF, SF,AF, CP	C	Wanger et al. 2009	< 1200	This study
Bronchocela cristatella	NE	N	PF, SF, SF, CP	C	This study	< 1600	Manthey & Grossmann 1997
Draco spilonotus	NE	?		?	McGuire et al. 2007	< 1016	McGuire et al. 2007
Draco walkeri	NE	?		?	McGuire et al. 2007	< 1840	McGuire et al. 2007
Gekkonidae							
Cyrtodactylus spinosus	NE	?	?	?	Wanger et al. 2009	~ 600	Linkem et al. 2008
Cyrtodactylus wallacei	NE	?		?	Hayden et al. 2008, $	NA	Hayden et al. 2008
Cyrtodactylus jellesmae	NE	Y	SF, AF	R	Wanger et al. 2009	< 850	Wanger et al. 2009
Gekko gecko	NE	Y	CP, OA	C	This study	< 900	Manthey & Grossmann 1997
Gekko monarchus	NE	N	PF, SF,AF, CP, OA	O	This study	< 1500	Manthey & Grossmann 1997

	IUCN Red List	Specialist	Habitat encountered	Abundance	Source LLNP	Elevation	Source El
Gehyra mutilata	NE	N		C	Whitten et al. 2002	< 1500	Manthey & Grossmann 1997
Hemidactylus frenatus	NE	N	OA	C	This study	< 1600	Manthey & Grossmann 1997
Hemidactylus platyurus	NE	N		C	Iskandar & Tjan 1996	< 1200	de Rooij 1915
Scincidae							
Sphenomorphus celebense	?	?		?	Iskandar & Tjan 1996	< 1200	de Rooij 1915
Emoia atrocostata	NE	Y		O	Iskandar & Tjan 1996	Lowland	de Rooij 1915
Emoia caeruleocauda	NE	Y		C	Iskandar & Tjan 1996	< 920	de Rooij 1915
Eutropis sp.	NE	N	SF, AF, CP, OA	C	Wanger et al. 2009, Wanger et al. 2010a	< 900	This study
Eutropis multifasciatus	NE	Y	CP, OA	C	Wanger et al. 2009, Wanger et al. 2010a	< 1800	Manthey & Grossmann 1997
Eutropis rudis	NE	N	PF, SF, AF, CP	C	Wanger et al. 2009, Wanger et al. 2010a	< 900	This study
Lamprolepis smaragdina	NE	?		?	Iskandar & Tjan 1996	< 300	de Rooij 1915
Parvoscincus sp.	NE	?	PF, SF, AF, CP	?	Wanger et al. 2009, Wanger et al. 2010a	< 850	This study
Lipinia inconspicua	NE	?	?	?	Wanger et al. 2009, Wanger et al. 2010a	< 1200	de Rooij 1915
Sphenomorphus cf. *textus*	NE	?	PF, AF, CP, OA	?	Wanger et al. 2009, this study	< 900	This study
Sphenomorphus nigrilabris	NE	Y	PF, SF, AF, CP	?	Wanger et al. 2009, Wanger et al. 2010a	< 900	This study
Sphenomorphus tropidonotus	NE	?		?	Iskandar & Tjan 1996	< 900	This study
Sphenomorphus cf. variegatus	NE	N	PF, SF, AF, OA	?	Wanger et al. 2009, Wanger et al. 2010a	< 900	This study
Tropidophorus baconi	NE	?		?	Hikida et al. 2003	< 1000	This study
Dibamidae							
Dibamus celebensis	NE	?		R	Iskandar & Tjan 1996	< 1400	de Rooij 1915
Varanidae							
Varanus salvator	NE	N		C	Iskandar & Tjan 1996, this study	< 1200	McKay 2006
Turtle species							
Geoemydidae							
Cuora amboinensis	V	N		C	D.T. Iskandar, pers. observ.	Lowland	Manthey & Grossmann 1997
Leucocephalon yuwonoi	CE	?		R	Ives et al. 2008	Lowland	D.T. Iskandar, pers. observ.
Testudinidae							
Indotestudo forstenii	E	?		R	Ives et al. 2008	Lowland	de Rooij 1915
Trionychidae							
Amyda cartilagínea	V	?	?	?	Koch et al. 2008	Lowland	de Rooij 1915

adapted to lower elevations. The remaining amphibians occur in the lowland or within a broad elevation range. None of the reptiles seem to be high-elevation specialists. For pictures of most of the encountered amphibian and lizard species see the Appendices. Photographs of most snakes of Sulawesi can be found in de Lang and Vogel (2005).

Discussion

Due to its geological past, Sulawesi's herpetofaunal diversity is lower compared to the neighbouring islands such as Borneo, the Moluccas or Papua (e.g., Whitten et al. 2002). Being a global endemism hotspot, our species list supports the notion of Iskandar and Tjan (1996) that Central Sulawesi is a very valuable area for the herpetofauna of the island. However, many areas in the region have not yet been covered by herpetological surveys – and the fact that dozens of species are awaiting formal description suggests that many more are likely to be discovered (D.T. Iskandar, pers. obs.). Our current result of few high-elevation specialist amphibian and no such reptile species may just reflect an under-sampling of mountainous habitats. A better estimate of an approximate number of elevation specialists is crucial, however, because these species will be most severely affected by climate change.

During this survey, we did not encounter some of the species found during previous surveys. One reason for this could be that species have declined in numbers or became locally extinct due to the rapidly progressing deforestation. This development is evident in the northeastern parts of the park (the Dongi-Dongi area), where immigrants from South Sulawesi, but also other parts of Indonesia, rapidly convert the forest into cacao plantations (Weber et al. 2007). As, for example, one of the study areas of the cited studies (Iskandar & Tjan 1996) focused in parts on this particular site, several species are likely to have since become at least locally extinct. In addition, the present study has not exhaustively sampled the area, even though most relevant habitat types were covered. We did not use pitfall traps because the effort required to maintain these setups are cost- and labour-intensive, but may not trade off well in terms of what they add to the species list. The penalty is that we are likely to have missed several secretive and fossorial species such as *Dibamus* spp., *Calamaria* spp., *Pseudorabdion* spp., and small skinks. The high herpetological diversity we found within this endemic hotspot is, however, severely threatened by the rapid forest conversion for cacao plantation; already one million ha of Sulawesi's land surface have been converted into these plantations to serve the global demand for cocoa (Direktorat Jenderal Perkebunan 2008).

Recently, two ecological studies explicitly investigated the effects of land-use change on amphibians and reptiles in the Lore Lindu National Park(Wanger et al. 2009, 2010). Results indicated clearly that amphibians will be severely impacted by forest conversion, most likely due to their sensitivity to desiccation. For these animals, extensive pristine forest coverage is crucial for survival. Many reptiles, however, may benefit from agricultural habitats, as their life histories in general are more dependent on thermoregulation in open canopy spots (Huey et al. 2009, Wanger et al. 2010a). The sensitivity of both groups to climatic alterations (Pounds et al. 2006, Huey et al. 2009, Wanger et al. 2009) can – to a certain extent – be made allowance for by a considerate structural management of these agricultural habitats. Cacao plantations with sufficient canopy cover, leaf litter thickness, and heaps of branches have a likely potential for sustaining greater herpetofaunal species richness and abundance than heavy-handedly managed, cleared lands. However, the main beneficiaries will certainly be common and "robust" species such as the Celebes toad (*Ingerophrynus celebensis*), the common sun skink (*Eutropis multifasciatus*), and a common but as yet undescribed skink species (*Eutropis* sp.).

Besides supporting conservation arguments with data (i.e., giving rough figures of how many species occur in an area), such species lists may greatly facilitate capacity-building of local researchers and field guides for ecotourism. For local researchers, learning the members of a local fauna by their scientific names is an important means for conducting sound scientific projects. Moreover, if ecotourists come to remote places to see wildlife, amphibians are often the only vertebrates they get to see. It is beneficial if local guides can then name a 'Celebes Toad' on the basis of a brochure instead of referring to it as 'Tete' (i.e., the species' name in the local language [Bahasa Toro]). Booklets for tourists will in addition provide financial support for the national park bureau to fund the paying of often insufficient salaries for local rangers.

Future research efforts should target an extensive and complete coverage of the herpetofauna of Sulawesi (D.T. Iskandar et auct., unpubl.) based on genetic and morphological analyses of species, many of which have so far remained undescribed. Simultaneously, explorative surveys in the region should continue in particular in remote mountainous areas where no herpetofaunistic sampling has so far been conducted. More ecological studies are needed to assess the effects of pesticides on amphibians and reptiles as well as biodiversity in general as forest is converted into plantation habitats (Wanger et al. 2010b). Conservation value assessments may provide guidelines of how to make secondary habitats more hospitable to biodiversity. However, this will only work if we can take potentially detrimental pesticide effects into account.

Acknowledgements

We would like to thank our assistants in Sulawesi, who made this project possible and in particular, the people of Toro for their hospitality and support. We thank S. Howard and U. Manthey for providing comments on the species list and G. Gillespie, S. Howard, J. A. McGuire and U. Manthey for giving us permission to use their photographs. Surveys were conducted under the research permits from Kementerian Negara Riset dan Teknologi Republik Indonesia (RISTEK; #1899/FRP/SM/VIII/2008; to T.C. Wanger) and Lembaga Ilmu Pengetahuan Indonesia (LIPI; #7374a/SU/KS/2007; to T.C. Wanger). Funding was provided through the German Science Foundation (DFG), an Endeavour International Postgraduate Research Scholarship, and a University of Adelaide Scholarship (to T.C. Wanger).

References

Brooks, T. M., R. A. Mittermeier, G. A. B. da Fonseca, J. Gerlach, M. Hoffmann, J. F. Lamoreux, C. G. Mittermeier, J. D. Pilgrim & A. S. L. Rodrigues (2006): Global biodiversity conservation priorities. – Science, **313**: 58–61.

de Lang, R. & G. Vogel (2005): The snakes of Sulawesi: a field guide to the land snakes of Sulawesi with identification keys. – Frankfurt/M.: Edition Chimaira.

De Rooij, N. (1915): The Reptiles of the Indo-Australian Archipelago. Vol. I. – Leiden: E. J. Brill.

De Rooij, N. (1917): The Reptiles of the Indo-Australian Archipelago. Vol. II. – Leiden: E. J. Brill.

Direktorat Jenderal Perkebunan, D. J. (2008): Statistik Perkebunan Indonesia 2006–2008. – Jakarta: D. P. D. J. Perkebunan.

Hayden, C. J., R. M. Brown, G. Gillespie, M. I. Setiadi, C. W. Linkem, D. T. Iskandar, Umilaela, D. P. Bickford, A. Riyanto, Mumpuni & J. A. McGuire (2008): A new species of bent-toe gecko *Cyrtodactylus* Gray, 1827 (Squamata: Gekkonidae) from the island of Sulawesi, Indonesia. – Herpetologica, **64:** 109–120.

Heyer, W. R., M. A. Donnelly, R. W. McDiarmid, L. C. Hayek & M. S. Foster (1994): Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. – Washington D.C.: Smithsonian Institution Press.

Hikida, T., A. Riyanto & H. Ota (2003): A new water skink of the genus *Tropidophorus* (Lacertilia: Scincidae) from Sulawesi, Indonesia. – Current Herpetology, **22:** 29–36.

Huey, R. B., C. A. Deutsch, J. J. Tewksbury, L. J. Vitt, P. E. Hertz, H. J. Álvarez Pérez & T. Garland (2009): Why tropical forest lizards are vulnerable to climate warming. – Proceedings of the Royal Society B: Biological Sciences, **276**: 1939–1948.

Inger, R. F., B. I. Stuart & D. T. Iskandar (2009): Systematics of a widespread Southeast Asian frog, *Rana chalconota* (Amphibia: Anura: Ranidae). – Zoological Journal of the Linnean Society, **155**: 123–147.

Iskandar, D. T. & E. Colijn (2000): Preliminary checklist of Southeast Asian and New Guinean herpetofauna I. Amphibians. – Treubia, **31**: 1–133.

Iskandar, D. T. & E. Colijn (2002): A checklist of Southeast Asian and New Guinean reptiles I. Serpentes. – Bandung: Biodiversity Conservation Project.

Iskandar, D. T. & K. N. Tjan (1996): The amphibians and reptiles of Sulawesi, with notes on the distribution and chromosomal number of frogs. – pp. 39–46 in Western Australian Museum, Australia for Lembaga Ilmu Pengetahuan Indonesia (ed.): Proceedings of the first international conference on eastern Indonesian-Australian vertebrate fauna. – Perth, Western Australia.

Ives, I. E. S., G. Platt, J. S. Tasirin, I. Hunowu, S. Siwu & T. R. Rainwater (2008): Field surveys, natural history observations, and Comments on the Exploitation and Conservation of *Indotestudo forstenii, Leucocephalon yuwonoi*, and *Cuora amboinensis* in Sulawesi, Indonesia. – Chelonian Conservation and Biology, **7:** 240.

Koch, A., I. Ives, E. Arida & D. T. Iskandar (2008): On the occurrence of the Asiatic softshell turtle, *Amyda cartilaginea* (Boddaert, 1770), on Sulawesi, Indonesia. – Hamadryad, **32**: 121–127.

Linkem, C. W., J. M. McGuire, C. J. Hyden, M. I. Setiadi, D. P. Bickford & R. M. Brown (2008): A new species of bent-toe gecko (Gekkonidae: *Cyrtodactylus*) from Sulawesi Island, East Indonesia. – Herpetologica **64:** 224–234.

Malkmus, R., U. Manthey, G. Vogel, P. Hoffman & J. Kosuch (2002): Amphibians and Reptiles of Mount Kinabalu (North Borneo). – Ruggell: ARG Gantner.

Manthey, U. & W. Grossmann (1997): Amphibien und Reptilien Südostasiens. – Münster: Natur und Tier Verlag.

McDiarmid, R. W., J. A. Campbell & T. A. Touré (2009): Snake Species of the World. A Taxonomic and Geographic Reference. Vol. 1. – Washington D.C., The Herpetologist League.

McGuire, J. A., R. M. Brown, Mumpuni, A. Riyanto, & N. Andayani (2007): The flying lizards of the *Draco lineatus* group (Squamata: Iguania: Agamidae): A taxonomic revision with descriptions of two new species. – Herpetological Monographs, **21:** 179–212.

McKay, J. L. (2006): A Field Guide to the Amphibians and Reptiles of Bali. – Florida: Malabar.

Pounds, J. A., M. R. Bustamante, L. A. Coloma, J. A. Consuegra, M. P. L. Fogden, P. N. Foster, E. La Marca, K. L. Masters, A. Merino-Viteri, R. Puschendorf, S. R. Ron, G. A. Sanchez-Azofeifa, C. J. Still & B. E. Young (2006): Widespread amphibian extinctions from epidemic disease driven by global warming. – Nature, **439**: 161–167.

Sodhi, N. S. & B. W. Brook (2006): Southeast Asian biodiversity in crisis. – Cambridge: Cambridge University Press.

Sodhi, N. S., D. Bickford, A. C. Diesmos, T. M. Lee, L. P. Koh, B. W. Brook, C. H. Sekercioglu & C. Bradshaw (2008): Measuring the meltdown: drivers of global amphibian extinction and decline. – PLoS ONE, **3**: e1636.

Sodhi, N. S., M. Posa, T. Lee, D. Bickford, L. Koh & B. Brook (2010a): The state and conservation of Southeast Asian biodiversity. – Biodiversity and Conservation, **19**: 317–328.

Sodhi, N. S., L. P. Koh, R. Clements, T. C. Wanger, J. K. Hill, K. C. Hamer, Y. Clough, Tscharntke, T., M. R. C. Posa & T. M. Lee (2010b): Conserving Southeast Asian forest biodiversity in human-modified landscapes. – Biological Conservation, in press: doi:10.1016/j.biocon.2009.12.029.

Vogel, G., P. David, M. Lutz, J. Van Rooijen & N. Vidal (2007): Revision of the *Tropidolaemus wagleri*-complex (Serpentes: Viperidae: Crotalinae). I. Definition of included taxa and redescription of *Tropidolaemus wagleri* (Boie, 1827) Zootaxa, **1644:** 1–40.

Wanger, T. C., A. Saro, D. T. Iskandar, B. W. Brook, N. S. Sodhi, Y. Clough & T. Tscharntke (2009): Conservation value of cacao agroforestry for amphibians and reptiles in South-East Asia: combining correlative models with follow-up field experiments. – Journal of Applied Ecology, **46**: 823–832.

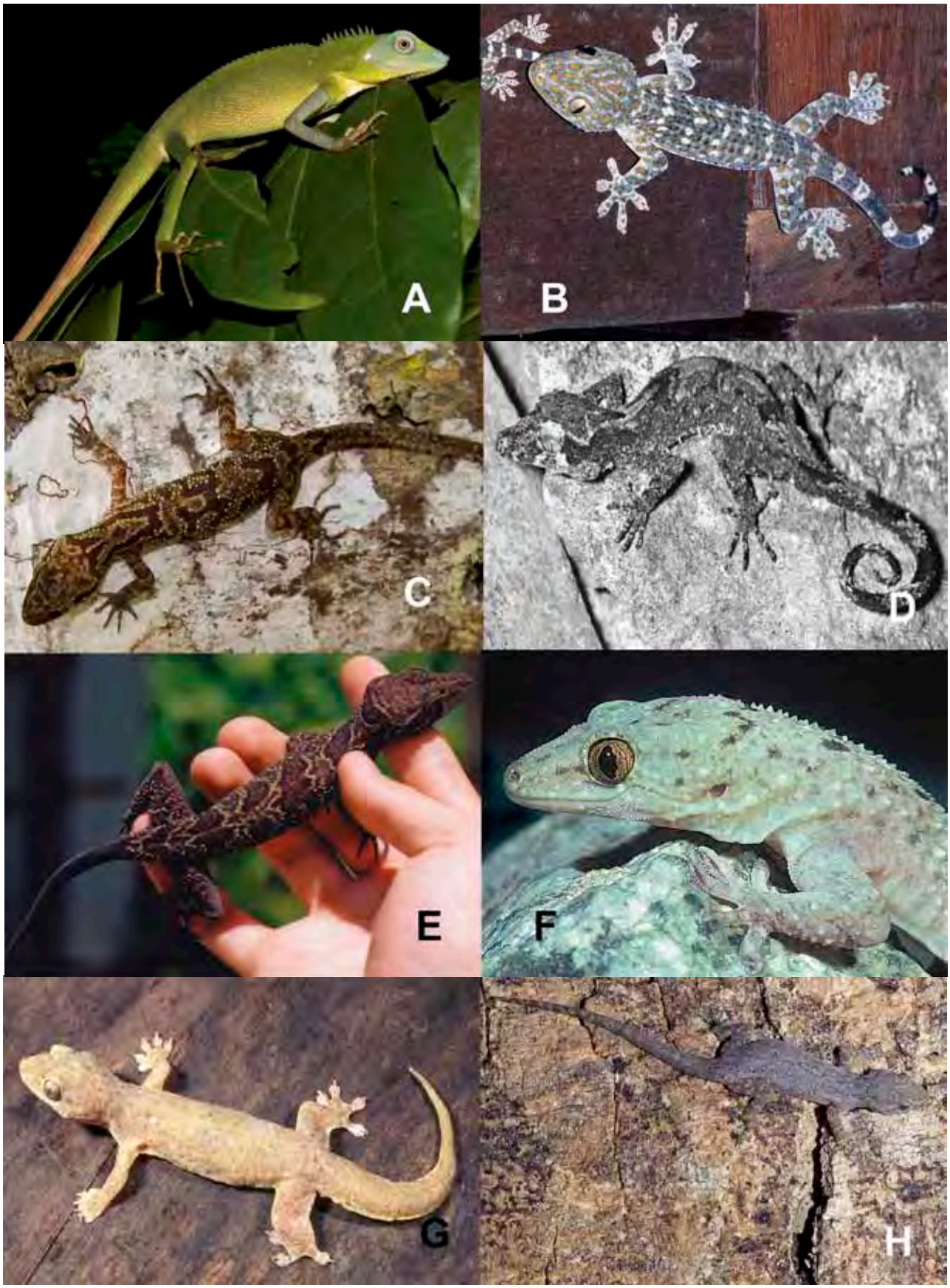
Wanger, T. C., D. T. Iskandar, I. Motzke, B. W. Brook, N. S. Sodhi, Y. Clough & T. Tscharntke (2010a): Land-use change affects community composition and traits of tropical amphibians and reptiles in Sulawesi (Indonesia). – Conservation Biology, in press: doi:10.1111/j.1523-1739.2009.01434.x.

Wanger, T. C., A. Rauf, & S. Schwarze (2010b): Pesticides and tropical biodiversity. – Frontiers in Ecology and the Environment, **4**, 178–179.

Weber, R., H. Faust, B. Schippers, S. Mamar, E. Sutarto, & W. Kreisel (2007): Migration and ethnicity as cultural impact factors on landuse change in the rainforest margins of Central Sulawesi, Indonesia. – pp. 417–436 in Tscharntke, T., C. Leuschner, M. Zeller, E. Guhardja & A. Bidin (eds.): Environmental Science and Engineering. – Berlin: Springer Verlag.

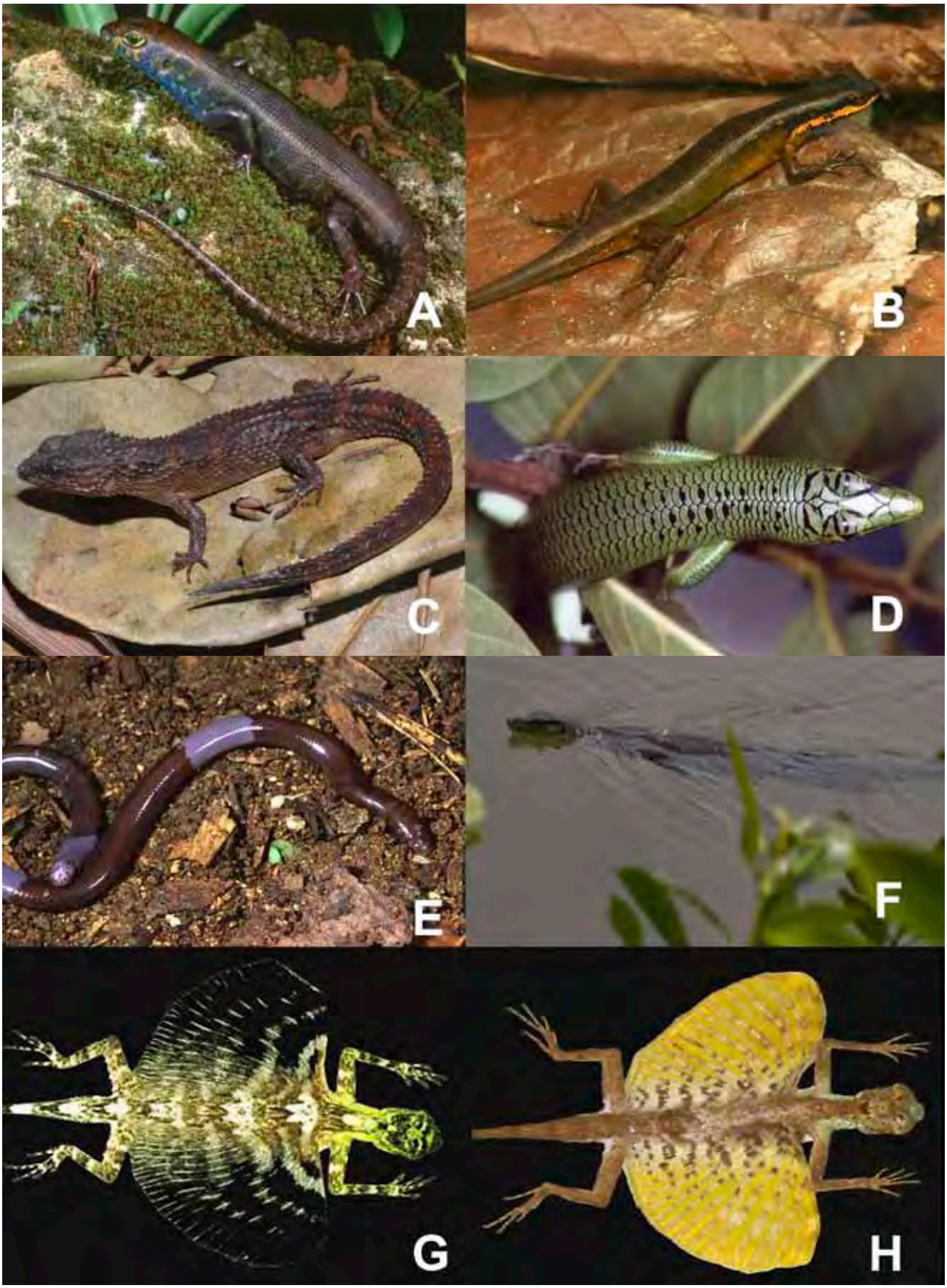
Whitten, T., M. Mustafa & G. S. Henderson (2002): The ecology of Sulawesi, 2nd. edition. – Yogyakarta: Gadjah Mada University Press.

Appendix 1. Agamidae: A = *Bronchocela celebensis*; Gekkonidae: B = *Gekko gecko* (West Malaysia; Photo by U. Manthey); C = *Cyrtodactylus jellesmae*; D = *Cyrtodactylus spinosus* (reproduced with permission from the authors and Allen Press); E = *Cyrtodactylus wallacei* (reproduced with permission from the authors and Allen Press); F = *Gekko monarchus* (West Malaysia; Photo by U. Manthey); G = *Gehyra mutilata* (Photo by G. Gillespie); H = *Hemidactylus frenatus* (Thailand; Photo by U. Manthey).

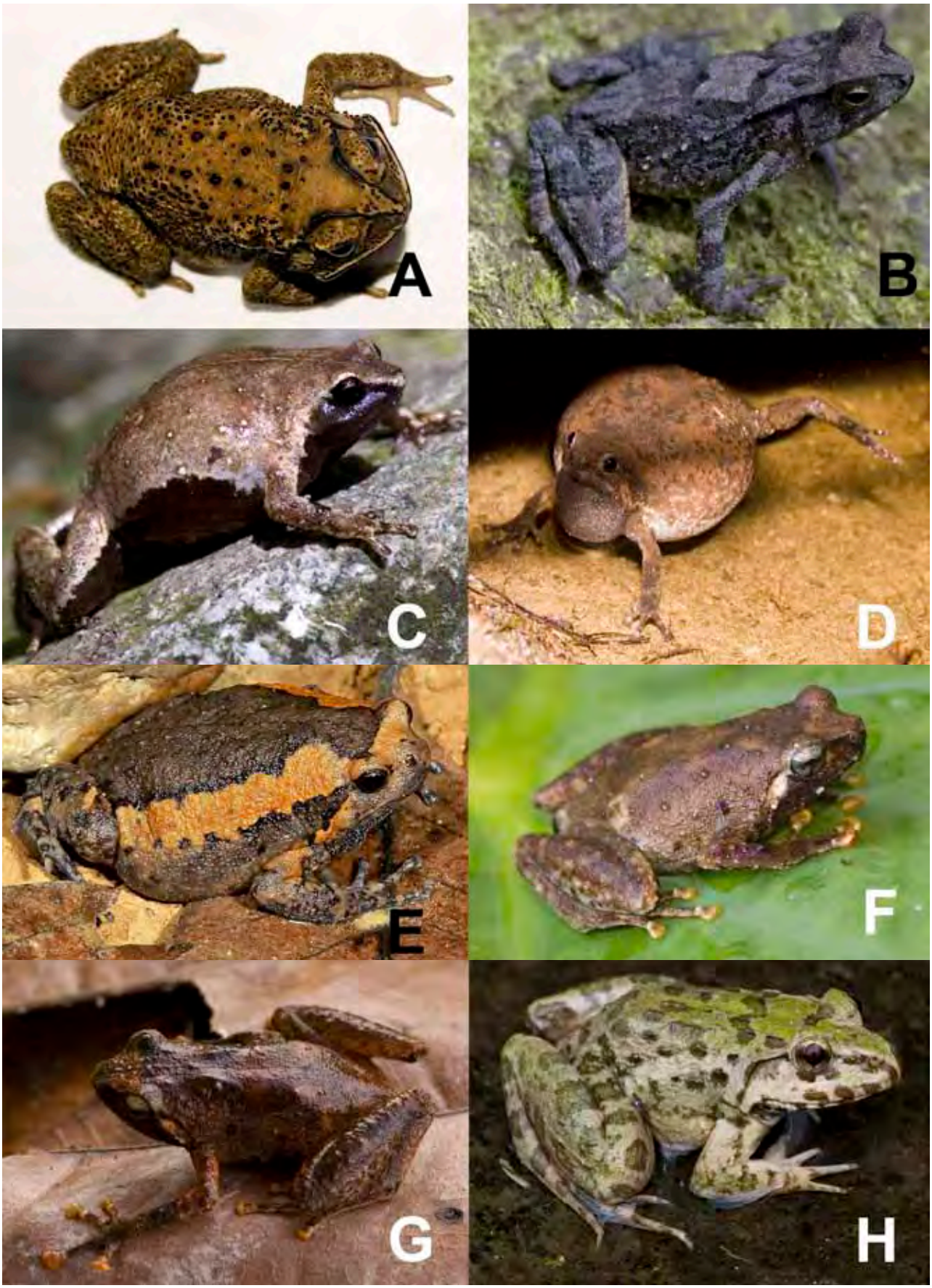


Appendix 2. Gekkonidae: A = *Hemidactylus platyurus* (Thailand; Photo by U. Manthey); Scincidae: B = *Emoia atrocostata* (Photo by G. Gillespie); C = *Eutropis* n. sp.; D = *Eutropis multifasciatus*; E = *Eutropis rudis*; F = *Parvoscincus* sp.; G = *Sphenomorphus* cf. *textus*; H = *Sphenomorphus nigrilabris*.

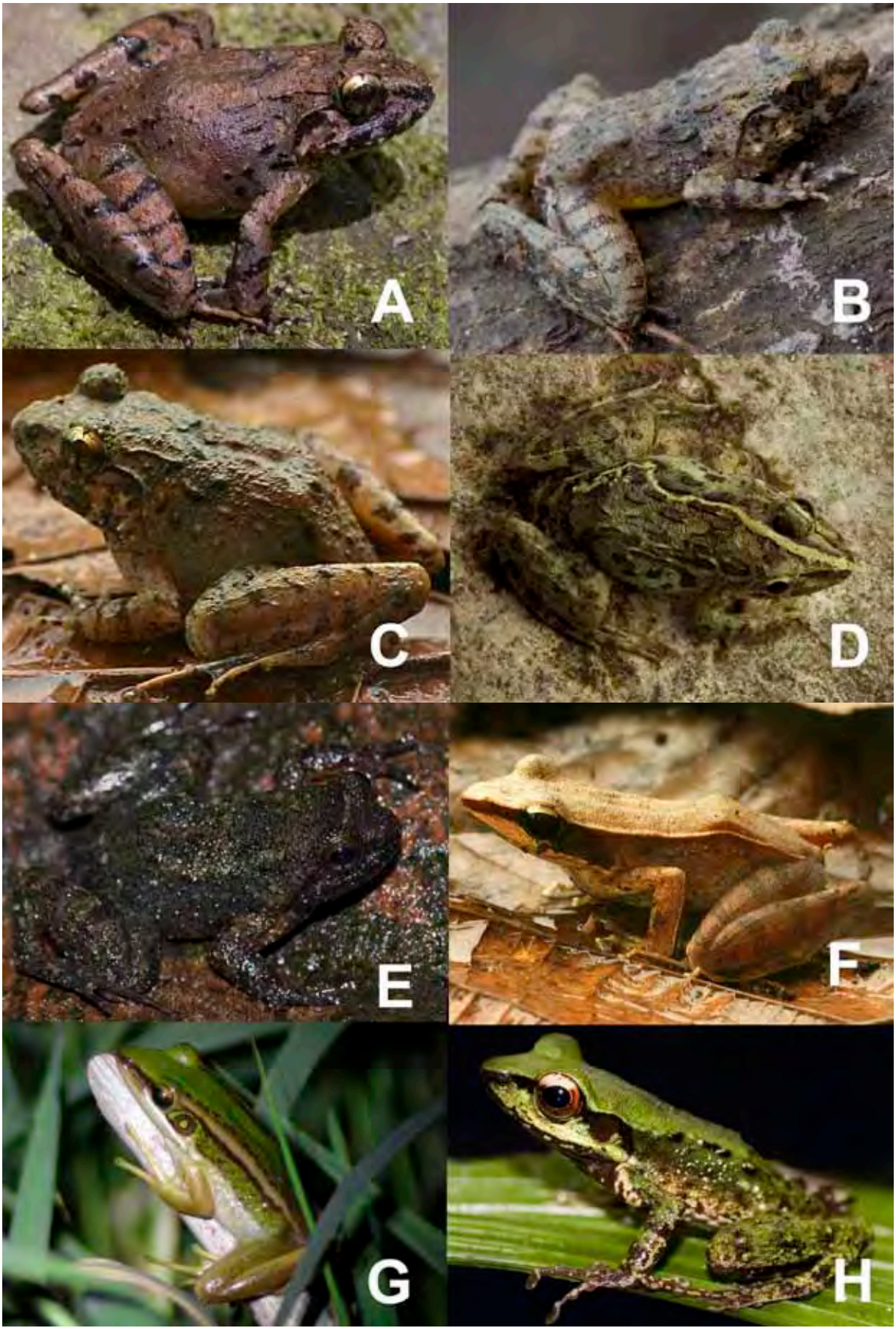
Appendix 3. Scincidae: A = *Sphenomorphus tropidonotus* (Photo by G. Gillespie); B = *Sphenomorphus* cf. *variegatus;* C = *Tropidophorus baconi* (Photo by J. A. McGuire); D = *Lamprolepis smaragdina* (Photo by S. Howard); Dibamidae: E = *Dibamus celebensis* (Photo by G. Gillespie); Varanidae: F = *Varanus salvator*; Agamidae (both pictures reproduced with permission from the authors and Allen Press): G = *Draco walkeri*; H = *Draco spilonotus*.



Appendix 4. Bufonidae: A = *Duttaphrynus melanostictus*; B = *Ingerophrynus celebensis* (juvenile); Microhylidae: C = *Callulops* n. sp.; D = *Kaloula baleata*; E = *Kaloula pulchra* (West Malaysia; Photo by U. Manthey); F = *Oreophryne* n. sp.1; G = *Oreophryne* n. sp.2; Dicroglossidae: *Fejervarya cancrivora*



Appendix 5. Dicroglossidae: A = *Limnonectes* cf. *modestus*; B = *Limnonectes* cf. *arathooni*; C = *Limnonectes* cf. *heinrichi*; D = *Fejervarya limnocharis*; E = *Occidozyga semipalmata*; Ranidae: F = *Hylarana celebensis*; G = *Hylarana erythraea*; H = *Hylarana macrops*.



Appendix 6. Ranidae: A = *Hylarana mocquardii*; Rhacophoridae: B = *Polypedates leucomystax*; C = *Rhacophorus* sp. (Photo by J. A. McGuire)