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TWO DECADES OF HERPETODIVERSITY RESEARCH IN VIETNAM AND LAOS: A REVIEW OF A GERMAN-VIETNAMESE LONG-TERM COOPERATION

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Abstract: This review summarizes two decades of herpetodiversity research and conservation projects within a German-Vietnamese long-term cooperation in Vietnam and Laos. My herpetological research activities in Vietnam began in central Vietnam's Ha Tinh and Quang Binh provinces, subsequently extending to the North and later also to the South of the country and to Laos. Besides diverse new records, herpetofaunal lists, redescriptions, reviews, larval and development descriptions, our team so far has described 57 amphibian and reptile taxa from Vietnam and in addition 19 herpetofaunal representatives from Laos. The application of Species Distribution Models led to the discovery of new populations of the rare *Tylostrotion vietnamensis* and *Shinisaurus crocodilurus vietnamensis* in northern Vietnam. Our ecological research, population and trade analyses were prerequisites for the inclusion of *S. crocodilurus*, *Goniurosaurus catbaensis* and *Cnemaspis psychedelica* in the IUCN Red List of Threatened Species, and the inclusion of *S. crocodilurus* and *C. psychedelica* on CITES Appendix I. Within the framework of student courses held both in Germany and Vietnam, young academics are trained and in part later on supervised thus promoting herpetological, conservation based research in Vietnam. Furthermore, the Cologne Zoo team has helped to build up a wildlife rescue station at Phong Nha - Ke Bang National Park, to develop the Amphibian Station Hanoi and the Me Linh Station for Biodiversity. At the latter station also an extensive environmental education programme has been developed together with the Friedrich-Ebert-Stiftung Vietnam Office. The Cologne Zoo team further has helped to build up conservation breeding facilities for *S. crocodilurus vietnamensis* and *C. psychedelica* in Vietnam and conducted several amphibian and reptile husbandry training courses in stations, institutions and zoos both in the North and the South of Vietnam.

Key words: Herpetofauna, conservation, cooperation, Vietnam, Laos.

HERPETODIVERSITY RESEARCH IN VIETNAM

My herpetological investigations in Vietnam began in the year 1997 within the framework of my PhD research dealing with the amphibian and reptile community of the Ky Anh - Ke Go Nature Reserve in Ha Tinh Province (Ziegler 2002). There, also my first herpetological discoveries in Vietnam took place, among them *Rhacophorus orlovi*, *Takydromus kuehnei vietnamensis*, and *Amphiesma leucomystax* (nowadays *Hebius leucomystax*). In Ky Anh - Ke Go I could also discover a new mammal species, the shrew *Crociodura kegoensis*, which was subsequently described together with mammalogists of the American Museum of Natural History in New York (Lunde *et al.* 2004). Later, my herpetological research focused on the Phong Nha Nature Reserve in Quang Binh Province, which consecutively was extended towards Phong Nha - Ke Bang National Park and appointed UNESCO World Heritage Site. Since 2000, I was involved in a number of herpetological discoveries in Phong Nha - Ke Bang, in total 13 new species and one new subspecies (see overview in Ziegler & Vu 2009, Table 1, and Fig. 1). Among the spectacular findings in Phong Nha - Ke Bang was also the rediscovery of the horned pit viper *Trimeresurus cornutus* (nowadays *Protobothrops cornutus*), which formerly was only known from two museum specimens collected at the beginning of the last century and which was believed to be extinct. *Triceratolepidophis sieversorum* (nowadays *Protobothrops sieversorum*) was another discovery of a horned pit viper in Phong Nha - Ke Bang (Fig. 2). Furthermore, three sympatrically occurring, cryptic bent-toed gecko species could be discovered by our team in the karst forests of Phong Nha - Ke Bang, which all proved to be new to science (*Cyrtodactylus phongnhakebangensis*, *C. cryptus*, and *C. roesleri*) (Fig. 3).

In October 2006, Cologne Zoo, where I am employed since 2003 as curator of the Aquarium/Terrarium Department and Coordinator of the Biodiversity and Nature Conservation

Projects in Vietnam, received the “EAZA Award for Nature Conservation” from the European Association of Zoos and Aquaria (EAZA) for our complex contributions to biodiversity research and conservation in Phong Nha - Ke Bang.

Table 1. List of herpetological descriptions from Vietnam (in chronological order) in whose discovery I was involved and which I have coauthored.

No	Described taxon	Journal	Type locality
1.	<i>Takydromus kuehnei vietnamensis</i> Ziegler & Bischoff, 1999	Salamandra	Ky Anh - Ke Go, Ha Tinh Province
2.	<i>Protobothrops sieversorum</i> (Ziegler, Herrmann, David, Orlov & Pauwels, 2000)	Russian Journal of Herpetology	Phong Nha - Ke Bang, Quang Binh Province
3.	<i>Rhacophorus orlovi</i> Ziegler & Köhler, 2001	Sauria	Ky Anh - Ke Go, Ha Tinh Province
4.	<i>Cyrtodactylus phongnhakebangensis</i> Ziegler, Rösler, Herrmann & Vu, 2002	Herpetofauna	Phong Nha - Ke Bang, Quang Binh Province
5.	<i>Boiga bourreti</i> Tillack, Ziegler & Le, 2004	Sauria	Phong Nha - Ke Bang, Quang Binh Province
6.	<i>Gekko scientiadventura</i> Rösler, Ziegler, Vu, Herrmann & Böhme, 2004	Bonner Zoologische Beiträge	Phong Nha - Ke Bang, Quang Binh Province
7.	<i>Tropidophorus noggei</i> Ziegler, Vu & Bui, 2005	Salamandra	Phong Nha - Ke Bang, Quang Binh Province
8.	<i>Calamaria thanhi</i> Ziegler & Le, 2005	Zootaxa	Dan Hoa, Minh Hoa, Quang Binh Province
9.	<i>Hebius andreae</i> (Ziegler & Le, 2005)	Zootaxa	Thuong Hoa, Minh Hoa, Quang Binh Province
10.	<i>Cyrtodactylus cryptus</i> Heidrich, Rösler, Vu, Böhme & Ziegler, 2007	Zootaxa	Phong Nha - Ke Bang, Quang Binh Province
11.	<i>Hebius leucomystax</i> (David, Bain, Nguyen, Orlov, Vogel, Vu & Ziegler, 2007)	Zootaxa	Ky Anh - Ke Go, Ha Tinh Province
12.	<i>Lygosoma boehmei</i> Ziegler, Schmitz, Heidrich, Vu & Nguyen, 2007	Revue Suisse de Zoologie	Phong Nha - Ke Bang, Quang Binh Province
13.	<i>Fimbrios smithi</i> Ziegler, David, Miralles, Doan & Nguyen, 2008	Zootaxa	Phong Nha - Ke Bang, Quang Binh Province
14.	<i>Goniurosaurus catbaensis</i> Ziegler, Nguyen, Schmitz, Stenke & Rösler, 2008	Zootaxa	Cat Ba Island, Hai Phong City
15.	<i>Opisthotropis tambdaensis</i> Ziegler, David & Vu, 2008	Zoosystematics and Evolution	Tam Dao, Vinh Phuc Province
16.	<i>Cyrtodactylus pseudoquadriangatus</i> Rösler, Vu, Nguyen, Ngo & Ziegler, 2008	Hamadryad	A Luoi, Thua Thien Hue Province
17.	<i>Gracixalus quyeti</i> (Nguyen, Hendrix, Böhme, Vu & Ziegler, 2008)	Zootaxa	Dan Hoa, Minh Hoa, Quang Binh Province
18.	<i>Dixonius aaronbaueri</i> Ngo & Ziegler, 2009	Zoosystematics and Evolution	Ninh Hai, Nui Chua, Ninh Thuan Province
19.	<i>Calamaria gialaiensis</i> Ziegler, Nguyen & Nguyen, 2009	Current Herpetology	Kon Ka Kinh, K' Bang, Gia Lai Province
20.	<i>Cyrtodactylus cattienensis</i> Geissler, Nazarov, Orlov, Böhme, Phung, Nguyen & Ziegler, 2009	Zootaxa	Cat Tien, Dong Nai Province

No	Described taxon	Journal	Type locality
21.	<i>Calamaria sangi</i> Nguyen, Koch & Ziegler, 2009	Hamadryad	Mang Canh, Kon Plong, Kon Tum Province
22.	<i>Lycodon ruhstrati abditus</i> Vogel, David, Pauwels, Sumontha, Norval, Hendrix, Vu & Ziegler, 2009	Tropical Zoology	Phong Nha - Ke Bang, Quang Binh Province
23.	<i>Gekko canhi</i> Rösler, Nguyen, Doan, Ho, Nguyen & Ziegler, 2010	Zootaxa	Huu Lien, Huu Lung, Lang Son Province
24.	<i>Cyrtodactylus roesleri</i> Ziegler, Nazarov, Orlov, Nguyen, Vu, Dang, Dinh & Schmitz, 2010	Zootaxa	Phong Nha - Ke Bang, Quang Binh Province
25.	<i>Tropidophorus boehmei</i> Nguyen, Nguyen, Schmitz, Orlov & Ziegler, 2010	Zootaxa	Hoang Lien, Lao Cai Province
26.	<i>Scincella apraefrontalis</i> Nguyen, Nguyen, Böhme & Ziegler, 2010	Folia Zoologica	Huu Lien, Huu Lung, Lang Son Province
27.	<i>Opisthotropis cucae</i> David, Pham, Nguyen & Ziegler, 2011	Zootaxa	Chu Mom Ray, Sa Thay, Kon Tum Province
28.	<i>Sphenomorphus tonkinensis</i> Nguyen, Schmitz, Nguyen, Orlov, Böhme & Ziegler, 2011	Journal of Herpetology	Cat Ba Island, Hai Phong City
29.	<i>Gekko truongi</i> Phung & Ziegler, 2011	Zootaxa	Ninh Hoa, Khanh Hoa Province
30.	<i>Cyrtodactylus huongsonensis</i> Luu, Nguyen, Do & Ziegler, 2011	Zootaxa	Huong Son, My Duc, Hanoi
31.	<i>Leptolalax nyx</i> Ohler, Wollenberg, Grosjean, Hendrix, Vences, Ziegler & Dubois, 2011	Zootaxa	Cao Bo, Vi Xuyen, Ha Giang Province
32.	<i>Cyrtodactylus bugiamapensis</i> Nazarov, Poyarkov, Orlov, Phung, Nguyen, Hoang & Ziegler, 2012	Zootaxa	Bu Gia Map, Binh Phuoc Province
33.	<i>Cyrtodactylus bidoupimontis</i> Nazarov, Poyarkov, Orlov, Phung, Nguyen, Hoang & Ziegler, 2012	Zootaxa	Bidoup - Nui Ba, Lac Duong, Lam Dong Province
34.	<i>Oligodon nagao</i> David, Nguyen, Nguyen, Jiang, Chen, Teynie & Ziegler, 2012	Zootaxa	Huu Lien, Huu Lung, Lang Son Province
35.	<i>Gracixalus waza</i> Nguyen, Le, Pham, Nguyen, Bonkowski & Ziegler, 2013	Organisms Diversity & Evolution	Ha Lang, Cao Bang Province
36.	<i>Gekko adleri</i> Nguyen, Wang, Yang, Lehmann, Le, Ziegler & Bonkowski, 2013	Zootaxa	Ha Lang, Cao Bang Province
37.	<i>Oreolalax sterlingae</i> Nguyen, Phung, Le, Ziegler & Böhme, 2013	Copeia	Hoang Lien, Sa Pa, Lao Cai Province,
38.	<i>Cyrtodactylus kingsadai</i> Ziegler, Phung, Le & Nguyen, 2013	Zootaxa	Dai Lanh Cape, Phu Yen Province
39.	<i>Sphenomorphus sheai</i> Nguyen, Nguyen, Van Devender, Bonkowski & Ziegler, 2013	Zootaxa	Quang Ngai and Kon Tum provinces
40.	<i>Hemiphyllodactylus zugii</i> Nguyen, Lehmann, Le, Duong, Bonkowski & Ziegler, 2013	Zootaxa	Ha Lang, Cao Bang Province
41.	<i>Cyrtodactylus thuongae</i> Phung, Van Schingen, Ziegler & Nguyen, 2014	Zootaxa	Ba Den, Tay Ninh Province
42.	<i>Cyrtodactylus cucdongensis</i> Schneider, Phung, Le, Nguyen & Ziegler, 2014	Zootaxa	Cuc Dong Cape, Khanh Hoa Province
43.	<i>Ichthyophis catlocensis</i> Geissler, Poyarkov, Grismer, Nguyen, An, Neang, Kupfer, Ziegler, Böhme & Müller, 2014	Organisms Diversity & Evolution	Cat Loc, Cat Tien, Lam Dong Province

No	Described taxon	Journal	Type locality
44.	<i>Ichthyophis chaloensis</i> Geissler, Poyarkov, Grismer, Nguyen, An, Neang, Kupfer, Ziegler, Böhme, Müller, 2014	Organisms Diversity & Evolution	Minh Hoa, Quang Binh Province
45.	<i>Cyrtodactylus bobrovi</i> Nguyen, Le, Pham, Ngo, Hoang, Pham & Ziegler, 2015	Zootaxa	Ngoc Son - Ngo Luong, Hoa Binh Province
46.	<i>Cyrtodactylus otai</i> Nguyen, Le, Pham, Ngo, Hoang, Pham & Ziegler, 2015	Zootaxa	Hang Kia - Pa Co, Mai Chau, Hoa Binh Province
47.	<i>Dixonius taoi</i> Botov, Phung, Nguyen, Bauer, Brennan & Ziegler, 2015	Zootaxa	Phu Quy Island, Phu Quy, Binh Thuan Province
48.	<i>Odorrana mutschmanni</i> Pham, Nguyen, Le, Bonkowski & Ziegler, 2016	Zootaxa	Duc Quang, Ha Lang, Cao Bang Province
49.	<i>Leptotalax ardens</i> Rowley, Tran, Le, Dau, Peloso, Nguyen, Hoang, Nguyen & Ziegler, 2016	Zootaxa	Kon Ka Kinh, Gia Lai Province
50.	<i>Leptotalax kalonensis</i> Rowley, Tran, Le, Dau, Peloso, Nguyen, Hoang, Nguyen & Ziegler, 2016	Zootaxa	Song Luy, Binh Thuan Province
51.	<i>Leptotalax pallidus</i> Rowley, Tran, Le, Dau, Peloso, Nguyen, Hoang, Nguyen & Ziegler, 2016	Zootaxa	Bidoup Nui Ba, Lam Dong Province
52.	<i>Leptotalax maculosus</i> Rowley, Tran, Le, Dau, Peloso, Nguyen, Hoang, Nguyen & Ziegler, 2016	Zootaxa	Phuoc Binh, Ninh Thuan Province
53.	<i>Leptotalax tadungensis</i> Rowley, Tran, Le, Dau, Peloso, Nguyen, Hoang, Nguyen & Ziegler, 2016	Zootaxa	Ta Dung, Dak Nong Province
54.	<i>Dixonius minhlei</i> Ziegler, Botov, Nguyen, Bauer, Brennan, Ngo & Nguyen, 2016	Zootaxa	Vinh Cuu, Dong Nai Province
55.	<i>Shinisaurus crocodilurus vietnamensis</i> van Schingen, Le, Ngo, Pham, Ha, Nguyen & Ziegler, 2016	Der Zoologische Garten	Son Dong, Bac Giang Province
56.	<i>Cyrtodactylus soni</i> Le, Nguyen, Le & Ziegler, 2016	Zootaxa	Van Long, Gia Vien, Ninh Binh Province
57.	<i>Theloderma annae</i> Nguyen, Pham, Nguyen, Ngo & Ziegler, 2016	Zootaxa	Tu Do, Lac Son, Hoa Binh Province

The beginnings of my research activities in Vietnam, viz. in Ha Tinh Province, were initiated by Prof. Dr. Manfred Niekisch, at that time executive director of the tropical forest foundation OroVerde. During that time I was supported from the Vietnamese side by Professor Dr. Vo Quy (Vietnam National University, Hanoi) and Dr. Hoang Xuan Quang (Biology Faculty, Vinh University). Later, during my research in Quang Binh Province, I cooperated with Vu Ngoc Thanh (Zoological Museum, Hanoi University of Science, Vietnam National University, Hanoi). During the subsequent research phase, I have intensively cooperated with Dr. Nguyen Quang Truong (Institute of Ecology and Biological Resources, IEBR, Hanoi). Within this long-term cooperation, which lasts to date, my research activities have extended from central Vietnam initially towards the North of the country, and later also to the South (see the overviews in Ziegler 2012, Ziegler & Nguyen 2015).

In the past 19 years I have published together with my Vietnamese project partners and later also with my student team in total 200 contributions towards the biodiversity of Vietnam, primarily focusing on the research and conservation of amphibians and reptiles (see Table 1, Fig. 2). By doing so I was involved in the publications of the following regional herpetofauna lists (from North to South): Ha Giang Province, Tay Yen Tu Nature Reserve (Bac Giang Province), Bai Tu Long National Park (Quang Ninh Province), Cat Ba National Park (Hai Phong City), Me Linh (Vinh Phuc Province), Thuong Tien Nature Reserve (Hoa Binh Province), Xuan Lien Nature Reserve (Thanh Hoa Province), Cua Lo (Nghie An Province), Ky Anh - Ke Go Nature Reserve

(Ha Tinh Province), Phong Nha - Ke Bang National Park (Quang Binh Province), Quang Ngai Province, Chu Mom Ray National Park (Kon Tum Province), Saigon Zoo (Ho Chi Minh City), and Hon Me (Kien Giang Province). Various further data sets are available, but so far not yet published. In addition, based on my own field research and cooperations with a number of Vietnamese partners, also a number of regional new amphibian and reptile records could be published (e.g. Ziegler *et al.* 2010, 2014, Luu *et al.* 2013, Pham *et al.* 2015), but also diverse first country records for Vietnam, such as *Leptobrachium masatakasatoi*, *Leptolalax eos*, *L. minimus*, *Megophrys daweimontis*, *Bufo gargarizans*, *Limnonectes gyldenstolpei*, *Amolops vitreus*, *Babina lini*, *Hylarana cubitalis*, *H. menglaensis*, *Odorrana lipuensis*, *Goniurosaurus luii*, *Scincella monticola*, *Sphenomorphus incognitus*, *Amphiesmoides ornaticeps*, and *Parafimbrios lao*. I also have contributed to several herpetological redescriptions, such as *Rhacophorus chuyangsinensis* (nowadays *R. calcaneus*), *Ateuchosaurus chinensis*, *Amphiesmoides ornaticeps*, *Dendrelaphis ngansonensis*, and *Protobothrops cornutus*. Species complex and genus reviews from Vietnam which I have coauthored among others dealt with unstriped *Ichthyophis*, *Leptolalax*, *Cyrtodactylus*, *Dixonius*, *Gekko*, *Dopasia*, *Shinisaurus*, *Lygosoma*, *Sphenomorphus*, *Tropidophorus*, *Cuora galbinifrons* and *Cuora mouhotii* complexes, *Cyclemys*, *Lycodon ruhstrati* group, *Sinonatrix*, as well as *Viridovipera*. Other papers have dealt with lizard trapping techniques (Ziegler 1999), parthenogenetic *Leiolepis* (Schmitz *et al.* 2001), turtle intergradation (Fritz *et al.* 2002), snake community (Ziegler *et al.* 2007b), phylogenetic analyses (e.g., Ziegler *et al.* 2007a, Dawson *et al.* 2008), faunal divides (Geissler *et al.* 2015, Luu *et al.* 2016), or pit viper venom and diversification (Mebs *et al.* 2003, Guo *et al.* 2016). In Table 1 in total 57 herpetological descriptions from Vietnam are listed (14 of which represent amphibian and 43 reptile descriptions), in whose discoveries I was involved so far and which I have coauthored, respectively.



Figure 1. A) The author in a forest camp in Ha Tinh Province (1997), B) together with Dr. Nguyen Quang Truong during a meeting with the Forest Protection Department of Ca Mau Province (March 2016, photo by A. Rauhaus), C) in Phong Nha - Ke Bang with a captured *Viridovipera vogeli* (May 2007, photo by B. Forster)

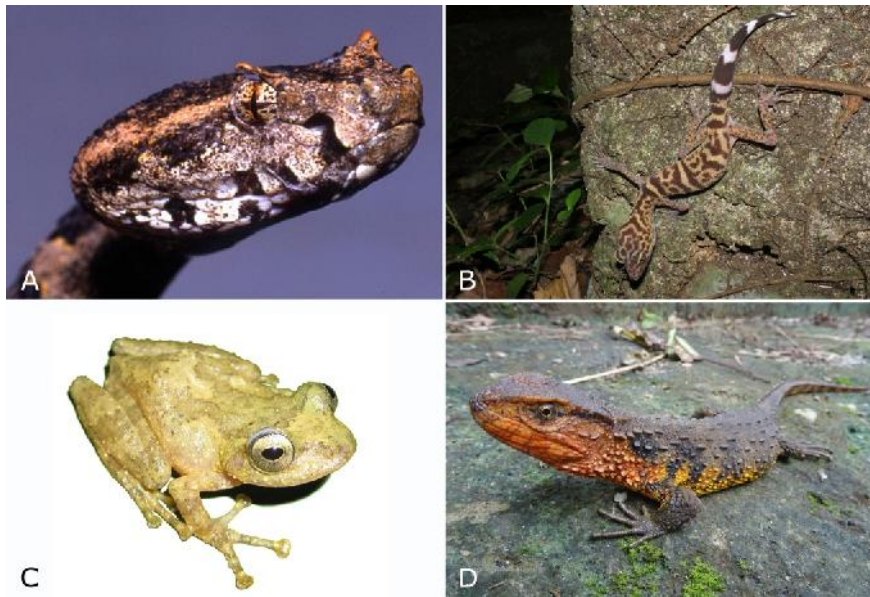


Figure 2. Some of the taxa described by our team from Vietnam: A) *Protobothrops sieversorum* (photo by T. Ziegler), B) *Goniurosaurus catbaensis* (photo by T. Ziegler), C) *Gracixalus waza* (photo by T.Q. Nguyen), D) *Shinisaurus crocodilurus vietnamensis* (photo by T. Ziegler)



Figure 3. The extensive karst forest of Phong Nha - Ke Bang: A) with its cryptic bent-toed gecko diversity: B) *Cyrtodactylus phongnhakebangensis*, C) *C. cryptus*, and D) *C. roesleri* (photos by T. Ziegler)

HERPETODIVERSITY RESEARCH IN LAOS

In the year 2010 our joint herpetodiversity studies could be extended to Laos based on a Memorandum of Understanding (MoU) between Cologne Zoo and IEBR with the National University of Laos (NUOL), Vientiane. Since then, Dr. Nguyen Quang Truong and myself published 20 papers dealing with the Laotian herpetofauna, together with our cooperation partners in Laos and subsequently also with our PhD students, Luu Quang Vinh and Nicole Schneider, among them reviews of *Gekko* and *Cyrtodactylus* from central Laos. Besides a number of new country records, altogether 19 amphibian and reptile species so far were described by our team

from Laos, but which were not included in Table 1 (1 *Leptolalax*, 11 *Cyrtodactylus*, 4 *Gekko*, 1 *Hemiphyllodactylus*, 1 *Lycodon*, and 1 *Oligodon*). A bent-toed gecko (*Cyrtodactylus vilaphongi*), described by our team from Laos (Schneider *et al.* 2014), also has achieved the interest of the media because it revealed to be the 10,000st reptile species in the “Reptile Database“, an internet database of the living reptile species. Of particular concern for nature conservation was the rediscovery of the Siamese crocodile (*Crocodylus siamensis*) by our Laotian-Vietnamese-German team in the central Laotian Province of Khammouane (Ziegler *et al.* 2015), where we currently are engaged with our Laotian partners in the creation of a Nature Reserve.

ECOLOGICAL STUDIES AND POPULATION ANALYSES AS BASIS FOR IMPROVED SPECIES CONSERVATION IN VIETNAM

For a better understanding of habitat requirements and ecological niches of threatened species, ecological studies are crucial as scientifically well-grounded base for improved conservation measures. Elementary natural history research can simply be conducted based on collections, such as reproductivity (by inspecting the condition of gonads) and trophic niche occupation (by stomach content analyses), as was performed for example for the herpetocommunity of the Ky Anh - Ke Go Nature Reserve. Direct ecological field research in the habitat was performed by our team for the first time concerning niche segregation in microhabitat use in three sympatric *Cyrtodactylus* in Phong Nha - Ke Bang (Loos *et al.* 2012) (see Fig. 3). Population analyses first were conducted for diurnal primates in the karst forests of Phong Nha - Ke Bang (Haus *et al.* 2009). Ecological studies and population analyses (Ngo *et al.* 2016a, 2016b, van Schingen *et al.* 2014b, 2015, in press) finally were together with trade analyses (van Schingen *et al.* 2015, Aulyia *et al.* 2016), important prerequisites to get *Shinisaurus crocodilurus*, *Goniurosaurus catbaensis* and *Cnemaspis psychedelica* being included in the IUCN Red List of Threatened Species (Nguyen *et al.* 2014, 2016a, 2016b), and most recently, the inclusion of *Shinisaurus crocodilurus* and *Cnemaspis psychedelica* on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

To find out the potential distribution of threatened taxa and to uncover unknown populations, Species Distribution Models (SDM's), jointly performed with Dr. Dennis Rödder (Zoologisches Forschungsmuseum Alexander Koenig, Bonn) and Dr. Ha Quy Quynh (Vietnam Academy of Science and Technology, Hanoi), revealed to be useful approaches for *Tylotriton vietnamensis* and *Shinisaurus crocodilurus* (Bernardes *et al.* 2012, 2013, van Schingen *et al.* 2014a, 2016b). By applying SDM's our PhD students Marta Bernardes and Mona van Schingen, jointly supervised with my colleague, the ecologist Prof. Dr. Michael Bonkowski (Cologne University), could discover new populations of aforementioned species together with our Vietnamese project partners (Bernardes *et al.* accepted, van Schingen *et al.* in press). Since our first country record of *Shinisaurus crocodilurus* for Vietnam (Le & Ziegler 2003) our working group has published more than ten papers dealing only with this species, likewise encompassing forensic aspects like the analysis of isotope markers to distinguish between wild and captive individuals for law enforcement agencies (van Schingen *et al.* 2016b), or the just tested analysis of environmental DNA, a non-invasive method for species records in difficult to access habitat. Ecological differences between Vietnamese and Chinese *Shinisaurus crocodilurus* populations finally led together with morphological and molecular distinctions to the taxonomical separation of the Vietnamese Crocodile lizards. As the Vietnamese population is very small and subpopulations isolated, which are threatened by habitat loss and poaching, improved conservation measures will be crucial to protect this endemic lizard for Vietnam (van Schingen *et al.* 2016a). At the suggestion of the forest protection department of the Tay Yen Tu Nature Reserve, to raise public awareness, our team developed a logo for the reserve together with a poster in English, Vietnamese and German languages, which points to the protection of the Crocodile lizard and further threatened, co-occurring species (Fig. 4). Also a nature reserve brochure could be jointly compiled and produced (see [http://www.eaza.net/campaigns/Documents/Brochure Tay Yen Tu Nature Reserve 2010.pdf](http://www.eaza.net/campaigns/Documents/Brochure_Tay_Yen_Tu_Nature_Reserve_2010.pdf)).

TEACHING ACTIVITIES

Since February 2009 I have been appointed as an Associate Professor at the Institute of Zoology, Cologne University. I always feel I must support young academics and introduce into the field of herpetology, in particular under consideration of nature conservation and zoo biological aspects. For students at Cologne University there exist three courses partly or fully conducted at the Cologne Zoo that also cover amphibians and reptiles: 1) Biodiversity for Bachelor of Science students, 2) Zoo biology for Bachelor of Science students, 3) Zoo biology for Master of Education students. Since recently, amphibians and reptiles are additionally treated in the new seminar “Modern Zoos: Animal prisons or centres of species conservation?”. Next to these four student courses taking place every year at Cologne University / Cologne Zoo, I am involved in the fifth university course, the modul “Evolution and Biodiversity of Lower Vertebrates” for Master of Science students at Bonn University, which was founded in the year 1997 together with my PhD supervisor Professor Dr. Wolfgang Böhme. In all these student courses the research and project activities in Vietnam are highlighted and a number of students subsequently conducted their theses dealing with a herpetological subject from or even in Vietnam.



Figure 4. Self-made poster pointing to the threats to *Shinisaurus crocodilurus* and sympatrically occurring endemic species of northern Vietnam. (Layout: M. v. d. Ploeg; text, photos, design & logo: T. Ziegler, T. Q. Nguyen, A. Rauhaus, M. Bernardes, M. v. Schingen, R. Dieckmann)



Figure 5. The author giving lectures during student courses: top: in Hanoi at the IEBR, together with Dr. Nguyen Quang Truong, below: in Ho Chi Minh City at the University of Science, together with Dr. Tran Anh Thi Dao (photos by A. Rauhaus)

Since more than ten years I am also engaged in the supervision of Vietnamese students in Vietnam, viz. planning and conducting their studies. In the year 2007, at the occasion of the conference “Development of Ho Chi Minh City Museum of Natural History” I was asked to prepare a brief instruction about field surveys and collection management as basis for herpetodiversity research and nature conservation in Vietnam, which was subsequently published in the Conference Proceedings (Ziegler 2007). I was particularly pleased about the chance to directly engage in the education of young researchers in the country. In 2014, together

with Dr. Nguyen Quang Truong, a herpetological student course of several day's duration was built up and performed at the IEBR in Hanoi, to which also herpetology students from other universities in Vietnam were invited. In parallel, an one-day herpetology course was built up together with Dr. Tran Anh Thi Dao at the University of Science in Ho Chi Minh City. Topics of the afore mentioned courses were diversity, systematics, anatomy, and morphological, molecular and bioacoustic diversity research, as well as introduction into field work including lectures about biodiversity crisis, conservation projects, amphibian development, husbandry and captive breeding, supported by our Vietnamese PhD and Master students and Cologne Zoo's reptile section keeper Anna Rauhaus.

A number of the students which we could train in our courses in Vietnam and Germany subsequently compiled their bachelor, master or dissertation theses in our international working group. By doing so, we jointly can handle more research topics at the same time and publish conservation based results contemporarily. In the herpetological working group of Dr. Nguyen Quang Truong and myself currently six PhD students are engaged: Marta Bernardes, Mona van Schingen, and Nicole Schneider in Cologne, Do Trong Dang (Phu Yen), Nguyen Van Hoang (Hue), and Pham The Cuong (Hanoi) in Vietnam. Pham Van Anh (Son La), Le Trung Dzung Trung (Hanoi), and Luu Quang Vinh (Cologne) have just successfully received their PhD in our working group.

ADMINISTRATIVE ASSISTANCE IN STATIONS AND ZOOS IN VIETNAM

During the long-term commitment of the Cologne Zoo in Phong Nha - Ke Bang (1999-2013), a wildlife rescue station was built up, that also comprised facilities for turtles (Miskovic & Ziegler 2013). In 2007, together with Dr. Nguyen Quang Truong from IEBR, the Amphibian Breeding Station in Hanoi was developed (e.g., Nguyen *et al.* 2009, Ziegler 2010, Ziegler *et al.* 2011, Nguyen & Ziegler 2012), where 14 amphibian species could be successfully reared / bred (1 *Tylototriton*, 1 *Hylarana*, 1 *Kurixalus*, 1 *Polypedates*, 6 *Rhacophorus*, and 4 *Theloderma* species). Our amphibian working group so far has published husbandry and breeding reports dealing with *Hylarana nigrovittata*, *Rhacophorus orlovi*, and *Theloderma corticale*; descriptions of larval stages so far were published by our team for *Ingerophrynus galeatus*, *Microhyala fissipes*, *Amolops cremnobatus*, *Hylarana attigua*, *H. guentheri*, *H. maosonensis*, *H. nigrovittata*, *Rhacophorus annamensis*, *R. maximus*, *R. orlovi*, *R. verrucosus* (now *Kurixalus bisacculus*), *Theloderma bicolor*, and *T. corticale* (e.g., Gawor *et al.* 2009, Rauhaus *et al.* 2013). Further larval staging reports are in preparation or submitted, such as for *Tylototriton vietnamensis* and *T. zieglerei*. Subsequently, the amphibian husbandry projects were relocated from the Amphibian Breeding Station to the Me Linh Station for Biodiversity of IEBR, where in addition to outdoor facilities also indoor enclosures could be set up. The Cologne Zoo team also helped to improve existing facilities, amongst others for confiscated primates and reptiles, as well as to develop new enclosures (see Ziegler *et al.* 2016a; for documentary films see also <http://reportagen.frogs-friends.org/de/vietnam>). As this project is a bilateral approach, not only Cologne Zoo staff was sent to Me Linh, but also staff of the station to Cologne Zoo for extended husbandry training. At Cologne Zoo also a number of Southeast Asian taxa are held both in the public area and behind the scenes, and there exist several species exhibits and breeding facilities pointing to the project activities in Vietnam. In the framework of Cologne Zoo's administration assistance at Me Linh also a conservation breeding project for the Vietnamese Crocodile lizard was developed (Ziegler & Nguyen 2016). For an environmental education programme, together with the Friedrich-Ebert-Stiftung (FES) Vietnam Office, new panels have been developed within a new education concept for school classes and visitors, together with the design of an environment exhibition at Me Linh. Also in the Hon Me Rescue Station of Wildlife at Risk (WAR) administrative assistance was provided together with IEBR, such as the development and building of a gecko facility for the threatened *Cnemaspis psychedelica*. The Psychedelic Rock gecko house, which comprises ten enclosures, also contains a large, self-made information banner at the opening and is intended to build the start of a conservation breeding programme.

Only recently, we could report about the first breeding success of the Psychedelic Rock Gecko in the newly built gecko house (Ziegler *et al.* 2016b). In the framework of a reptile husbandry training course at WAR, also staff of the U Minh Thuong National Park was invited to participate. Another husbandry training course was recently held at the Vietnam National Museum of Nature (VNMN) where we help to develop a country-wide rescue station. Also at the Saigon Zoo in Ho Chi Minh City, together with Cologne Zoo's reptile section keeper Anna Rauhaus, staff training and a reptile husbandry symposium was performed. Within the framework of another herpetological administrative assistance, tissue samples were taken at Saigon Zoo and Hanoi Zoo for a subsequent genetical screening of captive Siamese crocodiles, performed in cooperation with Dr. Le Duc Minh (University of Science, Vietnam National University, Hanoi). The test of purity of breeding of this threatened crocodile species is a prerequisite for subsequent conservation breeding and potential future restocking/release projects.



Figure 6. A) Newly built monitor lizard enclosures at the Me Linh Station for Biodiversity (photo by A. Rauhaus), B) new panel at the Me Linh station pointing to the Crocodile lizard breeding and conservation projects (photo by T. Ziegler, with the mascot “Shini” © C. Niggemann), C) gecko house with large information banner developed for the conservation breeding of *Cnemaspis psychedelica* (photo by A. Rauhaus), D) the author while taking a tissue sample for the subsequent genetical screening and transponding of an adult *Crocodylus siamensis* at the Saigon Zoo (photo by A. Rauhaus)

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