Review

In situ conservation powered by Public Aquaria

João P. S. Correia *, Nicole Kube , Lauren Florisson , Max Janse , Brian Zimmerman , Doris Preininger , Jonas Nowaczek , Anton Weissenbacher , Hugo Batista , Philippe Jouk

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Abstract: The European Union of Aquarium Curators (EUAC) includes 150 members and is an important association for the European public aquarium community. Since 2004, over one quarter of a million euros were awarded by the EUAC Conservation Fund to approximately 50 projects, which spanned across the globe. While projects varied greatly in content and scope, several achieved a significant impact in local populations and/or their focus species. This paper reports on results achieved by these conservation efforts and what improvements can be made, to ensure that the funding is indeed invested in conservation efforts *per se*. Perhaps the most valid conclusion to be drawn from the list of projects covered in this work is the fact that, regardless of the outcome, as far as preservation of the species are concerned, local communities were actively engaged in a subject that would, otherwise, remain unknown to them. Additionally, these EUAC funded projects highlight how public aquarium activities reach far beyond the acrylic panels surrounding the tanks and indeed the walls of the institution, as they spread around the world and raise awareness within local communities to preserve biodiversity. These results further suggest that a future direction for EUAC, as well as the public aquaria it consists of, could – indeed *should* - include more strenuous lobbying with legislating bodies, to ensure more adequate – and stronger – *in situ* conservation measures. In conclusion, with so many doubts being raised by different movements about the existence of aquaria and zoos, it is important that the public is aware that it is their visit to see the ambassadors of different species of animals that supports the funding of many of these pilot projects that aim to preserve species in their natural environment.

Keywords: funding; *ex situ*; education; EAZA; European Association of Zoos and Aquaria; EUAC; European Union of Aquarium Curators

Background

Public aquaria emerged in the mid nineteenth Century as 'windows' into the natural world, at a time when the public had no means to access, or visit, such wonders. One century later, the conservation of wildlife diversity and biological education and research are the central functions – and indeed Mission - of multiple aquaria. Occasionally, these institutions face controversy and an increasing choir of voices that beckon for their immediate closure and release of all captive animals back to the wild. However, this view mostly fails to acknowledge the powerful role that public aquaria play with *in situ* conservation efforts, while effectively struggling against human activities that continuously invade and destroy natural areas.

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For example, (1) seabeds rich in marine biodiversity destroyed by trawling (Thrush and Dayton, 2002; Clark *et al.*, 2016; Carlson *et al.* 2019), (2) freshwater ecosystems such as rivers, springs, lakes, and rainforests that have been systematically drained, polluted and dammed, leaving them cleared or severely degraded since the 1950s, imperilling thousands of species (Reid and Andrea, 2019; Dudgeon, 2019; Darwall *et al.*, 2009;); and (3) the sustained threat posed by climate change puts additional pressures on these fragile ecosystems. Likewise, (4) coral reefs have been severely affected by destructive fisheries, pollution, runoff, and unchecked tourism practices. During the last century, climate change also caused (5) stress and a raise in water temperature, resulting in enormous bleaching events all over the globe (refs for these two).

Aquaria support species conservation with species management expertise and public engagement. They not only advocate for a sensitive relationship between nature and society and provide a communication platform for conservation efforts, but also contribute directly to conservation with *in* and *ex situ* projects. While all institutions need to comply with modern legislation (e.g. the European Union's 'Zoo Directive [1] ', regulated by Council Directive 1999/22/EC of 29 March 1999), the vast majority have in fact, surpassed its scope (Correia 2020).

The role of public aquaria thus changed in recent years from focussing solely on recreation and the exhibition of exotic wildlife to the current three main roles of education, scientific research and conservation (Packer & Ballantyne 2010; Gusset & Dick 2011). Quoted directly from the European Commission: "The Zoos Directive seeks to promote the protection and conservation of wild animal species by strengthening the role of zoos in the conservation of biodiversity. In practice, the greatest efforts for the conservation and sustainable use of biodiversity need to focus on measures in the wild. This is the primary focus of the EU's policy: through the Birds and Habitats Directives, the EU Biodiversity Strategy, the Regulation on Invasive Alien Species and EC wildlife trade regulations implementing CITES, all of which contribute to achieving objectives of the Convention on Biological Diversity & other international agreements" (Correia 2020).

However, protecting wild animal species outside their natural habitat is also important for biodiversity conservation. In this context, the EU adopted Council Directive 1999/22/EC of 29 March 1999 on the keeping of wild animals in zoos. The Zoos Directive aims to strengthen the role of zoos in the conservation of biodiversity. It calls on Member States to adopt measures to licence and inspect zoos, ensuring that institutions respect certain conservation and protection measures, including appropriate accommodation of the animals (op. cit.).

Member States are responsible for applying the provisions of the Zoos Directive and ensuring their necessary enforcement. There is a very limited EU role in implementation as the Directive does not foresee the need for a committee or reporting obligations to the Commission. However, a lot of good practice approaches have been developed to help zoos and public aquaria increase their contribution to biodiversity conservation (op. cit.). Both the European Association of Zoos and Aquaria (EAZA[2]) and the North American Association of Zoos and Aquaria (AZA[3]) have produced multiple manuals of 'Good Practices' that are distributed freely amongst their members. Likewise, the 'Elasmobranch Husbandry Manual' (Volumes I[4] and II[5], by Smith *et al.*

1 https://ec.europa.eu/environment/nature/legislation/zoos/index_en.htm
2 https://www.eaza.net/about-us/eazadocuments/
3 https://www.aza.org/animal-care-manuals?locale=en
4 https://www.researchgate.net/publication/268339849_The_Elasmobranch_Husbandry_Manual_Captive_Care_of_Sharks_Rays_and_their_Relatives_Editors
5 https://www.researchgate.net/publication/319762551_The_Elasmobranch_Husbandry_Manual_II_-_Recent_Advances_in_the_Care_of_Sharks_Rays_and_their_Relatives

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2004 and Smith *et al.* 2017, respectively) and 'Advances in Coral Husbandry[6]' (Leewis & Janse 2008), are also distributed freely (in electronic format) amongst professionals in the field.

The European Union of Aquarium Curators

It was under this framework that the European Union of Aquarium Curators (EUAC) was created, during a symposium held in Basel Zoo, in May 24-25, 1972. At the time, participating aquarium curators decided to establish EUAC, which would ensure closer contact between aquarium professionals in the future. The main objective of this Union would be to organise regular symposia during which topics and problems of general interest would be discussed. The intention was to meet every year and annual – occasionally biannual - meetings occurred ever since. The number of participants as well as the number of presentations constantly increased and, in 2004, the organisation was financially robust enough to award funding to *in situ* conservation initiatives promoted by its members.

Such conservation activities can either be done directly by aquaria or via close collaboration with existing *in situ* conservation projects. Also, direct funding from EUAC, or indirect funding from other sources of *in situ* conservation activities, can be of great help. Funding can be provided by an individual institution or an association, including dedicated public fundraising initiatives. Every year, EUAC members are invited to submit their proposals by completing an application form.

Project categories include biological/ecological research, veterinary/conservation medicine, animal welfare, captive breeding, re-introduction/re-stocking/translocation, human-wildlife conflict, education/public awareness, training/workshops, community-based/social policy, ecotourism/sustainable development, sustainable use, wardening/law enforcement, and protected areas management. Projects are encouraged to involve local communities and be approved by local authorities. Participants are also required to give details about the study species, its IUCN Red List status, summarising the project and its objectives and itemise a budget. Applicants are required to provide match funding to demonstrate proportional commitment to the project.

Once applications are received, a review panel, appointed specifically for this purpose, reviews all applications, and assigns a score to each. The EUAC Committee then reviews these scores and, depending on current funding budgets awards financial support to one, or more proposals. Recipients of funds are obligated to deliver an oral presentation on their results and also submit a written report of the results achieved by their project.

Hereinafter we present achievements of nearly two decades of funding support by the EUAC (Tables 1 and 2) and highlight how short-term, targeted funding can initiate conservation and support dedicated teams around the world to develop and implement methods for species survival. Table 1 was done in 2019 and shows 42 projects, while Table 2 includes 7 additional projects.

6 https://www.researchgate.net/publication/288802992_Advances_in_coral_husbandry_in_public_aquariums

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Table 1. Projects funded by EUAC between 2004 and 2019 (42).

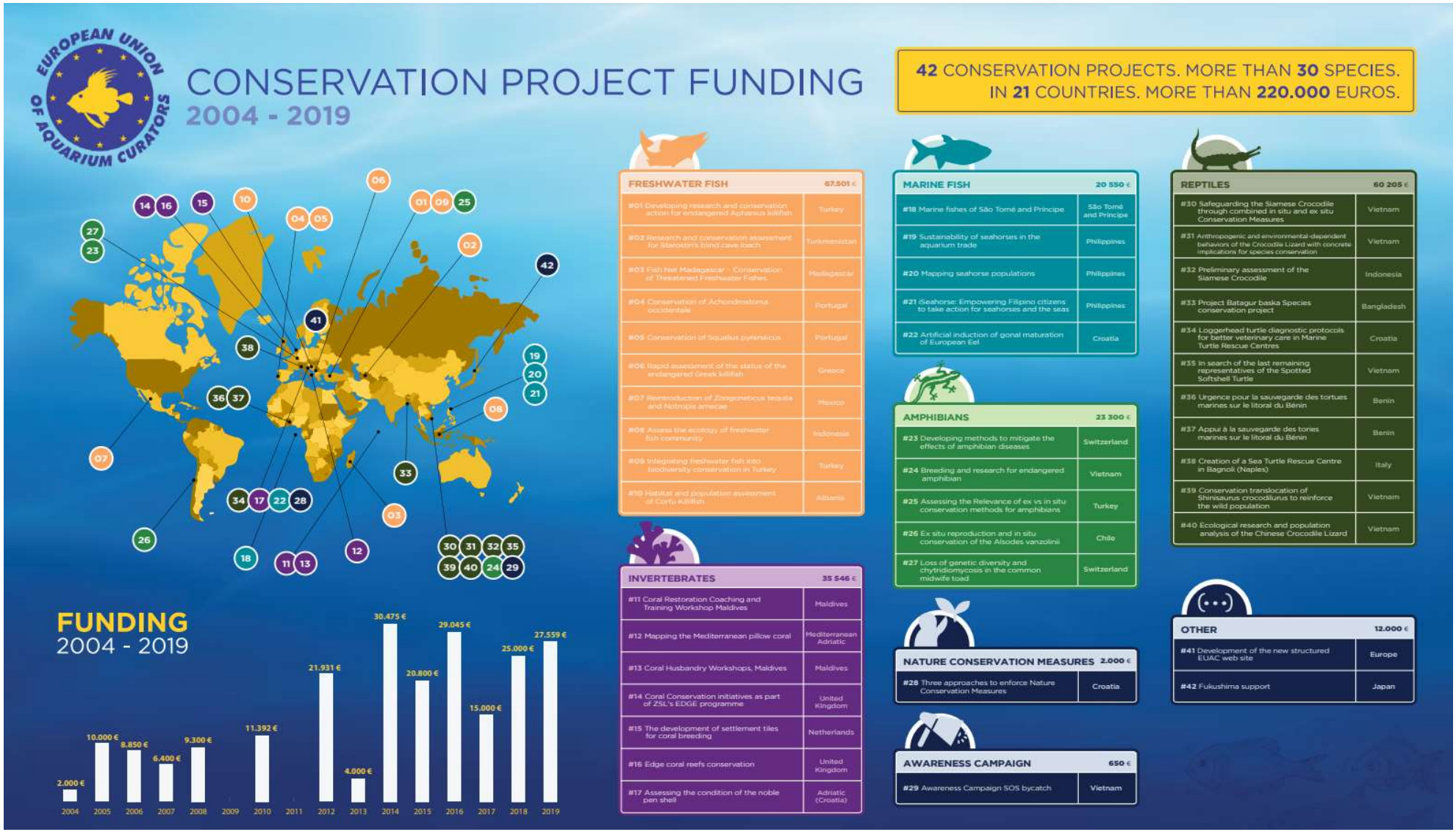

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Table 2. Projects funded by EUAC between 2004 and 2020 (49).

Year	Title	Amount funded	Location	Focal species	Recipient	Funding	Running	Follow-up	Amount	Publications	Extinction	Obs.
2004	Creation of a Sea Turtle Rescue Centre in Bagnoli (Naples)	2 000 €	Italy	*Caretta caretta*	Stazione Zoologica Anton Dohrn, Itlay	P	Y	Y	100 000 €	Y	n.a.	1
2005	Emergency for the protection of sea turtles on the Benin coast	2 285 €	Benin	Seaturtles	Nature Tropicale ONG Bénin	P	Y	n.a.	n.a.	n.a.	n.a.	2
	Rapid assessment of the status of *Valencia letourneuxi* , an endangered Greek killifish	7 715 €	Greece	*Valencia letourneuxi*	ZSL London, UK	I	Y	Y	100 000 €	Y	Y	3
2006	Three approaches how to enforce Nature Conservation Measures in Phon Nha-Ke Bang Vietnam	2 000 €	Vietnam	Multiple species	Cologne Zoo Germany	P	Y	n.a.	n.a.	Y	Y	4
	The development of settlement tiles for coral breeding as a part of the Secore Project	2 500 €	Caribbean	*Acropora* sp.	Rotterdam Zoo/SECORE foundation	P	Y	Y	2 000 000 €	Y	n.a.	5
	Sustainability of seahorses in the aquarium trade	4 350 €	Philippines	*Hippocampus* sp.	ZSL London	P	Y	n.a.	n.a.	n.a.	n.a.	6
2007	Support for the safeguarding of marine turtles on the Benin coast	2 250 €	Benin	Seaturtles	Nature Tropicale ONG Bénin	F	Y	n.a.	n.a.	n.a.	n.a.	7
	Artificial induction of gonal maturation of European Eel	2 500 €	Croatia	*Anguilla* sp.	Pula Aquarium, Croatia	I	N	N	n.a.	Y	n.a.	
	Awareness Campaign SOS bycatch	650 €	Unspecified or multiple	Unspecified or multiple	Unspecified or multiple	n.a.	n.a.	n.a.	n.a.	n.a.	Y	
	Habitat and population assessment of Corfu Killifish in Albania	1 000 €	Albania	*Valencia letourneuxi*	ZSL London, UK	P	N	N	n.a.	n.a.	Y	8
2008	Breeding and research program for rare and endangered amphibian amphibians from Vietnam	3 000 €	Vietnam	Various amphibians	Cologne Zoo, Germany	P	Y	n.a.	n.a.	Y	Y	
	Loss of genetic diversity and chytridiomycosis in the common midwife toad *Alytes* population in Switzerland	6 300 €	Switzerland	*Alytes* sp.	Zoo Zürich, Switzerland	P	N	N	n.a.	Y	n.a.	9
2010	Developing methods to mitigate the effects of the emerging amphibian disease chytriodiomycosis	3 000 €	Switzerland	Various amphibians	Zoo Zürich, Switzerland	F	N	N	n.a.	Y	n.a.	10
	Integrating freshwater fish into biodiversity conservation in Turkey	1 522 €	Turkey	*Aphanius* sp.	ZSL London, UK	I	Y	Y	15 000 €	n.a.	Y	11
	Edge coral reefs conservation	2 500 €	UK	*Corals* sp.	ZSL London, UK	P	n.a.	n.a.	n.a.	n.a.	n.a.	12
	Mapping seahorse populations across the Danajon Bank Philippines	2 500 €	Philippines	*Hippocampus sp.*	ZSL London, UK	F	Y	n.a.	n.a.	Y	n.a.	
	Preliminary assessment of the Siamese Crocodile population in Indonesia	1 870 €	Indonesia	*Crocodile* sp.	Cologne Zoo, Germany	I	N	n.a.	15 000 €	Y	Y	13
2012	Ecological research and population analysis of the Chinese Crocodile Lizard *(Shinisaurus crododilus)* in Vietnam	3 300 €	Vietnam	Crocodile lizard	Cologne Zoo, Germany	P	Y	n.a.	10 000 €	Y	Y	14
	Assess the ecology of freshwater fish community in the Menangat-Kenohan Suwi wetlands of Kalimantan Indonesia	3 985 €	Indonesia	Freshwater fishes	Cologne Zoo, Germany	I	Y	n.a.	n.a.	Y	n.a.	15
	Coral Conservation initiatives as part of ZSL's EDGE programme	2 646 €	UK	*Corals* sp.	ZSL London	F	N	n.a.	n.a.	n.a.	n.a.	16
2013	Ex situ reproduction and in situ conservation of the Critically Endangered *Alsodes vanzolinii*	4 000 €	Chile	*Alsodes vanzolinii*	Zoo Leipzig	P	Y	Y	20 000 €	Y	Y	17
2014	Project Batagur baska Species conservation project for the Northern River Terrapin (*Batagur baska*)	6 200 €	Bangladesh	*Batagur baska*	Zoo Vienna, Austria	P	Y	Y	25 000 €	Y	Y	
	Conservation translocation program of *Shinisaurus crocodilurus* to reinforce the dramatically small wild population in Vietnam	4 500 €	Vietnam	*Shinisaurus crocodilurus*	Zoo Cologne, Germany	F	Y	Y	n.a.	Y	Y	18
	Developing integrated approaches to research and conservation action for endangered Aphanius killifish - Building capacity for conserving endangered freshwater fish in Turkey	9 975 €	Turkey	*Aphanius* sp.	ZSL London, UK	F	Y	Y	80 000 €	Y	Y	19
	Research and conservation assessment for Starostin's blind cave loach (*Nemacheilus starosini*) in Turkmenistan	9 800 €	Turkmenistan	*Nemacheilus starostini*	ZSL London, UK	I	N	N	n.a.	n.a.	n.a.	20

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Table 2. (cont.). Projects funded by EUAC between 2004 and 2020 (49).

Year	Title	Amount funded	Location	Focal species	Recipient	Funding	Running	Follow-up	Amount	Publications	Extinction	Obs
2015	Coral Restoration Coaching and Training Workshop Maldives	7 900 €	Maldives	*Corals* sp.	German Oceanographic Museum, Germany	F	Y	Y	3 000 €	n.a.	n.a.	
	Marine fishes of São Tomé and Príncipe	10 000 €	São Tomé and Príncipe	Various fishes	Flying Sharks Ltd.	I	N	N	n.a.	n.a.	n.a.	21
	Anthropogenic and environmental-dependent behaviors of the Endangered Crocodile Lizard (*Shinisaurus crocodilurus*)	2 900 €	Vietnam	*Shinisaurus crocodilurus*	Cologne Zoo, Germany	P	Y	Y	8 000 €	Y	Y	22
2016	Safeguarding the Critically Endangered Siamese Crocodile (*Crocodylus siamensis*) through Combined in situ and ex situ Conservation Measures	5 000 €	Vietnam	*Crocodylus siamensis*	Cologne Zoo, Germany	P	Y	Y	15 000 €	Y	Y	23
	Loggerhead turtle diagnostic protocols for better veterinary care in Marine Turtle Rescue Centres	10 000 €	Croatia	*Caretta caretta*	Aquarium Pula, Croatia	P	Y	Y	600 000 €	Y	n.a.	24
	Project *Batagur baska*	5 000 €	Bangladesh	*Northern River terrapin*	Vienna Zoo, Austria	F	Y	Y	25 000 €	Y	Y	
	Fish Net Madagascar – Conservation of Threatened Freshwater Fishes	9 045 €	Madagascar	Freshwater fishes	ZSL London, UK	F	Y	Y	32 400 €	n.a.	Y	
2017	*Seahorse* : Empowering Filipino citizens to take action for seahorses and the seas	1 200 €	Philippines	Seahorses	ZSL London, UK	F	Y	n.a.	n.a.	n.a.	n.a.	
	Project *Batagur baska*	5 000 €	Bangladesh	*Northern River terrapin*	Vienna Zoo, Austria	F	Y	N	25 000 €	n.a.	Y	
	Conservation of *Achondrostoma occidentale* - a freshwater fish endemic to the Westernmost tip of Europe	8 800 €	Portugal	*Achondrostoma occidentale*	Vasco da Gama Aquarium Lisbon, Portugal	I	Y	Y	4 000 €	Y	Y	25
2018	Mapping the Mediterranean pillow coral	7 000 €	Mediterranean/Adriatic	Pillow coral	Pula Aquarium, Coratia	I	standby	N	n.a.	n.a.	n.a.	26
	Assessing the Relevance of ex vs in situ conservation methods for amphibians; a comparative study of the microbiota structure and diversity in palmate newts Lissotriton heveticus in the wild and in captivity.	7 000 €		*Palmate* newts	Cologne Zoo, Germany	P	Y	Y	n.a.	n.a.	n.a.	
	Reintroduction of *Zoogoneticus tequila* and *Notropis amecae*	7 000 €	Mexico	Mexican freshwater *(Zoogoneticus tequila/Notropis*	Haus des Meeres Aquarium, Austria	P	Y	Y	n.a.	n.a.	Y	
	Coral Husbandry Workshops, Maldives	4 000 €	Maldives	Stony corals	German Oceanographic Museum, Germany	F	Y	Y	13 000 €	n.a.	n.a.	27
	Reintroduction of the extinct in the wild species *Skiffia francesae* to its natural habitat, the springs of the Teuchitlán Riv	10 000 €	Mexico	*Skiffia francesae*	Haus des Meeres Aquarium, Austria	P	Y	Y	33 000 €	n.a.	n.a.	
	Conservation of *Profundulus oaxacae* in one of its habitats	2 000 €	Mexico	*Profundulus oaxacae*	Haus des Meeres Aquarium, Austria	P	Y	Y	2 500 €	n.a.	n.a.	
2019	In search of the last remaining representatives of the only recently described and already Critically Endangered Spotted Softshell Turtle *Pelodiscus variegatus* in Vietnam	4 900 €	Vietnam	*Peolodiscus variegatus* (Spotted softshell turtle)	Cologne Zoo, Germany	I	Y	Y	5 000 €	Y	Y	28
	Assessing the condition of the noble pen shell Pinna nobilis in the South Adriatic Sea	9 000 €	Adriatic (Croatia)	*Pinna nobilis*	Pula Aquarium, Croatia	I	Y	Y	150 000 €	Y	Y	
	Project *Batagur baska*	5 000 €	Bangladesh	*Northern River terrapin*	Vienna Zoo, Austria	F	Y	Y	25 000 €	n.a.	Y	29
	Conservation of *Squalius pyrenaicus* , a freshwater fish endemic to the Iberian Peninsula	8 659 €	Portugal	*Squalius pyrenaicus*	Vasco da Gama Aquarium, Lisbon, Portugal	F	Y	Y	4 000 €	n.a.	Y	30
2020	In situ Shark & Ray Conservation in Baucau, East Timor	5 000 €	East Timor	Sharks, rays & other megafauna	Flying Sharks Ltd. , Portugal	n.c.	standby	n.a.	n.a.	n.a.	n.a.	31
	Development of sustainable livelihood and upscaling reef restorations in Palau	10 000 €	Palau	Corals	Horniman Museums and Gardens London, UK	n.c.	standby	n.a.	n.a.	n.a.	n.a.	
	Harbour porpoise photo-identification research in the Eastern Scheldt, the Netherlands	4 980 €	Netherlands	Harbour porpoises	Burgers Zoo, Netherlands	n.c.	standby	n.a.	n.a.	n.a.	n.a.	
	Kura Kura (saving sea turtles in Indonesia)	8 610 €	Indonesia	Seaturtles	Brno Zoo, Slowakia	n.c.	standby	n.a.	n.a.	n.a.	n.a.	
	Total (€)	**250 342 €**							3 309 900 €			
	Total (no. projects)	**49**										

Caption: Funding) Initial funding (I); part of bigger Project (P); Follow up (F)? Running) Project still running? (Y/N). Follow-up) Follow-up funding received? (Y/N). Publications) Peer-reviewed publications from Project? (Y/N). Extinction risk) Involvement in protection of endangered species? (Y/N). **Obs.** 1) Bagnoli station is closed but a new facility opened at Stazione Zoologica Anton Dohrn in Naples, now a centre for excellence in sea turtle Rescue and Research with much bigger facility and veterinary unit. Annual budget: 20.000€ without personnel plus 100.000€ p.a. for Research Projects (1+1 Life). 2) NGO is still active: https://www.facebook.com/naturetropicaleong/. 3) Project grew into a long series of projects in Afresh, Pacim, and Decagon under the umbrella of 'Fish Net Greece'. 4) 13 new species (1 Frog, 6 lizards (Echsen), 6 snakes), scientifically described, Building of Rescue Centre together with Zoological Society Frankfurt, region became NP with enlargement, UNESCO World Heritage site, EAZA Conservation Award for Cologne Zoo. 5) EUAC support was more important than the actual money, specifically networking and acknowledgement opportunities; annual budget in 2022 is 2 million euros; SECORE is a prime example of how public aquaria can be a platform for Research and Conservation. 6) A significant

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ZSL-project with an abundancy of funders but contribution of EUAC money helped with certain questions. 7) NGO is still active: https://www.facebook.com/naturetropicaleong/. 8) Part of Greek Valencia- Project. 9) Yielded a PhD and publication; total project budget was 250 000 €. 10) Yielded a PhD and publications; total project budget was 300 000 €. 11) Received Darwin Scoping grant. 12) EDGE projects are done with foreign students and have limited duration. 13) Project duration 2 years. 14) Led to Red list status of this species and CITES level was raised from WA II to WA I; project focused on Vietnam with separate population unit, genetic screening for species protection and identification, *ex situ* in Zoo Köln (Vietnamese form) bred to F2 generation; Conservation breeding in Cologne Zoo and Melinh Station for Biodiversity in Vietnam, Monitoring of wild population in Vietnam ongoing. 15) Fish list being compiled together with ZFMK (Zoological Research Museum Alexander König). 16) EDGE projects are done with foreign students and have limited duration. 17) Zoo Leipzig and Universität Chile, built a Station from a container. 18) Led to Red list status of this species and CITES level was raised from WA II to WA I; project focused on Vietnam with separate population unit, genetic screening for species protection and identification, *ex situ* in Zoo Köln (Vietnamese form) bred to F2 generation. 19) Follow-up from 2010. 20) Part of a fixed termed project. 21) Yielded a book, poster, multiple lectures to locals, and a partnership with the Fisheries Board of São Tomé. 22) Yielded Vietnamese population ex situ breeding up to F2 generation, exchange with European Zoos, extensive new enclosure, positive outcome of the project result as member of staff now works for German Ministry for Conservation. 23) Yielded offspring of genetically tested Siamcrocodiles in Laos, raised for Conservation breeding network / release. 24) Sea turtle Program still running, with construction of new rescue station to begin immediately. 25) Predominantly yielded educational outputs and increased networking; the Portuguese navy finances the project, which also receives support from the municipality. 26) Exhibition; option to continue. 27) 150 people educated in 3 workshops, exhibition and presentation, follow up with sexual reproduction; currently in progress. 28) Search for genetically pure individuals, *Ex situ* breeding successful, specimen for rescue stations, exchange with Zoos and release to wild, One plan approach and habitat analysis. 29) Contribution to project purpose. 30) Predominantly yielded educational outputs and increased networking; the Portuguese navy finances the project, which also receives support from the municipality. 31) Project will be shifted to Azores/Portugal due to political issues in East Timor after pandemic.

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Further communication with project managers yielded results that allowed to compile Table 3.

Table 3. Status of 49 projects funded from 2004 to 2020 by the European Union of Aquarium Curators.

	I	P	F	Y	N	n.a.	n.c.	standby	Total
Funding	11	19	14	0	0	1	4	0	49
Running	- -	- -	- -	34	8	2	0	5	49
Follow-up	- -	- -	- -	24	8	17	0	0	49
Publications	- -	- -	- -	23	0	26	0	0	49
Extinction risk	- -	- -	- -	23	0	26	0	0	49

Caption: Funding: Initial funding (I); part of bigger Project (P); Follow up (F)? **Running:** Project still running? (Y/N). **Follow-up:** Follow-up funding received? (Y/N). **Publications:** Peer-reviewed publications from Project? (Y/N). **Extinction risk:** Involvement in protection of endangered species? (Y/N). **n.a.:** information not available. **n.c.:** not counted. **standby:** project on hold (usually due to Covid-19 pandemic).

Action - Projects

Below are more detailed explanations on some of the projects funded thus far, including outcomes and results.

Title of project: Assessing the condition of the noble pen shell (*Pinna nobilis* Linnaeus, 1758) in the south Adriatic Sea

Project leader: Milena Mičić **EUAC member:** Aquarium Pula

Year supported: 2019 **Amount supported:** 9 000 €

Summary of project: The aim of the project was to assess the state of the population of noble pen shells (Figure 1) in the south Adriatic. Results from the surveyed areas indicated a high level of mortality (up to 100%) and healthy individuals were removed from the site and kept in *ex situ* conditions. Noble pen shells suffer from a disease in the wild that has wiped out populations in Spanish and Mediterranean waters. The disease and the disappearance of other populations has been what motivated this project which received full support from the Croatian Ministry of Environmental Protection. The pen shells in aquaria were kept in a closed aquarium system with the subsequent induction of spawning. Any knowledge and findings from this project have been used to update information about the biology of the species and how they should be maintained under human care. Aquarium Pula collaborated with universities in Zagreb, Pula and Hungary together with the Croatian veterinarian Institution to further the project. During the project regular media coverages were undertaken to raise public awareness.

Title of project: In search of the last remaining representatives of the only recently described and already Critically Endangered Spotted Softshell Turtle *Pelodiscus variegatus* in Vietnam

Project leader: Thomas Ziegler **EUAC member:** Cologne Zoo

Year supported: 2018 **Amount supported:** 4 900 €

Summary of project: The softshell turtle (Figure 2) has been described as a new species based on genetic and morphological analyses. The project aimed at investigating whether wild populations of the soft-shell turtle still exist. This was achieved by checking potential freshwater habitats, interviewing local fishermen and by investigating farms and local markets where turtle trade is done. Genetic screening was undertaken on potential individuals at a molecular laboratory, after being inspected if they contained the unique markings on the belly of this species. When a genetically pure specimen was found, it was taken to a local rescue station to set up a conservation breeding programme. Any young were released to their natural habitat and potential surplus was brought to European institutions to extend the conservation breeding programme and to build an insurance colony.

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Figure 1. – *Pinna nobilis* in the south Adriatic Sea. Photo: Aquarium Pula.

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Figure 2. - Thomas Ziegler with *Pelodiscus variegatus* at Cologne Zoo. Photo: Thomas Ziegler.

Title of project: Mapping the Mediterranean Pillow Coral (*Cladocora caespitosa*) habitats in Medulin Bay, Istria, Croatia

Project leader: Milena Mičić **EUAC member:** Aquarium Pula

Year supported: 2018 **Amount supported:** 7 000 €

Summary of project: The aim of the project was to investigate the condition of coral colonies in relation to existing threats caused by different anthropogenic activities (nautical tourism, pollution, and unsustainable fishing). Additionally, it was essential to propose guidelines for sustainable management of the area for authorities to preserve the colonies in Medulin Bay (Figure 3). To highlight the importance of coral protection at local and global level, an outdoor poster exhibition was created and offered - at Aquarium Pula - to the wider audience, to raise awareness. The exhibition showed the degradation of corals and related species due to unsustainable human activities.

Figure 3. - *Cladocora caespitosa* in Medulin Bay, Istria, Croatia. Photo: Pula Aquarium.

Title of project: Coral Husbandry Workshops Maldives

Project leader: Nicole Kube & Pablo Montoto Gasser **EUAC member:** German Oceanographic Museum & ZooAquarium Madrid, Spain

Year supported: 2017 and 2018 **Amount supported:** 12 000 € (total)

Summary of project: In the archipelago of Maldives people are depending in their livelihood on coral reefs, as fisheries and tourism is the main income. Declining of coral reefs due to anthropogenic impacts, coral bleaching, and the loss of coral reefs also due to constructional work has made some activity for reef restoration possible. This applies to both hotel and local islands. This project focused on conducting a workshop to train locals (Figure 4) in coral husbandry and restoration techniques to ensure a better outcome of the conducted projects and help getting local people engaged into protection of coral reefs.

Workshops were held with the following topics: knowledge about ecology and biodiversity of coral reefs and threats, abundant coral species and status of corals of the islands, sampling strategy (Figure 5) with a minimum impact on the reef but maximizing the number of collected species, lessons about fragmentation techniques, different attachment methods and best spots to grow. The workshops consisted theoretical lessons and practical work underwater.

The aim of the project was to engage people more into actions to protect their coral reefs at their doorstep. Participants of the workshops have been trained to continue the work independently after the team left.

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Figure 4. – Practical lesson for attaching coral fragments with school class in Ukulhas, 2019. Photo: Coral Doctors Association.

Figure 5. – Lesson about Planting coral fragments directly in the reef, Konotta. Photo: Coral Doctors Association.

Title of project: Project *Batagur baska*
Project leader: Anton Weissenbacher **EUAC member:** Vienna Zoo
Year supported: 2019/2017 **Amount supported:** 5 000 €

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Summary of project: The aim of the project was to draw conclusions of migration routes and survival of the northern river terrapin (*Batagur baska)* in the natural habitat (Figures 6 and 7). In a previous project five males were released and this submission consisted of five more releases into the Sundarbans mangrove forest in Bangladesh. Satellite transmitters were fitted on the five individuals to track them. The combined data of the 10 males from 2018 and 2019 will help to discuss if a sustainable reintroduction is feasible, depending on the survival rate, and will help influence management suggestions for the *in situ* bred and reared population.

Figure 6. - Project *Batagur baska* - transmitter being fixed on a male. Photo: Rupali-Ghosh, Vienna Zoo.

This project constitutes a prime example of the importance of EUAC funding support. Wild populations of the Northern River Terrapin (*Batagur baska*) have been decimated to such an extent that the species can be considered as ecologically dead. The first breeding success at the Vienna Zoo in 2010 presented an opportunity to call attention to this Critically Endangered species. With combined efforts, the team assembled a breeding population in the terrapin´s natural habitat in Bangladesh. A conservation area was established in Bhawal National Park and started with 84 juveniles in the first years (Weissenbacher *et al.* 2015).

EUAC's financial support allowed to maximise the conservation approach when a second breeding facility was established in the historical distribution area, the Sundarbans. The breeding group was split to minimise risk and hatcheries, ponds and breeding beaches were established in the Karamjal conservation centre of the Bangladesh Forest Department. In early 2021, Project *Batagur* headstarted 406 juveniles in both Bhawal National Park and Karamjal centre and secured the survival of a Critically Endangered species.

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Figure 7. - Project *Batagur baska* - Male with transmitter being released in the Sundarbans. Photo: Rupert Kainradl.

Moreover, EUAC funding supported a further project step that permitted the first quantitative and qualitative observation of migration routes of adult terrapins in the brackish river system and coastal areas of Bangladesh. In two successive years, ten males were equipped with satellite transmitters and released in the Sundarbans mangrove forest. First results demonstrated a precarious situation of the terrapin's survival in its natural habitat and permitted fact-based discussions about sustainable reintroduction and management.

Title of project: Conservation of *Achondrostoma occidentale*: a freshwater fish endemic to the Western most tip of Europe (2017)

Project leader: Maria de Fátima Santos Gil **EUAC member:** Aquário Vasco da Gama

Year supported: 2017 **Amount supported:** 8 800 €

Summary of project: *A. occidentale* is a small cyprinid endemic to three small river basins (<40 km) located in the westernmost tip of Europe, isolated from its geographically closest congeneric species for more than 7 million years. It inhabits typical Mediterranean-type intermittent rivers, with winter floods and summer droughts of variable intensity. The dry season is particularly threatening for fish, due to major habitat contraction and population fragmentation (and consequent genetic bottlenecks), with exposure to higher competition for the limited space/food and poorer water quality. Other threats include habitat destruction, pollution and spread of the exotic crayfish *Procambarus clarkii*.

The imminent risk of extinction of *A. occidentale* after a severe drought prompted the launching of an *ex situ* Conservation programme in 2007. Captive stocks founded with wild caught adults are maintained at the Aquário Vasco da Gama (AVG) and reproduction occurs under a naturalist approach to prevent natural selection relaxation. Over 8.000 captive bred fish were already released (Figures 8 and 9) in their natural populations for population reinforcement and, consequently, to minimise the risk of extinction *in situ*. Since this program was pioneer in Portugal, it promptly gathered a high level of attention by the media and local communities, which have been invited to participate in restocking and environmental education actions.

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Figure 8. - Fish release in Alcabrichel. Photo: Aquário Vasco da Gama.

Figure 9. – Presenting fish to school children. Photo: Aquário Vasco da Gama.

This project was successful at addressing all its original objectives, which were:

1. Assess *in situ* benefits from the recently conducted restocking actions (monitoring the current density of individuals and compare it with previously gathered baseline data).
2. To support the logistics of a third restocking action.

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3. To implement *in situ* conservation measures, which were conducted with local students, to consolidate the need to have locals as allies in the conservation of the fluvial ecosystem. Without this funding, restocking actions would continue to be mere releases of fish without a formal involvement of the society.
4. Funding allocated to genetic analyses for the prosecution of the captive breeding programme targeting this species, since the quantification of an eventual loss of genetic diversity is essential to maintain or to change the ongoing procedures in the future. This objective was partially met, and DNA analyses are still underway with regards to assess whether current genetic diversity may be considered satisfactory, or not.

Title of project: Safeguarding the Critically Endangered Siamese crocodile (*Crocodylus siamensis*) through combined *in situ* and *ex situ* conservation measures (2016)

Project leader: Thomas Ziegler **EUAC member:** Cologne Zoo

Year supported: 2016 **Amount supported:** 5 000 €

Summary of project: This project was a follow-up to an impressive list of previous projects by the same author, also funded by EUAC:

1. Anthropogenic and environmental-dependent behaviors of the Endangered Crocodile Lizard (Figure 10) in Vietnam with concrete implications for species conservation (2015)
2. Conservation translocation program of *Shinisaurus crocodilurus* to reinforce the dramatically small wild population in Vietnam (2014)
3. Ecological research and population analysis of the Chinese Crocodile Lizard in Vietnam (2012)
4. Assess the ecology of freshwater fish community in the Menangat-Kenohan Suwi wetlands of Kalimantan Indonesia (2012)
5. Preliminary assessment of the Siamese Crocodile population in Indonesia (2010)
6. Breeding and research programme for rare and endangered amphibian amphibians from Vietnam (2008)

Figure 10. - Thomas Ziegler with *Crocodylus siamensis* at Cologne Zoo. Photo: Thomas Ziegler.

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The projects above yielded a publication (Behler *et al.* 2018) but this following summary is relative to the 2016 project.

The Siamese Crocodile (*Crocodylus siamensis*) is listed as Critically Endangered by the IUCN Red List because natural populations in its distribution range have been reduced by 80% over the last decades. Historically, this species was widely distributed in mainland Southeast Asia, including Cambodia, Indonesia, Lao PDR, and Vietnam. However, the natural populations in Vietnam have probably been extirpated due to the extremely high hunting pressure. Natural populations in Cambodia, Lao, and Thailand have also become highly fragmented and threatened. Most populations have less than ten individuals and might not be able to survive long into the future.

Recent surveys conducted by the project's team, near Ban Soc, Bualapha District, Khammouane Province, Lao PRD, identified an unknown, overlooked population of the species which at the same time represented the rediscovery of the Siamese crocodile in Khammouane Province. Similar to populations documented in previous studies, this population contains only few observed individuals. Based on external morphology, respective individuals could be identified as pure Siamese Crocodile. Additional interviews with local people revealed the sighted crocodiles to represent remains of a natural population. However, to ensure that sighted animals are not escaped farm hybrids, molecular testing of noninvasively collected samples from the site is currently underway.

One of the most cost-effective conservation options for the species would be to restock the diminished wild populations throughout its range or even conduct reintroduction in particular cases in suitable habitat where the species has become extinct in combination with habitat and species conservation measures. In Vietnam, the first population was introduced in Cat Tien National Park in the early 2000s. Breeding has been subsequently documented, which demonstrates initial success of the programme. A major challenge for the build-up of restocking/reintroduction efforts is to identify purebred individuals from captive programmes in the range countries. This process was carefully implemented in the introduction programme in Cat Tien National Park through genetic screening of captive individuals using microsatellite markers and mitochondrial genes. However, the remaining captive colonies in Vietnam and Laos have not been monitored closely to confirm purity of Siamese Crocodile individuals held in the facilities.

In addition to the previous two projects coordinated by Professor Thomas Ziegler, this researcher has been involved with numerous other projects in Southeast Asia, many of which receiving funding from EUAC and yielding an impressive collection of publications: Behler *et al.* (2018), Bernardes *et al.* (2011), Bernardes *et al.* (2013), Anon. (2012), Bernardes *et al.* (2012), Gawor *et al.* (2012), Gawor *et al.* (2009), Gawor *et al.* (2016), Gawor *et al.* (2012b), Gawor *et al.* (2011), Geissler *et al.* (2015), Geissler *et al.*(2014), Hecht *et al.* (2013), Hendrix *et al.* (2009), Hendrix *et al.* (2008), Hendrix *et al.* (2007), Hendrix *et al.* (2008), Le *et al.* (2015), Le *et al.* (2014), Lötters *et al.* (2011), Luu *et al.* (2014), Luu *et al.* (2013), Luu *et al.* (2013b), Nguyen Quang *et al.* (2008), Nguyen Quang *et al.* (2009), Nguyen *et al.* (2012), Nguyen *et al.* (2016), Nguyen *et al.*(2013), Nguyen *et al.* (2014), Nguyen *et al.* (2012), Ohler *et al.* (2011), Pham *et al.* (2014), Pham *et al.* (2016), Pham *et al.* (2015), Pham *et al.* (2016), Pham *et al.* (2016), Pham *et al.* (2016), Phung *et al.* (2013), Rauhaus *et al.* (2012), Rowley *et al.* (2016), Scheld *et al.* (2013), Strauß *et al.* (2013), Tarkhnishvili *et al.* (submitted), Ten Hagen *et al.* (2016), Tran *et al.* (2010), Tran *et al.* (2011), Van der Straeten *et al.* (2007), Wildenhues *et al.* (2010), Wildenhues *et al.* (2011), Wildenhues *et al.* (2012), Ziegler (2010), Ziegler (2009), Ziegler (2011), Ziegler (2007), Ziegler (2008), Ziegler (2008b), Ziegler (2010), Ziegler (2016), Ziegler *et al.* (2008), Ziegler & Nguyen (2008), Ziegler & Nguyen (2013), Ziegler & Pagel (2008), Ziegler *et al.* (2016), Ziegler *et al.* (2015), Ziegler *et al.* (2014), Ziegler *et al.* (2008), Ziegler & Vu (2009), Ziegler (2007), Ziegler *et al.* (2011), Ziegler & Dieckmann (2013), Ziegler & Nguyen (2010), Ziegler & Rauhaus (2015), Ziegler *et al.* (2013), Ziegler *et al.* (2015), Ziegler & Thanh (2009).

Title of project: In search of the Red Girl in Madagascar

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Project leader: Brian Zimmerman **EUAC member:** Zoological Society of London
Year supported: 2016 **Amount supported:** 9 045€

Summary of project: The expedition had the primary purpose of providing training and support for the Andapa aquaculture facility, which holds a number of highly threatened Malagasy endemic freshwater fish species, including its owner and the team of local people that he employs. Training in water quality analysis, pond design and infrastructure improvements, fish handling and transport and a review of diets and nutrition for each species were provided as requested. The expedition team also returned to the collection site in the Amboaboa River in order to assess changes to the habitat and to collect additional members of the focal species to improve the genetic integrity of the captive population in Andapa (Figure 11).

Figure 11. - Searching for the Critically Endangered Mangarahara cichlid and taking water quality samples from one of the locations, with the help of the local community. Photo: Tim McCaskie.

Key objectives of this project were:

1. To improve the welfare of the collection of over twenty Malagasy freshwater endemic species being managed at the Andapa aquaculture facility.
2. To increase the breeding success of each species being maintained in Andapa after a full review of their environmental triggers for spawning and their ecological requirements.
3. To ensure that robust, genetically healthy populations of each threatened Malagasy species is maintained long term for future restocking programmes.
4. To acquire and secure stable captive populations of those species of threatened Malagasy freshwater fish species that are not currently kept in the Andapa aquaculture facility including sufficient numbers of *Paretroplus gymnopreoperculatus*.
5. To raise the profile of Madagascar's unique endemic freshwater fish fauna on a national and international level with particular emphasis on teaching the local community of their value.

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6. To provide husbandry training to the Andapa aquaculture facility to help improve breeding success and encourage stable and sufficiently sizeable populations for future generations.
7. To provide training in fish handling and transport to the employees of the Andapa aquaculture facility in order to improve survival during translocation exercises.
8. To provide training in water quality management to the employees of the Andapa aquaculture facility to encourage greater monitoring of key parameters and avoid losses.
9. To hold a workshop with relevant people in Madagascar focused on developing a conservation management plan for species of freshwater fish under threat.

Title of Project: Marine fishes of São Tomé and Príncipe
Project leader: Nuno V. Rodrigues **EUAC member:** Flying Sharks
Year supported: 2015 **Amount supported:** 10 000 €

Summary of Project: São Tomé and Príncipe is an independent African country located in the Gulf of Guinea, crossed by the equator, and approximately 150 nautical miles off the west coast of Africa. It hosts a unique diversity of marine fauna, including endemisms and species of rare beauty, and therefore has been considered a hotspot of marine biodiversity by multiple authors, such as those involved in several studies on the coastal marine fish communities, such as Afonso *et al.* (1999), California Academy of Sciences (2009), Wirtz *et al.* (2007), Floeter *et al.* in 2008 and ultimately by the applicant (N. V. Rodrigues) in March 2014, November 2014, and February 2015. Nevertheless, local marine fauna was still one of the least known in the world and was facing alarming signs of overexploitation at the time of the application (2014), which is still very much the case. More importantly, local authorities have demonstrated their frustration by the lack of information left in-country by recent scientific expeditions. Therefore, there was an urgent need to (1) improve the scientific knowledge on fish communities of São Tomé and Príncipe, (2) increase the environmental awareness towards proper management of local resources and (3), most importantly, improve the knowledge transfer to local authorities and appropriated stakeholders.

The large majority of São Tomé and Príncipe's population depends directly on artisanal fishing. Recent reports demonstrated signs of overexploitation of coastal fishes and alarming collateral impacts of fishing activities, such as declining trend of large sized fish namely sharks, groupers, and snappers, increasing trend of lost fishing gears in the reefs and an increasing occurrence of small sized fish in the market including filefish, boxfish and other supposedly locally non-edible species, until recently. According to the applicants *in situ* observations and reports from local fishermen, overfishing may be caused by an increased fishing effort, increased fishing capacity of boats and engines, and the increase of destructive fishing practices such as the use of mosquito nets or scuba divers in seine-net fisheries. Therefore, it is not surprising that local authorities have asked for collaboration with increasing the environmental awareness and with increasing the local capacity for implementing proper management of local resources, including the establishment of marine protected areas.

During this project, a poster was made featuring all commercially exploited species (Figure 12), photographed with high resolution by the applicant, as well as the book 'Coastal Marine Fishes of São Tomé and Príncipe' (Figure 13), a bilingual (Portuguese and English) 123 pages edition, of which 1200 copies were made. The book launch, held at the Oceanário de Lisboa, welcomed a full room of marine biology enthusiasts, naturalists, and journalists.

Additionally, approximately 100 copies of the poster, and of the book, were offered to Government officials, namely from the Fisheries Board, with whom Flying Sharks (the applicant) signed a protocol for future cooperation. While cooperation did not occur since, multiple lectures were given throughout São Tomé – in schools and dive clubs – alerting for the dangers of overfishing. Local dive clubs were instrumental in getting this message across, as were multiple NGOs that partnered with the project, such as 'ATM – *Associação de Tartarugas Marinhas*', '*Projecto Tatô*', 'MARAPA', and '*Príncipe Trust*'.

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Figure 12. – Poster with commercially exploited marine fish species in São Tomé and Príncipe.

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Figure 13. – The book 'Coastal Marine Fishes of São Tomé and Príncipe' bilingual (Portuguese and English) edition.

Title of project: Integrating freshwater fish into biodiversity conservation in Turkey (2010)

Project leader: Anton Weissenbacher & Brian Zimmerman **EUAC member:** Vienna Zoo & Zoological Society of London

Year supported: 2010 **Amount supported:** 1 522 €

Summary of project: Several species in the genus *Aphanius* have very small distributions and are seriously threatened. The distribution of these small, maximum 6 cm long fish includes waters around the Mediterranean Sea, on the Arabian Peninsula and in parts of Africa, Turkey, Pakistan and India. *Aphanius* inhabit extreme habitats. High salt and sulphur concentrations cannot harm them, nor can daily temperature fluctuations of around 20°C. Nevertheless, almost all *Aphanius* species and their subspecies are threatened; some members of the group are even extinct. The causes of the endangerment include the destruction of habitats (e.g. for hotel buildings on the coast), intensive water abstraction for agriculture and drinking water production, as well as the introduction of non-native fish species. These small, completely economically insignificant fish have no lobby and stand in the way of national interests such as mass tourism and classic economic development measures. Strategies to protect *Aphanius* have only started a decade ago. Around 20 species and six subspecies of the genus are kept at the Vienna Zoo and are regularly and successfully bred, three of which are

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already Extinct in the Wild. The offspring was distributed to other zoos and organisations as part of the conservation programmes.

The research project on the Azraq killifish, *Aphanius sirhani*, has provided many previously unknown results about temperature requirements and egg development of this species. Such data are crucial to take the right measures for long-term conservation in natural habitat restoration projects.

The Vienna Zoo, together with the Zoological Society London, the University of Ankara and Birdlife Turkey, initiated a research project on the conservation status of *Aphanius* species in Turkey. As part of this project, genetic and morphological studies were conducted in cooperation with the University of Vienna and other institutions, in order to investigate the relationship of selected highly threatened *Aphanius* populations and species. The results showed that at least one of the populations examined was identified as an independent, previously undescribed species.

Title of Project: Fish Net Greece

Project leader: Brian Zimmerman **EUAC member:** Zoological Society of London

Year supported: 2005 **Amount supported:** 7 715 €

In 2005 the EUAC Conservation Fund contributed funding to support the first ever survey of the entire known and suspected range for the Critically Endangered killifish, *Valencia letourneuxi* in Western Greece and the Ionian islands (Crivelli 2006). The species was later split into two species (*V. letourneuxi* and *V. robertae*), which comprise two of only three species from the family Valenciidae, confined entirely to the Mediterranean Basin in Europe (Freyhof *et al.* 2013). All three species are found in lowland spring areas with the third species confined to spring areas on the Mediterranean Spanish coast (Bianco 1987).

The EUAC funded survey was conducted over two expeditions, sampling 92 sites in multiple basins from Corfu Island in the north to the Pinios River basin in the south, Peloponnese region (Figure 14). The findings of this survey were published in a report prepared by the Institute of Marine Biological Resources and Inland Waters (IMBRIW), which later formed the basis of several further monitoring expeditions and publications on the distributional findings and threats to the species (Kalogianni *et al.* 2010, Giakoumi *et al.* 2006).

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Figure 14. - Sampling for the Critically Endangered Corfu killifish, *Valencia letourneuxi*. Photo: Yannis Kapakos.

This expedition led to the establishment of a long-term partnership, 'Fish Net Greece', between the Hellenic Centre for Marine Research (HCMR) and the Zoological Society of London (ZSL) which lasted until 2020, when the UK half of the partnership was transferred to the Bristol Zoological Society (BZS). Over the course of the partnership, subsequent funding resulted in multiple research and conservation initiatives, including the support of several PhDs, a conservation translocation exercise, and live teleconferencing field to school-based conservation teaching and the establishment of insurance populations of both Balkan *Valencia* species at *ex -situ* facilities in Greece.

With the initial seed funding from EUAC a vast increase in the knowledge gained and disseminated to the scientific and conservation community for these two species was achieved. A PhD student focussed on using eDNA (environmental DNA) to monitor cryptic species such as *Valencia* killifish and led to the more widespread use of this protocol for monitoring freshwater basins in Greece for endemic and highly threatened species (Mauvisseau *et al.* 2020). EUAC funding of a species-based conservation project for a little known but highly threatened freshwater teleost has demonstrated the value of providing seed funding to small projects and what they can achieve over time.

Consequences - Discussion

Since 2004, more than one quarter of a million euros were awarded to 49 projects, which spanned all over the globe (Tab. 1 and 2). The majority of funded projects had a significant impact on local populations and/or their focus species, while only few were less extensive in content and scope. Nineteen projects were part of larger associations with several projects, while eleven of these received only initial funding from EUAC, and 14 received follow-up funding. Meanwhile, EUAC awarded more than 116 000 € to 23 projects focusing on species with extinction risk.

In 2020, five projects were on standby, mostly due to the Covid-19 pandemic and financial constraints that resulted from it. From 49, only eight were not continued after the initial funding period of one year, the majority due to a particular task or scientific question.

Nearly 70% of the projects (Tab. 3) are still ongoing and therefore have managed to get further financing. In some cases, it has led to an extraordinary enlargement of the projects. That is the case of the turtle rescue station in Naples, which has developed into an Excellence Centre with an annual research budget of 100 000 €. Aquarium Pula in Croatia managed to receive 600 000 € as investment into a new turtle rescue station in Croatia. Also, the freshwater fish projects managed either to get further project money to continue the work in Greece, Turkey and Madagascar with another 100 000 €, 15 000 € and 80 000 € respectively, or are now permanently supported by constant funding, such as the Vasco da Gama Aquarium project in Portugal.

Projects from Zoo Vienna, Cologne Zoo and Zoo Leipzig have constant funding from their respective zoo's conservation funds. Approximately 50% of the projects yielded numerous peer-reviewed articles (Tab. 3) and approximately 50% have a direct involvement in species protection programmes, often involving threatened species.

Results on projects mentioned earlier show that conservation efforts were in fact reached with the funding allocated by EUAC, and it is important to mention the *quality* of results achieved with limited funding, as less than 10 000 € of financial support are typically awarded per project. The majority of projects funded reported that they achieved their goals in their entirety, which were largely related to raising awareness in local populations about threatened species. Whether this fact has an actual impact in the conservation of such species, is not clear. One could however argue that, at least during the duration of each project, local communities were actively engaged with the researchers involved.

Such is the case with projects like the conservation of *Achondrostoma occidentale* in Portugal, *Batagur baska* in Bangladesh, *Crocodylus siamensis* in Indonesia, *Valencia letourneuxi* in Western Greece, or even corals in the Maldives and Croatia, and fisheries in São Tomé and Príncipe. While these

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projects may not have solved the underlying conservation issue, they certainly raised a considerable amount of awareness on the subject during their duration. Such projects could benefit from following up on two fronts: (1) ascertain whether any progress can be attributed to efforts conducted during the project, with the local communities originally involved, and (2) lobby for legislation that is conducive to results that benefit the project's aim, with local governments.

The major shortcoming of any conservation effort, not EUAC's alone, is converting financial aid into effective conservation of species. While EUAC's funded programmes mostly focused on gathering fundamental scientific knowledge and raising awareness on species within local communities, perhaps future endeavours could focus on assisting local populations in building businesses that can convert a sustainable and positive 'use' of species into revenue for local communities to optimise the impact of conservation efforts. This is the path that has largely been followed to protect sharks and sea turtles, with shark diving and turtle related ecotourism activities providing far more revenue than previous activities, focusing on killing these animals. Anderson & Waheed (2001), Topelko & Dearden (2005), Clua *et al.* (2011), Conte (2011), Tanner (2013), Mieras *et al.* (2017), and Gonzáles-Mantilla *et al.* (2022) provide prime examples for such conservation strategies. Conservation projects must become more engaged in the real world and be able to operate under human impact. On one hand, this means realising our limitations of conserving pristine environments, but on the other involving local people and especially younger generations in conservation efforts could generate appropriate strategies for counteracting the increasing loss of biodiversity.

At the same time, small funding sources like EUAC provide quick and targeted options when scientific knowledge is lacking. Knowledge of ecology, behaviour and dynamics in animal communities are still key factors in the success of conservation and offer an informed and measurable way to conserve biological diversity and educate others. Short-term funds similarly provide important options to test new conservation directions in particular habitats or head start *ex-* and *in situ* research as foundation for larger future projects. Small scale but speedy funding options and application process also allow projects to react to possible imminent risks of extinction, rapidly implement new scientific findings or respond to unforeseen events in a reasonable timescale.

One difficulty reported by project leaders of EUAC funded programmes was the actual amount of time available to be dedicated to conservation efforts. The projects are rarely their main activity but, rather, a secondary aspect of their main duties, which are traditionally related to husbandry practices within the institution they are affiliated with. It would therefore be advantageous to have more public aquaria and zoos allocate staff to deal specifically with conservation related issues, including requesting funding and implementation of projects on the ground, with adequate follow up in the end. Such is the case of the Zoological Society of London, with the team working on *Valencia letourneuxi* incorporating these conservation matters into their job description, but this is not the case in most other institutions, which have limited staff and funds to allow for a department allocated exclusively to *in situ* and/or *ex situ* conservation efforts.

This limitation became abundantly clear even during the preparation of this manuscript, which admittedly falls short of providing a thorough set of information on every single project. There were multiple reasons for this, ranging from lack of follow up on project updates, criteria for evaluation the outcomes of projects and information being lost due to projects being undertaken many years ago.

Conclusions

Perhaps the most valid conclusion to be drawn from the list of projects covered in this work, is the fact that, regardless of the outcome, as far as preservation of the species are concerned, local communities were actively engaged in a subject that would, otherwise, remain unbeknown to them. Additionally, these EUAC funded projects highlight how public aquarium activities reach far beyond the acrylic panels surrounding the tanks and indeed the walls of the institution, as they spread around the world and raise awareness within local communities to preserve biodiversity. These projects further suggest that a future direction for EUAC, as well as the public aquaria it consists of,

could – indeed *should* - include more strenuous lobbying with legislating bodies, to ensure more adequate – and stronger – *in situ* conservation measures. In conclusion, with so many doubts being raised by different movements about the existence of aquaria and zoos, it is important that the public is aware that it is their visit to see the ambassadors of different species of animals that allows for funding of many of these pilot projects that aim to preserve species in their natural environment.

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References

Anon. Verknüpfung ökologischer Nischenmodellierung mit naturschutzrelevanter in situ Forschung: Verbreitung und Bestandssituation des IUCN-gelisteten und endemischen Vietnamesischen Krokodilmolch Tylototriton vietnamensis im Norden Vietnams. Terraria 5, Nr. 12 (2012): 118–19.

Anon. Conserving Vietnam's biodiversity - The Cologne Zoo's nature conservation programme in Vietnam. Association of Zoos and Aquariums) Nr. 9 Zoos help sustaining the rich biodiversity of Vietnam" 9 (o. J.): 5–9.

Afonso P., Porteiro F.M., Santos R.S., Barreiros J.P., Worms J., Wirtz P. Coastal marine fishes of São Tomé Island (Gulf of Guinea). *Arquipélago. Life and Marine Sciences* 17 A (1999): 65–92.

Anderson C., Waheed A. The economics of shark and ray watching in the Maldives. *Newsletter of IUCN Shark Specialist Group*, Shark News, 13, Nr. Shark News (2001): 3.

Behler N., Kopsieker L., Staniewicz A., Darmasyah S., Stuebing R., Ziegler T. Population size, demography and diet of the Siamese crocodile, *Crocodylus siamensis* (Schneider, 1801) in the Mesangat swamp in Kalimantan, Indonesia. *Raffles Bulletin of Zoology*, Nr. 66 (2018): 506–16.

Bernardes M., Pham T.C., Nguyen Q. T., Ziegler T. Newt beginnings: How EAZA has facilitated public awareness training and in situ research of an IUCN listed newt species endemic to Vietnam. *Zooquaria* 73 (2011): 23.

Bernardes M., Rödder D., Nguyen T.T., Pham C.T., Nguyen T.Q., Ziegler T. Habitat chracterization and potential distribution of *Tylototriton vietnamensis* in northern Vietnam. *J. Nat. Hist.* 47 (2013): 17–18. https://doi.org/10.1080/00222933.2012.743611.

Bernardes M., Rödder D., Pham C.T., Nguyen T.Q., Ziegler T. Integration of species distribution modeling with in situ research for the conservation of the endemic Vietnamese crocodile newt (*Tylototriton vietnamensis*). *Froglog* 20, Nr. 5 (2012): 21–23.

Bianco P. G. Précision sur la distribution de Cobitis taenia Linnaeus, 1758 (Cobitidae) et de Valencia hispanica (Valenciennes, 1846) (Cyprinodontidae) dans les eaux douces d'Italie. *Cybium* 11 (2) (1987): 207–12.

Carlson, R.R. *et al.* Land Use Impacts on Coral Reef Health: A Ridge-to-Reef Perspective" *Front. Mar. Sci.* (18 September 2019)

Clark, M.R. *et al.* The impacts of deep-sea fisheries on benthic communities: a review". *ICES Journal of Marine Science* (73), Issue suppl_1, January (2016): i51–i69.

Clua E., Buray N., Legendre P., Mourier J., Plane S. Business partner or simple catch? The economic value of the sicklefin lemon shark in French Polynesia. *Marine and Freshwater Research* 62 (2011): 764–70.

Conte A. What is the Value of a Sea Turtle?: A Case Study of the Conservation Ethics of Sea Turtle Fishermen in the Caribbean Coast of Nicaragua. *Independent Study Project (ISP) Collection*, 2011, 1186.

Correia J.P.S. Marine Animals and Human Care Toward Effective Conservation of the Marine Environment. In *Leal Filho W., Azul A.M., Brandli L., Lange Salvia A., Wall T. (eds) Life Below Water*. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham., 2020.

Crivelli A.J. In *IUCN Red List of Threatened Species. Version 2012*. Bd. 1. IUCN, 2006.

Darwall, W. *et al.* Freshwater biodiversity: a hidden resource under threat." Wildlife in a changing world. *An Analysis of the 2008 IUCN Red List of Threatened Species 43* (2009).

Dick G. Gusset M. The global reach of zoos and aquariums in visitor numbers and conservation expenditures. *International Zoo Yearbook*, 2010. https://doi.org/10.1002/zoo.20369.

Dudgeon, D. Multiple threats imperil freshwater biodiversity in the Anthropocene." *Current Biology* 29 (19), (2019), Pages R960-R967.

Floeter S.R., Rocha L.A., Robertson D.R., Joyeux J.C, Smith-Vaniz W.F., Wirtz P., Edwards A.J., u. a. Atlantic reef fish biogeography and evolution. *Journal of Biogeography* 35 (1) (2008): 22–47. https://doi.org/10.1111/j.1365-2699.2007.01790.x.

Freyhof J., Kärst H., Geiger M.F. *Valencia robertae*, a new killifish from southern Greece (Cyprinodontiformes: Valenciidae). *Ichthyological Exploration of Freshwaters v.* 24 (4) (2013): 289–98.

Gawor A., Chapuis S., Pham C.T., Nguyen T.Q., Schmitz A., Ziegler T. Larval morphology oft wo species of the genus Theloderma (Tschudi, 1838) from Vietnam (Anura: Rhacophoridae: Rhacophorinae). *Zootaxa* 3395 (2012): 59–64.

Gawor A., Hendrix R., Vences M., Böhme W., Ziegler T. Larval morphology in four species of *Hylarana* from Vietnam and Thailand with comments on the taxonomy of *H. nigrovittata* sensu latu (Anura: Ranidae). *Zootaxa* 2051 (2009): 1–25.

Gawor A., Pham C.T., Nguyen T.Q., Nguyen T.T., Schmitz A., Ziegler T. The herpetofauna of the Bai Tu Long National Park, northeast Vietnam. *Salamandra* 52, Nr. 1 (2016): 23–41.

Gawor A., Rauhaus A., Karbe D., Van Der Straeten K., Lötters, Ziegler T. Is there a chance for conservation breeding? Ex situ management, reproduction, and early life stages of the Harlequin toad *Atelopus flavescens* Duméril & Bibron, 1841 (Amphibia: Anura: Bufonidae). *Amphibian and Reptile Conservation* 5, Nr. 3 (2012b): 29–44.

Gawor A., van der Straeten K., Karbe D., Manthey U., Ziegler T. Reproduction and development of the dark-sided frog *Hylarana nigrovittata* sensu lato at the Cologne Zoo. *Salamandra* 47, Nr. 1 (2011): 1–8.

Geiger C.C., Bregnard C., Maluenda E., Voordouw M. J., Schmidt B. R. Antifungal treatment of wild amphibian populations caused a transient reduction in the prevalence of the fungal pathogen, *Batrachochytrium dendrobatidis*. *Scientific Reports* 7 (2017). https://doi.org/10.1038/s41598-017-05798-9.

Geiger C.C., Schmidt B. R. Laboratory tests of antifungal agents to treat tadpoles against the pathogen *Batrachochytrium dendrobatidis*. *Dis Aquat Org* 103 (2013): 191–97.

Geiger C.C., Schmidt B. R., Origgi F.C. Accumulation of the pathogenic fungus *Batrachochytrium dendrobatidis* on the regressing tail of midwife toads *Alytes obstetricans* undergoing metamorphosis. *Amphibia-Reptilia* 34 (2013): 255–58.

Geissler P., Hartmann T., Ihlow F., Rödder D., Poyarkov N. A., Nguyen T.Q., Ziegler T., Böhme W. The Lower Mekong: an insurmountable barrier to amphibians in southern Indochina? *Biological Journal of the Linnean Society* 114, Nr. 4 (2015): 905–14.

Geissler P., Poyarkov N. A., Grismer L., Nguyen T.Q., An H.T., Neang T., Kupfer A., Ziegler T., Böhme W., Müller H. New *Ichthyophis* species from Indochina (Gymnophiona, Ichthyophiidae): 1. The unstriped forms with descriptions of three new species and the redescription of *I. acuminatus* Taylor, 1960, *I. youngorum* Taylor, 1960 and *I. laosensis* Taylor, 1969. *Organisms, Diversity and Evolution* 15, Nr. 1 (2014): 143–75. https://doi.org/10.1007/s13127-014-0190-6.

Giakoumi S., Zimmerman B., Zogaris S., Economou A.N., Kalogianni E. Current population status of Valencia letourneuxi (Sauvage 1880) in the Mornos River Delta. Poster., 2006.

Gonzáles-Mantilla P.G., Gallagher A.J., León C.J., Vianna G.M.S. Economic impact and conservation potential of shark-diving tourism in the Azores Islands. *Marine Policy* 135 (2022): 12.

Gusset M., Dick G. The global reach of zoos and aquariums in visitor numbers and conservation expenditures. *Zoo Biol.* 30 (2011): 566–69.

Hecht V.L., Pham C.T., Nguyen T.T., Nguyen T.Q., Bonkowski M., Ziegler T. First Report on the herpetofauna of Tay Yen Tu Nature Reserve, northeastern Vietnam. *Biodiversity Journal* 4, Nr. 4 (2013): 507–52.

Hendrix R., Böhme W., Ziegler T. The tadpole of the helmeted toad, *Ingerophrynus galeatus* (Günther, 1864), from Vietnam (Anura: Bufonidae). *Herpetology Notes* 2 (2009): 155–60.

Hendrix R., Gawor A., Vences M., Ziegler T. The tadpole of the narrow-mouthed frog *Microhyla fissipes* from Vietnam (Anura: Microhylidae). *Zootaxa* 1675 (2008): 67–68.

Hendrix R., Grosjean S., Le Khac Q., Vences M., Vu Ngoc T., Ziegler T. Molecular identification and description of the tadpole of the Annam Flying Frog, *Rhacophorus annamensis* Smith, 1924 (Anura: Rhacophoridae). *Salamandra* 43 (1) (2007): 11–19.

Hendrix R., Nguyen Quang T., Böhme W., Ziegler T. New anuran records from Phong Nha – Ke Bang National Park, Truong Son, central Vietnam. *Herpetology Notes* 1 (2008): 23–31.

Kalogianni E., Giakoumi S., Zogaris Y., Chatzinikolaou Y., Zimmerman B., Economou A.N. Current distribution and ecology of the critically endangered *Valencia letourneuxi* in Greece. *Biologia* 65 (2010): 128–39.

Le D. T., Pham A.V., Nguyen S, H. L., Nguyen Q. T., Ziegler T. First records of *Megophrys daweimontis* Rao and Yang, 1997 and *Amolops vitreus* (Bain, Stuart and Orlov, 2006) (Anura: Megophryidae, Ranidae) from Vietnam. *Asian Herpetol. Res.* 6, Nr. 1 (2015): 66–72.

Le D. T., Pham A.V., Nguyen S.H.L., Ziegler T., Nguyen T.Q. *Babina lini* (Chou, 1999) and *Hylarana menglaensis* Fei, Ye et Xie, 2008, two additional anuran species for the herpetofauna of Vietnam. *Russian Journal of Herpetology* 21, Nr. 4 (2014): 315–21.

Leewis R.J., Janse M. Advances in Coral Husbandry in Public Aquariums. *Public Aquarium Husbandry Series*, Public Aquarium Husbandry Series, 2 (2008): 460.

———. Advances in coral husbandry in public aquariums. In *International Symposium of Coral Husbandry in Public Aquaria*. Arnhem: Burgers' Zoo, 2008.

Lötters S., Ellwein D., Karbe D., van der Straeten K., Luger M., Rautenberg J., Rödder D., Venegas P. J., Werner P., Ziegler T. Erforschung und Schutz der letzten Harlekinfrösche. *Elaphe* 19, Nr. 2 (2011): 6–11.

Luu V.Q., Calame T., Nguyen T.Q., Ohler A., Bonkowski M., Ziegler T. First records of *Gracixalus supercornutus* (Orlov, Ho and Nguyen, 2004) and *Rhacophorus maximus* Günther, 1858 from Laos. *Herpetology Notes* 7 (2014): 419–23.

Luu V.Q., Le C. X., Do H. Q., Hoang T.T., Nguyen T.Q., Bonkowski M., Ziegler T. New records of amphibians from Thuong Tien Nature Reserve, Hoa Binh Province, Vietnam. *Herpetology Notes* 7 (2013): 51–58.

Luu V.Q., Nguyen T, Q., Pham C.T., Dang K. N., Vu T. N., Miskovic S., Bonkowski M., Ziegler T. No end in sight? Further new records of amphibians and reptiles from Phong Nha – Ke Bang National Park, Quang Binh Province, Vietnam. *Biodiversity Journal* 4, Nr. 2 (o. J.): 285–300.

Mauvisseau Q., Kalogianni E., Zimmerman B., Bulling M., Brys R., Sweet M. eDNA-based monitoring: Advancement in management and conservation of critically endangered killifish species. *Environmental DNA*, 2020, 1–13.

Mieras P.A., Harvey-Clark C., Bear M., Hodgin G., Hodgin B. Chapter Five - The Economy of Shark Conservation in the Northeast Pacific: The Role of Ecotourism and Citizen Science. *Advances in Marine Biology* 78 (2017): 121–53.

Nguyen T.Q., Hendrix R., Böhme W., Vu Ngoc T., Ziegler T. A new species of the genus *Philautus* (Amphibia: Anura: Rhacophoridae) from the Truong Son Range, Quang Binh Province, central Vietnam. *Zootaxa* 1925 (2008): 1–13.

Nguyen Quang T., Dang That T., Pham The C, Nguyen Thien T, Ziegler T. Amphibian breeding station in Hanoi: a trial model for linking conservation and research with sustainable use. *Froglog* 91 (2009): 12–15.

Nguyen T.Q., Le M.D., Pham C.T., Nguyen T.T., Bonkowski M., Ziegler T. A new species of *Gracixalus* (Amphibia: Anura: Rhacophoridae) from northern Vietnam. *Organisms Diversity & Evolution*, 2012. https://doi.org/10.1007/s13127-012-0116-0.

Nguyen T.Q., Pham C.T., Nguyen T.T., Ngo H.N., Ziegler T. A new species of *Theloderma* (Amphibia: Anura: Rhacophoridae) from Vietnam. *Zootaxa* 4168, Nr. 1 (2016): 171–86.

Nguyen T.Q., Phung T.M., Le M.D., Ziegler T., Böhme W. First record of the genus *Oreolalax* (Anura: Megophryidae) from Vietnam with description of a new species. *Copeia* 2 (2013): 213–22.

Nguyen T.Q., Phung T.M., Schneider N., Botov A., Tran D.T.A., Ziegler T. New records of amphibians and reptiles from southern Vietnam. *Bonn zool. Bulletin* 63, Nr. 2 (2014): 148–56.

Nguyen T.Q., Ziegler T. Amphibian research and conservation in Vietnam. *Froglog* 20, Nr. 5 (2012): 21–23.

Ohler A., Wollenberg K.C., Grosjean S., Hendrix R., Vences M., Ziegler T., Dubois A. Sorting out Lalos: description of new species and additional taxonomic data on megophryid frogs from northern Indochina (genus *Leptolalax*, Megophryidae, Anura). *Zootaxa* 3147 (2011): 1–83.

Ohler A., Wollenberg K.C., Grosjean S., Hendrix R., Vences M., Ziegler T., Dubois A. Sorting out Lalos: taxonomic revision of a group of megophryid frogs from northern Indochina (genus *Leptolalax*). *Zootaxa*, o. J.Packer J., Ballantyne R. The role of zoos and aquariums in education for a sustainable future. *New directions for adult and continuing education* 127 (2010): 25–34.

———. The role of zoos and aquariums in education for a sustainable future. *New Directions for Adult and Continuing Education* 127 (2010). https://doi.org/10.1002/ace.378.

Pham A.V., Le D.T., Nguyen S.H.L., Ziegler T., Nguyen T.Q. First records of *Leptolalax eos* Ohler, Wollenberg, Grosjean, Hendrix, Vences, Ziegler et Dubois, 2011 and *Hylarana cubitalis* (Smith, 1917) (Anura: Megophryidae, Ranidae) from Vietnam. *Russ. J. Herpetology* 21, Nr. 3 (2014): 195–200.

Pham A.V., Le D. T., Pham C.T., Nguyen S.L.H., Ziegler T., Nguyen T.Q. Two additional records of megophryid frogs, *Leptobrachium masatakasatoi* Matsui, 2013 and *Leptolalax minimus* (Taylor, 1962), for the herpetofauna of Vietnam. *Revue Suisse de Zoologie* 123, Nr. 1 (2016): 35–43.

Pham C.T., Dogra A., Gawor A., Rauhaus A., Kloeble G., Nguyen T.Q., Ziegler T. First record of *Amolops cremnobatus* from Thanh Hoa Province, Vietnam, including an extended tadpole description and the first larval staging for *Amolops*. *Salamandra* 51, Nr. 2 (2015): 111–20.

Pham C.T., Nguyen T.Q., Bernardes M., Nguyen T.T., Ziegler T. First records of *Bufo gargarizans* Cantor, 1842 and *Odorrana lipuensis* Mo, Chen, Wu, Zhang et Zhou, 2015 (Anura: Bufonidae, Ranidae) from Vietnam. *Russ. J. Herpetology* 23, Nr. 2 (2016): 103–7.

Pham C.T., Nguyen T.Q., Hoang C. V., Ziegler T. New records and an updated list of amphibians from Xuan Lien Nature Reserve, Thanh Hoa Province, Vietnam. *Herpetology Notes* 9 (2016): 31–41.

Pham C.T., Nguyen T.Q., Le M.D., Bonkowski M., Ziegler T. A new species of *Odorrana* (Amphibia: Anura: Ranidae) from Vietnam. *Zootaxa* 4084, Nr. 3 (2016): 421–35.

Phung T.M., Nguyen T.Q., Rauhaus A., Ziegler T. The first record of the Middle Back-stripe Bullfrog, *Kaloula mediolineata* (Anura: Microhylidae), from Phu Qui Island, Binh Thuan Province, southern Vietnam. *Herpetology Notes* 6 (2013): 463–65.

Rauhaus A., Gawor A., Perl R.G.B., van der Straeten K., Karbe D., Pham C.T., Nguyen T.Q., Ziegler T. Larval development, stages and an international comparison of husbandry parameters of the Vietnamese Mossy Frog *Theloderma corticale* (Boulenger, 1903) (Anura: Rhacophoridae). *Asian Journal of Conservation Biology* 1, Nr. 2 (2012): 51–66.

Reid, A. J., *et al.* Emerging threats and persistent conservation challenges for freshwater biodiversity." *Biological Reviews* 94.3 (2019): 849-873.

Rodrigues N.V., Bertoncini Á., Fontes J. Peixes marinhos costeiros de São Tomé e Príncipe | coastal marine fishes of São Tomé and Príncipe. *Flying Sharks & European Union of Aquarium Curators*, 2018, 123.

Rowley J. J. L., Tran D.T.A., Le D. T.T., Dau V.Q., Peloso P. L. V., Nguyen T.Q., Hoang H. D., Nguyen T.T., Ziegler T. Five new, microendemic Asian Leaf-litter frogs (*Leptolalax*) from the southern Annamite mountains, Vietnam. *Zootaxa* 4085, Nr. 1 (2016).

Scheld S., Perl R.G.B., Rauhaus A., Karbe D., Van Der Straeten K., Hauswaldt J. S., Randrianiaina R.D., Gawor A., Vences M., Ziegler T. Larval morphology and development of the Malagasy frog *Mantidactylus betsileanus*. *Salamandra* 49, Nr. 4 (2013): 186–200.

Schmidt B. R., Küpfer E., Geiger C.C., Wolf S., Schär S. Elevated temperature clears chytrid fungus infections from tadpoles of the midwife toad, *Alytes obstetricans*. *Amphibia-Reptilia* 32 (2011): 276–80.

Smith M., Warmolts D., Thoney D., Hueter R., Murray M., Ezcurra J. The Elasmobranch Husbandry Manual II: Recent Advances in the Care of Sharks, Rays and their Relatives. *Special Publication of the Ohio Biological Survey* 8 (2017): 504.

Smith M., Warmolts D., Thoney R., Hueter R. The Elasmobranch Husbandry Manual: Captive Care of Sharks, Rays and their Relatives. *Special Publication of the Ohio Biological Survey* 15 (2004): 589.

Strauß S., Ziegler T., Allmeling C., Reimers K., Frank-Klein N., Seuntjens R., Vogt P. M. In vitro culture of skin cells from the Critically Endangered Chinese giant salamander, *Andrias davidianus* (Blanchard, 1871) (Amphibia, Caudata, Cryptobranchidae). *Amphibian and Reptile Conservation* 5, Nr. 4 (2013): 51–63.

Tanner C. Sea Turtle Conservation in Ghana's Western Region: The Bigger Picture. *Marine Turtle Newsletter*, 2013, 136 Auflage.

Tarkhnishvili D., Schmitz R., Ziegler T. Trends in the variability of body proportions in Vietnamese anurans: Influence of climatic conditions versus climate-independent geographic clines. *Amphibia-Reptilia*, o. J.

Ten Hagen L., Rodriguez A., Menke N., Göcking C., Bisping M., Frommolt K.-H., Ziegler T., Bonkowski M., Vences M. Vocalizations in juvenile anurans: common spadefoot toads (*Pelobates fuscus*) regularly emit calls before sexual maturity. *Sci Nat* 103, Nr. 75 (2016). https://doi.org/10.1007/s00114-016-1401-0.

Thrush, S.F., Dayton, P.K. Disturbance to marine benthic habitats by trawling and dredging: Implications for marine biodiversity". *Annu Rev Ecol Syst* 33 (2002): 449–473.

Topelko K.N., Dearden P. The Shark Watching Industry and its Potential Contribution to Shark Conservation. *Journal of Ecotourism* 4 (2) (2005): 108–28.

Tran A.T.D., Le Q.K., Le K.V., Vu T.N., Nguyen T.Q., Böhme W., Ziegler T. First and preliminary frog records (Amphibia: Anura) from Quang Ngai Province, Vietnam. *Herpetology Notes* 3 (2010): 111–19.

Tran D.T.A., Nguyen T.T., Phung T.M., Böhme W., Ziegler T. Redescription of *Rhacophorus chuyangsinensis* Orlov, Nguyen & Ho, 2008 (Anura: Rhacophoridae) based on new collections from south Vietnam. *Revue Suisse de Zoologie*, o. J.

Tran D.T.A., Nguyen T.T., Phung T.M., Ly T., Böhme W., Ziegler T. Redescription of *Rhacophorus chuyangsinensis* Orlov, Nguyen & Ho, 2008 (Anura: Rhacophoridae) based on new collections from new south Vietnamese provincial records: Lam Dong and Khanh Hoa. *Revue Suisse de Zoologie* 118, Nr. 3 (2011): 413–21.

Van der Straeten K., Karbe D., Olbort S., Ziegler T. First record of the Asian horned frog, *Megophrys nasuta*, in the Aquarium of the Cologne Zoo. *Terraria* 62, Nr. 4 (2007): 45–51.

Weissenbacher, A., Preininger, D., Ghosh, R., Morshed, A.G.J., Praschag, P. 2015. Conservation breeding of the Northern river terrapin Batagur baska at the Vienna Zoo, Austria, and in Bangladesh. International Zoo Yearbook 49: 31-41.

Wildenhues M., Gawor A., Nguyen T.Q., Nguyen T.T., Schmitz A., Ziegler T. First description of larval and juvenile stages of *Rhacophorus maximus* Günther, 1859 ‚1858' (Anura: Rhacophoridae) from Vietnam. *Revue Suisse de Zoologie* 117, Nr. 4 (2010): 1–18.

Wildenhues M. J., Bagaturov M., Schmitz A., Tran D. A. T., Hendrix R., Ziegler T. Captive management and reproductive biology of Orlov's tree frog, *Rhacophorus orlovi* Ziegler & Köhler, 2001 (Amphibia: Anura: Rhacophoridae), including larval description, colour pattern variation and advertisement call. *Der Zoologische Garten N.F.* 80 (2011): 287–303.

Wildenhues M., Rauhaus A., Bach R., Karbe D., van der Straeten K., Hertwig S.T., Ziegler T. Husbandry, captive breeding, larval development and stages of the Malayan horned frog *Megophrys nasuta* (Schlegel, 1858) (Amphibia: Anura: Megophryidae). *Amphibian and Reptile Conservation* 6, Nr. 1 (2012): 15–28.

Wirtz P., Ferreira C.E.L., Floeter S.R., Fricke R., Gasparini J.L., Iwamoto T., Rocha L., Sampaio C.L.S., Schliewen U.K. Coastal Fishes of São Tomé and Príncipe islands, Gulf of Guinea (Eastern Atlantic Ocean)—an update. *Zootaxa* 1523 (2007): 1–48.

Woodhams D. C., Geiger C.C., Reinert L. K., Rollins-Smith L.A., Lam B., Harris R. N., Briggs C. J., Vredenburg V. T., Voyles J. Treatment of amphibians infected with chytrid fungus: learning from failed trials with itraconazole, antimicrobial peptides, bacteria, and heat therapy. *Dis Aquat Org* 98 (2012): 11–25.

Ziegler T. Amphibian and reptilian diversity research, conservation and breeding projects in Vietnam. In *Building a future for wildlife: zoos and aquariums committed to biodiversity conservation*, 117–22. Gland: WAZA Executive Office, 2010.

———. Breeding and diversity research: "ex situ" and "in situ" Asian amphibian projects of the Cologne Zoo. In *Programme and abstract book, Biology of the amphibians in the Sunda Region, South-East Asia*, 25. Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, University Hamburg, 2009.

———. Breeding, research and conservation of tropical herpetodiversity: Linking ex situ with *in situ* approaches. In *Biodiversity is Life*, 73–77. Gland: WAZA Executive Office, 2011.

———. Field surveys and collection management as basis for herpetodiversity research and nature conservation in Vietnam. In *Development of Hochiminh City Museum of Natural History*, herausgegeben von Ho Chi Minh City People's Committee, Viet Nam Union of Science and Technology Associations, Colivam, PTC, 230–48. Chi Minh City, 2007.

———. In situ and ex situ amphibian conservation projects of the Cologne Zoo: Research and breeding as our contribution towards species protection. *Zeitschrift des Kölner Zoos* 51(2) (2008): 67–88.

———. Protecting amphibian diversity. *The Federal Government informs, Magazine of development policy 03/2008* 062 (2008): 27–29.

———. Research as important challenge of Zoological Gardens to preserve biodiversity. In *Verhandlungsbericht des IV. Rigi-Symposiums*, 75–80. Goldau-Rigi, 2010.

———. Two decades of herpetodiversity research in Vietnam and Laos: A review of a German-Vietnamese long-term cooperation. In *Proceedings of the 3rd National Scientific Conference on Amphibians and Reptiles in Vietnam*, 5–18. Hanoi, Vietnam: Publishing House for Science and Technology, 2016.

Ziegler T., Hartmann T., Van der Straeten K., Karbe D., Böhme W. Captive breeding and larval morphology of *Tylototriton shanjing* Nussbaum, Brodie & Yang, 1995, with an updated key of the genus *Tylototriton* (Amphibia: Salamandridae). *Der Zoologische Garten N.F.* 77 (2008): 246–60.

Ziegler T., Nguyen T.Q. Amphibian and Reptile breeding - The amphibian and reptilian breeding station at Hanoi. *WAZA Magazine (World Association of Zoos and Aquariums) Nr. 9 Zoos help sustaining the rich biodiversity of Vietnam"* 9 (2008): 10–14.

Ziegler T., Nguyen T.Q. *Gracixalus waza*: May we introduce the WAZA Treefrog? A recently discovered amphibian species from northern Vietnam and named in honour of WAZA. *WAZA news* 1, Nr. 13 (2013): 2–3.

Ziegler T., Pagel T. The contribution of the Cologne Zoo towards the Amphibian Ark: Breeding projects, research and education for the protection of amphibians. *Draco* 9(34) (2008): 87–96.

Ziegler T., Rauhaus A., Mutschmann F., Dang, P. H., Pham C.T., Nguyen T.Q. Building up of keeping facilities and breeding projects for frogs, newts and lizards at the Me Linh Station for Biodiversity in northern Vietnam, including improvement of housing conditions for confiscated reptiles and primates. *Der Zoologische Garten* 85 (2016): 91–120.

Ziegler T., Rauhaus, A., Nguyen T.Q., Nguyen K. V. Südlichster Nachweis von *Gekko badenii* Szczerbak & Nekrasova, 1994, mit Bemerkungen zur Herpetofauna der Hon Me-Auffangstation in der Provinz Kien Giang, Südvietnam. *Sauria* 37, Nr. 2 (2015): 3–14.

Ziegler T., Tran D.T.A., Nguyen T.Q., Perl R.G.B., Wirk L., Kulisch M., Lehmann T., u. a. New amphibian and reptile records from Ha Giang Province, northern Vietnam. *Herpetology Notes* 7 (2014): 185–201.

Ziegler T., Van der Straeten K., Karbe D. *The Asian Horned Frog Megophrys nasuta.* Art für Art. NTV Terrarienbibliothek, 2008.

Ziegler T., Vu Ngoc Thanh. Mười năm nghiên cứu đa dạng lưỡng cư bò sát tại Vườn Quốc gia Phong Nha - Kẻ Bàng. In *[Ten years herpetodiversity research in Phong Nha - Ke Bang National Park*, Bd. 167–178. Hue City: Hue University Publishing House, 2009.

Ziegler T. Batrachological basis research within the nature conservation project of the Cologne Zoo in Vietnam. In *Amphibians deserve our support. A contribution for the implementation of the WAZA resolution concerning measures against amphibian decline*, herausgegeben von Dollinger P., 124, 2007.

———. Conserving Vietnam's biodiversity - The Cologne Zoo's nature conservation programme in Vietnam. *Association of Zoos and Aquariums) Nr. 9 Zoos help sustaining the rich biodiversity of Vietnam"* 9 (o. J.): 5–9.

Ziegler T., Dang T.T., Nguyen T.Q. Breeding, natural history and diversity research: Ex situ and in situ Asian amphibian projects of the Cologne Zoo and the Institute of Ecology and Biological Resources. In *Proceedings of the Conference Biology of the amphibians in the Sunda region, South-east Asia"*, 137–46. Sarawak, Malaysia: Institute of Biodiversity and Environmental Conservation, Universiti Malaysia Sarawak, 2011.

Ziegler T., Erfassung, D.R., Erhalt der Amphibienvielfalt. Projekte des Kölner Zoos. *Praxis der Naturwissenschaften BIOLOGIE in der Schule / Artensterben bei Amphibien* 62, Nr. 2 (2013): 10–16.

Ziegler T., Nguyen T.Q. New discoveries of amphibians and reptiles from Vietnam. *Bonn zoological Bulletin* 57, Nr. 2 (2010): 137–47.

Ziegler T., Rauhaus A. Erste herpetologische Amtshilfe aus Köln im Zoo Saigon. *Terraria / Elaphe* 54 (2015): 72–80.

Ziegler T., Rauhaus A., Karbe D., Nguyen T.Q., Pham C.T., Huy P. D. New amphibian keeping and breeding facilities created at the Me Linh Station for Biodiversity, northern Vietnam. *Amphibian Ark Newsletter Number 23 June 2013*, 2013, Abschn. 14-15.

Ziegler, T., Rauhaus A., Tran T. D., Pham C.T., Van Schingen M., Dang H. P., Le M.D., Nguyen T.Q. Die Amphibien- und Reptilienfauna der Me-Linh-Biodiversitätsstation in Nordvietnam. *Sauria* 37, Nr. 4 (2015): 11–44.

Ziegler T., Thanh V.N. Ten years of herpetodiversity research in Phong Nha – Ke Bang National Park, central Vietnam. In *Ke Bang National Park and Cologne Zoo, 10 years of cooperation (1999-2009)*, 103–24. Quang Binh:, 2009.