FROGS & FRIENDS

BIG STORIES FROM SMALL MESSENGERS

DARWIN & GOLIATH

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A home for amphibians

The Amphibium at Hanover Adventure Zoo – a project by Frogs & Friends

Editorial

Björn Encke, managing director of Frogs & Friends

In past centuries, becoming independent from nature was considered cultural progress. Nature was either degraded to a place that had to be subjugated by humans or embellished into a romantic mirage of paradise lost. Those who spent time with animals were ridiculed or, at best, labelled as the oddballs of a society in which 'cultured' circles met at premieres and art exhibitions. Modern humans had conquered nature.

Today, we know that this will lead straight to disaster. The future viability of human civilisation will depend largely on the extent to which we succeed in redefining our relationship with nature as an integral part of our cultural identity.

Zoos play a key role in this context. They have always been a central forum for discourse, where the relationship between humans and animals is negotiated and reflected upon. Presentation has traditionally been based on the principle of the theatre's peep-box stage. An animal enclosure designed according to social fashion (and zoological expertise) serves as a stage for the audience, who can thus witness the spectacle of the inhabitants. The audience's favourites are therefore particularly social species, which offer a correspondingly varied programme through their interaction. Amphibians are rather total failures in this respect; neither social nor particularly interactive, they usually sit motionless somewhere. They are therefore underrepresented in zoos. The problem is that amphibians are the most endangered class of animals. If zoos define themselves as responsible for species conservation, and if the traditional display case principle does not work for amphibians, then alternative forms of presentation must be sought in order to address the issue.

Frogs & Friends has made this its mission, and we are very grateful that Hanover Adventure Zoo has decided to tackle this topic with us as a partner. There are more than enough stories to tell. Just think of the more than 40 amphibious reproduction strategies that have been described – as mammals (with exactly one strategy between us), we can only pale with envy. So it's about finding ways and means to spark people's interest in a world that doesn't flaunt its charms. I believe we have been quite successful in this regard. However, that is not all. Ultimately, we must steer the social discourse in what we believe to be the right direction. One way to achieve this is by abolishing the peep-box principle, which implicitly reduces the audience to the role of consumers. The collapse of biodiversity threatens our very existence, but in this case we are by no means limited to the role of passive spectators. Each and every one of us can do something, can take responsibility.

This message is conveyed at the end of the exhibition, which highlights the need for coordinated conservation breeding programmes in human care and uses the example of citizen conservation to illustrate concrete ways in which civil society can participate. The example of amphibians in particular shows that zoos, as scientifically managed institutions, can play a central role as coordinators, but that civil society has far greater capacities in terms of the sheer number of potential keepers – in Germany alone, there are more than three million aquariums and terrariums in private households. This potential must be tapped.

We can overcome the extinction crisis if we remember the key ability that has made humans the dominant species on Earth: the ability to cooperate. Ultimately, it is a question of cultural self-image.

This, in a nutshell, is the social meta-level of the Amphibium at Hanover Adventure Zoo, which we would like to present to you in this issue of Darwin & Goliath. We hope that we have contributed to an actual frog-leap into the future.

With best regards,

Contents

It was a cold, snowy winter day in the pandemic year of 2021 when we first set off for Hanover to think about frogs in barns …

Bernd Schultheis, Camillo Kuschel and Adriaan Klein from the Frogs & Friends exhibition team during their first tour of the former pasta restaurant at Hanover Adventure Zoo. This is where the frogs will move in.

From pasta restaurant to Amphibium

Planning and realisation of an amphibian house at Hanover Adventure Zoo

Björn Encke

In early 2021, we received a phone call. The Hanover Adventure Zoo had been forced to close all of its restaurants during the coronavirus pandemic, and one of them would not be reopening. The idea was that instead of pasta, frogs and newts would delight visitors in a half-timbered barn. Perhaps we had some suitable suggestions for what could be done there?

Of course! We quickly gathered our 'friends,' our tried-and-tested exhibition team consisting of architect/designer duo Adriaan Klein and Camillo Kuschel, our digital and sound engineer Bernd Schultheis, film writer and exhibition curator Susann Knakowske, and myself as project manager. And off we went to Hanover.

We had 250 m^2 at our disposal, and a viable idea had to be developed by the summer. The requirement was to preserve the character of the barn as much as possible – so we first set about thinking up facilities and themes around the numerous wooden posts until we were slightly desperate but had gained the insight that behind the wood was a steel frame construction under a 3.55 m high concrete ceiling. This suddenly opened up significantly more and more 'amphibian-friendly' options for the interior design. The 'octopus design' proposed by our architect Adriaan Klein convinced not only us, but also the zoo's management team led by director Andreas Casdorff. The next step was to develop a detailed concept so that a valid cost estimate could be made and the project submitted to the zoo's supervisory board for approval.

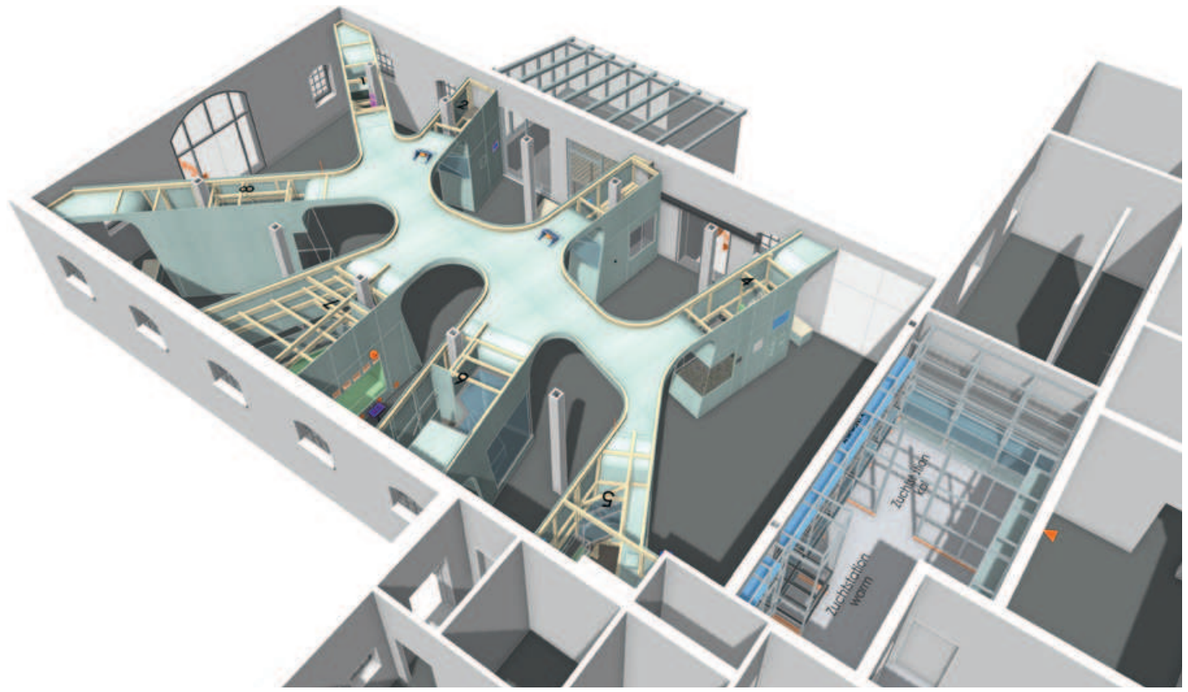
The basic architectural and educational concept

The basic idea was to introduce visitors to selected species of amphibians as they walked through the exhibition, while at the same time familiarising them with various research disciplines. The aim was to convey the message that keeping wild animals in human care is both sensible and necessary.

A general challenge is that there is no such thing as 'the zoo visitor'; rather, it is an extremely heterogeneous group of people with very different expectations and needs: grandparents or parents with their children, school classes, season ticket holders, couples and zoo enthusiasts who make a special trip to Hanover to visit the zoo in general and a particular area in particular. What all these groups have in common is that they usually arrive at the House of Amphibians at the end of their tour. So we tend to be dealing with people who are already slightly tired. This means that we have to design the exhibition in such a way that it can be 'consumed in stages'. In case of doubt, visitors should be able to understand the message intuitively through the visual design of the exhibition alone, without having to read a single word.

These considerations resulted in a specific hierarchy in the approach. Design was the top priority. The shape and colour scheme were to have an inviting and unobtrusive character. Ideally, this would lead to a feeling of relaxed relief upon entering the room, coupled with a curiosity to engage with a new topic, because it is not a repetition of previous experiences with different content, but appeals to completely different senses. It was therefore essential to avoid the impression that this room was crammed full of information.

Adriaan Klein's octopus design was convincing in both aesthetic and functional terms.



The framework consisted of choosing an organic-looking octopus shape as structuring element and a central empty space beneath the octopus‘s body, which appears to float beneath the ceiling. From there, the eight ‘arms’, each with a minimum width of 110 cm, clearly structure the room.

Their technical function is to integrate the animal enclosures and accommodate all the technical equipment so that it can be easily accessed and operated by the keepers.

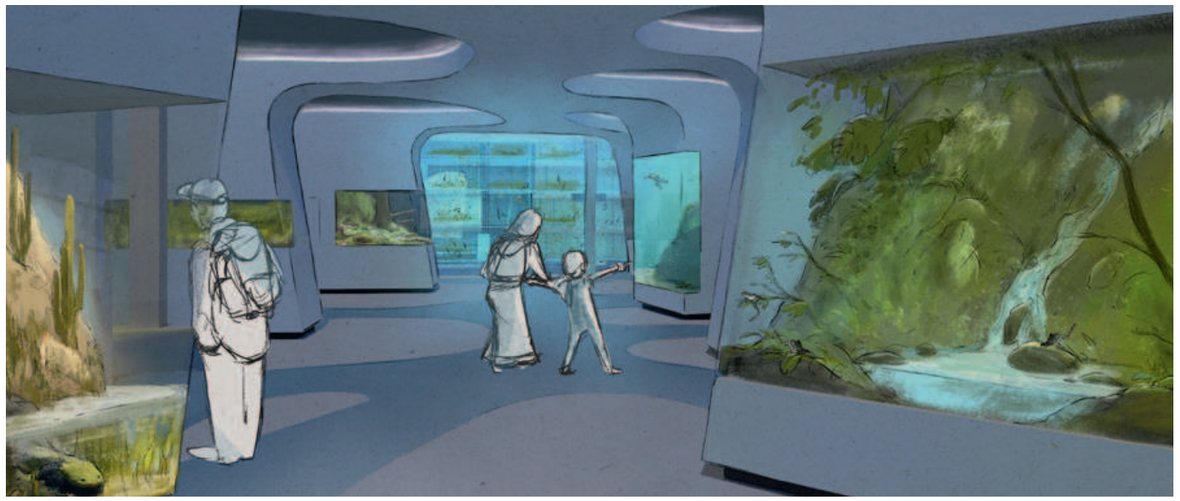
The attention of visitors is drawn directly to the animal enclosures, which are staged as illuminated parts of the octopus arms and fit seamlessly into the organic overall structure, including the front sides, which are inclined at an angle of nine degrees.

The second challenge was staging the content, because even though we wanted to avoid overwhelming exhibition visitors with too much information we have a lot to tell.

Moreover, it is unfortunately one of the peculiarities of amphibians that, although they possess the most amazing abilities, these are not usually available at the touch of a button, unlike digital offerings.

We started by making two decisions to structure the content of the experience. Firstly, the entire front exhibition area inside the octopus shape should primarily be fun and inspire fascination for the biological abilities of the amphibians on display. Only in the rear section, directly in front of the ceiling-high species wall with a view of the breeding area, are the threats to and protection of amphibians addressed – specifically the same species that were previously presented.

Secondly, people identify primarily with other people, not with animals (and certainly not with amphibians).
For this reason, each animal species presented is accompanied by people who have a special connection to it, whether as discoverers, keepers or researchers. In this way, biological phenomena are transformed into human stories, which in turn can help to make them more accessible.



Before and after: The reality of 2024 differs from the illustrations of 2021 almost exclusively in terms of colour, which is now slightly brighter and more cheerful.

How do we actually know how many animals of a species exist?

Simple question, simple answer: you count and then calculate. Visitors can try their hand at amateur research around the 7 m² open enclosure for Oriental Fire-bellied Toad, counting the toads and giving their estimate of the total population in the enclosure.

At the back, things get musical. Many frogs don‘t like to show themselves, but they call all the more conspicuously during the mating season – and calls can be counted if you have good ears (but beware: in most species, only the males call). Using the example of five native frogs, you can hold a little acoustic location contest and guess the number of frogs calling at the pond. The best ear at the pond wins – and learns that not all frogs croak.

You don‘t have to be dead to be honoured at the Amphibium

Viennese scientist Doris Preininger, very much alive, has even raised a glass with her own image – to the Foot-flagging Frogs, of course.

Unfortunately, French physician and zoologist Auguste Duméril, after whom the Lake Patzcuaro Salamanders are named, will not be able to enjoy this honour, as he died in 1870.

Medical research has its own ‘Kraken Room’ and a video terminal. Among the most relevant amphibians for research are the axolotl, which has the extraordinary ability to completely regenerate entire limbs and even parts of the brain, and the African Clawed Frog, formerly known in many parts of the world as the Pharmacist‘s Frog because it was kept in pharmacies worldwide from the 1940s onwards to identify pregnancies. Both one of the leading regeneration researchers, Elli Tanaka, and (posthumously) the inventor of the frog pregnancy test, zoologist Lancelot Hogben, are featured here.

Amphibian medicine

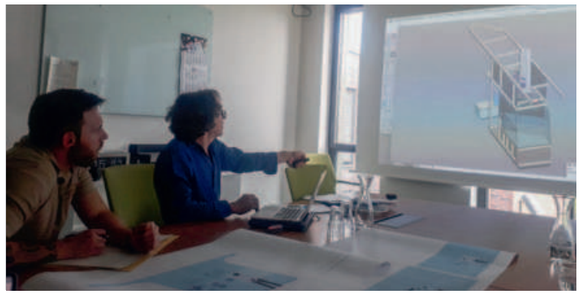
Frog cinema

Additional digital features, such as some 60 videos and twelve podcasts, are available exclusively in seating alcoves away from the main viewing areas. Here, visitors can sit down and delve deeper into selected topics such as medical research, Fire Salamander conservation, frog communication and Jacques Cousteau‘s legendary expedition to Lake Titicaca.

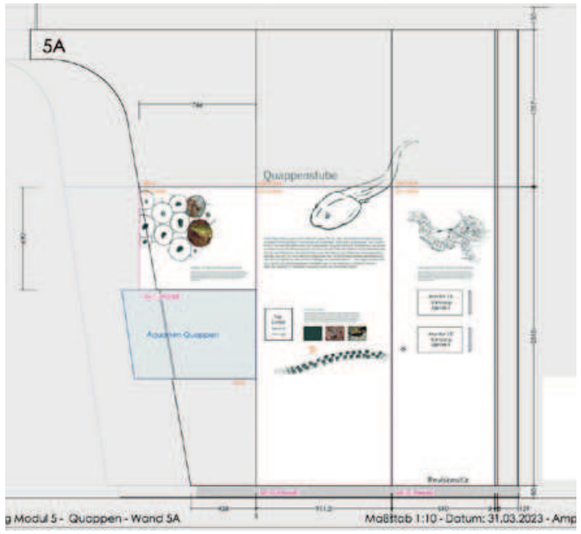
When designing the information layout for the individual topics, which generally correspond spatially to the respective walls of the octopus arms, we also opted for a multi-level approach. The focus is on the animal enclosure itself, which is labelled with a corresponding animal sign in a classic and informative manner. The overarching theme is clarified by a headline with a brief explanation. This can be understood in less than a minute – and even if you limit yourself to that, the puzzle comes together as a whole.

Further individual aspects are presented in a variety of ways. In addition to stories by and about the 'godparents', these can include illustrated information boxes, interactive elements or small monitors, models or drawers that provide a wealth of in-depth background information for a wide range of target groups. In order to avoid creating visual competition with the animal enclosures, we decided to keep the audio-visual videos out of the primary field of vision and to offer them in specially designed niches.

This meant that the basic structure of the exhibition in terms of construction and content was in place, and we were able to draw up an initial cost estimate. In summer 2021, the supervisory board of Hanover Adventure Zoo approved the commissioning of the million-euro project. Work then began on the detailed elaboration of the concept and the implementation planning, on the basis of which the tenders could be issued. The zoo took on all the basic work, i.e. the preparation and development of the building, including the suspension of the ceiling and floor coating, as well as the practical construction management. We were responsible for planning, assisting with the awarding of contracts and, together with the zoo, supervising the construction of the exhibition, as well as the design and layout of the animal enclosures and the entire educational programme.



Each module was discussed in detail with district manager Revin Meyer to determine the best possible compromise between technical, design and animal welfare requirements.



Layout of the tadpole wall

In summer 2022, the barn will be cleared and empty.

Meanwhile, the tank for the future rainforest is already filling with water.

From concept to implementation

In spring 2022, we completed the basic implementation plans. The subsequent tendering process took much longer than expected due to the consequences of the war in Ukraine. Among other things, our architect Adriaan Klein redesigned all the panel dimensions for the exhibition walls in response to the sanctions against Russia in order to find an alternative to the multiplex birch panels we had originally wanted, which are mostly sourced from Russia and have slightly different basic dimensions to other multiplex panels.

The planning of the exhibition didactics went smoothly, so that most of the elements were in production during the course of 2022. This included filming and editing more than 60 individual videos, programming the digital modules, and creating the layout for the walls – a process that involved constant back-and-forth between image research, creating and adapting illustrations and texts, not to mention the fact that the layout of an entire wall had to be changed at times due to structural requirements.

Initially, it proved somewhat difficult to find a partner for the interior design of the facilities, which is, after all, the heart of any zoological exhibition. We also took care to ensure that the habitats to be designed covered as wide a range as possible. The final goal was to design three terrariums, four aquariums, three paludariums of various sizes and a 24 m^2 rainforest. We did this in the first step by creating scale models out of cardboard and plasticine.

We were very happy to find the right partners in the artificial rock builders at Sculpturescoop, with whom we were able to further refine the designs and implement them. We were able to bring Sabine Hohmann on board as an experienced partner for the botanical design.

However, in the end, the first challenge was not the carpentry work or the construction of the terrariums, but the electrical, ventilation and water technology, for which it took a long time to find suppliers, which delayed the entire construction process. In the winter of 2022/23, work finally got underway, and once the pressurised water pipes for osmosis and mixed water had been installed, work could begin on suspending the ceiling and installing the octopus modules.

The first thing to be installed is the shelving for the future breeding area.

By March 2023, most of the pipes will have been laid under the ceiling.

The exhibition takes shape

The first truly uplifting moment came on 28 March 2023, when the entire Kraken corpus was assembled and manually hoisted up to the ceiling. Each of the eight walls was then attached precisely to the frame. The Schirm carpentry had assembled all the wooden modules in advance in their workshop for testing and then dismantled them into their individual parts.

The precision and speed with which the carpentry team led by site manager Steffen Planken went about their work was equally impressive. Since the arms are grouped around the load-bearing ceiling supports and require precise connections to the central octopus shape, even the slightest shift would have caused the entire structure to become unstable.

On 28 March 2023, the Schirm carpentry in Hanover will arrive to install the body of the exhibition octopus.

The entire module will be assembled and lifted by hand to the ceiling as a whole.

Starting from the ceiling structure, the individual exhibition walls can now be attached with centimetre precision.

Special care was also required when handling the panels, as each one had been double-glazed in advance and then printed using a complex process. To prevent any colour distortion caused by the glaze showing through, white paint was first printed onto the panels, which was then completely covered by the corresponding content.

responsible for the piping of the systems – and, of course, with the artificial rock builders Oliver Blomeier and Andreas Gehlen, who in most cases had to install their designs before the respective tanks could be closed.

Electrician Mathias Kroisleitner from Prokot was involved in every aspect of the project.

Interlocking trades: Part of the cladding on the Fire Salamander module is in place, now half of the basin has to be fitted and the artificial rock tree designed before the basin and cladding can be completed.

In June 2023, the first artificial rock structures, the tubs for the toad enclosure, will be manufactured individually, positioned on the site and connected to each other.

Even the slightest shift in the plates would have resulted in white borders around text and images. The challenge for the teaching team was to ensure that the templates were perfectly positioned. Even a single printing error would have meant that the entire plate would have had to be replaced and remade.

The installation of exhibition walls and terrariums marked the start of what was probably the most challenging phase of the project in terms of coordinating the various trades on site. The Schirm carpentry had to consult with terrarium builder Hans-Jürgen Hohls, because once the basic framework of the modules had been constructed, the terrariums and aquariums had to be installed before the modules could be fully assembled. The installation had to be closely coordinated with colleagues from the water technology company Sander, who were

At the same time, the digital stations had to be installed and connected. All these interdependencies inevitably mean that even a single missing screw can set off a chain reaction that throws all schedules into disarray. These 'missing screws' exist on every complex construction site, and it is in their nature that they cannot be anticipated; they are simply not there.

It is mainly thanks to the patience and strong nerves of site manager Marco Hustedt from Hanover Adventure Zoo that we got through this phase without any major disasters.

Super-secret glimpse into the Titicaca Lake aquarium through a porthole – almost like being in a submarine.

An important milestone in this phase was the installation of the voluminous aquarium for the Titicaca Water Frogs. Due to the water column of almost 2 metres, we opted for a 7 cm thick acrylic glass pane because of the enormous pressure load and the necessary cooling of the water. This was manufactured in one piece, i.e. in an L-shape, in South Korea and had to be lifted by crane into the body of the stainless steel frame, which weighed several tonnes. Before that, our art designers had created the Titicaca riverbank directly inside the steel colossus. The next hurdle was to get the aquarium, which now weighed over four tonnes, into the building and position it with centimetre precision. The solution was a specially built sled on steel rollers.

On 6 June 2023, the colossus rolled precisely through the door into the Amphibium. On 17 July 2023, the aquarium was filled with water for the first time. From then on, it took several months and numerous water changes until the water chemistry had stabilised at levels suitable for the Titicaca Water Frogs.

This is what a Titicaca Water Frog aquarium looks like when it is still under construction.

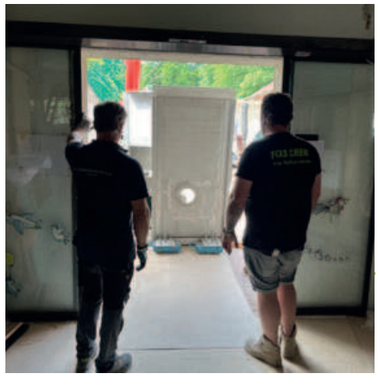
Artificial rock builders Andreas Gehlen and Oliver Blomeier installing riverbank embankments on Lake Titicaca.

Before that, the acrylic glass pane arrives from South Korea via Rotterdam and is installed.

After inserting the pane, the upper steel frame is placed on top and screwed into place. Now everything is ready and we can get started.

What you can't see: after months of rinsing, the water values are finally right. What you can see: the bluish light emphasises the special role of this aquarium.

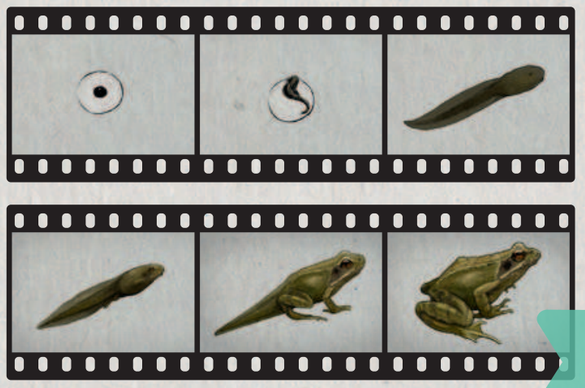
The tank slides into the room without a scratch on the door arch. The final challenge is to position it exactly. Here, every centimetre counts to ensure a precise connection to the exhibition octopus.



The object, which weighs several tonnes and has a clearance of 2 cm in all directions, must pass through this door.

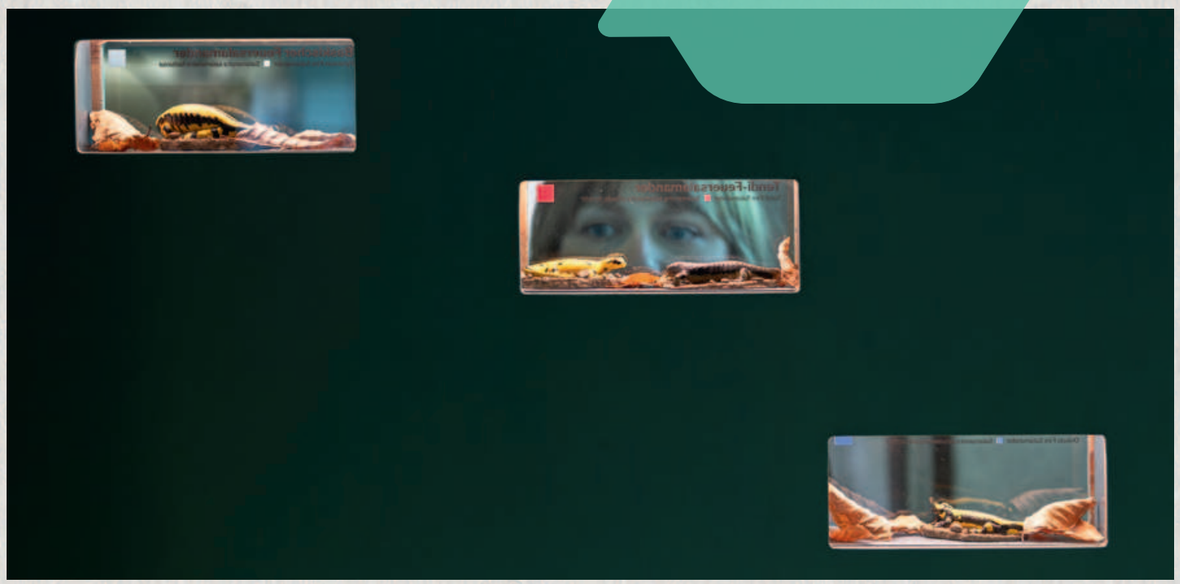
The Titicaca Frog basin is lifted onto a special sled.

Here, everything revolves around metamorphosis. With the digital flipbook, visitors can explore the developmental stages of frogs and butterflies, and future Mallorca Midwife Toads swim in the tadpole aquarium. These can grow into giant tadpoles, which then rightly become small toads. They can also be seen in the wall, but befitting their status, through a rather small peephole.



In the tadpole nursery

Not all Fire Salamanders are the same



There are 14 subspecies of Fire Salamander in Europe – and in Hanover, they can be found as life-like models, artfully modelled by Uwe Seidel.

By October 2023, the remaining artificial rockwork had been completed. Now it was time to focus on the details – the last facilities had to be closed and set up, and the educational modules had to be put into operation and tested. Unfortunately, the hope of having the exhibition ready for the first animals by Christmas was not fulfilled. A basic prerequisite for this was the completion of the breeding room so that the animals could move in first and the keepers and animals had enough time to get used to each other.

But as we all know, the devil is in the details, and the breeding area with its 30 individual tanks had plenty of those. Connecting the cold water aquariums to the cooling circuit and biofilter, ventilation for terrariums and aquariums in the cold and warm areas, sprinkler systems, drains, lighting, interior fittings, a dripping connection here, the famous missing screw there – in the end, it seems to be a law of nature that the hectic activity increases significantly in the final stages and continues until the evening before the opening.

Once the dusty work is complete, the digital modules can be put into operation. Bernd Schultheis setting up the projector projections of poison dart frogs in December 2023.

Filming the construction work. The entire construction project was documented on film. The result can be viewed both in the exhibition and on the Frogs & Friends YouTube channel (film title: 'Creating an amphibian house: the 'Amphibium' at Hanover Adventure Zoo').

Last but not least, even site manager Marco Hustedt donned his work clothes to close the lid of the Foot-flagging Frog enclosure before the future residents arrived from Vienna.

The link to the making-of of the Amphibium

An excellent investment in the future!

Two million for a house full of amphibians? To mark the first anniversary of the opening of the Amphibium, Heiko Werning from Frogs & Friends spoke to Andreas Casdorff, Managing Director of Hanover Adventure Zoo.

Zoo director Andreas Casdorff is a trained businessman and has been managing the Hanover Adventure Zoo since 2013.

One year of Amphibium at Hanover Adventure Zoo – congratulations! How did this extraordinary project come about?

At the time, we had an unused building in the zoo, a closed restaurant, for which we were looking to find a new use. On the other hand, we looked at our animal population and it was obvious that a highly exciting group of animals was significantly underrepresented in our zoo, as in most other zoological institutions: amphibians.

However, because these are particularly fascinating species, we wanted to fill this gap.

Now, amphibians are not elephants, so they are not necessarily audience favourites. How do zoo visitors react when they enter the Amphibium?

That was actually an interesting question! Observing amphibians requires a certain amount of concentration. They are often better camouflaged, smaller in size, and you have to search a little to discover them in their habitats. So, of course, we wondered how such a house would be received by our visitors. But after a year of experience, I can say that the length of time visitors spend in the Amphibium is extremely high! We are really pleasantly surprised by how intensively zoo visitors search for these animals and take their time doing so.

What role does the presentation play, with its large, natural-looking facilities on the one hand and the wealth of additional information, interactive features and digital content on the other?

It all comes together. On the one hand, there are the truly fantastic terrariums and aquariums. They are fascinating to look at in their own right because they beautifully recreate the animals' habitats. And they impressively demonstrate how the individual species have adapted to them. It takes a little time to discover them.

But the educational elements are also very important. Visitors who say, 'That's exciting, I want to know more,' make good use of this information. Finally, the picture is rounded off by the rear area, where we show how conservation breeding actually works and where the public can watch the animal keepers at work. For many, this is a real eye-opener.

Wasn't it, to stay with the metaphor, a bitter pill to swallow, after all the wonderful terrariums and aquariums at the end of the exhibition, to show these efficiency-oriented facilities for conservation breeding?

This balancing act has been very successful. It is particularly important for zoos to be honest and show what the hard work involves if they really want to protect species. It's not all about creating facilities that are attractive to the human eye; you also have to look at animal welfare from a different perspective.

And the audience accepts that?

It is more than accepted – it is understood. The concept is very well received by school classes, for example. It also gives our employees the opportunity to provide further explanations.

What were the biggest challenges in building the Amphibium?

Well, at first I thought it would be easier. I thought you just had to put a few terrariums in there, a bit like building a model railway ... But then we quickly realised that we needed specialists who knew what conditions the different species of amphibians need and how to design something like this. That's why we hired Frogs & Friends. Converting the building was relatively easy, but fine-tuning the terrariums and the technology required for them is really a job for experts. And there's a lot of technology involved! The Amphibium is extremely complex. The inhabitants of each terrarium have their own specific requirements in terms of water, air and the different seasons, and all of this has to be replicated.

Then there is the challenge of needing a cool pool on one side, while visitors have to stand in the warm on the other. It is important to ensure that the windows do not fog up. There are simply a lot of details – which has led to well over 300 sockets being installed, and every socket has some kind of device plugged into it ... – that was quite a challenge.

What significance does the Amphibium have in the overall concept of the adventure zoo?

It is, of course, a bit out of the ordinary, because we usually have immersive worlds themed according to geographical aspects, where people can immerse themselves and feel transported to other habitats. This is different in the Amphibium, even though the individual tanks themselves represent their own little worlds.

However, the Amphibium is located in an area of the zoo that focuses on education. We want to showcase diversity, teach and educate. The Amphibium is perfect for this and has become an essential part of this area.

In the species wall at the end of the exhibition, Citizen Conservation is also presented, a joint conservation breeding initiative between zoos and private animal keepers. In the exhibition itself, Uwe Seidel, a private keeper, is portrayed as a Fire Salamander expert. How important do you think the involvement of private individuals is?

The project has already shown how essential this cooperation is. Amphibians are animals that private keepers have a great deal of expertise and passion for. There are many people who do this very well. There is probably even more expertise in this area among private individuals than in zoos, because private keepers usually have a special focus.

For species conservation, it is urgently necessary to utilise this widely distributed expertise and also the privately kept animal populations in order to establish something sustainable.

That is why we are very happy to support Citizen Conservation. It is also important to us to have an organisation like CC that pays close attention to expertise and the right attitude. This allows us to be confident and proud to say that the private keepers we work with through CC are true experts.

Grand opening of the Amphibium on 14 May 2024. District manager Revin Meyer, zoo director Andreas Casdorff and Frogs & Friends managing director Björn Encke cut the obligatory ribbon.

You are one of the few zoo directors in Germany who are business administrators by training. How would you assess the investment of over two million euros that the Amphibium cost from a commercial point of view now, after one year?

We did spend a lot of money, more than we had originally planned, but if you measure returns not only in monetary terms but also in terms of values such as education and species conservation, then you can say without a doubt that the two million was well invested. We see that visitors enjoy spending time in the Amphibium, that they are very fascinated and ask a lot of questions when they meet the animal keepers – education made fun! They stay in the Amphibium for a long time, especially with children. This is often not so easy, because children usually don't want to search for long before they discover something.

The Amphibium offers adults a good opportunity to guide children to concentrate and look closely. So today I can say with conviction: it was definitely worth it.

So what is your overall conclusion about the Amphibium one year after it opened?

Personally, I am very happy that we have turned this initial idea of 'Hey, let's do something with amphibians!' into such a fantastic project, which is also extremely well received by visitors. I was really pleasantly surprised and it far exceeded my expectations.

You couldn't ask for a better result. Have you found your personal favourite amphibian among the residents of the Amphibium?

For me, it's always exciting to see the diversity that exists. With amphibians in particular, there's also the fact that many habitats are often very small, how strongly a species has adapted to them and how fragile it all is. We have globalisation, we all want to travel and transport goods from A to B – that's just the way it is today. There are also many more people in the world than there used to be. All of this leads to the destruction of many of these small biotopes and their inhabitants, which have developed over a long period of evolution.

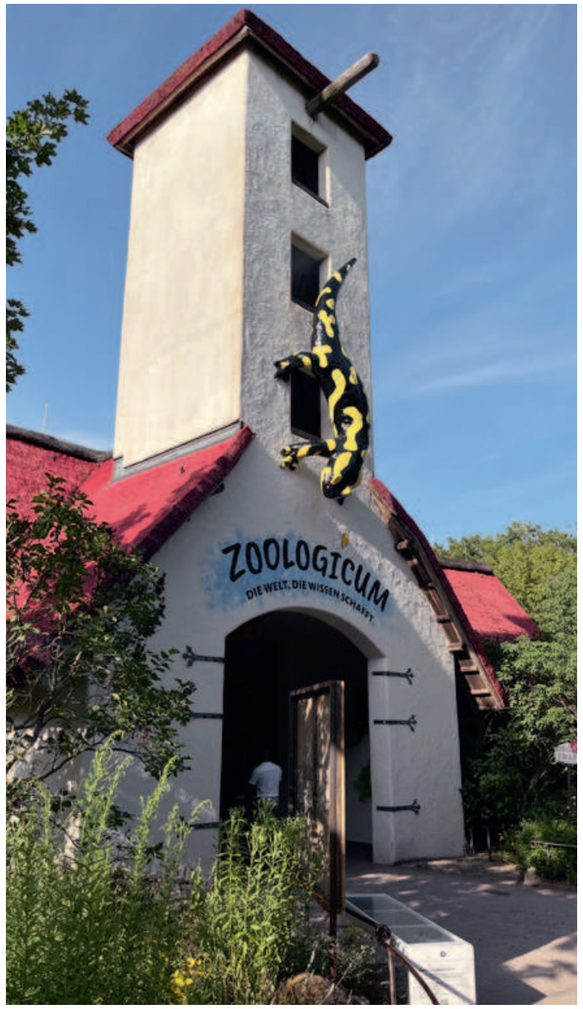
This makes it all the more important today to preserve this diversity, this gene pool. We don't have all the answers yet, and we'll have to see what else we can come up with in the future to solve these challenges, but we can at least say that it's a particularly important task today to preserve as much of this diversity as possible.

Which is undoubtedly one of the most important tasks for modern zoos ...

Among other things, we are tackling this with the Amphibium. I truly believe that we can inspire many people to take an interest in amphibians, who will then take a lot of this knowledge home with them and continue to think about the issues raised. If we can also make a case for private ownership being something very valuable when done properly, and if we can bring this topic into focus, then that is also very important to me.

That's a perfect closing statement!

Many thanks also to the entire Frogs & Friends team for their support. Even though it may have cost me a few grey hairs when I heard that something else had to be added here and something else moved there because these amphibians need their very specific habitats – it was really complex. But when we see the Amphibium today, we can say: this investment in the future was really worth it!



Visible from afar, the Fire Salamander takes on the role of patron for the entire Zoologicum, the zoo area where the Amphibium is located.

Keep them safe

On the different roles of the transparent breeding area in the Amphibium

Björn Encke

Zoological gardens are both a reflection and, in the best case, a barometer of the current social discourse on human-animal relations, animal welfare, nature conservation and species preservation. Against the backdrop of the species crisis on the one hand and a generally zoo-critical public on the other, the transparent breeding area at the Amphibium in Hanover Adventure Zoo has not only a practical but also a strategic function.

From colonial exhibition to species conservation centre

Many zoos in Germany were founded in the second half of the 19th century by members of the upper middle class who were interested in natural science. During this period of colonialism, animals were systematically collected and described for the first time and exhibited in zoological gardens in appropriately elegant, mostly ethnologically designed animal houses. Little was known about the conditions in which the animals were kept, nor was this a focus of attention. Visiting the zoo was an expensive pleasure, usually reserved for the more affluent classes, who used it to demonstrate their interest in natural science. With the crises of the 1920s, many zoos fell into financial difficulties, were municipalised and opened to the general public as local recreational facilities. From the 1960s onwards, nature conservation and species protection became a greater focus for the first time, and the then director of Frankfurt Zoo, Bernhard Grzimek, became the first nationally popular conservationist (and the first German Oscar winner after the war for ‘Serengeti Shall Not Die’).

When zoos across Europe launched the coordinated conservation breeding programme (EEP) in the 1980s, they were perhaps at the height of their role as social trendsetters. Then came German reunification, which shifted priorities. Local

Visitors have the opportunity to watch the keepers at work in the glass breeding room.

In contrast to the habitat sections in the exhibition, the technology here is deliberately made clearly visible.

government budgets were empty, and pressure grew on zoos to professionalise their operations and reduce their need for subsidies.

Species conservation is not a money-spinner, but attractive leisure activities certainly are. Zoos therefore invested in marketing and in designing their offerings in line with the spirit of the times – and reduced their capacity for keeping animals behind the scenes.

In fact, the proportion of municipal zoos that are self-financed has almost doubled over the last 30 years, but this has come at the price of a loss of social acceptance in relation to the core brand values of zoological gardens, namely their expertise in animal welfare and species conservation. Ironically, the industry that is more networked than any other in the world and is dedicated to researching animal behaviour and preserving animals in human care is often seen in media discussions about biodiversity loss and species extinction as part of the problem rather than the solution.

This experience has led to a shift in thinking, and more and more zoos are now positioning themselves as modern species conservation institutions in terms of content and communication, thereby significantly strengthening their brand essence. It is precisely this transformation that we want to highlight with the transparent breeding room in the Amphibium by making it an integral part of the exhibition.

The contrast between harmoniously designed habitat sections and functionally equipped breeding facilities is intended to deliberately trigger cognitive dissonance in visitors, reflexively provoking them to engage with the content.

Keeper Alex Klimcuk operating the tanks in the species wall, which can only be accessed from the rear.

The Fire Salamander as ambassador for the One Plan Approach

In the Amphibium, we show a lovingly arranged section of a native beech forest, a typical habitat of the Fire Salamander, and directly opposite, two sparsely furnished Fire Salamander breeding units, equipped with a water bowl, a tin with moss and a stone as a hiding place. The questions arise naturally: Where does the salamander feel more comfortable? Is the amphibian suffering? Why would anyone do this, especially in a zoo? Is it even allowed?

All these questions are not only justified, they are important and valid. They are precisely the questions that zoos, scientists and, in this case explicitly, private experts have been addressing for many years because they care deeply about animal welfare and species conservation.

Using the Fire Salamander as an example, we have attempted to answer these questions in the exhibition. We do not know exactly what the salamander wants, but scientific research is being conducted to find out where it feels more comfortable.

These findings will be taken into account in the further development of rearing systems. What we can say with certainty is that the amphibian does not suffer when it lives in a functionally equipped terrarium that offers it the appropriate structures from which it can choose according to its needs. We now also know that salamanders live longer and produce healthier offspring in appropriately structured Euro boxes than in terrariums designed to mimic their natural habitat. While this does not answer all the questions, it is at least an indication that this form of keeping salamanders cannot be entirely wrong.

Why a zoo does one or both of these things is easy to explain. In its role as an attractive leisure and educational facility, the beech forest habitat serves to give people an impression of the natural habitat, which makes them feel good – this is about human well-being and education. In its role as a species conservation facility, however, the zoo is solely concerned with animal welfare and the most efficient use of resources. Here, the effort and benefit must be in reasonable proportion. The cost of caring for a salamander in a beech forest habitat is incomparably higher than in a breeding tank, not to mention the production costs.

In this respect, it makes sense for a zoo to display a breeding group of salamanders in a beech forest habitat (for the benefit of humans) and to manage nine additional breeding groups in a systematic environment. The benefit of nine additional beech forest habitats would be negligible for both humans and the species; it would simply be a waste of resources.

The final question remains: Is this permitted? Answer: It is actually necessary! Given the threat to Fire Salamanders posed by the introduced fungal disease *Batrachochytrium salamandrivorans* (*Bsal*), which is leading to local extinctions, there is currently no alternative to extensive, coordinated conservation breeding in human care if the diversity of the species is to be preserved.

This requires parallel and coordinated action at all levels, i.e. the situation in the habitat must be investigated and, where possible, improved (*in situ*), while reserve populations are established and managed in human care (*ex situ*) – and all this must, of course, be scientifically coordinated and supported by a broad majority of society. This is the essence of the One Plan Approach, to which the International Union for Conservation of Nature (IUCN) and the World Association of Zoos and Aquariums (WAZA) are committed. Since the native Fire Salamander is a species for which the Federal Republic of Germany has a special responsibility, zoos have a prominent role to play as the competent executive bodies for the ex situ part of the One Plan Approach.

Its outstanding national significance is also the reason why we have positioned the topic of Fire Salamanders directly at the transition between the exhibition and breeding areas. This allowed us to discuss the pressing questions on the spot using a real-life example. In a modified form, this argument also applies to all other species presented in the exhibition and which are to be bred specifically in the breeding area.

Fundamental to this is the ethical conviction that inaction is not an option, even if we are aware that we cannot answer all questions in advance. This insight is also important. There is no such thing as infallibility; mistakes will happen.

The crucial thing is to make a demonstrable effort not to repeat mistakes. This requires transparency in communication and exchange between all actors working on the same issue. This, too, is inherent in the One Plan Approach.

In the immediate vicinity of the naturally designed terrarium, the much more spartan, so-called systematic breeding of Fire Salamanders is presented using drawers with themed dioramas.

Threat

Its worst enemy is the chainsaw. With an area of less than 1,500 square kilometres, its habitat is already very small, and the remaining 5% is under massive pressure. All the deterrents in the world are useless – this unique frog is in danger of becoming homeless.

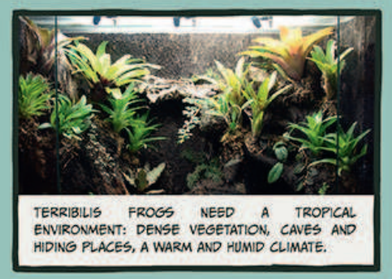
Jens Hoberg,
Primary school teacher from Troisdorf

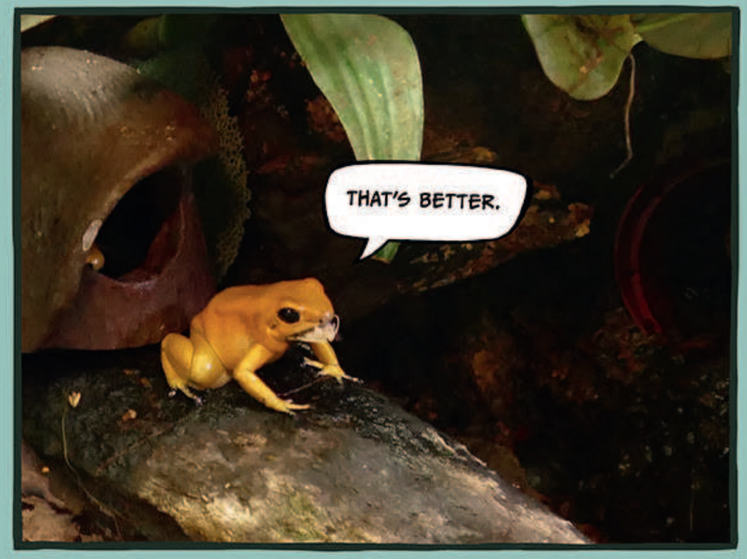
Active in nature conservation since the age of six, he is interested in grass frogs, newts and other creatures. He enjoys sharing his enthusiasm and founded the NaturGut Ophoven nature and school biology centre in Leverkusen.

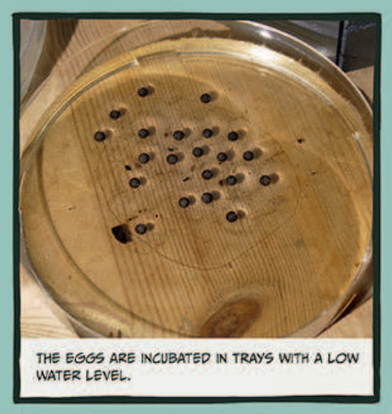
citizen conservation

Requirements for participation:

Easy to breed and suitable for beginners. Keep in pairs or groups.
'I participate in Citizen Conservation to help preserve endangered species, because animal venom also holds incredible potential for the development of new medicines.'







Opposite the glass breeding room, visitors have the opportunity to find out more about each individual species in the species wall on a touch monitor, including through easy-to-read photo stories in which 'real' keepers present their care conditions and certain special features of the respective species.

Practical features of the glass breeding room

The challenge in designing the glass breeding room was that it had to fulfil its practical function as well as possible. The animal care staff must be able to act quickly and flexibly and manage breeding groups and/or offspring as required. On the other hand, it is also a display facility in the sense that it is intended to illustrate and explain this work to visitors.

This naturally leads to some restrictions in operational flexibility, starting with the technical design of the species wall, i.e. the partition between the visitor area and the breeding room. This consists of a 3.12 m high and almost 9 m wide aluminium shelving system in which the individual glass tanks are inserted on the visitor side. The front panes are larger than the width and height of the tanks, so that from the visitor area, the impression of a continuous glass front is created, allowing a view through the tanks into the breeding room.

What is good for visitors can sometimes be a challenge for the care staff, especially when it comes to the interior design of the pools. In order to maintain the transparency of the species wall, vertical structures can only be installed on the two side walls. Flexibility is also limited when it comes to stocking the tanks with animals, as the aim is to show visitors as many species as possible that are also found in the breeding area. The layout must therefore be such that each species has at least one 'place' on one of the three lower floors. The top, fourth floor is not visible to visitors as it is simply too high.

Accordingly, the carers also need a stepladder to access them, which naturally restricts regular visual checks. Nevertheless, the fourth floor was important to us in order to symbolise the 'overwhelming height' of the task ahead of us in the field of species conservation – and, of course, the need for efficient use of space.

The entire breeding room is divided into a warm and a cold area to separate the room climates from each other. In the cold area, a total of five aquariums are available for the aquatic Cross-toothed Newts and Titicaca Water Frogs, which can be operated in two separate circuits at different temperatures. Attached to this are appropriate larval rearing tanks, which can be divided into a total of 45 individual compartments for separate rearing. These capacities can be expanded if necessary. In the warm breeding area, two aquariums and a 'tadpole window' are available for larval rearing. Here, tadpoles that need to be reared individually can be presented.

At the rear walls of the breeding room, we have additional tanks that are suitable for keeping salamanders and toads (cold) as well as Leaf Frogs, Poison Dart Frogs and Foot-flagging Frogs (warm).

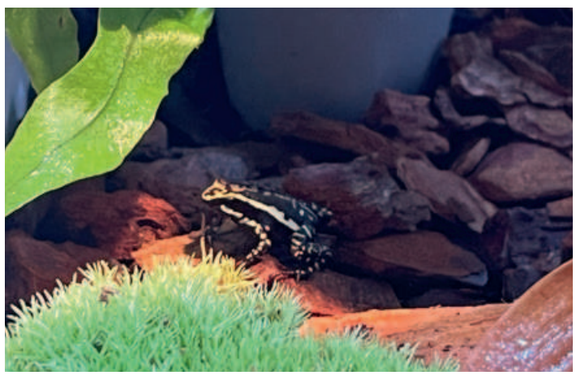
The terrariums on the back wall of the breeding room are made of Forex, a lightweight plastic.

Always an eye-catcher: the Golden Poison Frog (Phyllobates terribilis)

The offspring of the Lake Patzcuaro Salamander (Ambystoma dumerilii) are kept in a 'larvae bank' in individually partitionable compartments above the breeding aquarium.

All systems are connected to a central air pump for window or aquarium ventilation and to a central sprinkler system, depending on their function. The shared water treatment system for the entire Amphibium is located in the rear feed kitchen with three 500-litre tanks for osmosis and fresh water (for settling) and a mixed water tank that can be mixed as required.

The Phantasmal Poison Frogs (*Epipedobates tricolor*) of the 'Cielito' morph can only be seen in the breeding room so far. Later, they will also be settled in the greenhouse.



The Phantasmal Poison Frogs (Epipedobates tricolor) of the 'Cielito' morph can only be seen in the breeding room so far. Later, they will also be settled in the greenhouse.

Keep them safe

The words 'Haltung rettet Arten' (literally: 'Keeping saves species', but in English we decided use the claim 'Keep them safe') are emblazoned above the species wall. This is the slogan of Citizen Conservation – most of the species cared for here are part of the CC conservation breeding programme. Citizen Conservation is presented on a board right next to the entrance door to the breeding area.

This is where the Amphibium comes full circle. While we aim to spark interest and fascination in the exhibition area, the area in front of the species wall confronts visitors with the threats facing not only amphibians, but also ourselves.

But in the end, there is still hope. Despite the complexity of the task we take on with each new species, we know that we can succeed if everyone pitches in. We need experts who can work together to develop and identify solutions, but we also need the necessary resources to maintain stable reserve populations in human care. Anyone who has the means to do so can contribute, for example by actively participating in and supporting citizen conservation. At least this is one positive message that emerges from the species crisis – you can do something without making sacrifices, but instead even gain something in return, true to the motto: Save a frog and you save the world!

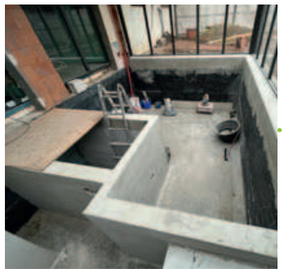
Of course, there is also room for temporary tenants in the breeding room. The Sakishima Grass Lizards (Takydromus dorsalis) will later move in as flatmates with the Oriental Fire-bellied Toads.

Metamorphosis: A ball pit becomes a walk-in Poison Dart Frog terrarium

It all started with a ball pit – a 24 m² extension to the building, which at that time was still a pasta restaurant and was to become Amphibium in the future.

A miniature South American rainforest is being designed on a scale of 1:10, bordered on one side by a steep wall and a moat leading to the visitor platform.

The entire structure remains a tub, divided in the middle by the visitor entrance. On one side, the lowland rainforest is planted in mineral substrate, while on the other, a slope of lava stones is being built.



We are sourcing the lava stones from a quarry in the Eifel region: several tonnes of hand-picked rocks are being delivered to Hanover and now need to be stacked and secured stone by stone.

Due to its porous structure, lava rock is ideal as a substrate for plants, which find sufficient support and moisture here. This would be difficult to achieve with artificial rock, i.e. concrete.

Some of the thick chunks can only be positioned with combined forces.

The many epiphytic plants, such as bromeliads, grow on and around trees, so suitable habitats must be created that also distract visitors' attention from the greenhouse shell. We cut the oak and robinia branches to size from the zoo's stock.

An artificial rock tree is integrated as a design feature to separate the exhibition area. Its 'board roots' flow around the natural boulders between which it 'grows'.

We are obtaining most of the plants from the Wilhelma botanical garden in Stuttgart, which is opening its greenhouses to us so that we can transport a truckload of the finest South American flora to Hanover.

The effort required for water technology, ventilation and aeration is enormous and will be largely hidden under the visitor platform or concealed as well as possible.

The best part of the work comes at the very end: planting the garden. Bromeliads are untied, trees, shrubs, vines and ferns are put in place.

And now it's time to wait, measure and readjust. The plants need to grow and the climate values must remain stable. As this is a sun-exposed cultivation, it is by no means trivial to guarantee temperatures between 18 and 24 °C on the ground at all times.

The frogs will only be introduced once the systems have been tested and have reliably survived the first Hanover heat waves. Once released, it will be difficult to get the animals out of their 24 m^2 rainforest in the event of an accident.

So the new residents will remain in the 'antechamber' of their little kingdom for a while longer, because we have also incorporated a special feature: the Poison Dart Frog terrarium in the exhibition is connected to the rainforest enclosure by a direct passageway. When the day comes, it will be time to open the flap and let the frogs march in!

From obscurity to the spotlight – amphibians in zoos

Heiko Werning

The most commonly kept amphibian in VdZ zoos is the Blue Poison Dart Frog (Dendrobates tinctorius, here in the Azureus variant).

‘Children speak the truth’, is a somewhat overused saying, but if that is the case, then one can assume that children‘s books can also speak the truth. If we look at books on the subject of ‘zoos,’ we encounter the idealised notion of what a zoo animal is. And we realise that amphibians are clearly not included.

Of course, most zoos still display some representatives of the amphibian class. But often they are only found in the back corners of marginal buildings or as exceptions in aquarium and terrarium houses among dozens of tanks for fish or reptiles.

This subjective impression can be objectified. In 2020, Jacken et al. published a study evaluating amphibian husbandry in zoos. The study covered a twelve-month period between May 2016 and April 2017. The results are sobering. Only 540 amphibian species were recorded worldwide. This corresponds to about 6% of the approximately 9,000 known species.

A closer look causes even this modest result to collapse like a soufflé: only about 10% of the species were kept in relevant numbers and at more than one location, while 10% were represented by only a single individual and should therefore be deducted. A whopping 44% were kept by a single institution. Only 10% were bred in at least two institutions during the year under review.

VdZ zoos with 10 or more amphibian species
(number of CC species on the right)

Chemnitz	97	5
Berlin (Zoo)	49	3
Cologne	42	1
Vienna (Schönbrunn)	35	3
Vienna (Aqua Terra Zoo)	27	0
Dusseldorf	27	2
Frankfurt	26	2
Stuttgart	23	0
Karlsruhe	20	4
Leipzig	19	2
Hamburg	19	0
Zurich	16	2
Wuppertal	15	3
Rostock	15	1
Hanover	15	10
Munich	14	3
Bern	14	0
Schwerin	13	6
Münster	13	3
Kronberg	13	1
Darmstadt	13	1
Berlin (Animal park)	13	0
Augsburg	11	1
Nuremberg	10	1
Basel	10	1

As of 1 June 2025

Institutional amphibian conservation

To gain a more accurate overview of the situation in German-speaking countries, we will examine the data from Zootierliste.de (as of 1 June 2025). The platform is run on a voluntary basis by volunteers from the Zoological Society for the Conservation of Species and Populations (ZGAP) and has proven to be relatively up to date and reliable, at least for the DACH region (Germany, Austria, Switzerland). Looking at the 70 larger, scientifically managed zoos organised in the Association of Zoological Gardens (VdZ), we get a good overview of the situation of institutional amphibian keeping in German-speaking countries.

There are a total of 706 amphibians kept in VdZ zoos, an average of around eleven species per zoo. However, the distribution is very uneven. Nine zoos do not keep any amphibians, 26 keep only up to three species. Only 24 zoos keep ten or more species, of which nine keep more than 20. The top three spots are taken by the zoos in Cologne (42 species), Berlin (49) and Chemnitz (97). These three alone account for 30% of all amphibian holdings in VdZ zoos.

A total of 204 amphibian taxa are kept, but 90 of these are only kept in one zoo. Only 45 are kept in at least five zoos, and only 16 taxa are kept in more than ten zoos.

List of the most common amphibian species kept in VdZ zoos with number of facilities

Dyeing Poison Dart Frog (*Dendrobates tinctorius* incl. ‘azureus‘ variant)	27
Fire Salamander (*Salamandra salamandra*)	24
Bumblebee Poison Frog (*Dendrobates leucomelas*)	19
Golden Poison Frog (*Phyllobates terribilis*)	18
Mossy Frog (*Theloderma corticale*)	18
Anthony‘s Poison Arrow Frog (*Epipedobates anthonyi*)	15
Lake Patzcuaro Salamander (*Ambystoma dumerilii*)	14
Axolotl (*Ambystoma mexicanum*)	14
Yellow-bellied Toad (*Bombina variegata*)	14
Mission Golden-Eyed Tree Frog (*Trachycephalus resinifictrix*)	13
Green-and-black Poison Dart Frog (*Dendrobates auratus*)	12
Australian Green Tree Frog (*Ranoidea caerulea*)	12
Madagascar Tomato Frog (*Dyscophus antongilii*)	10
Marañón Poison Frog (*Excidobates mysteriosus*)	10
Cane Toad (*Rhinella marina*)	10
Oriental Fire-bellied Toad (*Bombina orientalis*)	9
Kaiser's Mountain Newt (*Neurergus kaiseri*)	9
Golfodulcean Poison Frog (*Phyllobates vittatus*)	9
Mallorca Midwife Toad (*Alytes muletensis*)	9
Rio Pescado Harlequin Toad (*Atelopus balios*)	8
European Tree Frog (*Hyla arborea*)	8
Alpine Newt (*Ichtyosaura alpestris*)	8
Colorado River Toad (*Incilius alvarius*)	8
Rubber Eel (*Tylphlonectes natans*)	8

Aspiration and reality

It is not that the zoo community has not been aware of amphibians. After the global amphibian crisis came to the attention of experts in the 1990s with the sudden extinction of dozens of species, the World Association of Zoos and Aquariums (WAZA) founded the Amphibian Ark in 2005. Its task is to promote ex situ conservation breeding for endangered amphibians, as called for by the International Union for Conservation of Nature (IUCN). As a result, WAZA declared 2008 the 'Year of the Frog'. At the same time, the European Association of Zoos and Aquaria (EAZA) launched an amphibian campaign called 'Frog Alarm!'. It was agreed to coordinate ex situ conservation efforts internationally, raise funds and carry out public relations work. By 31 March 2008, 320 WAZA institutions in 50 countries had already confirmed their participation (Dollinger 2008).

The VdZ also got involved and agreed on a joint ex situ amphibian conservation programme with various partners, including the German Zoo Association (DTG), the German Wild Animal Park Association (DWV) and the German Society for Herpetology and Terrarium Science (DGHT).

Looking back at the EAZA's conservation breeding programmes, the EEPs, 20 years after the launch of the Amphian Ark, the results are sobering. As of October 2024, the EAZA lists exactly eight EEPs, namely for the Giant Ditch Frog (*Leptodactylus fallax*), Lemur Leaf Frog (*Agalychnis lemur*), Black-eyed Leaf Frog (*Agalychnis moreletii*), Lake Patzcuaro Salamander (*Ambystoma dumerilii*), Fire Salamander (*Salamandra salamandra*), Montseny Brook Newt (*Calotriton arnoldi*) and the Mountain Brook Newts of the genus Neurergus.

In comparison, EAZA runs 26 EEPs for fish, 41 for reptiles, 154 for birds and 254 for mammals. One can therefore speak of a real 'amphibian gap', a lack of representation of amphibians in zoos. This is all the more painful when one considers that amphibians are the most endangered class of vertebrates, accounting for around 42% of the species examined.

Are amphibians not to blame themselves?

Why is that? Well, it's pretty obvious that rhinos, lions and toucans are more spectacular than toads, newts and frogs at first glance – at least they're bigger. Amphibians generally attract less attention. They don't trigger 'aww, how cute' reactions, but unlike poisonous snakes, crocodiles or big cats, they don't instil fear either. For reasons incomprehensible to us amphibian lovers, they are also perceived as unattractive and unsympathetic.

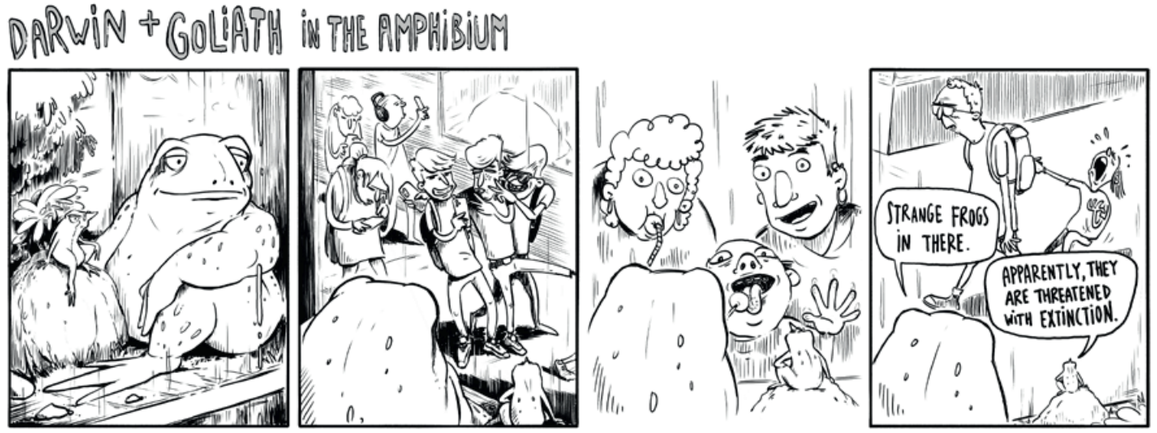
To make matters worse, they are quite adept at avoiding detection: most species are either nocturnal, difficult to see due to their excellent camouflage, live buried underground or spend most of their time motionless under a root or in the mud. Many species disappear completely for months at a time, either to hibernate or to rest during dry periods – there's always something going on. This means that they are often difficult or impossible to see in terrariums, and even when they are visible, they usually do nothing. Not very exciting.

What's more, they are often not that easy to keep, let alone breed. Different species require very specific climatic conditions, and the larvae often have to be raised in aquariums under completely different conditions. Finally, they do not usually socialise well with many other species, at least not as efficiently as fish, of which there are often more species in a single aquarium than there are amphibians in an entire zoo. In short: at first glance, amphibians are not exactly recommended as zoo animals.

It's all about presentation

But a second glance reveals that there are countless, almost unbelievable, highly interesting stories to tell about amphibians, most of which most people have never heard of and which would fascinate even ordinary people if they knew about them.

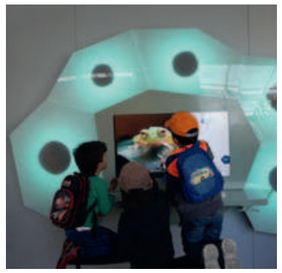
The challenge lies in the presentation. The classic small display terrarium with a simple animal label is only suitable for a few species to inspire



visitors. Frogs & Friends has set itself the task of increasing interest in this highly endangered group of animals through innovative concepts in amphibian exhibitions. The 'Frogs & Friends Bars' set up in the zoos in Zurich, Vienna and Cologne were a building block for this. These were interactive screens on which short reports about the amphibian projects and their protagonists from the participating zoos could be viewed in a recreated bar atmosphere with an amphibious look (the videos can be viewed under the menu item Project Videos at www.frogs-friends.org). At Schönbrunn Zoo in Vienna, we also designed an exhibition on frog communication, with a special focus on Foot-flagging Frogs. In addition to the living stars of the show, the exhibition featured the interactive game 'Das Ohr am Teich' (The Ear at the Pond), videos, a hands-on robot frog model and attractively designed information boards on the topic. With the Amphibium at Hanover Adventure Zoo, Frogs & Friends now had its first opportunity to prove on a larger scale that amphibians can be fascinating animals that will delight normal zoo visitors.

So it is possible – you just have to want it! And Frogs & Friends has plenty more ideas up its sleeve for presenting amphibians in an attractive and informative way. The ex situ initiative Citizen Conservation (CC), which we designed, also offers zoos and other institutional keepers the opportunity to set up conservation breeding programmes for endangered species in collaboration with private animal keepers.

The Robofrog in the Foot-flagging Frogs exhibition at Schönbrunn Zoo – an exhibit to touch and try out | Daniel Zupanc, Schönbrunn Zoo



The 'Frogs & Friends Bars', here at Zurich Zoo, provide visitors with video reports on the zoos' amphibian conservation programmes.

Even amphibians, which are largely immobile, can inspire awe – enclosures for giant salamanders in the amphibian house at Chemnitz Zoo. | Kevin Rüffer

Amphibious exhibition facilities in German-speaking countries

Below are a few interesting examples of amphibian presentations in zoos, which are by no means exhaustive. Until the opening of the Amphibium, Chemnitz Zoo had a unique selling point in the German-speaking world with its own amphibian house. Around 100 amphibian species currently live there – making it the undisputed number one in terms of amphibian biodiversity.

This unusual focus dates back to the 'Amphibian Vivarium' in the Natural History Museum at Schleusingen Castle, which was built up during the East German era to become the most species-rich collection in Europe. Unfortunately, it was dissolved after reunification, but an important part was preserved at Chemnitz Zoo.

The presentation is classic, with highlights including large enclosures for giant salamanders and sirens (Sirenidae), which are kept together with fish from their natural habitat. The aquarium at Berlin Zoo also has its own area for amphibians (and invertebrates) on the second floor. The traditional, classic exhibition, which mainly consisted of display terrariums with simple animal information signs, has recently been renovated, enriched with interactive and tactile exhibits, and reopened at the end of 2024. Incidentally, Frogs & Friends collaborated on the project – we contributed sound recordings of amphibian voices.

The Cologne Zoo Aquarium is particularly committed to ex situ species conservation for amphibians and maintains close links with in situ conservation through its partnership with the Me Linh Station in Vietnam. Several rooms in the aquarium have been specially converted for amphibian breeding, and breeding facilities have also been set up in Vietnam with support from Cologne. This commitment is highlighted in the exhibition area in Cologne with examples of species. The zoo is also involved in the protection of the native Green Toad. For several years, in cooperation with local authorities and nature conservation associations, tadpoles have been collected from the Rhine floodplains, raised in the aquarium and later released back into the wild as fully grown amphibians in order to support the weakened population.

The exhibition on amphibian communication designed by Frogs & Friends at Vienna's Schönbrunn Zoo had to make way for the redesign of the Rainforest House, and the traditional old terrarium building has also been closed due to major restructuring. Nevertheless, the zoo continues to display amphibians in various locations and is also dedicated to their ex situ conservation with rear-winged breeding rooms and a special research and breeding container for Foot-flagging Frogs. Vienna is, alongside Chemnitz, the amphibian capital of the German-speaking world – the Haus des Meeres (Aqua Terra Zoo) in the city centre, which is run by an association, is also a hotspot with 27 species.

The Aquazoo Löbbecke Museum Dusseldorf is a mixture of natural history museum and aqua/terra zoo. With its own breeding facility, it was one of the pioneers in Germany in ex situ species conservation for amphibians.

The entrance area of the Allwetterzoo Münster features an aquarium displaying several species of amphibians, as well as the International Centre for Turtle Protection, an ex situ initiative in cooperation with private owners and a precursor to CC. In 2023, the two areas were merged to form a new 'species conservation campus', which also displays amphibians.

This includes a Fire Salamander breeding station, which opened in 2025, and a rear cold room for breeding Ambystomatidae and Titicaca Water Frogs. Wuppertal Zoo is also involved in Fire Salamander conservation and is part of a regional project in collaboration with the University of Wuppertal, the local conservation fund and private individuals. Another notable feature is a collection of endangered and rarely kept Madagascan Golden Frogs.

In addition to Ambystomatidae from CC in the aquarium, the Nuremberg Zoo is particularly interesting for its 'free-range' Poison Dart Frogs, Leptodactylidae and Red-eyed Leaf Frogs in the Manatee House, a large tropical hall.

The zoo is also involved in Fire Salamander conservation and, with the support of Frogs & Friends, has set up a container for treating animals infected with the salamander-eating fungus.

Zurich Zoo also has a 'free-range' area in the large, natural Masoala Rainforest Hall, where Tomato Frogs live, for example.

During the day, visitors need a lot of luck to spot any of the animals, but on night tours, amphibious inhabitants regularly appear in the glow of flashlights. Their calls also create an authentic 'rainforest feeling.'

The zoo's species-rich terrarium is currently undergoing renovation, but a new research station will open at the end of 2024, where the targeted breeding of highly endangered amphibian species, including CC species, will be demonstrated in a 'transparent research workshop'.

The aquarium/terrarium at Basel Zoo is not only architecturally interesting due to its spindle-shaped visitor route, but also because its very attractive display terrariums showcase 10 species of amphibians, including the Rio Pescado Harlequin Toad, a CC species that has been successfully bred in captivity.
The large paludarium for Mud Devils shows that amphibian enclosures can also be spectacular. It is a real eye-catcher that effectively showcases these primitive amphibians alongside fish from the same habitat.

Finally, Schwerin Zoo is displaying Fire Salamanders and Lake Patzcuaro Salamander as CC species in two large outdoor pools. Display boards designed by Frogs & Friends tell the exciting stories behind them. Amphibians are represented in the zoo's newly opened Red List Centre as well as in the South America House, and the 'Frog House' is one of the few zoo buildings designed specifically for amphibians. Fire Salamanders and other native amphibians are on display there, with outdoor terrariums in front. The zoo is currently planning to convert it into a breeding station for Fire Salamanders.

The surrounding ambience also plays a role: the terrarium exhibition at Cologne Zoo's aquarium is built into a greenhouse-like tropical landscape. The 'Frogs & Friends Bar' can be seen at the edge of the picture, providing information about amphibian conservation projects. | Thomas Ziegler

A quick look across borders

The Prague Zoo has what is probably the most spectacular amphibian enclosure in Europe, with its own building for giant salamanders. Here, the world's largest amphibians are displayed from all angles, embedded in a Chinese stream landscape modelled on their natural habitat and complemented by other species from the habitat – as well as a small special exhibition on the Czech anti-fascist classic book 'War with the Newts' by Karel Čapek. Definitely worth seeing!

Equally worthwhile is a visit to Plzen Zoo, which displays over 70 species of amphibians both on its grounds and in a separate aquarium and terrarium building in the city centre, and breeds them behind the scenes in several rooms. Particularly original and impressive is a converted bunker complex designed around the theme of 'life in caves'. It also houses a glass amphibian breeding room. At the Bosque de Chapultepec Zoo in Mexico City, the former elephant house was converted into a modern axolotl house in 2023 to mark the 100th anniversary of the facility. In addition to live animals, it features an exhibition on the most important laboratory amphibian, which is virtually extinct in its natural habitat. An artificially created water garden is reminiscent of the famous floating gardens of the Aztecs of Xochimilco, the original habitat of the 'water monsters'.

In the Ecuadorian capital of Quito, Sapoparque is dedicated exclusively to Ecuadorian amphibians. In impressive large terrariums and an extensive exhibition, it shows the endangered species that are researched, bred and marketed internationally by the breeding centre Centro Jambatu, which belongs to the complex, through its partner company Wikiri in order to support the work of the centre.

Towards a more amphibious future for zoos

In US and Australian zoos, too, especially in the wake of the 'Year of the Frog', some have built their own small amphibian houses or sections or launched ambitious amphibian breeding projects. It is therefore to be hoped that more and more zoos will recognise that the presentation of amphibians should be significantly expanded, not only because of their exciting stories and the serious threats they face, but also because it offers the opportunity to design new and fresh exhibitions that have the potential to inspire visitors. Perhaps amphibians will one day become 'real' zoo animals after all and even appear in children's books …

Readings

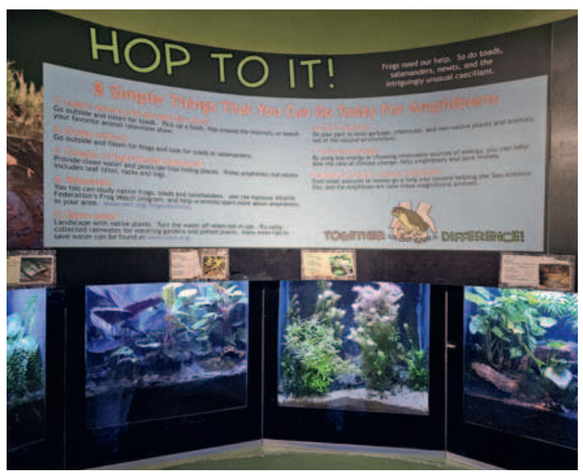
Dollinger, P. (2008): Von Zoos und Fröschen. – Draco Nr. 34: 18–21.
Jacken, A., D. Rödder & T. Ziegler (2020): Amphibians in zoos: a global approach on distribution patterns of threatened amphibians in zoological collections. – International Zoo Yearbook 54. 1–19.

A slice of nature with primitive inhabitants: the impressive hellbender enclosure at Basel Zoo | Fabian Schmidt

Research and species conservation in the heart of the zoo: Foot-flagging Frogs in containers at Schönbrunn Zoo in Vienna

Outdoor aquarium and terrarium for Fire Salamanders and Lake Patzcuaro Salamander at Schwerin Zoo. The information boards were developed by Frogs & Friends.

Outdoor terrarium for Fire Salamanders at Wuppertal Zoo with information board about the species conservation project



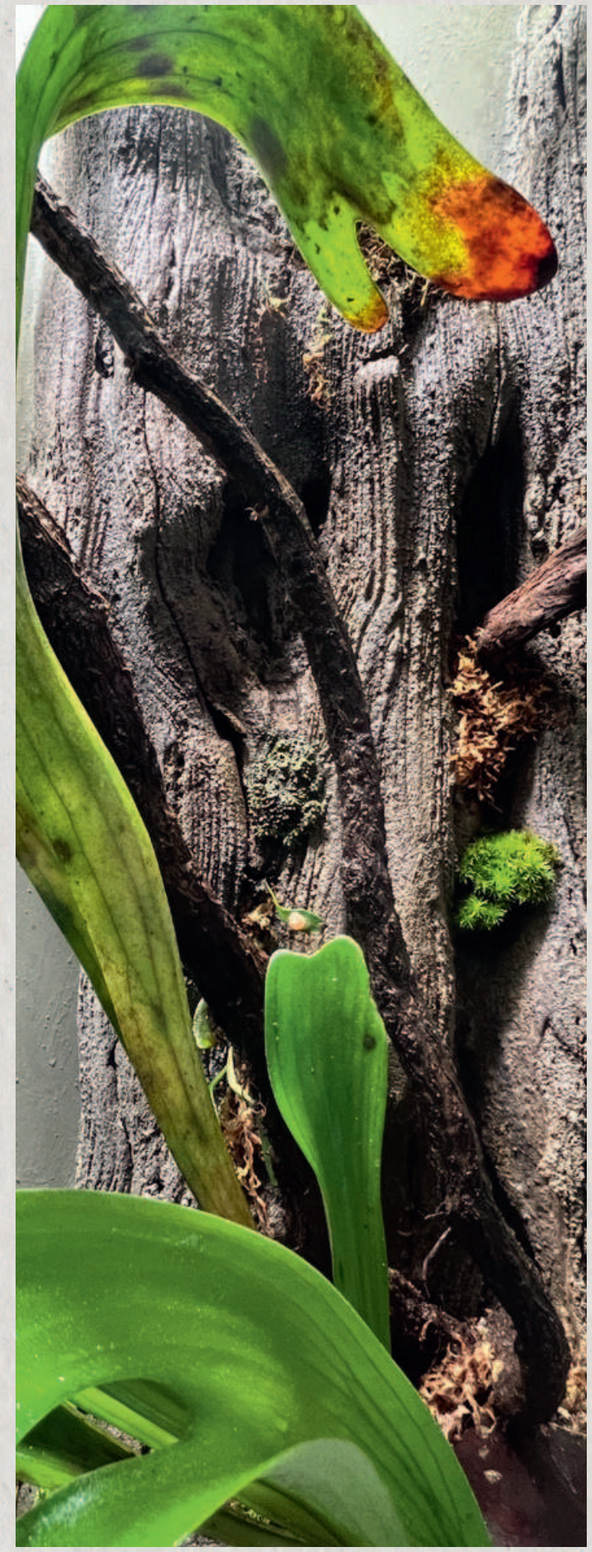
View of the exhibition in the amphibian house at San Antonio Zoo, USA

The wild Red-eyed Leaf Frogs in the Manati House at Nuremberg Zoo are difficult to spot – which makes it all the more exciting when zoo visitors come across one. It doesn't matter that it's fast asleep.

Shy of light, but definitely there – the Fire Salamander in its little mini beech forest at the Amphibium

The Oriental Fire-bellied Toads have settled in well at Hanover Zoo – the first tadpoles were spotted just a few days after they moved in.

Attractiveness does not necessarily have anything to do with beauty – the giant Titicaca Water Frog, here in a not-so-giant version in the large aquarium of the Amphibium.



I can't see you, but I know you're here ... The Mossy Frog, a classic of camouflage art, is also a must-see at the Amphibium.

A species that you can only really see if you lift the bark under which it sits: Ziegler's Crocodile Newt (Tylototriton ziegleri) is nevertheless allowed to move in with the moss frogs in Hanover as a CC species.

Rarely active, but usually easy to see: the Lake Patzcuaro Salamander in its Hanover habitat, complete with water lilies from its original home.

‘There are just as many exciting stories to tell about a frog as there are about an elephant.’

The human minds behind the amphibious stars – and what drives them

Susann Knakowske
Didactics

The educational concept behind the Amphibium combines experience, knowledge and species conservation to create a fascinating exhibition. First and foremost, it aims to appeal to visitors on an emotional level. Here, they encounter the incredible diversity of amphibians: from tiny and inconspicuous to brightly coloured and poisonous. Frogs and other amphibians can be discovered in naturalistic terrariums and aquariums or via multimedia videos and games. The idea is that everyone becomes a researcher. You learn how to count frogs through play. In addition to biological facts, you also learn exciting stories about research and culture – for example, that the African Clawed Frog was once used as a pregnancy test or what magical abilities were attributed to an amphibious ‘water monster’.

A highlight of the exhibition is the glass breeding station, which provides insights into methods of species conservation in human care. The approach here is also interactive and participatory: touchscreens allow visitors to look into each tank and receive comic strip tips on how to care for each species – enabling them to become part of Citizen Conservation themselves.

‘My highlight of the exhibition: the huge Titicaca Water Frog tank. It‘s great fun watching these squishy frogs pop up and dive down. Together with the information about Jacques Cousteau‘s diving expedition in the Andes, I get a full dose of edutainment here. I would have loved to put Cousteau‘s submarine in the tank with the frogs as a remote-controlled miniature version …’

Bernd Schultheis
Audiovisual media

As a musician, I am a person who listens, and I experience time and again how important hearing and listening are for our orientation in the world. If we listen carefully, sounds can often tell us more about our world than images. This is especially true because we hear sounds around us all the time, whereas our line of sight allows us to perceive only a very selective part of our surroundings. In the immersive audio installation ‘Froschkonzert’ (Frog Concert), for example, visitors can learn about the acoustic counting of frogs and try their hand at counting them themselves in a playful way. Sound recordings of the calls of different species are arranged in sound fields. This creates the impression of sitting in habitats surrounded by animals. Based on the calls, it is possible to locate their position and determine their number. A game to try out!

‘The toad facility particularly impresses me because it not only shows a habitat and its inhabitants, but also allows visitors to experience and understand different counting methods – visual location using transects and acoustic location through attentive listening.’

Camillo Kuschel
Colour and Design

We anticipated that visitors would have already walked a long way through the zoo, past lions, buffalos and elephants, and that they might therefore be a little overwhelmed. The aim of the Amphibium design was to give visitors a moment of relaxation, surprise and encouragement right from the start. The room installation hints at an abstract, undiscovered and intriguing world, while the design language is friendly and inviting. The colour scheme of the exhibition architecture reinforces this effect and adds a refreshing touch with its glazed and muted turquoise tones. The design thus serves to pave the way for the realisation that there are just as many interesting stories to tell about a frog as there are about an elephant.

'These mini Foot-flagging Frogs and their story are so exciting to me! Because they could no longer communicate with each other in their habitat near the loud waterfalls, they developed a kind of sign language – fantastic. It opens your heart.'

Adriaan Klein
Concept

During the design process, a fan-shaped exhibition architecture was developed, resembling the eight arms of an octopus. This shape allows visitors to get an overview from the centre of the exhibition space and gradually explore the individual niches, where they can see the various amphibians and use digital media to delve deeper into specific topics and discover insider stories.

Since the individual exhibition modules are accessible from almost all sides, an incredible amount of technology for water treatment, disinfection, temperature control, lighting control and media control had to be accommodated in a small space alongside the visible terrariums and aquariums. The shape of the exhibition architecture allows for large open spaces for the public and plenty of wall space for terrariums, graphics and digital media.

'I find the species wall fascinating – there's so much to see, and the transparency allows you to see the room behind it. But the blue glow of the Titicaca Water Frog aquarium also draws me in every time ...'

The Foot-flagging Frogs are flagging their feet. Greetings from the black-spotted Foot-flagging Frog (Staurois guttatus). | Doris Preininger

Photos of typical Foot-flagging Frog habitats, such as here in Brunei, serve as the basis for the enclosure design. | Doris Preininger

A waterfall for Foot-flagging Frogs

Design and construction of a paludarium for small specialists from Borneo

Björn Encke

The little Foot-flagging Frog (*Staurois parvus*) lives near waterfalls in the tropical rainforest of Borneo. And because waterfalls are noisy places, it has developed another form of intra-species communication in addition to calling – waving. Viennese herpetologist Doris Preininger from Schönbrunn Zoo in Vienna specialises in researching this special form of visual communication in frogs.

In 2010, the first Foot-flagging Frogs (*Staurois parvus* and the slightly larger black-spotted Foot-flagging Frog, *Staurois guttatus*) moved into research containers specially built for this purpose at the zoo, and the first offspring were born at the end of 2011.

Since then, the little Foot-flagging Frog has been regularly bred and passed on to other institutions. Foot-flagging Frogs were also released in the zoo‘s rainforest house, where they could be regularly spotted by visitors.

Reliable breeding continued to be successful only in Vienna, and so what should not have happened ultimately did: the disappearance of a species that had already been ‘cracked,’ for which it was believed that the recipe for reliable breeding had been found. When the Viennese breeding programme for the black-spotted Foot-flagging Frog faltered one day, there was simply no other functioning breeding group left in Europe, and when the last female died in Vienna, this also marked the end – at least for the time being – of *Staurois guttatus* in human care.

This is extremely annoying, but unavoidable if you do not manage to establish several independent and permanently breeding subpopulations of a species in time. This was – apart from the undoubtedly spectacular stories that the Foot-flagging Frogs can tell us – the reason why we wanted to give the small Foot-flagging Frog a special place in the Amphibium. The aim is to make Hanover Adventure Zoo a second reliable location for Foot-flagging Frog breeding.

Keeping and breeding these tiny creatures, which are no more than 3 cm long (males are another 8 mm smaller), is not as trivial as it may seem once breeding is underway – this is another common pitfall that can be encountered: You find a recipe that works, or you have a terrarium in which a species reproduces easily and reliably, as if it were paradise, and then it happens that it doesn‘t work at all elsewhere with other animals under supposedly the same conditions. And no one knows exactly why.

The males of both species are significantly smaller than the females. Here is the black-spotted Foot-flagging Frog (Staurois guttatus). | Doris Preininger

Young specimen of the small Foot-flagging Frog (Staurois parvus) | Daniel Zupanc

The plans for the Foot-flagging Frogs in the Amphibium were based on the groundbreaking work of Doris Preininger and her team in Vienna. In practice, it works very collegially: a phone call to Vienna. 'Doris, we want to establish a backup population of Foot-flagging Frogs in Hanover.

Tell us what parameters you would use if you had to do it.' This is how we arrived at our assumptions: The floor space for keeping the frogs should be at least one square metre, there need to be pools of water at different levels that serve different purposes (egg laying and tadpole growth), suitable mating arenas, which should be taken into account when structuring the seating areas, coarser substrates as a habitat for the tadpoles, a year-round temperature of around 26 °C with extreme humidity, and so on. Direct exchange with our colleagues in Vienna was invaluable, because even though all the hard facts about keeping Foot-flagging Frogs have long been published and are readily available, learning about the habits of a species is always a dynamic process in which certain modifications are not only conceivable but also desirable, as they contribute to a better understanding of the species.

When designing the breeding facility in the species wall, we simply adhered to all the specifications from the Vienna breeding facility and implemented them relatively strictly. At 120 x 160 x 120 cm (width x height x depth), the body is slightly larger than desired for *Staurois parvus*, but would also meet the specifications for the larger *Staurois guttatus* should a second opportunity arise at some point. The setup follows the Vienna model: Styrodur rocks painted and covered with Java moss and other plants, constantly surrounded by water, a few smaller pools as egg-laying sites and the water tank with a water level of 16 cm as a breeding area. The coarser light-coloured pebbles in the water tank are intended to give visitors the opportunity to regularly spot some of the very light-coloured tadpoles. Below the tank is the visible biofilter with a planted pre-filter.

Foot-flagging Frogs (here Staurois parvus) stick their eggs to stones in the water. | Doris Preininger

The tadpoles of Foot-flagging Frogs like to stay between small stones. | Norbert Potensky

The floor space required for the waterfall in the exhibition is more than sufficient due to the requirements of the waterfall (which should be audibly splashing). The entire installation has a floor space of just over three square metres (approx. 116 x 268 cm) and a height of approx. 220 cm.

The 'rock formation' with its small pools in the Foot-flagging Frog tank in the breeding wall consists simply of painted Styrodur panels covered with Java moss.

The idea of a waterfall is, of course, that it comes from above. Accordingly, we decided to design the basin so that visitors could see it from quite a height, giving the impression that they were actually looking up at a rock face in the rainforest from a frog's perspective. Technically, this presents the challenge of avoiding a direct view of the technology above, not to mention the lighting, which would of course detract from the overall impression. Once the basic structure had been decided, we sat down with a 1:10 scale clay model and tried to incorporate all the wishes and specifications while still modelling a natural-looking rock face.

All these decisions should, of course, be in harmony with the habitats of the foot-flagger in Borneo. At the same time, however, the rock work is part of the exhibition, which means that we always kept an eye on the tonality of the other installations in order to achieve as much variety as possible.

For example, the aquaterrarium for the Ambystomatidae, located directly opposite from the foot-flaggers, has a very contrasting colour scheme due to the light sandstone layer in the background, which is partially overlaid by cooled magma in deep black. The rough surfaces of both rock types also contrast with the rather smooth, dark rock in the Borneo rainforest.

The stepping stones in the 15–16 cm deep water basin had to be arranged so that the caretakers could move around and work safely and easily in the enclosure. At the same time, they had to create another small pool with a water depth of just under 20 cm towards the rock wall to give the fire-bellied toads an additional option in terms of water depth and flow velocity.

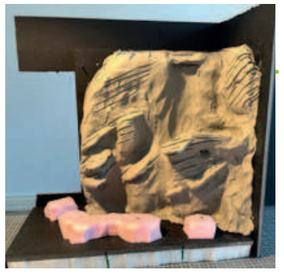
In order to avoid making the rock face excessively heavy – after all, it essentially only has to support Foot-flagging Frogs and plants, and occasionally a human being – our artificial rock builders Oliver Blomeier and Andreas Gehlen opted for a lightweight substructure based on Styrodur panels and plastic pipes covered with fabric mats and then sprayed with artificial rock. Although the concrete layer has to be a few centimetres thick, it is by no means solid, which in this case has the practical advantage that if water 'runs' behind the rocks, it ends up in the base tray like the rest, without affecting the stability of the rock.

The surge tank had to be accommodated in the upper area, as there are to be several ways for the water to flow back into the tub, mostly falling several dozen centimetres into a ledge that serves as a collection basin and splash guard, but also running over most of the visible rock surfaces.

Things get exciting again at the end of the artificial rock design when it's time to turn on the water for the first time. The flow of water is then directed by shaping the artificial rock accordingly. Once the result is satisfactory, it's time to dry everything off. Only then is the rock painted according to the previously agreed colour scheme. This is followed by many weeks of rinsing. The waterfall is left running continuously while area manager Revin Meyer regularly measures the water values and makes adjustments by adding hydrochloric acid and changing the water until the calcareous washouts from the artificial rock subside and the water chemistry stabilises.

Due to the warm, humid climate, condensation can form during the cooler seasons. Installing heated panes was not an option for cost reasons, so we opted for continuous pane ventilation with preheated air blown up from below the panes. To provide better protection for the wooden panelling of the module, the top of the tank was almost completely sealed with Forex panels, with gauze panels incorporated into the lid for light and ventilation. The extracted air is fed directly outside via the ceiling to further reduce condensation in the room.

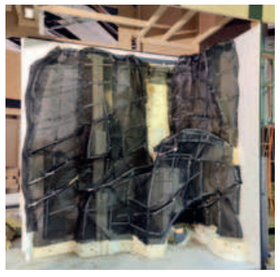
Only at the very end, when the pool is completely closed, can the botanical design begin. For this purpose, we had obtained most of the South American plants for the Colombian rainforest from the Wilhelma Botanical Garden in Stuttgart, as well as some Southeast Asian plants from our partner for botanical landscape design, Sabine Hohmann, we were able to obtain a few special species from the Würzburg Botanical Garden, which we were actually able to plant in the enclosure three days before opening. On the same day, the Foot-flagging Frogs arrived from Schönbrunn Zoo in Hanover – transported personally by curator Robin Walb.



The 1:10 scale model is kneaded until it fits.

This is where the waterfall goes!

First, a Styrodur-reinforced framework is built ... | Oliver Blomeier



... which is covered with a mesh to hold the artificial rock in place. | Oliver Blomeier

The artificial rock is sprayed on in several layers.

The rock is finished and covered with plenty of texture to give the plants something to hold on to.

Oliver Blomeier modelling the rock

Water test: The rock is reworked until the water from the surge tank at the top runs down the rock in the right places.

Then it is left to dry and painted.

The panes can then be inserted.

180 animals, packed in individual containers of five in a travel compartment, could now be transferred directly to their two breeding facilities. While the adult Foot-flagging Frogs were all moved to the breeding facility in the species wall, the display facility was stocked exclusively with sub-adult animals, which certainly did not make it any easier for visitors to spot at least one or two of the numerous inhabitants during the first few months.

With their moss-green-brown colouring, the frogs blend in perfectly with the rocks and vegetation. Only when they actually wave do the telltale white webbed feet on their hind legs flash for a moment.

Just under five months later, the moment had arrived – the first clutches were spotted in the breeding tank, followed shortly afterwards by the first tadpoles and then the first frogs to venture onto land. The idea of establishing a second reliable location for the Foot-flagging Frogs in Hanover therefore seems to be paying off for the time being.

Now it's time for branches and plants.

Sabine Hohmann planting

Expectation management: one would think that such a large paludarium would have large animals.

But oh, they are so small. However, there are plenty of them.

A big moment: three days before opening, Revin Meyer can release the Foot-flagging Frogs that have just arrived from Vienna into the enclosure.

Look at our feet ... | Doris Preininger

Mission accomplished. Five months after moving in, the first offspring arrived. | Revin Meyer

The Amphibium is a joint production of Hanover Adventure Zoo and Frogs & Friends.

Overall concept: Frogs & Friends (Björn Encke, Adriaan Klein)
Construction management: Hanover Adventure Zoo (Marco Hustedt)
Exhibition architect: Adriaan Klein
Exhibition design: Adriaan Klein & Camillo Kuschel
Didactic concept: Björn Encke, Susann Knakowske, Bernd Schultheis
Architect, greenhouse: Sabine Trog
Design concept, facilities: Björn Encke
Education board: Susann Knakowske
Technical management, education, sound design: Bernd Schultheis
Editors: Susann Knakowske, Heiko Werning
Videos: Susann Knakowske, Leendert de Jong (camera), Ed van Megen (editing)
Programming: Bernd Schultheis, Floris van der Hulst, Timo Langpeter
Illustration & animation: Jonas Lieberknecht
Layout: Ines Bärwald, Philipp Schmitt

Exhibits: Andreas Seidel (models of native frogs + Foot-flagging Frogs), Uwe Seidel (models of Fire Salamanders)
Photography: Benny Trapp
Frog sounds: Bernd Schultheis, Immo Tetzlaff
Image research: Vanessa Dubberke, Tina Nagorzanski
Expert advice: Stefan Inselmann, Johannes Penner, Doris Preininger, Uwe Seidel, Thomas Wampula, Anton Weissenbacher
Botanical design: Björn Encke, Sabine Hohmann
Artificial rock construction: Sculptorscoop Blomeier/Gehlen GbR
Carpentry: Schirm Objekteinrichtungen GmbH
Terrarium construction: Glaserei und Terrarienbau Hohls
Acrylic glass aquarium construction: Prinzip & Innovation GmbH
Painting: Bernd Wöbbekind GmbH
Electronics: Axel Prokot Elektrotechnik e. K.

Water technology: Erwin Sander Elektroapparatebau GmbH
Drywall construction: Axel Werner
Ventilation and cooling: B&H Gewerbe- und Klimakälte GmbH
Heating and plumbing: Wisag Gebäude- und Industrieservice Nord GmbH & Co. KG
KG Structural work: BBK Bau GmbH
Floor coating: Kotan Bau GmbH
Sealing work: W. Kirschke GmbH
Sliding glass doors: Glasfischer Glastechnik GmbH
Glass façade and roof Rainforest: Nagelschmidt Fenster- und Rolladen GmbH
Fire alarm system: Telcat Multicom GmbH
Video technology: Smartlogy Sicherheitstechnik GmbH
System shelving for breeding area: IBK Ingenieur Consult GmbH
Locksmith work: Metall-Team Kuhnt UG
Media technology: AVE Audio Visual Equipment

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Björn Encke
Chairman:
PD Dr. Mark-Oliver Rödel
Registration:
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Bank: GLS Gemeinschaftsbank
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Vanessa Dubberke, Björn Encke,
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Ines Bärwald
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Frogs & Friends e.V. · Großbeerenstr. 84 · 10963 Berlin
Chairman: Dr Mark-Oliver Rödel · **Managing Director:** Björn Encke