

Basic information and husbandry
recommendations for *Telmatobius culeus*,
Titicaca Water Frog





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1. Profile

Scientific name: *Telmatobius culeus* (GARMAN, 1876)

Common names: Titicaca Water Frog, Lake Titicaca Frog, Rana gigante del Lago Titicaca (Spanish)

Head-torso length: over 10 cm to approx. 20 cm

CC#Amphibians category: I

Endangered status according to the IUCN Red List: endangered

CITES protection status: Appendix I

Protection status EU species protection regulation: Annex A

Habitation: Cold water aquarium with long-term temperatures not exceeding 16 °C. From 300 litres for about 2-3 adult frogs. Underwater hiding places, (artificial) plants.

Required equipment: Aquarium with aerator or filter, water cooling if necessary; water thermometer, muck extractor or hose for extracting muck

Food: Earthworms, enchytrae, red mosquito larvae, *tubifex*, shiny worms, axolotl pellets; tadpoles: Algae, pellets, fish etc.





2. Why is *Telmatobius culeus* a Citizen Conservation Species?

The Andean frogs of the genus *Telmatobius*, which are little known in Europe, are one of the groups most affected by global amphibian extinction. Three of the 61 species are possibly already extinct, around 37 % are officially classified as „critically endangered“ according to the IUCN Red List, 35 % as „endangered“ and 14 % as „vulnerable“. From an environmental didactic perspective, a representative of the Andean *Telmatobius* is therefore particularly well suited to highlight the threatening global amphibian crisis and its causes, but also to demonstrate effective problem-solving strategies. *Telmatobius culeus* is one such „highly endangered“ representative of this genus. It only occurs in one lake, Lake Titicaca in the highlands of Peru and Bolivia. This world-famous lake is also particularly affected by environmental pollution, as well as threats such as invasive species, overhunting and climate change. The fate of the Titicaca Water Frog is a perfect example of the problems surrounding the „amphibian crisis“.

The frog used to be very common there. During his dives in the early 1970s, the famous nature filmmaker Jacques-Yves Cousteau saw the seabed still densely covered with frogs (the legendary episode of the TV series „Secrets of the Sea“ can still be seen on YouTube: <https://www.youtube.com/watch?v=iybmJDPOlr4>). Since then, populations of this amphibian species have plummeted dramatically.



View of Lake Titicaca | SL-Photography, Shutterstock



In recent years, mass deaths of Titicaca Water Frogs have become increasingly frequent in Lake Titicaca.

| Arturo Muñoz-Saravia



The idyllic impression is deceptive: the region around Lake Titicaca is densely populated, many people are very poor and there is a lack of basic facilities such as sewage treatment plants. | NiarKrad, Shutterstock

Of course, the protection of the frogs in situ, i.e. in Lake Titicaca - and thus the protection of the lake itself - is of the utmost importance for the conservation of the species. Unfortunately, no rapid improvement is to be expected here. The region around the lake is densely populated, with over two million people living here, many of whom are poor. There is a lack of sewage treatment plants and of wastewater treatment for industry and mining. Livestock roam freely along the banks, causing organic pollution of the water, destruction of riparian vegetation and erosion of the banks. Climate change is leading to a reduced inflow of clean, fresh water. The Titicaca Water Frog can certainly serve as a flagship species for its habitat here - because Lake Titicaca is not only of great cultural and historical value for Bolivia and Peru, it is also home to another 21 endemic fish species and 15 endemic bird species, which are therefore only found there and are also dependent on this highland ecosystem not collapsing.



Considering the current precarious situation of the lake and the realistic assessment that effective habitat protection measures cannot be effectively implemented in just a few years, it seems urgently necessary to establish populations of the Titicaca Water Frog ex situ, i.e. in human care, for safety reasons, especially as mass deaths of the frog have been occurring at an ever-increasing rate in recent years, giving additional cause for concern.

Ex-situ breeding successes have been achieved in breeding centres in Peru and Bolivia since 2010 and 2012 respectively: at the Universidad Peruana Cayetan Heredia (UPCH) and the Huachipa Zoological Park (HZP) in Lima on the Peruvian side and at the Museo de Historia Natural Alcide D'Orbigny in Cochabamba and with the „Conversación Anfibios de Bolivia“ (Bolivian Amphibian Initiative) on the Bolivian side.

These efforts are flanked by political and in-situ conservation measures: For example, Bolivian and Peruvian conservationists have developed an action plan to save the Titicaca Water Frog, educational work has been carried out on the ground and efforts have been launched to initiate environmental protection measures and establish protected areas or to enforce the protection of existing protected areas in practice. Many of these activities were largely funded by Denver Zoo, which launched a conservation project for the Titicaca Water Frog in 2007 in collaboration with the UPCH. The Aquazoo Löbbecke Museum in Düsseldorf and the Species Conservation Foundation, which is supported by German zoos, have also regularly supported local projects since 2009.



Ex situ conservation both on site, as here at the K'ayra Centre in Bolivia, and for risk distribution, for example in Europe, are an important building block for the long-term conservation of the Titicaca Water Frog.

| Ricardo Zunita, Museo de Historia Natural Alcide



It makes sense to establish ex-situ populations outside South America as well, as a safeguard in case of an emergency, to gather further knowledge about the husbandry and biology of this species and to raise awareness of the precarious situation of the frog, its relatives, Lake Titicaca and the people living around it. The Titicaca Water Frog is an excellent way to draw attention to the ecological problems of many lakes, especially Lake Titicaca, which has been severely affected. Thanks to its unusual biology and appearance, the frog is also an excellent ambassador for the topic of amphibians and the threats they face.

For this reason, Denver Zoo signed a memorandum of understanding with the regional government in Puno, Peru, in 2015 and supported the establishment of husbandry facilities at the UPCH and the Huachipa Zoological Park (HZIP), where the frogs have been successfully bred since 2008. As a result, Denver Zoo imported 20 Titicaca Water Frogs from HZIP to the USA in November 2015 with the aim of studying their behaviour and increasing their numbers (IUCN SSC Amphibian Specialist Group 2020). With success: On 14 February 2017, the first offspring of *Telmatobius culeus* hatched in Denver. In order to distribute the population internationally, 150 of these two-year-old offspring were imported from Chester Zoo to Europe on 14 February 2019 and then initially distributed to 11 zoos (HONIGS et al. 2021). In Germany, the Aquazoo Löbbecke Museum Düsseldorf and the Allwetterzoo Münster received animals, in Austria the Tiergarten Schönbrunn. In all three facilities, they again reproduced at around two years of age. Some of these F2 offspring were then transferred to Citizen Conservation as founder animals in 2021 and early 2022 with the approval of the chairman of the EAZA amphibian TAG, Gerardo Garcia, in order to put the ex situ network on a broader footing with the involvement of private keepers and to permanently establish coordinated conservation breeding in Europe. The Amphibian Ark's population calculator was used to determine the desired population size for a demographically healthy ex situ population of 225 animals to be distributed over 40 enclosures for maximum safety.

Given the very narrow genetic basis of the European population, it would of course be desirable to broaden it in the future by adding further, not directly related animals to the population. If this opportunity should arise in the future or if rapid emergency measures should become necessary for these or closely related frogs, CC will already have sufficient capacity available that is experienced in keeping and breeding these frogs. This creation of additional ex situ capacities is the declared aim of CC.

Thanks to the good international cooperation and the close interlinking of both in-situ and ex-situ measures in the area of origin and the complementary international conservation breeding network, *Telmatobius culeus* is suitable for becoming a model for successful conservation efforts for a highly endangered species in the sense of the One Plan Approach of the world zoo community and the International Union for Conservation of Nature (IUCN).



3. Biology and species conservation



Telmatobius culeus is found exclusively in Lake Titicaca in the South American Andes. Peru and Bolivia share the lake.

| Mitlon Rodriguez, Shutterstock

3.1 Biology

Telmatobius culeus belongs to the family Telmatobiidae within the order of frogs (Anura). The Andean *Telmatobius* (*Telmatobius*) is the only genus in this family. It includes 61 species, which are distributed in the Andean region of South America from Ecuador to Argentina and live either completely aquatic or closely bound to water.

Telmatobius culeus occurs exclusively in the 8,400 square kilometre and up to 280 m deep Lake Titicaca (including smaller tributaries) on a high plateau of the Andes in Peru and Bolivia at an altitude of 3,810 m above sea level, so that this species can be considered a single, contiguous population (IUCN SSC AMPHIBIAN SPECIALIST GROUP 2020). *T. culeus* plays an important role in the mythology of the indigenous inhabitants of the lake. It is considered the protector of the lake and its inhabitants.

The adult frogs prefer muddy or sandy lakebed areas at a depth of 1.5-3 m, which are interspersed with individual rocks and where a lot of underwater vegetation grows, where the males in particular prefer to stay. The water temperature at this depth is around 14 °C all year round. However, the frogs also dive deeper into the lake and have been recorded at depths of 50 metres. At midday, they like to sunbathe on stones in the shallow water. Tadpoles and metamorphs prefer to live in shallow shore areas up to a depth of 50 cm, young metamorphosed frogs prefer to stay in rocky areas where they like to hide under stones (HONIGS et al. 2021).



The adult frogs prefer muddy or sandy lakebed areas
| Arturo Muñoz-Saravia



The scientific species name „culeus” means „sack-like” and refers to the frogs’ overly large-looking skin
| Arturo Muñoz-Saravia

The species was described in 1876 as *Cyclorhamphus culeus* by the American zoologist Samuel Garman (GARMAN 1876) and later placed in the genus *Telmatobius* by Thomas Barbour and Gladwyn Kingsley Noble (BARBOUR & NOBLE 1920).

The scientific species name „*culeus*” is derived from Latin and means „sack-like”, which refers to the skin of the Titicaca frog. Its skin, which appears to sit loosely on the body and is characteristically strongly folded, looks as if it is much too large, which has earned it the unconventional nickname „scrotum frog” in its native country. The colouring of the skin varies and ranges from a dark marbled olive green to grey and black with white marbling. The individual patterning is so distinctive that, according to HONIGS et al. (2021), clear identification is possible through photo documentation.

The Titicaca Water Frog is undisputedly one of the largest frogs in the world. Jacques-Yves Cousteau reported animals measuring 20 cm in length and weighing one kilo after his dives. In the wild, around 5% of the population are large, old frogs. The frogs grow very slowly and apparently become quite old, the generation sequence in nature is now assumed to be 12 years (IUCN SSC AMPHIBIAN SPECIALIST GROUP 2020). Even animals with a body length of 10-14 cm are large and can weigh 250 g. The females are somewhat longer and heavier than the males. The Titicaca Water Frogs in our aquariums are still significantly smaller.

The frog has a massive appearance. The body and head are flat, the eyes are round and directed forwards. The hind legs are strong, with large webbed feet. The front legs are also strong, but the hands are without webbed feet.



The frogs prefer to live at a water depth of 1.5 to 3 metres | Arturo Muñoz-Saravia

The frogs are perfectly adapted to their habitat in a cold, relatively oxygen-poor high mountain lake. Their metabolism is particularly slow compared to other amphibians - an adaptation to the low water temperatures. The wrinkled skin enables them to largely dispense with lung respiration, which is why the lungs are reduced to only about a third of their size in comparable other frogs. There is a dense network of veins in the skin so that oxygen reaches the circulatory system quickly via the skin. To enhance this effect, the frogs have developed a typical movement pattern: they stretch out all four limbs and have at least their hind legs in contact with the ground. They then move up and down in such a way that the skin vibrates and can unfold. This rocking behaviour allows fresh water and therefore oxygen to enter the skin folds.

This allows the frogs to stay under water for several hours without having to breathe atmospheric oxygen. Another special adaptation is the greatly reduced size of the red blood cells (erythrocytes; they consist of 90 % of the red blood pigment haemoglobin). Small bodies have a relatively larger surface area, which is why they can bind more oxygen. Accordingly, *Telmatobius culeus* has the largest amount of haemoglobin of all the amphibians examined. Titicaca Water Frogs do not have an eardrum and only have a slightly developed tympanic cavity. This is probably due to the fact that the males do not call above, but under water. Therefore, the sounds are at a low frequency level (309-941 Hz, average 605 Hz) and with sequences of 117-151 notes/ms. It is therefore possible that vibrations are perceived rather than acoustic calls.



3.2 Threat situation



Untreated urban and industrial wastewater and agricultural pollution are responsible for an ecological disaster in Lake Titicaca. | Arturo Muñoz-Saravia



The poor water quality causes mass mortality among the frogs. | Arturo Muñoz-Saravia

There are many threats to the Titicaca Water Frogs. Firstly, there are massive changes to the habitat. Water pollution is increasing due to untreated wastewater from cities, factories, mining and agriculture, and at the same time the water level of the lake is falling. The often free-roaming livestock in the shore regions also leads to organic pollution of the water. However, *Telmatobius culeus* needs clean, oxygen-rich water. Currents in the lake are also changing due to dams and climate change.

Poor water quality has repeatedly led to localised mass mortalities in recent years, namely in 2009, 2011, 2013, 2015 and 2016 (IUCN SSC AMPHIBIAN SPECIALIST GROUP 2020). In 2015, over 10,000 frogs died in a short space of time on the Bolivian side of the lake due to localised pollution of the water as a result of an algal bloom caused by organic contaminants. The frog population was completely wiped out over an area of around 450 square kilometres (MUÑOZ & MARRIOTT 2023). In 2016, there was a comparable mass extinction with around 10,000 dead animals on the Peruvian side (IUCN SSC AMPHIBIAN SPECIALIST GROUP 2020). There is great concern that such pollution events could occur again at any time.

Invasive species such as the rainbow trout have been introduced into the lake and threaten not only the frogs directly, but also their prey. One problem may be that the populations of their main food source, the Ispi, a fish from the Andean carp group that is around 7 cm long, have declined sharply.



For many *Telmatobius* species, the chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) is a major threat; the fungus is also regularly detected on Titicaca Water Frogs, as is the Ranavirus. Titicaca Water Frogs appear to be one of the amphibian species that can at least tolerate *Bd*. However, there is always a risk that the fungus will become pathogenic and ultimately fatal if other environmental stress factors are added. Another important threat is illegal hunting, because despite their protected status in their home countries, the frogs are used in a variety of ways as food and medicine. They are processed into an extract, the „extracto de rana“, which is said to have all kinds of miraculous effects against ailments of all kinds. The „Viagra peruano“, valued as an aphrodisiac, is also obtained from the frog. Their legs are also a popular delicacy. The frogs are sold live, processed or dried in the villages directly on the shores of the lake, but are also transported to towns in the surrounding area as far as La Paz, in quite relevant quantities of many thousands of specimens a year. There is also the risk of spreading diseases.

Climate change also harms the frog population in the long term. It is assumed that there will be increased evaporation rates and water temperatures in the lake, which may make the frogs more susceptible to *Bd*. At the same time, less fresh water is flowing into the lake, partly because the glaciers in the Andes are retreating more and more.

In 2004, *Telmatobius culeus* was placed on the Red List of the International Union for Conservation of Nature (IUCN) in the highest risk category „critically endangered“. The reason for this was an estimated population decline of 80 % in the previous ten years. Since then, the situation in the lake has deteriorated even further. The water quality has deteriorated and the population on the Bolivian side has now declined by 90 % (IUCN SSC AMPHIBIAN SPECIALIST GROUP 2020).



Despite the ban, the giant frogs are still caught for human consumption. | Edgar Lehr



Market stall with Titicaca Water Frogs, which are often made into a frog smoothie that is said to have all kinds of miraculous powers. | Arturo Muñoz-Saravia

However, more recent findings on the biology of the species have led to the generation time (the average interval between two successive generations; in humans around 25 years) being increased from 5 to 14 years. This changes the assessment of the population decline over three generations, which is essential for the Red List classification, so that it is now assumed that this is between 50 and 80 % for the period 1994 to 2036. This then „only“ corresponds to the criterion for the second-highest endangerment level „critically endangered“ (IUCN SSC AMPHIBIAN SPECIALIST GROUP 2020).



3.3 Conservation efforts



Building for keeping *Telmatobius culeus* at the K'ayra Centre and the Museo de Historia Natural Alcide d'Orbigny, co-financed by the Aquazoo Löbbecke Museum in Düsseldorf and the Stiftung Artenschutz foundation

| Ricardo Zurita, Museo de Historia Natural Alcide d'Orbigny

There are several initiatives and projects in Bolivia and Peru that are endeavouring to protect frogs locally. One example is the „Conservación Anfibios de Bolivia” project, which endeavours to keep, research and breed various *Telmatobius* species, including of course *T. culeus*. Both the Bolivian and Peruvian sides have established ex-situ husbandries in the country. To increase security and generate awareness, the conservation breeding network was later extended to the USA and finally to Europe, where Citizen Conservation has become part of the supporters.

The two countries bordering Lake Titicaca, Peru and Bolivia, have drawn up a joint action plan for the species. The species is listed as „threatened with extinction” on the red lists of both countries and is officially strictly protected. Trade, processing and consumption are therefore actually prohibited, but there has been a lack of effective enforcement of the legal regulations to date.

The protection measures also include raising awareness of the threat to the frogs. Among other things, information boards have now been erected at the lake and there are brochures providing information about the Titicaca frogs and their protection.

Since the late 2000s, Denver Zoo, the Aquazoo Löbbecke Museum Düsseldorf and the Stiftung Artenschutz foundation have regularly provided financial and logistical support for the conservation measures on site.

Telmatobius culeus is internationally protected under the Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in the highest protection category (Appendix I) and is accordingly listed in Appendix A of the EU Endangered Species Regulation.



4. Keeping and Husbandry

The biggest challenge for keeping Titicaca Water Frogs in an aquarium is that they require permanently cold and hard water. Temperatures should not exceed 16 °C in the long term and 20 °C in the short term. Otherwise, the species has proven to be easy to care for and easy to keep and breed.

The husbandry recommendations given here are based on the experience of the Aquazoo Löbbecke Museum Düsseldorf and the Allwetterzoo Münster. This text is based on the publications by HONIGS, PELZER & MESSING (2021), MUÑOZ SARAVIA & MARRIOTT (2023) and the IUCN SSC AMPHIBIAN SPECIALIST GROUP (2020).

They were supplemented by further husbandry experiences at the Aquazoo Löbbecke Museum Düsseldorf (Sandra Honigs) and the Allwetterzoo Münster (Philipp Wagner). The president of the species protection initiative Conservación Anfibios de Bolivia, Arturo Muñoz Saravia, has kindly supported Citizen Conservation and Frogs & Friends with his outstanding photographic material.



Philipp Wagner, species conservation curator at Allwetterzoo Münster, feeding Titicaca Water Frogs | Sebastian Rohling



4.1 Requirements and documentation obligation

As animals listed in Appendix A of the EU Species Protection Regulation, *Telmatobius culeus* is subject to official reporting and documentation requirements. The animals may only be passed on with the appropriate CITES papers.

All keepers, including CC keepers, must report their animals and any changes to the population (offspring, deaths, relinquishments) to the responsible authority immediately. This is usually the lower nature conservation authority, but responsibilities vary from place to place - simply google „notification of protected animals“ with the name of your place of residence.

For the transfer of offspring, a corresponding CITES certificate must be applied for from the competent authority for Appendix A animals. The CC animals are the property of the non-profit Citizen Conservation Foundation gGmbH. This also applies to all resulting offspring. Keepers are therefore not allowed to give or sell the offspring independently (which is not permitted by law anyway due to the existing marketing ban as a result of the Appendix A listing). *Telmatobius culeus* is classified as CC category I within CC and is therefore also excluded from any commercialisation.

Animals of species protected under Appendix A are subject to individual labelling, which can be replaced by photo documentation if the individual markings are recognisable. The Titicaca Water Frogs show such an individual

spot pattern. In previous official practice, photo documentation was recognised for *Telmatobius culeus*. The animals should therefore be photographed at regular intervals, e.g. annually, from above against a light-coloured background (preferably with size comparison). When the animals are passed on, appropriate photo documentation should be included.

In principle, Titicaca Water Frogs kept in CC should be held in so-called species tanks, i.e. not socialised with other amphibian species. There is nothing to be said against suitable additional stocking with fish or aquatic invertebrates, apart from the risk of the tankmates being eaten.

As described, the current genetic basis of the CC stock is very narrow; the CC animals are offspring of at least the F2 generation. Cross-breeding between generations is, however, genetically much more problematic than within the siblings of a generation; parents must therefore be permanently separated from their offspring in order to prevent cross-breeding between the parents and their offspring. However, the separation is initially due to the fact that large frogs eat their offspring. It can therefore be a population management measure to leave tadpoles or young frogs with their parents. However, at the latest when the offspring reach sexual maturity, i.e. from the age of around 1.5 years, they must no longer be kept together with their parents in order to avoid intergenerational interbreeding.



An essential part of CC is the coordination of our inventory, which is why we must always be informed about its development. CC participants are contractually obliged to submit a stock report twice a year, currently on 1 March and 1 September. From 2024, this notification of the population (number of animals, their sex if possible, animals that have died or bred in the last six months) can be made online via the Wild at Home platform. We are also happy to receive observations and experiences gained in keeping and breeding, as an important goal of CC is to generate knowledge about ex-situ husbandry and the biology of the species in our conservation breeding network. We are also happy to receive photos, which we then use for publications or social media, for example. Permission to use the images within the framework of the CC programme is deemed to have been granted upon sending them, unless expressly objected to; we always name the image authorship in publications, unless expressly objected to. Please inform the CC office about deaths briefly and informally by e-mail to amphibien@citizen-conservation.org between the stock reports, so that further steps can be discussed, such as examinations of the other animals, a necropsy or veterinary care, if necessary.

In the case of clutches and young tadpoles, it is often only possible to make estimates, which are nevertheless helpful. The CC office should also be informed about breeding success outside of the population reports so that new owners can be found in good time to place the offspring or population management measures can be agreed.

If owners can no longer or no longer wish to keep the animals or offspring, the CC office must be informed as early as possible so that we can place the animals in subsequent homes. For every change of location within CC, i.e. the transfer of animals from one person to the next, veterinary tests must be carried out beforehand; a skin swab for the chytrid fungus *Bd* and a faecal sample for parasites must be tested, if necessary also for *Bsal*. Instructions and the necessary dry swab and faecal sample tubes are provided by CC, the examination costs are borne by CC. A corresponding test order for a suitable test laboratory is available from the CC office.

When animals are handed over, a CC transfer and certificate of origin must be completed. A copy of the papers of origin including photo documentation will be handed over to new owners, the animals must be officially deregistered by the previous owners and immediately registered by the new owners.

In principle, the general guidelines of CC and the provisions of the hiring contract apply to all animals kept at CC.



The frogs are photographed for identification purposes. Even as juveniles, they can be clearly distinguished by the individual dorsal pattern of the spots.

| Image archive Aquazoo LÖbbecke Museum



4.2 Transport

The animals should not be fed for four to five days before transport. Nitrile or veterinary gloves should be used for catching and transferring (never use latex gloves!). Alternatively, a commercially available aquarium landing net can also be used, whereby particular care should be taken as otherwise there is a risk of injury to the skin. Touching with bare hands should be avoided.

It is advisable to pack the animals individually for transport. Use 0.5 litre plastic containers (wide-necked containers) with an opening measuring approx. 8-10 cm. For adult animals or longer transports, it is better to use one-litre containers. These should be half-filled with water from the aquarium in which the animals were previously kept so that the water chemistry and temperature remain stable. It is also possible to transport several animals in larger containers.

The containers are packed in a well-insulated box (e.g. polystyrene box) and secured with paper or bubble wrap so that they cannot slide around.

Alternatively, fish transport bags can also be used for transport. These are filled to a quarter with water and three quarters with air and then closed tightly with rubber bands. The further procedure is then as described above. Please note that, unlike with fish, the bags must not be filled with highly concentrated oxygen, as this causes skin irritation in amphibians.

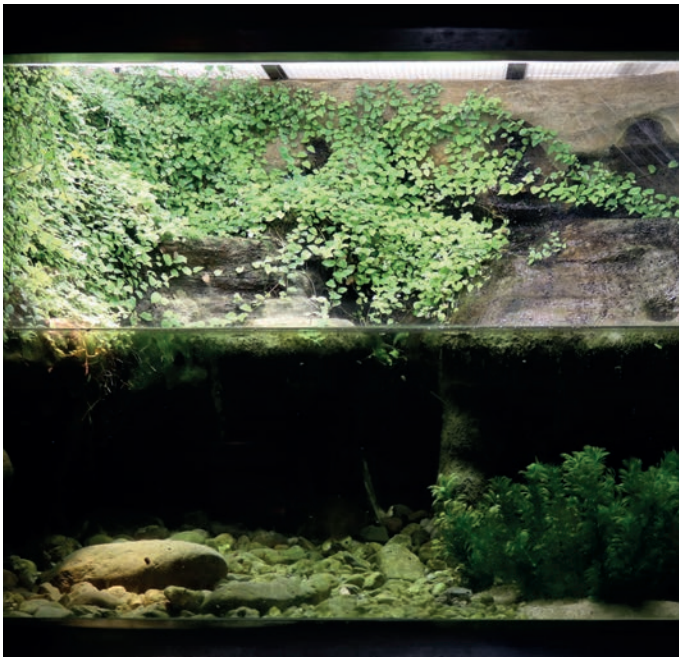
Important: The water temperature should not exceed 20 °C during transport!



Transport can also take place in fish transport bags
| Sandra Honigs



The containers or bags with the frogs are placed in a polystyrene box to prevent them from slipping during transport, so that the animals are not exposed to high temperatures during their journey. | Image archive Aquazoo Löbbecke Museum



Show aquarium in the Aquazoo Löbbecke Museum Düsseldorf
| Image archive Aquazoo Löbbecke Museum



Show aquarium in the amphibium at Hannover Adventure Zoo
| Heiko Werning

4.3 The Aquarium

The basic requirement for keeping Titicaca Water Frogs is sufficiently cold water, as water temperatures of over 16 °C for longer periods of time should be avoided, as should temperatures of below 6 °C. Temperatures should not rise above 20 °C even for short periods.

At the Aquazoo Löbbecke Museum in Düsseldorf, water temperatures between 6.4 and 19.4 °C with an average temperature of 13.8 °C have proved successful in greenhouse husbandry.

The water temperature should be permanently monitored using appropriate thermometers.

Aquazoo Düsseldorf also uses large, food-safe, blue plastic tanks with an internal size of 112 x 72 x 60 cm and a water level of 40 cm. One tank contains approx. 320 litres of water. In the exhibition, the animals are kept in 450 litre aquariums. Tanks of this size can be used for 2-3 animals. Larger groups can also be kept in larger aquariums, the animals get on well with each other.

The minimum size for 2-3 animals is a 300 litre aquarium.



According to numerous reports, the frogs never leave the water - but this is not true. They do go ashore occasionally and can certainly climb up the sides of the aquarium. The aquarium must therefore be secured against escape.

In appropriately sized aquaria, it is possible to keep them on a natural substrate of sand and stones. The maintenance effort is then higher because finding and removing the faeces is more time-consuming. Keeping them without a substrate has also proven to be a hygienic alternative. Various types of plastic plants, plastic tubes, clay bowls etc. have been introduced as hiding places and egg-laying facilities. For hygienic reasons, only plastic plants are used in some cases. Aquatic plants, including artificial ones, are very readily accepted by the animals as cover. Each tank is filtered with a powerful external filter.

The lighting is provided by fluorescent tubes, for example, which are controlled by a timer. The extent to which a UV component in the lighting is beneficial in the long term is still being discussed. MUÑOZ SARAVIA & MARRIOTT (2023) argue in favour of such a UV component, which must be strong enough for the radiation to penetrate the water.

If the aquarium cannot be set up in a constantly cool cellar or room, a water cooling system must be installed, which is available in the aquarium supplies section for all possible applications. Apart from this possibly necessary water cooling, the effort required to keep these frogs is not very high (but: observe the water values, see point 4.4). If necessary, a small amount of water is replaced, for example to remove dead food animals from the bottom or the water surface. The filters and the flexible hoses of the outlets and inlets are cleaned approximately every two months.



View of the show aquarium at the Allwetterzoo Münster; sand as substrate, hiding places with stones, roots and aquatic plants | Heiko Werning



Keeping in a large plastic tub without substrate | Heiko Werning



Aquarium system for breeding Titicaca Water Frogs | Sebastian Rohling



Cooling unit for setting the required low water temperature | Sebastian Rohling



4.4 Water chemistry, technology and temperatures



Filter systems help to maintain water quality | Heiko Werning

Titicaca Water Frogs prefer regions in the lake with a pH value of 8 to 8.5, a KH between 4-5 dH and a total hardness of 12-13 dH. This means that the frogs require hard water. The carbon dioxide value is between 0.4 and 0.7 mg/L.



Earthworms are eagerly eaten | Sebastian Rohling

4.5 Feeding

According to HONIGS et al. (2021), the adults are fed twice a week with red earthworms (*Lumbricus rubellus*), small individuals of earthworms (*L. terrestris*), giant redworms (*Eisenia hortensis*, *Dendrobaena*), enchytraea (*Enchytraeus albidus*), freshwater amphipods (*Gammarus*) and various indeterminate aquatic snails or pellets for *Ambystoma* species (axolotl food) as varied as possible. The food should not be too high in fat and the calcium-phosphorus ratio should be positive (i.e. more calcium than phosphorus; MUÑOZ & MARRIOTT 2023). It goes without saying that all food animals should be fed a good, balanced diet.

In the wild, Titicaca Water Frogs eat around 65 % amphipods (including *Hyaella*) and snails (large sand snails, disc snails, limpets, *Heleobia*, *Biomphalaria*), as well as plate leeches, beetles, chironomid and caddis fly larvae. Large frogs also eat small fish (e.g. Andean carp, *Orestias*), tadpoles and smaller amphibians - including their own species. Young frogs increasingly favour amphipods and adult snails. The older the animals get, the more snails they eat. The snail shells are not digested. Perhaps the snail shells are helpful for digestion, analogous to stones in the stomachs of birds. Another hypothesis is that the snail shells slow down the intestinal passage of the food slurry so that more nutrients can be absorbed. The snails offered to the frogs at the Aquazoo Löbbecke Museum Düsseldorf, such as post horn snails (*Planorbidae*) and bladder snails (*Physella*), were eaten rather reluctantly (HONIGS et al. 2021).

Small fish can probably also be offered, but it may be difficult to remove them from the aquarium when the frogs lay eggs, and there is a risk that the fish will harm the spawn.



4.6 Offspring

In Bolivia and Peru, Titicaca Water Frogs have been bred in ex-situ initiatives since around 2010, initially only experimentally, but after the mass extinctions in 2015 also specifically to establish a conservation breeding population (MUÑOZ & MARRIOTT 2023).

Titicaca Water Frogs reach sexual maturity relatively late by frog standards. In European zoos, they start laying eggs at around the age of two.

Mating in the wild can take place all year round. Mating takes place in shallower lake shore areas. The male clasps the female in the axillary amplexus, i.e. under the armpits, so that the male's belly comes to rest on the female's back.

Mating can also take place in the aquarium all year round. A partial water change can help to trigger them (MUÑOZ & MARRIOTT 2023).

A clutch can contain 80-500 eggs (there are also observations of clutches with over 900 eggs). They are attached to the underwater vegetation in clusters of around 20-50 eggs, in the aquarium they are also laid on plastic plants or simply on the bottom. The males guard the clutches.

At a water temperature of 13-14 °C, the tadpoles hatch after around 12 days. At this point at the latest, the tadpoles must be caught from the aquarium and placed in a separate tank if they are to be reared. As mentioned, the adult frogs are cannibalistic and also eat tadpoles of their own species.

During the first two days after hatching, the tadpoles begin to scrape algae from the bottom and sides of the tank. This is also when they are first offered axolotl pellets or fish flake food.



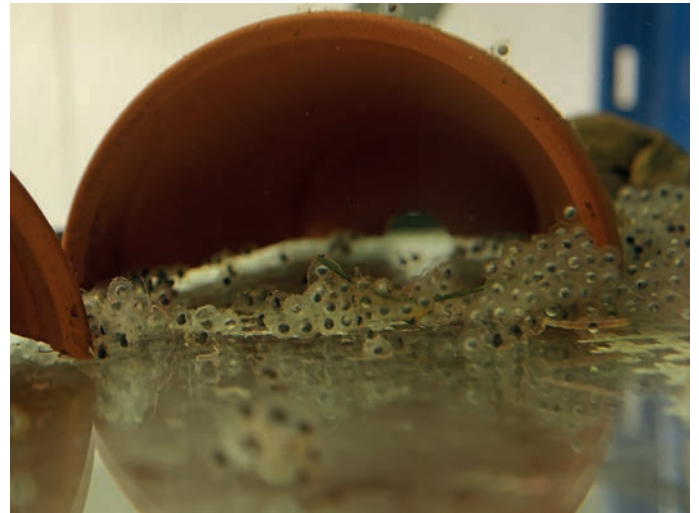
Titicaca Water Frogs in amplexus in the wild ...
| Arturo Muñoz-Saravia



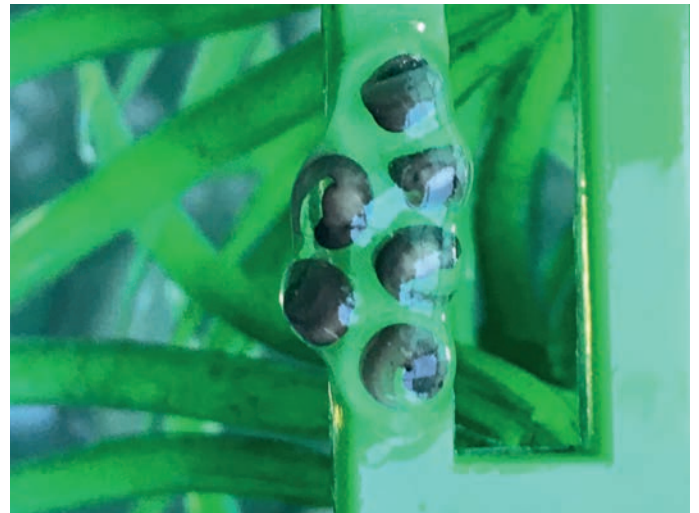
... and in the aquarium | Tina Nagorzanski



After the eggs are laid | Sebastian Rohling



Freshly deposited spawn balls | Sebastian Rohling



The tadpoles slowly develop in the eggs | 1&2: Image archive Aquazoo Lötbecke Museum; 3&5: Arturo Muñoz-Saravia



The same tadpole at the age of 77 days, approx. 3 cm long. Especially the pigmentation and the already large round eyes can be seen. | Image archive Aquazoo Löbbecke Museum

Tadpoles of *T. culeus* are omnivorous. They also gnaw on pieces of fish, e.g. salmonids (*Salmonidae*) and atherinids (*Atherinidae*), which are commercially available as frozen food. The same applies to mussels, enchytrae, gammarus and water fleas (*Daphnia*) (HONIGS et al. 2021). According to previous experience, the tadpoles take between two months and a year to metamorphose in the aquarium, in individual cases even longer (WAGNER, pers. comm.).



Large tadpole | Sebastian Rohling



Freshly hatched tadpoles | Christian Bittner



The next generation | Image archive Aquazoo Löbbecke Museum



Tadpole of *Telmatobius culeus* shortly after hatching, approx. 1cm long. | Image archive Aquazoo Löbbecke Museum



Mature offspring | Image archive Aquazoo Löbbecke Museum



4.9 Problems

Special attention should be paid to the calcium-phosphorus ratio in the diet. The feed should contain a higher proportion of calcium than phosphorus. This can be influenced by an appropriate diet for the food animals and/or by selecting food animals with a particularly high calcium content (shell snails, isopods).

UV radiation is very strong at the high altitude of Lake Titicaca. Some of it also penetrates deeper into the water and can reach the frogs when they are in shallower areas and apparently even sunbathe on stones under water.

MUÑOZ & MARRIOTT (2023) suspect that frogs kept in aquaria without UV light can suffer from bone metabolism disorders in the long term. To our knowledge, such problems have not yet occurred in German aquaria, but should be considered. A diet rich in calcium and supplemented with vitamin D3 can prevent such disorders, as can a UV component in the lighting that is strong enough to ensure that sufficient light in this spectral range is also received under water.

Care must be taken to ensure that the frogs cannot climb out of the aquarium. Although Titicaca Water Frogs live an almost exclusively aquatic life, they are perfectly capable of climbing out of the water.



Caution - Titicaca Water Frogs can also leave the water. The aquarium must therefore be escape-proof so that the animals cannot escape and then dry out. | Image archive Aquazoo Löbbecke Museum



5. Further Reading

A detailed list of further literature can be found in HONIGS et al. (2021). The information in this basic information and husbandry recommendations is essentially based on the following sources:

BARBOUR, T. & G.K. NOBLE (1920): Some amphibians from northwestern Peru, with a revision of the genera *Phyllobates* and *Telmatobius*. – Bulletin of the Museum of Comparative Zoology 63: 395–427.

GARMAN, S. (1876): *Cyclorhamphus culeus* (nov. Sp.), Pl. 1. Bull. – In: Exploration of Lake Titicaca. I. Fishes and reptiles. Bulletin of the Museum of Comparative Zoology: 276–277.

HONIGS, S., B. PELZER & M. MESSING (2021): Die Geschichte des Frosches mit der viel zu großen Jacke – der Titicaca-Riesenfrosch (*Telmatobius culeus*) und die Amphibienkrise. – elaphe 6/2021: 12–23.

HONIGS, S., B. PELZER & M. MESSING (2021): Keeping and breeding of the Titicaca giant frog (*Telmatobius culeus*) in the Aquazoo Löbbecke Museum. – Der Zoologische Garten 89: 37–56.

IUCN SSC AMPHIBIAN SPECIALIST GROUP (2020): *Telmatobius culeus* (errata version published in 2020). – The IUCN Red List of Threatened Species 2020: e.T57334A178948447. <https://dx.doi.org/10.2305/IUCN.UK.2020-2.RLTS.T57334A178948447.en>.

MUÑOZ SARAVIA, A. & T. MARRIOTT (2023): Captive Breeding *Telmatobius* with the Bolivian Amphibian Initiative. – Responsible Herpetoculture Journal September/October 2023: 24–33.



Telmatobius culeus in Lake Titicaca | Arturo Muñoz-Saravia