

Basic information and care recommendations
for *Salamandra salamandra salamandra* and
S. s. terrestris, Central European
fire salamanders





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1. Profile

Scientific name: *Salamandra salamandra salamandra* & *Salamandra salamandra terrestris*

Common name: Fire salamander

Length: Up to 20 cm

CC#Amphibians-Kategorie: I

IUCN Red List conservation status: Least concern

CITES conservation status: No

EU species protection regulation status: No

German Federal Species Protection Ordinance status: Appendix¹

Protection status according to the Federal Nature Conservation Act: Specially protected

Endangerment status according to Red List in Germany: Pre-warning²

Accommodation: Terrarium with water part or water bowl

Required equipment: Escape-proof, systematized or natural terrariums, land part and water part or water bowl, food tweezers, sprayer; outdoor terrariums possible in suitable regions after consultation with the CC office

Diet: Animal food of suitable size such as earthworms, crickets, isopods, snails, pellets

¹For species *Salamandra salamandra*, meaning all subspecies across the entire range are combined in one assessment.

²However, without taking into account the current threat posed by *Bsal* (see chapter 3.2 conservation status)





2. Why are Central European fire salamanders kept at Citizen Conservation?

The fire salamander is widespread in Europe. Its range extends from the Iberian Peninsula across Western, Central and Eastern Europe to the Ukraine and Romania as well as Bulgaria. In the south, it can be found as far as southern Italy and in the north as far beyond the Elbe. Numerous subspecies are distinguished throughout the entire range, some of which can also differ greatly in their ecology. In Germany, two subspecies occur, *Salamandra salamandra salamandra* (Spotted Fire Salamander) and *Salamandra salamandra terrestris* (Striped Fire Salamander), as well as a third genetically differentiated lineage (PREISLER 2020).



The two subspecies of the fire salamander native to Germany, the spotted fire salamander (left) and the striped fire salamander (right) | Benny Trapp



Due to its large distribution range, the species is considered as „least concern“ on the global Red List of the World Conservation Union IUCN. In Germany, it has been placed on the Red List in the category „pre-warning“. The reason for this is anthropogenic (man-made) landscape changes, especially in the water bodies used for larval settling.



The massive local extinctions observed in the Netherlands, Belgium and some regions of Germany (especially in the Eifel and Ruhr regions) do not yet threaten the species throughout its range and have not yet been taken into account in the national assessment in Germany. The reason for these drastic local population declines up to local extinction events is the chytrid fungus *Bsal* (an abbreviation of the scientific name *Batrachochytrium salamandrivorans*), also called salamander killer or salamander plague, which causes affected populations to collapse within a short time. Currently, there is no way to control *Bsal* in the wild, but in human care affected fire salamanders can usually be treated successfully.



Citizen Conservation is therefore taking action before it is too late and is already building capacity to conserve the diversity of the native fire salamander in Germany in the long term. This means that Citizen Conservation is establishing reserve populations for areas that are already affected by *Bsal*, but also for areas where the fungus may appear in the future, and wants to advance the expertise for keeping and breeding this fascinating species and spread it over many shoulders.



The markings of the fire salamanders are always unique, making it easy to recognize each animal... | Benny Trapp



3. Biology and conservation

3.1 Biology

The native fire salamander belongs to the family Salamandridae within the order Caudata. In Germany, it is differentiated into three genetic lineages (PREISLER 2020). Two of them correspond to the two subspecies *S. s. salamandra* and *S. s. terrestris*. The native fire salamander is a typical species of moist mixed deciduous forests at medium altitudes, about 200 to 400 m above sea level, where it is mainly found in springs and streams. It feels particularly at home in forests with a high proportion of beech trees. Nevertheless, it is very adaptable and can be found in a variety of terrestrial habitats, including forest edges and near humans, using a wide range of water bodies for its larvae, even temporary ponds. The altitudinal distribution ranges from sea level to about 900 m a.s.l. in the Black Forest and 1,000 m a.s.l. in the Bavarian Alps. Predominant habitats are therefore the forest floor, forest edges, adjacent open areas, but also suitable habitats in settlements such as cemeteries, parks and semi-natural gardens. It is important to have a sufficient number of daytime hiding places and winter quarters, which are often available through sufficient deadwood and open holes under roots and on slopes.



Fire salamanders are typical inhabitants of beech forests. | Benny Trapp



Characteristic natural habitats of the fire salamander. It feels at home in deciduous and mixed forests with numerous hiding places. | Benny Trapp

In nature, fire salamanders are subject to a distinct annual rhythm. The predominantly nocturnal animals become active for the first time from the end of March or beginning of April until May and then have a second intensive activity period at the end of August and in September. However, the most important factor is the weather, so fire salamanders can be found in the wild in any month, provided temperatures (between 3°C and 12°C) are suitable and humidity is high (often over 90%). Unique among caudates, the female fire salamander deposits live larvae in a body of water. This usually happens in spring, after the larvae have reached birth maturity between mid-September and the end of October (SEIDEL & GERHARDT 2016). Depending on the respective habitat conditions, metamorphosis of the inconspicuous brown-patterned larvae takes place after 40 to 120 days, and the finished salamanders go ashore in their typical black and yellow colouration.

Adult native fire salamanders usually have an overall length of between 14 cm and 17 cm, with males often being minimally smaller. Occasionally, individual animals can grow up to 20 cm long, and even an animal of 22 cm has been measured. Pregnant females can weigh more than 50 g, males are usually lighter than 20 g. Males are thus somewhat slimmer than females, but their heads are often broader. At breeding time, the cloaca of females is swollen like a bulge. The tail length is slightly shorter than the head-torso length. In terms of colour, almost all animals have the typical black and yellow pattern, whereby the respective colour proportions can vary greatly between and within a population, from almost completely yellow animals with some black to the opposite case. Rarely, there may also be individuals with orange or even red colouring instead of yellow. Based on their respective individual patterns, both individual larvae and adults can easily be distinguished individually.

Fire salamanders are long-lived animals. Some specimens reach an age of 30 years, the age record is even proven to be over 50 years. There are numerous articles and very nice summaries on the biology of the fire salamander. For further reading, the following books can be recommended, among others: THIESMEIER 2004, SCHORN & KWET 2010, PASMANS et al. 2014, SEIDEL & GERHARDT 2016.



3.2 Conservation status



Animals suffering from chytridiomycosis caused by *Bsal*. You can clearly see the „holes“ in the skin of both animals. On the right, these are highlighted by the green arrows. | left: Miguel Vences; right: Frank Pasmans

The fire salamander is currently not considered to be endangered in its entire range, and therefore has the status „Least Concern“ on the Red List of the World Conservation Union IUCN. Nevertheless, the overall population is declining and in some places severely threatened locally.

In Germany, the species is included in the Red List in the category „Pre-warning“. However, at the time of this assessment, the threat from the chytrid fungus *Bsal* was not yet taken into account. Amphibians are considered vulnerable to introduced diseases such as the chytrid fungus *Bd* and ranaviruses. In recent years, however, fire salamanders in particular have been facing a completely new threat, which in some cases has dramatic consequences for affected populations: in 2013, a new disease was discovered that is triggered by the so-called „salamander-killing fungus“. Its full scientific name is *Batrachochytrium salamandrivorans*, usually abbreviated to *Bsal*. Fire salamanders infected by it die in a short time, so that entire populations can be wiped out within a few months. In the border triangle of the Netherlands, Belgium, Germany and neighbouring areas, this has already happened in several places. Currently, *Bsal* is spreading continuously, especially to the east, and is already known from two regions in Bavaria (Steigerwald and Allgäu). The further spread of *Bsal* therefore threatens the fire salamander in its entire range and thus in its diversity. Even complete extinction in Germany seems conceivable in the medium term. For this reason, it is important to build up stable reserve populations in human care and to protect them from infection with *Bsal* and other diseases. Therefore, a special focus of Citizen Conservation #Amphibians is on disease hygiene.



3.3 Conservational efforts

In many regions of Germany, parts of the natural habitat of the native fire salamander are protected. However, *Bsal* does not stop at protected areas, of course, as it can be spread in many ways. On the one hand, through animal vectors such as other amphibians that do not contract it, as well as numerous other vertebrates and invertebrates also come into question for this purpose. On the other hand, the spores of the fungus can also survive in the environment (e.g. in the soil, water, on plants or in foliage) for some time. Unfortunately, people who unknowingly spread the spores of the fungus probably have a large share in the spread of the fungus. Cleaning and disinfection of vehicles, materials, etc. is therefore strongly recommended.

Precise recommendations for action can also be found here:

- <http://bsaleurope.com/hygiene-protocols/>
- https://www.lanuv.nrw.de/fileadmin/lanuv/natur/dokumente/Hygieneprotokoll_Amphibien_und_Praxistipps_April_2019.pdf



Mass mortality in the forest near Solingen. The reason for this is the salamander plague *Bsal*. | Rainer Stawikowski



4. Care

Fire salamanders have been successfully kept and bred in private hands, institutions and zoos for decades. Therefore, there are a number of well-tested ways to successfully keep and breed them. The recommendations given here are mainly based on the experiences of Uwe Seidel, Philip Gerhardt, Frank Pasmans and numerous other people, which are nicely summarised in PASMANS et al. 2014, SCHORN & KWET 2014 and SEIDEL & GERHARDT 2016, among others, and can be read in more detail in these husbandry recommendations.



Uwe Seidel and Philip Gerhardt together have more than half a century of experience in salamander conservation. Integrating such expertise is one of the goals of Citizen Conservation. | Benny Trapp, Frogs & Friends



4.1 Requirements and documentation obligations

There is no international protection status. In Germany, *Salamandra salamandra* is listed as „specially protected“ in Annex 1 of the Federal Species Protection Ordinance and the Federal Nature Conservation Act. The animals as well as all population changes such as deaths, but also offspring or releases must therefore be reported to the competent authority (usually the Lower Landscape Authority). A copy of the certificate of origin of CC #Amphibians must be submitted for this purpose. Any change in the population must be reported in writing within four weeks to the CC #Amphibians office (a simple e-mail is sufficient) as well as to the competent authority. If animals are sold or purchased through CC #Amphibians, this change of stock must also be reported to the competent authority. The notification of offspring can be made to the CC #Amphibians office at the age of about six months, when the number of young animals expected to reach adulthood becomes manageable. The procedure for reporting offspring to the competent authority must be discussed individually with the authority.

4.2 Transport

CC animals, including their offspring, may only be transferred in consultation with the CC office. Before each change of location within CC, a swab sample of the animals must be taken in accordance with the CC instructions (see separate information sheet) and submitted for examination for the chytrid fungi *Bd* and *Bsal*. In addition, a faecal sample should be sent in for parasitological examination (use CC's examination order, available from the CC office; CC bears the costs). Once the test results are negative or it has been confirmed that there is no parasite load requiring treatment, the animals can be handed over, either personally or by a forwarding agent approved for animal transport. An information sheet from the CC office provides information on the appropriate contact persons. The costs of transport are borne by the recipients of the animals.

Please note: There is a special regulation within Citizen Conservation for taking fire salamanders into care. If keepers who already care for amphibians at home take over fire salamanders from CC, the entire stock is to be tested once beforehand by means of pool samples in order to ensure that no *Bsal* is present there undetected, possibly on other species. The costs for this initial test is borne by CC. If further amphibians are added to the stock of the keepers during the keeping period, these must also be tested for *Bsal* beforehand (which should be a matter for amphibians anyway). The costs for these standard examinations of own animals are borne by the keepers themselves.



In preparation for a transport, the salamanders should no longer be fed one week before the planned date. This prevents the animals from soiling their transport container with faeces. Fire salamanders, both adults and juveniles, should always be transported individually in a plastic box with air holes appropriate to their size. The air holes should be designed so that there are no sharp edges inside the box where the animals could injure themselves. It should be possible to close this container securely; if necessary, adhesive tape can be used to ensure that the lid is securely fastened.

Moderately moist sphagnum moss has proved very effective as a transport medium. This can be purchased dried and neatly packaged. The animals must be able to burrow into the substrate if they want to avoid stress. For this purpose, the transport box should be filled to approx. 75 % with the substrate. The moss can be much wetter than is usual in normal husbandry.

Transporting only on damp household paper has led to problems in many cases. The salamanders constantly run up and down the container looking for a hiding place and may die of exhaustion. The use of living forest moss as a transport substrate should also be avoided in any case. At a time when the chytrid fungus *Bsal* is spreading in nature, the infection may possibly enter the terrarium stock this way.

The individually canned salamanders are always transported in thermostable boxes (polystyrene boxes), never in the car or in bags without outer packaging! The polystyrene boxes provide protection against abrupt temperature changes and can be additionally cooled in summer with water bottles (5-6 °C) stored in the refrigerator (and secured against rolling around). The temperature inside the box should be checked with a thermometer with sensor.

Attention, very important: Never put frozen cooling elements in a polystyrene box! The temperatures drop too much and the salamanders may freeze. Basically, if the owner changes within CC, personal handover should be the goal. According to animal welfare legislation, postal shipping may only be carried out by certified shipping companies that specialise in live animal shipping. Live animals should not be shipped during extreme weather conditions (frost or high summer temperatures). If necessary, the CC Office can assist in finding a certified animal shipping company. According to the CC guidelines, the costs for shipping and delivery are borne by the recipients.

Larvae should only be transported in rare exceptional cases. They are much more sensitive and must be transported individually in a sufficient amount of cooled water (see also in detail: „Transport“ in SEIDEL & GERHARDT 2016).



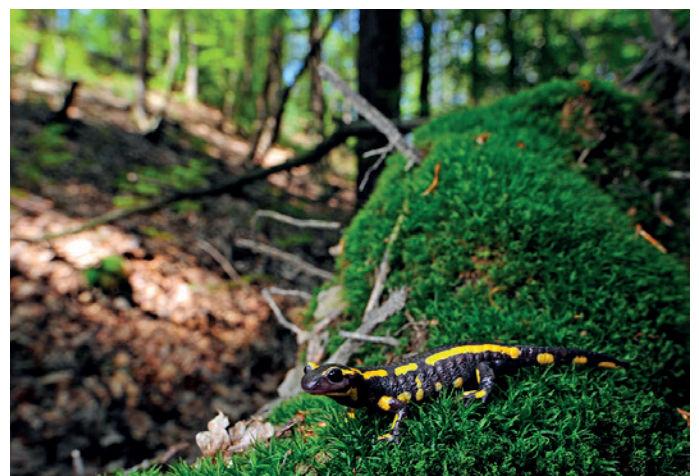
4.3 Group composition

Ideal for breeding is a group of one male and one female (1,1) or one male and two females (1,2). Larger groups can harmonise, but can also lead to the animals stressing each other. Males are particularly susceptible to this; in mixed-sex groups, they may engage in combat fights among themselves and may harass females severely. Male-only groups, on the other hand, have been successfully kept and are sometimes useful and necessary in a managed breeding programme. In principle, groups can be reassembled, but it may happen that they do not harmonise. Therefore, such changes should only be made in exceptional cases. Juveniles (after metamorphosis) can be raised together in larger groups until sexual maturity. Larvae can eat each other if not enough food is offered or if they are of different sizes. It makes sense to divide larvae and juveniles according to growth size.

Citizen Conservation generally recommends keeping them in species tanks, i.e. without socialising with other amphibian species. Additional stocking with invertebrates (e.g. isopods, earthworms or springtails in the terrestrial part) is possible. It is generally not permitted to keep CC animals together with conspecifics that do not belong to the CC programme or with their own offspring. When keeping several CC groups of the fire salamander, please ensure that the animals are not mixed and that they are reported separately by group in the semi-annual population reports. The CC programme is based on coordinated breeding, and special attention must be paid to the genetic background of the animals in order to avoid unnecessary inbreeding and narrowing of the gene pool in the CC population. Therefore, animals may only be placed in other groups after consultation with the CC office or on the instruction of the studbook keeper.

4.4 The terrarium

For 2-3 animals, a terrarium with dimensions of 80 cm x 40 cm is required, 100 cm x 50 cm is better. For ventilation, the terrarium should have large ventilation areas with gauze; stagnant air as well as stagnant moisture should be avoided at all costs. Like many amphibians, fire salamanders are very good at escaping, so it is essential to ensure that this is not possible. Three things are essential for keeping them: hiding places, the possibility for the fire salamanders to regulate their skin moisture themselves, and a high degree of hygiene.



The typical natural home of a fire salamander, which can occasionally be seen during the day in suitable weather conditions. | Benny Trapp



4.5 Location, temperature requirements, technical terrarium equipment

The terrarium should be placed in a room that is not heated and preferably not facing south. Especially in summer, make sure that overheating is avoided at all costs. In addition, the containers must not be able to overheat due to sunlight coming in through windows! Attic rooms are also generally not suitable for keeping fire salamanders.

Fire salamanders have a certain adaptability with regard to the average temperatures in their terrariums. This means that seasonal differences (and not only the average temperature) are important for long-term successful husbandry. Optimal temperatures in the terrarium are lower in winter than in summer and lie between 2 °C and 6 °C in winter and a maximum of 20 °C in summer. If 20°C is exceeded for several days, cooling is necessary. Normal room temperature is sufficient for permanent keeping during the annual activity period. A maximum of 26-27 °C in summer can be tolerated for a short time, but then a significant night-time reduction is necessary! Especially at higher temperatures, avoid stagnant air and dampness!

A hibernation of 6-10 weeks at low temperatures, for example constant 4 °C to 6 °C in the period from November to March, is recommended. Hibernation can begin 2-3 weeks after the last feeding. Animals are transferred individually into small containers (e.g. plastic boxes with closable lids and ventilation holes) with black peat as substrate and slightly moist (living) Sphagnum moss. The overwintering is done either in a suitable cellar room or in a refrigerator. A check should be carried out every fortnight. A slow acclimatisation to higher temperatures (e.g. one day at 15 °C to 17 °C) followed by a bath at low water level and the same temperatures is also recommended. After 2-3 days, feeding can be started again. If the hibernation lasts longer, it should be carried out in a somewhat larger container with a hiding place and a water container. Then it should be checked weekly and cleaned if necessary. At winter temperatures of 9-12 °C in the terrarium, hibernation can be dispensed with without any problems. If no specific hibernation is carried out, early weaning of the larvae can be expected from autumn onwards at these temperatures. A summer rest, also called summer dormancy or aestivation, can also be carried out with appropriate hiding places that offer climatically suitable retreat possibilities. Aestivation can last 8-12 weeks. During this time, feeding is rare to non-existent and spraying is minimal to non-existent. Increased spraying initiates the end of summer dormancy and often initiates larval weaning.

Important: Permanently low temperatures, i.e. throughout the year, around 10-12 °C, as still recommended in older literature, are counterproductive. Fire salamanders also need higher temperatures to carry out their metabolism. It makes more sense to have temperatures that vary with the time of day in summer, i.e. a noticeable night-time reduction. The basic brightness in a normal room with windows is sufficient for keeping fire salamanders, the animals are mainly nocturnal. Additional terrarium lighting can of course be provided in display tanks for aesthetic reasons, but then lighting fixtures should be used that do not produce additional heat, e.g. LEDs.



Systematised posture in a Euro container according to Uwe Seidel and Philip Gerhardt. All crucial elements are marked.

| Illustration: Jonas Lieberknecht

4.6 Terrarium furnishing

The basic needs of a fire salamander are: suitable substrate, water bowl and hiding places. With appropriate structuring and various hiding places, a humidity gradient can be ensured under certain circumstances, so that a „wet box“ can be omitted. An important question in keeping fire salamanders is the substrate in the terrarium. Basically: No excreta (faeces) of the salamanders should accumulate in the substrate. This will inevitably lead to health problems! It is also important that fire salamanders need a relatively dry environment. The animals cover their liquid requirements by bathing in the water tank at night. Too much „basic humidity“ or even wetness will inevitably lead to skin problems. It is advantageous to create two spatially separated, different (dry) substrates, for example one part of the terrarium with clay and one with black peat. This allows the animals to visit environments with different pH values. It should be noted that depending on the substrate, contamination may be more difficult to detect. The setup can be kept simple with a clay substrate, a water bowl and a few simple clay hiding places. However, it can also be elaborately designed with soil, leaves, humus, dead wood, bark, stones, living moss, other plants, etc. Living plants need an appropriate light source and adequate water supply. It must be ensured that this does not conflict with the needs of the salamanders, for example, the terrarium must not become too warm or too humid. However, even with a complex setup, it must be possible to ensure the necessary hygiene and the effort required for control, cleaning, feeding, etc. must be taken into account. As with any terrarium setup, an unintentional introduction of pathogens or toxins through natural materials must be prevented. Therefore, no material from outdoors (danger of *bsa!*) may be used without prior sterilisation!



For systematic husbandry (according to SEIDEL & GERHARDT), newspaper has proven to be a good substrate. This can be replaced quickly (every three to six weeks, depending on the degree of soiling), is hygienic and always available. However, no colour printed sheets should be used, but normal daily newspapers. Never spray in such containers! Therefore, a water bowl and a wetbox with moist Sphagnum moss are absolutely necessary. Please replace the moss about every eight weeks. Hollow pieces of cork bark or clay form the hiding places. It is important that the animals can always choose their place of residence between „moist“ and „dry“ according to their needs. A water bowl with an exit aid (absolutely necessary) completes the simple set-up and should be checked every one to two weeks. During the breeding season, this should be done daily, as the larvae are deposited in it. A standardised Euro container (height 12 cm or 22 cm) can be used as a container. The handle openings are closed with gauze. This type of husbandry is designed purely functionally to keep the animals healthy, to meet their needs and to reproduce the salamanders and therefore already has a kind of „laboratory character“. The aesthetic value of such a tank is low, but the husbandry is very successful. When it comes to targeted reproduction while meeting the needs of the animals, it is currently our recommended husbandry within the CC #Amphibians project.



This is what the systematised furnishing looks like in real life. | Uwe Seidel



However, concepts based on a paludarium can also be realised for display enclosures - be it in zoos and other public institutions, or in private homes if the visual aspect is to play a role. This can also be designed in such a way that the salamanders can be seen during the day, for example through visible hiding places in a designed back wall or something similar.

Firmly tamped and then dried clay is often used as natural substrate. This should also be kept dry. Droppings must be carefully removed. The replacement of this substrate becomes due after a certain period of time and is of course much more time-consuming. According to the experience of many keepers, it is recommended to change the natural substrate about once a year (if, as mentioned, good hygiene is taken care of in the meantime). An alternative to clay is bentonite. This clay mineral mixture can be bought everywhere in the form of cat litter. It has similar properties to clay, but is less complicated to obtain. Other natural soil types are forest, flower or peat soil. (Do not use natural soil without sterilising it first!) The soil must not be fertilised. It must also be changed regularly, which is time-consuming if there are several terrariums. On the positive side, decomposers such as earthworms, isopods and especially springtails do well in this substrate. Peat soil can have an antibacterial effect due to its acidic pH value, but is to be considered problematic for nature conservation reasons. Natural substrate should be placed at an incline; this creates a certain moisture gradient so that the animals can choose the best place for themselves.



Terrarium set up with natural substrate | Philip Gerhardt



Another „artificial“ housing option is the use of foam or filter mats as terrarium substrate. Filter mats are made for aquariums, so they can be used without hesitation after a good rinse, in contrast to conventional foam, which can contain toxic softeners. The terrarium floor is covered with the filter mat, leaving one corner free. Then water is poured into the entire terrarium in such a way that a water level of about 1-2 cm is reached, depending on the thickness of the foam (it should be at least 3-4 cm thick). The part of the terrarium floor that is not covered by the foam will automatically become the water part of the terrarium. Here too, please make sure that there are easy ways to get out! The bottom substrate is cleaned by adding water and sucking out the old water in the water section. In this way, the filter mat or foam is regularly rinsed. One advantage of this procedure is that it is easy to regulate the humidity in the substrate. Springtails keep relatively well in the mat. However, despite regular flushing, this housing method is somewhat more susceptible to bacteria and germs that settle in the mat. It is particularly suitable for boxes with young animals, which need more moisture than adult salamanders. A small box for young animals can then simply be rinsed through in the sink for cleaning, which is quick and uncomplicated and very practical, especially with larger numbers of young animals. Various terrarium keepers also practise other types of keeping, e.g. keeping on forest moss or on gravel. All forms of husbandry have their advantages and disadvantages. In the end, everyone has to find their own way. However, the main requirements provide orientation: Despite the always necessary humidity (water part, humid areas such as wetbox), the substrate must be rather dry, and great impor-

tance should be attached to hygiene! Adding live plants is often difficult and not relevant for keeping fire salamanders, so it is a purely visual issue and should only be considered for display terrariums. It must be avoided that too much moisture, which plants often need, gets into the substrate, and salamanders like to burrow into the plant containers. If you do not want to do without a little greenery for aesthetic reasons, you can use well-made plastic plants. These can also be easily cleaned and disinfected if necessary.

In order to achieve the necessary humidity gradient in the terrarium, it is recommended, especially in summer, to spray with water twice a week. As a rule, the basins should be dried on the surface again after 2-3 hours.



Terrarium for fire salamanders set up close to nature, but very time-consuming to maintain | Jörg Beckmann



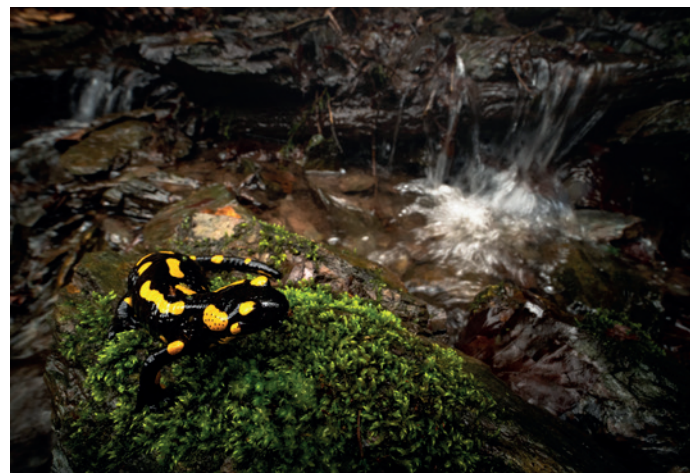
4.7 Outdoor terraria

The free-range keeping of fire salamanders can only happen after consultation with the CC-#Office. Of course, suitable sites and facilities are essential. In principle, free-range husbandry is possible in temperate latitudes within the natural range and in climatically comparable regions. This can be done either all year round, with suitable wintering facilities, or seasonally, so that the animals only remain in the outdoor terrarium from spring (March/April) to autumn (October/November) and overwinter under controlled conditions indoors. This is especially recommended for smaller enclosures where safe overwintering cannot be guaranteed. In nature, fire salamanders always hibernate in frost-free places, i.e. in the outdoor terrarium it should be possible for the animals to get at least 1-2 m below the ground surface. Depending on climatic conditions, 50 cm may be sufficient. For hibernation, a suitable shaft (hibernaculum) or appropriately constructed rock fills that allow passages down to this depth are necessary.

Fire salamanders can be successfully kept in outdoor enclosures of 0.5 x 0.5 m if they have a good choice of location (shade) and sufficient retreat possibilities, provided that the climatic conditions in the enclosure must be well known and regularly checked. In addition, this type of husbandry requires supplementary feeding. In enclosures in the forest in the natural habitat with a size of 2.4 x 1.2 m, individual adults live without supplementary feeding and gain weight. On a floor space of 3.14 m², 2.4 adult animals were successfully kept and overwintered in closed outdoor facilities (aviaries). with biweekly supplementary feeding. For three to four adult pairs a floor space of 12-15 m² should be sufficient to forage, breed and hibernate independently.

The size and local conditions of the area determine to a large extent whether the project can be replicated or not.

| Jakl Zdenek, Shutterstock



Basically, the following points must be observed when keeping the animals outdoors:

Flooding due to heavy rainfall, adjacent water bodies and/or waterlogging must be prevented by an appropriate system and drainage. For smaller outdoor terrariums, a roof can also prevent too much rain, but then water may need to be sprayed regularly. There should be enough hiding places and retreats in the enclosure so that the animals can avoid heat and find the optimal microhabitats they need (especially in terms of temperature and humidity). This can easily be achieved through appropriate planting, shading of the enclosure and natural hiding places such as dead wood. It is optimal if the animals can retreat into the subsoil via a deep gap system. If overwintering is to take place in the enclosure, the animals must be able to retreat safely into the depths. Care must be taken to ensure that the retreat areas cannot be buried or flooded and remain frost-free throughout the winter, even during short-term extreme events.

The enclosure must be constructed in such a way that fire salamanders cannot escape, either by appropriate covers (for example grids or nets) or by overhanging edges. Fire salamanders come up vertical walls, but overhangs of at least 6-10 cm are not overcome.

The biggest challenge, especially if the facility is large enough, is to prevent intrusions of any kind. On the one hand, this is important to exclude the creation of escape possibilities for the fire salamanders, but also to prevent potential predators from entering the facility. In addition, other amphibians such as newts or frogs like to enter the facility. However, these pose a great risk as they can bring in diseases such as Bsal. The plant can be secured against burrowing intruders by burying the boundaries at a suitable depth (at least 60-70 cm). For smaller plants, the ground can be secured with an appropriate grid. Covers prevent unwanted intruders. If the enclosure is large enough, walk-in structures (similar to „aviaries“) can also be used. Electrical wires attached from the outside can also be used to secure the facility against intruders.



A fire salamander coloured red and black instead of the usual yellow and black costume | Benny Trapp

4.8 Feeding

Fire salamanders are exclusively carnivorous as larvae and adults, i.e. they feed only on other animals. In nature, at least 60-70 % of their diet consists of snails, earthworms, spiders, millipedes and beetles. Differences were observed between the sexes. Females fed more often on snails and millipedes, whereas males fed more often on centipedes and isopods.

In husbandry, crickets, steppe crickets, two-spotted crickets and earthworms are particularly suitable feeders for adult salamanders because of their easy availability. As with almost all other species, care should be taken that these are regularly supplemented („pollinated“) with appropriate vitamin and mineral supplements and that feeders are fed with high quality food („well loaded“) for several days before feeding. As a special treat, collected nudibranchs of appropriate size can be fed, but not all species are equally suitable. Some nudibranch species are too slimy or have a higher probability of ingesting pollutants and parasites due to their diet, e.g. faeces or carrion, and thus passing them on to the fire salamanders. Suitable species are mainly vegetarian species, such as the common field snail (*Deroceras reticulatum*); unsuitable species are, for example, slugs (*Arionidae*). Shell snails can also be fed; it should be noted that these are eaten with their shells and therefore even more attention must be paid to the appropriate size. So far, there is no known case of *Bsal* being transmitted by snails, but this cannot be ruled out and therefore no collected snails should be fed in regions where *Bsal* has already been detected.



Feeding with food pellets for turtles is also possible. The pellets are softened in water and then fed to the fire salamanders by hand using tweezers. „Grub Pie“ from the terrarium food manufacturer Repashy can also be used successfully as a non-living food. The advantage of the pellet food is that it is enriched with minerals and vitamins, especially calcium, as it was designed for turtle keeping. Salamanders can quickly develop metabolic bone disease such as rickets if they are fed inappropriately and are not supplied with sufficient minerals and vitamins.

As a general rule, adult animals should be fed about every 10-14 days, young animals weekly. Salamanders should always be a little hungry and immediately take up any upgraded food offered. Live food should always be „well loaded“, which means that the feeders themselves must have been fed as well as possible before feeding. In addition, they are dusted with a vitamin-mineral preparation (see also in detail: Feed management in SEIDEL & GERHARDT 2016). It is natural for salamanders not to find food every day, but to be actively foraging only when weather conditions are suitable. Healthy animals are able to survive longer feeding breaks well. These are naturally taken seasonally during winter dormancy and in summer when it is dry for longer periods. Longer feeding breaks of several weeks probably correspond to natural conditions, the animals grow somewhat slower and thus probably also become sexually mature later. Immediately after weaning offspring, a feeding break is not recommended for females. No food animals should remain in the terrarium for longer than 1-2 days; this applies especially to crickets.



Cut pieces of worm powdered with vitamin-mineral preparation are served on a piece of household paper (here: *Salamandra atra*) | Uwe Seidel



Uwe Seidel feeding from the tweezers | Benny Trapp



4.9 Breeding

In suitable weather in summer (thunderstorms or drop in air pressure), a light mist of water from a flower sprayer can trigger the fire salamanders' readiness to mate. The moisture should dry off again after 2-3 hours. Mating of fire salamanders takes place on land. The male deposits a spermatophore in a ritualised mating game. The female picks up the sperm package to later use it to fertilise the eggs in the womb. Mating takes place all year round when the weather is suitable. The female stores the sperm in a sperm pocket. Internal fertilisation is thus independent of mating and can take place up to two years later. During the first pregnancy, unfertilised eggs are often laid, sometimes up to 100 %. After about 12 weeks, larvae are deposited in water containers mainly at night over the course of several nights. This can take up to 50 days.

Fire salamanders give birth to live larvae (larviparity) - as already mentioned: a unique mode of reproduction among caudates! The larvae develop in the womb and break through the egg shells at „birth“. Afterwards they are immediately able to move and go hunting, in contrast to newt larvae, which go through an attachment phase in which their yolk sac is used up. Salamander larvae have no yolk reserves and must find food soon. Fire salamanders release up to 30 or 40 larvae, in extreme cases even up to 80, depending on the size and age of the female. Larvae are released during the activity period, more often in spring or summer.



Larvae of the fire salamander in different stages of development until shortly before metamorphosis (below). The clear patterning, external gills and typical yellow spots at the base of the legs are clearly visible. | Benny Trapp



Shortly before shore leave, the typical black and yellow colouring is already clearly visible.
I Ivana Stevanovski, Shutterstock



4.10 Rearing

As inhabitants of spring creeks and high mountain waters, the gill-bearing larvae are sensitive to water contamination. Good filtration or frequent water changes are therefore absolutely necessary for breeding. A well-functioning rearing system that significantly reduces the workload is described in SEIDEL & GERHARDT (2016). The larvae are highly cannibalistic and eat each other when there is a lack of food or strong differences in size. Therefore, only larvae of the same size should be kept together and sufficient feeding should always be provided, at least if the aim is to raise as many larvae as possible. Otherwise, keeping larvae of different sizes together can be used as a method of population management, since discarding the spawn, which is easy to implement in other amphibian species, is not possible in viviparous fire salamanders. If in doubt, please consult the CC office in time.

The larvae are reared in separate tanks. Shallow plastic bowls of 20 x 20 cm with a water level of 4-8 cm for four to five larvae as well as bowls of 40 x 30 cm (10 cm height) with a water level of 5 cm or 0.5 l per larva have proved successful. As mentioned at the beginning, it is important to pay attention to the right water quality. The water temperature should be between 15 °C and 20 °C, and the water must be rich in oxygen. At lower temperatures the larvae grow very slowly, higher temperatures are only tolerated for a short time. A pH value between 6 and 7 is recommended, no ammonia and nitrite in the water (upper limits: ammonia 0.02 mg/l, nitrite 0.1 mg/l, nitrate 50 mg/l). The water should be kept in motion with a bubbling stone and an aquarium pump and have a high oxygen content. Mould formation must be avoided at all costs, i.e. food remains must be removed immediately. The addition of oak leaves (*Quercus* sp.), sea almond leaves (*Terminalia catappa*) or an extract of boiled alder twigs and cones (*Alnus* sp.) has a positive effect on the water quality and prevents fungal diseases. Larvae with fungal diseases (mycoses) have little chance of survival and must be separated. Leaves, stones and shards of clay as hiding places are sufficient as tank equipment. A daily check of the larvae is necessary, a water change every two days. Tap water must not contain chlorine, letting it stand for a day will cause it to evaporate.

The duration of the larval period depends strongly on the water temperatures. When reared at a water temperature of 15-20 °C, the larvae need 8-12 weeks until metamorphosis. It is quite normal that not all larvae reach metamorphosis. Weaker animals are readily taken as food by their siblings. This is a biologically normal process and ensures that only the strongest young develop further. Feed the larvae with well rinsed Tubifex, Enchytraea, Daphnia, Copepoda, Ostracoda, Gammarus fossarum, Artemia salina, mosquito larvae or small earthworm pieces, all of which are available in normal pet shops as fish food for aquarists. White mosquito larvae (*Chaoborus crystalinus*) are not recommended. Food remains must be removed before they spoil the water. Shortly before they come ashore, the typical black-yellow colouration is already clearly visible.



For metamorphosis, the small salamanders must have an easily accessible exit from the water so that they cannot drown. If necessary, they must be transferred to an inclined metamorphosis container. The upcoming metamorphosis can be recognised by the regression of the gill tufts, the disappearance of the fin seams on the tail, a clear emergence of the yellow-black dorsal markings and the change in the shape of the head. The metamorphosis lasts about 10 days, during which time no food is needed.

The young salamanders that have gone ashore are kept with small crickets and pieces of earthworms, as is the case with the adults. Dewflies or springtails are also suitable for small animals. Breeding is usually problem-free. Freshly transformed fire salamanders need to be kept much more humid during the first weeks of life. The terrariums should not be too large, so that a high density of food animals can easily be guaranteed. For example, plastic containers with a base area of 20 x 20 cm are sufficient for 3-6 young animals. No water bowl is necessary for the first three months due to the humid conditions. Systematic keeping with a maximum group size of five animals on damp kitchen roll paper is suitable here. After two to three months, natural substrate can be used.



View into a professional larvae rearing facility as described in SEIDEL & GERHARDT (2016) | Uwe Seidel



4.11 Problems

Damp or even wet housing and poor hygiene inevitably lead to skin problems, which are then difficult to treat. An insufficient supply of minerals and vitamins leads to rickets, which are also difficult to treat. Fire salamanders are escape artists, so a securely closed container is a basic requirement for keeping them! Animals that have escaped into the home are often difficult to find again and quickly dry out. It is imperative to ensure that fire salamanders cannot escape into the open under any circumstances (danger of faunal distortion and spread of disease). Intraspecific stress probably weakens the immune system and makes salamanders more susceptible to diseases. Therefore, special attention should always be paid to group composition (see point 4.3).



Regular control of the animals is important. | Benny Trapp, Frogs & Friends



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