The salamander fungus: too hot to handle?

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A novel detected infectious disease caused by a chytrid fungus has wiped out a native population of fire salamanders in the Netherlands within a few years. It is suspected that this fungus originates from Asia and was transported to Europe via the pet trade. In this article we would like to provide information on this devastating disease, on the threat it poses to naïve species and populations, and on precautionary measures that could be taken to prevent the spread of the fungus.

Fire salamander with severe Bsal. PHOTO: FRANK PASMANS

Following the enigmatic 99.9% decline of the fire salamander (*Salamandra salamandra*) in the Netherlands, it was discovered in 2013 that the newly described fungal disease, *Batrachochytrium salamandrivorans* (Bsal), was the cause of this decline. Subsequent research showed that Bsal specifically affects salamanders and newts (collectively called urodelans), while frogs and toads remain unaffected. By causing superficial skin erosion, deep ulcerations and skin necrosis, Bsal eats away the skin, which is lethal for many urodelan species (Martel *et al*, 2013).

Bsal is closely related to another chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), which has already caused declines and extinctions of many amphibian species all over the world (Kolby and Daszak, 2016). The fear is that Bsal will have a similar impact on urodelans. Bsal was found lethal for all North American newt species and nearly all European, North African, and Middle Eastern urodelan species tested (Martel *et al*, 2014).

Cynops ensicauda*, a carrier species of the fungus.* PHOTO: SERGÉ BOGAERTS

Disease transmission and symptoms

The optimum temperature for the growth of Bsal is lower (10-15˚C) than that of Bd (17-25˚C), which means that Bsal is likely to pose a greater threat to salamanders and newts in temperate climate zones than Bd. The disease is highly contagious and can be easily transferred between different species of salamanders and newts. Common modes of transmission are direct contact of the animals (skin-to-skin) or contact with dispersed zoospores (Martel *et al,* 2013).

Urodelans infected by Bsal may develop ulcers on the skin. Depending on host susceptibility, Bsal may cause extensive mortality in salamander and newt collections. However, not all infected animals become ill and show these symptoms. Also, skin ulcers can have many other causes besides Bsal. Therefore, urodelans may carry Bsal without any symptoms and can spread Bsal unnoticed. East Asian salamanders, in particular, may be symptomless carriers of Bsal (Martel *et al,* 2013; 2014).

Testing for Bsal and treating an infection

To detect Bsal with high confidence in live salamanders and newts the animals need to be tested. This can be done by collecting skin swabs, which are subsequently tested for Bsal in a dedicated laboratory by PCR, a highly sensitive method which detects the DNA of Bsal. Swabs and dead animals can be examined by veterinary diagnostic laboratories trained in diagnosing Bsal (Blooi *et al*, 2013).

Encouragingly, Bsal can be successfully treated. This involves treatment of the skin with fungicidal compounds, prolonged incubation at increased temperatures, or a combination of both. Bsal cannot survive at temperatures higher than 25°C, so many urodelan species can be successfully treated by keeping them at 25°C for 10 days.

However, it needs to be stressed that not all species tolerate these temperatures. Also, it cannot be excluded that Bsal strains exist which tolerate higher temperatures. Consequently, it is recommended to confirm the absence of Bsal by PCR of skin swabs after treatment (Blooi *et al*, 2015a,b).

Current distribution and impact

Bsal outbreaks have currently been detected in western Germany and in Belgium, including a location close to the French border. The webpage www.ravon.nl/bsal provides an up-to-date map on the current distribution of the fungus.

It appears that Bsal is spreading across Europe and will likely have a large impact on urodelan populations (Spitzen – van der Sluijs *et al*, 2016). Major causes for concern are rare and range-restricted urodelan species, which may face extinction when Bsal reaches these populations.

Besides these environmental outbreaks, Bsal has also been detected in captive-held urodelans in Germany and the United Kingdom (Sabino-Pinto *et al*, 2015; Cunningham *et al*, 2015).

A sharp decline in the number of live fire salamanders has been observed in the Netherlands since 2010. In 2013, this enigmatic decline was linked to an outbreak of Bsal. Within a few years the population of fire salamanders collapsed and is now close to extinction without any signs of recovery (Spitzen – van der Sluijs *et al*, 2013). This pattern is seen in outbreak locations in Belgium and Germany, too, which means that the chytrid fungus has the capacity to eliminate populations of salamanders within a short period of time.

Tanicha granulosa ***is a US species which is susceptable to Bsal.***

PHOTO: MAARTEN GILBERT

Spread of the disease

A large-scale infection experiment comprising many urodelan species of various families from across the world indicated the East Asian salamander species *Cynops pyrrhogaster*, *Cynops cyanurus*,