

## ***Stygichthys typhlops* (Teleostei: Characiformes), a phreatobitic fish from eastern Brazil: Comments on Sampaio et al. (2012): A response**

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Criticisms of scientific papers are always welcome, as long as they are well-supported by appropriately contextualized data or information. When dealing with new approaches, the criticism becomes even more pertinent, because it points out directions towards eventual solutions or interpretations of data, many times unviable in cases where the literature is scarce or inexistent. It is precisely from this perspective that science is built: mature and properly supported discussions among different approaches of a same theme.

*Stygichthys typhlops* Brittan & Böhlke, 1965 is known from a broad geographical region with significant agricultural activity. Such levels of agriculture and farming require a great water demand that increasingly exploits local groundwater resources in this region and consequently the unique species that live therein (Sampaio et al., personal observation). Therefore, a great need exists to better understand this species, its habitat and threats. Considering this, and especially due to restrictions imposed by the Brazilian Environmental Agency (IBAMA) on the capture of this endangered species, we believe we must maximize the amount of gained information per captured individual.

According to local residents, countless sinkholes exist in the region where the presence of this species has already been verified, although this is anecdotal information. Trajano and Moreira (2014) consider the locality we sampled as a peripheral habitat and one used by a low fraction of a fluctuating population or even a sink population. Populations in marginal habitats tend to differ from those in core habitats in some demographic characteristics (Kawecki 2008): they usually have low density relative to core habitats, usually produce fewer offspring, are often considered demographic sinks, and small changes in environmental conditions may have a large

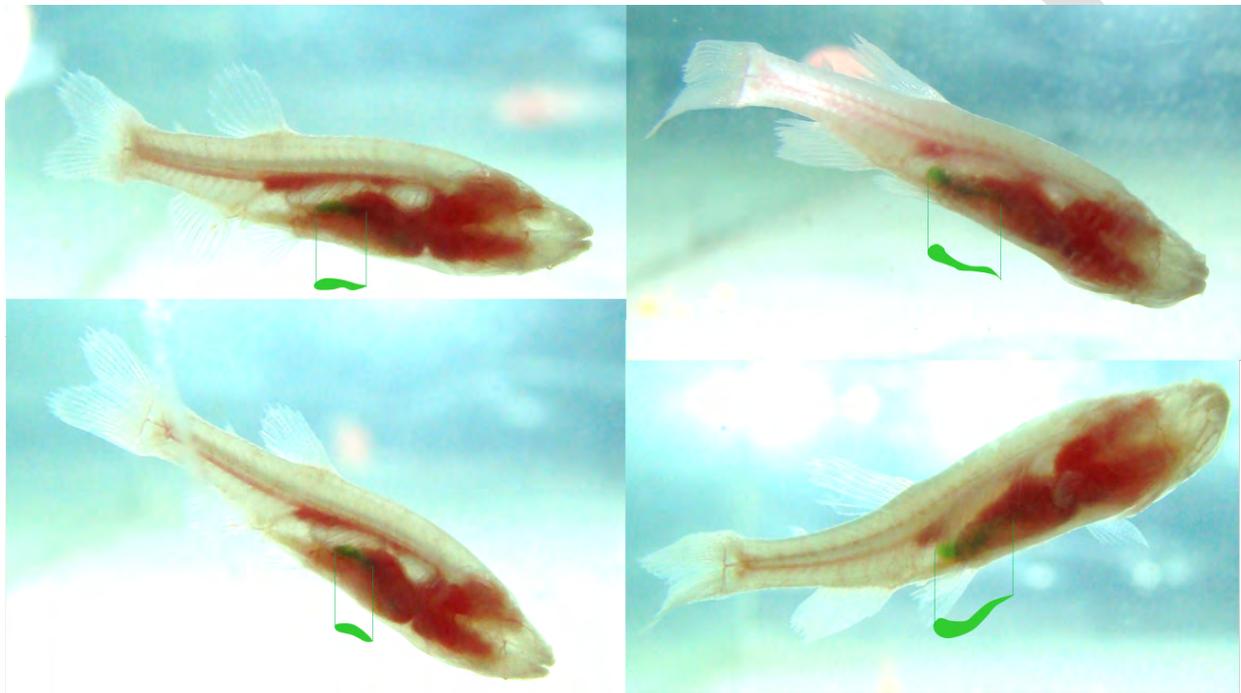
impact on the persistence of local populations. Although this sampled sinkhole fits the last assumption, information on density and reproduction are not available, and are difficult to assess. However, even considering this locality could be considered a marginal habitat, it is important to point out that even though they may be of little ecological importance, they are important from the evolutionary perspective, playing a major role in the evolution of species ranges (Kawecki 2008). Moreover, in the case of *Stygichthys typhlops* this is the only habitat accessible to humans to sample.



**Figure 1.** A) and B) Presence of *Elodea* sp. in the sinkhole where *Stygichthys typhlops* were collected; C) a submerged trap near some macrophytes; and D) *Stygichthys typhlops* swimming above the trap. Photographs by Rodrigo L. Ferreira.

Likewise, when Trajano and Moreira (2014) refer to the locality as spatially restricted, partially illuminated and with a small and fluctuating fish population, obviously we do not believe that this sinkhole exercises the ecological and evolutionary effects on an entire population. However, on the other hand, we cannot rule out the possibility that

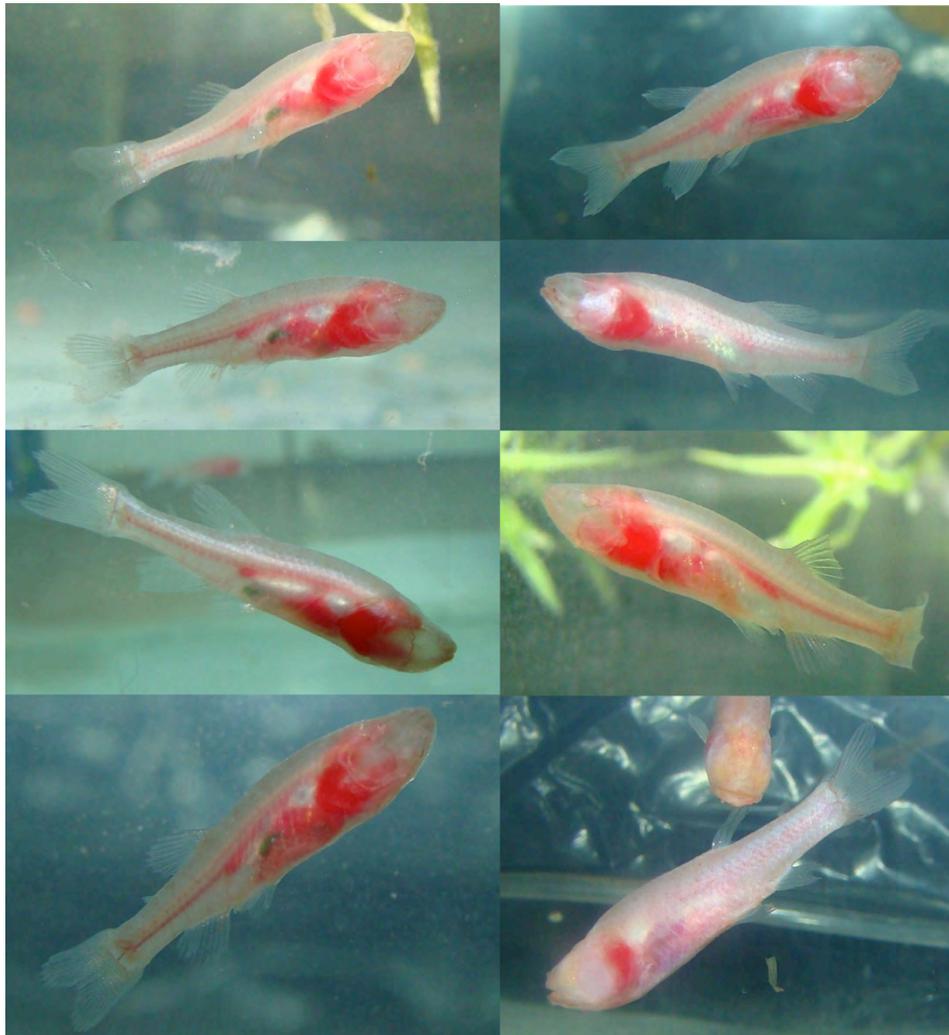
such abiotic and biotic characteristics are found in other sinkholes, given the lack of formal knowledge on *S. typhlops* habitat and distribution. In addition, with regards to Trajano and Moreira (2014) never observing aquatic vegetation during their various visits, we find this statement peculiar. During all our visits, aquatic macrophytes covered 50–75% of the water surface and cavefishes were swimming amidst or near the macrophytes (**Figure 1**). Furthermore, we would expect to find macrophytes and algae throughout the year in this particular sinkhole given the surrounding landscape, which is relatively well lit. Banana tree plantations that make use of a substantial amount of chemical fertilizers dominate the surrounding area. Such fertilizers are regularly washed into sinkhole, promoting the development of macrophytes. Unfortunately, Trajano and Moreira did not provide any photographs showing the sinkhole without macrophytes, which would be of great importance for comparisons between different time periods of this unusual sinkhole habitat.



**Figure 2.** Specimens of *Stygichthys typhlops* with green masses highlighted. These photographs were taken from two specimens in different positions to show the green mass, which are clearly different in shape and position. Photographs by Rodrigo L. Ferreira.

Trajano and Moreira (2014) questioned the importance of aquatic plants in the diet of *S. typhlops*. However, we pose other questions, such as why would *S. typhlops* not use an abundant resource (albeit unusual) in an environment where food resources are likely scarce, and how can it not be thought of as an opportunistic diet under such conditions? Most of the sampled individuals possessed a green mass visible inside the fish when captured, clearly indicating that we were not describing an abnormal behavior in the laboratory. In addition, even after several days in the laboratory (and when offered

other food items such as insect larvae), why did *S. typhlops* continue feeding on vegetation? Moreover, as indicated by Trajano and Moreira (2014), the green mass position and shape was different among the specimens (**Figure 2**), precluding the raised hypotheses that the mass was an internal organ. Furthermore, as we expected, the green mass was no longer visible in any specimen within a few days after macrophytes were removed from the diet, clearly indicating that the green mass was not an internal organ (**Figure 3**).

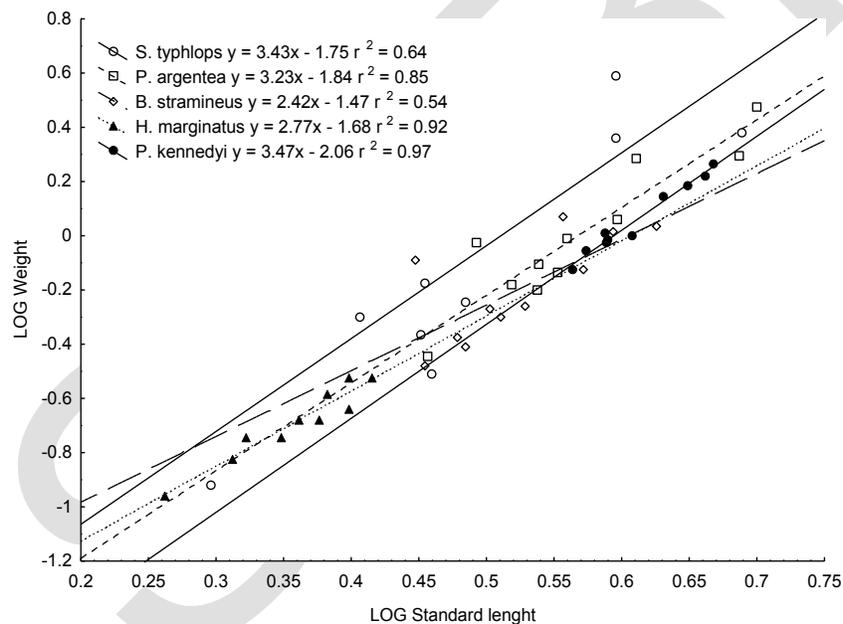


**Figure 3.** Cavefish that fed on macrophytes in the laboratory (on the left) compared to cavefish that were not feeding on macrophytes. Note the green mass visible through the abdomen in fish that fed on macrophytes (on the left) and the lack of a visible green mass in fish that did not feed on macrophytes (on the right). Photographs by Rodrigo L. Ferreira.

It seems to us unlikely that *S. typhlops* does not feed on plant material as part of its diet in face of evidence obtained *in loco* and in the laboratory. The fact that *S. typhlops* feeds on plant material obviously does not classify it as an herbivore, but it also does

not suggest that the species is strictly carnivorous either. Such observations *in loco* should be interpreted as feeding plasticity, which has been recognized as a pre-adaptation to the hypogean life (Culver and Pipan 2009).

Trajano and Moreira (2014) also stated that a subterranean carnivorous diet would be consistent with pronounced allometric growth due to a progressive accumulation of fat. We compared the body length–weight relationship of *S. typhlops* and similarly sized characids (**Figure 4**), which Sampaio et al. (2012) also compared swimming performance. *Stygichthys typhlops* showed allometric-like growth as presented by Trajano and Moreira (2014), but this growth was also found in two other characids as well (Sampaio et al., unpublished data): *Piabina argentea* Reinhardt, 1867 and *Psellogrammus kennedyi* (Eigenmann, 1903). When the relationship between weight and length was compared among species by an analysis of covariance, only *Bryconamericus stramineus* Eigenmann, 1908 showed a significantly different slope ( $F=64,18$ ;  $p<0,001$ ). It is important to emphasize that *P. kennedyi*, which had the most similar body length–weight relationship to *S. typhlops*, is considered an omnivore, feeding on filamentous algae, insects, zooplankton and seeds (Pompeu and Godinho 2003). Therefore, the pronounced allometric growth in *S. typhlops* cannot be strictly associated with a purely carnivorous diet.



**Figure 4.** Weight–length relationship for *S. typhlops* and for other similarly sized characid fishes ( $p<0.001$  for all relationships).

Related to the conservation of this highly endangered species, some methods suggested by Trajano and Moreira (2014), such as dissections for stomach content analysis, were not employed to prevent excessive collection and death of specimens. There are no studies documenting the population size of this species, which may be

very small. During our study, the Brazilian Environmental Agency (SISBIO) allowed us to collect only 10 specimens to minimize adverse effects to this population, which we judged as appropriate considering this species' conservation status. An additional 45 specimens have been collected from this sinkhole since 2004 (Trajano and Moreira 2014) and at least four additional specimens have been collected from a nearby locality (Moreira et al. 2010). Consequently, because the size of this population is unknown but believed to be small, this population may be jeopardized by future collections for scientific purposes at similar sampling intensity.

In conservation biology, the gathering of information that can contribute to the long-term conservation of a particular species is vital. As insignificant as it may seem, any information about a species at risk of extinction is important. To affirm that a cavefish feeds on macrophytes does not imply such a food item is a staple in its diet. However, this is the type of information that can be of importance for the management of a species.

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