

The roles of landscape of fear and light in allowing the exploitation of spring habitats by subterranean amphipods: an experimental and field approach

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Abstract

Border habitats such as interfaces and ecotones promise research targets from an evolutionary and zoological point of view. Springs are typical ecotones that border two strongly distinct environments: surface and underground. They are exploited by both subterranean and surface species for which they may provide specific environmental pressures promoting phenotypic plasticity and local adaptations.

The aim of this study is to understand how the landscape of fear (LOF) and physical constraints, like light occurrence, affect springs' exploitation by both a subterranean (*Niphargus thuringius*) and a surface crustacean amphipod species (*Echinogammarus stammeri*).

From March to May 2021, we surveyed 15 springs, divided into 25 plots according to their distance to the border, and both day and night, we recorded amphipods activity and LOF levels for them. In a subterranean laboratory, we also reared 80 *N. thuringius* and 80 *E. stammeri* in safe and risky conditions with constant darkness and diel light variation assessing their activity and survival for 30 days. Risky conditions were represented by meso-predators (four fire salamander larvae) alone or with a top-predator (a dragonfly larva of the species *Cordulegaster boltonii*).

While in field conditions, the activity of *N. thuringius* seemed negatively affected by the number of active predators, in laboratory experiments, the main role was played by the light treatment; activity was significantly higher in constant darkness conditions.

E. stammeri activity in the field was higher in surface plots, while in laboratory conditions was affected by LOF. Predation risk negatively affected the survival of both amphipods.

Our findings reveal that while light conditions seem to shape activity patterns of stygobionts strongly, predators have a lower effect on activity, even though predators have negative effects on survival. Moreover, physical constraints, such as light exposure, can affect antipredator responses of subterranean organisms, thus representing selective pressures for the exploitation of surface environments.

Keywords

Groundwater; springs; amphipods; light; landscape of fear.

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Matteo Galbiati; Stefano Lapadula (poster)

Presented at

25th International Conference on Subterranean Biology (Cluj-Napoca, 18-22 July 2022)

Conflicts of interest