ABSTRACTS BOOK

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Experimental evidence of how contamination might modify the shrimps' population dynamics and make them susceptible to spatial isolation

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ABSTRACT

Contamination is likely to affect the landscape composition, usually linked to ecological fragmentation, which may impact the distribution, persistence and abundance of species. In the current study, the estuarine shrimp *Palaemon varians* was exposed to copper (25 and 0.5 µg/L) simultaneously to predation signal and food to evaluate the organism's spatial distribution within a spatially heterogeneous landscape. All experimental landscapes were simulated in the Heterogeneous Multi Habitat Assay System (HeMHAS). As results, *P. varians* detected and avoided copper, however, predation signal shifted the response to preference over regions with conditions previously avoided, even if that meant to increase copper exposure. When confronted to move towards environments with high food availability, lower connectivity occurred among the shrimps' populations isolated by contamination and predation risk simultaneously. This indicate that contamination might: (i) trigger avoidance in shrimps, (ii) prevent the colonisation towards foraging areas, (iii) enhance the populations' isolation and (iv) make populations more susceptible to local extinction.

KEYWORDS

Spatial distribution, stressors, ecological fragmentation, HeMHAS.

INTRODUCTION

Landscape ecology studies the use of resources that are spatially heterogeneous and how organisms live, reproduce, disperse and interact within a landscape mosaic (Turner, 2005). Several factors, either natural or anthropogenic may cause ruptures in the connectivity changing the landscape composition (Fuller, et al., 2015), which is typically linked to ecological fragmentation, limiting the mobility of organisms among habitats and affecting the populations persistence (Holyoak, 2000).

Contamination has particularly shown to play an important element for the plasticity on habitat selection by aquatic organisms (Araújo, et al., 2020b). This role has received special attention with the novel methods of exposure to contaminants, in which the effects of contamination can be assessed from a landscape perspective. In this sense, organisms are exposed to a chemically heterogeneous scenario and then it is possible to assess how contamination affects the spatial distribution of organisms.

The aim of the present study is to evaluate the role of contamination (copper) on the connectivity loss among habitats and the consequences for the spatial isolation of populationsof the estuarine shrimp *Palaemon varians*. The HeMHAS (Heterogeneous Multi-Habitat Assay System) was used to simulate spatially heterogeneous landscapes. In order to provide more ecological relevance to the study, in addition to contamination as stressor, two factors were also simultaneously tested: fish kairomones (as predation signal) and food availability.

MATERIALS AND METHODS

The estuarine shrimp *P. varians* was sampled in the salt pond Salina La Esperanza (Puerto Real, Spain). This species is able to detect and avoid some contaminants (Araújo, et al., 2020b). Tests were performed in the HeMHAS, which comprises several independent compartments that can be connected to simulate environmental scenarios with different levels of connectivity among them (Fig. 1).

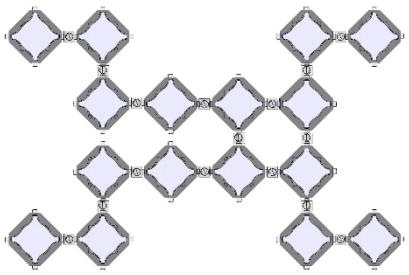


Figure 1: Spatial arrangement design of the experiments

Copper was used as reference substance due to its repellent effect previously observed in *P. varians* (Araújo, et al., 2020a). Two levels of contamination were used: low (0.5 µg/L) and high (25 µg/L), representing, respectively, an environmentally relevant concentration and a highly

contaminated environment. As predator signal, it was used fish kairomones collected from filter of a recirculating aquaculture system culturing *Seriola dumerili* and *Sparus aurata*.

Different scenarios varying regarding the levels of contamination and presence of predators and food were simulated in the HeMHAS to create heterogeneous landscapes (Fig. 2). Experiments were conducted in darkness, under regulated temperature (~20°C) and the location of organisms was recorded each 30 min for 4 hours.

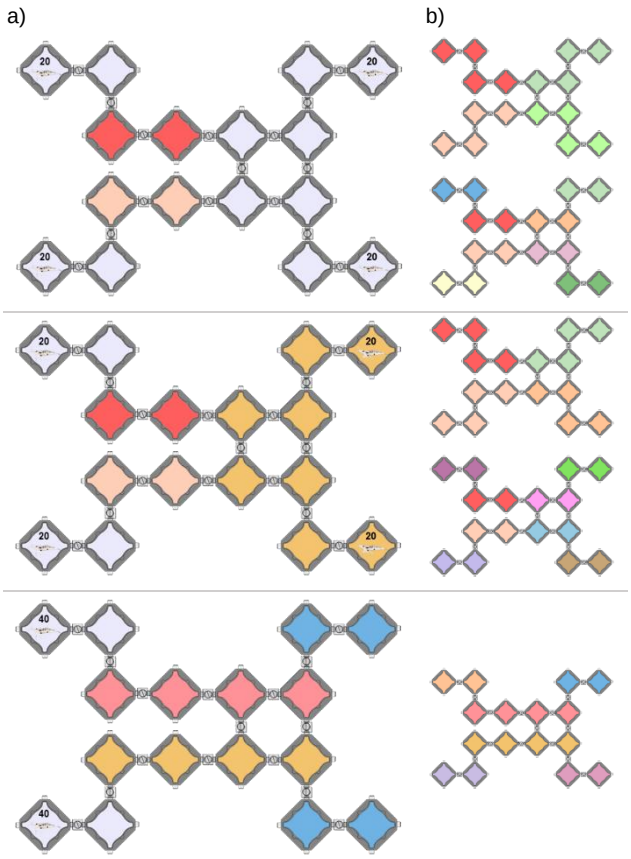
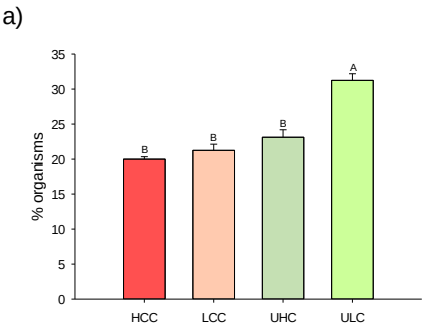


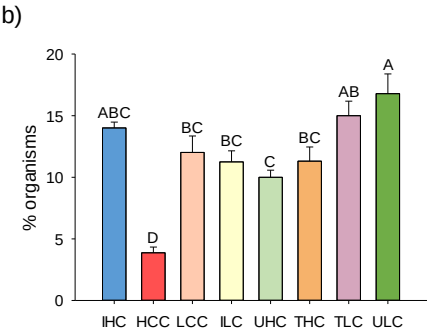
Figure 2: Experimental design of experiments. Column a): experiments with copper (up), copper vs kairomone (middle), and colonisation (down) experiments. Compartments colored in white: control water; red: 25 µg/L copper; light pink: 0.5 µg/L copper; ocher: kairomones; salmon: kairomones + 25 µg/L copper; blue: food. Column b): arrangement for data analysis in regions (4 compartments) and areas (2 compartments)

RESULTS

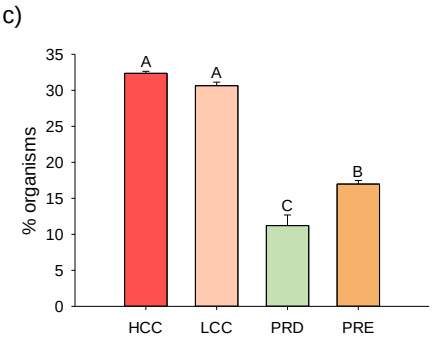
Fig. 3 shows that shrimps were able to detect copper and avoided the higher concentration, in the arrangement for areas (HCC in plot *b*) and for regions (HCC in plot *a*). With kairomones (plots *c* and *d*), the response changed: shrimps preferred the compartments with copper (HCC and LCC). This preference is discriminated in the plot *d*, since within the regions with copper influence, organisms preferred the areas without the contaminant (IHC and ILC).



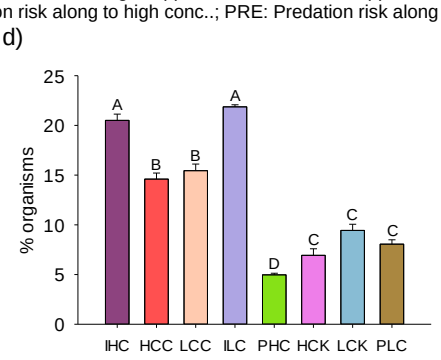
Regions: HCC: High copper conc.; LCC: Low copper conc.; UHC: Undisturbed along to high conc.; ULC: Undisturbed along to low conc.



Areas: IHC: Isolated along to high conc.; ILC: Isolated along to low conc.; UHC, THC, TLC and ULC represent areas with no contaminant



Regions: HCC: High copper conc.; LCC: Low copper conc.; PRD: Predation risk along to high conc..; PRE: Predation risk along to low conc.



Areas: IHC: Isolated along to high conc.; ILC: Isolated along to low conc.; PHC, HCK, LCK and PLC represent areas with predation signal

Figure 3: Distribution of organisms exposed to copper (*a* and *b*) and copper + kairomones (*c* and *d*). The columns' colors are coincident with the colors of arrangements for data analysis

For colonisation assays (Fig. 4), the shrimps were able to colonise the areas with food; although, higher (not

statistically different) dynamic transit seems to occur in the region with kairomones and no copper (Fig. 4 plot *b*).

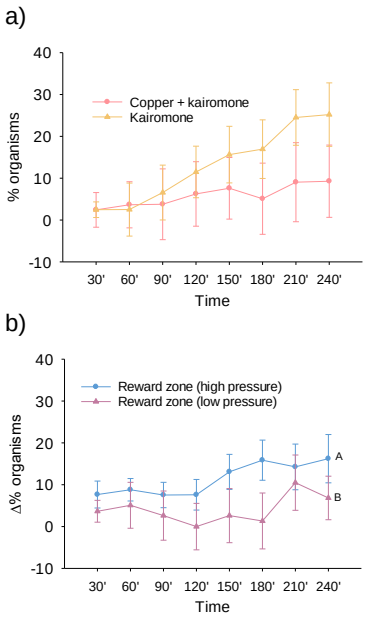


Figure 4: Population dynamic once exposed to stressors/stimulus simultaneously. a) dynamic on disturbed regions, b) dynamic on reward areas with food. Letters A and B represent that the Δ% of organisms within reward areas under high pressure (influenced by the region with copper + kairomone) and low pressure (influenced by the region with kairomones only) at 240' were statistically different

DISCUSSION

The estuarine shrimp *P. varians* was able to detect and avoid copper; however, predation signal shifted the response to prefer the previously avoided regions influenced by copper, although the clean and undisturbed area within both regions was prioritized (Fig. 3). Although under forced exposure to copper fish might decrease the anti-predator response (Sovová, et al., 2014), under free-choice exposure assay system, Araújo, et al. (2020) found that shrimps make a balance between a minimal risk of predation with an acceptable contamination level at an acceptable energy-cost requirement. Considering that copper is harmful for the sensory system (Ferrari, et al., 2010), the exposure to copper may increase the organism's susceptibility to both toxic effects of the contaminant and the predation risk.

Furthermore, food requirements plays an important role as well. Organisms in starvation were able to reach areas with food crossing through a relatively high disturbed region, albeit the region with copper presence seemd to have a lower populational dynamic. Our results are similar to previous ones in which the authors suggest that contamination may supposse a barrier for foraging activities (Araújo et al., 2016: Islam et al., 2019). Due to the repellence caused by contamination, organisms are likely to underuse the habitat food resources, which provokes a chemical fragmentation of habitat and changes in the ecological balance at the landscape level.

CONCLUSIONS

The populations of shrimps avoided stressors, either chemical contamination or the signal of predator. Although populations tended to inhabit clean areas with available food, contamination can create a chemical barrier reducing the connectivity among populations. In summary, these results showed that contamination can trigger avoidance and prevent the colonisation, which might isolate populations making them more susceptible to local extinction.

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