Exploring the Intersection of Sensory and Chemical Information in the Anti-Predator Response of *Daphnia Pulex*

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BACKGROUND

Impact of Predation at the Organismal Level

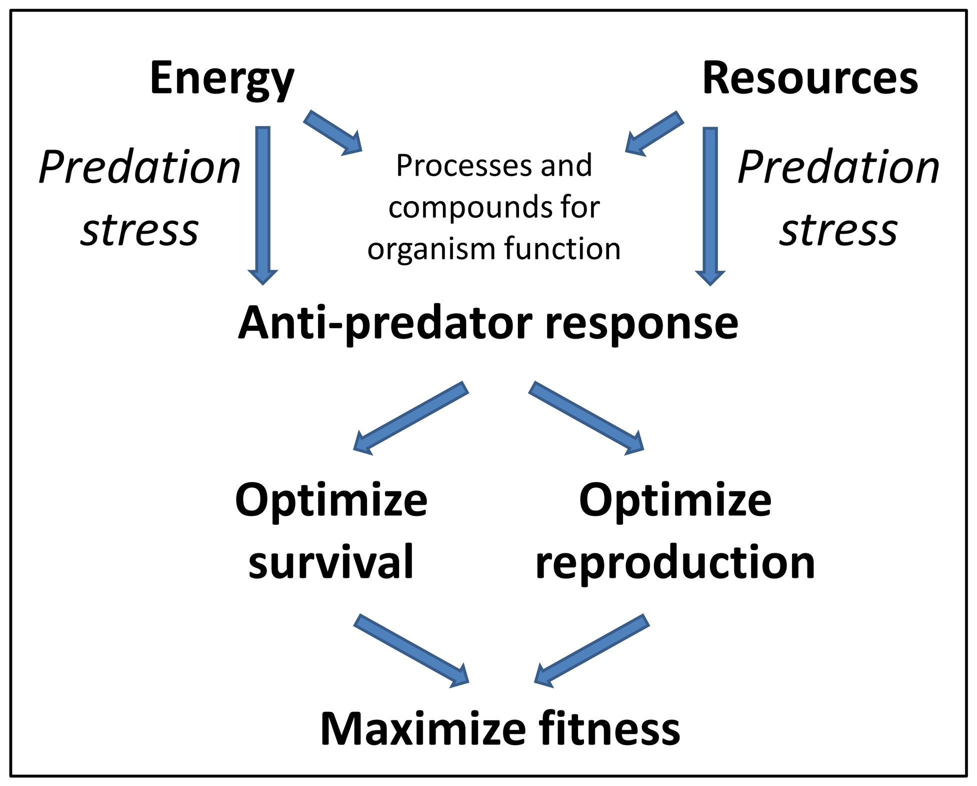

Figure 1. Schematic of how predation stress affects an organism.

Predation stress causes energy and resources to be invested in anti-predator responses, which optimize survival and reproduction to maximize the organism's fitness. Anti-predator responses can be costly because they reduce the amount of energy and resources allocated to other processes or compounds important for organismal function, such as immunity.

Guppy and Water Flea Predator-Prey System

Prey: *Daphnia Pulex* (Water flea)

A tiny freshwater crustacean that can reproduce by parthenogenesis to generate clones. This makes it an excellent experimental prey for examining its anti-predator responses while controlling genetic variation.

Predator: *Poecilia reticulata* (Guppy)

A small fish that preys on *D. pulex*; during digestion of *D. pulex*, it will produces kairomones, which stimulate anti-predator responses in nearby *D. pulex.* Since *P. reticulata* is a visual predator, light may modify the specific anti-predator responses of *D. pulex* to *P. reticulata*.

Process of Anti-Predator Response in *D. pulex*

1. **Predation of *D. pulex***
   D. pulex is consumed by a fish predator (e.g., *P. reticulata*).
2. **Secretion of predator kairomones**
   Kairomones result from the digestion of *D. pulex* by the predator; these kairomones serve as a cue of predation stress for nearby *D. pulex*.
3. **Predator-specific anti-predator response**
   D. pulex alter their behavior, morphology, and life history (reproductive strategy); the nature of this response depends on the predator.

BACKGROUND

Can Sensory Cues Moderate Response to Kairomone?

The life history and morphological anti-predator response of *D. pulex* to predators like *P. reticulata* is usually described as kairomone-mediated responses. To explore if sensory information can modify these responses in *D. pulex,* we set up an experimental system to test if dim light, which reduces the predation success of visual predators like *P. reticulata*, will suppress kairomone-induced predator-specifc changes.

EXPERIMENT PURPOSE & DESIGN

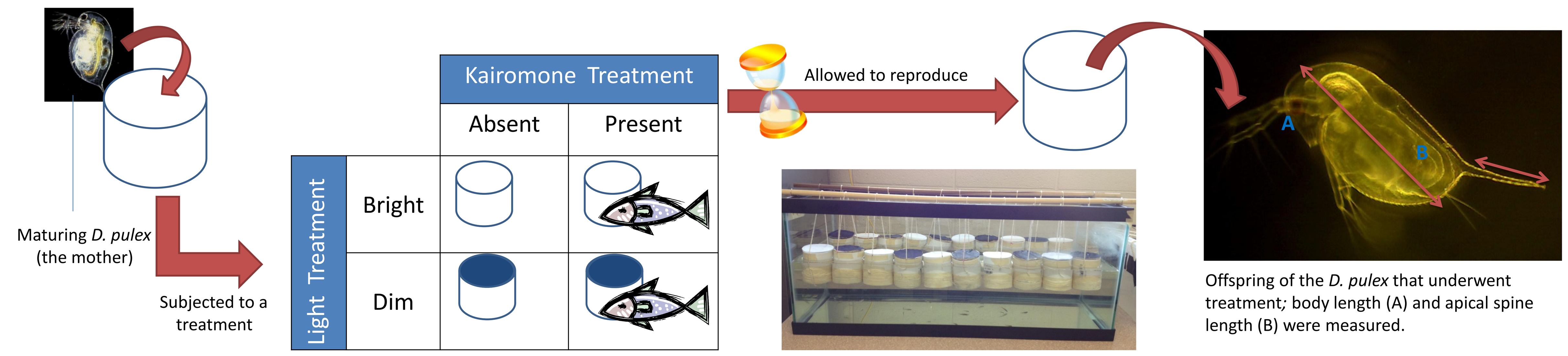

Figure 2. Schematic of the experiment design. We generated a population of *D. pulex* clones over several generations in the absence of kairomones. Immature clones were placed into PVC containers in the experimental or control tank. The experimental tank contained 20 *P. reticulata* feeding on 75 *D. pulex* per day, producing kairomones. The control tank contained no *P. reticulata*, and hence no kairomones. Each tank contained 20 PVC tubes immersed in the water, 10 with white cloth on either end to permit penetration of light and diffusion of kairomones (if present) and 10 with dark cloth to limit penetration of light but allow diffusion of kairomones (if present). For each PVC container, we recorded the number of offspring produced by the *D. pulex* in the first reproductive bout and the length of each offspring's body and apical spine.

ANALYSIS & RESULTS

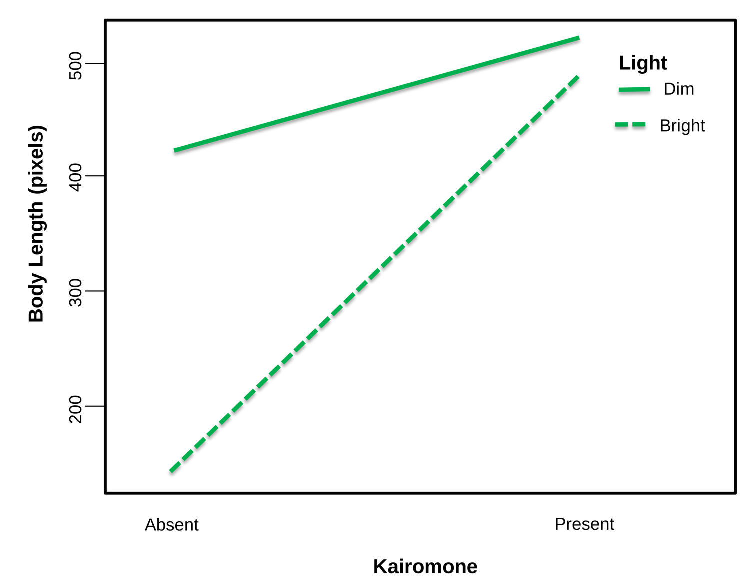

Figure 3. Interaction plot of how body length varies with light and kairomone treatment.

Body & Spine Length. We applied analysis of variance (ANOVA) to determine how the body length of *D. pulex* offspring varies with light and kairomone treatment. Trials 1 and 2 show that body length is longer for the offspring of *D. pulex* exposed to kairomone when compared to the control ($p<0.001$). Furthermore, the increase in body length due to presence of kairomone is greater under bright light than under dim light ($p<0.10$) due to an interaction between light and kairomone ($p<0.10$). However, independent from the effects by kairomone, body length is longer for offspring of *D. pulex* under dim light when compared to those under bright light. ANOVA uncovered an identical trend with apical spine length (data not shown), a trait strongly correlated to body size ($r=0.97$, $p<0.001$).

Relative Apical Spine Length (RASL). We applied ANOVA to explore how relative apical spine length (RASL, calculated as length of apical spine / length of body) in *D. pulex* offspring varies with light and kairomone treatment. Trial 1 showed that light as well as kairomone alone significantly affected RASL ($p<0.001$). The effect of kairomone treatment on RASL did not vary with light treatment, nor vice versa ($p>0.10$). Like Trial 1, Trial 2 showed that under dim light, *D. pulex* produced offspring with shorter RASL than *D. pulex* under bright light ($p<0.001$); this difference in RASL due to light treatment was greater if kairomone was present, a trend not observed in Trial 1. Trial 2 also differed from Trial 1 in that kairomone treatment alone did not affect RASL ($p>0.10$). However, overall, differences observed were small.

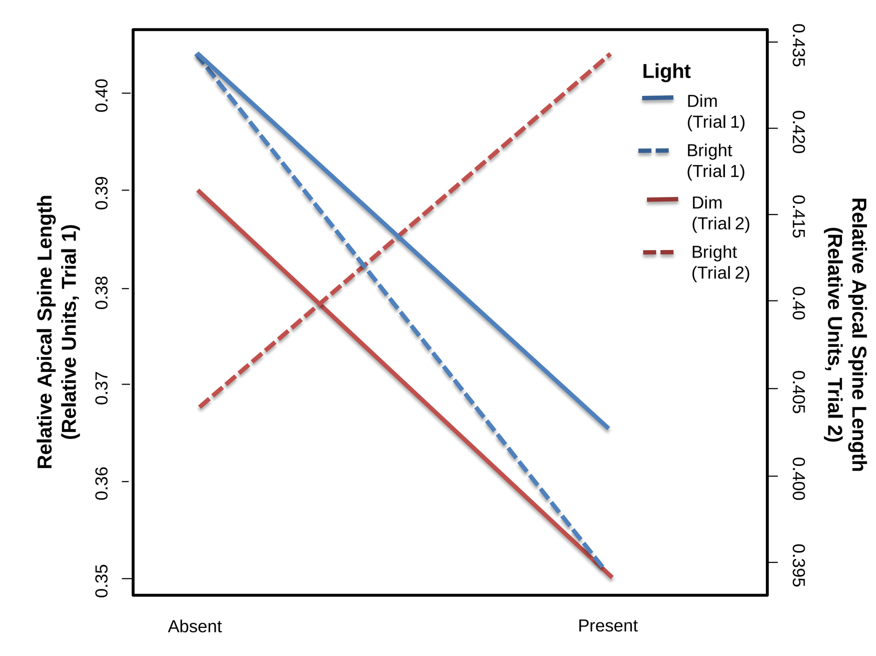

Figure 4. Interaction plot of how relative apical spine length varies with light and kairomone treatment.

Clutch size. ANOVA showed that the clutch size (number of offspring produced in a single reproductive bout) did not vary with light or kairomone alone, but was affected by an interaction between light and kairomone ($p<0.10$). However, the nature of how this interaction affected clutch size was not consistent or strong.

DISCUSSION

Experiments that have explored the effect of light on the anti-predator response of *D. pulex* focus mainly on behavioral consequences. Our results suggest light also affects life history and morphological anti-predator responses stimulated by kairomones: under bright light, spine and body length was much greater for offspring of *D. pulex* exposed to kairomones than *D. pulex* not exposed to kairomones; RASL was significantly longer for offspring of *D. pulex* exposed to kairomones under bright light than dim light. Thus, anti-predator defenses (e.g. longer body, apical spine, and RASL) by *D. pulex* against *P. reticulata* were enhanced under bright light when *P. reticulata* prey more efficiently. Our experiments show that sensory information related to predation vulnerability impacts anti-predator responses in *D. pulex*, and underscore the role of habitat in interspecies relationships.

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