Photosynthesis and the Green Isopod *Pentidotea resecata*

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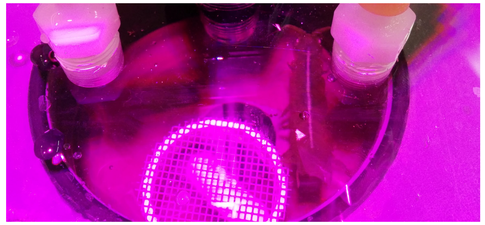

Abstract

The isopod *Pentidotea resecata* can be found living on the eelgrass *Zostera marina* and *Macrocystis spp.* along the western coast of the United States. Two separate color morphs can be found, a brown morph which lives on *Macrocystis* and a green color morph on *Zostera marina.* Diet consists mainly of their primary substrate along with epiphytes such as diatoms which often grow on the substrate surface. In this study respirometry was done on individuals of the green color morph to determine whether chloroplasts consumed in their diet maintained functionality. Light and dark respirometry was conducted on living specimens with as many diatoms and other epiphytes removed from their body surface as possible. Each isopod was then sacrificed and its gut removed before repeating both light and dark respirometry to determine the contribution to photosynthesis from the epiphytes. Most individuals used for respirometry were between 4.5 and 5 cm to eliminate variation in metabolic rate due to body mass. These sizes are all greater than the size range reported in the literature. Little size-dependent variation in metabolic rate was seen within the range used. All respirometry was conducted with partial pressures of oxygen above 100 mm Hg and no oxyconformity was observed. During live respirometry the mean respiration rate was consistently higher during the dark than during the light, indicating photosynthesis. Comparison of whole-animal respiration with that of animals with their guts removed showed that although epiphytes do contribute to both respiration and photosynthesis, the material within the gut is likely contributing as well. Over a three week experimental period the level of respiration increased in the dark, possibly due to increased diatom load. Trends in metabolism over time as measured during the light were not as clear.

Introduction

The isopod *Pentidotea resecata* is found along the western coast of the United States. Individuals of this species are the same color as their substrate and primary food source with green color morphs found on the eelgrass *Zostera marina* and brown color morphs found on *Macrocystis spp.* Due to this variation in color it was hypothesized that chloroplasts may be taken in with their food. In this study we investigated whether chloroplasts are retained in the gut and maintain some functionality.

Methods

Respirometry was conducted using oxygen optodes to measure the oxygen levels inside sealed chambers containing an isopod in seawater held at a constant temperature. Both light and dark respirometry was done on living specimens and repeated on dead specimens with their gut removed. Light respiration was done using LED lights with a photosynthetically active spectrum (Fig. 1). A different group was measured each week for three weeks. Variations in activity between light and dark conditions were recorded on a video camera and quantified based on isopod movement across a grid.

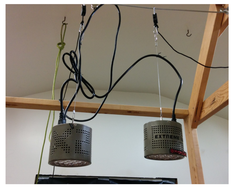

Figure 1. Pictures showing LED Grow Lights and the experimental setup with respirometry chambers and oxygen optodes.

Results

No significant difference was found in isopod activity between light and dark environments. (Fig. 2) If anything their activity in the light was higher. Both light and dark trials were conducted during the day to eliminate interference from any pre-existing circadian cycles.

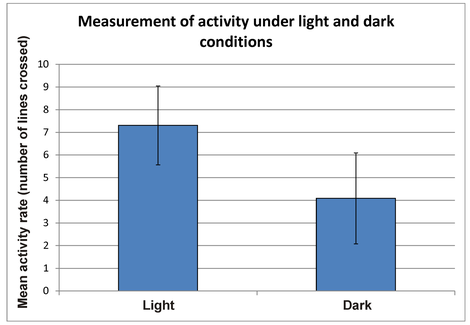

Figure 2. Activity levels as measured by movement across a grid. No significant difference was found between light and dark activity levels in 20 animals. Paired randomization t-test with 10,000 randomizations, p=0.1256. Error bars indicate standard deviation.

The mean respiration rate of live individuals in the dark was significantly higher than the mean respiration rate of live individuals in the light as well as dead individuals in both light and dark conditions (Fig. 3). The difference between light and dark metabolism in dead individuals (with gut removed) was much less pronounced with no significant difference between the two.

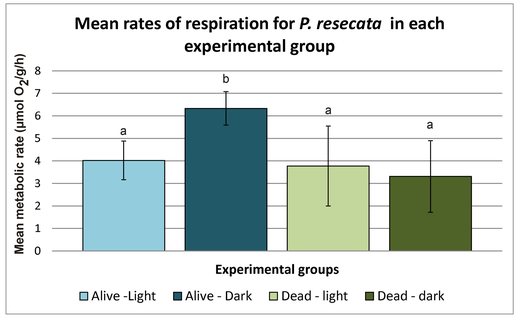

Figure 3. Mean metabolic rate seen in the light and dark in both live and dead animals. The mean metabolism for live animals in the dark was significantly higher than any of the other groups. There was no other significance found. Letters indicate groups which are significantly different. Two-way ANOVA, $p \leq 0.001$. Error bars indicate standard deviation.

For live individuals the apparent rate of respiration was significantly higher in the dark than in the light. This suggests that some of the respired oxygen is being replaced via photosynthesis in the light. Over the three week experimental period this effect increased (Fig 4).

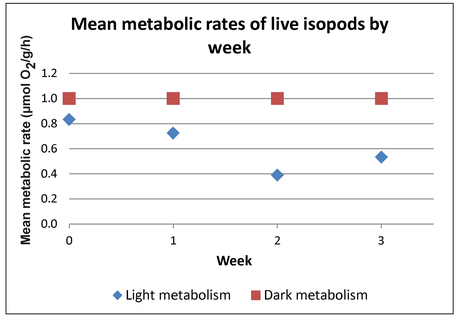

Figure 4. The mean metabolic rate of live animals in the light and the dark. Data normalized to dark metabolism. For every week the apparent metabolism in the light was significantly lower than the dark. Paired means t-test, p<0.01.

Discussion

For live individuals the respiration rate was significantly higher in the dark than it was in the light. This strongly suggests photosynthesis contributing oxygen to the system in the light and lowering the apparent metabolism. It also rules out differences in activity which would have had the opposite effect since isopods showed similar activity or were even slightly more active in the light. Over the three week period the amount of photosynthesis appeared to increase, likely due to increased diatom growth on the exoskeleton of the isopods. Diatoms were brushed off prior to respirometry, however it was impossible to remove them all.

The results for dead isopods (with an exoskeleton but no gut) showed a less pronounced difference between light and dark metabolism. Metabolism of dead isopods in the light was not significantly different from that of dead isopods in the dark. This suggests that the contents of the gut, present only in live animals, make an important contribution to photosynthesis. With the gut removed from dead animals, no difference was observed between light and dark experimental periods, suggesting little photosynthesis by surface diatoms under these conditions.

Conclusions:

- Differences in apparent metabolism in the light and dark of live animals suggested that substantial photosynthesis is taking place in the light
- Some of the photosynthetic activity appeared to be due to diatoms growing on the outer surface of the animals
- Our data suggest that at least some of the photosynthesis may have been from viable chloroplasts within the gut of the animal
- Whether these cells make any contribution to the animal's metabolism is unclear

Acknowledgements

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