Effects of rhizocephalans on their king crab hosts

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Abstract:

Rhizocephalans are external parasites that attach to the carapace of a crabs and sterilize the host. However, rhizocephalans may also cause more subtle loss of fitness in crabs, like changing their metabolic and energy expenditure processes. Golden king crab (*Lithodes aequispinus*) are hosts to the rhizocephalan species, *Briarosaccus*. This study will consider how this species of rhizocephalan impacts the metabolic, and digestive rates of golden king crabs and whether it can modify the foraging rate of these crabs. There are many possible outcomes of this study but, based on existing information, it seems likely that the rhizocephalans will not have significant impact on the metabolic and digestive rates, but may hinder the crab’s ability to find and process food by slowing the crab’s foraging. This could be due to the rhizocephalan parasite delaying the motor skills of the crab, or a behavioral modification of the parasite so the crab allocates its energy into nursing the parasite, rather than spending energy to forage for food. Overall rhizocephalans may have sufficient impacts on golden king crabs to affect commercial fisheries.
Introduction

There are many complex relationships in ecology, like symbioses. One specific type of symbiosis is parasitism, where one symbiont (the parasite) benefits, while the other (the host) loses fitness as a result of the interaction. Parasites can have an array of effects on behavior, metabolic processes, and reproductive processes (Belgrad & Griffen 2015, Robles 2002, Shukalyuk 2005), and therefore play important roles in ecosystems (Wood 2015). Parasites can in in the form of ectoparasites where they are outside of the host, or endoparasites which means they are on the inside of their host.

Rhizocephalans are barnacle ectoparasites of crab hosts. When the rhizocephalan settles on its crab host abdomen it develops an internal stalk into the crab’s body cavity (Walker 2001). Then the rhizocephalan develops a sac like structure on the outside of the crab (Fig.1), on the ventral side of the crab’s carapace (Elumalai et al 2014). Rhizocephalans impact the crab’s reproductive system by making the host crab sterile (Hoeg 1995). Rhizocephalans also impact the molt cycle and the growth of its crab host (Hoeg 1995).

The golden king crab (*Lithodes aequispinus*) are king crab species that can be found in Alaskan waters near Kodiak, and the Aleutian Islands (Hawkes et al 1986, Siddeek et al. 2016). Golden king crab and king crab in general are the top fisheries in Alaska and the west coast and is divided into two sub-stocks, the eastern and the western (Siddeek et al. 2016). The golden king is parasitized by a rhizocephalan species (Bower & Sloan 1985). Historically, the rhizocephalan has been identified as the species *Briarosaccus callosus*, however recent research has found a new species now called *Briarosaccus auratum* are infected the golden king crabs (Noever et. al 2016).

Motivation for Research
Much of the research done on rhizocephalans has been conducted on the east coast of North America, in the Atlantic Ocean (Belgrad & Griffen 2015, Gehman & Byers 2016). There is limited knowledge of rhizocephalans and their host species in the Pacific. Rhizocephalans on the west coast parasitize hermit crabs (Weatherly 1960), and more importantly, commercially harvested king crabs (Hawkes et. al 1986). The main known impact of rhizocephalans is that they make their host crabs sterile and unable to reproduce. However, with more recent research, there are indications that they may have broader impacts on their hosts. One of those impacts is behavioral. Belgrad and Griffen conducted a metabolism/digestion study on *Eurypanopeus depressus* and its rhizocephalan parasite. Begrad and Griffen found that the parasite did alter the feeding rate in *Eurypanopeus depressus*. This implies that there could be a metabolic effect on west coast crabs.

A study published in 2016 (Noever et. al 2016), described two new species of rhizocephalans that were found parasitizing king crabs in Alaska. It was previously thought that the species *Briarosaccus callosus* was infecting all king crabs, until recently. Noever found that a new species *B. regalis* parastizes *Paralithodes camtschiticus* and *P. platypus*, while another new species called *B. auratum* parasites *Lithodes aequispinus*. Therefore, more studies about rhizocephalans and their impacts on relatively local species need to occur. Since king crab is an important commercially harvested species, we should understand the ecology and biology of these crab to help determine future projection of this fishery (Kuris & Lafferty 1992). This has immense economic implications because the king crab fishery is one of the most important
fisheries in Alaska and the west coast.

Fig 1. Photo of rhizocephalan (*Briarosaccus callosus*) on golden king crab (*Lithodes aequispinus*) Photo from Shields 2012 and Sloan 1984.

**Research Questions**

1. Are the metabolic and digestive rates reduced in golden king crabs (*Lithodes aequispinus*) that are parasitized by rhizocephalans relative to uninfected crabs?

2. How are the rates of foraging in golden king crabs (*L. aequispinus*) altered by this parasite (*Briarosaccus spp.*)?

**Hypotheses**

1a. Hosting a parasite may have energetic costs to the crab. Rhizocephalans may decrease the metabolic and digestive rates of their crab host by reducing the energy for the crab to spend on growth or movement, and instead channeling that energy into the development and reproduction of the parasite.

1b. There would be in increase of metabolism and digestion rate to be able to maintain the energetic requirements for the crab and the rhizocephalan parasite.
1c. There is no difference between metabolism and digestion rate in infected versus healthy crabs.

2a. The rhizocephalans may have behavioral effects on the crabs, therefore infected *L. aequispinus* may have delayed motor skills which would make them slower at foraging and finding food than the non-infected crabs.

2b. The crab (*L. aequispinus*) would need to find food faster in order to maintain the metabolic needs for the crab and the parasite.

2c. The foraging rate stays the same between the infected and uninfected crabs.

**Experimental Design and Methods**

*Sample collection*

Golden king crab specimens will be collected in the fjord systems of Alaska with commercial crab pots (~50 infected, ~50 uninfected). In a previous study (Noever et. al), golden king crab were sampled from Southern Lynn Canal, Mid- and Lower-Chatham Strait, and Holkham Bay. Another option would be to gather specimens from commercial harvests.

*Briarosaccus species confirmation*: In accordance to the described rhizocephalan species in Noever et. al, the type of species of rhizocephalan will be determined and I will only be experimenting on one. For the sake of consistency in the lab experiment, the crabs parasitized with the rhizocephalan species *Briarosaccus auratum* will be selected. If a crab species with the rhizocephalan *B. callosus* is found, it will be noted but returned to the water.

*Metabolic Rate*

Infected and uninfected crabs would be placed into sealed plastic containers/chambers with seawater that match the conditions of seawater in the wild (salinity 32-34 ppt, temperature 5-10°C), then a magnetic stir would be placed on the bottom to regulate the amount of dissolved
oxygen in the container. Each trial would last about an hour, with a ten-minute buffer time to reduce stress of handling, the amount of oxygen would be measured every ten minutes. The metabolism rate would be calculated by measuring the change of dissolved oxygen concentrations between ten minutes, we would account for the crab weight and container water volume in the calculation. Then this process would be replicated many times (>10 according to Belgrad and Griffen).

Digestion rate

This would be an observational study looking at whether the parasite slows or speeds up the rate of digestion in the crab. A set of crabs, with standardized weight and size, without the parasite (control), would be starved for approximately 24 hours to ensure an empty gut. Then they would be placed in a container for five minutes to acclimate the crab. After the five minutes, a single mussel (standardize size for all crabs) will be placed in the center of the container. The crabs will be observed and will record the start and end time of mussel consumption. After the crab consumes the mussel, it will be monitored over time and periodically checked over 15 minute intervals to see when they produce feces. This process will then be repeated for the infected crabs.

Rate of foraging/ Behavioral observations

To better understand the effects of rhizocephalans on the foraging rate, a set of infected and uninfected crabs will be observed and timed for their foraging rate. In a container with unlimited food at an equal distance away, a crab (standardized weight and size) will be timed for how long it takes to find the food. Once the crab finds the food, the crab will be monitored to see how much food the crab would eat over the course of approximately six hours. Other
behaviors of the crab would be noted while the crab feeds, like whether the crab is feeding at a rather quick pace, or at a slower pace.

Statistics

For the metabolism study, the amount of dissolved oxygen consumed by each set of crabs will be compared to see any major differences in the change of metabolism. For the digestion rate, I would compare the time it took for the infected and uninfected crab to digestion the single mussel and determine any significant differences. Similar values would be compared for the foraging rates.

Anticipated Results

Figure 2 details the anticipated results of this study. Overall results that would support my hypotheses are that the rhizocephalans do have a significant impact on the crabs. But it is possible that rhizocephalans may not have a significant impact on their host’s metabolism and energetic usage.

![Graph showing metabolism/digestion/foraging rates](image)

Fig. 2. Potential results of lab surveys of the rates of metabolism, digestion and foraging.

Energetic cost would mean that the parasite is taking up the majority of the host’s nutrients, while the increased needs would mean that the crab ate and processed more.
Discussion

When the rhizocephalan has an energetic cost to the host, there would be a reduction in metabolism and digestion rate. This is not good for the host because it means that the rhizocephalan host is taking up a lot of resources from the host. Rhizocephalans have been reported to take nutrients from their crab’s host directly from the hemolymphs (Shirley et. al 1986). Another implication for reduced metabolism/digestive rate would be the parasite redirects the crab’s energy to suit the needs of the parasite. Alterations in crab behavior (slower foraging rate) implies reduced energy spent on movement for the crab. This could be an example of a behavior modification by the rhizocephalan.

If there is no change in metabolism/digestive rate this means that the parasite is not active in altering metabolic aspects of the crab. So if there are not metabolic effects, and reproductive effects are already generally known, could there be a life stage effect of rhizocephalans on the crabs. This could be an interesting study to look into how rhizocephalan larvae impact the crabs. For example, in tapeworms the larval stage has huge metabolic costs for its stickleback host (Heins et al 2002). Whereas in Hymenoleis diminuta adult phase, the parasite did not take up much of its rat host’s energy (Bailey 1974).

Increased foraging rate would mean that the parasite drives the host for an increased need for nourishment, or sporadic behavior to be noticed by predators, or simply to maintain the needs of the crab and parasite (Gehman & Byer 2016).

Rhizocephalans prevent successful reproduction of crabs therefore reduces the crab’s fitness fewer numbers of new generations of king crabs (Shukalyuk 2005). The golden king crab fishery in important in Alaska and ultimately the west coast. Rhizocephalans have high infection rates and are adaptable, but golden crabs potentially have the ability to possess some defense
against rhizocephalans (Shirley 1986). Overall, it is important to understand the biology and ecology effects of parasites on commercially valued species. With information about how parasite can affect the physiology, then we can start to determine management strategies to continue the viability of harvesting these species. (Kuris & Lafferty 1992, Shields 2012).

**References**

Belgrad BA, BD Griffen. 2015. Rhizocephalan infection modifies host food consumption by reducing host activity levels. *Journal of Experimental Marine Biology and Ecology* **466**: 70-75.


