Exploring the biology of the Siberian Prawn, *Palaemon modestus*

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**Abstract**

The Siberian Prawn, *Palaemon modestus*, is an invasive species recently introduced into the San Joaquin Delta, Central California, through ballast water from Southeastern Asia. They are now the most dominant shrimp species in the area. Previous studies have shown their morphometric and current distribution, but very little is known about their ecological profile. In this study, we evaluate their salinity tolerance level from 0ppt to 72ppt and analyze their salinity regulation method using a microsyringe and an osmometer. By determining these two factors, we aim to predict their future distribution pattern to make appropriate conservation plans for any native species that may be threatened by their dispersal. In our pilot study, they exhibited no behavioral issues in 0ppt environment but are susceptible to ammonia poisoning caused by failed nitrogen cycling due to the lack of Ammonia Oxidizing Bacteria (ABO) and Nitrobacter. Future mortality from ammonia poisoning in a laboratory setting can be prevented by mixing in bacteria pills in the tank or by replacing a third of the tank water with the water from the capture site.

**Keywords:** prawn, biology, environment, ecology, conservation, salinity

**Introduction**

Organisms that are not native to the region and may cause harmful effects to humans or to the ecology of the native species in that area are considered invasive species (Castro et al. 2017). The San Francisco Bay delta has been prone to introduction of many invasive species (Nichols et al. 1986). Many such species distribute themselves further upstream through San Pablo Bay, Suisun Bay, the Sacramento River, and the San Joaquin River. The Siberian Prawn, *Palaemon modestus*, is an invasive species recently found in all of the aquatic environment listed above (Brown and Hieb 2014), and is thought to have been introduced in ballast water from its original habitat, which extends from Siberia down to Southeastern Asia (Holthuis 1980). Previous studies of the population of Siberian Prawn in California have been focused primarily on their morphometric and current distribution, but little is known on their overall ecological profile.

Animals are classified as either osmoregulators or osmoconformers depending on how their body responds to the environmental salinity level. Osmoregulators maintain the salinity of their extracellular fluid at a constant level regardless of the environment, whereas osmoconformers allows their osmolarity to match the environment (Hill et al. 2012). Most birds, reptiles, and mammals are osmoregulators, but other vertebrates and invertebrates are highly variable in which characteristic they possess. There are a few species such as the *Hemigrapsus nudus* that may osmoregulate at certain salinity levels and become osmoconformers at other levels (Dehnel 1962). Thus, it is impossible to determine a species’ osmoregulatory behavior solely based on its phylogeny. Regardless of whether the species is an osmoregulator or osmoconformer, most organisms have a minimum and maximum level of environmental salinity that they can tolerate without a lethal outcome. Freshwater consists of 0-3ppt of salt, seawater has around 35-37ppt, and any bodies of water between those two ranges are classified as estuary environments. The Siberian Prawn has been found in rivers and the delta, but their specific lower and upper limits of salinity tolerance have not been discovered yet. The goal of this study is to evaluate the salinity tolerance of this species and determine their profile as an osmoregulator or osmoconformer in various salinity levels. By determining these two factors, we aim to predict their distribution pattern in the future to make appropriate conservation plans for any native species that may be threatened by their dispersal.

**Materials and Methods**

**Specimen collection**

The Siberian Prawn used in this study were collected by midwater trawling in the San Joaquin Delta estuary near Chipps Island, California, that connects the Suisun Bay with the Sacramento River and the San Joaquin River. The deepest part of the delta is over 80m...
in depth, thus the trawling net (Figure 1) is only able to capture organisms swimming within 3.1m below the surface of the water. Each tow was held for 20 minutes before retrieving the net, and a total of ten tows was performed. If the invasive prawns were captured in the net, they were stored in an 18-gallon ice chest filled with the water collected from the sampling site and a battery powered aerator. After ten tows, the specimens were transported back to the Lodi Fish and Wildlife Office (FWO), then to the research facility at California State University Stanislaus. Collections were made once in September and twice in October 2016, yielding a catch of 40, 12 and 7 shrimp respectively.

Fig. 1. Midwater trawling net used to capture the Siberian Prawn in the Chipps Island (from Brandes and McLain 2001).

Specimen maintenance

The first batch of collected specimens were kept in the cooler with the lid open in the lab room to allow the shrimps to acclimate to lab conditions for 24 hours. However, the aerator batteries died overnight and caused the shrimps to suffocate in the anoxic water. All 40 individuals were found dead the next morning and all were stored in the freezer for future morphological analyses and parasitic inspections. The next batch of specimens contained 12 individuals, which were all placed in a 12-gallon tank filled with room temperature tap water with an outlet powered aerator and water filter. The next group of 7 individuals were added to the same tank.

The shrimps were fed one shrimp pellet per individual at approximately noon every weekday, and nothing on the weekends. Observational notes on the shrimp behaviors were made during feeding time as well. Lids were originally not put on the tanks. Consequently, a few individuals jumped out of the tank and were found dried up and dead on the floor the day after. A plastic lid was later placed on top of the tanks to prevent the shrimps escaping as well as reduce water loss from evaporation and splashing due to the water filter.

Microscopic observations

The original 40 individuals were inspected under a dissection scope for the presence of potential ectoparasites. The morphometrics of the specimen were also measured and compared to the data collected by Brown and Heib (2014).

Salinity tolerance and hemolymph analysis

Due to the low specimen count, this analysis will be done at a later time with a total of 200-300 individuals. Thirteen 10-gallon tanks will be set up with various levels of salinity ranging from 0ppt to 72ppt with 6ppt increments. The salinity of each tank will be adjusted by mixing distilled water with appropriate amount of Instant Ocean™. During the study, 15-20 shrimp will be placed in each tank for 48 hours and the mortality rate in each tank will be recorded at the end of this time period to determine their sub-lethal limit. In order to sustain the salinity of each tank, the shrimps will not be fed during this period. Upon completion, each shrimp’s hemolymph will be collected using a microliter syringe inserted into the carapace over the heart. Collected hemolymph will be analyzed using an osmometer to record its osmolarity. This information will be used to determine the osmoregulatory behavior of _P. modestus_.

Results and discussion

Behavioral observation

When first introduced to the tanks, the majority of the shrimps showed signs of stress such as swimming back and forth restlessly, jabbing towards the surface or the glass, or curling up their abdomen while floating in place by beating their pleopod. These behaviors were seen much less frequently after 3 weeks. Some individuals appeared to be very possessive of the food when the pellets were given. These individuals would use their maxilliped to hold the food to their mouth as they chewed on the first piece of the pellet, while holding onto a second piece with their chelipeds. This behavior was more prominent on Mondays when they were starved during the weekend. Competition for food was observed in few instances where one individual jabbed aggressively towards their competitors that were attempting to also obtain the pellets. However, the most extreme effect of their starvation was cannibalism. Two incidents of cannibalism occurred within the nine-week period. The first event was discovered on Monday of Week 6, where one shrimp was missing and some of the shrimp’s body parts were found scattered around the bottom of the tank. Only bits and pieces of the exoskeleton were found in the tank, so whether it was predated while it was molting remains unknown. On the following Monday, a relatively small shrimp was observed eating a decapitated, naked (without the
exoskeleton) shrimp of similar size (Figure 2a). We were able to gather almost the entire exoskeleton that was cleanly separated from the body (Figure 2b, 2c), suggesting that it came off naturally through molting rather than being stripped off by the predator. These observations correspond with the findings of Abdussamad and Thampy (1994) on the Tiger shrimp, where cannibalism is most likely to occur against individuals that very recently molted, and the size of the individuals does not play a significant role on the predator/prey relationship. When the pellets were introduced again on the same day, the predator shrimp released its prey and held onto the pellet instead, suggesting that when food supply is low *P. modestus* may eat members of its species, but it is not their preferred diet. Additionally, other members of the tank showed no interest in the predated shrimp and seemed to distance themselves from the cannibalistic individual. Whether this was a learned behavior from the predator shrimp’s aggressive behavior in the past or simply dependent on the hunger level and diet preference of the individual remains unknown.

Fig. 2. (A) *Palaemon modestus* consuming another molted individual in the tank. (B) The cephalothorax carapace of the predated individual that presumably has been molted off. (C) The exoskeleton of the abdomen of the predated individual that has been presumably molted off on the left and its half-eaten muscular body on the right.

**Ammonia poisoning**

After six weeks, some individuals started to show signs of weakening such as lower activity level, rejection of food, and disorientation, shown by individuals swimming or resting in a slanted manner. By week nine, all individuals were found dead. The tank water was brought into Tropical Haven aquaria store to test its water quality. The test showed that the tank water contained a high concentration of ammonia, a toxic nitrogenous waste (Ip et al. 2001) excreted by the aquatic invertebrate. We hypothesize that the shrimp mortality was primarily caused by ammonia poisoning through the tank water. In the natural aquatic environments, the *Nitrosomonas* bacteria, also known as the Ammonia-Oxidizing Bacteria (AOB), breaks the ammonia down into nitrite (Urakawa et al. 2006), which is then further broken down to nitrate by the Nitrobacter (Mellbye et al. 2015). Nitrate is a non-toxic chemical that often acts as a fertilizer along with ammonia for many aquatic plants or photosynthetic algae (Bracken et al. 2006). This whole process is often referred to as biological nitrogen cycling (Ward et al. 1989). We had hoped the *Nitrosomonas* bacteria culture would naturally grow in the tank before the ammonia reached a toxic concentration, but it failed to do so. In future experiments, a biofilter containing Nitrobacter and AOB and will be mixed into the tank water prior to the introduction of the shrimp to prevent future mortality through ammonia poisoning.

**Parasitic infection and morphometrics**

No obvious parasites were found on the surface of the shrimp’s bodies. The presence of endoparasites was not investigated in this study, but it is of great interest for future studies because *P. modestus* is the most common shrimp found in the Sacramento-San Joaquin delta (Brown and Hieb 2014) and as such there is a chance of bioaccumulation of toxins in commercial fish that predate on the shrimp if they contain parasites harmful to humans.

The morphometric of *P. modestus* matched the range given by Brown and Hieb (2014) with the total body length ranging from 62mm to 80mm.

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**References**


