INSTITUTIONEN FÖR BIOLOGI OCH MILJÖVETENSKAP

Reproductive traits in euryhaline gobies
insights into physiology, adaptations and biological invasions

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ABSTRACT

Organisms are adapted to reproduce in their specific environment by a range of different traits. For many animals, reproduction is tied to specific conditions, that trigger or enable the reproductive events. This thesis deals with traits associated with reproduction, their functions and interactions with the environment. Some traits are plastic, and can change in an individual's lifetime depending on the environment, while other traits are more or less fixed. The variation in trait expression will enable selection when environments change, as some individuals will survive and reproduce to a larger degree. For the gobies, a large family of fishes (ca. 2000 species) found in a wide range of different salinities, reproduction can be affected by the environment. Since their sperm and eggs meet to fertilize externally, surrounded by water, sperm need to be able to swim. The salinity environment can limit this process. However, of all the environmental conditions that can affect reproduction, salinity variation seems to be one that they are highly tolerant towards. This is unusual, since most fishes are adapted to reproduce in a very narrow salinity range. Studying what different environmental adaptations gobies have in their reproductive traits can help us to better understand the eco-evolutionary processes they partake in. For example, the round goby (*Neogobius melanostomus*), is a non-native species in many regions of the world. It is important to understand what limits their reproduction, and if they can adapt to cope with drastically new environmental conditions. Another common species, the sand goby (*Pomatoschistus minutus*), is well studied, but more knowledge on their reproduction will increase the understanding of this budding model organism.

As round gobies are spreading into different salinities, there is likely strong selection for the ability to reproduce in their new environments. This may lead to evolutionary adaptations that greatly strengthens the species' invasiveness. In the Baltic Sea, round gobies are spreading into both lower and higher salinities. By measuring their sperm velocity in a range of salinities representing the Baltic salinity gradient, I found that males from these different invasion fronts showed different responses to salinity. Also, the more generations a population had spent in their local salinity, the higher their sperm velocity when spawning there. This change in sperm velocity is most likely an adaptive, evolutionary response to natural selection.

To understand if a population can also acclimate and increase their reproductive success in a new salinity, I exposed adult round gobies to novel salinities and enticed them to spawn. Despite a lack of acclimation in their sperm traits, they were still able to reproduce. A key to this could be the finding that, in freshwater, low sperm velocity seems to increase fertilization success, while the opposite is true for brackish conditions. Moreover, round goby eggs grew equally well in low and high salinity, although eggs from Baltic Sea parents had better overall development, regardless of what salinity the eggs were spawned or treated in.

Gobies have a pair of special organs called sperm duct glands, that produce chemical substances contributing to the male's ejaculate. In the marine sand goby, I found that these substances increased their sperm velocity, but they did not help sperm survive. However, when testing these substances on sperm in round gobies from freshwater and brackish water, there was no positive effect on sperm. Importantly, gland contents did not improve poor sperm velocity in freshwater. Round gobies have 'sneaker' males, which reproduce by parasitizing nest-holders for fertilizations. I found that in the sampled freshwater river, these males invested little energy in testes growth, compared to the brackish males. This suggests that the elsewhere naturally occurring 'sneaker' tactics are limited by poor sperm performance and could be rare in the freshwater river that was sampled.

Overall, I show that salinity influences round goby reproduction, and that in some cases they can adapt to salinity conditions, while in others it limits their behaviour and physiology. Similarities between the sand goby and round goby exists, but they likely have different uses for their sperm duct glands. Since round gobies from brackish waters can reproduce in both brackish conditions and freshwater, management should try to limit round goby spread from brackish environments into freshwater.

Keywords: Sperm | Reproduction | Life-history Strategies | Local Adaptation | Fish | Invasion Biology | Salinity