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Shrimps remove ectoparasites from fishes in temperate waters

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We have found that two very common species of North Atlantic shallow water shrimp, *Palaemon adspersus* and *Palaemon elegans*, remove and feed on ectoparasites on plaice (*Pleuronectes platessa* L.). The relationship could be mutualistic, as we did not observe any attempts by the fishes to feed on the shrimps. The ectoparasites removed included monogenean worms (*Gyrodactylus* sp.) and sea lice (*Lepeophtheirus pectoralis*). An experiment showed that there were 65% more *Gyrodactylus* parasites on the fishes that had been apart from compared with those that had been together with shrimps for 48 h. Shrimps on coral reefs are known for cleaning fishes, but that shrimps in temperate waters show parasite-cleaning behaviour is, to our knowledge, a new observation.

Keywords: cleaning symbiosis; *Gyrodactyus*; parasitism; plaice; *Pleuronecta*; *Palaemon*

1. INTRODUCTION

Parasites have been found to affect the population dynamics and community structure of many of their hosts, and parasitic associations may cause a decrease in the host's nutritional status, condition, growth, fecundity, competitive ability and mating success (Combes 1996; Bush *et al.* 2001).

Cleaning associations involve cleaner organisms that remove ectoparasites and other material from the body surfaces of other apparently cooperating animals (Feder 1966). These associations between animals from different taxa have been described as one of the most complex and highly developed inter-specific interactions documented (Feder 1966) and occur among a wide range of animals from diverse environments (Nicolette 1990; Grutter 2002). The majority of examples of cleaning, however, are aquatic and restricted mostly to fishes (for a review see Grutter 2002).

In tropical coral reef habitats, cleaning activity performed by cleaner fishes has been shown to have definite effects on the numbers of fish parasites and to benefit the fish clients (Grutter 1996, 1999). Moreover, the maintenance of the diversity of fishes is dependent on the presence of cleaners (Grutter *et al.* 2003), and fishes with large ectoparasite loads tend to spend more time with cleaners (Sikkel *et al.* 2000).

Also, certain species of coral reef shrimps remove ectoparasites from client fishes (Bunkley-Williams & Williams 1998; Becker & Grutter 2004). Recent findings have shown that the coral shrimp *Periclimenes holthuisi* reduce monogenean (*Benedenia* sp.) loads by 75% on captive surgeonfish *Ctenochaetus striatus* within 48 h (Becker & Grutter 2004). Like shrimp–fish cleaning symbiosis, this indicates that shrimp fish cleaning has as significant an impact on parasite population dynamics.

Inspired by occasional observations by the first author of shrimps displaying what looked like cleaning behaviour on flatfish in tanks (plaice, *Pleuronectes platessa* L. and flounder, *Platichthys flesus* L., Swedish West coast), we decided to examine the possibility that shrimps in temperate waters could also be involved in cleaning symbiosis.

2. MATERIAL AND METHODS

The study was performed during May and June at Klubban Marine Station, at the Gullmarsfjord, Lysekil, Sweden. Two species of shallow water shrimps, *Palaemon elegans* and *Palaemon adspersus*, were caught by hand trawling in shallow water (less than 1 m deep) near the station and kept in 100 l aquaria with sand and seaweed. The plaice (weighing 80–250 g) were bought from a local fisherman and released into the ocean after the experiments. The fishes were kept individually in 100 l aquaria with bottoms of aquaria covered with local beach sand. They were allowed to acclimatize for 3 days. All aquaria were supplied with water pumped directly from the ocean ($2\ l\ min^{-1}$, 18 °C). These aquaria were also used for the first experiment described below. The fishes were fed daily with peeled and minced shrimps (*Pandalus borealis*).

First we investigated the impact of the apparent cleaning on the abundance of monogenean parasites (*Gyrodactylus*) on the plaice, using the methodology described by Becker & Grutter (2004). In short, half the body of each fish (left to the lateral line) was bathed in a anthelmintic solution ($2\ \mu g$ praziquantel l^{-1} for 2 min) and gently rubbed, whereupon the bath water was filtered and the number of *Gyrodactylus* was counted. Half of the fish ($n=13$) were put together with five shrimps (*P. adspersus*), while the other half were left alone in the aquaria. Care was taken to introduce the shrimps in a way that would not make them look like food dropped from the surface. Thus, they were put into the aquaria by releasing them from a hand net at the bottom away from the head of the fishes. 48 h later, the whole fishes were bathed in the same anthelmintic solution as above and the number of *Gyrodactylus* was counted.

In a second experiment, we used the method described by Becker & Grutter (2004) to confirm that the shrimps (*P. adspersus*) do consume *Gyrodactylus* Here, 10 shrimps were put singly in 2 l plastic aquaria together with 60–100 *Gyrodactylus* (removed from fishes by washing them in freshwater for 2 min). After 24 h, the shrimps were anaesthetized by placing them on ice and their gut contents were examined.

3. RESULTS AND DISCUSSION

Palaemon elegans and *P. adspersus* do remove parasites. Both species were clearly attracted by the fishes, walking on them and examining various parts, including the mouth region (figure 1*a*). They used their pincers in a manner indicating that they were feeding on dermal ectoparasites. As most of the ectoparasites are very small (less than 1 mm) it was generally not possible to identify the food item visually. However, we did once observe how a shrimp (*P. adspersus*) removed a few millimetre-long sea lice (*Lepeophtheirus pectoralis* Müller). Interestingly, the fishes did not make any attempt to feed on the shrimps, suggesting a symbiotic relationship similar to that seen on coral reefs. It is possible that the shrimps behave in a way that inhibits the feeding response of the fishes, as we know from experience that plaice readily accept dead shrimps as

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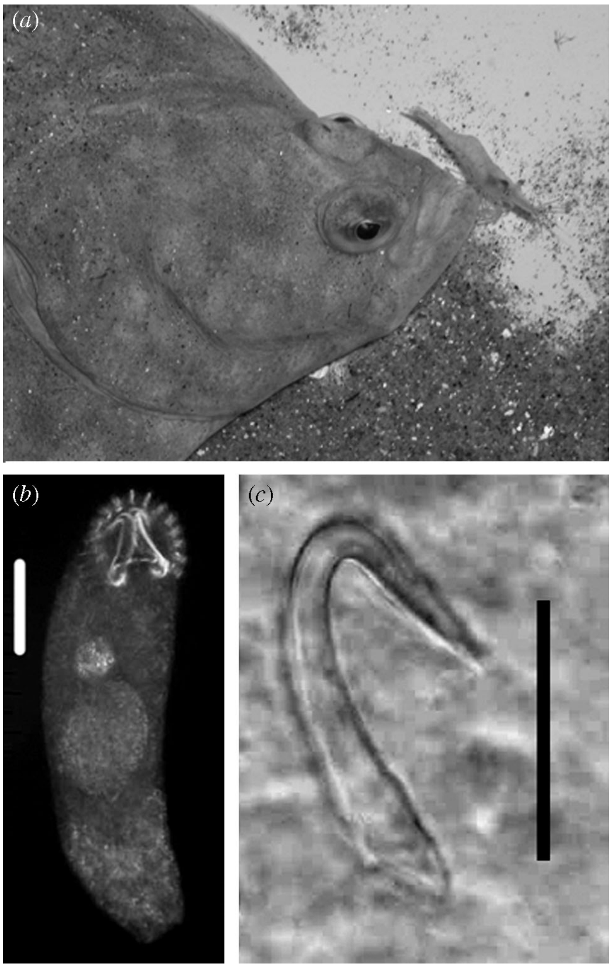

Figure 1. (*a*) A shrimp (*P. adspersus*) cleans the mouth region of a plaice. (*b*) A monogenean parasite (*Gyrodactylus* sp.) found on the skin of a plaice. Scale bar, 250 µm. (*c*) Hooks from the attachment organ of a *Gyrodactylus* found in the gut of a shrimp (*P. adspersus*). Scale bar, 100 µm.

food items. Such behavioural signals from a coral reef cleaning shrimp (*Urocaridella* sp.) towards the client fishes were recently described (Becker *et al.* 2005).

The filtrate from bathing half a fish in anthelmintic solution contained 51±6 monogeneans (mean±s.e.m. from 26 fishes, range 13–116) of the genus *Gyrodactylus* (*G. unicopula* Glukhova and/or *G. unipons* Malmberg; figure 1*b*). When we subsequently allowed the same plaice to be with or without shrimps for 48 h, there was a significant effect of the presence of shrimps on the estimated number of *Gyrodactylus* on the fishes (figure 2; $p=0.039$; Wilcoxon signed-rank test). Thus, at the end of 48 h, there were 65% more *Gyrodactylus* sp. on the fishes that had been alone compared with those that had been together with shrimps. The apparent (but non-significant) increase in the estimated number of *Gyrodactylus* on plaice that were not together with shrimps could indicate that this parasite was present in the water pumped in from the ocean, or that not all parasites were removed from the body half during the first anthelmintic solution treatment. Of the 65 shrimps included in this experiment, only one could not be accounted for after the 48 h and may have been eaten by the fishes.

In the second experiment, we could confirm that the shrimps (*P. adspersus*) do consume *Gyrodactylus*. All of

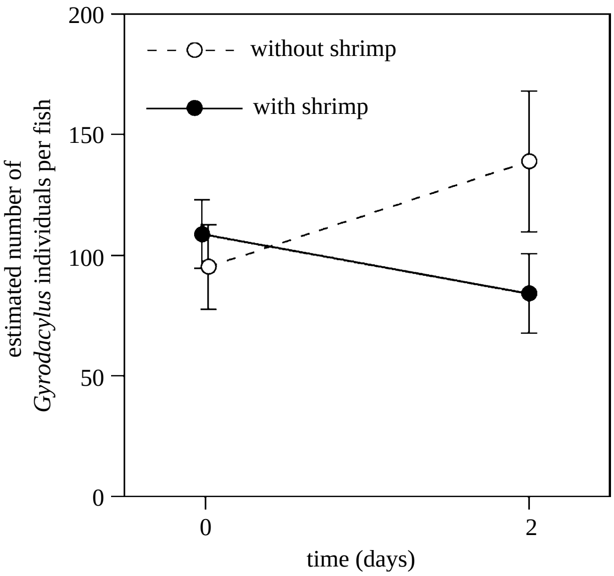

Figure 2. Estimated number of *Gyrodactylus* sp. on plaice before and after 2 days in aquaria with or without shrimps. Values (means±s.e.m) were significantly different after 2 days ($p<0.05$; Wilcoxon signed-rank test).

the 10 shrimps that were put singly together with 60–100 *Gyrodactylus* appeared to feed on the parasites. When examined after 24 h, all *Gyrodactylus* were gone from the containers. The presence of hooks from the attachment organ of *Gyrodactylus* could be verified, but only in three shrimp guts (where 2–8 hooks were detected; figure 1*c*). Since it was clear that the monogeneans were consumed by the shrimps (as seen from the feeding behaviour and complete disappearance of all *Gyrodactylus* from the small aquaria), the low incidence of monogenean attachments hooks in the gut content indicates a fast gastrointestinal throughput and/or fast digestion of the hooks. Moreover, the small translucent hooks are readily overseen in a microscopic examination. These factors could explain why we in our initial experiments failed to find hooks in the guts of shrimp that had been together with plaice, and why Becker & Grutter (2004) failed to detect remains of monogenean hooks in guts of cleaner shrimp collected from a coral reef.

Our results suggest that cleaner shrimps could play a role in suppressing ectoparasite infections on fishes in temperate ecosystems. As the *Palaemon* shrimps often reside in wrack and seaweed, it is possible that their cleaning behaviour is not restricted to bentic fishes, but may include fish species that occupy the algae belt. Finally, the results raise the possibility that these highly abundant shrimps can be used as cleaners in aquaculture, where ectoparasites can have a significant negative impact.

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