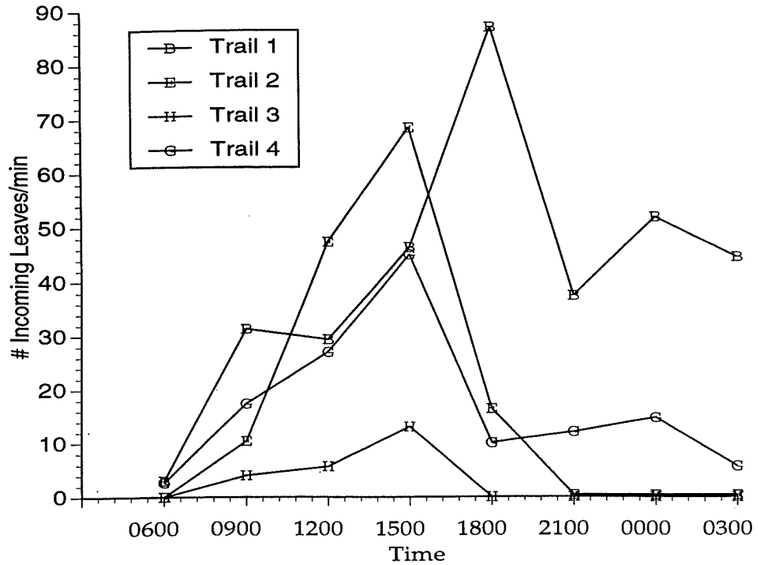

FIG. 3. Diel pattern in number of ants carrying leaves toward the colony nest/min for all four trails. Data points represent means of three samples for each trail at each time.

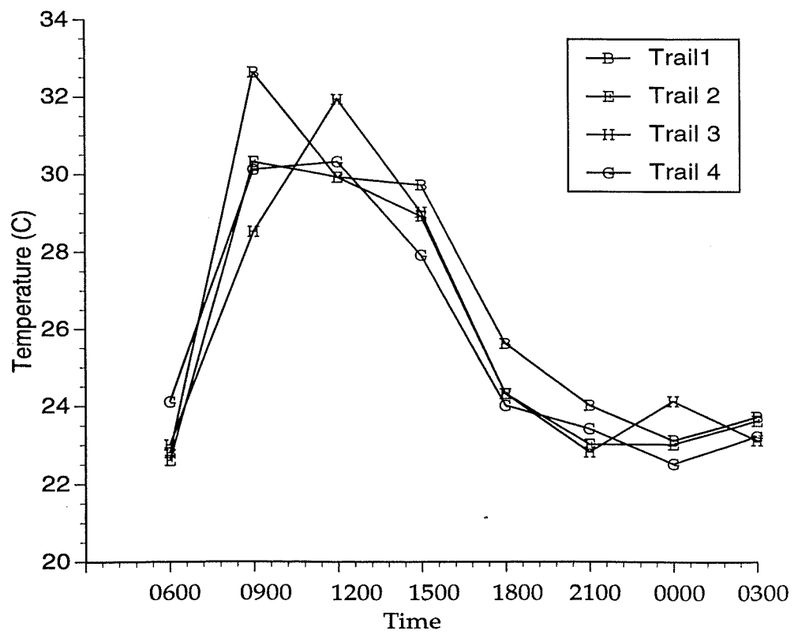

FIG. 4. Diel pattern in temperature(degrees celcius) for all four trails.

PREDATOR AVOIDANCE BEHAVIOR IN PALAEMONID SHRIMP IN RIO CLARO ESTUARY

SARA C. GOODWIN AND ANTHA N. WILLIAMS

Abstract. The abundant population of small shrimp of the family Palaemonidae in the Rio Claro Estuary, Corcovado National Park, Costa Rica are the prey of many fish species. We studied the ability of the shrimp to avoid predation. In the presence of a natural predator, the shrimp in an experimental enclosure decreased activity to reduce their visibility, oriented toward the predator, and spatially separated themselves from the predator. These findings suggest that not only are shrimp aware of the presence and location of a predator, but they are able to avoid it in space. Effective use of shallow zones or refuges by the shrimp in avoiding predation, might decrease their availability as a food source, leading to more competitive interactions among their predators.

Key Words: Palaemonidae, predator avoidance, tropical estuaries

INTRODUCTION

Shrimp (Crustacea: Palaemonidae) make up a high proportion of the primary aquatic consumers in the Rio Claro estuary, Corcovado National Park, Costa Rica (Winemiller 1983). They are preyed upon by numerous freshwater and marine fish predators, and are therefore an important base of the trophic pyramid at this site. In order to survive, we expected that these shrimp would have to exhibit strong predator avoidance behavior. We examined their interactions with their natural predators, since predator/prey interactions themselves are often strong forces in shaping communities. For these reasons, we studied the behavior of these shrimp, specifically, their mechanisms of predator avoidance. We hypothesized that palaemonid shrimp would react to predators in three ways: (i) by decreasing activity levels and thereby decreasing their apparency (ii) by orienting toward the predator and increase their vigilance, and (iii) by spatially avoiding potential predators. We tested this in an experimental enclosure near the Rio Claro estuary.

METHODS

The experiment was conducted at the Rio Claro estuary near Sirena, Corcovado National Park, Costa Rica on 4 February 1997. Using a seine net, we obtained three similarly sized angelfish *(Pomadasys bayanus)*, which are natural shrimp predators (Winemiller 1983). We collected palaemonid shrimp from the estuary using hand nets. We set up a test arena in a plastic tub (64x36x26 cm2) and partitioned it into two halves using wire mesh with 1.25x2.5 cm2 holes. For each experiment, we first placed 10 shrimp into the partitioned tub and allowed them to acclimate for 10 min. We measured the activity level of the shrimp immediately after the 10 min acclimation period, and then again after 30 s and after 60 s. Activity level was quantified as the number of shrimp moving at each specified time. We recorded spatial distribution of the shrimp by placing them into three categories: those occurring to the left of the partition, the right of the partition, and within 1 cm on either side of the partition. Finally we measured the orientation of the shrimp, with respect to a rock placed in the tub. These measurements were taken prior to the experimental trials, and served as the controls.

After these initial measurements were taken, one angelfish was placed into the right side of the tub for the experimental trial. The wire mesh partition that divided the left from the right side of the tub allowed the shrimp to move freely to all parts of the tub but restricted the angelfish to one side. The activity level of the shrimp was measured immediately after the fish was placed in the tub, and again 30 s later. The last activity level measurement was taken 1 min after the fish was placed in the tub. We also recorded the spatial distribution of the shrimp 1 min after the introduction of the predator to the tub, their orientation in relation to the fish, using the fish as the 12 o'clock position. The number of shrimp facing each clockwise position was recorded. For each trial we refilled the tub with fresh estuary water, and three different angelfish of similar size were used in the experiments, each for two consecutive trials.

RESULTS

After the introduction of the predator, the shrimp significantly decreased their activity from the mean activity level of the control treatment prior to introduction (paired t-test, t=1.98, df=12, P=0.04, Fig. 1). Within the predator treatment, there was significantly greater activity directly after introduction of the predator (0 s) than at 30 s (t=2.31, df=12, P=0.02). There was no difference in the activity at 30 s and at 60 s after the introduction (t=-1.33, df=12, P=0.90). The shrimp in the predator treatment showed significantly less deviation from direct orientation toward the fish, than the shrimp in the control (t=8.22, df=12, P<0.001, Fig. 2). An analysis of variance showed that the presence of a predator had a highly significant effect on the distribution of the shrimp in the tub (two-way ANOVA, F=16.30, df=73, P<0.001, Fig.3). A multiple comparison Tukey-Kramer HSD test showed no significant difference between the left, right, and partition distributions prior to the predator introduction. After the introduction of the predator, the numbers of shrimp were greater on the predator-free side than on the predator side or the partition. There was no difference between the distribution of the shrimp on the predator side and on the partition.

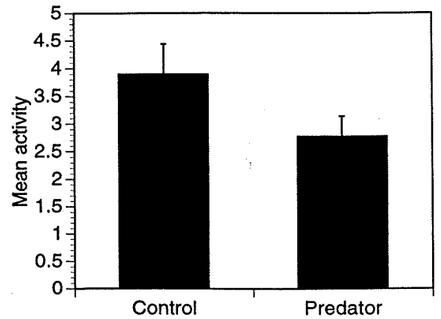

Fig. 1. Mean (± 1 S.E) activity of shrimp in the presence and absence of a fish predator, measured as the number of shrimp moving at three sampling times (time zero, 30 s, and 60 s).

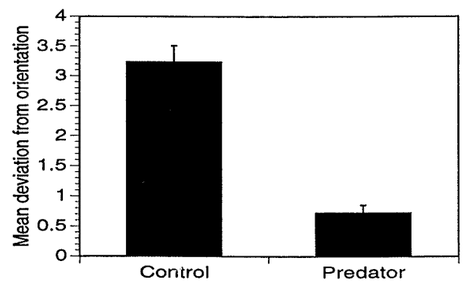

Fig. 2. Mean (± 1 S.E) deviation from orientation toward the focal object (a rock in the control and a predator in the experimental treatment). Thedata indicates that shrimp increase vigilance by orienting toward a predator, while in the absence of a predator they exhibit random orientation.

DISCUSSION

Our data support the hypothesis that shrimp activity decreases with the introduction of a predator. The initial shrimp activity at the introduction of the predator was due to their movement away from the fish. Once spatially removed from the predator, the shrimp decreased activity, possibly to make them less visible, and also to increased their vigilance to the predator. The shift from random orientation to orientation toward the fish by the shrimp supports the idea that shrimp are aware of both the presence and the location of the predator. An awareness of the location of the predator is further supported by our findings that the shrimp spatially avoid the predator. After the introduction of *P. bayanus*, the shrimp moved from an even distribution across the tub to aggregate on the predator-free side of the tub. We observed another risk avoidance behavior by the shrimp in our experimentation; the shrimp often chose to remain close to the wire mesh partition in both the presence and absence of the predator. It is possible that they were using the complex structure of the partition as a refuge.

Since shrimp comprise much of the primary aquatic consumer population in estuaries in Corcovado National Park, and are preyed upon by both freshwater and marine fish species, their behavior has clear implications for the food chain and community structure here. The distribution and predator avoidance by shrimp can affect the distribution, behavior, and foraging success of many fish species. The ability of shrimp to utilize shallow areas and submerged structures as refuges could decrease their availability as a food source and increase competitive interactions among their predators. Further studies are necessary in order to fully understand the interactions between palaemonid shrimp and the species that feed on them. A better understanding of the actual spatial distribution and abundance of shrimp in the estuary could provide insights into niche partitioning and trophic interactions.

Table 1: Mean activity, deviation from direct orientation, and distribution for control and predator trials

	Control	S.E.	Predator	S.E.
Activity at 0 seconds	4.31	0.64	3.46	0.50
30 seconds	3.31	0.75	2.23	0.46
60 seconds	4.07	0.54	2.62	0.46
Mean of three activity measurements	3.90	0.54	2.77	0.37
Deviation from direct orientation	3.23	0.28	0.72	0.13
Number of shrimp on predator-free side of tub	2.85	0.44	6.15	0.67
predator side	4.15	0.55	1.92	0.45
partition	3.0	0.47	1.85	0.48

LITERATURE CITED

Winemiller, K.O. 1983. An introduction to the freshwater fish communities of Corcovado National Park, C.R. Brenesia 21: 47-66.

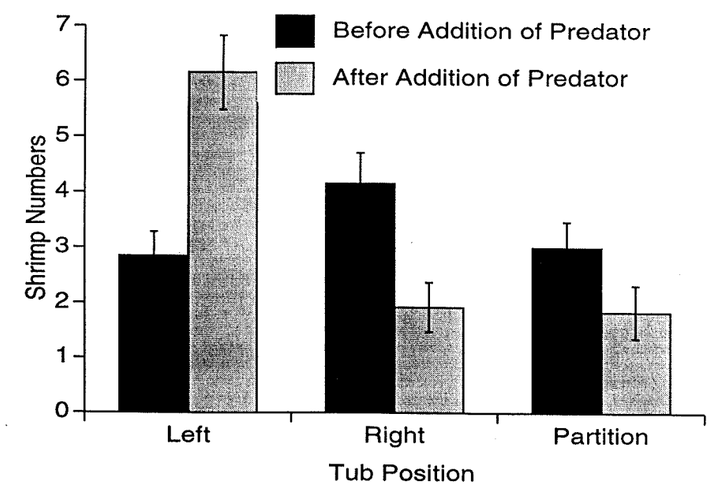

Fig. 3. Spatial avoidance of a fish predator by palaemonid shrimp, as indictated by the mean (± S.E) distribution of shrimp in the experimental tub before and after the addition of the predator which was always added to the right side of the tub.