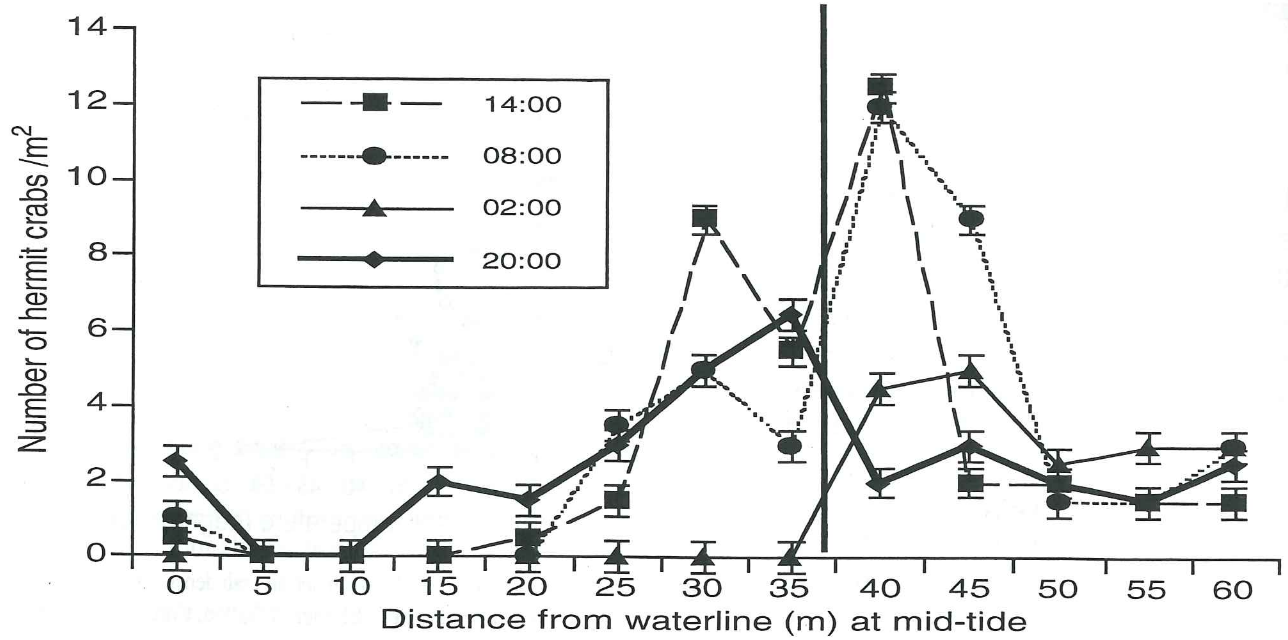

FIG. 3. Distribution of hermit crabs on the beach at Sirena Biological Station, Corcovado National Park, Costa Rica, through a 24 hr period (mean ± SE). Vertical line represents the transition between forest and beach habitats. Data are from 1x1 m plots along a 60 m transect (n = 251).

when food had probably been deposited, than during the incoming tide at 02:00, suggesting a role of tidal cycles and food availability in hermit crab distribution. Due to interspecific competition for food resources, hermit crabs may differentially distribute themselves across the beach (Karlsberg and Hubbard 1995, Biedron and Theoharides 2003). We observed much feeding activity on the beach at night after the tide had fallen, further implicating the beach as an important foraging site.

We found the most hermit crabs in the transitional zone between beach and forest habitats, regardless of time (Fig. 3). This area may be preferred because it provides protection from desiccation and predators and is close to foraging sites along the high tide line. We found that overall hermit crab density was higher in the forest than the beach, which may be due to less variable temperatures in this habitat.

Environmental conditions in hermit crab habitats vary greatly over a daily cycle. We found that hermit crabs make clear habitat choices over the course of a day in order to avoid severe and potentially lethal heat stress. It is possible that hermit crabs make other choices that may further mitigate the effects of daily temperature fluctuations. For example, crabs choose shell colors ranging from nearly white to black. Future studies could examine whether shell color affects hermit crab distribution in relation to spatial and temporal temperature variation.

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Spatial and temporal patterns in shrimp activity in a tropical stream

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Abstract: Shrimp and fish compete for some of the same resources, but fish are also visual predators that consume shrimp. We found that freshwater shrimp in the Rio Claro in Corcovado National Park, Costa Rica are more abundant in shallow areas during the day, and increase activity in the deeper zones and throughout the water column at night. These behavioral patterns of shrimp may help reduce predation and increase access to food resources. The cues that induce diurnal movement in shrimp remain unclear.

Key Words: diurnal behavioral variation, predator avoidance

Introduction

Small aquatic organisms vary their activity in space and time to exploit food resources and avoid predation. Freshwater shrimp (Crustacea: Palaemonidae) are consumed by many freshwater and marine fish predators. Like many fish, shrimp are omnivores, so they may share some food resources with their predators. To exploit these resources and avoid predation by diurnal fish, which are visual predators, shrimp may vary their activity levels through the day. Goodwin et al. (1997) found that shrimp spatially avoid fish predators. We predicted that shrimp would occupy shallow zones or substrate refugia during the day and increase their activity in the water column and deeper zones at night.

Methods

We conducted our study in the Rio Claro, 2 km northeast of the Sirena Biological Station, Corcovado National Park, Costa Rica. Our study area was approximately 1 km upstream of the river mouth, beyond tidal influence. We established nine transects across the river that included a range of substrate types, flow rates, and vegetative cover. We measured depth and substrate type every 0.5 m along each transect. We classified substrate as sand, gravel, pebble, cobble, or bedrock. To determine flow rate, we timed how long a floating film canister took to travel a 10 m reach across each transect. We ranked depth, substrate, and flow measurements into classes.

On 4-6 February 2003, we measured shrimp activity during both the day and night to characterize space use and activity patterns. Day samples were conducted between 08:00 and 11:00 on all three days. We measured shrimp density along each transect by counting all visible shrimp within a 1 m by 0.5 m plot centered at points 1 m apart along the transect. Night samples were taken between 20:00 and 22:00 on all three days. We were unable to replicate our daytime methods due to the high activity of the shrimp and their distribution throughout the water column. Using a flashlight, we determined the activity of shrimp in each 0.5 m by 1 m plot by counting all shrimp viewed in one minute. This may have included a small proportion of repeat counts, but was consistent across nighttime counts.

We standardized for different day and night methods by converting our estimates of density to shrimp frequency: daytime shrimp frequency = shrimp per plot / total shrimp counted during all days; nighttime shrimp frequency = shrimp per plot / total shrimp counted during all nights. We used Spearman Rho non-parametric statistics to analyze the relationship between depth, flow rate, and shrimp frequency.

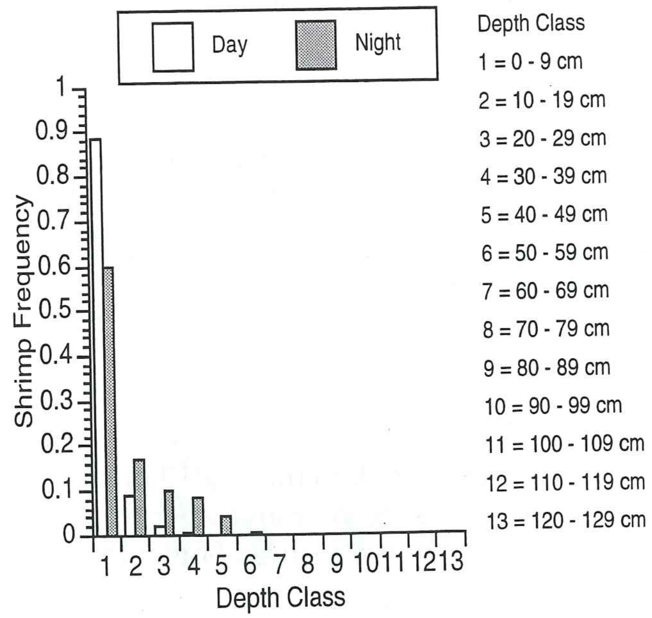

FIG. 1. Frequency of shrimp found at each depth class during the day and night in the Rio Claro, Corcovado National Park, Costa Rica. Daytime shrimp frequency = daytime shrimp per plot / total daytime shrimp; nighttime shrimp frequency = nightime shrimp per plot / total nighttime shrimp.

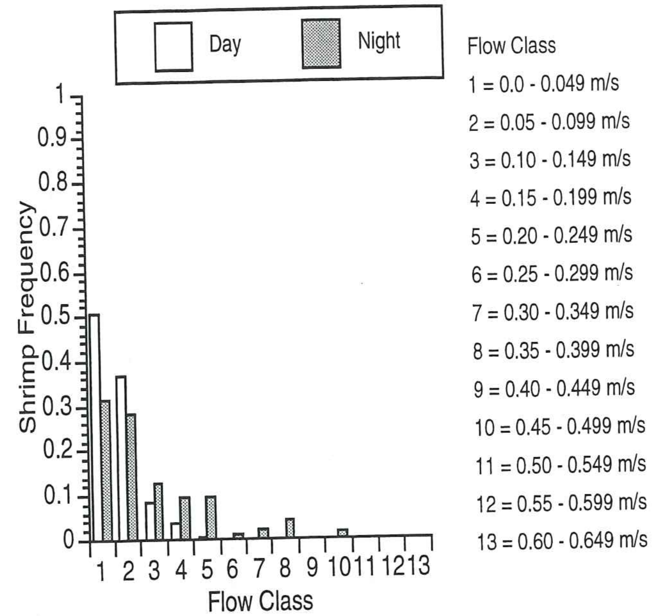

FIG. 2. Frequency of shrimp found at each flow class during the day and night in the Rio Claro, Corcovado National Park, Costa Rica. Daytime shrimp frequency = daytime shrimp per plot / total daytime shrimp; nighttime shrimp frequency = nightime shrimp per plot / total nighttime shrimp.

Results

We found that shrimp activity was negatively correlated with stream depth at all times (Day : Rho = -0.82, P < 0.001; Night: Rho = -0.60, P < 0.001). During the day, 88% of the shrimp were found at depths less than 9.0 cm, with none greater than 29.0 cm deep (Fig. 1). During the night, shrimp were present up to depths of 59 cm, with 23% found at depths greater than 20 cm. Night and day shrimp densities were both negatively correlated with flow (Day: Rho = -0.56, P < 0.001; Night: Rho = -0.64, P < 0.001). Shrimp were not found at flows > 0.2 m/s during the day, but were present at night in flows up to 0.5 m/s (Fig. 2). At night we observed the shrimp moving actively throughout the water column and on the streambed, whereas during the day they were only found on the streambed. Depth and flow were positively correlated (Rho = 0.42, P < 0.001). There was no relationship between shrimp abundance and substrate type.

Discussion

As predicted, we found that during the day shrimp were most abundant at shallow depths. Although this was also true at night, shrimp were more abundant in deeper zones at night than in the day (Fig. 1). During the day, all shrimp were in low flow areas. In contrast, at night some shrimp were active in regions of higher flow, possibly due to the increased availability of suspended food items. These patterns were consistent across substrate types. Shrimp may migrate into the water column from refugia in the substrate or move from shallow edge zones into deeper water. The cues that induce shrimp migration remain unclear. Shrimp may react to fish presence by visual or chemical cues, or may respond to changes in light levels or circadian rhythms.

The diurnal patterns we observed are consistent with the hypothesis that shrimp use spatial and temporal refuges to avoid predation. The tendency to move toward

deeper water at night also suggests that shrimp use food resources at night that they forgo in the day, possibly due to predation risk.

Literature Cited

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