Our results suggest that if M. pigra's sensitive leaf closing is an active defense, it may even be more effective than passive defenses such as leaf toughness or chemical defenses in deterring herbivory. Further research should examine leaf palatability and to determine if species that do not invest in active defenses allocate their resources to passive chemical defenses.

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DIEL SHIFTS IN ZOOPLANKTON ABUNDANCE WITHIN THE OPEN WATER MICRO-HABITATS OF THE RÍO TEMPISQUE MARSH

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Abstract. Although vertical diel migration of zooplankton is common in lakes throughout the world, it is unclear to what extent it occurs in shallow tropical marshes. We investigated diel shifts in zooplankton abundance within the open waters of the Rio Tempisque marsh at Palo Verde National Park, Costa Rica. Copepods and cladocerans dominated the zooplankton populations within the marsh. Zooplankton were significantly more abundant at night than during the day in the open water. We suggest that this could be due to horizontal migration instead of vertical migration.

Keywords: vertical diel migration, copepods, cladocerans

Intróduction

Diel migration of zooplankton is a well known phenomenon in lakes throughout the world. However, it is unclear to what extent vertical migration occurs in shallow waters of tropical marshes. During the winter dry season, the Río Tempisque marsh at Palo Verde National Park, Costa Rica is a vast expanse of floating vegetation upon a relatively shallow (1 m deep) water column. This mat of vegetation is perforated by small, open water areas where light may penetrate the water column. Carson et al. (1995) found an abundance of zooplankton beneath the vegetation mat and a relative dearth of zooplankton in the open water during the day. These authors suggested that the presence of visually-searching fish predators might explain the absence of zooplankton in the open waters. This mechanism could work in two ways: (1) fish eat zooplankton and reduce their abundance in high light areas, and/or 2) zooplankton may avoid areas of high light, migrating to open water only at night to gain access to the relatively abundant phytoplankton. We hypothesized that if either one, or both, of these mechanisms are operating, zooplankton abundance within the Río Tempisque marsh should increase in the open water during the night.

Methods

On 13 January 1997 we sampled zooplankton from the open water micro-habitats within the marsh at Palo Verde. These open areas were at least one meter square and free of the floating vegetation which dominates the marsh. We collected nine samples at 13:00 in full sun, and ten samples at 23:00, five hours after sunset.

Each three liter sample was collected from a different patch of open water within the marsh. Samples were taken 0.5 m below the surface and concentrated to one deciliter by straining through a 153 gauge screen. In the lab, each sample was restrained through the screen, treated with 60% alcohol solution, and transferred to a petri dish. We then identified and counted the zooplankton present.

We also trapped several fish from within the open water patches and examined stomach contents by both stomach pumping and dissection.

Results

As predicted, zooplankton were more abundant in the open water of the Río Tempisque marsh at night than during the day (t-test, t=5.33, df=17, P=0.0001). There were an average of 12.8 ± 1.6 zooplankton per liter at night and 0.66 ± 1.66 zooplankton per liter during the day (Fig. 1).

Copepods were approximately three times as abundant as Cladocerans during the night, and were the dominant zooplankton species within the open water (Fig. 2). Other zooplankton species were present at lower abundance (Fig. 2).

Several zooplankton were found within the stomachs of the fish we caught in the marsh, but were unidentifiable due to partial digestion.

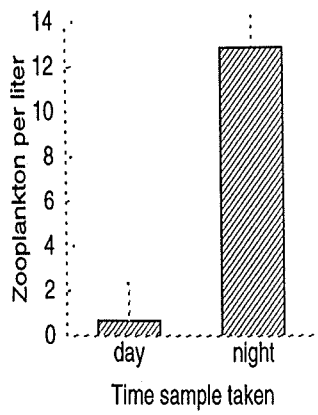

FIG. 1. Mean (± S.E.) abundance of zooplankton in open water habitats of the Río Tempisque marsh during the day (n=10) and at night (n=9).

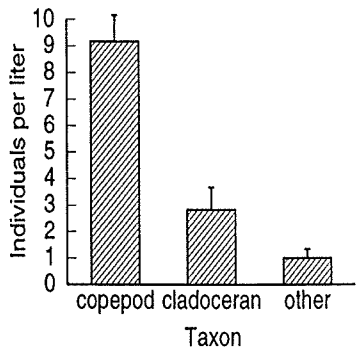

FIG. 2. Mean (± S.E.) abundance of zooplankton taxon at night in the open water of the Río Tempisque marsh. Nine samples were taken from 0.5 meters below the surface.

DISCUSSION

We found a marked difference in the abundance of zooplankton between night and day within the open water micro-habitats of the Río Tempisque marsh. Pennak (1978) has shown that various species of copepods and cladocerans exhibit daily vertical migrations in lakes throughout the world; rising at dusk and returning to the bottom at dawn. Pennak (1978) suggested that this behavior is an evolved mechanism to avoid visual predators such as fish, although on a proximal level the migration may be a reaction to changing light conditions within the water column.

Within the Río Tempisque marsh, Carson et al. (1995) reported that zooplankton were more abundant under the vegetation than in the open water during the day. We also sampled (n=2) under vegetation during the day and found a high abundance of zooplankton present (unpubl. data). These observations, coupled with our findings of more zooplankton in the open water at night, suggest a horizontal migration hypothesis, i.e., that zooplankton may retreat horizontally to the dark conditions under the vegetation during the day and then move out again into the open water at night. This could be related ultimately to selective pressures from visually-feeding fish, with zooplankton avoiding high light areas to escape predation, or more proximally, to local removal of zooplankton from these areas during the day by fish, and then movement of zooplankton out from the vegetation to the open water at night. However, because the vegetation mat is so expansive relative to the open water patches, it is unlikely that a large scale migration of all zooplankton under the vegetation to the open water occurs. This migration may occur on a local level with those zooplankton near the open water patches migrating, and those further from open water remaining under the vegetation.

To test the fish predation hypothesis further, it might be possible to design an experiment using a barrier in the open water through which zooplankton, but not fish, could pass. By sampling for zooplankton within this barrier during the day the extent of control in zooplankton abundance by fish predators could be determined.

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