surface temperatures become moderate enough to allow pit construction in "sunny" areas. By 22:00, soil temperatures in both sites were equal (26°C). It is likely that soil temperatures at the depth of pit construction are tolerable, even when surface temperatures are not. Nocturnal pit building may allow ant lions to exploit some habitats that would otherwise be unusuable.

We suggest that ant lions construct pits under the canopy to avoid high light and excessive temperatures, but must at the time avoid leaf litter. Bare soils beneath the canopy may be a limiting resource for ant lion populations at Palo Verde. Future work is required to assess prey abundance, light, temperature, and litter as independent variables that may affect ant lion habitat preference

EXAMINATION OF CURRENT TYPHA LATIFOLIA MANAGEMENT IN A FRESHWATER MARSH, PALO VERDE, COSTA RICA

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ABSTRACT (EHA)

The freshwater marsh in the Rio Tempisque floodplain, Palo Verde National Wildlife Refuge, Costa Rica, has undergone a variable management history. Vegetation abundances in the area vary with the introduction or removal of cattle. We tested the hypothesis that with an increasing density of Typha latifolia (cattails), marsh floral diversity decreases more steeply than with increasing densities of other abundant marsh plants. We found a significant negative relationship between cattail density and floral diversity in the marsh. However, we found similar relationships between densities of water lilies or tall grasses and diversity. Thus the importance of the cattail diversity relationship lies in the tendency of Typha to out-compete other vegetation. Therefore, we examined floral composition along several transects of marshland for what we hope will be a continuing study of the trends of vegetation abundances over time, and how they relate to management schemes.

Key Words: Typha latifolia, marsh management, Palo Verde National Wildlife Refuge

INTRODUCTION (EHA)

Until 1987, cattle grazed extensively in the freshwater marsh area of the Tempisque River floodplain, Palo Verde Wildlife Refuge, Costa Rica. Prior to removal of the cattle in 1987, the marsh was classified as "grass-sedge" (Gill, 1989). The area provided habitats for a high diversity of flora and fauna, including water hyacinth, snails, and many bird species such as kites, jacanas, limpkins, teal, black bellied whistling ducks and Peregrine falcons. Withing two years of removing the cattle from the marsh, cattails began to form large monospecific stands, apparently reducing the populations of many bird species (Gill, 1989). Attempts to maintain some open water by machete were largely futile due to the "aggressive growth" of the cattails. In 1987, controlled numbers of cattle were reintroduced into the marsh (Gill, 1989). Successional changes in vegetation have apparently not been quantified since that point, although the abundance of cattails appears to be reduced from 1983 levels.

We have begun what we hope will be a continuing study of the effects of cattle grazing on marsh diversity. We hypothesized that floral diversity would decrease more steeply with increasing abundance of cattails than with increasing densities of other marsh plants.

We further hypothesized that sites with intermediate densities of cattails represent a transitonal stage leading to monospecific stands. Our sampling protocol was designed to provide a baseline against which future measurements can be compared.

METHODS (DBZ)

On 13 January, 1994, we quantified the species composition of aquatic plants along

three transects in the marsh in Palo Verde National Wildlife Refuge, Guanacaste Province, Costa Rica. The three transects began at the southwest corner of the observation tower near the airstrip. Transects were 60m in length. Transect compass directions were randomly selected from within the southwestern quadrant (180-270°). Our selected vectors were 275°, 229°, and 251°.

On each transect we examined ten $1m^2$ plots. The first plot was 14m from the tower, and each of the following plots were 4m from the preceding plot. Within each plot, we distinguished among plants visible on or above the surface of the water. We identified plants to species level when possible, and estimated the proportion of surface area covered by each type of plant as reviewed from above. We also estimated the surface area of each plot covered by open water.

To estimate diversity in each plot, we used the Shannon Diversity Index, $H = -\sum P_i \log P_i$, , where P_i is the proportion of each species (Begon et al., 1990). We included the proportion of open water as one of the components of this index because the open water at the surface provides sunlight for underwater flora that we were not able to observe.

We examined diversity as a function of the proportion of cattails using linear regression. We repeated the analyses for two other plant species with a comparable range of abundance (large water lilies and "tall grass"). Points with a proportion value less than 0.05 were not included in regression analysis because the function was already non-linear in this range.

RESULTS (DBZ)

We found 18 types of vegetation in the marsh. Large water lilies were the most abundant (20.8%), followed by tall grass (19.5%) and cattails (16.0%) (Table 1).

Diversity of aquatic plants was the highest with a low proportion of cattails. Diversity decreased as the cattail proportion increased, dropping below themean diversity of quadrants with no cattails ($H = 1.23 \pm 0.09$) when cattail proportion approached 0.25 (Figure 1).

Diversity also decreased as a function of large water lily and tall grass proportions. The slopes and intercepts of the three regressions were very similar (Table 2).

Table 1. Average proportion of plot area occupied by each vegetation type. (Means and standard errors based on n = 3 transect means).

Vegetation type	x ±SE
water lily	0.208 ± 0.034
40-70 cm grass	0.195 ± 0.027
Typha latifolia	0.160 ± 0.042
colonial algae	0.115 ± 0.017
open water	0.063 ± 0.009
duck weed (Lemma sp.)	0.057 ± 0.006
short sedge	0.040 ± 0.023
water hyacinth	0.038 ± 0.020
legume with white runners	0.031 ± 0.020
triangle sedge	0.024 ± 0.024
Eutrichalaria sp.	0.008 ± 0.007
10-15 cm diameter lilies	0.008 ± 0.004
floating plant, 5mm yellow flower	0.007 ± 0.002
Parkinsonia aculeata	0.002 ± 0.002
20cm sedge with tuft flower	0.001 ± 0.001
small, broad leaf	trace
1m high bromeliad	trace
15cm high, 1.5cm wide grass	trace

Table 2: Regression analyses[a] of aquatic floral diversity (Shannon Index) as a function of: (1) Typha latifolia density; (2) large water lily density, and (3) tall grass density.

	Intercept	Slope	SE of Slope	r^2	p
Typha latifolia	1.52	1.16	0.47	0.43	0.034
large water lily	1.70	0.99	0.32	0.38	0.007
tall grass	1.68	1.17	0.35	0.46	0.006

[a]Analyses exclude densities < 0.05.

DISCUSSION (EHA)

The negative relationship between cattail density and floral diversity suggests that as cattails increase in abundance, diversity of other species decreases. However, this is at least partly a consequence of the way in which diversity is defined. Diversity actually declined at the same rate with increasing abundance of grass and lily. Thus, there was no indication that cattails at any given density had a greater negative effect on diversity than other abundant species. Although it is beyond the scope of our data, history suggests that low and intermediate cattail densities are only transitional periods while cattails colonize the area, eventually to exclude other species and form monotypic stands. Current management practices assume that cattle grazing is necessary to control growth of cattails and maintain floral diversity in the area.

Our results provide a baseline against which to assess the effects of current management practices on floral diversity at Palo Verde. In the past, cattails outcompeted other vegetation and spread aggressively from one end of the marsh to the other. If they were to spread again, floral diversity would probably decrease dramatically. Comparisons of vegetation patterns described here with these along the same transects in future years would indicate the extent to which cattail abundance is changing, and help to evaluate the effects of controlled cattle grazing.

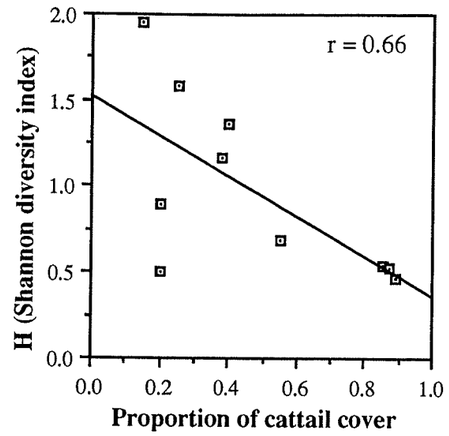

Figure 1. Relationship between proportion of T. latifolia per one square meter and aquatic plant diversity (Shannon index) in Palo Verde marsh.

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