THE NUTRITIONAL STATUS OF THREE *ENCYCLIA TAMPENSIS* (ORCHIDACEAE) POPULATIONS IN SOUTHERN FLORIDA AS COMPARED WITH THAT OF *TILLANDSIA CIRCINNATA* (BROMELIACEAE).

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Introduction

Bromeliaceae and Orchidaceae are well represented in the New World tropics where both families have generated numerous xeric species including some that are well adapted to exploit the driest, most nutrient-deficient portions of the epiphytic biotope. Two very common epiphytes which grow in a variety of forest communities, including some relatively infertile ones in southwestern Florida, are the butterfly orchid *Encyclia tampensis* (Lindl.) Small and the bromeliad *Tillandsia circinnata* Schlecht. Although these two epiphytes are ecologically equivalent in that they share the same hosts in many of the same forest communities, *E. tampensis* depends, as do all epiphytic orchids, on its modified root system for moisture and salt absorption. *Tillandsia circinnata*, like other specialized epiphytic members of subfamily Tillandsioideae, produces a much reduced root system which is specialized for holdfast. Moisture and mineral nutrients enter the plant through the trichomed shoot surface.

In spite of a capacity to scavenge mineral nutrients from dilute sources, *T. circinnata* is limited in vigor on extremely sterile sites like the dwarfed cypress forests of southwestern Florida by its inability to accumulate at least K, P and, to a lesser degree, N to levels that will promote the same robust growth and reproductive effort which occurs on more fertile sites (Benzing and Renfrow, 1974). It is not known whether *E. tampensis*, like its bromeliad associate, also fails to realize a full growth potential and reproductive capacity in very sterile forest communities. Mature *E. tampensis* specimens are considerably smaller on dwarfed cypress hosts than on many other trees, but the reasons for this lack of vigor are not known. The observations reported here were made in an attempt to determine whether this orchid is also limited in vigor in some of its habitats by mineral deficiencies.

Description of Study Areas and Sampling Procedures

The dwarfed cypress site is located just south of Florida State Route 84 near mileage marker No. 7. Orchids were collected within 500 m of the south side of the road. Here *E. tampensis* is growing on dwarfed cypress (*Taxodium ascendens* Brogn.) less than 5 m tall. Individual mature plants consisted of numerous very small pseudobulbs, most bearing one leaf, interconnected by short rhizomes. Flowering shoots usually produced no more than 5 flowers. Shoots with one or two flowers were not uncommon. A second series of samples was collected in a well-developed mixed broadleaf-cypress forest within 300 m south of Route 837, 40 km west of State Route 29. *Encyclia tampensis* on this site is characterized by shoots which individually had much larger pseudobulbs and leaves than those at the dwarfed cypress site; many shoots had two leaves. Inflorescence borne by many of these plants supported as many as 10 flowers. A third site in a mangrove

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swamp within the Ding Darling Federal Wildlife Preserve on Sanibel Island, Florida was chosen because of the unusal high vigor exhibited there by butterfly orchids. Individual plants were made up of many shoots with large pseudobulbs often bearing two large leaves each and inflorescences with 10 or more flowers. Samples were collected from *Rhizophora mangle* L. and *Conocarpus erecta* L. hosts.

Materials and Methods

Single shoots of *E. tampensis* which appeared mature enough to produce an inflorescence the following spring were collected from healthy colonies in late January, 1977. Postflowering shoots were easily identified and were avoided so that all samples were of the same degree of maturity. Some samples were made by pooling shoots from several individual plants in order to obtain sufficient material for analysis. Roots were removed, specimens were oven-dried at 85 C for 24 h and ground to a powder with a Wiley mill. Concentrations of elements were determined by spark-emission spectroscopy using the services of the Plant Analysis Laboratory of the Ohio State University Agricultural Experiment and Development Station in Wooster, Ohio (Jones and Warner, 1969). Total N was determined by micro-Kjeldahl analysis at Oberlin, Ohio.

Results

Plants from the Sanibel Island location were much larger than those from the other two sites (Table 1). Specimens taken from the mixed broadleaf-cypress forest were of intermediate vigor but more closely approached the Sanibel population in shoot size. Smallest by far were those from dwarfed cypress. Of the macronutrients, K and Mg concentrations were much lower in the orchid shoots from dwarfed cypress than from the other hosts. Nitrogen and P levels were somewhat lower in this collection. Except for Mo and Mn, mean micronutrient levels were moderately to very uniform among the three sample collections. Manganese was at least 3-fold higher in the dwarfed cypress samples and Mo concentrations were lowest here. (Manganese levels frequently fell below the detection limits of 10 ppm in the Sanibel and mixed broadleaf-cypress forest samples. Where this was the case, samples were assigned Mn = 9.9 ppm in order to permit statistical analysis.) With the exception of Mo, concentrations of micronutrients in the shoots of all three collections fell below those considered adequate for the maintenance of healthy plant growth (Stout, 1961; Epstein, 1972).

Comparisons of shoot dry weight with the concentrations of nutrients within each member of a sample group revealed significant positive correlations for Fe and shoot size in plants from the mangrove swamp on Sanibel Island, and for P in those from dwarfed cypress. Zn was negatively correlated with shoot vigor in the mixed broadleaf cypress site (Table 2). Manganese exhibited a negative correlation with shoot weight in the mixed broadleaf-cypress collection but the sample here is rather small. When samples from all three locations were compared together, positive correlations were found for shoot weight vs. K, P and Mg concentrations. A strong negative correlation existed between vegetative vigor and Ca and Mn concentrations. Of additional note are high r (= correlation coefficients) values approaching significance for N and Mo in the pooled sample; for Mg, P and Mo in the Sanibel collection and for Fe, K and N in dwarfed cypress orchids. Correlation coefficients which

Table 1. Mean concentrations ± S.E. for nutrient content and dry weights (mean g ± S.E.) of shoots of *E. tampense* from three localities in southern Florida.

		% of dry weight						ppm					
	Dry Wt.	N	P	K	Ca	Mg	Na	Mn	Fe	B	Cu	Zn	Mo
Sanibel Island site N=24	1.62 ±0.14	5.70 ±0.19	0.132 ±0.004	1.74 ±0.07	1.54 ±0.07	0.580 ±0.037	0.0871 ±0.0041	10.32 ±0.30	86.58 ±7.34	14.58 ±0.46	9.38 ±0.18	22.79 ±0.65	2.19 ±0.15
Dwarfed cypress site N=18	0.328 ±0.061	4.93 ±0.17	0.116 ±0.005	0.767 ±0.031	2.15 ±0.06	0.344 ±0.020	0.0778 ±0.0019	29.8 ±2.44	93.11 ±5.76	17.33 ±1.52	9.56 ±0.30	21.78 ±0.54	1.44 ±0.01
Mixed broad-leaf-cypress site N=7	1.19 ±0.15	6.13 ±0.36	0.0140 ±0.011	1.89 ±0.17	2.01 ±0.18	0.511 ±0.077	0.0800 ±0.0069	12.6 ±1.6	88.57 ±6.06	17.14 ±1.30	9.71 ±0.42	25.14 ±1.47	1.62 ±0.19

Table 2. Correlation coefficients (r) for dry weight of shoot against tissue concentration of each element (** = P<1%; * = P<5%) in *E. tampensis* specimens from three localities in Florida.

	N	P	K	Ca	Mg	Na	Mn	Fe	B	Cu	Zn	Mo
Sanibel Island site	-0.094	0.297	-0.191	-0.188	-0.313	-0.165	0.053	0.428 *	0.060	-0.0002	-0.034	-0.302
Dwarfed Cypress site	0.402	0.616 *	-0.450	-0.117	0.217	0.049	0.050	0.390	0.107	-0.076	-0.162	0.357
Mixed broadleaf-cypress site	-0.358	-0.098	0.029	-0.624	-0.316	-0.105	-0.654 *	0.350	-0.545	0.177	-0.856 **	0.011
All samples pooled	0.250	0.382 **	0.560 **	-0.551 **	0.306 *	0.100	-0.582 **	0.187	-0.202	0.077	0.036	0.263

are high but below significant levels in the mixed broadleaf-cypress collection are of less note since only 7 samples were assayed from this site.

Discussion

Whole shoot analyses of *T. circinnata* from several localities in southern Florida revealed that this widespread epiphyte exhibits varying degrees of vigor, seed production, and mineral nutrient concentrations in its vegetative body depending on its habitat of origin (Benzing and Renfrow, 1971). On vigorous cypress growing on deep moist soils, *T. circinnata* specimens, although few in number, were much larger and bore greater numbers of capsules than populations on several broadleaf hosts or on dwarfed cypress. Smallest and least fruitful of all those sampled were specimens growing on dwarfed cypress located on the extensive, shallow, sterile soils of the Big Cypress Swamp of southwestern Florida. When individuals from all collection localities were considered, fruiting shoot size and number of capsules present showed a strong positive correlation with tissue concentrations of P and K. Nitrogen exhibited a similar but weaker correlation and Ca, Mg and Na showed no correlation with either expression of vigor. Micronutrients were not investigated. From these data we concluded that, in spite of its specialized absorbing trichomes and other adaptations for life in nutrient-deficient habitats (Benzing, 1973), *T. circinnata* is incapable of accumulating sufficient quantities of several macronutrients in unusually sterile habitats to achieve maximum growth and reproductive potential.

Encyclia tampensis occurs in similar densities and with parallel degrees of vigor in the same environments in southern Florida as does *T. circinnata.* By some mechanism, *E. tampensis* is able to accumulate higher concentrations of Ca, K, Mg, N and P in its leaves than is *T. circinnata* when the two are growing on the same nutrient-stressed host (Benzing and Renfrow, 1974). This disparity in the elemental composition of mature plant parts could be attributable to several factors such as differing rates of growth, disproportionate expenditures of nutrient elements for seed production vs. asexual propagation or more efficient nutrient mobilization among serially produced asexual offshoots (Benzing, 1973); it need not be explained by logic that describes the orchid as the more effective accumulator of mineral nutrients from highly dilute solutions. Still, the butterfly orchid has a root system which has retained its absorbing capacity and is in intimate contact with the bark of a host. Bark with its associated epiflora and exchange capacity is probably a richer source of many mineral nutrients than the stemflow, canopy fallthrough and unaltered rainfall from which *T. circinnata* must draw its mineral nutrients. Having nonabsorptive root systems, atmospheric bromeliads cannot draw nutrients directly from their substrata. Nutrient uptake by *T. circinnata* and its kind can occur only while the shoot surface is moist. In well-aerated habitats, bromeliad shoots are usually surface-dried shortly after rainfall ceases. By contrast, following a heavy rainstorm, bark remains moist for some time and roots in contact with this medium can continue absorbing nutrients until the capillary water present there has evaporated.

Given the access this orchid has, to what is probably a richer nutrient source than that available to the bromeliad, *E. tampensis* seems a less likely candidate for nutrient stress than *T. circinnata* when the two are growing in the same nutrient-deficient site. Nevertheless, these data reveal that *E. tam-*

pensis, like the bromeliad, exhibits limited vigor on dwarfed cypress because of low tissue concentrations of several nutrient elements. In fact, so many mineral nutrients occur in unusually low concentrations in the dwarfed-cypress-site populations of *E. tampensis* that it seems unlikely that any one element is primarily responsible for the reduced vigor and reproductive effort this orchid exhibits on nutrient-stressed cypress hosts. Identification of the major mineral deficiencies of dwarfed-cypress-site orchid specimens is further confounded by this plant's general adaptations to epiphytic life where nutrients may never be as abundant as they are in many terrestrial habitats. Doubtless *E. tampensis* and other epiphytes have evolved capacities to complete their life cycles with tissue concentrations of several mineral nutrients which would be inadequate for plants adapted to more fertile sites.

In essence, neither epiphyte is clearly superior to the other as a scavenger of nutrients on very sterile sites in spite of its distinct morphological and physiological specializations for nutrient procurement. Whether nutrient salts are taken up through a velamen-equipped root system from bark saturated with stemflow, or directly through the shoot surface from stemflow, canopy fallthrough and rain, neither species can fully compensate for the sterility of some of their shared habitats and avoid reduced nutrient concentrations with concomitant reductions in vigor and reproductive effort. Both epiphytes must endure mineral deficiencies sufficient to reduce appreciably their vigor in order to grow on dwarfed cypress in the Big Cypress Swamp, yet successful populations of each species are hosted there. In fact, the densities of reproducing *E. tampensis* and *T. circinnata* are higher in these nutrient-stressed forests than in most other habitats in southern Florida, including some which are substantially more fertile.

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