

A Comparative Evaluation of Freshwater Mitigation Wetlands in Broward County, Florida, Using Chironomid (Diptera) Pupal Exuviae: A Potential Technique for Assessing Mitigation Success.

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Background

Over the past century, anthropogenic changes to south Florida's landscape have resulted in the disappearance or severe alteration of many of the region's historic wetlands. Intensified agriculture, increased development pressures, and changing land management policies have dramatically weakened the health and integrity of both the inland Everglades system and estuarine systems such as Biscayne and Florida Bays. Broward County historically supported immense tracts of wetlands, yet the County is rapidly nearing "build out" and nearly every parcel of land has now been developed. A symptomatic mix of development pressures, economic incentives, and poorly developed environmental regulations has resulted in a vast mosaic of planned residential communities characterized by concrete homes, asphalt drives, and lake-front properties with heavily irrigated, exotic vegetation that bears no resemblance to South Florida's natural landscape. Although policies for management and protection of the region's remaining wetlands were established years ago, current legislation has proven inadequate.

Introduction

Broward County's wetlands are currently regulated at the County, State, and Federal levels. However, the separate regulatory agencies often interpret and apply wetland legislation inconsistently. One of the most confounding inconsistencies is the perceived value of smaller mitigation wetlands. Generally, the smaller a mitigation area is the more poorly it is valued by regulatory agencies. State or Federal regulators recognize the intrinsic benefits of large, contiguous, mitigation wetlands and/or wetland "banks", and subsequently endorse them as the most desirable form of wetland mitigation [1]. As a result, many developments now perform all mitigation at an established wetland bank [2] so that the mitigation is part of a larger, more stable system. Since Broward County currently does not have any such banks, this policy directly results in the loss of wetlands from County lands. Therefore, County regulations have begun to encourage retention of on-site wetlands (regardless of size) as a means of preserving some wetland functions within the County. Landscape/regional scale evaluations of mitigation projects which address the holistic value of the site are the basis for the County's policy, but Federal and State level regulation do not follow suit [3]. While most research does favor large scale mitigation, a substantial amount of literature justifies either approach, and the better solution is not readily apparent [4].

The bulk of south Florida's wetland studies are conducted in natural or altered wetlands, and few projects have evaluated the status or attributes of artificial wetlands or mitigation areas. Much information about the ecology and maturation of created wetlands is needed to improve efficiency and accuracy during the regulatory process and to develop standards for improved evaluation of mitigation success. Currently, wetland regulation remains an imprecise and unpredictable process. Erwin's exhaustive evaluation of mitigation sites permitted by the South Florida Water Management District identified major research needs to improve wetland management policies, including reliable evaluations of mitigation success [5: page 246]. Additionally, Kentula [3] and Erwin emphasized that realistic goals and measurable success criteria are essential elements of successful mitigation.

Approach

To address existing regulatory shortfalls, I propose to examine community composition of the insect family Chironomidae as a reflection of wetland status. The Chironomidae (non-biting midges) are an ancient and diverse lineage of true flies that exploit a wider variety of microhabitats than other freshwater invertebrates[6]. Jacobsen [7] found over 130 species in collections from Everglades National Park alone, and individual species often have very narrow microhabitat requirements[7]. Consequently, review of a wetland's chironomid fauna can yield substantial information on most of the physical, chemical, and biological aspects of the site [6, 8, 9]. King [10] observed chironomids to be the most informative group for assessing water quality in northern Everglades wetlands, thereby locally corroborating reports from other systems which showed their effectiveness as bio-indicators [11-14].

Specifically, I propose to: 1) examine the effect of wetland size on chironomid community structure as it pertains to the ecological value of different sized mitigation wetlands, 2) monitor the influence of several environmental parameters on chironomid community structure, and 3) evaluate a faunal approach for evaluating wetland success. To achieve these goals, I will compare community assemblages sampled from a varied selection of natural and artificial wetlands in Broward County. To validate the findings, I will also examine the relationship between chironomid community changes and environmental variables such as pH, alkalinity, dissolved oxygen, temperature, wetland area, water depth, and plant and algal community composition thought to influence chironomid communities. I expect to find significant relationships between chironomid community composition with one or more of these variables, but I hypothesize that wetland size will have no significant effect on community structure, thereby validating presumptions which value small wetlands. I will then evaluate the success of mitigated wetlands based on their relative similarity to natural wetlands. I hypothesize that similarity will be greater among either natural or artificial wetlands than between natural and artificial wetlands. The findings will ultimately be related to current management policies in South Florida and will be reviewed for applicability towards future management goals, techniques, and policies for both freshwater and marine systems.

Materials and Methods

Chironomids will be sampled by collecting their pupal exuviae (shed exoskeletons), a technique first described by Thienemann in 1910 [15], and since proven to be the most thorough, efficient, and sensitive method of sampling of aquatic chironomid communities [11, 16-18]. The chironomid pupal exuviae technique (CPET) [19] is an ideal alternative to traditional larval sampling because it provides reliable and detailed results with far less effort [9, 16, 17] since large samples can be collected quickly from driftlines and eddies on the water's surface. The technique integrates both horizontal and vertical habitat variations without bias, thereby providing an accurate picture of midges emerging from all microhabitats simultaneously [9, 18]. Exuviae are also easily preserved and, because of their transparency, require minimal slide preparation which permits rapid taxonomic identification to the species level [6]. Several European studies have endorsed the usefulness of CPET for classification of lakes or rivers [9, 15, 18, 20-23], but few researchers have applied the CPET to wetland assessment, especially in the western hemisphere [18, 24, 25].

Samples will be collected quarterly at 14 sites of various sizes in suburban Broward County: 8 mitigation "study" wetlands ranging between approximately 1 and 1000 acres, and 6 natural "model" wetlands. Each individual sample will be an amalgam of exuviae collected along

several habitat ecotones. Because no research has reviewed chironomid phenology (cued/seasonal emergence patterns) for the Everglades system, bi-weekly samples will be collected at two sites to address the possibility of pulse emergences which could bias results. Because several studies observed strong correlations between chironomid species and various environmental parameters, I will also monitor temperature [26], pH [27], dissolved oxygen [9], and total phosphorus [14, 28]. In situ water quality will be recorded with a calibrated YSI 600XL datasonde, and additional water samples will be analyzed for total phosphorus by County laboratory staff certified by the National Environmental Laboratory Accreditation Conference (NELAC). I will also characterize the plant and algal communities at each site, and record basic meteorological data including wind direction and speed, and percent cloud cover to guard against the most likely sources of “noise” that might corrupt statistical analyses.

After collection, samples will be; 1) concentrated in a 125- μ m sieve and excess plant material will be removed, 2) back-rinsed with ethanol and transferred to 1-pt (500-mL) jars for preservation in 95% ethanol, and 3) mixed thoroughly and sub-sampled in 25-mL aliquots for examination under a stereomicroscope. All exuviae will be removed from successive subsamples until the total count of identified exuviae exceeds 200 per sample. This technique prevents preferential “picking” of large/rare taxa, does not affect relative abundances of specimens, and is the generally accepted minimum sample size [9, 29, 30] for statistical analysis. Results will be tallied as percent abundances; a relative measure of community structure which reflects both richness and diversity. For each site, data from the four quarterly samples will be pooled as a total “annual” chironomid assemblage. Statistical comparisons to address the effect of wetland size on chironomid community structure will use Analysis of Similarity (ANOSIM) on standardized Bray-Curtis matrices. Similarity Percentage (SIMPER) breakdowns will be used to identify which taxa provide the strongest indication of difference, and non-metric multi-dimensional scaling (NMDS) will be used to graphically illustrate results. Linear ordination techniques such as Principal Components Analysis (PCA) will be used to evaluate community correlations with environmental data. To simplify direct comparison, the environmental data will be standardized to have zero mean and unit variance [9]. By applying a non-parametric Wilcoxon rank sum test to compare pooled abundance datasets from artificial and natural wetlands [31], the statistical similarity between each annual study assemblage and the annual model assemblage may be viewed as a rudimentary measure of mitigation success.

Career Goals

While I originally expected to pursue a career in fisheries research or management, I’ve lately realized a greater appreciation for the complexities of wetland ecosystems. I find the challenge of fitting the “puzzle pieces” together in order to understand a particular system intriguing. My work experience as a Natural Resource Specialist II for Broward County’s Environmental Protection Department has exposed me to a web of political, social, and environmental interaction which has helped me realize that, while cutting-edge research can undoubtedly be rewarding, only a small fraction of research projects are ultimately applied or implemented by those actually regulating the resource. I am most interested in the practical incorporation of landscape-scale ecology into working environmental policy, and would like to apply some of my similar interests in a PhD program to that effect. That being said, my eventual hope is to be able to help facilitate the adoption of pro-active, realistic, management and conservation schemes by acting as an environmental “liaison” and focusing what I believe can be a contagious passion or appreciation for the natural world we live in for the betterment of all.

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