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Studies on the nutritional constituents and the aquatic insect fauna associated with water hyacinth, *Eichornia crassipes* in Singanallur Lake, Coimbatore

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Abstract
Wetlands are considered the most biologically varied of all ecosystems that act as link between terrestrial and aquatic habitats. Wetland vegetation plays an important role on invertebrate communities, as many invertebrates are found on these vegetation and they are used as shelter from predators, and for obtaining their food. Invertebrate communities may also vary according to plant growth form or morphology. Hence the present investigation was carried out to study the nutritional composition of the water hyacinth, *Eichornia crassipes* and the study of insect and plant interaction between *Eichornia crassipes* and selected aquatic insects. The nutritional constituents revealed that *Eichornia crassipes* was found to be rich in high protein and total organic matter that makes it more attractive to aquatic insects which adhere to the plant for its survival.
The inventory of insect species present in the water hyacinth was grouped into four orders namely; Orthoptera; Coleoptera; Hemiptera and Odonata. The larvae, nymphs and adult of the insect species feed preference was on the upper leaf surface, lower leaf surface and the petiole of water hyacinth. This clearly indicates that the density and size of water hyacinth mats appear to have played an important role in determining invertebrate density, diversity, and assemblage composition.

Keywords: *Eichornia crassipes*, aquatic insects, crude protein, Orthoptera, Coleoptera; Hemiptera, Odonata

1. Introduction
Wetlands are actually biologically diverse and productive ecosystems which provide a home to a variety of plant life, and support diverse communities of invertebrates, which in turn support a wide variety of aquatic and terrestrial vertebrates [1]. Primary consumers rely on the abundance of algae, plants, and detritus for food. Wetland insects play a prominent role in the consumption and processing of primary production and associated detritus and serve as an important food source for higher trophic levels, including a large number of fish, invertebrate, and avian species [2].
The emergence of adult insects from aquatic habitats represents an important export of nutrients and energy from one environment to the other and is a unique mechanism linking terrestrial and aquatic ecosystems [3]. Wetlands are the areas of marsh or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt including areas of marine water, the depth of which at low tide does not exceed 6 meters [4, 5]. Thus, wetlands of the world maintain biologically diverse communities of ecological and economic value.
Coimbatore is the second largest city in the Indian state of Tamil Nadu. It is situated in the western corner of Tamil Nadu and is surrounded by the Western Ghats on all sides. Coimbatore is located at 11.0161°N 76.971°E. The study site is situated in Coimbatore at 10° 59'46" N 77° 01'11" E, near Singanallur. The area of the water body is 288 acres with maximum depth of 13.95 feet and storage capacity of 52.27 M. cft. It has 3 inlets (1 & 2 are major) - a canal from river Noyyal, Sanganur drain brings in city sewage and a sewage outlet from Kallimadai area.
Singanallur Lake situated in Coimbatore contains the aquatic plant, *Eichornia crassipes* which causes eutrophication of the lake. Water hyacinth grows in still or slow-flowing fresh water in tropical and temperate climates [6]. Optimum growth occurs at temperatures of between 28 °C and 30 °C, and requires abundant nitrogen, phosphorus and potassium. Although this plant will tolerate a wide range of growth conditions and climatic extremes including frost, it is rapidly

killed by sea strength salinity and will not grow in brackish water [7].

Eichhornia crassipes is an erect free-floating and stoloniferous perennial herb, which belongs to the Family Pontederiaceae.Water hyacinth is justifiably called the world's worst aquatic weed due to its ability to rapidly cover whole waterways [8, 9]. When not controlled, water hyacinth will cover lakes and ponds entirely; this dramatically impacts water flow, blocks sunlight from reaching native aquatic plants, and starves the water of oxygen, often killing fish. The plants also create a prime habitat for mosquitos, the classic vectors of disease, and a species of snail known to host a parasitic flatworm which causes schistosomiasis (snail fever) [10, 11]. Water hyacinth is often problematic in man-made ponds if uncontrolled.

Macroinvertebrates serve as the link among algae, macrophytes and micro-organisms, which serve as their primary food resources, and the fish (and other vertebrates), which prey on them [12]. Their role in the trophic webs of the littoral zone is very important because of the shortage of benthos biomass in the lakes. Invertebrates living on aquatic macrophytes have received much less attention than benthic and plankton communities in spite of their importance in lakes [13, 14]. This research aims to document the nutritional constituents of the water hyacinth, *Eichhornia crassipes* and the study of insect and plant interaction between *Eichhornia crassipes* and selected aquatic insects.

2. Materials and Methods

2.1 Study area

The study site is situated in Singanallur Lake, Coimbatore at 10° 59'46" N 77° 01'11" Eat an approximate altitude of 470m near Singanallur. The area of the water body is 288 acres with maximum depth of 13.95 feet and storage capacity of 52.27 M. cft. A total of three stations located at approximately 1km intervals were sampled.

2.2 Sample Collection and Analysis of *Eichornia crassipes*

The plants of *Eichornia crassipes* were collected from the sample stations along the Singanallur lake of Coimbatore. After collection, the plant materials were oven dried in the laboratory, ground with an electronic blender and stored in plastic containers at room temperature for a week before they were analyzed. The crude protein content was determined using the modified micro-kjeldahl method. Moisture content was determined by drying in an oven 100-105 ^{o}C to constant weight. The crude protein content was evaluated by digestion of the sample and the crude protein was obtained by multiplying the quantity of nitrogen by the coefficient 6.25. Total lipids were determined by continuous extraction in a Soxlet apparatus for 8 hours using hexane as solvent. Ashing was carried out by incinerating in a furnace at 550 ^{0}C. Crude fibre was determined by sequential hot digestion of the defatted sample with dilute acid and alkaline. Total carbohydrate was determined by difference (100- moisture, crude protein, ash, crude fibre and crude lipid).

2.3 Aquatic Insects Sampling and Identification

The stems of *E. crassipes* were cut off at about 50-70 cm below the water surface and collected with a mesh net. The insect sampling period was during August 2014-October 2014.Samples extracted in triplicate were placed in plastic bags and preserved in 4% formaldehyde [15, 16]. At the laboratory, the stems were washed to detach macro invertebrates, and suspensions obtained were filtered through 1 mm and 500 µm sieves. The largest fraction was processed, and then invertebrates were manually separated from plant and detritus rests. An aliquot of the smallest size fraction was counted under the microscope.Subsequently they were identified to order and family using identification key guide [17-21].

3. Results and Discussion

The results of the nutritional content of the *Eichornia crassipes* were presented in Table 1. The leaves had the least moisture content of 84.25% while the roots which are constantly in contact with water had the highest water content of 90.43%.It showed that the leaves had the highest percentage of crude protein level of 16.34 while the petioles gave lowest value of 8.93. The roots were low in crude protein level (6.93) and crude fat/lipid but high in moisture and ash which proves to be unfit as nutritional supplement to aquatic organisms.

Table 1: Mean Percentage Nutritional Content of the Samples of *Eichornia crassipes*

Analysis	Leaves	Petioles	Roots	Whole Plant
Moisture content	84.25	90.43	93.56	92.80
Ash content	15.54	17.22	38.65	28.65
Crude Protein	16.34	8.93	6.93	7.02
Crude lipid	1.48	2.63	1.34	1.42
Crude fibre	15.20	19.54	13.10	15.82

The percentage crude protein varied from 6.93 in the roots to 16.34 in the leaves. The percentage ash content on dry matter basis of the samples ranged from 15.54 in the leaves to 38.65 in the roots. The high value obtained might be the direct contact and absorption of nutrients by the growing roots. The root system possesses a lot of fibrous roots that help in the rapid absorption of nutrient materials from its environment.

The percentage crude lipid varied from 1.34 in the roots to 2.63 in the petiole. The petiole possesses the vascular tissues, xylem and phloem tissues for storage and transportation of food materials and this is responsible for the high fat content. The value of crude fibre varies from 13.1 in the roots to 15.82 in the whole plant. Thus the high percentage total organic matter, crude protein and amino acids have helped the plant as a valuable source of organic feed to the aquatic organisms.

Table 2: Insect assemblage of macroinvertebrate fauna in the Singanallur Lake, Coimbatore

Order	Family	Genus	Microhabitat Location of the insect species	Sampling period		
				Aug	Sep	Oct
Hemiptera	Corixidae	*Micronecta sp*	Rhizome	70	68	55
	Belostomatidae	*Diplonychus sp*	Petiole	90	82	62
	Notonectidae	*Enithares sp*	Rhizome	85	72	45
	Nepidae	*Laccotrephes sp*	Rhizome	68	50	20
	Nepidae	*Ranatra sp.*	Shoot	55	45	25
	Gerridae	*Tenagogonus sp*	Leaf Surface	75	65	45

Coleoptera	Dytiscidae	*Laccophilus sp*	Petiole	85	72	62
	Curculionidae	*Phytoscaphus sp.*	Leaf surface	48	25	15
	Curculionidae	*Neochetina sp*	Leaf Surface	52	45	32
Odonata	Libellulidae	*Pantala sp*	Petiole	25	18	10
	Coenagrionidae	*Ischnura sp*	Rhizome	21	15	13
	Coenagrionidae	*Pseudagrion sp*	Rhizome	32	21	15
Orthoptera	Acrididae	*Omocestus sp*	Leaf Surface	15	16	11
	Tetrigidae	*Tettigidea armata*	Leaf Surface	12	10	08

Table 2 showed the assemblage of macroinvertebrate fauna in the Singanullur lake, Coimbatore. The insect species collected on water hyacinth at the study sites were grouped into four orders namely; Orthoptera; Coleoptera; Hemiptera and Odonata. There were two families in the order Orthoptera: Acrididae and Tetrigidae The order Coleoptera also had two families: Dytiscidae and Curculionidae. The order Hemiptera was represented by only two families- Corixidae, Belostomidae, Notonectidae, Nepidae and Gerridae. The order Odonata was represented by the family Libellulidae and Coenagrionidae.

The various developmental stages of each insect species and their densities found on the water hyacinth were noted. The stages of development of insects collected were the larvae, nymphs and adults. There were seasonal variations in the abundance of the larvae, nymphs and adults of the insect species. The insect species were collected from different parts of the water hyacinth plant namely the leaf surfaces, petioles and rhizomes. *Tenagogonus sp, Phytoscaphus sp, Neochetina sp, Omocesatus sp and Tettigidea species* were mainly on leaf surfaces throughout the period of the study. *Diplonychus sp, Laccophilus sp and Pantala species* were found on the petioles of the plant. Larvae of *Ischnura sp* and *Pseudagrion sp* were found in the rhizome.

4. Conclusion

Thus the study concludes that the presence of water hyacinth generally increased density of dominant invertebrates and it appeared to have played an important role in determining invertebrate density, diversity, and assemblage composition. The high percentage total organic matter, crude protein and amino acids have helped the plant as a valuable source of organic feed to the aquatic organisms.

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