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Interactions of nutrients, plant growth and herbivory in a Parangipettai mangrove ecosystem of the Vellar estuary, Southeast coast of India

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HIGHLIGHTS

- Relationship among nutrients, plant growth and herbivory in mangrove ecosystem has been studied.
- Total amino acids, nitrogen, phosphorus and potassium were highest in *Rhizophora mucronata*.
- Tannin and total sugars were maximum in *Avicennia officinalis*.
- Young leaves suffered higher losses to herbivory than mature leaves due to leaf chemistry.
- This study revealed influence of nutrients and leaf chemistry in mangroves on herbivory intensity.

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ABSTRACT

The objective of this present attempt was to investigate the relationship between leaf quality and level of herbivory at study site during August 2010–July 2011. Total amino acids with a maximum of 9.47 mg g^{-1} during February 2011 in *Rhizophora mucronata* and a minimum of 4.671 mg g^{-1} in May 2011 in *Avicennia officinalis* were noticed. Tannin was maximum (6.844 mg g^{-1}) during April 2011 and minimum (0.667 mg g^{-1}) in July 2011 in *A. officinalis*. Total nitrogen showed a maximum of 9.851 mg g^{-1} during February 2011 in *R. mucronata* and a minimum of 2.158 mg g^{-1} in February 2011 in *A. officinalis*. Total sugars registered a maximum of 4.075 mg g^{-1} during March 2011 in *A. officinalis* and a minimum of 0.063 mg g^{-1} in March 2011 in *R. mucronata*. Total phosphorus recorded the maximum (4.321 mg g^{-1}) during November 2010 in *R. mucronata* and minimum (0.258 mg g^{-1}) during May 2011 in *A. officinalis*. Potassium content was maximum (3.710 mg g^{-1}) during October 2010 in *R. mucronata* and minimum (0.039 mg g^{-1}) in July 2011 in *A. officinalis*. These data suggest that artificially developed mangrove ecosystems may be an adaptive mechanism related to nutrient conservation, and that it is associated with mangrove survival in phosphorus-deficient soil rather than an adaptation to herbivory.

1. Introduction

Herbivory level of leaves is often attributed to differences in their nutrient status, which affects their nutritive value to herbivores, and to secondary compounds that may act as chemical deterrents to herbivores (Schoonhoven et al., 1998). However, physical properties of leaves such as their thickness and toughness may be equally significant determinants of herbivory levels (Hochuli, 1996). Both the chemical and physical properties of leaves will vary as they age, with major changes expected to occur as the young leaves develop and as mature leaves senesce. In many species, especially in tropical forests, there is a clear ontogenic pattern of susceptibility to herbivore damage and leaf loss to herbivore damage (Coley and Aide, 1991; Kursar and Coley, 1991). Therefore, mangrove herbivory, apart from causing injuries to the trees themselves, may cause a significant decrease in coastal water productivity. In a survey of the extent of damage caused by herbivores in Asian mangrove forests, Johnstone (1981) reported up to 20% of total leaf area consumed while the leaves were still attached to the trees, thus decreasing the availability of plant detritus to the

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Table 1
Herbivory insects assemblage in mangrove ecosystem.

Order/family	Host plant	Part of attacked	Month of collection (2010–2011)
Coleoptera			
Scolytidae			
Dendroctouns micans	*A. officinalis*	Stem borer	January & February
Qulema gallaeciana	*A. officinalis* & *R. mucronata*	Fruits & flowers	January, February &March
Chrysomelidae			
Monolepta sp.	*A. officinalis* & *R. mucronata*	Flowers	February & March
Diptera			
Culicidae			
Culex tarsalis	*A. officinalis* & *R. mucronata*	Tree & flower	February
C. pipiens	*R. mucronata*	Tree & flower	February
Aspidotus destruotor	*R. mucronata*	Flowers	February
Lepidoptera			
Lymantriidae			
Dasychira sp.	*A. officinalis*	Leaf miner	May
Gracillariidae			
Phylloenistis sp.	*A. officinalis*	Stem borer	January & February
Pyrrhocoridae			
Mandio histero	*R. mucronata*	Fruit borer	April
Dysdurus cinguls	*R. mucronata*	Leaf miner	April & May
Pyrrhocoris apterus	*R. mucronata* & *A. officinalis*	Flower borer	August & September
Alydidae			
Lepiocoresa varicomis	*R. mucronata*	Leaf miner	April
Stephaniella falcaria	*R. mucronata*	Stem borer	April
Aschishus brevicornis	*A. officinalis*	Tree and flower	April, May & June
Capua endocypha	*A. officinalis* & *R. mucronata*	Leaf miner, fruits & flowers	May & June
Hymenoptera			
Vespidae			
Solenopsis sp.	*A. officinalis* & *R. mucronata*	Leaf miner	January & February

aquatic food web. Intersite variations in herbivory have been documented by Onuf et al. (1977) who found that *Rhizophora mangle* in a high nutrient site was consumed more extensively by insects than their counterparts in a low nutrient site, although contrasting findings have also been reported (Farnsworth and Ellison, 1991; Feller, 1995). Most reports on mangrove herbivory provide negligible information on the herbivore assemblages, with the exception of Murphy (1990) and Burrows (2003) who provide comprehensive catalogues of insect herbivores on mangroves, in Southeast Asia and northeastern Australia.

Young leaves may be more susceptible to herbivory because of their greater nutrient and water content, which increases their nutritional value. Young leaves typically have 2–4 times more nitrogen content than older leaves (Coley and Aide, 1991; Kursar and Coley, 1991) which can increase herbivore fitness. Leaf water content is also related to herbivory and larval growth rates (Coley and Aide, 1991) and photosynthetic rate (Gulmon and Chu, 1981). It is commonly suggested that young leaves are heavily damaged because they are less tough than older leaves and have higher nutrient contents (Kursar and Coley, 1991). In this study, however, the main objective was to investigate the relationship between leaf quality and level of herbivory at study site during August 2010–July 2011.

2. Materials and methods

2.1. The herbivore assemblages

Sampling of herbivorous insects present in the Vellar estuary mangrove was conducted from August 2010 to July 2011. During each monthly visit, a 1 h survey on herbivores was carried out from all trees in the plots. Any herbivore encountered on the trees within accessible height (<1 m) was collected for later identification. No quantitative sampling was performed on the abundance of the herbivores order *viz.*, Coleopteran, Diptera, Lepidoptera and Hymenoptera (Table 1).

2.2. Measurement of herbivory intensity

Leaves were sampled monthly for 12 months to estimate the leaf area consumed by herbivores following the discrete sampling approach. Discrete sampling tends to under-estimate herbivory impact (Filip et al., 1995; Burrows, 2003) by ignoring impacts other than direct loss of photosynthetic biomass, such as leaf longevity (Lee, 1990, 1991).

2.3. Leaf chemical composition

For analysis, leaves of *Avicennia officinalis* and *Rhizophora mucronata* were collected from the mangroves of Vellar estuary. The collected leaves were taken to the laboratory and the leaf area was measured. The leaves were washed with distilled water, dried at 80 °C, ground in a mechanical mill to pass a 1 mm sieve and stored for chemical analyses. About 0.2 g of ground leaf tissue was digested for analysis following the methods of Baethgen and Alley (1989) for nitrogen, Anderson and Ingram (1989) for phosphorus and Robert Cotton (1945) for potassium. Nutrient content was expressed both as a percentage of leaf dry weight (this being common in the literature) and as the absolute amount of nutrient per leaf using the mean dry weight of leaves for each leaf developmental stage. Total nitrogen was determined calorimetrically by the Nessler reaction, after acidic digestion of 0.1 g of dried subsample with conc. H_2SO_4 following the method of Oliveira (1981). Soluble sugars were estimated following Nelson–Somogyi methods (1944). Third and fourth pairs of leaves (thus leaves were mature and of approximately the same age) were collected from *A. officinalis* and *R. mucronata*. Herbivory intensity was determined by drawing leaf contours on graph paper and counting the number of squares under intact and damaged parts. The advantages and problems of this methodology are discussed by Johnstone (1981).