Seagrass research in the eastern Africa region: emphasis on diversity, ecology and ecophysiology

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This paper presents a brief review of seagrass research in the eastern African region, including Somalia, Kenya, Tanzania, Mozambique, eastern South Africa, Seychelles, Comoros, Madagascar, Reunion and Mauritius. Only about 60 references have been published from this region since the 1930’s, covering mainly seagrass diversity and ecology, and only about 30 of these have been published during the last 10 years in international journals. These covered mainly ecology, ecophysiology and anatomy/histochemistry. Considering this and the fact that eastern Africa with its 12 species is a region of high diversity of seagrasses, seagrass research in the region appears to be in its infancy. Apart from the need for continued survey and mapping activities, future research has to focus on the significance of seagrass beds in the region, their role in the coastal ecosystem and how they are affected by various anthropogenic changes.

Introduction

Seagrasses comprise a small taxonomic group of marine angiosperms with only about 50 species, which have a world wide distribution and have adapted to a life in seawater by the development of a specific morphology with an anchorage system made up of rhizomes and roots, air lacunae to supply roots with oxygen, flowers with hydrophilous pollination and, in some species, vivipary (Den Hartog 1970, Larkum et al. 1989, Elmqvist and Cox 1996). They have the ability to take up nutrients by both roots and leaves (Stapel et al. 1996, Pedersen et al. 1997, Hemminga 1998), and are mostly clonal plants with shoots (vertical rhizomes) arising from horizontal rhizomes below the ground. Most species have more or less flat linear leaves with parallel veins, except Halophila spp., with petiolate leaves, and Syringodium isoetifolium (Aschers.) Dandy, with terete leaves. Many of the intertidal seagrass species generally have short stems, while plants growing subtidally may reach considerable lengths. The tallest seagrass species encountered in the East African region is Thalassodendron ciliatum, which can measure up to 126cm in length. This was observed from a collection in Inhassoro (21°32’S, 35°12’E), southern Mozambique. Enhalus acoroides can also attain considerable length and was observed having up to 100cm length in this region. The smallest ones are the three species of the genus Halophila, the species H. minor normally only reaching less than 2cm height above bottom.

Seagrasses play an important role in shallow-water ecosystems of both tropical and temperate zones. They have a high productivity, and the rate can be compared to that of crop plants (Dring 1982, Larkum et al. 1989). The seagrass beds increase the biodiversity of plants, animals, fungi etc. in the areas where they occur (e.g. Oshima et al. 1999, Rindi et al. 1999), act as a shelter for juvenile animals and as nursery and foraging areas for many species (e.g. Harlin 1980, Larkum et al. 1989). In addition, they trap nutrients (Gacia et al. 1999) and promote their recycling, as seagrass decomposition is quite high (Newell et al. 1984, Ochieng and Erftemeijer 1999). Seagrass meadows may also act both as sinks and sources for particles (e.g. Gacia et al. 1999, Koch 1999). Some of these particles, containing different nutrients, play an important role in seagrass growth dynamics and nutrient budgets. The importance of seagrass beds for littoral nutrient budgets is complex, as a number of models try to explain (e.g. Pergent et al. 1994, Erftemeijer and Middelburg 1995, Pergent et al. 1997, Oshima et al. 1999). In Kenya, Ochieng and Erftemeijer (1999) estimated that around 82 tonnes of dry weight of beach cast material (dispersed in about 10km of coastline) belonged to seagrasses, most of it (c. 62 tonnes) were leaves of T. ciliatum. Senescent and detached leaves of T. ciliatum are also common in coastal areas and sand dunes, increasing the nutrient content of these nutrient poor marginal areas. De Boer...
(2000) estimated that the seagrasses such as *Halodule wrightii* Aschers. and *Zostera capensis* Setchell were the main nutrient source in the southern bay at Ilhaca Island contributing altogether with 49, 30 and 2 tones of C, N and P, respectively.

Economically, seagrasses can be utilised for paper production, green manure, flour (seeds of *Zostera marina* L. in Mexico) and fodder. *Thalassia hemprichii* is used in salads in the Philippines (Cordero 1981). Seeds of *Enhalus acoroides* are eaten raw or boiled in the Philippines (Montano et al. 1990) and reported to be used as food in periods of food scarcity in Kenya (Cox 1991). Seagrasses are also used in traditional medicine in India (Parthasarathy et al. 1991). Overall economic value of seagrasses can be divided in use value (e.g. direct/indirect uses and/or benefits to humans), and existence value (abstract values not necessarily related to human benefits or use). These values are good indicators of the ecological and economical losses when seagrass habitats are destroyed (Thorhaug 1990, Costanza et al. 1997, NSW Fisheries 1997). In money terms, this overall seagrass value has been estimated by Costanza et al. (1997) to 19 004USD ha⁻¹ year⁻¹.

The present study presents a review of seagrass research performed in the eastern African region. Emphasis is given to studies on seagrass diversity and ecology. We have based the review on research work from the region and it covers published research in the eastern African countries including the island states located in the western Indian ocean viz: Somalia, Kenya, Tanzania, Mozambique, eastern South Africa, Seychelles, Comoro, Madagascar, Reunion and Mauritius.

**History of seagrass research in the western Indian Ocean**

Around 60 published references (see bibliography in reference list) on seagrasses have been published in the region covering the following main fields of research: Taxonomy and distribution (e.g. Isaac 1968, Bandeira 1997a, Spalding and Phillips 1998), ecology (e.g. Hemminga et al. 1994, Duarte et al. 1996, Ochieng and Erftemeijer 1999), eco-physiology (e.g. Björk et al. 1997, 1999, Beer and Björk 2000), anatomy and histochemistry (e.g. Barnabas 1982, 1983, 1991, 1994), flowering and pollination (e.g. McMillan 1980, Cox 1991) and feeding preferences (Mariani and Alcoverro 1999). Pioneering publications on seagrasses in the region are the ones by Moss (1937), Cohen (1939), Chassé (1962), Isaac (1968) which all covered mainly taxonomical descriptions of seagrasses in Kenya, Madagascar and Mozambique. The dominant part of seagrass research from the region covered the field of ecology (Figure 1). Work from the period 1991–2000 indicates that most recent research on seagrasses was performed in Kenya, Tanzania, Mozambique and South Africa (Figure 2). Examples of important references per country are given in Table 1.

**Diversity of seagrasses in eastern Africa**

Twelve seagrass species occur in the eastern African region, grouped in three families: Hydrocharitaceae with the species *Enhalus acoroides* (L.f.) Royle, *Halophila minor* (Zoll.) den Hartog, *H. ovalis* (R. Br.) Hook. f., *H. stipulacea* (Forsk.) Aschers. and *Thalassia hemprichii* (Ehrenberg) Ascherson; Zosteraceae with *Zostera capensis* Setchell and Cymodoceaceae with *Cymodocea rotundata* Ehrenb. et Hempr. ex Aschers., *C. serrulata* (R. Br.) Aschers. et Magnus, *Halodule uninervis* (Forsk.) Aschers. in Bossier, *H. wrightii* Ascherson, *Syringodium isoetifolium* (Ascherson) Dandy and *Thalassodendron ciliatum* (Forsk.) den Hartog. These 12 species comprise about a fifth of the worlds total seagrass species. This is quite diverse if compared with some other seagrass areas such as the Mediterranean Sea with four species and eight species in the Caribbean Sea with the Gulf of Mexico and Florida. However, Western

![Figure 1: Number of papers per subject groups published in the eastern African region](image1)

![Figure 2: Number of publications per country in the period 1991–2000 (grid bars indicate publications in international journals)](image2)
Table 1: Examples of important seagrass references given per country

<table>
<thead>
<tr>
<th>Country</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seychelles</td>
<td>Parnik et al. 1992, Tilyanov et al. 1995</td>
</tr>
<tr>
<td>Comoros</td>
<td>UNEP 1997</td>
</tr>
<tr>
<td>Madagascar</td>
<td>e.g. Pichon 1964</td>
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</tbody>
</table>

Australia has more than twice as many, 26 species (Den Hartog 1970, Kuo and McComb 1989). Occurrence of Enhalus acoroides, Halophila stipulacea and Halophila minor is mainly reported from northern Mozambique to Tanzania and Kenya, whereas Zostera capensis is most common in southern Mozambique (e.g. Maputo bay) (Isaac 1966, Bandeira 2000). Mixed seagrass beds are common in the region, often with a high diversity. Eight seagrass species occur in the small southern bay of Inhaca Island, Mozambique (Bandeira 2000), and 11 out of the 12 species reported from the region have been found in one seagrass bed in Zanzibar, with only Zostera capensis lacking (Bandeira, Björk and Beer, unpublished).

T. ciliatum in Kenya is called ‘Mikuku’ in Swahili (Cox 1991), in Tanzania seagrasses and seaweeds are generally called ‘Mwani’ in Kiswahili (Bandeira 1997b) and at Inhaca Island they are called ‘Tahi’ in Xironga. Zostera capensis occurs mostly in southern Mozambique and South Africa where monospecific stands may occur. Halophila minor and Enhalus acoroides are common in Tanzania and Kenya and areas of northern Mozambique.

Seagrasses disperse by the lateral growth of the rhizomes and several species have only rarely been seen flowering. Out of the 12 species occurring in the region, flowering have been observed in Cymodocea serrulata, Enhalus acoroides, Halodule unineurvis, Halophila minor, H. ovalis, H. stipulacea, Syringodium isoetifolium, Thalassodendron ciliatum and Thalassia hemprichii (Isaac 1968, McMillan 1980). Frequent flowering occurs in a few species such as Halophila ovalis, Syringodium isoetifolium, Thalassia hemprichii and Thalassodendron ciliatum.

Seagrass ecology and ecophysiology

The ecological seagrass research in the region has mainly covered aspects of distribution, structure and productivity (e.g. Duarte 1996, Bandeira 1997b), tolerance to salinity (e.g. Adams and Bate 1994a), seagrass associated with seaweeds (e.g. Coppejans et al. 1992), and seagrass epiphytes (Sernesi 1968, Leliaert et al. 2001, Uku and Björk in this volume).

Leaf growth rate in Thalassodendron ciliatum has been reported to vary between 7.5 to 9.5 g DW m⁻² day⁻¹, and the total biomass of this species could reach 862 g DW m⁻² in sandy habitats (Bandeira 2000). Research on nutrients, covered mainly the study of C, N and P concentrations in Thalassodendron ciliatum (e.g. Hemminga et al. 1995), nutrient resorption from older to younger leaves of species such as T. ciliatum (e.g. Stapel and Hemminga 1997, Bandeira 2000) and nutrient fluxes between mangroves and seagrasses (De Boer 2000). Hemminga et al. (1994) also studied carbon fluxes from mangrove forest to seagrass T. ciliatum and coral reefs. This issue also publishes a paper on nutrient concentrations and resorption on Thalassia hemprichii in Mozambique (see paper by Martins and Bandeira).

Ecophysiological research in the region has compared photosynthetic performances of different seagrasses (e.g. Johnson et al. 1993, Björk et al. 1997, 1999, Beer and Björk 2000, Schwarz et al. 2000) using oxygen and carbon measurements as well as PAM fluorometry. Björk et al. (1997) proposed that eight seagrass species in Zanzibar were all limited by the inorganic carbon availability in the natural seawater and could not reach maximal photosynthetic rates. Schwarz et al. (2000) conducted a similar study, with in situ measurements on seagrasses in Zanzibar and found contrary to Björk et al. (1997), that subtidal populations, were not carbon limited, thus highlighting the need for in situ measurements for a better understanding of inorganic carbon limitation in seagrasses. Measurements of photosynthetic performances from other countries in the region are scarce, but the adaptation level seem to be comparable in different parts, the saturating irradiance for T. ciliatum from Inhaca (Johnson et al. 1993) was quite similar to what could be measured in shallow-growing plants of the same species in Seychelles (Tilyanov et al. 1995). In a study on desiccation tolerance on intertidal and upper subtidal species, Björk et al. (1999) reported that the species growing in the highest intertidal did not appear to be more resistant to desiccation stress than other more submerged species. It was instead suggested that other factors, such as avoidance of dehydration, plays an important role in the zonation pattern of seagrasses exposed to high tidal variations.
Other research on seagrasses in the region


Mariani and Alcoverro (2000) pioneered in studying fish feeding-preference of seagrasses in Kenya. This study concluded that fish grazing had less preference for long-lived species such as Enhalus acoroides and Thalassodendron ciliatum, in contrast with higher preference for short-lived species such as Cymodocea rotundata and Syringodium isoetifolium.

A study on genetic diversity in Thalassodendron ciliatum from southern Mozambique was recently carried out using random amplified polymorphic DNA (RAPD) (Bandeira and Nilsson, in press). A high genetic diversity was observed in this species.

Future needs in seagrass research in the region

Research on seagrasses in eastern Africa is still in its infancy. Thus basic research such as studies on distribution, structure and growth dynamics are still greatly needed. However, there is an even greater lack of studies on ecological valuation, impact assessment, studies on pollution effects and linkages to other habitats. In our view, one of the most important challenges for researchers will be to assess the ecological and social importance of seagrass beds in the region, especially those potentially threatened by human activities. Effermeyer et al. (see this volume) pointed out five broad research themes for marine botanical work in the eastern Africa region: Pollution, river discharges, habitat degradation and recovery, climate changes, mariculture and natural products. It is our suggestion that future seagrass research in this region follow the same themes and that a strong emphasis is put on supplying the required knowledge and monitoring data for proper management of seagrass habitats in the future.

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