Journal of Applied Phycology (2006) 18: 565–573
DOI: 10.1007/s10811-006-9058-2


# Factors influencing the growth rates of three commercial eucheumoids at coastal sites in southern Kenya

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*Key words: Eucheuma denticulatum*, *Kappaphycus alvarezii*, growth, commercial eucheumoids, morphotypes, mariculture, Kenya

## Abstract

As a possible means of improving the livelihoods of local villagers, off-bottom rope cultivation of commercial eucheumoids was investigated on the southern Kenyan coast at three sites, representative of the variety of environments. The morphotypes used were brown *Eucheuma denticulatum* and green and brown *Kappaphycus alvarezii*. The study was carried out over a 15 month period from August 2001 until October 2002. Relative growth rates were highest at a sandy flat in a mangrove system (Gazi; 5.6% $d^{-1}$), and lowest in an intertidal reef flat (Kibuyuni; 3.2% $d^{-1}$) with a lagoon being intermediate (Mkwiro; 4.8% $d^{-1}$). The brown *E. denticulatum* had the highest growth rate of 4.7% $d^{-1}$ compared to the green and brown *K. alvarezii* which were 4.3% $d^{-1}$ and 4.2% $d^{-1}$ , respectively. Growth was more variable at Kibuyuni and Mkwiro. The growth was higher during the southeast monsoon (4.7% $d^{-1}$) than during the northeast monsoon (4.0% $d^{-1}$). This is part of a larger study and the effects of water motion, salinity, temperature, thallus nitrogen, and 'ice-ice' syndrome on growth of morphotypes is discussed. The water motion was observed to increase thallus nitrogen and hence the growth of eucheumoids. The 'ice-ice' condition affected both brown *E. denticulatum* and brown *K. alvarezii* but not green *K. alvarezii*. The results suggest that commercial cultivation of eucheumoids in Kenya will be feasible.

## Introduction

The marine algae, *Eucheuma denticulatum* (Burman) Collins and Hervey and *Kappaphycus alvarezii* (Doty) Doty ex P.C. Silva are the most important carrageenophytes commercially (McHugh, 2003). However, several morphological and pigment forms of each species are used in farming, which makes the taxonomy and naming of commercial *Kappaphycus* and *Eucheuma* species problematic (Doty, 1987). The term "eucheumoid" (by adding "oid" to the genus *Eucheuma* as in gracilarioid) is used here to refer to both *E. denticulatum* and *K. alvarezii* and their associated forms. The nomenclature of *Eucheuma* and *Kappaphycus* species is according to Silva et al. (1996) and Prud'homme van Reine and Trono (2001).

The demand for carrageenan has been increasing over the years, and to meet this requirement (and possibly at a cheaper cost), carrageenan producers such as CP Kelco and FMC BioPolymer have been promoting the geographic spread of eucheumoids to non-endemic locations such as Indonesia, Tanzania, Madagascar, Fiji and Kiribati (Ask et al., 2003). In addition, the mariculture of eucheumoids is also gaining popularity in developing countries as a source of foreign exchange and a means of broadening the livelihoods for coastal communities (Ask & Azanza, 2002; Ask et al., 2003). For example, about 180 000 families in the Philippines (Hurtado & Cheney, 2003) and over 20 000 people in Tanzania (Mtolera, 1996) benefit from seaweed cultivation. The effects of the introductions on the local environment have not yet been determined.

Thus these species are being cultivated in East African countries such as Djibouti (Braud & Perez, 1978), Madagascar (Mollion & Braud, 1993), Zanzibar (Lirasan & Twide, 1993) and recently in Mozambique (R. Piezas, pers. comm.). Although Kenya has similar environmental conditions to Tanzania (McClanahan, 1988), there is as yet no commercial exploitation or farming of seaweeds. Coppejans (1989) reported that there is little suitable shallow water area (compared to Tanzania) for seaweed cultivation in Kenya. He also suggested that there might be conflicts for water space with other reef users. However, there are no reports of the suitable area for seaweed cultivation in Kenya. Furthermore, some farming systems such as the floating raft and long line methods are used in deep waters (Hurtado-Ponce et al., 2001; Paula & Pereira, 2003). Yarish and Wamukoya (1990) found no suitable natural sources and concluded that utilisation of eucheumoids in Kenya could only be realised by mariculture, which is supported by other reports (Lirasan & Twide, 1993; Oyieke, 1998; UNEP, 1998). However, McHugh (2002) did not consider that Kenya had good prospects for a seaweed industry. He felt that the pilot studies were not promising but he did not reference these studies. The purpose of this study was to evaluate the feasibility of growing three commercial eucheumoids under field conditions in Kenya.

## Materials and methods

### *Study sites*

Based on a preliminary survey of potential study sites along the southern Kenya coast, three areas, Gazi Bay, Kibuyuni and Mkwiro were selected because they are sheltered from wave action, accessible, and represent a range of environmental conditions in Kenya. Gazi Bay (4°25′S, 39°30′E) is a shallow mangrove system which receives freshwater from rivers. However, both a shoreward wind and tidal currents mix the water in the Bay, leading to seawater with near oceanic salinity (Kitheka, 1996). A prominent seagrass bed of *Thalassia hemprichii* (Ehrenberg) Ascherson exists at the centre of the bay. However, at the cultivation sandy flat, only *Halodule*, *Halophila* and *Cymodocea* were common. The major substratum consisted of a mixture of sand and silt. The sandy flat was covered with approximately 20–30 cm of water at the lowest tide and 3.8 m at the highest tide.

Kibuyuni (4°38′S, 39°20′E) is a large, intertidal reef flat covered by a belt of *Thalassodendron ciliatum* (Forsskal) den Hartog. Patches of *E. denticulatum* and *Kappaphycus striatus* (M.F. Schmitz) Doty ex P. Silva were also common in this area. There was however, insufficient and unhealthy material for the study. The substratum at the study site consisted of coral rubble and small pockets of sand. The reef-flat was covered with 10 cm of seawater at the lowest tide and 3.2 m at the highest tide. The dominant animals were soft corals, large sponges, starfishes, brittle stars, sea urchins and rabbit fishes.

Mkwiro (4°40′S, 39°23′E) is located on the eastern side of Wasini Island, about 2 km from the mainland. It is a lagoon characterized by sandy substratum where *Thalassia hemprichii*, *Syringodium isoetifolium* (Ashers.) Dandy., *Turbinaria*, and *Sargassum* predominate, with occasional coral heads. *Eucheuma platycladum* F. Schmitz was found growing in patches. Numerous sea urchins, starfishes, and soft corals were also evident at the site.

The coastal belt of Kenya experiences a tropical monsoon climate dominated by two seasons, the southeast monsoon (SEM) prevailing from April to September and the northeast monsoon (NEM) from October to March. The two seasons are characterised by distinct differences in physical and chemical conditions of the coastal waters (McClanahan, 1988). The SEM is associated with strong winds, low air and water temperatures, low solar radiation and heavy rains, with the lowest tides occurring during the night. During the NEM, these conditions are reversed with the lowest tide occurring during the day. The tides are mixed semidiurnal, with tidal ranges of about 4.0 m (McClanahan, 1988).

### *Plant materials and cultivation methods*

Three morphotypes from two species (brown *Eucheuma denticulatum*, and green and brown *Kappaphycus alvarezii*), were collected from a seaweed farm in Zanzibar, although they originally came from Bohol, Philippines. The plant material (2.5 kg for each morphotype) were washed clean of silt, associated animals and plants, and transported to Mombasa, Kenya where the materials were placed in outdoor culture tanks at Kenya Marine and Fisheries Research Institute (KMFRI) for 4 weeks, inspected and cleaned of any foreign organisms before use.

The fixed, off-bottom farming technique as described by Lirasan and Twide (1993) was used. In order