Extension Bulletin

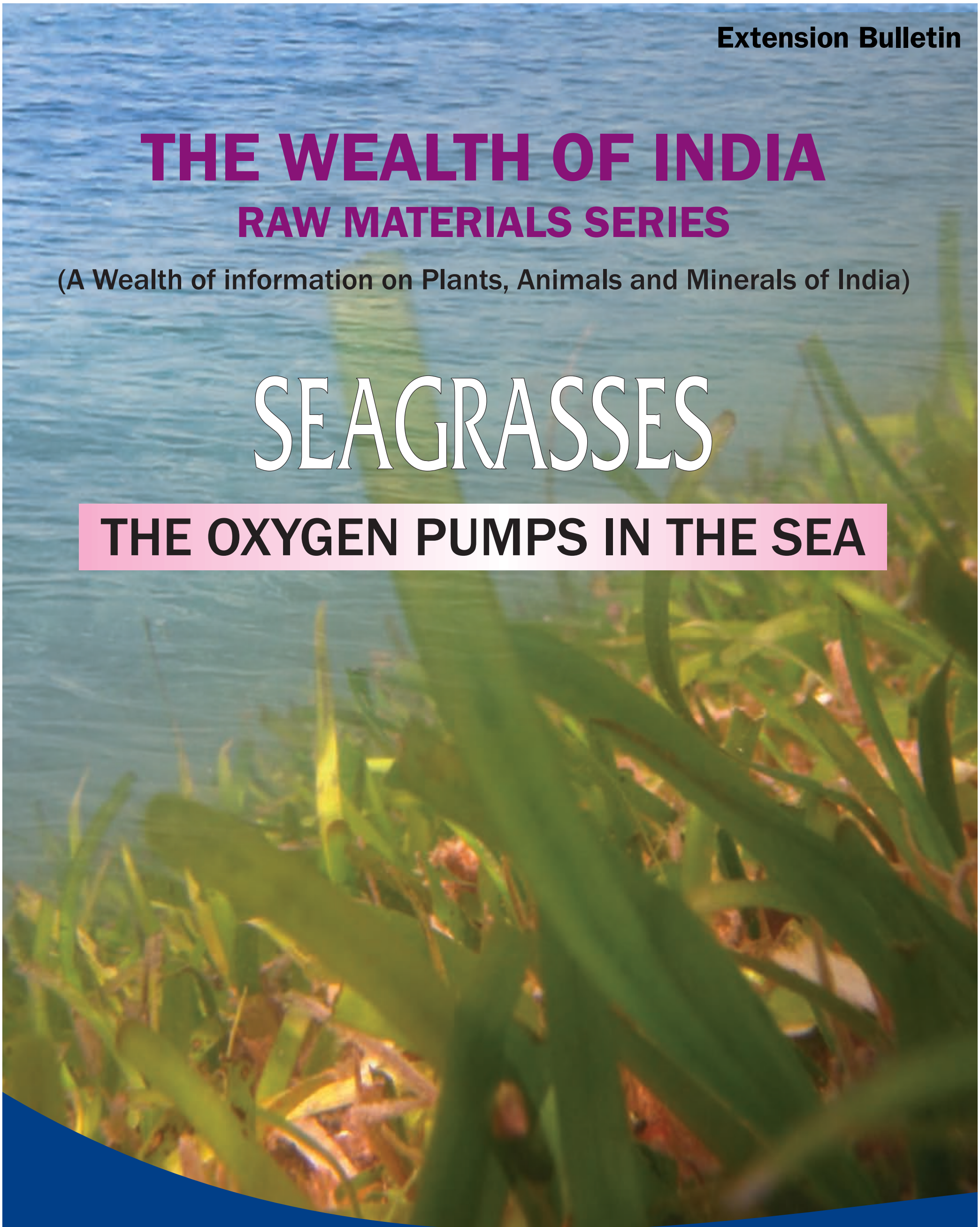
THE WEALTH OF INDIA

RAW MATERIALS SERIES

(A Wealth of information on Plants, Animals and Minerals of India)

SEAGRASSES

THE OXYGEN PUMPS IN THE SEA



Wealth of India Division

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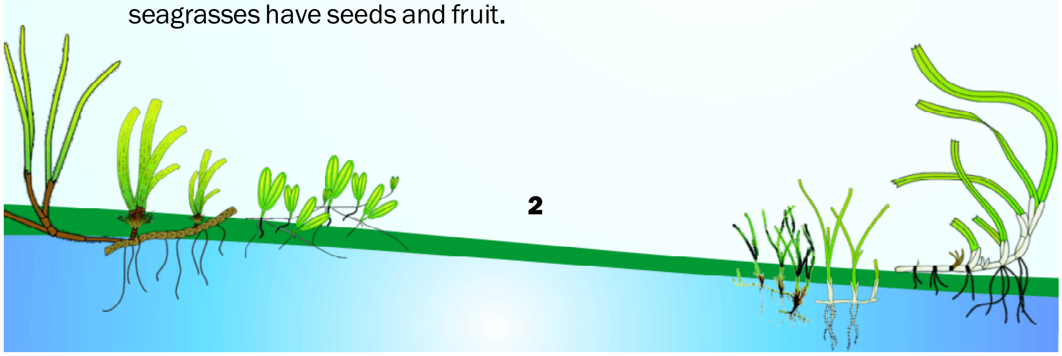
When it is about Marine Environment, every one is keen to listen about colourful coral reefs, beautiful ornamental fishes, dolphins, sharks and other kind of fishes but not about seagrasses because their importance has never been highlighted which they deserve. Seagrasses, the gentle yet very important residents of the coastal waters are the lesser known wealth of the ocean that rated as one of the most valuable ecosystem globally. It is believed that, seagrasses originated on land and later went on to adapt to underwater life. They are the only flowering plants that have colonized the ocean floor since the time of the dinosaurs.

Seagrasses are marine flowering plants capable of completing their life cycle when they are submerged in sea water. Seagrass ecosystem is one of the most widespread coastal vegetation types when compared to coral and mangrove ecosystems. These plants, acting as ecological engineers comprise $<0.02\%$ of the Angiosperm flora, represented by sixty odd species but occur in all the coastal areas of the world except the polar regions because of ice scouring. They are an important food source for mega herbivores such as green turtles, dugongs and manatees, and provide critical habitat for many animals, including commercially and recreationally important fishery species. A variety of medicines and chemicals are prepared from seagrass and their associates.

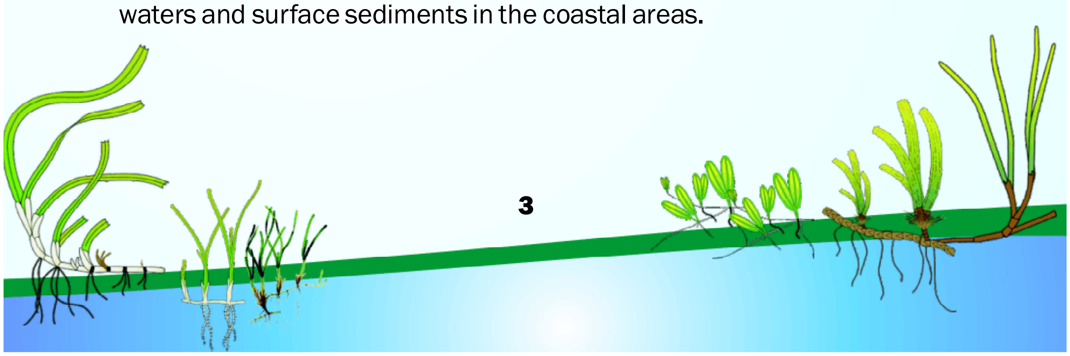
Seaweeds (Algae), the plants that also colonise the sea are often confused with seagrasses; however, they are more primitive than seagrasses. In contrast to seagrasses, algae do not have a true root system (they have holdfasts) and do not have veins that carry molecules around the plant. Algae have spores and do not flower or produce fruit, while seagrasses have seeds and fruit.



Seagrasses represent one of the highly productive coastal ecosystem of the world and protects the shorelines against erosion in the middle and lower intertidal and subtidal zones. This ecosystem is conspicuous and often a dominant habitat in shallow coastal waters and well known for its higher primary and secondary productivity and supports diverse floral and faunal communities by generating vast quantity of detritus. They release oxygen to the water column during photosynthesis, also pump oxygen into the sediments via their roots and create an oxic environment around roots that supports extensive nutrient uptake.

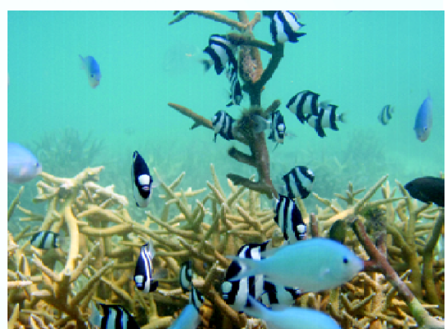
The scientific communities and environmentalists in the tropics and particularly in India have given low priority in research on seagrass ecosystem. But, in the late nineties and early 2000's, the scenario has changed slowly and research activities started gaining momentum. Indian seagrass habitats are mainly limited to mud flats and sandy regions. It extend from the lower inter tidal zone to a depth of 10-15 m along the open shores and in the lagoons around the islands.

These plants have developed unique morphological, ecological and physiological adaptations for a completely submerged existence, including internal gas transport, epidermal chloroplasts, submarine pollination and marine dispersal which provide with important ecological services to the marine environment. They profoundly influence the physical, chemical and biological environments in the coastal waters. Water flow, nutrient cycling and food web structure in sea is also some times altered by seagrasses. They are considered to be critical aquatic plants as they maintain the water quality by effectively removing nutrients from marine waters and surface sediments in the coastal areas.

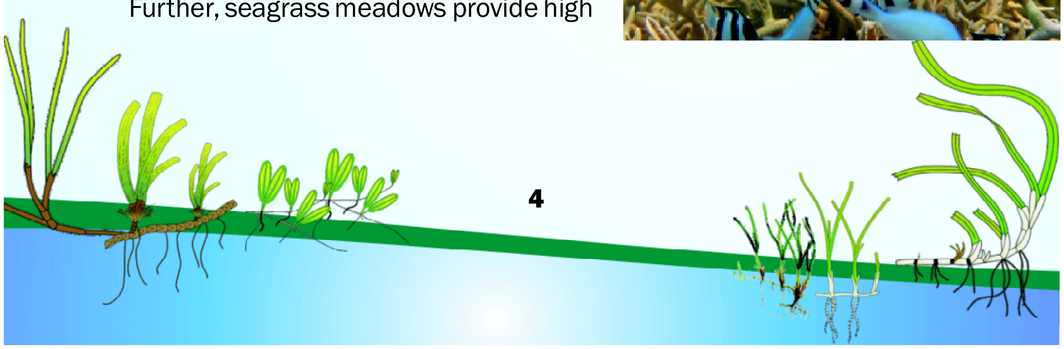


Fresh seagrasses are the direct food source to sea urchins, fishes, seacows, geese and ducks and when they get decomposed, innumerable insect larvae and amphipods feed on them. Several species of this group produce antimicrobial compounds that may act to reduce or control microbial growth. In traditional medicine, they have been used for a variety of remedial purposes, e.g. for the treatment of fever and skin diseases, muscle pains, wounds and stomach problems, remedy against stings of different kinds of rays, tranquillizer for babies, etc.

The major role of these plants is in protecting our planet from the increasing build-up of carbon dioxide and are responsible for about 15% of total carbon storage in the ocean with long-term carbon burial of 83 $gC/m^2/yr$ and this translates to global storage rates between 27 and 40 TgC/yr. They can act as carbon sink, sequestering carbon dioxide from the atmosphere. It is estimated that seagrass meadows sequester between 0.012 to 1.33 metric tons of carbon per hectare per year (tC/ha/yr). The amount of CO_2 that is sequestered by seagrasses differs greatly and depends on species, whether it is fast or slow growing, the local environment and the time of year. Seagrasses are also known as the warriors of ocean acidification as they always cause an increase in pH, as CO_2 is withdrawn from the water column during the photosynthesis, so the protons associated with carbonic acid.



These plants form one of the most productive ecosystems on earth, rivalling even crops of corn and sugar cane. Further, seagrass meadows provide high

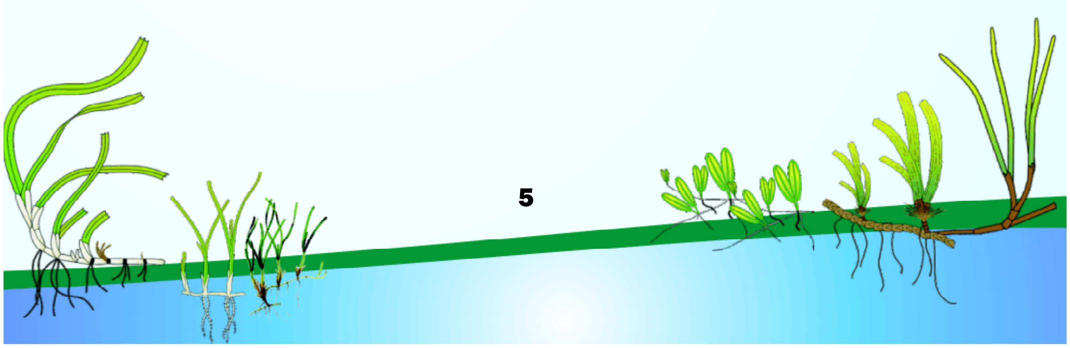


value ecosystem services such as supporting commercial fisheries worth as much as $3500/ha/yr. Vegetated coastal habitats, viz. seagrasses have much in common with rain forests: they are hot spots for biodiversity, provide important and valuable ecosystem functions, including a large carbon sink capacity, indeed, the world is losing its coastal habitats four times faster than its rain forests and the rate of loss is accelerating.

Seagrasses are assigned mainly to six families encompassing 14 genera of Angiosperms and are often separated into tropical and temperate genera, with 7 genera each. Furthermore, the presence of seagrass meadows is global (except the polar regions because of ice scouring), unlike mangroves, corals or salt marsh plants, which have a more limited spatial distribution.

Seagrass flora of India is represented by 6 genera and 13 species, out of which the Gulf of Mannar and Palk Bay harbour the maximum number of species followed by Andaman and Nicobar and Lakshadweep islands.

The Wealth of India-A Dictionary of Indian Raw Materials, a novel publication from CSIR-NISCAIR has inscribed only four species of seagrasses, therefore, it is the right time to update the series with the latest knowledge and the list of seagrasses species found in India and make the society aware about the ecological, commercial and economical importance of these life saving guards of coastal ecosystem.



SEAGRASSES OF INDIA

Class: Monocotyledons

Order: Helobiae

Family : Hydrocharitaceae

Genera and species:

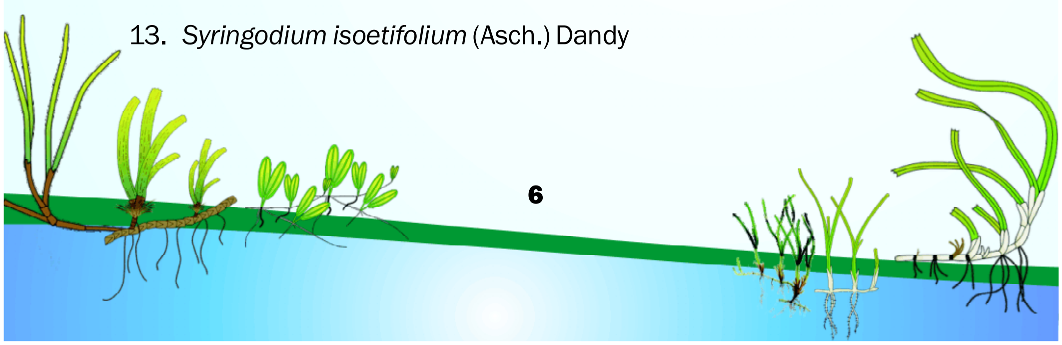
1. *Enhalus acoroides* (Linn.f.) Royle
2. *Halophila ovalis* (R. Br.) Hook. f.

   (i) *H. ovalis* (R. Br.) Hook.f. subsp. *ramamurthiana* Ravikumar & Ganesan
3. *H. ovata* Gaud.
4. *H. stipulacea* (Forsk.) Asch.
5. *H. beccarii* Asch.
6. *H. decipiens* Ostenf.
7. *Thalassia hemprichii* (Ehrenb.) Asch.

Family : Potamogetanaceae

Genera and species:

8. *Cymodocea rotundata* Ehrenb. & Hempr. ex Asch.
9. *C. serrulata* (R.Br.) Asch. & Magnus
10. *Halodule uninervis* (Forsk.) Asch.
11. *H. pinifolia* (Miki) Hartog
12. *H. wrightii* Asch.
13. *Syringodium isoetifolium* (Asch.) Dandy



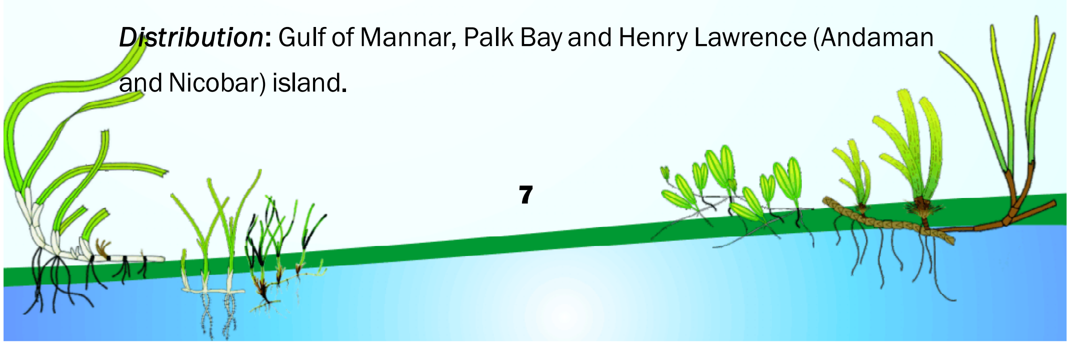
Enhalus acoroides (Linn.f.) Royle

Common names: Tape seagrass; Olai pasi (Tamil)

It has dark green long linear grass like leaves 1.0-1.5 cm wide, 50-170 cm long. Common in shallow intertidal areas with sandy and muddy substrata but can extend down to 6 m depth. It is the only seagrass species which forms aerial surface pollination. *Enhalus* with long strap like leaves form good wave breakers and extensive beds give some protection to shorelines exposed to strong waves. Such thick vegetation also provides good hiding places for small species and the young of other organisms. It is a common food for the dugong and the fruits are consumed as food by the local fishers. *Enhalus* is highly productive and contribute greatly to oxygenation of the seas as well as carbon sequestration, leading to reduction in the effects of global warming.

Biochemical analysis of *E. acoroides* recorded 5.8 mg/g carbohydrate, 7.2 mg/g protein, 4.1 % lipid, 2.4 mg/g tannin and 9.2 mg/g phenol. Studies found that calorific contents of the seagrasses were equivalent to Bengal gram, Peas, Potato and sweet potatoes. Studies also showed higher antioxidant activity (11.770 mg ascorbic acid equivalent/g), higher radical scavenging activity and higher reducing power by the seagrass leave extracts and reported that seagrasses can be effectively used for treatment of various oxidative stress related diseases.

Distribution: Gulf of Mannar, Palk Bay and Henry Lawrence (Andaman and Nicobar) island.



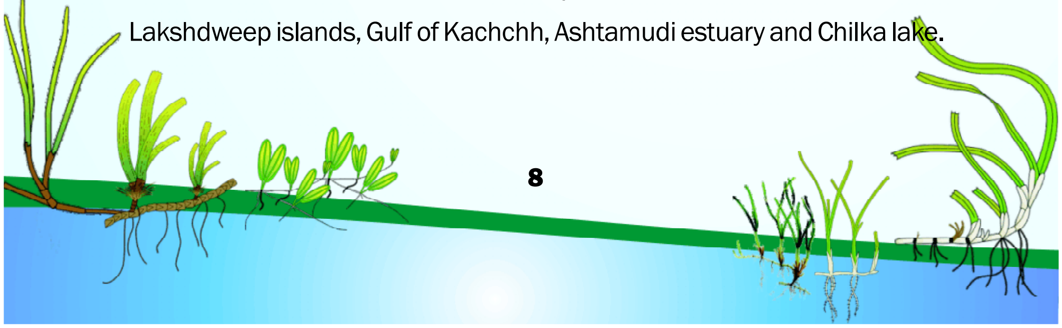
Halophila ovalis (R. Br.) Hook. f.

Common names: Paddle weed; Kouth pasi/Saethu pasi (Tamil)

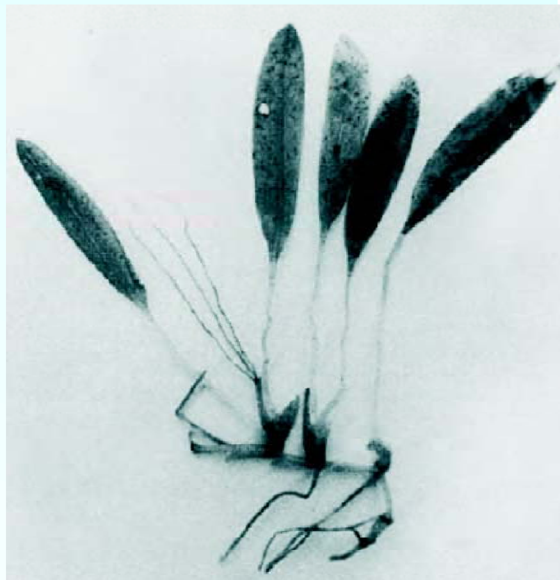
H. ovalis is a small herbaceous plant. The leaves are ovate in outline, appearing on stems that emerge from rhizome beneath the sand. The roots get up to 80 cm long and are covered in fine root hairs. It is also connected by a series of interconnecting rhizomes as in grasses. This seagrass has one of the widest salinity tolerances. It is found from shallow subtidal areas to the deepest waters where seagrasses can be found, 30 m and deeper. It can tolerate areas with freshwater runoff and thus lower salinity, as well as hyper saline waters. This seagrass is among the favourite food of dugongs (sea cow). Its leaves provide a surface for small algae to grow on. Tiny snails graze on these plants and in turn they are eaten by larger creatures. In this way, it contributes to the rich biodiversity on the shores.

Biochemical analysis of *H. ovalis* recorded 5.2 mg/g carbohydrate, 1.8 mg/g protein, 0.01 % lipid, 1.3 mg/g tannin and 6.1 mg/g phenol. *Halophila* spp. has antifungal activity, a strong medicine against malaria, used for skin diseases and reported to be effective in the early stages of leprosy. Various skin diseases, burns and boils are treated with its leaves and a paste made from turmeric.

Distribution: Gulf of Mannar, Palk Bay, Andaman and Nicobar islands, Lakshdweep islands, Gulf of Kachchh, Ashtamudi estuary and Chilka lake.



Halophila ovalis (R. Br.) Hook.f. subsp. *ramamurthiana* Ravikumar & Ganesan



H. ovalis (R. Br.) Hook.f. subsp. *ramamurthiana* Ravikumar & Ganesan is closely related to the typical species, but differs distinctly in having oblong or rarely elliptic leaves with a cuneate base and an acute apex, 7-16 paired cross-veins and fruits with 6-12 (-18) seeds. The male and female populations of this taxon are found growing in separate patches. The subspecies is named to honour Dr. K. Ramamurthy, Scientist, Botanical Survey of India for his contribution to the field of Angiosperm taxonomy.

This species is found growing well in the substratum having loose, soft black mud full of decayed plants. The male and female populations of this species are found growing in separate patches. This species is only recorded in the backwaters and not from the open sea.

Distribution: Marakkanam and Theetapuram backwaters of the Eastern Coast of peninsular India.

Halophila ovata Gaud.

Common names: Spoon grass; Pottal/Poduthali pasi (Tamil)

H. ovata is fast growing and pioneering seagrass. It is found in a variety of habitats, including sand and sandy mud bottoms and is often found in exposed areas. Reproduction is mainly vegetative. Plants are separated as male and female. Fleshy, unbranched (rarely branched) rhizomes, unbranched solitary roots at the nodes up to 6 cm long, with root hairs. Leaves, paired at each node, lamina transparent, oblong, glabrous with 4-24 mm long petiole, entire margin, cross-veins 3-9 pairs, sub-opposite or alternate, merging with intramarginal nerves. Fruits, ovoid with 20 seeds. Seeds, globose, beaked at both the ends, white when young and brown when mature.

The fresh leaves contain palmitic acid, linoleic acid and linolenic acid and relatively high abundance (Ca 5%) of the acid hexadeca-7,10, 13-trienoic acid (16:3<7 >). Phytochemical analysis revealed the presence of alkaloids and saponins.

Local fishermen in Tamil Nadu use seagrasses to treat common ailments such as dandruff for which they ground the leaves in to paste and apply onto the scalp. For iron deficiencies, a handful of leaves is mixed with sesame oil and consumed with daily meals.

Distribution: Gulf of Kachchh, Konkan coast, Lakshadweep islands, Gulf of Mannar, Palk Bay, Sunderbans and Andaman and Nicobar islands.

Halophila stipulacea (Forsk.) Asch.

Common name: Minni passi (Tamil)


Plants are dioecious with male and female flowers produced at each leaf node. Rhizomes are creeping, branched and fleshy, and roots appear solitary at each node of the rhizome, unbranched and thick with dense soft root hairs. Pairs of leaves are distributed on petioles along a rhizome, rooted in the sand. Leaves from 3-8 mm wide, obovate, not narrowing at base, thin and hairy; margin spinulose. Petiole 3-15 mm long.

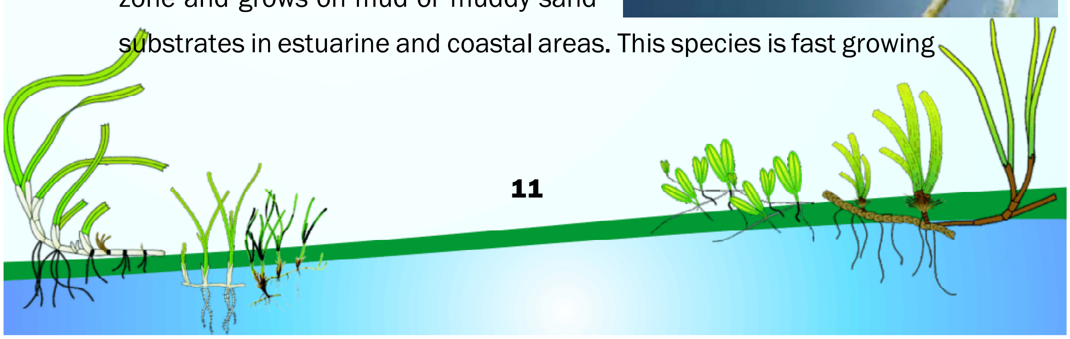
Chemical examination of *H. stipulacea* yielded a new malonylated flavone glucoside, genkwanin-4′-O-(6″-malonyl-glucopyranoside) with known flavone glucosides. Studies on insecticidal activity with the crude extract of this species showed 100 % mortality against the rice weevil, *Sitophilus oryzae*.

Distribution: Gulf of Mannar and Palk Bay.

Halophila beccarii Asch.

Common name: Ocean Turf Grass

H. beccarii is found in the upper intertidal zone and grows on mud or muddy sand substrates in estuarine and coastal areas. This species is fast growing

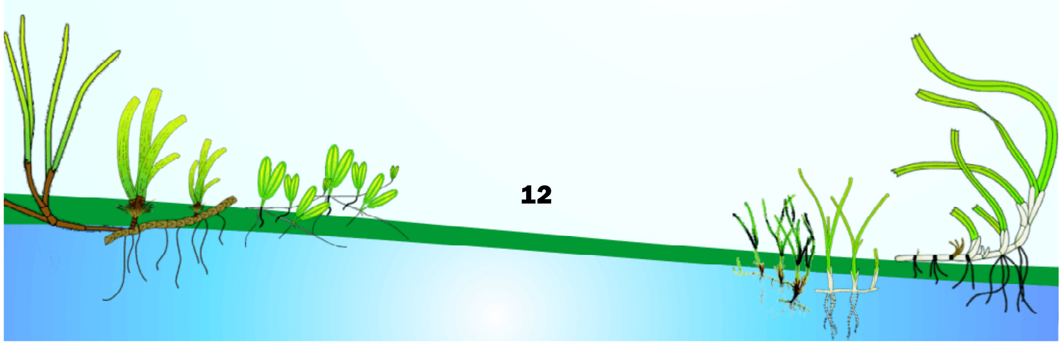


with large seed production. It is a colonizing species. It flowers year round and has annual and perennial populations in Malaysia and Bangladesh. In India, it acts as a pioneer species in the succession process leading to mangrove formation. This species is now listed in The IUCN Red List of threatened plants.

This species has a narrow, restricted depth range right at the intertidal zone. It has a wide salinity tolerance (euryhaline) and can recover quickly from disturbance, such as increased sedimentation. This species is one of two in the oldest lineage of seagrasses, and therefore, has a high evolutionary value (i.e., living dinosaur).

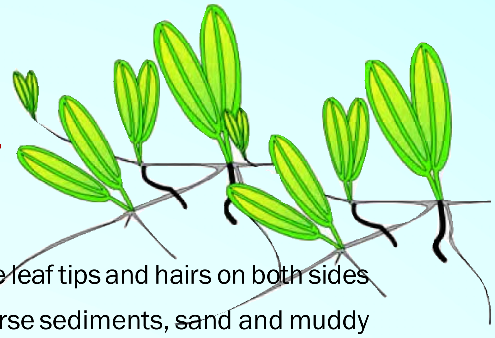
Biochemical analysis of *H. beccarii* recorded 3.8 mg/g carbohydrate, 1.7 mg/g protein, 1.2 % lipid, 1.2 mg/g tannin and 3.2 mg/g phenol. Phytochemical analysis also showed the presence of alkaloids and sugars in this seagrass. The extracts of this species also showed antifungal activities against *Trichophyton mentagrophytes* and *Microsporum gypseum*.

Distribution: Gulf of Mannar, Palk Bay, Mandovi Estuary, Kumbala Estuary (Kerala).

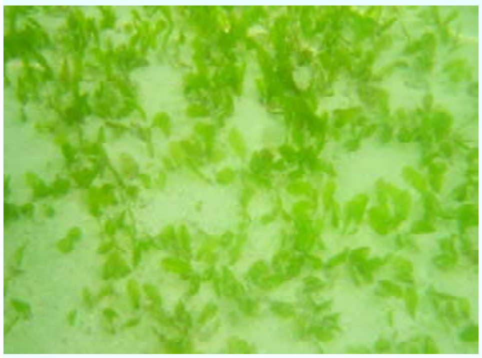


Halophila decipiens Ostenf.

Common name: Paddle grass



H. decipiens is monoecious, has serrate leaf tips and hairs on both sides of its leaves. It is typically found on coarse sediments, sand and muddy



bottoms. It is a deep water species but also found in shallow water under docks and in turbid areas. *H. decipiens* can grow in areas with high sedimentation. Female flowers produce approximately 30 seeds. In the Indo-Pacific region it is found even up to a depth of 58 m.

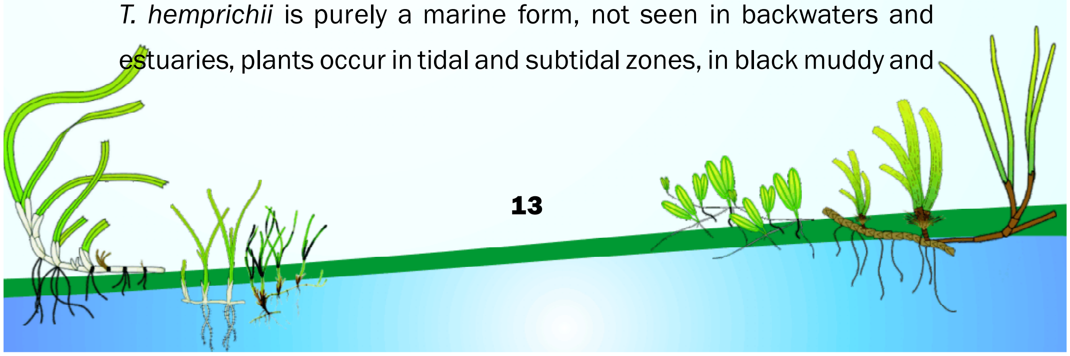
This species can propagate through budding, but primarily relies on a buried seed bank for population re-establishment in seasonally fluctuating or high disturbance environments. It is a highly fecund, annual and opportunistic species that may be favoured by disturbance, but unable to compete once the other species are established.

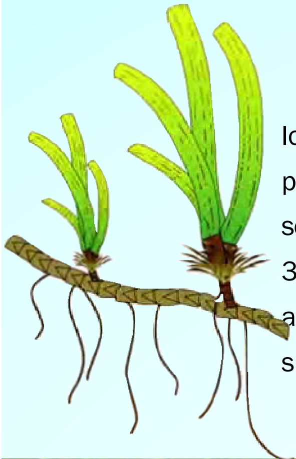
Distribution: Gulf of Mannar, Palk Bay and Kalpeni island (Lakshadweep).

Thalassia hemprichii (Ehrenb.) Asch.

Common names: Turtle grass; Kadal Korai/Kattai passi (Tamil)

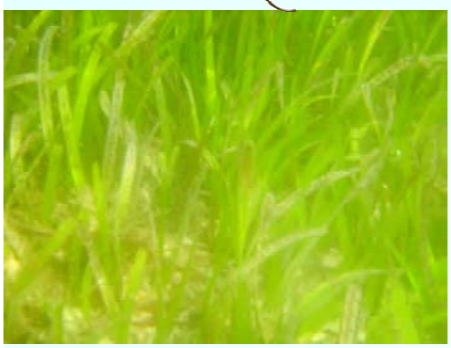
T. hemprichii is purely a marine form, not seen in backwaters and estuaries, plants occur in tidal and subtidal zones, in black muddy and





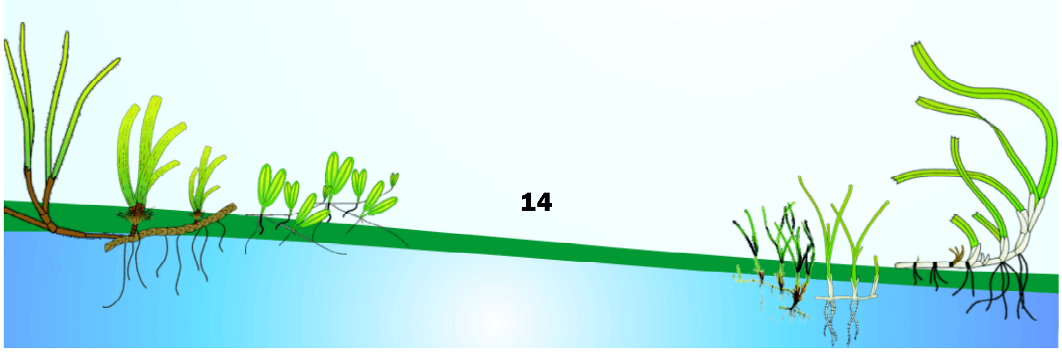
loose sandy soils. Male and female plants are separate, perennial with creeping rhizome; rhizome with scales and scale scars; shoot erect, covered by 2-6 old decayed leaves, 3-7 leaves in each shoot, measuring up to 15.5 cm in length and 1.2 cm in width, leaf blade linear, sometimes leaf tips show some serration.

In the Indo-Pacific region, *T. hemprichii* is commonly the climax seagrass species. Monospecific stands of this species has higher net primary production rates, reaching 1.5 mg carbon/m^2/day to 1.9 mg carbon/m^2/day, equivalent to a maximum of 694 mgC/m^2/yr. The species is fast-growing and is grazed by turtles and dugongs and is important for fish grazing.



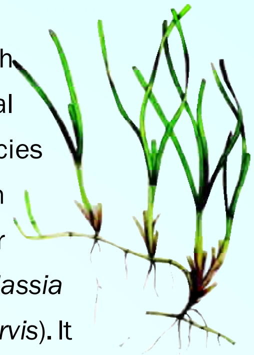
Reports show that, a phenylethane derivative, (*S*)-methoxy-(3′, 5′-dimethoxy-4′- hydroxyphenyl) ethanediol, 3,4,5-trihydroxybenzoic acid, (*E*)-3-(4-methoxyphenyl)-2-propenoic acid, syringin (**7**), 5-hydroxy-3′, 4′, 7-trimethoxyflavone, and 4′-hydroxy-3′,5,7-trimethoxy flavones were isolated from this species. The species is also used as medicine against fever and malaria in countries like Japan. For mental illnesses, people use the dried rhizome powder for treatment.

Distribution: Gulf of Mannar, Palk Bay, Andaman and Nicobar islands, Lakshadweep islands.



Cymodocea rotundata Ehrenb. & Hempr. ex Asch.

Common names: Ribbon seagrass; Vella thazhai passi (Tamil)



C. rotundata occurs in clear water, and often in the high intertidal zone. This species is resilient to marginal conditions. Like many intertidal species, this species morphology can vary widely, and for this reason it can

some times be confused with other species (i.e. with narrow leaf *Thalassia hemprichii* or wide *Halodule uninervis*). It has separate male and female plants, rhizomes creeping, branched, jointed; roots single at each node, branched, 2-4 mm thick; shoots erect, up to 31 cm long, each shoot bearing 3-4 leaves with persistent leaf scars.

This species does not like full exposure at low tide (dry conditions). In the Andaman Sea, it occupies the lower littoral zone on muddy sand areas or sandy bottom mixed with dead coral fragments. *C. rotundata* can survive a moderate level of disturbance.

Biochemical analysis of the species estimated 8.5 mg/g carbohydrate, 3.6 mg/g protein, 2.4 % lipid, 1.8 mg/g tannin and 6.4 mg/g phenol. *Cymodocea* spp. is used as a tranquillizer for babies, as soothing help during pregnancy and against cough and malaria. Phenolic compounds, cardiac glycosides and saponins are present in this species. Studies revealed that this species possesses antioxidant activity. Presence of 8.2 g/100 g soluble fiber and 6.7 g/100 g insoluble fiber has also been reported.

Distribution: Lakshadweep islands, Gulf of Mannar, Palk Bay, Andaman and Nicobar islands.

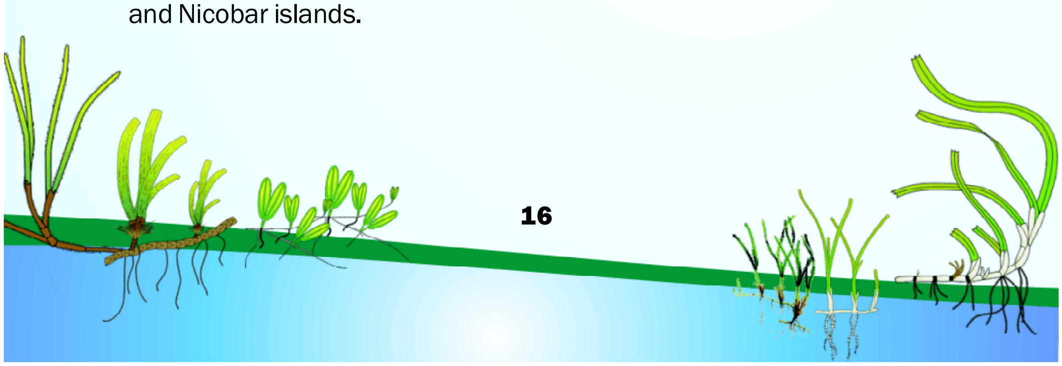
Cymodocea serrulata (R. Br.) Asch. & Magnus

Common name: Karumbu passi (Tamil)

Cymodocea serrulata has separate male and female plants. It has creeping rhizome with scales and scale scars; shoot erect, with 2-6 leaves, shoot covered by old decayed leaves. *C. serrulata* grows on muddy sand, fine sand or sand with coral rubble substrates in the intertidal zone. It is a mid-successional species and can colonize very quickly once established. This species can quickly recover or return after a disturbance. This occurs in deeper sediments and has been linked to increased rates of sediment accretion. This species is a food for dugongs when other resources are low. It is also grazed on by fish and urchins.

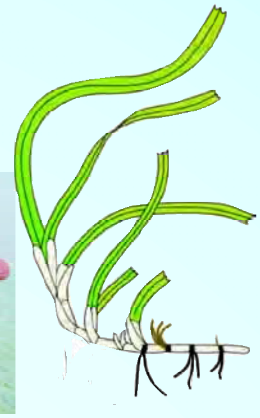
Biochemical analysis of *C. serrulata* revealed that it has 7.6 mg/g carbohydrate, 2.3 mg/g protein, 1.8 % lipid, 1.6 mg/g tannin and 6.3 mg/g phenol. The extracts of this species also showed antibacterial activity. Chemometric analysis of *C. serrulata* found the presence of Mg (905.57 mg/kg), Fe (69.456 mg/kg), Na (30 mg/kg), Ca (19.4 mg/kg), Zn (13.573 mg/kg), Mn (12.83 mg/kg), K (10 mg/kg), Cu (7.496 mg/kg), Cr (0.983 mg/kg), Pb (0.813 mg/kg), Ni (0.413 mg/kg), Co (0.283 mg/kg) and Cd (0.23 mg/kg).

Distribution: Lakshadweep islands, Gulf of Mannar, Palk Bay, Andaman and Nicobar islands.



Halodule uninervis (Forsk.) Asch.

Common name: Sinna eekku passi (Tamil)



Halodule uninervis is a sub-littoral seagrass found from the mid-intertidal to a depth of 20 m. Its characteristic features include: shoots up to 30 cm long and erect, having 2-4 leaves in each branch, leaf linear, narrowed at base with sheath, margin entire, nerves 3, midrib conspicuous and lateral ribs inconspicuous, ending in well developed lateral teeth at leaf apex, teeth tridentate.

It can grow in a range of different habitats and very common between 0-3 m in sub-littoral lagoons and in front of reefs. It is very fast growing, colonizes rapidly and can flower prolifically. It can form dense meadows at some sites or is patchy and intermixed with other seagrass species, and frequently observed on back reefs in association with larger algae. It is one of favoured foods of the Dugong and often heavily grazed.

Biochemical analysis of *H. uninervis* estimated 5.3 mg/g carbohydrate, 3.2 mg/g protein, 0.9 % lipid, 0.56 mg/g tannin and 8.9 mg/g phenol. The antimicrobial activities of the methanol and dichloromethane extracts of the leaves, rhizomes and roots showed significant activities against *Bacillus subtilis, Staphylococcus aureus* and *Streptococcus pneumoniae*. The antimicrobial compounds present in the extracts are phenol and anthraglycoside.

Distribution: Lakshadweep islands, Gulf of Mannar, Palk Bay, Tamilnadu coast, Andaman and Nicobar islands.

Halodule pinifolia (Miki) Hartog

Common name: Arugampul Passi (Tamil)

H. pinifolia have separate male and female plants, with rhizomes slender and branched, roots creeping, formed at each node. It generally grows on sandy to muddy soils along the coasts, mangrove creeks, coral platforms, etc. Leaves measure about 1-6 cm long and 1-5 mm width, linear with entire margin and with 3 prominent midribs, lateral ribs form lateral teeth on leaf apex.

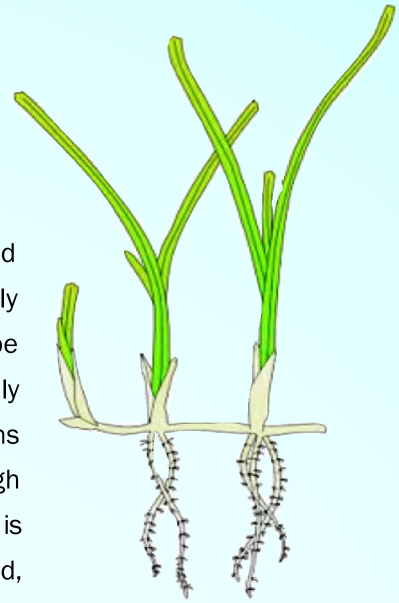
It is widespread and common although the population is most likely to be decreasing due to a number of localized threats throughout its range. This species is fast growing and can recolonize areas if removed; forms homogenous patches in intertidal places or occasionally intermixed with other seagrasses. It is ephemeral with rapid turn-over and high seed set, and is well adapted to high levels of disturbance. This species is often heavily epiphytised.

Biochemical analysis of the species estimated 5.4 mg/g carbohydrate, 1.9 mg/g protein, 0.3 % lipid, 1.2 mg/g tannin and 7.5 mg/g phenol. The phytochemical composition also revealed the presence of flavonoids, alkaloids, glycosides and steroids and possesses significant antimicrobial activity against both Gram positive and Gram negative bacteria.

Distribution: Lakshadweep islands, Gulf of Mannar, Palk Bay, Andaman and Nicobar islands.

Halodule wrightii Asch.

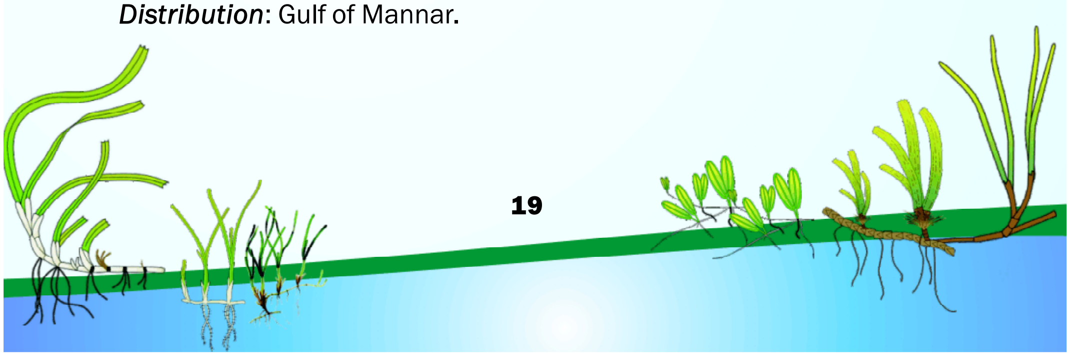
Common name: Shoal grass



Halodule wrightii has a disjunct global and predominantly tropical distribution. It is typically found on sandy to muddy bottoms and can be found in mixed seagrass species beds. It is highly tolerant to a range of environmental conditions including wide ranging salinity (hypersaline), high temperatures, turbidity and eutrophication. This is dioecious plant with creeping rhizome, branched, often moniliferous; internodes up to 2.6 cm long with 1-7 roots at each node; roots up to 13cm long, unbranched. It has 5-12 cm long leaves, lamina linear, narrowed at base, covered; leaf margin entire, nerves ending in lateral teeth at the leaf tip, teeth bidentate.

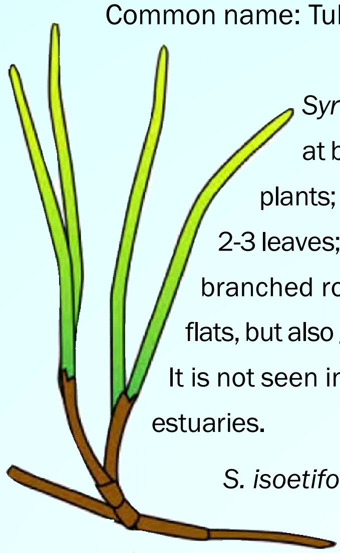
This species is ephemeral with rapid turn-over and high seed set and forming effective seed banks, well adapted to high levels of disturbance. *H. wrightii* can rapidly and densely recolonize denuded areas in warm months. Most bed maintenance and new shoot production probably occurs through rhizome elongation.

Distribution: Gulf of Mannar.



Syringodium isoetifolium (Asch.) Dandy

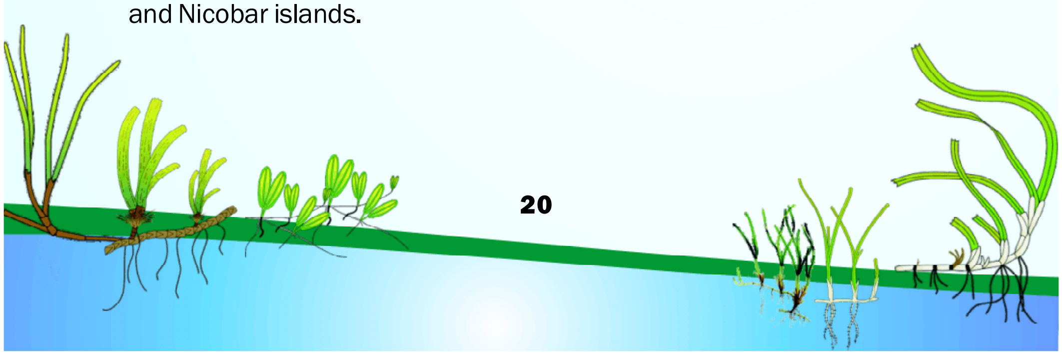
Common name: Tube grass, Neer passi (Tamil)



Syringodium isoetifolium leaves are tubular, narrowed at base and pointed at the apex. They are herbaceous plants; rhizomes creeping, shoots erect, branched, bearing 2-3 leaves; rhizomes and shoots have scars; rhizomes produce branched roots at each node. It generally grows well on coral flats, but also grows on sandy to muddy bottoms up to 15 m depth. It is not seen in backwaters and estuaries.

S. isoetifolium can be used as potential larvicidal agent against *Aedes aegypti* mosquito larvae. Biochemical analysis of *S. isoetifolium* estimated 4.8 mg/g carbohydrate, 3.1 mg/g protein, 1.2 % lipid, 1.6 mg/g tannin and 6.8 mg/g phenol. Ethyl acetate extract of *S. isoetifolium* was reported to show stronger DPPH radical-scavenging activity. This species is also reported to have higher content of insoluble fibres (8.13 g/100 g). Local fishers reported to feed Tube grass to their cattle which could apparently cure their illness.

Distribution: Lakshadweep islands, Gulf of Mannar, Palk Bay, Andaman and Nicobar islands.



SEAGRASSES IN THE SERVICE OF HUMAN

Seagrass as food

In India, the local fishers are said to consume *Cymodocea* spp. (it taste like sugar cane) and seeds of *Enhalus*. People in Japan prepare salads with seagrasses and even candies are made from the leaves. In Indonesia, fishermen sometimes use the rhizome of *Enhalus acoroides* as an emergency food source, while the seeds of this seagrass, are eaten by local children as snacks between meals.The seeds are also eaten by fishermen and others in Thailand, Malaysia and the Philippines. Recently in the Philippines there has been some experimental use of flour made from these seeds in the manufacture of cookies.

The seeds of *Enhalus acoroides* (Linn. f.) Royle are known to the Philippine coastal people to be edible. Its approximate nutritional composition is similar to that of rice. It is eaten raw or boiled and tastes like sweet potato when cooked. Some fishermen believe that it is an aphrodisiac. With the aim of developing seagrass seed as human food in small islands, researchers from the University of the Philippines have developed a flour made from dried mature seeds of *E. acoroides*.

Insulation

Dried seagrass material was commonly used as housing insulation, until well into this century. Its thermal and sound-proofing properties derived largely from the air spaces which occur in mats of seagrass material. One of the major beneficial properties of seagrass as insulation was that it was non-flammable, because of its high silicon content. A popular form of insulation in the United States was something called a Cabot's quilt, named after its inventor was a mat of dried seagrass material, inserted into the walls of houses. The material was also used to sound-proof radio studios in USA and the UK.

Roofing thatch

Seagrass material was popularly used to thatch roofs in rural coastal areas in Europe and the UK. Its use dates from the seventeenth century (and possibly before), and was used as a substitute for straw. The major advantages of seagrass were that it was slow to rot, and was flea-proof. Presumably its poor combustion properties were also an advantage.

Binding soil

Seagrass material was extensively used to bind clay and soil in embankments; for example, in the dikes of the Netherlands. This use has found a translation into modern times, with seagrass drift being used to produce mulch applied to sand dunes to help with stabilization. It appears to form an erosion resistant mat, suitable for seed germination in sand dune rehabilitation programmes, and has been used in Australia; presumably similar trials have been conducted elsewhere.

Stuffing and packaging

Zostera marina has found use as a substitute for horse hair in Europe and the USA, as a material for stuffing pillows, mattresses and upholstery. The crab industry in Chesapeake Bay used seagrass as a packing material for exporting crabs from the region. Seagrass fibre was used to fill leaks in ships hulls in the seventeenth century.

Manure, stock feed supplement, minerals

Several references document the use of seagrass as manure, although this is probably more for the algae and other marine organisms entangled within the seagrass mat, than the seagrass itself. *Posidonia oceanica*, when mixed with lime and phosphates, was used in Mediterranean countries as a meal for feeding poultry. This was also experimented with in South Australia, although only on a limited basis. Washed up seagrass wrack is commercially used to make garden mulch, although there is speculations that this is largely for bulk.

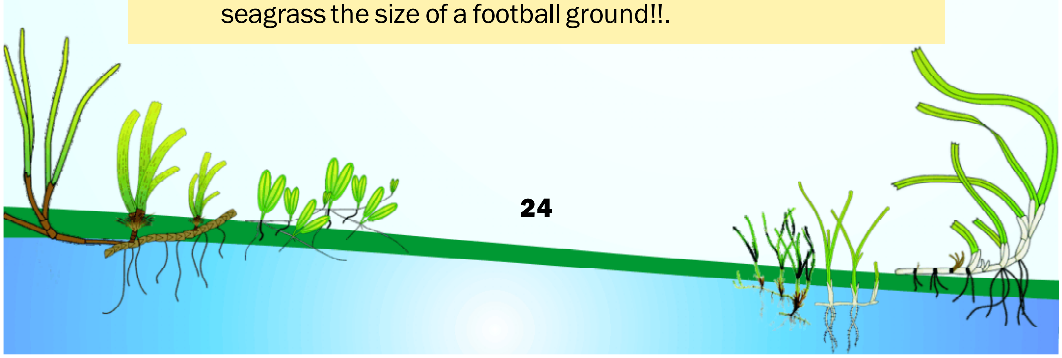
Various workers over the past few decades have studied the mineral composition of seagrasses, and concluded that, while considerable quantities of minerals such as Boron occur in seagrass material, it is not commercially viable to extract. There are suggestions that in Denmark seagrass material may have been burned as a source of salt, soda minerals or simply for warmth. Old reports also exist about seagrass as a relief for rheumatism.

Weaving, fibre products, paper-making

Japanese fishers used *Phyllospadix iwatensis* as a material for making wet weather gear up to the 1930s, when rubber became popular. There are unconfirmed reports of seagrass fibre being used for basket-weaving from the east coast of the USA, although other aquatic (freshwater) vegetation may actually be used in this instance). Seagrass fibre is used to make “coir” mats and rugs sold in Australia. During the Second World War seagrass fibre was used as a substitute for cotton in the manufacture of nitrocellulose in Germany. Experiments were carried out in England, on the use of seagrass fibre for paper making.

INTERESTING FACTS ABOUT SEAGRASSES

1. Over a billion people live within 50 km of seagrass meadow and obtain their protein from animals that live in seagrasses.
2. Globally over 177,000 km^2 of seagrasses cover were estimated.
3. A hectare of seagrasses absorbs about 1.2 kg of nutrients per year, equivalent to the treated effluent from 200 people.
4. Seagrasses meadows have higher carbon sequestration capacity. It sequesters around 33 grams of carbon per square meter per year, equivalent to the CO_2 emissions from an automobile travelling 2,500 km.
5. One square metre of seagrass can produce up to 10 litres of oxygen per day.
6. In Australia, primary productivity of seagrass meadows is higher than a mangrove forest, a terrestrial forest or grass land.
7. Seagrass occupy only 0.1 % of the seafloor, yet are responsible for 12 % of the organic carbon buried in the ocean, which help reduce greenhouse gases.
8. There is a single clone of seagrass that is over 6000 years old (*Posidonia oceanica*).
9. The longest known seagrass (*Zostera caulescens* Miki) is about 7 m found in Japan and deepest growing seagrass is *H. decipiens* (86m) in the Mauritius waters.
10. The anchor from one cruise boat can destroy an area of seagrass the size of a football ground!!.



THE WEALTH OF INDIA
A DICTIONARY OF INDIAN RAW MATERIALS

The National Institute of Science Communication And Information Resources (NISCAIR), a constituent of Council of Scientific and Industrial Research (CSIR), has been involved in dissemination of information for S&T community through its various scientific books, journals and magazines. One of its major publications is **The Wealth of India which is an authentic encyclopaedic publication on Indian Raw Materials—Plants, Animals and Minerals.** It is a recognized biodiversity and bioresources document and regarded as '**Top 70 Socially Transforming S&T Interventions of CSIR since inception'**. Started in 1942, with an encouraging foreword from a great scientific visionary, the then Prime Minister of India, Pandit Jawaharlal Nehru, the "Wealth of India" is one of the longest projects in the history of CSIR still trying to make its presence adopting available modern tools in the field of information dissemination. It indeed played an important role in successfully contesting turmeric patent, a decade ago. As of now, it has about 10000 pages of meticulously compiled and collated valuable information on Indian Economic Plants, Animals and Minerals in print form. Wealth of India is often the source of reference for various other ministries and departments of the Govt. of India for making certain policy decisions.

The encyclopaedia, aptly named The Wealth of India amasses the renewable resources of the country including the rich biodiversity of plant and animal species as also the mineral wealth abounding in the Indian subcontinent. The plants are dealt with under their generic and specific names but articles on animals appear under the English names and minerals with their English names or scientific equivalents at appropriate places. There are also some polymerous entries, such as Algae, Bamboos, Corals, Fungi, Insects and Insect pests, Prawns, Shrimps and Lobsters, etc.

Correct identity of each plant has been ensured, its distribution in wild or occurrence as cultivated plant in India is provided, and the parts of economic importance have been adequately described. In the case of crop-plants, methods of cultivation, harvesting and storage are given, Diseases and pests and their control measures are also mentioned. The zoological entries give the habits and habitat of the animals, their status and important products derived from them. Regarding minerals, their occurrence and distribution in the country and methods of exploration and utilization are given.

The main series consists of 11 volumes and 2 supplements: Fish & Fisheries and Livestock including Poultry. An exhaustive cumulative index in 4 parts, viz. botanical names, zoological names, active principles and other important compounds and names in regional languages, trade-names and common English names, covering more than 250 pages, is appended to the final volume. This cumulative index is immensely useful to users in locating the entries by scientific, trade as well as common English and vernacular names in available regional languages.

For facilitating easy access to information, each volume includes features such as cross-references, lists of books and journals cited and a meticulously made index of the synonyms of plants dealt with, cultivars of crops, common English, vernacular and trade names, drugs, products, active principles and important chemical compounds. Adequate references to the sources of information are provided at appropriate places, and the articles are well illustrated with halftone and coloured plates, line-drawings, charts, maps, etc.

In addition to 11 volumes of main series, 3 revised and updated (A, B and Ca-Ci alphabets) plus a supplement on Bird has been brought out. The revised volumes boasts of an elaborate use based index as an additional feature. Subsequently, supplements (covering information from 1982-1996) have been brought out in 8 volumes maintaining the style and format of the parent series and every effort have been made to give a cohesive presentation so as to easily blend with the parent volumes. Thus the complete set of 23 volumes of *The Wealth of India-Raw Materials* series is much sought after as a ready reference for its extensive, authentic coverage on distribution, cultivation, production, diseases and pest control measures, harvesting and post harvesting care, chemical composition, utility including community knowledge, conservation, statistical data, etc., especially in the search for natural resources in the life of living beings in broader prospective. Compiled and collated by a body of subject experts with the collaboration of specialists in various fields all over the country, the entire work is a treasure house of knowledge on natural raw materials.

The complexity, heterogeneity and voluminousness of this encyclopaedic work can be visualized from the fact that whole series covers more than 6000 plant-species, 52 articles on animals and their products and 73 articles on minerals.

The Wealth of India is indispensable to research workers especially beginners dealing with life sciences, chemical sciences, pharmacology, environmental sciences, students of economic botany, government departments and rural development agencies, planners, industrialists and all those interested in the availability of Indian raw materials, their production, value addition, exports and imports.

The alphabet wise volume's arrangement along with price list is given below to facilitate access of information on relevant botanical, zoological and mineral entries.

A to Z of Wealth of India and Prices list

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1.	Vol. I (A-B)**		
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* Also available in Hindi entitled *Bharat-ki-Sampada*

** Vol. I & II of Original Series are not being printed as the updated information is available in the Revised Series of Vol. 1A, Vol. 2B, Vol. 3 (Ca-Ci) & First Supplement Series Vol.2 (Cl-Cy).

*** Including revised version of major entries, viz. Cocos, Coffea, Curcuma, Cymbopogon, Corals, Crabs, Crocodiles, Clays, Cobalt, etc.

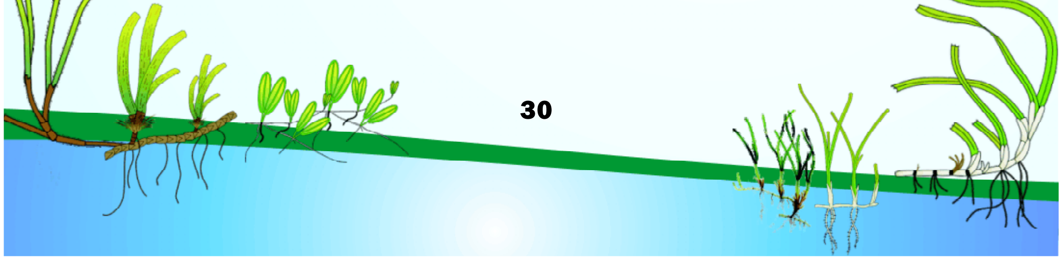
The Wealth of India"– what a vision of past history and splendour it brings, when the Indies attracted adventurers in search of wealth and fortune from the most distant countries! .... Nevertheless, India is wealthy and the wealth of India is there. But in spite of this wealth, the people are poor. The problem for us is to utilize this stored–up wealth of the country in the soil and under the soil, for the benefit of Indian humanity. This book is a kind of encyclopaedia or dictionary, and dictionaries seldom make attractive reading, but I have found this particular dictionary rather fascinating and it has opened out vistas of thought to me. The pictures are good.

I have no doubt that this book, produced by many scholars and experts and after much labour, will be of great value to the builders of new India. It should be of value also in educating the average citizen, who should take interest in this fascinating land and its enormous potentialities.

New Delhi
21st December 1948

Jawaharlal Nehru

Jawaharlal Nehru



ACCOLADES

Producing an uo-to-date Dictionary of Raw Materials and Industrial Products under the auspices of CSIR is necessary.

..........Dr. S.S. Bhatnagar
FRS, First Director General of CSIR (1942-1954)

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..........UNIDO Ind.Res.Develop.News, 1973, 6(4), 31.

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..........Tropical Agriculture, 1951, 28, 34

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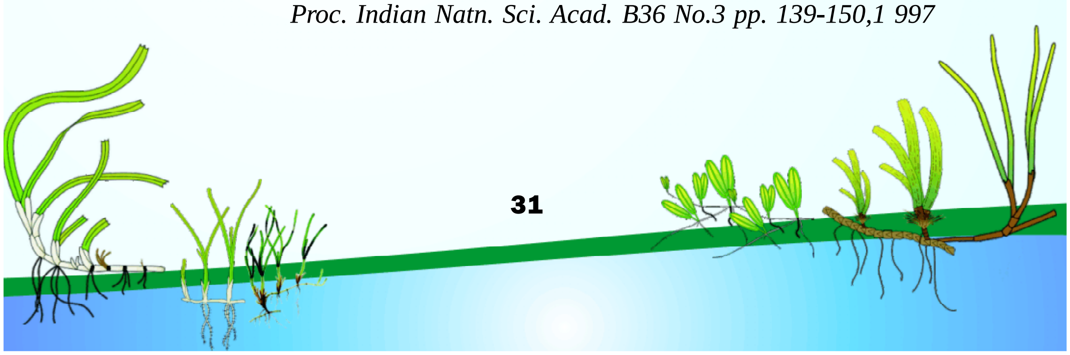
USDA letter to the editor, Wealth of India
Proc. Indian Natn. Sci. Acad. B36 No.3 pp. 139-150,1 997



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