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Turtle herbivory of seagrass ecosystems in the Lakshadweep atolls: concerns and need for conservation measures

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Original Article

Abstract

Green turtles and turtle grass are interdependent in the atoll ecosystems of Lakshadweep as green turtles are herbivores and the latter are being consumed by the turtles. Since the herbivore is being protected by legislation, their herbivory on turtle grass is uncontrolled and had resulted in near total wiping of seagrass meadows. This case study was made from Agatti atoll in detail and the status of seagrass meadows in three neighboring atolls. The present communication stresses the need for the earliest restoration and to conserve the seagrass meadows from being destroyed by the increasing population of green turtles which is essential for the very existence of turtles itself in Lakshadweep Sea.

Keywords: *Turtle, turtlegrass, herbivory, Ecosystem based conservation, Agatti atoll, Lakshadweep.*

Introduction

Sea turtles are marine reptiles declared endangered as they are in the brink of extinction due to destruction of nesting beaches, predation of eggs and hatchlings (70-90%), accidental catch by gill nets and trawl nets, predation by sharks, entrapment in ship or boat propellers during migration and sand mining. From Indian waters, five species of turtles have been reported and all of them are totally protected by law, having listed under the Schedule - I, Subsection (1), Section 61 of the Indian Wild Life (protection) Act 1972 and are classified as endangered species in the IUCN Red List. Lakshadweep atolls and Andaman-Nicobar archipelago are known for nesting sea turtles which have dense seagrass beds besides, certain selected beaches along the Peninsular coast. Seagrass meadows are the feeding grounds of turtles and breeding and nursery grounds for a variety of other marine living organisms and hence, they are also known as swim-in-restaurants. Seagrass meadows of Lakshadweep coral lagoons are known to harbour dense and rich macro invertebrate assemblages (Ansari *et al.,* 1991).

Turtlegrass, *Thalassia hemprichii* is one of the most favoured forage food of *Chelonia mydas* (Mortimer, 1979). Stomach content of sea turtles revealed forage of other seagrass species like *Cymodocea, Halophila*(Deraniyagala,1961;Agasthesapillai and Thiagarajan, 1979; Frazier, 1971), *Posidonia oceanica* and *Syringodium* sp. and also some seaweeds (Kar, 1980). Bjorndal (1980) has studied extensively on nutrition and grazing behavior of the green turtle. A historical decline in the seagrass beds of Maho and Francis Bays, St John, Virgin Islands observed has been attributed to heavy boat usage and grazing by green turtles (Williams,1988). The first survey of turtles in Lakshadweep was conducted during 1976 (Bhaskar, 1978; 1979). Later Silas (1984) and Lalmohan (1989) reported

a few sightings and nesting of turtles from Lakshadweep and Rajagopalan (1997 worked on the current national status of turtles and their conservation. During 2001-2002 the Wildlife Institute of India conducted detailed survey on turtles from the Lakshadweep atolls (Tripathy *et al.,* 2002).

Seagrasses have a well developed creeping rhizome, bearing branched or unbranched roots at each node besides erect shoot bearing several leaves and hence serve as sediment traps and stabilize the bottom. They are also involved in cycling of nutrients from both water and sediment. Indian waters contains 14 species of seagrasses belonging to six genera and distributed to various parts of Indian peninsular and archipelagoes with varying species diversity (Lakshmanan and Rajeswari, 1982; Jagtap, 1991; Ramamurthy *et al.,* 1992; Kaliaperumal *et al.,* 1989; Kannan *et al.,* 1999). In the northern islands of the Lakshadweep, such as Agatti, Bangarum, Kiltan and Chetlat, seagrasses are termed as *kavarattipullu* in the local parlance as they were introduced from Kavaratti lagoon in the late 1960s by the native Islanders for beach stability. Structure of dominant seagrass vegetation from three coral reef atolls of Lakshadweep was described by Jagtap (1998).

Cropping of turtle grass by turtles and other anthropogenic activities in the lagoons and reef flats of Lakshadweep Islands pose serious threats to the existence of seagrass beds and warrant immediate measures for conservation. Green turtles have been found capable of modifying seagrass meadows (Lal *et al.,* 2010). Conservation efforts in marine fisheries need a shift from single species management to ecosystem based management. The care and conservation measures enjoyed by turtles (herbivores) in Lakshadweep is not given to primary producers such as turtle grass in particular and sea grasses in general. In the present communication an attempt is made to evaluate the current status of seagrass meadows of three atolls which are subjected to severe grazing pressure especially in Agatti Island and the need to restore the seagrass habitats in the light of possible consequences to the island ecosystem of Lakshadweep.

Material and methods

Agatti Island is located at $10^0$51'N lat. and $72^0$11'E long. in the Laccadive Sea. The harvestable wet biomass of seagrass vegetation was determined by harvesting shoots within a standard area (0.25 x 0.25 m quadrate) selected randomly. Leaves, shoots and rhizomes dug out from the quadrate were cleaned to remove sand and attached flora and fauna and weighed after draining the water completely. The harvestable wet biomass of seagrass was determined as follows

$$W = \frac{w \times A}{a \times n}$$

Where, a- Area of the quadrate used
n - Number of times the quadrate was operated
w- Total wet wt of seagrass harvested from the quadrates
A-Total area of the region studied

Data on turtle sightings from Agatti atoll and direct observation on seagrass vegetation from Agatti, Kavartatti, and Kiltan atolls were made during 25 Nov - 6 Dec 2009, 9-13 Feb 2010, 7-11 May 2010, 27 Dec 2010 - 2 Jan 2011 and again on 8 -12 Dec 2011 employing boat based grid (500 x 500 m) counting method and also from the opportunistic turtle sighting information from Agatti atoll supplied by some tour operators and divers who regularly cruise and dive in the lagoon and over the reefs who can identify green turtles.

Results and discussion

Seagrass ecosystems are one of the most productive ecosystems in the world and have very high rate of growth, producing organic matter of about 300- 600 g dry wt/m^2/yr (Hartog, 1970; Thayer *et al.,*1975). Seagrasses have shown decisive role in the productivity and oxygen budget of coral atoll (Qasim and Bhattathiri, 1971; Nair and Pillai, 1972; Kaladharan and David Raj, 1989). Among the Amindivi group of Laccadive atolls, Amini (11^0 07'N and 72^0 44'E) is one of the atolls supporting dense vegetation of *Cymodocea* and *Thalassia*, whereas its closely adjoining Kadamat atoll (11^0 13'N and 72^0 47'E) was lacking seagrass vegetation during 1987. Net primary productivity (NPP) of Amini atoll was 3.327 gC/m^3/day and that of the Kadamat atoll was only 2.013 gC/m^3/day. This significant difference of 65% hike in the NPP in Amini atoll was attributed to the contribution of seagrass beds (Kaladharan and David Raj, 1989). Specific rate of net primary production of different seagrass species of Lakshadweep Islands studied in *in situ* conditions also revealed highest compensation point (P/R of 3.34) for turtlegrass, indicating maximum contribution of net primary production to the atoll (Kaladharan *et al.,* 1998).

The present status of seagrass beds of Agatti, Kavaratti and Kiltan atolls revelas that seagrass have become too sparse and the biomass above the sediment (shoots) have reduced considerably (Table 1). Seagrass beds in these atolls are heterospecific comprising *Thalassia* and *Cymodocea*, S*yringodium*, *Halodule* and *Halophila* at varying densities and dominated by *Cymodocea*. Perusal of earlier reports indicate that seagrass vegetation cover in Agatti atoll is shrinking rapidly from 0.05 km^2 and the wet biomass above sediment of 895 g / m^2 (Ansari *et al.,* 1991) to 0.005 km^2 and dry biomass of 0.74 tonnes within seven years (Jagtap, 1998). Our present observation corroborates further decline after two decades in

Table 1. Estimated wet biomass of seagrass (g/m^2 ± SD) in three Lakshadweep atolls

Seagrass biomass	Kavaratti	Agatti	Kiltan
Above the sediment (leaf and stem)	112±37	116±29	420± 64
Below the sediment (Rhizome and root)	488± 74	596±88	1080± 103

the three atolls registering only 116 g/m^2 wet biomass (Table 2) and the seagrass vegetation cover of 0.0023 km^2.

It is interesting to note that wet biomass of seagrass below the sediment (Rhizomes and roots) in an unit area is considerably higher than the wet biomass of shoots (leaves and shoot) in all the three atolls (Table 1) and the difference in the shoot/root ratio indicates the degree of herbivory. Grazing was found more severe in Agatti (Fig. 1) than Kavaratti and Kiltan atolls might be due to more number of sea turtles (Fig. 2). Seagrass herbivory by turtles is established beyond doubt (Jackson, 1997; Bjorndal and Jackson, 2003; Moran and Bjorndal, 2005; Lal *et al.,* 2010). Reduction in the wet biomass of seagrass above the sediment than the underground parts indicate intense grazing (Fig. 1).

Exploitation of sea turtles from Indian waters deliberately or accidentally was banned legally in the year 1980 onwards. After the ban being introduced, degradation of seagrass beds in Lakshadweep atolls started (Table 2) and the turtle population increased exponentially (Table 3). Sea turtle population visiting seagrass meadows and reef flats of Agatti lagoon was estimated to be within 205 to 240 numbers per Km^2 which is lower than the earlier estimate reported by Lal *et. al.* (2010) which might be due to their feeding migration to other islands in search of fresh seagrass beds. During the sea turtle survey by Tripathy and team (Tripathy *et al.,* 2002), juvenile, sub-adult and adult green and hawksbill turtles were reported caught in gillnet during fishing in the

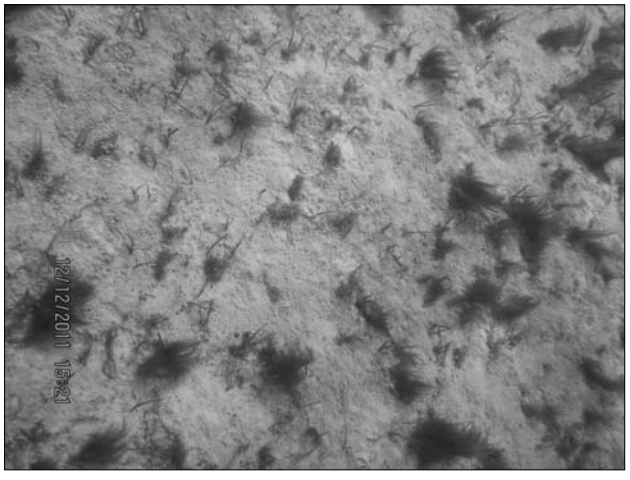

Fig.1 Overgrazed seagrass meadow- Underwater photo from Agatti.

Fig.2 Green turtle swimming off Agatti Island.

lagoons of Agatti, Kavaratti and Minicoy and most of them were observed in the deeper part of the lagoon and outside the reef between the depths of 2-5 mts. Green turtles were the most abundant species and olive ridleys were observed only occasionally outside the reef or in the lagoon. Among the different islands, Agatti had the maximum number of green turtles in the lagoon followed by Minicoy and Kadamat (Tripathy *et al.,*2002).

Since these turtles enjoy the benefit of conservation legally, their fishing mortality is zero and their population increases exponentially as the turtles here have very few chances of predation or fishing mortality coupled with their longer lifespan. Lack of predators or fishing mortality can cause imbalance in the food web and the trophic level. The recent Puffer fish menace in the southern Arabian Sea is attributed to the decline in their predatory control (Mohamed *et al.,* 2013). Another example for the impact of lack of predatory control can be the current over exploitation of octopus from the Lakshadweep atolls. Octopus is one of the benthic predators and a sought after resource in Lakshadweep. Due to the demand and innovative fishing skills, octopus exploitation

Table 2. Reduction of seagrass shoot biomass over decades in Agatti atoll

Sl No	Area of seagrass cover (km^2)	Wet biomass of shoots	Reference
1	0.05	895 ± 165	Ansai *et al.,* 1991
2	0.005	---	Jagtap, 1998
3	0.0023	116 ± 29	Present study

Table 3. Estimated Turtle population in Agatti atoll (lagoon and surrounding sea at the vicinity) during 2011

Number of turtle sighted	Area of Agatti lagoon and reef flat	Total no of turtles
205- 240/ km^2	17.5 km2	3587-4200

in the entire Lakshadweep atolls, once confined to lagoons and exposed reefs during low tide has been expanded to outside the reef flat to the reef slope using long rods and snorkels. As a result, availability of octopus has reduced a lot within the reef flat area and the population of crabs has increased considerably due to the reduction of their predators. Crabs feed on *Modeolus* and hence *Modeolus* (locally known as *kallumekai* in Lakshadweep) population is also now threatened (K.P. Saidkoya, pers.comm.) as rightly cautioned by Appukuttan (1996) that any over exploitation of octopus in Lakshadweep might cause imbalance in reef ecosystem.

Sea urchin is also a well known seagrass herbivore in the Western Indian Ocean and a few cases of overgrazing of seagrass beds has been reported from Jamaica (Camp *et al.,* 1973), Florida USA (Rose *et al.,* 1999), Gulf of Mexico and the Caribbean (Greenway, 1995; Heck and Valentine, 1995) and Kenya (Alcoverro and Mariani, 2002). However, their occurrence and distribution in the seagrass meadows were very much limited though they were found in reef flats of Lakshadweep atolls. It could be understood that sea turtles emigrate or immigrate within the Amindivi group of Lakhshadweep Islands in search of seagrass meadows for cropping. During our latest visit to Agatti atoll, turtle sighting within the lagoon has reduced as they have moved towards the western side where some patches of seagrass beds exist (Fig 3) and some have moved to nearby Bangaram and Thinnakara lagoons in search of new pastures.

Possible consequences of seagrass overgrazing include habitat and biodiversity loss, reduction in productivity, erosion of intertidal area, siltation, creation of turbid plume of silt particles, death of corals due to sedimentation and poor molluscan diversity (Rose *et al.,* 1999). One of the authors (KPS) a skin diver and a native of Lakshadweep Island has experienced difficulty in underwater observation due to the plume of silt and sediment in Agatti lagoon settling over branched corals. Williams (1988) studied the disturbance of *Thalassia testudinum* from boat usage and grazing by turtles with emergent fences and found that within 3 months of protection, the areal and shoot specific productivity of *T. testudinum* leaves and leaf size increased significantly compared to unprotected plants. Degradation of seagrass meadows in Lakshadweep atolls can increase the level of dissolved CO_2 as they are excellent carbon sequesters. Hence seagrass meadows should be protected and the barren lagoons should be restored with strong emergent net fencing to prevent the grazing by turtles. At the same time excess turtles can be confined to large pens in any one or more uninhabited atolls of Lakshadweep.

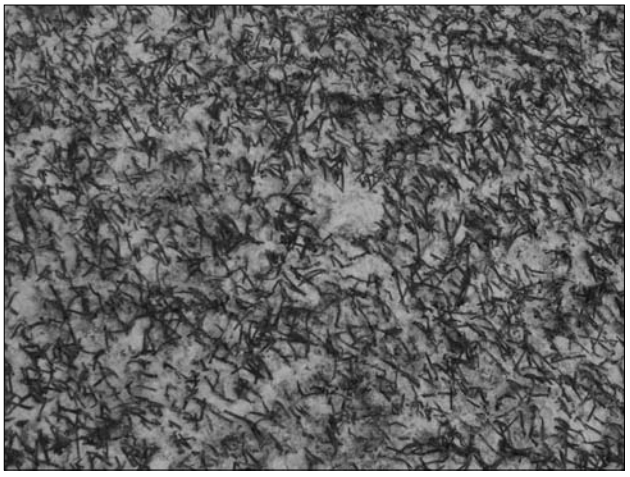

Fig.3 Western side of Agatti lagoon showing sand covered loose vegetation of turtle grass.

Turtlegrass is the dominant among the seagrass vegetation in the Laccadive archipelago. These swim-in-restaurants which are facing severe herbivory by turtles in the coral atolls must be conserved with protective net fences. To sustain the seagrass meadows, following measures can be adopted: Turtle grass meadows can artificially be established on floating platforms. Afforestation of seagrass beds can be taken up along the lagoons employing bamboo split rafts. Seagrass beds can be protected in the lagoon and reef flats by suitable net-fencing to prevent the transplanted seagrasses being grazed during the initial period of restoration. Carrying capacities of turtles in each atoll can be investigated to regulate the turtle population.

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