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Short Communication

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Observations on the female flowers and fruiting of Tape Grass *Enhalus acoroides* from South Andaman Islands, India

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Abstract: Documenting phenologic events is crucial in obtaining deeper insights into the life cycle of seagrasses. We documented and compared the flowering and fruiting of the seagrass *Enhalus acoroides* from multispecies seagrass meadows at two sites, Henry Lawrence and Tarmugli islands located inside the marine national parks in South Andaman Islands. At these two locations, the average density of shoots ranged between 30.9/m^2 and 18.16/m^2, fruits between 5/m^2 and 2.33/m^2, and flowers between 6.7/m^2 and 3.83/m^2, whereas the mean length of the peduncles ranged from 40.59cm at Henry Lawrence to 32.44cm at Tarmugli Island. We observed significant differences between the densities of shoots and fruits and peduncle lengths in the two sites. The density of flowers, however, did not vary significantly. These observations of fruiting and flowering in *E. acoroides* establish an important reproductive stage in the life cycle of the species and open avenues for further seagrass research in the Andaman Islands. We describe the findings and emphasize on the need to establish a long-term phenology monitoring program for *E. acoroides* in the Andaman Archipelago.

Keywords: Andaman Islands, flowering, Henry Lawrence Island, marine national park, phenology, seagrass, Tarmugli Island.

Seagrasses are marine angiosperms usually confined to sandy substrates in shallow temperate and tropical waters throughout the world (Vermaat et al. 2004; Fortes 2013). Sixty seagrass species are reported globally, of which 14 species are found in the Indo-Pacific (Short et al. 2007). Throughout their distribution, seagrasses are threatened by trawl fishing, sand mining, coastal construction, nutrient enrichment, sewage, and other terrestrial pollutants (Duarte 2002; Baden et al. 2003; Short & Waycott 2010). One of the consequences of these pressures is meadow fragmentation, which lowers seed output and is considered one of the reasons for seagrass declines worldwide (Green et al. 2003; Unsworth & Cullen 2010). Realizing their ecologic importance, many countries have provided varying degrees of protection to seagrass meadows (Short & Waycott 2010).

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Amongst these, the Tape Grass *Enhalus acoroides* (L.f.) Royle, which is distributed throughout the Indo-Pacific (Short & Waycott 2010), is the tallest species with leathery leaves which can grow up to 150cm. Due to its large shoot size, *E. acoroides* forms one of the major contributors to the productivity and biomass of seagrass meadows (Brouns & Heijs 1986; Rollón 1998). Clumps of this species form important habitats for juvenile fish, benthic invertebrates, and scores of burrowing organisms (Nakamura & Sano 2004, 2005). It is a source of nutrients for the Green Sea Turtle *Chelonia mydas* and a few reports indicate feeding of Dugong *Dugong dugon* on its shoots (Nair et al. 1975; Erftemeijer et al. 1993; Andre et al. 2005; Adulyanukosol & Poovachiranon 2006; D'Souza et al. 2013). *Enhalus acoroides* is dioecious, flowering twice a year from March to July and November to December (Rollón 1998; Rollón et al. 2003; Vermaat et al. 2004). In view of *Enhalus*' hydrophobic mode of pollination (Rattanachot & Prathep 2011), this flowering, when compared to that of other seagrass species, is unique in that the male flowers are released for surface pollination whereas the female flowers have to extend their coiled peduncles (stalk bearing the fruit or flower) to the water surface to capture pollen (Johntone 1979; Rollón et al. 2003). Once the pollination is complete, the female peduncle coils back towards the bottom (Sulochanan & Korabu 2009). The length of the peduncle increases with increase in depth (Johnstone 1979; Rollón 1998) and the peduncles terminate into pinkish-green flowers, the ovaries of which pollinate into green, bulbous fruits (Sulochanan & Korabu 2009).

In India, *Enhalus acoroides* is reported from the Palk Bay and Gulf of Mannar in the state of Tamil Nadu and along the Andaman & Nicobar Islands (Mahalingam & Gopinath 1987; Das 1996; Manikandan et al. 2011). In the Andaman & Nicobar Islands, before the tsunami of 2004, *E. acoroides* was reported from Paschim in Bihar, North Reef, Inglis, Henry Lawrence, Havelock, and Cinque islands in the Andaman group and Camorta, Trinket, Nancowry, Katchal, Pilomilow, Little Nicobar, and Great Nicobar islands in the Nicobar group (Das 1996). Post-tsunami, however, its presence was reported only from Henry Lawrence and Tarmugli in the Andaman Islands and Kamorta and Nancowry in the Nicobar Islands (Thangaradjou et al. 2010; D'Souza et al. 2015). This could be attributed either to lack of focused studies on the distribution of *E. acoroides* meadows or the loss of these meadows to natural disturbances (tsunami and cyclones). Owing to their ecosystem services, documenting and understanding various life cycle events of *E. acoroides* is necessary to obtain deeper insights into their ecology and to develop effective conservation strategies.

Sexual reproduction (characterized by flowering and fruiting) is an important event in the life history of *Enhalus acoroides* as they release floating propagules into the water column, which helps in recolonization of new areas (Rollón et al. 2003). This also helps in mixing of genes, which is an important evolutionary adaptation to cope with environment changes (Marbà & Walker 1999; Alexandre et al. 2006). Thus, understanding the flowering season in *E. acoroides* is of particular importance. There, however, is limited information on the flowering and fruiting of *E. acoroides* and most studies are limited to taxonomic documentation and distribution of the species across the island chain. In such a scenario, opportunistic natural history observations of *E. acoroides* can act as baselines and probe hypothesis-driven studies on the phenology, ecology, and biology of the species. We report the observations on the flowering and fruiting phenomenon of *E. acoroides* at two important seagrass meadows, Henry Lawrence and Tarmugli islands in the South Andaman group of islands.

Material and methods

Study area

The study was carried out at Henry Lawrence (12.130^{0}N & 93.099^{0}E) and Tarmugli (11.589^{0}N & 92.531^{0}E) islands in the Andaman Archipelago (Fig. 1). Henry Lawrence Island is part of the Rani Jhansi Marine National Park (RJMNP) in Ritchie's Archipelago, South Andaman, and covers an area of 54.7km^2 (Singh 2003). The coast is lined by a thick mangrove forest, whereas coral reefs and seagrass meadows are found in the shallow coastal waters surrounding the island. The seagrass meadow at Henry Lawrence is composed of multiple seagrass species including a large patch of *Enhalus acoroides* (c. 600m^2). Similarly, Tarmugli Island, with a total area of 12.6km^2, is part of the Mahatma Gandhi Marine National Park (MGMNP) in Wandoor, South Andaman (Fig. 1). The island has a dense coastal forest along with coral reefs and nearshore seagrass meadows. Unlike Henry Lawrence, however, the seagrass meadow at Tarmugli is exposed to the open ocean and the *E. acoroides* patch is significantly smaller (c. 150m^2). The meadows at both sites are relatively shallow, ranging from 1–3 m at Tarmugli and 2–6 m at Henry Lawrence, and the substrate is sand mixed with coral rubble, which is an ideal habitat for the seagrass associated faunal communities such as sea cucumbers, sea anemones, juvenile fish, and burrowing worms (Image 1).

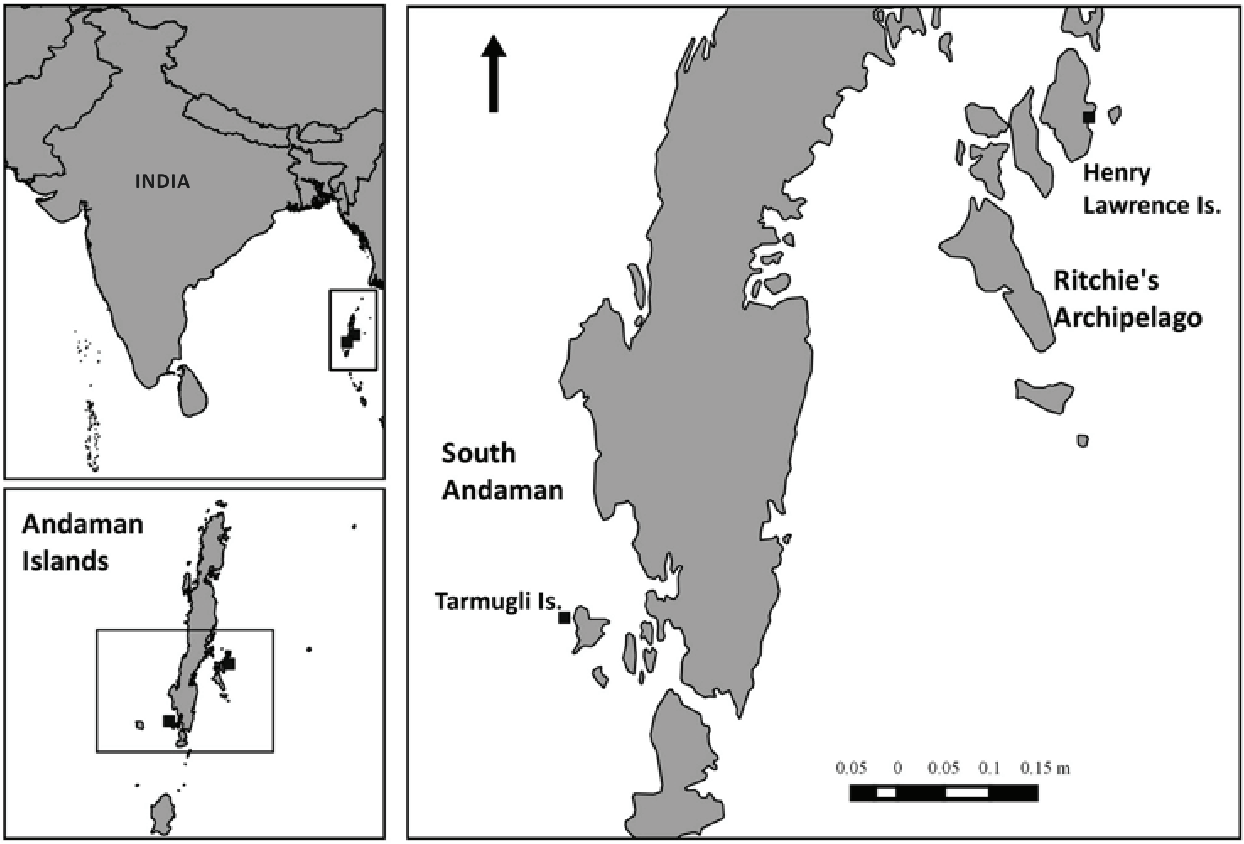

Figure 1. Study area showing sampling locations in South Andaman. Black cells indicate *Enhalus acoroides* patches at the sites.

Sampling protocol

We carried out data collection after incidental observation of flowering and fruiting of the species between 02 and 27 May 2016, using snorkelling and scuba gear at depths of 1–6 m at high tide. We placed 10 random 1m x 1m quadrats in the *E. acoroides* meadow at Henry Lawrence at depths of 2–4 m and six quadrats at Tarmugli Island at depths of 1–3 m. Due to the relatively smaller size of the *E. acoroides* meadow at Tarmugli Island, we limited the number of replicate quadrats to six. Within these quadrats, we counted the number of shoots, fruits, and female flowers and estimated their density per square metre. For the morphometric data, we measured the length of the peduncles, i.e., the distance from the base of the peduncle to the base of the fruit, and the female flower using a measuring tape. The average number of shoots, fruits, and flowers, and the mean lengths of the peduncles were compared between the two sampled sites by performing Welch's two sample t-test to account for unequal sample sizes. Data was explored in Microsoft Excel v.2016 and analyzed using R v3.2 (R Development Core Team 2015).

Results and Discussion

We observed a significant difference between peduncle lengths and the number of shoots and fruits between the two sites, whereas we did not observe significant difference in the number of female flowers between the two sampled sites (Table 1). The male flowers were not observed during the sampling.

We observed a wide variation in the number of shoots and fruits and the peduncle lengths of *E. acoroides* across the two meadows, which can be attributed to several inherent processes. The meadow at Henry Lawrence Island is considerably larger, deeper, surrounded with mangroves, and shielded from the open ocean, which could be some of the reasons for the longer peduncle lengths and higher density and abundance of the species as compared to Tarmugli Island. The variation across these two meadows shows the importance of local environment factors (location, meadow size, depth, exposure) in influencing the *E. acoroides* meadow dynamics (Rollón 1998; Marbà et al. 2005).

As our study was necessarily opportunistic and conducted on incidental observations, we were unable to document the male flowers and monitor the extent

Table 1. Difference in the abundance of shoots, fruits, and flowers and the mean length of the peduncles at Henry Lawrence and Tarmugli islands in South Andaman. Significance between sites was tested using Welch's two sample t-test (T).

Attributes	Henry Lawrence	Tarmugli	T	df	*p*-value
	Mean				
Length of peduncle	40.59±1.67	32.44±1.73	3.3866	77.519	**0.001114***
No. of shoots	30.9±3.11	18.16±1.53	3.6633	12.568	**0.003018***
No. of fruits	5±0.61	2.33±0.55	3.2129	13.476	**0.006528***
No. of flowers	6.7±0.76	3.83±0.60	2.9567	13.956	0.01044

*Significance at alpha=0.05, $P<0.01$
All the attributes are expressed as mean±standard error.

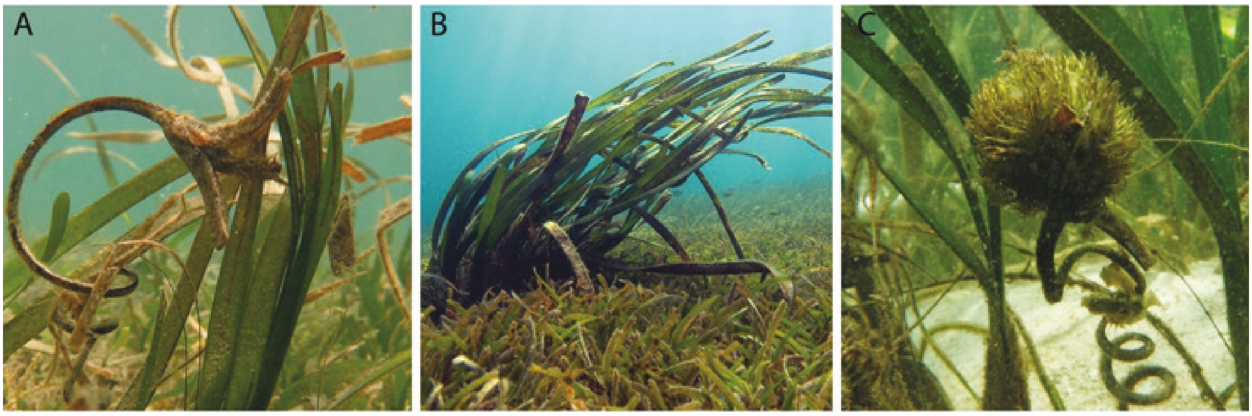

Image 1. *Enhalus acoroides* at South Andaman: A - flower at Henry Lawrence Island | B - meadow at Tarmugli Island | C - fruit with coiled peduncle. © Vardhan Patankar.

of the flowering season of *E. acoroides* in our study area. Previous studies carried out on the flowering of *E. acoroides* from the Philippines and Thailand recorded March to July and November to December as the flowering season (Rollón 1998; Vermaat et al. 2004; Rattanchot & Prathep 2011) whereas in the Gulf of Mannar flowering was reported in June (Sulochanan & Korabu 2009). Our observation of flowering of the female plant in May is within the flowering season recorded at Philippines, Thailand, and the Gulf of Mannar.

Various studies showed that *E. acoroides* forms an important refuge for juvenile fish populations (Nakamura & Sano 2004); therefore, protecting these sites should be of utmost importance especially as climate change increases the frequency and intensity of benthic disturbances (Hoegh-Guldberg et al. 2007). We recommend that extensive surveys be carried out in all potential seagrass meadows of the Andaman & Nicobar Archipelago to understand the phenology of all 11 seagrass species (Das 1996; Savurirajan et al. 2015; Immanuel et al. 2016). The state forest department in collaboration with research institutions should establish long-term monitoring programs to collect specific data on seagrasses as well as to assess potential seed banks, seed dispersal, meadow connectivity, genetic variability, and gene flow. The detailed studies and long-term monitoring of *E. acoroides* meadows in Henry Lawrence and Tarmugli islands will help establish the flowering season and increase our understanding of the factors controlling sexual reproduction, the time of release of male flowers, dispersal abilities, colonisation strategies, and resilience to natural catastrophes. Such research will not only provide new information on the phenology, ecology, and biology of *E. acoroides* and other seagrass species, but also provide empirical and technical support for seagrass meadow conservation in the face of rapid climate change and expanding threats to seagrasses and coastal areas in the Andaman Islands.

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