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FLOWERING DISTRIBUTION AND FRUITING SUCCESS OF *SYRINGODIUM ISOETIFOLIUM* (CYMODOCEACEAE) IN BOGTONG BAY, LAHUY ISLAND, CARAMOAN, PHILIPPINES

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ABSTRACT

Quantification of flowering and fruiting success is essential in understanding dispersal and recruitment characteristics of different seagrass species. In this study, the variation in the spatial extent of flowering and fruiting of a sub tidal seagrass population in a small bay was described. A total of 72 core samples were collected within the mixed-seagrass area in the Bogtong Bay, Lahuy Island, Caramoan, Philippines, in order to distribution of flowering and fruiting of the most abundant seagrass species in the bay, Syringodium isoetifolium. In three water depth categories (e.g., shallow, ½ deep depths, and deep), the intensity and allotment of flowering and fruiting were determined by examining 780 shoots of S. isoetifolium. Results revealed that the variation in abundance of sexual structures that contain the seeds (i.e., flowers and fruits) at various depths. Although, the relationship between abundance of such structures is independent with water depth, the differences in the proportion of sexual structures of S. isoetifolium was consistently significant between sampling stations and water depth categories. S. isoetifolium in the middle (i.e., ½ deep water depth category) part of the seagrass bed are more successful in flowering and fruiting than in the near shore or offshore portions. Only 10 % of the shoots of S. isoetifolium are flowering. And the smaller proportion of fruits (i.e., 1.8 % to 18.8 %) compared with flowers (24.2 % to 29.74 %) reflects the numerous abortion of fruits or difficult fruiting dynamics of S. isoetifolium. There are more female flowers (89.5 %) than male flowers (10.5 %) of S. isoetifolium in Bogtong Bay; hence there are about 9 female flowers for every one male flower. Therefore, the reproductive effort and success of S. isoetifolium exhibit spatial heterogeneity and that the colonization and that their recovery depends more on rhizome growth than on sexual reproduction.

Keywords: *Syringodium isoetifolium*; seagrass flowering; seagrass demography, Philippines

INTRODUCTION

Studies of seagrass reproduction and phenology are important in determining the contribution of reproduction to the population dynamics of different seagrasses. Quantification of flowering, fruiting and seed production is essential in understanding dispersal and recruitment characteristics of different seagrass species, especially for seagrasses where seed production is critical to colonization processes. Determining flowering frequency, sex ratios and reproduction success also allows the mating system of plants to be determined (Waycott and Sampson 1997), enhancing the understanding of genetic structure. Reproductive biology may also be critical in the re-establishment of declining seagrass populations and in targeting the best species for use in revegetation (Orth et al. 1994).

Knowledge of seagrass phenology is still relatively poor. For some species, the flowers have never been completely described because of the difficulty in locating the relatively infrequent produced flowers. For example, *Cymodocea angustata*, an endemic species to northwestern Australia first described in 1916 has never been recorded with male flowers (McMillan et al. 1983). The extreme patchiness of flowers and fruits makes quantification of the extent of flowering very difficult (Kuo and Kirkman 1992). Even for widespread and much-studies species such as *Zostera marina* which flowers frequently (Phillips and Backman 1983, Orth and Moore 1983, Olesen 1999), there are considerable variations in the spatial and temporal extent of flowering and successful seed production.

Seagrass es can exhibit male and female plants (dioecious), or have both sexes on the same plant (monoecious). For example, the Posidoniacease are exclusively monoecious, the Hydrocharitaceae and Zosteraceae have both monoecious and dioecious species and the Cymodoceaceae are exclusively dioecious. Overall, about 75% of all seagrass species are dioecious (Waycott and Les 1996). Floral parts include petals, sepals, stamens and pistils. The flower structure is usually simple, with a reduced perianth (Kuo and McComb 1989), but with considerable variation between species. Flowers are usually solitary and terminal on erect shoots or their branches.

Flowers and fruits of seagrass es are usually small and inconspicuous and so are often not collected. They often have a restricted flowering period, which makes the quantification of the process quite difficult. The extent and timing of flowering in seagrass es worldwide is variable, between species, and between locations, making generalizations difficult. In tropical regions, seagrass flowering is a year-round phenomenon but with variations in intensity related to location. In temperate regions, flowering often occurs in spring, but the timing of the whole reproductive cycle varies with both species and location (Walker et al 2001).

The dioecious *Syringodium isoetifolium* (Asherson) Dandy (Noodle seagrass) one of the two closely related but geographically separated species. The other species, *Syringodium filiforme,* is found only in the Caribbean Region (Florida to Brazil, i.e., Carribean Sea and Gulf of Mexico to Brazil). *S. isoetifolium*, on the other hand, is found in the Regions of South Africa, Indo-Pacific, and South Australia (Kuo and den Hartog 2001). Easily recognized by its cylindrical, solid leaves; rhizomes that are slender, up to 1.5 mm in diameter, the roots of *S. syringodium* is laxly branched that arise below the erect shoots, which in turn bear 2-3 leaves, and the lower part of the leaf covered with sheath. Male and female flowers are in separate clusters in the same plant and are covered by sheaths of reduced leaves (Calumpong and Meñez 1997). *S. syringodium* was found to be the most abundant seagrass species in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur, Philippines (Clores unpubl. data).

The male flower of Genus *Syringodium* is stalked with 2 anthers attached at the same height on the stalk while the female flower has 2 free ovaries each with a very short style, which divides into 2 short stigmata. The blade is up to 30 cm long, 1-2 mm in diameter, with 7-10(-15) peripheral veins, which have a considerably smaller diameter than the central vein. Fruit is oblique ellipsoid, 3.5-4 mm long, 1.75-2 mm wide, and 1.5 mm thick (Kuo and den Hartog 2001). *S. isoetifolium* has 4-8 mm size seeds with hard coverings and distinct dormancy; dioecious breeding system, and persistent seed bank type (Inglis and Waycott 2001).

Recent interest on many chemically unique compounds of marine origin with different biological activity, lead to the discovery of antibacterial compounds that exist in *S. isoetifolium* root extract which was found to be effective against fish pathogens and therefore proved as excellent source for novel antibacterial compounds for the management of fish bacterial diseases (Ravikumar 2011).

This study focused on the variation in the spatial extent of flowering and fruiting of a seagrass population of *Syringodium isoetifolium* in a subtidal mixed-seagrass meadow at

Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur. The intensity and allotment of flowering and fruiting were determined by examining shoots of *S. isoetifolium* collected in three water depth categories (e.g., shallow, ½ deep and deep depths). At present no data is available, especially in the phenology of *S. isoetifolium* found growing in a sub tidal meadow.

Hence, a study like this is groundwork in understanding the contemporary and historical patterns of recruitment and the processes by which such seagrass population or meadow are established and maintained in this area, is an essential step to describe their demography and evolution of their history strategies. If combined with genetic typing studies in the future, results of the present study could also provide inputs on the processes that control the long-term dynamics of seagrass meadows, particularly, the ability of seagrass populations to respond to a range of natural and anthropogenic stresses. At the most fundamental level, similar researches help unravel the complex systematic relationships within this plant group, and accordingly, the true global range of species and genetic diversity of seagrass es that ought to be protected (Inglis and Waycott 2001).

MATERIALS AND METHODS

Study Site

Two (2) sampling stations, separated by approximately 150 m, were established in seagrass meadow at Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur. The meadow extends to an approximate length of 375 m (Figure 1).

Adapted from Google Maps (www.maps.goggle.com)

Figure 1. Map of Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur, Philippines ($13^0$57'N, $123^0$50'E)

Sampling Strategy

In each station, a 100-m transect were placed through the center of the seagrass bed from shore to deep edge which in turn were crossed by three (3) perpendicular 50-m transects, with 12 randomly chosen 0.25 m^2 quadrats at each water depth (e.g., shallow; ½ deep; deep depth) (Burdick and Kendrick 2001). The water depth was measured 5 times using a marked pole across the transect at approximately 10 m interval. At the center of each quadrat, one core

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sample was obtained using a Ponar device, which grabs seagrass es with its substrate from an area of about 714 cm^2 (i.e., 28 cm x 25.5 cm). Thus, a total of 72 core samples (36 from each of the 2 stations or 12 from each of the 3 depth categories per station) were collected within the mixed-seagrass area in the bay. Also, the total area sampled equaled to 51408 cm^2 or (i.e., A =714 cm^2 x 72 sampling effort). This is to conform with the rule-of-thumb for seed bank studies that a large number of small samples are preferable to a small number of large samples (Gross 1990). Samples will be washed in the field through sieves (with apertures of 4.75 mm, 2.45, and 2.0 mm). The seagrass samples were transferred to plastic bags, which were placed in an icebox during transport, and then frozen in the laboratory until processing. Sampling was done on October 2011.

Estimating Flowering and Fruiting Distribution

In the laboratory, 130 shots from each transect (or depth category) were pooled and processed, thus a total of 780 sexual shoots in each of the two stations (or 390 samples per station) were prepared for analysis. Flowering shoot samples were counted and in each of these flowering shoot samples, the number of each reproductive structural unit of *Syringodium isoetifolium* (e.g., male and female flowers and fruits, if any) were counted and recorded. This estimate of flowering and fruiting distribution is also an estimate of total seed production (i.e., number of flowering shoots, male and female flowers, and fruits per m^2) because it is a measure of variation in the abundance of different sexual structures that contains the seeds (Inglis and Waycott 2001).

Data Analysis

Abundance and frequency distribution of flowering shoots, male and female flowers and fruits according to station and water depth were analyzed using descriptive statistics (e.g., count and percentage) and inferential statistics (Chi-square test, X^2) in testing hypotheses regarding significant differences of the observed proportions or values of variables between sampling stations and among depth categories and as well as significant relationship of flowering and fruiting success to water depth.

RESULTS

A total of 780 shoots (n=130 per water depth sampling transect line) of *Syringodium isoetifolium* were collected in the two sampling stations. From these shoot samples, about 78 (10%) shoots are flowering. More female flowers (274 or 89.54 %) than male flowers (32 or 10.46%) were noted in the total of 308 male and female flowers counted. A total of 112 fruits still attached to the shoots were counted. The female to male ratio of flowers shows that in general there are about 9 female flowers for every one male flower, and such ratio increased when in ½ deep water (i.e., 11 female flowers for every 1 male flower) (Table 1).

Taking both the data together from the two stations, as shown also in Table 1 and Figure 2, about 50 or 64.10 % of the 78 shoots were collected in ½ deep depths. In both counts of male and female flowers, the highest was noted in ½ deep depths (18 or 56.26 % for male and 201 or 73.36 % for female flowers, respectively). The same was observed in the fruiting success wherein about 110 or 98.21 % of the fruits were collected also in ½ deep depths. There are more female than male flowers as indicated by the overall ratio of about 9 female for every male flower. The differences of the proportion of flowering shoots, male and female flowers and fruits across the three water depths were found to be significant at $p = 0.05$ using χ^2 – test (Table 1).

Table 1. Overall distribution of flowering shoots, fruiting success and female to male flower ratio of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur.

Variables	*Depth Categories in Stations I and II*			*Total*	
	Shallow	*1/2 Deep*	*Deep*	*N*	χ^2 *(df = 2)*
Flowering shoots	25 (32.05)	50 (64.10)	3 (3.85)	78 (10)	42.54
Male flowers	10 (31.25)	18 (56.25)	4 (12.5)	32 (10.458)	49.57
Female flowers	68 (24.82)	201 (73.36)	5 (1.82)	274 (89.542)	219.26
Fruits	2 (1.79)	110 (98.21)	0 (0.00)	112	212.23
Flower Sex Ratio (Female: Male)	6.8	11.2	1.25	8.6	

(Percentage in parenthesis)
Note: Chi-square tests were used to test differences in group proportions. All ps > 0.05

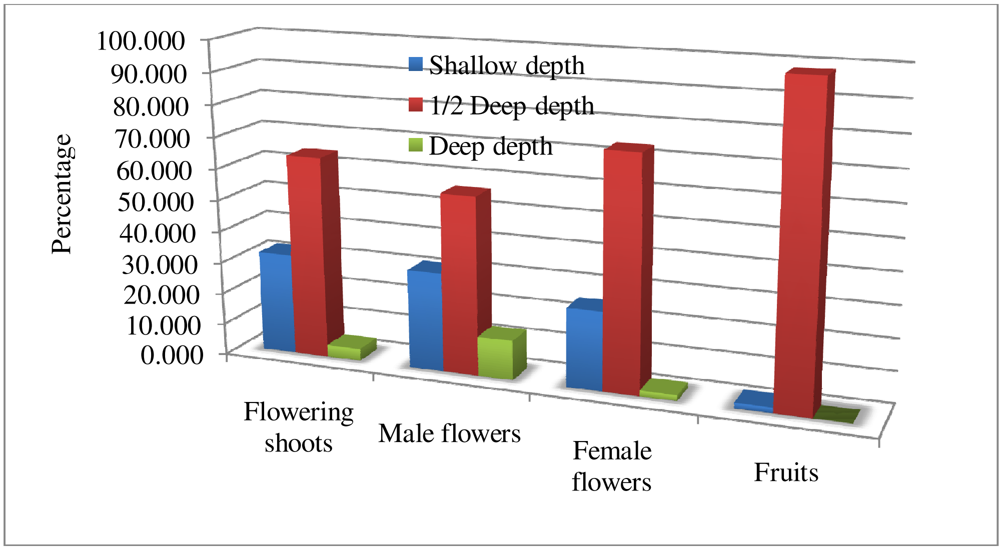

Figure 2. Overall flowering and fruiting distribution of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur

Analysis of data by station and depth category revealed that that there was more flowering shoots of *S. isoetifolium* observed in Station 1 (54 or 41.54 %) compared with Station 2 (24 or 18.46 %). In both stations, the most number of flowering shoots was counted in ½ deep depth (34 or 26.15 % in Station 1 and 16 or 12.31 % in Station 2) while the least number of flowers was at the deep depth (2 or 1.54 % in Station 1 and 1 or 0.77 % in Station 2) (Tables 2-3 and Figure 4).

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Table 2. Flowering and fruiting distribution of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur (Station I) (N=390 or 130 shoots per transect or depth category).

	Station 1				χ^2
Variables	*Depth Categories*				*(df = 2)*
	Shallow	*1/2 Deep*	*Deep*	*Subtotal*	
Flowering shoots	18	34	2	54	28.44
	(13.846)	(26.154)	(1.538)	(41.538)	
Male flowers	6	9	4	19	2.00
	(18.750)	(28.125)	(12.500)	(59.375)	
Female flowers	50	143	3	196	155.41
	(18.248)	(52.190)	(1.095)	(71.533)	
Fruits	0	91	0	91	182.02
	(0.000)	(81.250)	(0.000)	(81.250)	

(Percentage in parenthesis)
Note: Chi-square tests were used to test differences in distribution across various depth categories in Station I.
All *ps* > 0.05, except for male flowers distribution.

Table 3. Distribution of flowering, sex of flowers and fruits of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur (Station II) (N=390 or 130 shoots per transect or depth category).

	Station 2				χ^2
Variables	*Depth Categories*				*(df = 2)*
	Shallow	*1/2 Deep*	*Deep*	*Subtotal*	
Flowering shoots	7	16	1	24	14.25
	(5.385)	(12.308)	(0.769)	(18.462)	
Male flowers	4	9	0	13	9.39
	(12.500)	(28.125)	(0.000)	(40.625)	
Female flowers	18	58	2	78	64.00
	(6.569)	(21.168)	(0.730)	(28.467)	
Fruits	2	19	0	21	31.14
	(1.786)	(16.964)	(0.000)	(18.750)	

(Percentage in parenthesis)
Note: Chi-square tests were used to test differences in distribution across various depth categories in Station II.
All *ps* > 0.05

Except for male flowers distribution in Station I, the χ^2 – tests found significant differences in the proportions of the given variables between stations and across water depth categories with *p*-value set at 0.05 using χ^2 – tests (Tables 1-3).

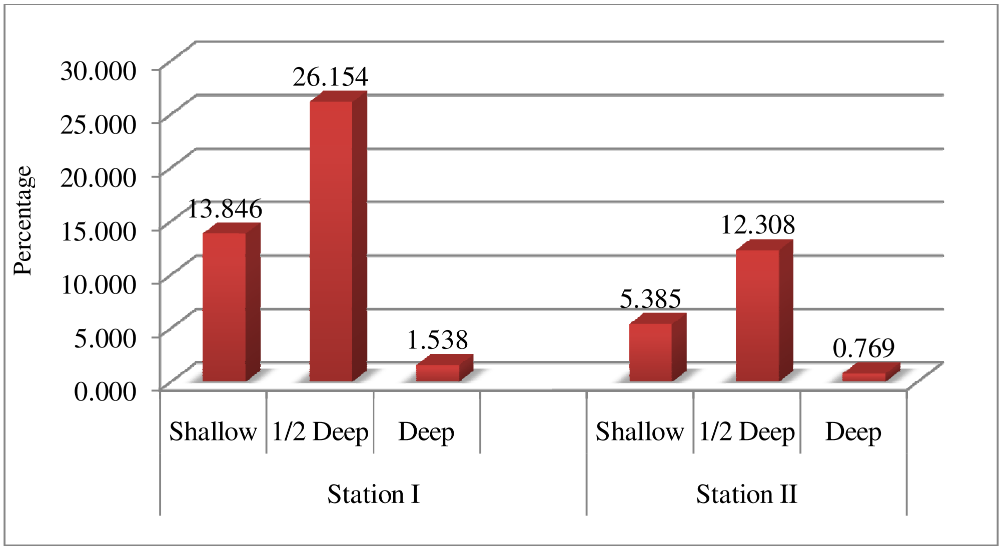

Figure 4. Distribution of flowers of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur

From a total of 32 male flowers of *S. isoetifolium* collected, 19 or 59.38 % were from Station 1 while 13 or 40.63 % were collected in Station 2. In both stations, the most number of male flowers were collected at ½ deep depth (9 or 28.13 %). In Station 1, the least number of male flowers were collected at deep depth (4 or 12.50 %); no male flower was collected in deep depth of Station 2 (Tables 2-3 and Figure 5).

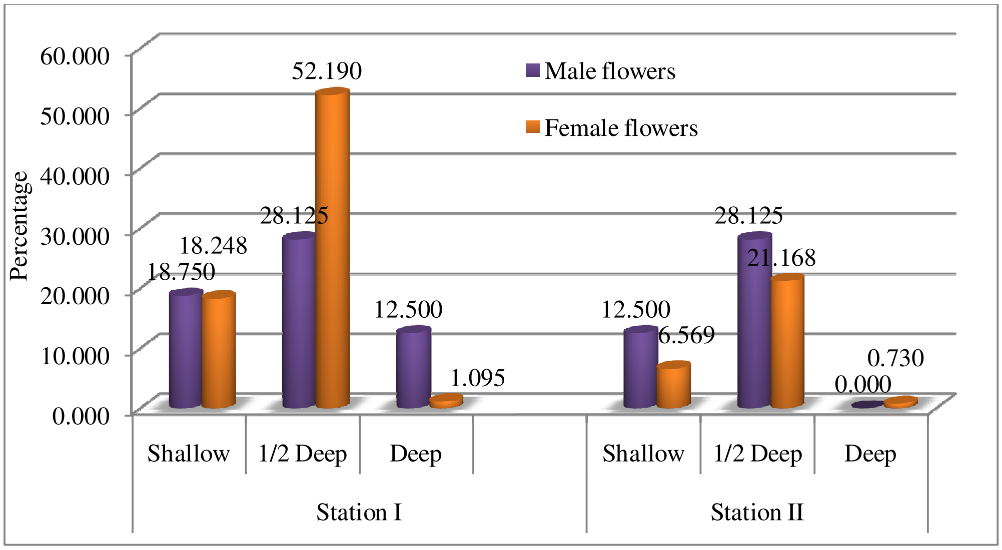

Figure 5. Distribution of flowers of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur

Of the 274 female flowers of *S. isoetifolium*, 196 or 71.53 % were collected in Station 1 while7 8 or 28.47 % were collected in Station 2. In Station 1, the most number of female flowers were located at ½ deep depth (143 or 52.19 %) while the least were at deep depth (3 or 1.10 %). In Station 2, most of the flowers were collected also at ½ deep depth (58 or 21.17 %) while the least were collected also at deep depth (2 or 0.73 %) (Table 2-3 and Figure 4).

Table 4. Comparison between the distribution of male and female flowers of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur.

Sex of flower	*Station 1*				*Station 2*				χ^2 *(df = 1)*
	Depth Categories			*subtotal*	*Depth Categories*			*subtotal*	
	Shallow	*1/2 Deep*	*Deep*		*Shallow*	*1/2 Deep*	*Deep*		
Male	6	9	4	19	4	9	0	13	2.03^a
	(18.750)	(28.125)	(12.500)	(59.375)	(12.500)	(28.125)	0.000	(40.625)	0.79^b
Female	50	143	3	196	18	58	2	78	0.07^c
	(18.248)	(52.190)	(1.095)	(71.533)	(6.569)	(21.168)	0.730	(28.467)	2.06^d

(Percentage in parenthesis)

Note: Chi-square tests were used to test differences in distribution of male and female flowers across and between various depth categories in the two stations. All *ps* < 0.05. [a]Across all water depths; [b]Between shallow depths of the two stations; [c]Between ½ deep depths of the two stations; [d]Between deep depths of the two stations.

As indicated in Table 4, The χ^2 – test ascertained that the differences in the proportions of male and female flowers between stations and across water depth categories were significant at *p* - value set at 0.05 (Table 4).

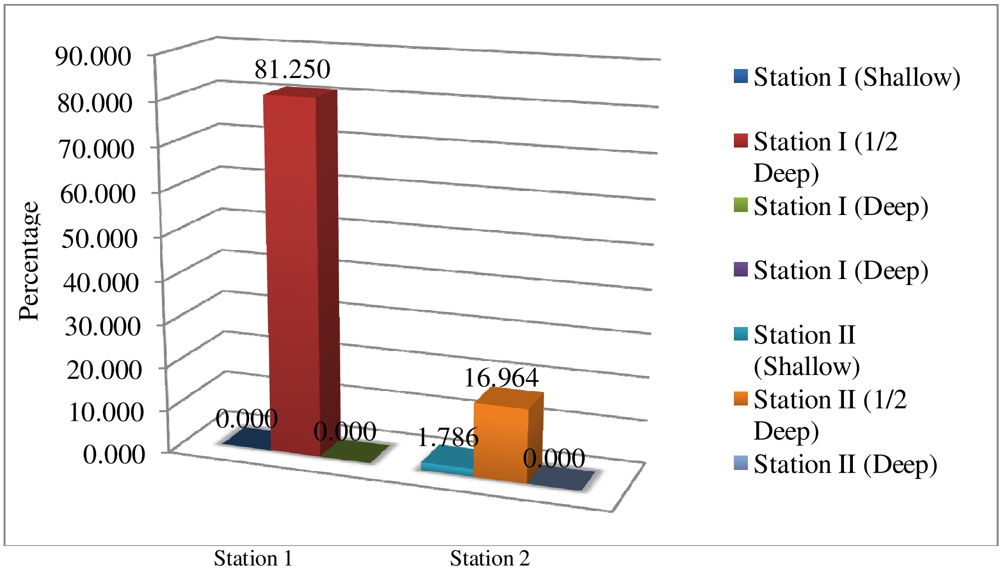

Figure 6. Distribution of fruits of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur

More fruits were counted in Station 1 (91 or 81. 25 %) than in Station II (21 or 18.75 %). All the fruits in Station I were found in ½ deep depth while most of fruits in Station 2 were collected also in ½ deep depth (19 or 16.96 %) (Tables 1 & 5 and Figure 5).

Table 5. Comparison between the distribution flowers and fruits of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur

Sexual Reproductive Structure	*Station 1*			*subtotal*	*Station 2*			*subtotal*	χ^2
	Shallow	*1/2 Deep*	*Deep*	*N (%)*	*Shallow*	*1/2 Deep*	*Deep*	*N (%)*	*(df = 1)*
Flowers	56	152	7	215	22	67	2	91	5.05^a
	(26.047)	(70.698)	(3.256)	(70.261)	(24.176)	(73.626)	(2.198)	(29.739)	5.68^b
Fruits	0	91	0	91	2	19	0	21	6.73^c
	(0.000)	(81.250)	(0.000)	(81.250)	(1.786)	(16.964)	(0.000)	(18.750)	1.79^d

(Percentage in parenthesis)

Note: Chi-square tests were used to test differences in distribution of flowering and fruiting across and between various depth categories in the two stations. All *ps* > 0.05, except for deep depths. [a]Across all water depths; [b]Between shallow depths of the two stations; [c]Between ½ deep depths of the two stations; [d]Between deep depths of the two stations.

The differences in the proportions of flowers and fruits between stations and across water depth categories were significant based on χ^2 – test with p - value set at 0.05 (Table 5).

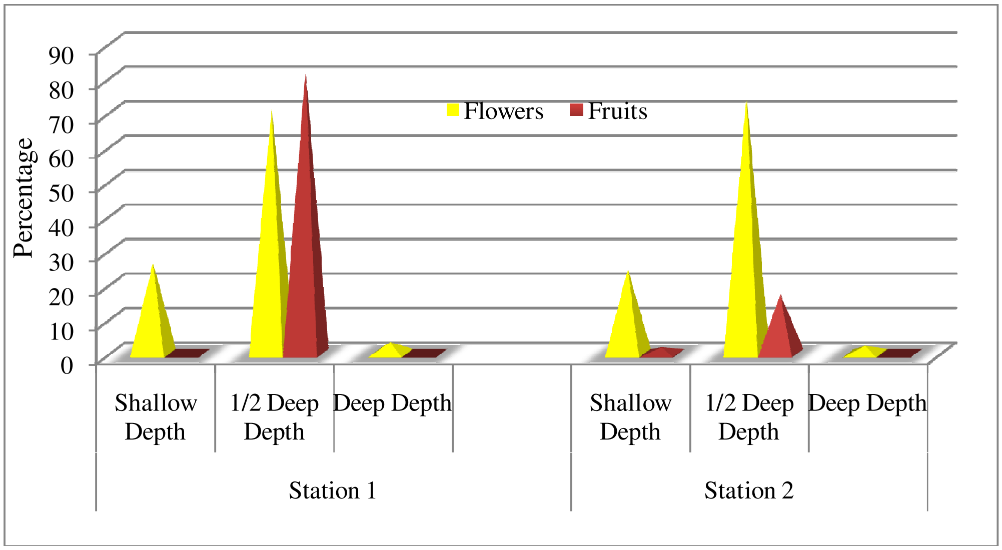

Figure 6. Distribution of flowers and fruits of *Syringodium isoetifolium* in Bogtong Bay, Lahuy Island, Caramoan, Camarines Sur

To be able to estimate the total seed production of *Syringodium isoetifolium* in the study site, the frequency count of flowering shoots, male and female flowers, and fruits per m^2 were reported and then tested using chi-square test. As shown in Table 6, *S. isoetifolium* in Station I and in the ½ deep water depth categories in both stations had more abundant sexual structures that contain the seeds (i.e., flowers and fruits). The same data revealed however, that such abundance is not related to water depth (χ^2 = 15.51, *df* = 8, *p* = 0.05 level). The sample differences are therefore attributed to the operation of chance alone.

In Figures 5-6, the floral morphology of *Syringodium isoetifolium* was shown. The female unit was recognized by the extended stigmata. Its carpel continues as a short style, which

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further extends into two rather stout stigmata. The male unit was identified by the anther that is enclosed by its pair of bracts while others, which, are in dehiscence have elongated floral axes. From the pair of carpel of female units, fruits develop, but abortion of one or both of them was obvious.

DISCUSSION

In a small bay like Bogtong Bay, *Syringodium isoetifolium* showed variation in abundance of sexual structures that contain the seeds (i.e., flowers and fruits). Even though, the relationship between abundance of such structures is independent with water depth, the differences in the proportion of sexual structures of *S. isoetifolium* were consistently significant between sampling stations and water depth.

There are many factors that influence the over-all seagrass meadow characteristics, including flowering and fruiting success. As sub tidal plants, seagrass does not tolerate exposure well because when exposed to the air and heat, they lose water continuously until they dry out. Hence, exposure at the shallow end of the depth gradient limits the depth distribution of seagrass es (Kenworthy and Haunert 1991). Additional factors that affect light availability include shading either by epiphytes (small algae attached to the surface of seagrass blades) in shallow water seagrass beds (de Boer 2007).

Light availability sets the lower distribution boundary depth affecting the light attenuation in the water column (de Boer 2007). Morris and Tomasko (1993) indicate that light is the primary environmental factor controlling the survival and the depth distribution of seagrass es. More specifically, light in the range of wavelengths from 400 to 700 nm (known as photo synthetically active radiation) provides the predominant source of energy for seagrass photosynthesis to occur. Phytoplankton blooms due to nutrient enrichment, turbidity, and water color due to dissolved organic material also weaken or attenuate light as it travels through the water column (de Boer 2007).

Therefore, minimum water depth is mainly determined by wave orbital velocity, tide and wave energy; and maximum depth by light availability. This also explains why in Bogtong Bay, the success in flowering and fruiting of *S. isoetifolium* was observed in the middle (i.e., ½ deep water depth category) part of the seagrass bed than in the near shore (i.e., shallow water depth category) or offshore (i.e., deep water depth category) portions.

Seagrass flowers are usually small and inconspicuous. They are pollinated by water. Their seeds are also dispersed by water. In some species, the same plant produces male and female flowers. In others, male and female flowers are produced in separate plants, like *Syringodium isoetifolium*. However, seagrass es seldom flower. They spread mainly through vegetative reproduction through their underground rhizomes. Thus, seagrass es do not easily colonise new places (www.wildsingapore.com/wildfacts/)

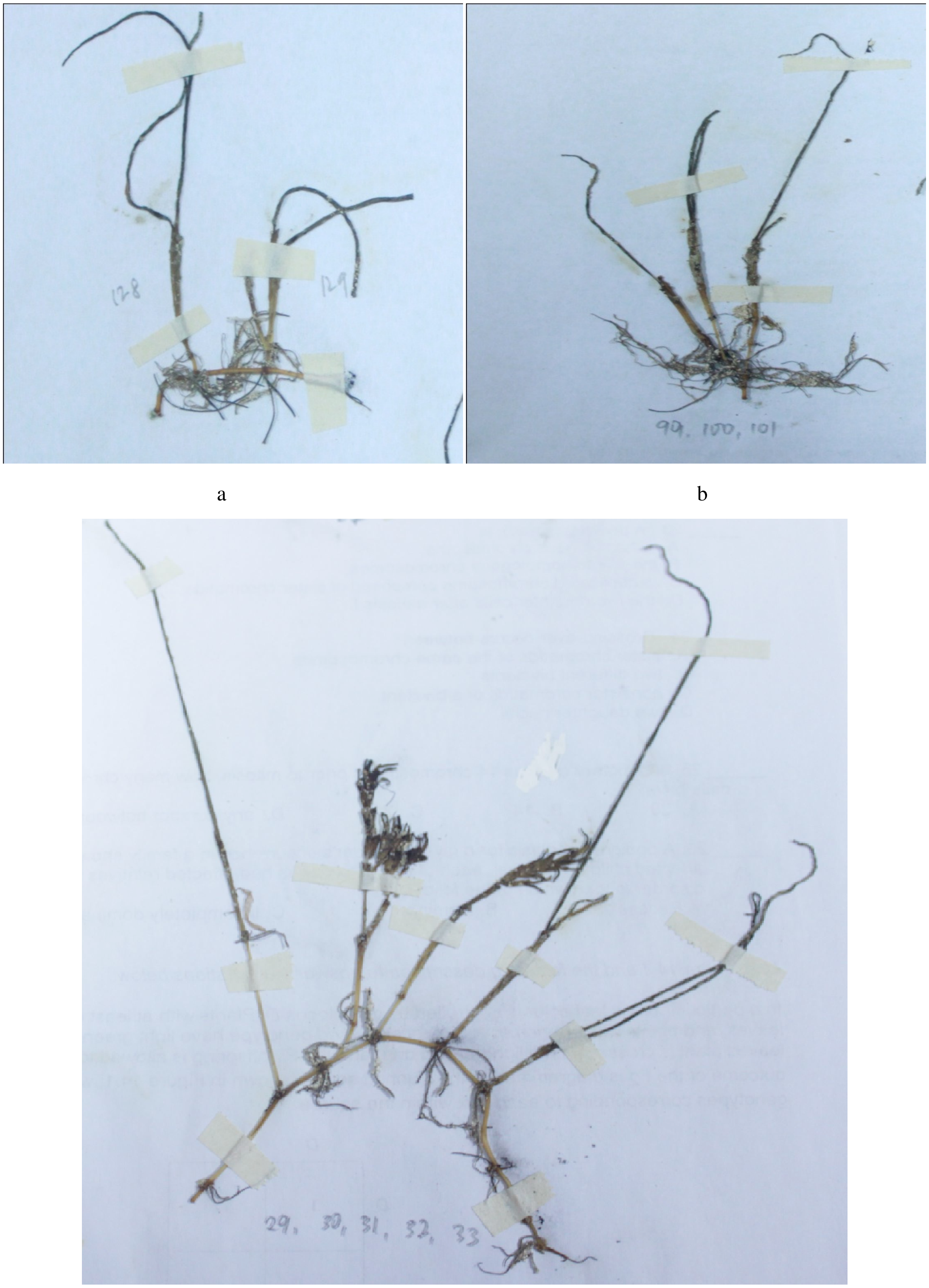
Plants/seagrass/syringodium.htm). The results of the present study confirmed the observations also of Kuo and Kirkman (1992) and Borum et al (2004) on extreme patchiness of flowers and fruits. In Bogtong Bay, only 10 % of the shoots of *S. isoetifolium* are flowering. And the smaller proportion of fruits (i.e., 1.8 % in Station I and 18.8 % in Station II) compared with flowers (i.e., 24.2 % in Station I and 29.74 % in Station II) reflects the numerous abortions of fruits or difficult fruiting success of *S. isoetifolium.* This frequent abortion of fruits was consistent with Borum et al (2004).

Table 6. Frequency count of flowering shoots, male and female flowers, and fruits per m^2. This estimate of flowering and fruiting distribution is also an estimate of total seed production (i.e., number of flowering shoots, male and female flowers, and fruits per m^2) because it is a measure of variation in the abundance of different sexual structures that contains the seeds (Inglis and Waycott 2001).

Variables	*Station I*				*Station II*				*Overall*
(n=frequency count)	*Shallow*	*1/2 Deep*	*Deep*	*Subtotal*	*Shallow*	*1/2 Deep*	*Deep*	*Subtotal*	
(count per m^2)									
Area sampled (A)	85.68 m^2	85.68 m^2	85.68 m^2	257.04 m^2	85.68 m^2	85.68 m^2	85.68 m^2	257.04 m^2	514.08 m^2
Flowering shoots (n)	18	34	2	54	7	16	1	24	78
Flowering shoots per m^2	*0.21*	*0.40*	*0.02*	*0.21*	*0.08*	*0.19*	*0.01*	*0.09*	*0.15*
Male flowers (n)	6	9	4	19	4	9	0	13	32
Male flower per m^2	*0.07*	*0.11*	*0.05*	*0.07*	*0.05*	*0.11*	*0.00*	*0.05*	*0.06*
Female flowers (n)	50	143	3	196	18	58	2	78	274
Female flower per m^2	*0.58*	*1.67*	*0.04*	*0.76*	*0.21*	*0.68*	*0.02*	*0.30*	*0.53*
Total no. of flowers (n)	56	152	7	215	22	67	2	91	306
Total no. of flower per m^2	*0.65*	*1.77*	*0.08*	*0.84*	*0.26*	*0.78*	*0.02*	*0.35*	*0.60*
Fruits (n)	0	91	0	91	2	19	0	21	112
Fruits per m^2	*0.00*	*1.06*	*0.00*	*0.35*	*0.02*	*0.22*	*0.00*	*0.08*	*0.22*

Note: The total area sampled (A) in the two stations was 51408 cm^2 or 514.08 m^2 (i.e., the area sampled by ponar device =714 cm^2 x 72 sampling effort). The area sampled per station was 25704 cm^2 or 257.04 m^2 (i.e., the area sampled by ponar device =714 cm^2 x 36 sampling effort). The area sampled per transect was 8568 or cm^2 or 85.68 m^2 (i.e., Area sampled by ponar device =714 cm^2 x 12 sampling effort). Chi-square (χ^2) test was used to test the relationship between the depth of water and the abundance of the reproductive structures per m^2 at 0.05 level. A χ^2-value of 15.51 was needed to reject the null hypothesis. Since the obtained χ^2-value is only 1.76, the null hypothesis is accepted. The sample differences can be attributed to the operation of chance alone. Water depth and the abundance of reproductive structures per m^2 are independent.

In other seagrass es like *Pocedonia oceanica*, the number of flowering shoots is usually very low, generally lower than 3 % per year. However, flowering intensity widely fluctuates between years. Massive flowering events (when more than 10% shoots flower) have been observed associated to extremely warm summers. Flowering intensity also varies with water depth, decreasing the number of flowering shoots with increasing water depth, and it depends on local conditions. *P. oceanica* female flowers do not succeed to develop viable fruits as a consequence of fruit abortion and, to less extent, predation. Actual seed production is less than 1% of potential seed production provided the amount of ovaries produced during flowering (Borum et al 2004).



a b

c

Figure 8. *Syringodium isoetifolium*, habit and inflorescence. (A, B) Rhizomes with erect leafy shoots, all non-flowering. (C) Older part of rhizome with 5 erect leafy shoots, two with terminal inflorescence

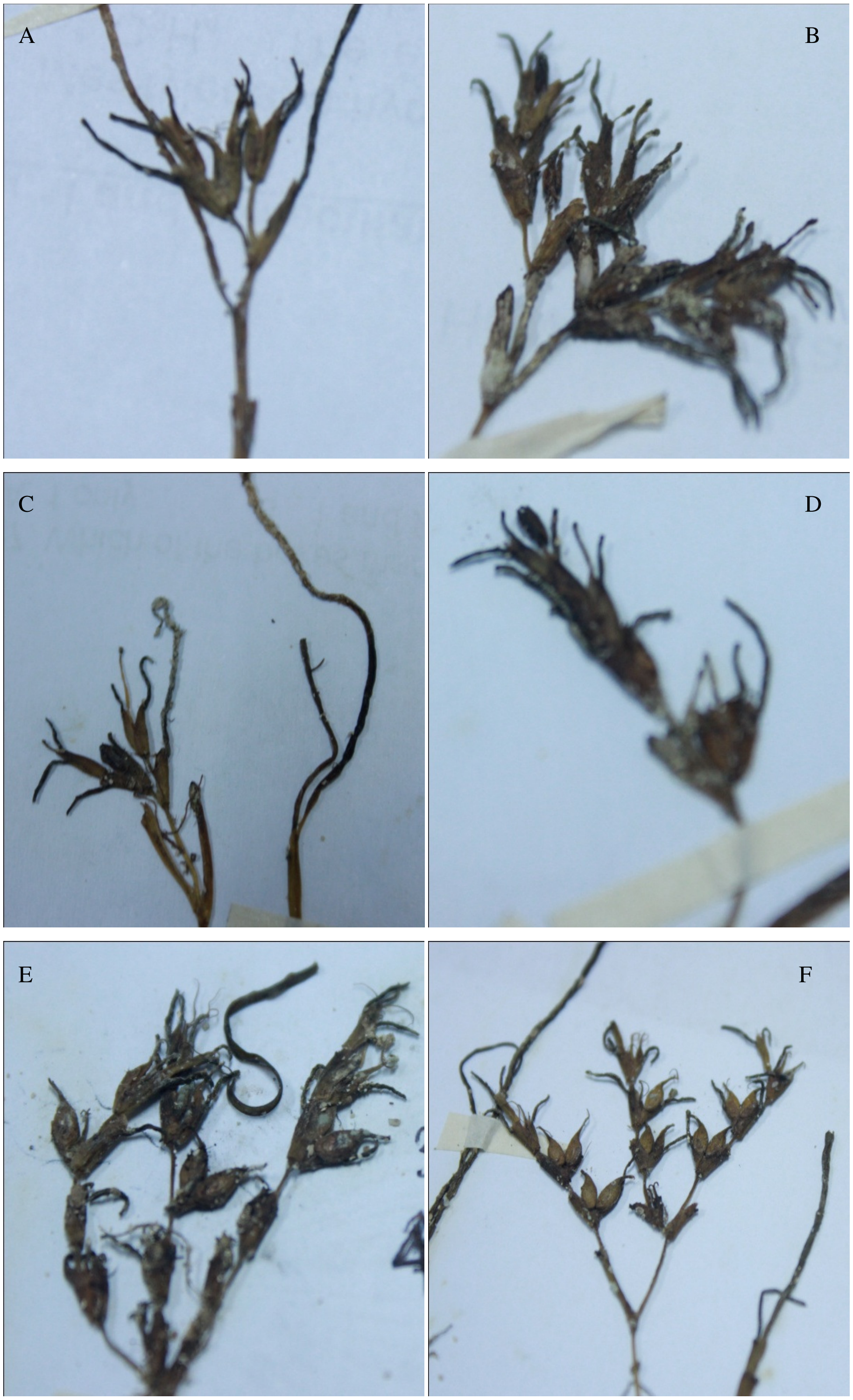


Figure 9. *Syringodium isoetifolium*, inflorescence complexes, flowers and fruits. (A) Female flower; Terminal units are shown, bract pair enveloping terminal female flowers; Also, the bicarpellate structure enclosed by the bract pairs, (B) Female and Male flowers. (C) Female and male flowers; Male flower still enclosed by its pair of bracts. (D) A male flower shown with elongated floral axes indicating dehiscence. (E, F) Fruits; Shown to have developed or originated from a pair of carpels at

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right angles to the subtending tract, other displaced into an oblique position; Some shows abortion of one or both of them (Description adopted from Tomlinson and Posluszny (1978)

Indeed, flowering is a rare event for most seagrass species, where typically < 10 % of the shoots flowers each year. In other seagrass es, the reproductive effort of seagrass es can be highly variable between years and among populations, and episodic mass flowering can occur in connection to climatic extremes. Disturbances, such as burial derived from the migration of sand waves may also enhance seagrass flowering. Because of the low probability of flowering, sexual reproduction is a negligible component of the carbon allocation of seagrass es, involving < 10 % of the annual production for most species (Borum et al 2004).

Syringodium isoetifolium was similar with *S. filiforme* morphologically, except for the difference in the number of peripheral veins in their blade. The latter occurred only in the Caribbean Region (Kuo and den Hartog 2001). The floral morphology of the two species was visibly identical. The extended stigma distinguishes the female unit. Also, the carpel continues as a short style, which further extends into two rather stout stigmata. On the other hand, the male unit was recognized by the anther that is enclosed by its pair of bracts while others, which, are in dehiscence have elongated floral axes. Fruits develop from the pair of carpels of female units. Nonetheless, abortion of one or both of them was frequently observed.

There are more female flowers (89.5 %) than male flowers (10.5 %) of *S. isoetifolium* in Bogtong Bay. This is confirmed by the ratio of female and male flowers, wherein over-all, there are about 9 female flowers for every one male flower. Such ratio found to be higher in ½ deep water (i.e., female: male ratio = 11.2:1) than in the shallow (i.e., female: male ratio = 6.8:1) or deep (i.e., female: male ratio = 1.2:1) parts of the bay. These findings indicate the reproductive effort and success of *S. isoetifolium* in Bogtong bay exhibits spatial heterogeneity. The seed production therefore can also be constrained by the observed spatial distribution and abundance of male and female units.

This was similar with the case of *Cymodocea nodosa* at Algrarve (S Portugal) wherein flowering intensity has been observed to increase in response to sand burial, hence, seed production was constrained by the spatial distribution and abundance of male and female clones. The consequences of clone sex composition on reproductive success are evident when examining *C. nodosa* meadow genetic diversity. Thus, there is almost no genetic diversity in a *C. nodosa* meadow at the Algarve (S Portugal), where no female flowers have been observed (Borum et al 2004). Coincidentally in Bogtong Bay, both male and female units are still observed, genetic diversity can still be expected, albeit, probably less as well since the unequal distribution of male and female units.

The main mechanism of seagrass es to occupy habitat space is vegetative proliferation, and thus it is a critical process for seagrass meadows to spread and persist. Rhizome growth is the process that regulates the rate of formation and the spatial distribution of ramets (and, thus, modules) within seagrass meadows, and, thus, it constrains the development of their populations. But the spread, and maintenance, of seagrass meadows also depend on sexual reproduction since it is the main mechanism regulating patch formation. Hence, information about the effort and success of seagrass reproduction and rhizome growth patterns are essential to predict the time scales of seagrass colonisation and, thus, recovery (Borum et al 2004).

From the results of the present study, it can be inferred that the colonization and recovery of *S. isoetifolium* in Bogtong Bay depends more on rhizome growth than on sexual reproduction. Nonetheless, further study must be needed to augment the limitations of the present research particularly in determining whether flowering intensity widely or thinly fluctuates between years. And even if the present study confirmed that flowering intensity also varies with water depth, the local conditions must be thoroughly monitored to infer the rate of formation and the spatial distribution of ramets (and, thus, modules) of *S. isoetifolium* within the seagrass meadow at Bogtong bay and the constraints of the development of their populations.

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