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Distribution and reproductive phenology of the seagrass *Cymodocea nodosa* (Ucria) Ascherson in the Canary Islands

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Abstract

Cymodocea nodosa (Ucria) Ascherson is the most common seagrass in the Canary Islands. Data about its insular distribution as well as observations on its flowering, fruiting and seed germination are shown. *Cymodocea nodosa* forms scattered meadows mainly along the southeastern coasts of these islands. The reproductive phenology was studied in meadows at El Médano, south of Tenerife. Flowering was detected from March to July, when fertile shoots were observed. Fruiting began in April and fruits were observed attached to shoots until December. Throughout the year numerous fruits were detected buried in the sediment. Seed germination was observed from February to September.

1. Introduction

In the Canary Islands, three species of seagrasses are present: *Cymodocea nodosa* (Ucria) Ascherson (Afonso-Carrillo and Gil-Rodríguez, 1980; Reyes, 1993), *Zostera noltii* Hornemann (Gil-Rodríguez et al., 1987) and *Halophila decipiens* Ostenfeld (Gil-Rodríguez et al., 1982). Although *Zostera marina* Linnaeus has been previously mentioned from the Canary Islands (Johnston, 1969; Acuña, 1970; Santos, 1972; González, 1976, 1977), all these reports were misidentifications of *Cymodocea nodosa*. The most common is *Cymodocea nodosa* that forms the most important marine ecosystem in areas of sandy bottom. Actually, the distribution of this seagrass is known for most of the Canarian coasts; nevertheless, few areas have been studied intensively and we lack data about the demarcation and maximum depth of meadows.

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Cymodocea nodosa is widely distributed along the Mediterranean coasts, the North Atlantic coast of Africa and the Canary Islands, reaching its southern limit of distribution in Senegal (Den Hartog, 1970; Afonso-Carrillo and Gil-Rodríguez, 1980; Lüning, 1990).

Bornet (1864) described in detail the morphology and anatomy of vegetative and reproductive structures of *Cymodocea nodosa*, as *Phucagrostis major* Cavolini. After the studies of Bornet (1864), the flowers, seeds and seedlings of this seagrass have been observed occasionally in some localities in the Mediterranean (Feldmann, 1937; Simonetti, 1973; Lipkin, 1977; Piré et al., 1983; Mazzella et al., 1983–1984; Caye and Meinesz, 1984, 1985; Pérez, 1989). The complete life history of *Cymodocea nodosa* in nature has recently been studied by Buia and Mazzella (1991), in meadows at the island of Ischia (Italy), and by Terrados (1991) in the Mar Menor coastal lagoon and other places on the southeastern Mediterranean coasts of Spain. Although regular germination of seeds has only been recorded in these localities, according to Terrados (1993) it appears that germination of seeds is uncommon in other zones of the Mediterranean Sea.

Although different aspects of the biology, ecology and sexual reproduction of *Cymodocea nodosa* have been the aim of numerous investigations in the Mediterranean Sea (e.g. Caye and Meinesz, 1985; Piré et al., 1986; Duarte and Sand-Jensen, 1990a,b; Peduzzi and Vukovič, 1990; Terrados, 1991, 1993; Buia and Mazzella, 1991; Pérez and Romero, 1992; Terrados and Ros, 1992), knowledge of these subjects on the Atlantic coasts is scarce and has been directed to observations about taxonomical aspects and local distribution (Afonso-Carrillo and Gil-Rodríguez, 1980; Wildpret de la Torre et al., 1987), its production during few days (Johnston, 1969; Van Lent et al., 1991) and its epiphyte community (González, 1976, as *Zostera marina* Linnaeus; Reyes, 1989).

The only data known on the reproduction of *Cymodocea nodosa* in the Atlantic Ocean were those reported by González (1980), who observed male flowers in a meadow in Las Canteras (north of Gran Canaria, Canary Islands), and those recently reported by Reyes and Sansón (1994) who described in detail the morphology and anatomy of the vegetative and reproductive structures of this species based on plants collected in El Médano (south of Tenerife, Canary Islands).

The aim of this paper is to present a compilation of the distribution of *Cymodocea nodosa* in the Canary Islands and to document flowering, fruiting and seed germination of this seagrass based on a study carried out during two successive flowering periods (1991 and 1992) in El Médano.

2. Materials and methods

Data on the distribution of *Cymodocea nodosa* in the Canary Islands are based on previous observations (Wildpret de la Torre et al., 1987) and on observations made during numerous dives along the Canarian coasts from 1988 to 1993. These data are summarised in map form, providing information on the location of the meadows detected.

To obtain reproduction data, one locality with representative meadows of *Cymodocea nodosa* was selected. The sampling site is situated at El Médano, a small bay of about 1 km^2, located south of Tenerife, Canary Islands (UTM 28RCS4801, 28RCS4802, 28RCS4902) (Fig. 1). The average depth in this bay is 4–5 m. Water salinity ranges from

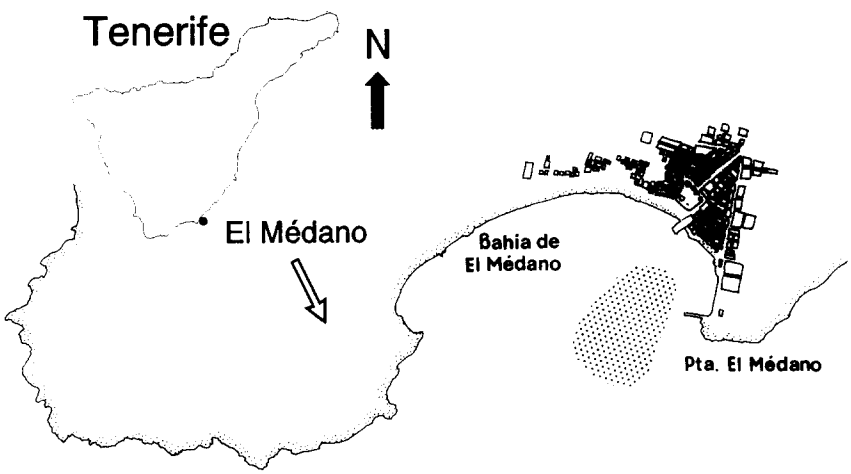

Fig. 1. Geographical location of the study area. Stippled surface represents the position of the meadows studied.

36.7 to 36.9‰ throughout the year (Mascareño, 1972) and water temperature varies from 18.5°C (January–February) to 24.5°C (August–September). The meadows studied are located off Punta El Médano, about 200 m from the shore and 50 m from El Médano harbour, at 5–7 m depth.

The reproductive phenology of *Cymodocea nodosa* was studied from January 1991 to July 1992. Monthly observations were carried out by SCUBA diving. The density of fertile shoots was estimated using four quadrats of 30 cm × 30 cm × 20 cm, randomly located and sunk in the sediment. Plants in these quadrats, including rhizomes and roots, were harvested with a shovel. Samples were carefully sieved in situ through a fine plastic mesh. At the laboratory, plants, fruits and seedlings were isolated and sorted. For each sample, the total number of shoots, number of shoots bearing male or female flowers or fruits, fruits in the sediment and seedlings were recorded.

Past flowering events were estimated by assessing the orthotropic rhizomes, taking into account the plastochrone interval (*PI*) (Erickson and Michelini, 1957; Caye and Meinesz, 1985) and the scars of stamens and fruits.

3. Results and discussion

3.1. Distribution

Cymodocea nodosa plants are generally established in shallow areas of reduced water activity to about 35 m depth. This seagrass forms monospecific submarine meadows or populations mixed with the green alga *Caulerpa prolifera* (Forsskål) Lamouroux. Meadows are generally located along the semi-exposed and sheltered southeastern coasts of the central (Tenerife and Gran Canaria) and eastern islands (Fuerteventura and Lanzarote). In the western islands (Gomera, Hierro and La Palma) they are only located in restricted areas (Fig. 2).

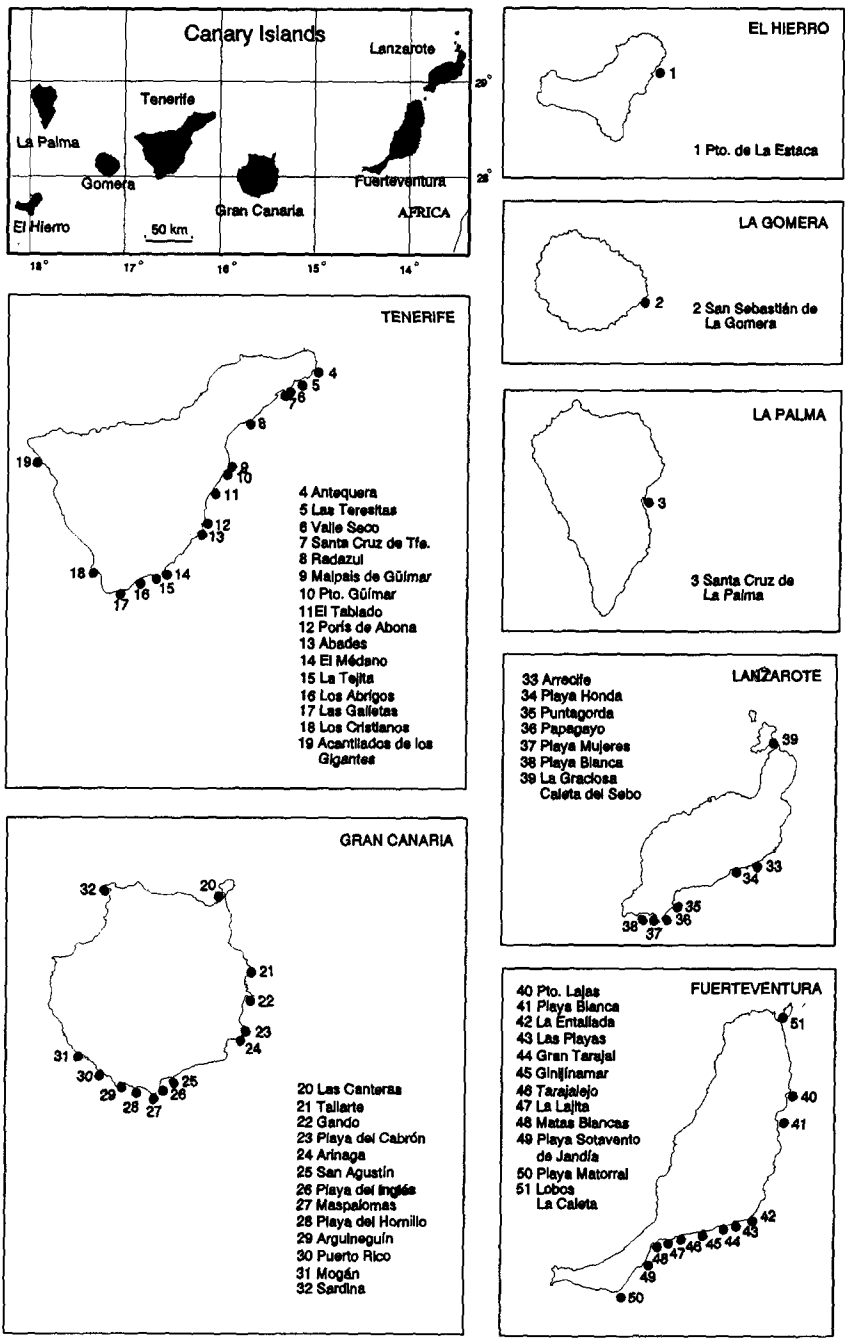

Fig. 2. Distribution of *Cymodocea nodosa* in the Canary Islands.

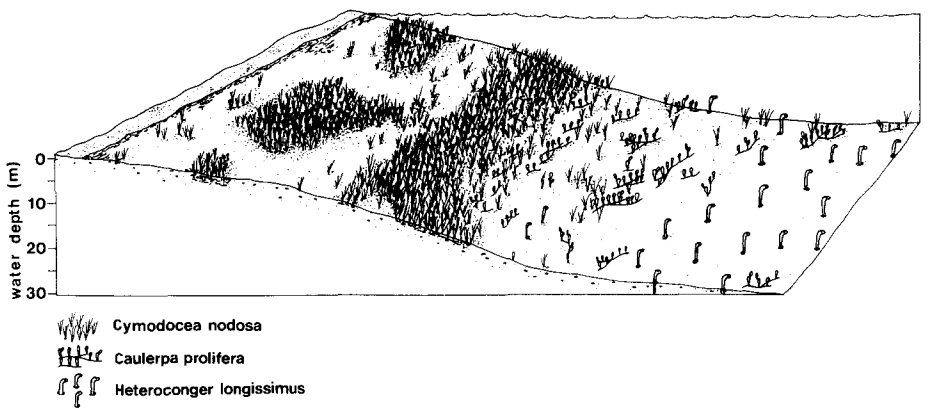

Fig. 3. Vertical distribution of *Cymodocea nodosa* in El Médano.

The northern coasts of the islands are influenced by the Alisios Winds coming from the northeast (Huetz de Lemps, 1969), that lead to high water activity, with strong currents and frequent swell period. These high hydrodynamics, as well as the rocky nature of the shallow bottom, prevent the establishment of *Cymodocea nodosa* meadows. However, southern coasts are partially protected from the action of the predominant winds and their shallow submarine bottoms show extensive areas with sandy–muddy substrate that permit the development of these meadows.

In the western islands (Gomera, Hierro and La Palma) *Cymodocea nodosa* only forms meadows in the harbour areas. In contrast, meadows are not produced in the non-harbour littoral regions. The reason for this seems to relate to the topography of the latter areas where there is a predominance of either rocky and steeply inclined, or unstable sandy bottom. These meadows are sparse and plants are generally smaller than those developed in a more natural environment.

Cymodocea nodosa shows a patchy distribution in shallow meadows that are formed at less than 5 m depth, in areas with high water activity. The boundaries of these patches are subject to continuous changes in their perimeters, showing obvious modifications in the aspect of the meadows in time. The minimum depth that this species can tolerate is usually imposed by instability of substrate or exposure at low tide. Some *Cymodocea* shoots were detected in an intertidal zone growing in a sandy pool. Between 5 and 35 m depth, *Cymodocea nodosa* forms more continuous meadows. The maximum depth to which it grows is imposed by light availability (Duarte, 1991), reaching 35 m depth in some Canarian localities. At these depths, *Cymodocea nodosa* is less abundant, in some cases being progressively replaced by *Caulerpa prolifera*, that can colonise bottoms to 50 m depth. Zones with muddy bottoms subject to continuous currents are not suitable for the establishment of *Cymodocea nodosa* but are appropriate for the benthic fish *Heteroconger longissimus* Günther. In some areas (13–40 m depth) southeast of Tenerife and Gran Canaria, *Cymodocea nodosa* is replaced by the seagrass *Halophila decipiens*, which forms extensive meadows (Gil-Rodríguez et al., 1982).

In El Médano, the locality selected for the study of the reproductive phenology of *Cymodocea nodosa*, this species forms meadows between 1 and 30(–35) m depth (Fig.

3). In the sandy–muddy bottom of the bay, *Cymodocea nodosa* shows a patchy distribution, sometimes forming mixed populations with *Caulerpa prolifera*. Out of the bay, at 10–20 m depth, *Cymodocea nodosa* forms continuous monospecific meadows that are partially mixed and replaced in depth by *Caulerpa prolifera* and the amphiatlantic tropical fish *Heteroconger longissimus*, that lives in a vertical hole with its head directed to the dominant current to feed.

3.2. Reproductive phenology

Cymodocea nodosa is a dioecious seagrass. Both male and female flowers were observed from 3 to 10 m depth. The first male flowers were detected at the end of March, when the seawater temperature began to rise after the winter minimum. The water temperature for flowering ranged from 19 to 20°C. In April, male flowers were easily recognisable by the swelling of the anthers and elongation of the filaments. In mid-April the first female flowers, with their filamentous stigmata arising from the leaf sheath, were seen. At the end of this month, young fruits were observed. In May, both male and female flowers were still detected. Some male flowers were observed releasing the filamentous pollen and the others were senescent. Many female flowers were fertilised and different post-fertilisation stages were observed. The first mature fruits attached to plants were found at the end of May. In June, all flowers were senescent. Shoots bearing mature fruits were detected until December although progressively the fruits fell and were deposited on the sediment. The germination of seeds was seen from February to September.

In El Médano meadows, the flowers are not randomly distributed but in separate male and female patches, although in some areas they form mixed patches. This microdistribution of flowers is similar to those observed by Caye and Meinesz (1985) in some localities of the French Mediterranean coasts, by Buia and Mazzella (1991) in the Island of Ischia (Italy) and by Terrados (1993) in Mar Menor lagoon (Spain).

The densities of vegetative and reproductive shoots of *Cymodocea nodosa* in the meadows studied are shown in Table 1. Although the density of flowers in 1992 was considerably lower than in 1991, the flowering of *Cymodocea nodosa* was similar in timing. Probably, the less abundant flowering in 1992 was likely a consequence of a short but intense storm which produced a great detachment of plants in the study area. High numbers of fruits and seedlings were detected in the sediment (Table 1). Based on flower density (up to about 25% of the shoots flowered in spring 1991) and seed bank size (up to 1378 fruits m^{-2}), flowering and fruiting of *Cymodocea nodosa* in El Médano seem to be more important than was reported from the Mediterranean Sea (Caye and Meinesz, 1985; Pérez, 1989; Buia and Mazzella, 1991; Terrados, 1991). However, in relation to the high number of fruits in the sediment, only a low number of seedlings, always less than 1 year old, was detected with developed rhizome. The seeds remain on the bottom or may be transported by currents, useful for the recolonisation of damaged meadows or for settlement in new open areas, although according to Terrados (1993) the survival of seedlings and their contribution to the maintenance of a patch in established meadows may be higher than on bare substrate.

The vegetative and reproductive phenology of *Cymodocea nodosa* in El Médano is summarised in Fig. 4. The life cycle of *Cymodocea nodosa*, from flowering to seed germination, lasts 1 year, with about 1–2 months for flowering, 2–3 months for fruiting and 7–9

Table 1
Density (shoots m^{-2}) of vegetative shoots, shoots with flowers or fruits, fruits in the sediment and seedlings in *Cymodocea nodosa* in El Médano from January 1991 to July 1992 ($n=4$; mean ± standard deviation)

Month	Vegetative shoots		Shoots with male flowers		Shoots with female flowers		Shoots with fruits		Fruits in sediment (m^{-2})		No. seedlings (m^{-2})	
	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
Jan.	1075 ± 149	1005 ± 35	–	–	–	–	–	–	55 ± 54	225 ± 157	–	–
Feb.	1001 ± 138	1186 ± 130	–	–	–	–	–	–	97 ± 100	192 ± 63	5 ± 3	14 ± 6
Mar.	1033 ± 112	1217 ± 96	353 ± 160	6 ± 6	–	–	–	–	97 ± 100	206 ± 37	50 ± 48	75 ± 51
Apr.	1291 ± 180	1333 ± 95	164 ± 105	19 ± 12	55 ± 45	–	3 ± 4	–	122 ± 62	211 ± 148	64 ± 32	14 ± 10
May	1283 ± 179	1669 ± 224	34 ± 24	11 ± 13	25 ± 14	6 ± 9	153 ± 135	19 ± 22	155 ± 95	141 ± 87	50 ± 42	58 ± 40
Jun.	1566 ± 274	1812 ± 38	3 ± 4	3 ± 4	3 ± 4	3 ± 4	95 ± 84	28 ± 19	591 ± 416	216 ± 92	25 ± 20	28 ± 17
Jul.	1652 ± 202	1850 ± 110	3 ± 4	–	–	–	47 ± 48	30 ± 15	325 ± 239	366 ± 131	25 ± 20	20 ± 8
Aug.	1916 ± 434		–		–		11 ± 19		365 ± 585		17 ± 10	
Sept.	1514 ± 138		–		–		19 ± 22		638 ± 572		11 ± 3	
Oct.	1125 ± 119		–		–		36 ± 9		439 ± 123		–	
Nov.	1200 ± 17		–		–		5 ± 5		377 ± 164		–	
Dec.	930 ± 127		–		–		3 ± 4		386 ± 125		–	

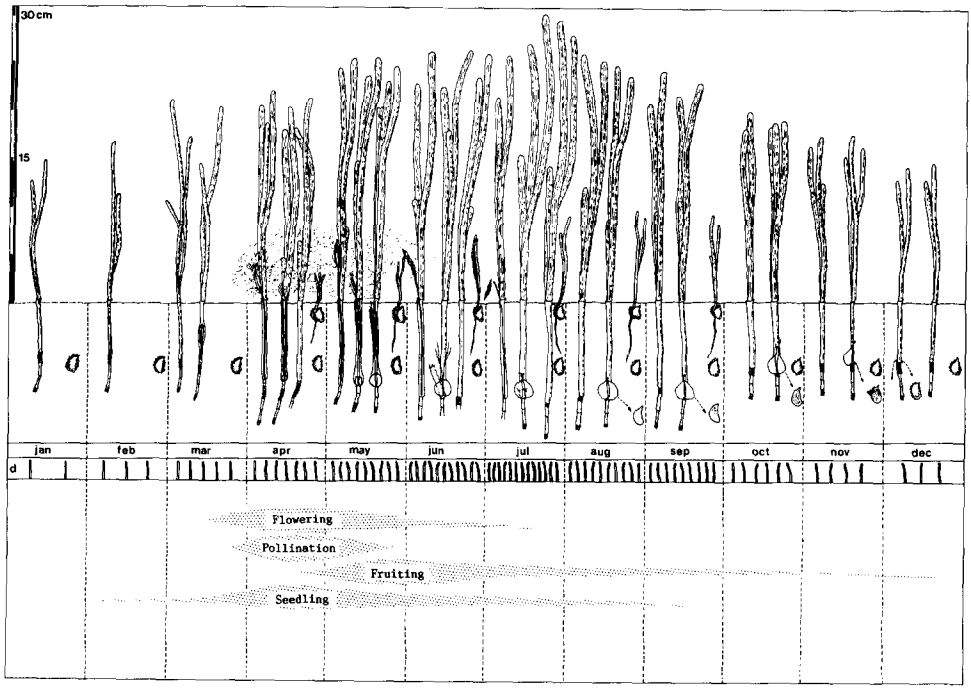

Fig. 4. Schematic representation of the vegetative and reproductive phenology of *Cymodocea nodosa* in El Médano, Canary Islands. Note the variations in the length and width of the leaves, the number of leaves per shoot and the shoot density in the meadows (d), as well as the flowering, pollination, fruiting and seedling periods. The detachment and presence of fruits in the sediment is also shown. The extent of the stippled surfaces indicates the intensity of each event throughout the year.

months of seed dormancy. This behaviour is similar to that reported for this species in different localities of the Mediterranean Sea (Buia and Mazzella, 1991; Terrados, 1993) although, in El Médano, formation of fruits was earlier, probably because of the differences in the temperature and light conditions between this locality and the Mediterranean.

Reyes (1993) using the plastochrone interval (*PI*) for El Médano meadows obtained a mean *PI* annual value of 27.9 days. This value is equivalent to 13 leaves produced per shoot per year, at variable intervals of time along the year. Based on this *PI* value and the presence of stamen and fruit scars, we could establish that several orthotropic rhizomes had flowered each year at least since 1985. These results support the idea that flowering in these meadows is common each year. Although flowering and fruiting have been observed in some localities off the Canary Islands in similar periods of the year, further studies are necessary in other meadows to evaluate their intensity and frequency.

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