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Distribution of the Invasive Species *Caulerpa prolifera* along the Coasts of the Suez Canal, Egypt

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ABSTRACT

Seven years-round since 1999, distribution and percentage cover were investigated in *Caulerpa prolifera* collected from 13 stations along the coast of the Suez Canal at different depths and from different types of substrates as well as from monthly collected samples in a dense unshaded meadow at a depth of 3-7 m at Great Bitter lakes. *Caulerpa prolifera* start increasing their cover in Spring and continued to increase into Autumn, with maximum cover in Winter. The seasonality patterns have been correlated with changes in light, temperature, desiccation and grazing. A rapid spread and high abundance of the invaded *Caulerpa prolifera* were observed on sandy or muddy sea bottom in shallow protected area of the Great Bitter Lakes. *Caulerpa prolifera* changes the ecology of area by reducing the abundance of native marine fauna and flora.
Key words: *Caulerpa prolifera*, chlorophyta, Seaweeds, invasion, Bitter Lakes, Suez Canal.

INTRODUCTION

Caulerpa prolifera (Forsskål) Lamouroux, 1809 (*Fucus prolifer*a Forsskål, 1775) is widely distributed species in the Western Mediterranean (Terrados, 1991; Hegazi, 1999). All representatives of this genus have thalli consisting of long branching horizontal stolon which gives rise to rhizoids at its ventral side for attachment and many simple or branched erect portions which are green in color (Dawes, 1981).

Marine algae from the genus *Caulerpa* get most of the attention in the reef aquarium hobby. *Caulerpa* species are fast-growing, decorative algae that have been mainstay livestock items in the hobby for years. They are an integral component of some current methods of natural filtration such as the mud refugium systems. While it may be hard to argue against *Caulerpa*'s effectiveness as a nutrient exporter, these algae are prone to grow out of control in aquaria and ultimately cause as many headaches as they relieve. A viable alternative for the reef keeper interested in a group of decorative algae with growth rates matching *Caulerpa* spp. are the cactus algae.

Caulerpa prolifera has the ability to grow and reproduce more rapidly than native species, directly or indirectly prevents other algae or seagrasses from growing nearby and any gain for it is a loss for the native.

However, Great efforts have been made to study the taxonomy and distribution of seaweed in the Suez Canal (Fox, 1926; Nasr, 1947; Por, 1971; Lipkin, 1972a and 1972b, Aleem, 1980; Farghaly, 1985; El-Manawy, 1987; Farghaly *et al*., 1988; El-Manawy, 1992). The presence of *Caulerpa prolifera* in the Suez Canal has been recorded by Aleem (1980). His report was based on one drifted specimen collected from Bitter Lakes. Since then this species has not been recorded in the Suez Canal, nor has been reported on the Gulf of Suez or northern Red Sea (Nasr, 1947; Rayss, 1959; Rayss and Dor, 1963; Papenfuss, 1968; Dor, 1984; Lipkin, 1979; Natour *et al.,* 1979a and 1979b; Hegazi, 1992).

The invasive *Caulerpa prolifera* has recently become established at several locations in Suez Canal waters. *C. prolifera* is native to Mediterranean (type locality: Alexandria, Egypt), but through recent years, it has spread via either purposeful or accidental introductions to numerous coastal areas of the Suez Canal. Both *C. prolifera* population dynamics and its effects upon native communities, have been found to vary greatly among invaded areas. Thus, the potential effects of *C. prolifera* upon Suez Canal marine communities cannot be predicted from previous studies.

This paper aims to describe and discuss the geographical distribution, habitats and predicted problem effects of *Caulerpa prolifera* in the Suez Canal.

MATERIALS AND METHODS

A regular periodic program of 13 stations (Port Said, Ras El-Ish, El-Tina, El-Cap, El-Kantara, El-Ballah, El-Ferdan, Ismailia (Lake Timsah), Deversoir, Fayed (Bitter Lakes), Kabrit, El-Shallofa and Suez) along the coasts of the Suez Canal (Fig. 1) at different depths and from different substrates**,** as well as monthly observations and seasonal field trips collecting *Caulerpa prolifera* for 7 years from 1999 to 2005 at most of the sites now known to be colonized, was carried out. To complete and rationalize this existing set of investigation, samples were taken by Snorkeling or SCUBA diving. Each sample was collected by cutting out a square of *C. prolifera* contained within a 400 cm^2 metal quadrate. Percentage of algal cover was estimated by four randomly placed quadrates (20 x 20 cm) within a horizontal distance of 2 m in each of the depths. Cover was estimated at monthly intervals to determine patterns of algal seasonality. The methods of estimating algal percentage cover and choice sampling scale (i.e. size and number of quadrates) were more extensively described earlier (Jernakoff, 1983). Samples were returned to the laboratory, and immediately rinsed with filtered seawater, shaken to remove excess water and

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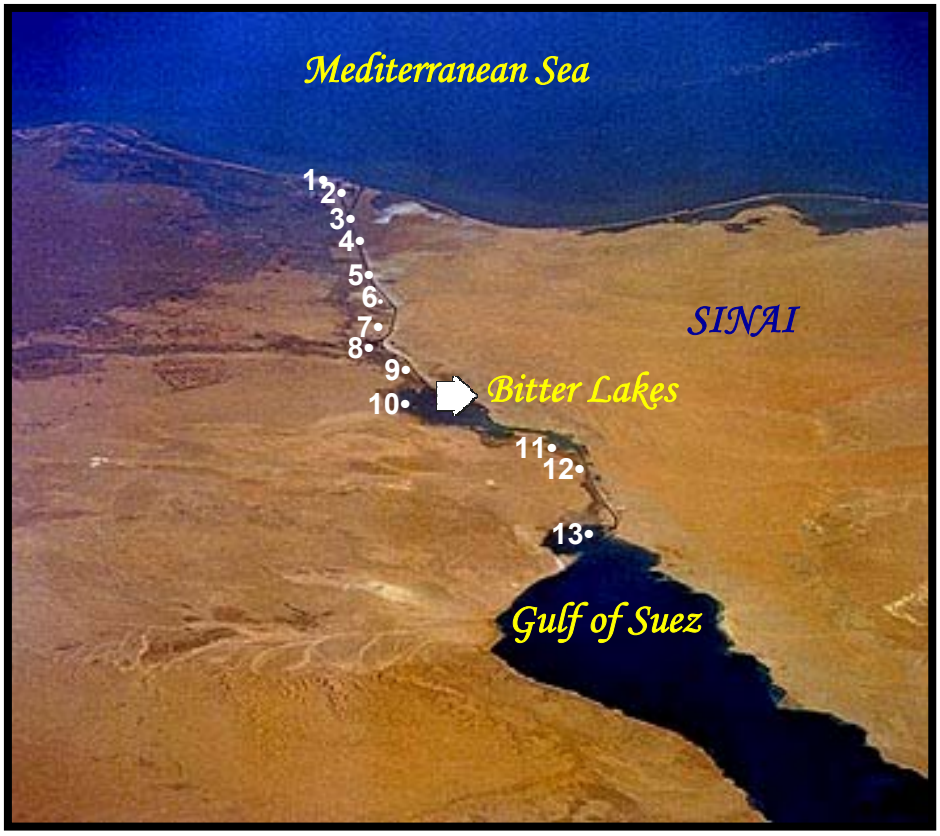

Figure (1): Satellite map showing sites where *Caulerpa prolifera* was investigated, 1) Port Said, 2) Ras El-Ish, 3) El-Tina, 4) El-Cap, 5) El-Kantara, 6) El-Ballah, 7) El-Ferdan, 8) Ismailia (Lake Timsah), 9) Deversoir, 10) Fayed (Bitter Lakes), 11) Kabrit, 12) El-Shallofa, and 13) Suez.

dried to constant weight at 60° C. The biomass is expressed as g/m^2 dry weight biomass.

RESULTS

While investigating the intertidal rocky and sandy shores of the Lake Timsah and Bitter lakes in 1999, we encountered populations of *Caulerpa* which appeared to be *C. prolifera*. It is a very popular alga now in the Suez Canal, not only for its nutrient export, but also for its beauty. This alga forms long a vine-like structure with leaves 4 to 5 inches long. After a short while the vines interconnect and form a luscious green mat. Rhizomes and rhizoid of a coenocytic *C. prolifera* meadows allow it to attach to the sandy and muddy bottom in shallow waters. Therefore, the swift currents that are characteristic with ships movement don't pull it off. The vertical axes that are potentially independent units can withstand fragmentation and regenerate after a stolon is cut.

Caulerpa prolifera has been observed in El-Ballah, El-Ferdan, Ismailia (Lake Timsah), Deversoir, Fayed (Bitter Lakes), and Kabrit in a wide range of habitats as compared to any other genus of seaweed in 1999. In that time, it was very common in muddy bottom with great biomass at a small and great Bitter Lakes. *C. prolifera* started there to spread rapidly along the coastal lines during the study period and appeared in all investigated stations from Port Said to El-Suez harbor (Table 1).

Table (1): The Distribution (presence/absence) of *Caulerpa prolifera* at different investigated sites in the Suez Canal from 1999 to 2005.

	Port Said	Ras El-Ish	EL-Tina	El-Cap	El-Kantara	El-Balah	El-Ferdan	Ismailia	Deversoir	Fayed	Kabrit	El-Shallofa	Suez
1999	-	-	-	-	-	+	+	+	+	+	+	-	-
2000	-	-	-	-	+	+	+	+	+	+	+	-	-
2001	-	-	-	-	+	+	+	+	+	+	+	+	-
2002	-	+	+	+	+	+	+	+	+	+	+	+	+
2003	+	+	+	+	+	+	+	+	+	+	+	+	+
2004	+	+	+	+	+	+	+	+	+	+	+	+	+
2005	+	+	+	+	+	+	+	+	+	+	+	+	+

Caulerpa prolifera during the study period altered the ecological relationships among native species of the canal and affect function, and economic value of the ecosystem. Many species of marine plants such as *C. racemosa*, *C. serrulata* and *Halophila stipulacea* with other species of animals that had lived there before, are endangered now and suffer losses due to competition by the invasion of *C. prolifera*, which started gradually to increase the percentage of cover from 20 to 80% on the bottom in 1999 and 2005, respectively, at Fayed site from 3-7 m depth (Fig. 2).

Mean seasonal changes in biomass indicated that *Caulerpa prolifera* community in Fayed has a similar pattern to Ismailia. It showed maximum dry weight/m^2 in winter 2003 (49.3 g/m^2) and (27.5 g/m^2), respectively, and minimum value in summer 2003 was 29.4 g /m^2 for Fayed area and 18.8 g/m^2 for Ismailia (Fig. 3).

The number of primary fronds increases progressively during autumn and winter, essentially resulting from the growth of new intercalary primary fronds. At the end of winter, the number of primary fronds decreases and starts to increase again in early Spring, reaching a further maximum in Summer and Autumn (Fig. 4). Frond length varies considerably depending on the illumination.

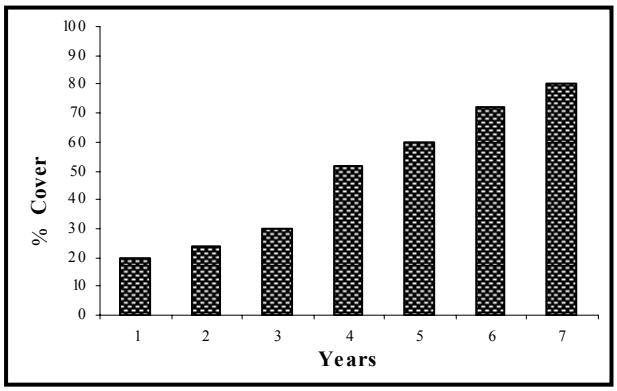

Figure (2): Annual variation of the % Cover of *Caulerpa prolifera* in the bottom of Bitter lakes from 1999 to 2005.

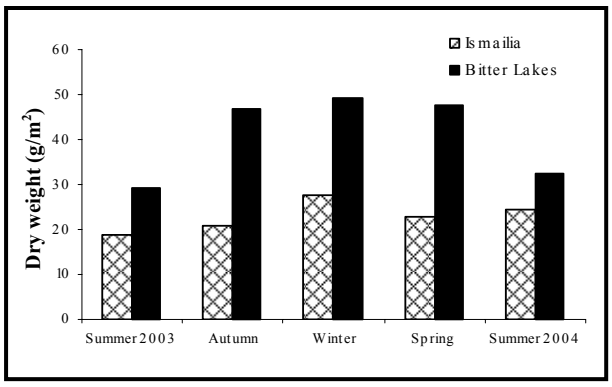

Figure (3): Seasonal variation of the biomass of *Caulerpa prolifera* in Ismailia (Lake Timsah) and Bitter lakes from Summer 2003 to 2004.

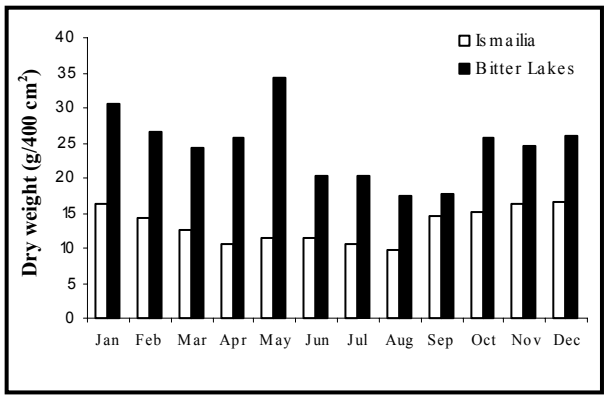

Figure (4): Monthly variation of the biomass of *Caulerpa prolifera* in Ismailia (Lake Timsah) and Bitter lakes in 2005.

Discussion

The enlargement and newly constructed branches of the Suez Canal channel project has involved an increase in the interchange rates between the Bitter Lakes and Seas. Thereafter, organic-rich sediments, fine-grained sediments and areas of low seagrass density in Bitter Lakes has favored to the introduction and growth of *C. prolifera*, which may quickly become a strong competitor for space and light.

A high percentage of cover and biomass of *Caulerpa prolifera* had many general impacts, specially on the beaches of Fayed (Bitter lakes), El-Ferdan and Ismailia (Lake Timsah) from 1999 to 2005, causing problems when rotting, producing offensive smells on resort beaches and less use of water areas (e.g. swimming, sail boarding, dinghy sailing and fishing). From Port Said a wide variety of substrates from rock, sand and mud. *C. prolifera* is usually found in depths of 0.5-7 m, but has been recorded up to 8 m in the bottom of the Great Bitter Lake. It occupies up to 100% of the available substratum in some area in Fayed and El-Ferdan. Native populations of the other seaweed in the Suez Canal are found on rocky substrate and seagrass meadows in sheltered or moderately wave-exposed areas.

From this investigation, *Caulerpa prolifera* observed inedible to local herbivores, which varies from place to another in the Canal. The flourishment of *C. prolifera* population reduce light, dampen flow, increase sedimentation, and reduce ambient nutrient concentrations available for native species from Port Said to Suez harbor. The presence of *C. prolifera* in the studied area had a negative impact on *Halophila stipulacea* in south part of the Suez Canal, these results coincide with those reported by De Gaillande (1970), who noticed that the decline of the *Posidonia oceanica* beds in the Gulf of Gabes, Tunisia resulting in part from the spread of autochthonous *C. prolifera*. This species also causes a nuisance to human when it accumulates on beaches and rots producing a foul odor.

Finally, the spreading of *Caulerpa prolifera* is still in progress and it is colonizing also rocky substrates.This invasive species causes massive damage to the local flora and fauna by supplanting the local vegetation. The alga adapted very well to its new habitat. Its success is based among others, on a very efficient reproductive strategy and a highly active chemical defense. Effects on human are mostly related to the reduction of catches for commercial fishermen due to the elimination of fish habitat by *C. prolifera*, although the entangling of nets and boat propellers with this weed also affect efficiency. In order to understand and control this species, preventing the establishment of *C. prolifera* is always the best method of control spreading by manual removal

by hand and SCUBA diving or using suction pump to remove all fragments and use them in pharmaceutical industries for their clinical value as mentioned by Abdel-Wahhab *et al.* (2006) and Selim *et al.* (2006). More material of *Caulerpa prolifera* should be examined from different localities and depths to raising public awareness, and greater research using alternative methods are needed in the future.

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توزيع غزو نوع الكوليربا بروليفيرا على طول شواطىء قناة السويس، مصر

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الملخص العربـــى

تم دراسة توزيع ونسبة الكساء الخضرى للكوليربا بروليفيرا و تجميعها من ثلاثة عشرة محطة على طول ساحل قناة السويس من أعماق وبيئات مختلفة منذ عام 1999 ولمدة سبع سنوات، وتم عمل تجميعات شهرية من الروضة الكثيفة للكوليربـا فى البحيرات المرة على أعماق من 3-7 متر، وأظهرت النتائج أن الكساء الخضرى للكوليربا بروليفيرا يبدأ فى الإزديـاد مـن بداية الربيع ويستمر فى الزيادة حتى فصل الخريف، وسجل أعلى معدل للكساء الخـضرى فـى فـصل الـشتاء، وسـجلت الملاحظات الحقلية أن أنماط التغيرات الفصلية لها علاقة بنسبة الكساء الخضرى مثل شدة الضوء ودرجة الحـرارة والجفـاف والرعى.

وقد تم تسجيل ملاحظة الإنتشار السريع والوفرة العالية لغزو الكوليربا بروليفيرا فى القيعان الرملية والطينيـة فـى المناطق الضحلة المحمية للبحيرات المرة الكبرى، وقد أظهرت الدراسة أن الكوليربا بروليفيرا تغير بيئة المنطقة الموجودة بهـا عن طريق تقليل تواجد الحيوانات والنباتات البحرية الأصلية للمنطقة.