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Factors Affecting the Distribution of the Genus *Candida* (Berkhout) Along the West Coast of Baja California Sur, Mexico

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Summary

Of 141 yeast strains isolated from 98 samples of sea water off the Pacific coast of Baja California Sur, Mexico, 22% were of the genus *Candida*. Five different groups of *Candida* were found based on physiological characteristics. A distribution pattern was established which correlated these group to physicochemical parameters of the sea water samples. We found that temperature and dissolved oxygen influenced the distribution of this genus, while the amount and kind of nutrients influenced both distribution and population density.

Key words: *Candida* – Distribution – Pacific Oean – Marine Yeast – Coastal environments

Introduction

Studies of yeast populations in sea waters have indicated that *Candida* is one of the most common genus in marine environments (*Fell,* 1967; *Fell* and *Uden,* 1963; *Goto* et al., 1969; *Kriss* et al., 1967; *Uden* and *Fell,* 1968). Usually, the genus *Candida* is not found in open sea waters, but in coastal waters, often in close proximity to urbanized regions (*Fell* et al., 1960) where waters are highly polluted by domestic wastes (*Paula* et al., 1983). In studies performed in the northeast and northwest Pacific Ocean and in the Okhotsk Sea, this genus was not one of the five most common yeasts (*Kriss* and *Novozhilova,* 1954; *Uden* and *Castelo-Branco,* 1963), and prior to this study it had not been isolated below 20° latitude.

We chose this open water study zone because of its unique conditions of mixing currents, being located where the warmtemperate Californian current and the tropical Panamanian stream meet (27° 10′N, 110° 28′ 45″ W; 27° 26′ 38″ N, 114° 45′ W; 23° 53′ 20″ N, 110° 11′ 15″ W and 23° 8′ 40″ N, 112° 30′ W). This results in high nutrient availability that favors an unusual distribution of living forms in the zone (*Lechuga-Deveze* et al., 1989a). Previously, we presented a paper on the distribution of the genus *Sporobolomyces* in this same study zone which was found to be the most common and widely distributed yeast genus (*Hernández-Saavedra* et al., 1992). We also found a strong correlation between the presence of *Sporobolomyces* and the salinity and dissolved oxygen concentration of the ocean water. In that research, *Candida* was the third most predominant yeast in such study area, and here we attempt to further define its environmental parameters.

Materials and Methods

Sea water samples were collected from May to June of 1986 off the western coast of B.C.S. during the research cruise CIB-CICIMAR 8605 on the oceanographic ship "El Puma". The water samples were taken and processed as described earlier (*Hernández-Saavedra* et al., 1992). Identification was based on procedures described by *Lodder* and *Kreger van Rij* (1983). The *Candida* genus was identified by the absence of carotenoid pigments, ascospores, teliospores, ballistospores and arthrospores, and by the presence of multilateral budding, and in some cases, chlamydospores.

Results

From 98 samples obtained at 37 stations (Fig. 1), we isolated 141 apparently different yeast strains. The *Candida* genus was found in about 22% of the total isolates. Of the *Candida* isolates, 5 different kinds were identified based on their physiological characteristics (Table 1). The

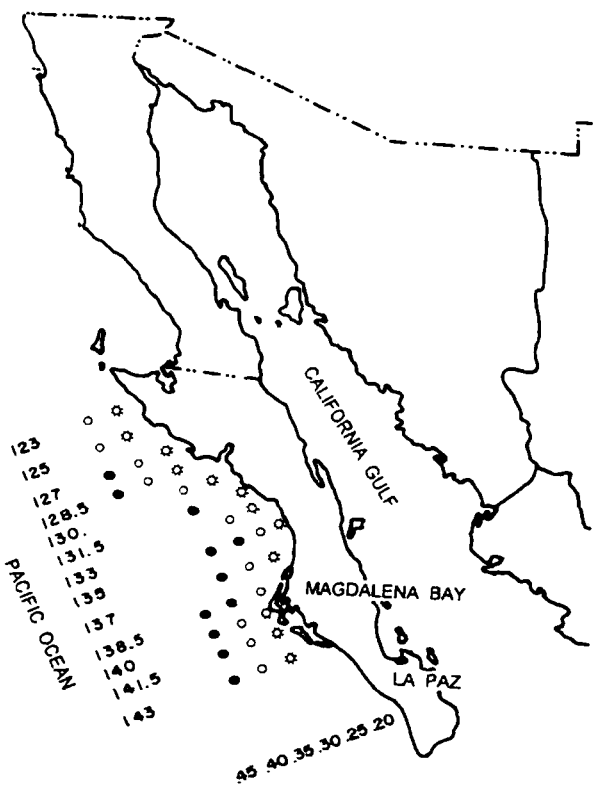

Fig. 1. CIB-CICIMAR 8605 cruise. Sampling zone for this report. ✡ zone A, O zone B, and ● zone C.

table 2 shows the number of isolates in each group, at different depths and sampling stations within the study area. Figure 2 shows the physicochemical conditions of the stations from which *Candia* strains were isolated.

Discussion

The genus *Candida* is an important pathogen in medicine (*Lodder* and *Kreger van Rij*, 1983) and has potential biotechnical applications in enzymatic processing (*Battistel* et al., 1991; *Borde* and *Birnbaum*, 1991; *Linardi* and *Machado*, 1990; *Linko* et al., 1990; *Machado* and *Linardi*, 1990) and others (*Enwefa* et al., 1992; *Tani* et al., 1990; *Umemura* et al., 1992; *Wegner*, 1990). Some authors have reported a close relationship between the presence of *Candida* and domestic waste waters (*Paula* et al., 1983; *Fell* et al., 1960), and it has been proposed as a good indicator of water pollution (*Paula* et al., 1983; *Gardova* et al., 1991).

In earlier studies of marine yeasts in the Pacific Ocean, *Candida* was not found to be one of the common isolates, they have been seldomy observed (*Goto* et al., 1974b; *Kriss* and *Novozhilova*, 1954; *Taga* and *Seki*, 1962; *Uden* and *Castelo-Branco*, 1963). The most common yeast genera found in the Pacific Ocean have been: *Rhodotorula*, *Debaryomyces*, *Cryptococcus* and *Torulopsis* (*Fell* and *Uden*, 1963; *Goto* et al., 1974a; *Goto* et al., 1974b; *Kriss* and *Novozhilova*, 1954; *Uden* and *Fell*, 1968; *Yamasato* et al., 1974). However, in oceans other than the Pacific, *Candida* is among the first 5 most widespread genera (*Ahearn* et al., 1968; *Fell* and *Uden*, 1963; *Uden* and *Fell*, 1968), especially in areas near to estuarine environments (*Uden*, 1960, 1963) where organic matter exists in high concentrations. In our study zone, which can be regarded as awn open sea, we found that *Candida* was the third most common genus (*Hernández-Saavedra* et al., 1992).

The *Candida* isolates were classified into 5 groups of strains based on physiological characterisitcs (Table 1). The distribution of the two main kinds of *Candida* strains (groups I and II) does not follow a defined pattern, whereas, the other three (groups III, IV and V) were isolated only once (Table 2), under specific hydrographic conditions

Table 1. Physiological and growth characteristics, in several sources of nitrogen and carbon, of the five groups of the *Candida* genera

Test	Group				
	I	II	III	IV	V
Arabinose	+	−	−		+
Cellobiose	+	−	−		
Citric acid	−	−	+		−
Erythritol	+	+	−		
Galactose	+	V	−	+	+
Glucuronic acid	−	−	−	−	−
Glucose	+	+	+	+	+
Glycerol	+	V	+	+	+
Inositol	−	−	−	−	−
Lactose	−	−	−	−	
Maltose	V	−		+	+
Mannitol	+	V	+	+	+
Mannose	+	+		+	−
Melezitose	V	−	−		
Melibiose	−	−	−		
Methanol	+	+	+	+	
Raffinose	−	−	−	−	+
Rhamnose	+	−	−	−	
Ribose	V	V	+	−	−
Sorbitol	+	V	+	+	
Sorbose	V	+	−	+	+
Starch	−	−	−	−	−
Succinic acid	−	+	−	+	+
Sucrose	+	+	+	+	+
Trehalose	−		−	−	
Xylose	+			+	+
NO_2	+	−	−	−	−
NO_3	−	−	−	−	−
Lysine	−	V	+	+	+
Urease activity	−	−	−	−	−
Growth 37 °C	−	+	−	+	+
DBB	−	−	−	−	−
Fermentation	+	−	−	+	−

(+) presence of growth, (−) absence of growth, (V) variable response in the group.

Table 2. Number of isolates of *Candida* groups found within the study zone at different depths

Group	Area			Depth (m)			Total
	A	B	C	0.3	50	100	
I	9	4	0	7	6	0	13
II	4	7	4	6	9	0	15
III	1	0	0	1	0	0	1
IV	1	0	0	1	0	0	1
V	1	0	0	0	1	0	1

(Fig. 2). Unfortunately, at this stage it is not possible to say whether these groups comprise various species, although, the differences between the 5 groups are shown in table 1.

The fact that the *Candida* strains were found in high concentration at the coastal areas A and B (Fig. 1, Table 2), indicate its tendency to occupy such environments; however, as reported here *Candida* strains do not appear to be restricted to sites where oxygen concentration, temperature, hydrostatic pressure and salinity fall within certain limits (Fig. 2). This suggests a higher adaptability than previously reported by *Uden* and *Fell* (1968) for *Candida* yeast, which can be found together with other species frequently isolated from the open sea.

Yeast populations in the sea usually decrease in number and density at increasing depth and distance from the coast line. One reason for this is that an important percentage of the total primary marine production is generated in the zone of the continental platform, closely related to the coast line (*Lechuga-Deveze* et al., 1989a).

A published study already recognized that the yeast distribution in the sea stems from geographical and hydrographic environmental conditions (*Fell*, 1967). In the present study, temperature, salinity and dissolved oxygen were correlated with the distribution of various *Candida* sp. Our results suggest a correlation (R = 0.75) between the presence of *Candida* and the dissolved oxygen concentration and temperature (Fig. 2). However, these are not the only parameters that combine to allow the presence and development of this particular genus; the amount and kind of nutrients strongly influence both yeast populations and its distribution.

The distribution of *Candida* in the selected area was not influenced by the presence of high pollution from human activities, as may occur in other zones. The west coast of Baja California Sur peninsula is virtually uninhabited and there are no factories or major industries that may affect the organic matter concentration. The high availability of nutrients or organic matter in this zone is due to special conditions of water mixture through upwelling events combined with one important influence from a marine ecosystem Magdalena Bay. This system has been reported as a major exporter of organic matter to the open sea (*Lopez-Cortez* et al., 1990), where our study zone is located. In fact, this zone is one of the principal Mexican fishing sites of sardine (*Sardinops sagax* and *Opisthonema libertate*) and anchovy (*Engraulis mordax*) (*Hewitt*, 1988). Thus, we may conclude that the presence of *Candida* in this particular zone is due to both a nutrient rich enviroment and some special physicochemical conditions. Interestingly in areas where *Sporobolomyces* is abundant (*Hernández-Saavedra* et al., 1992) *Candida* appears to be absent.

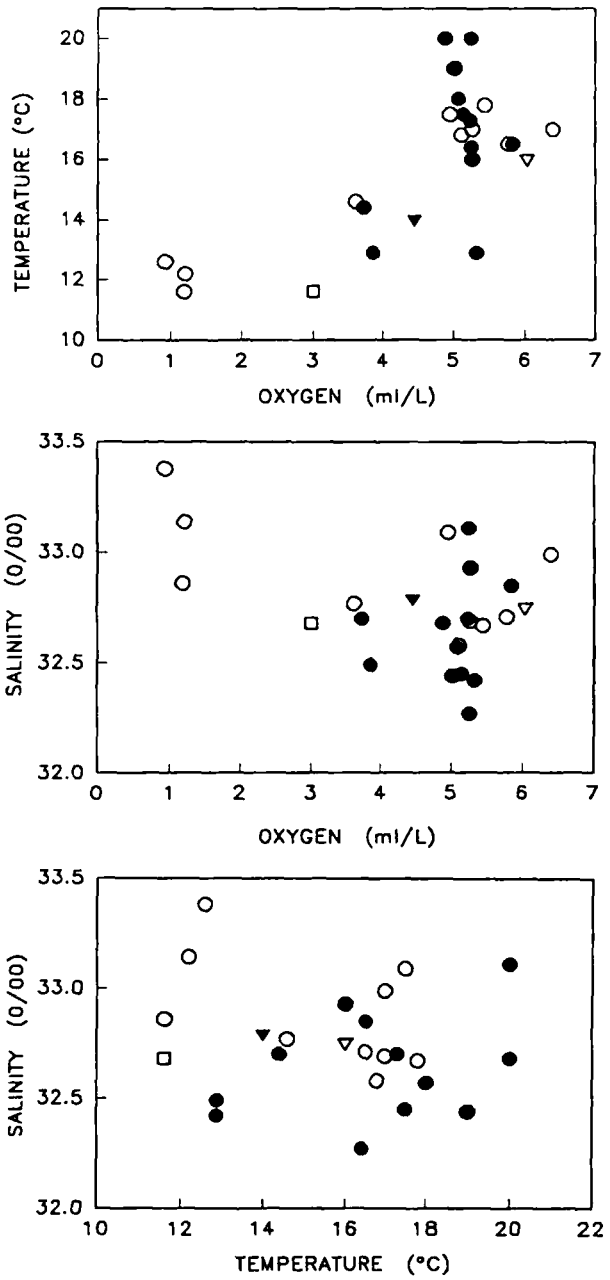

Fig. 2. Presence of *Candida* groups at different conditions corresponding to the study zone. ○ group I, ● group II, □ group III, ▲ group IV, and △ group V.

Although this study is not quantitative, the presence of yeasts gives us an idea of the importance of the "nano" fraction (2–38 μm) of non-photosynthetic particulate organic matter (POM), in the sea water. This particular fraction is considered a potential food source for organisms located in the trophic chain base (*Lechuga-Deveze* et al., 1989b). Further research on the participation and dispersion of yeast populations would contribute to our understanding of marine ecology.

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