ECOLOGICAL NICHES OF HERMATYPIC CORALS AT ILHA DO SAL (ARQUIPÉLAGO DE CABO VERDE)

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With 4 figures

ABSTRACT. Field observations and data, together with laboratory measurements of polyp size, were used to define the ecological niches of the 4 hermatypic corals of Ilha do Sal: *Siderastrea radians* (PALLAS), *Porites astreoides* LAMARCK, *Porites porites* (PALLAS), and *Favia fragum* (ESPER). *Porites porites* was shown to inhabit, preferentially, a different microhabitat with respect to the other three species; these, on the contrary, showed large overlaps in terms of light and water movement conditions, and were more widespread. Polyp sizes suggested sharp separation of trophic niches among the four species. Only the two *Porites* exhibited a partial overlap, but in any case conformed to the "HUTCHINSON's rule", having a ratio of 1.31 between the sizes of their feeding structures. As a whole, the ecological niches of the four coral species at Sal correspond well to those that the same species have in the Western Atlantic, but only *Siderastrea radians* showed some bioconstructional capability at Sal.

INTRODUCTION

The hermatypic coral fauna of the Arquipélago de Cabo Verde is relatively well known from a taxonomical point of view. CHEVALIER (1966a,b) first presented a complete systematic account of the known scleractinian species. LABOREL (1974) and BOEKSCHOTEN & BEST (1988) updated knowledge, underlining the West-Atlantic affinity - and hence origin - of the Cape Verde coral fauna.

However, little still is known on the ecology of hermatypic corals at Cape Verde Islands, apart from short notes in the paper of LABOREL (1974). WELLS (1988) reported that they may be locally abundant, although they never form true coral reefs.

In the winter of 1990-1991, the Zoology Institute of Genova University organized a scientific SCUBA diving expedition to study cnidarian zonation (MORRI & BIANCHI, 1995)

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at Ilha do Sal, the island situated in the north-eastern corner of the archipelago.

The aim of the present paper, in particular, is to examine the distribution of hermatypic corals at Sal according to depth and habitat. Field observations and data, together with laboratory measurements of polyp size, are used to define the ecological niches of the species found. Niche is intended here as the HUTCHINSON's *n*-dimensional hypervolume, including both spatial and trophic niches (ROSSI, 1985).

As pointed out by GILLER (1984) microhabitat and food represent a combination of the important and easy-to-measure components of the niche. Microhabitat is described in terms of light and water movement, the two major factors affecting coral zonation (DONE, 1983; GRAUS & MACINTYRE, 1989). As far as the food components of the niche are concerned, they are inferred using polyp size. Hermatypic corals, besides exploiting the primary production of their symbiotic zooxanthellae, also feed by capturing zooplankton (VERON, 1993): it may be supposed that polyp size correlates with the zooplankton size they mainly feed upon.

MATERIALS AND METHODS

Coral species were inventoried along ten depth-transects perpendicular to the shore (Fig. 1), according to the method described by BIANCHI *et al.* (1991). Due to persistent bad weather conditions, only west and, to a lesser extent, south coasts of Sal were explored, from a maximum depth of 33 m to the surface.

Coral cover for each species was visually assessed within physiognomically homogeneous areas or "relevés" (BIANCHI *et al.*, 1991) of varying sizes, usually about 20 m^2 or more.

Depth of each relevé was measured by diving computer, and substrate inclination with a hand-made clinometer (GAMBLE, 1984). Wave exposure was evaluated through the fetch-energy index proposed by HUMMON (1989).

The above field measurements were used to produce rough estimates of "light" and "water movement". The following two formulas were applied:

$f(L) = \cos(\alpha) / [1+\ln(z+1)]$, and: $f(WM) = FE / [1+\ln(z+1)]$,

where $f(L)$ = "light" and $f(WM)$ = "water movement" (both resulting in arbitrary units), α = substrate inclination (in radians), z = depth (in meters), FE = HUMMON's fetch-energy index (%). The cosinus function was chosen to express the fact that, depth being equal, a horizontal surface will receive more light than a steeply sloping one. The logarithmic function of depth at the denominator in both formulas was introduced in order to account for the exponential decrease of light and water movement with increasing depth; 1 was added where appropriate to avoid negative logaritms and division by zero.

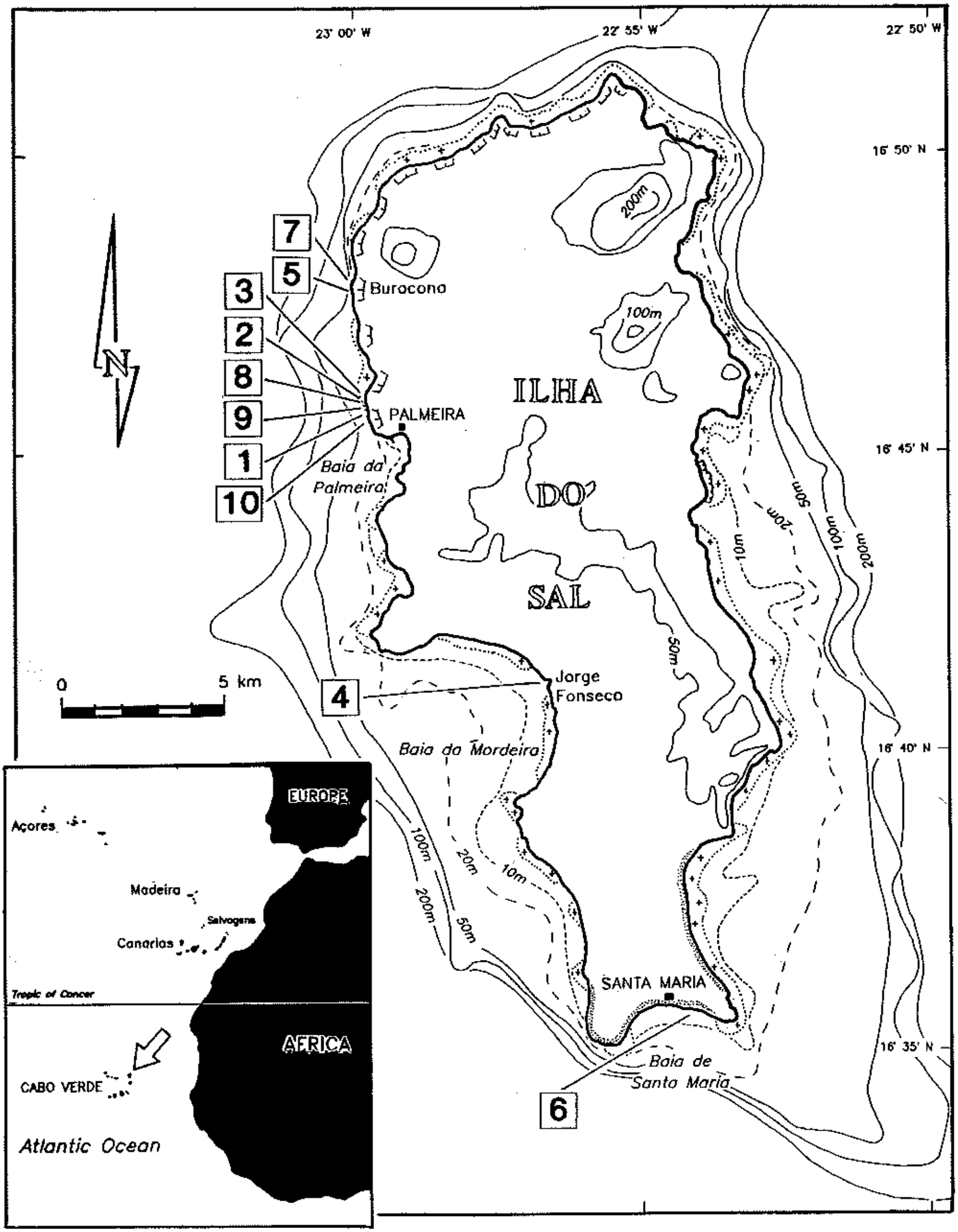

Figure 1 - Ilha do Sal with location of transect stations (numbers in boxes).

Direct gradient analysis of both total and individual species' cover values *vs* depth was performed (GAUCH, 1984). Spatial niche breadth (B) was computed according to the formula $B = 1/\Sigma p_i^2$ (LEVIN, 1968): cover was considered as the proportion (p_i) of resource (*i.e.*, the substratum) used by each species. Frequential analysis (DAGET & GODRON, 1982) was performed to obtain a graphical representation of the individual species' niches on the factorial plane formed by $f(WM)$ and $f(L)$ axes.

Polyp size was determined on a reduced number of colonies (collection of specimens was kept to the minimum). The diameters of thirty-one calices were measured for each species under a stereomicroscope with a 15 X micrometric eyepiece to a precision of 0.08 mm.

RESULTS

Four species were found in 9 depth-transects (transect 5 gave no corals): *Siderastrea radians* (PALLAS), *Porites astreoides* LAMARCK, *Porites porites* (PALLAS), and *Favia fragum* (ESPER).

Corals inhabited three major habitats: 1) rubble and pebbles in a back reef situation, 0 to 1 m deep, exemplified by the Jorge Fonseca creek (transect 4); 2) beach rocks (and also the wreck of the Santo Antão, sunk in 1965) on sandy floor, 4 to 10 m deep, in the Baía de Santa Maria (transect 6); 3) basalt cliff at Brocona (or Buracona), 8 to 20 m deep (transect 7), and/or boulder slopes, 0.5 to 15 m deep, at sites between Ponta da Joãosinho and Pisqueiro Ti Culão, near Palmeira (all the remaining transects).

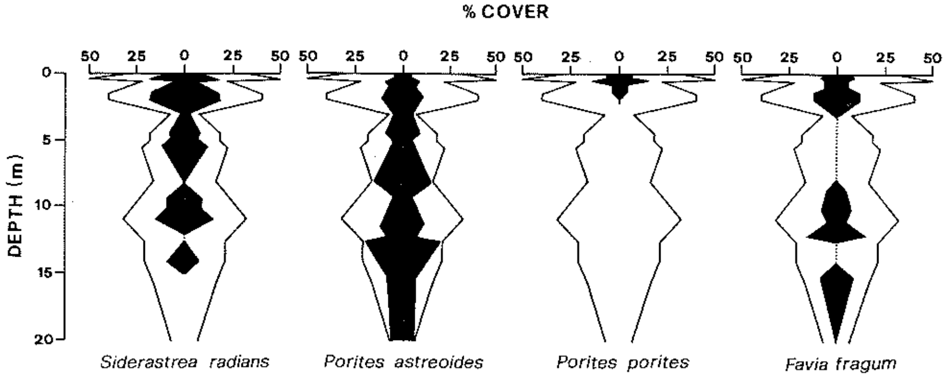

Figure 2 - Overall depth distribution of coral cover, all transects taken together. In each case, the outer line is total coral cover, the solid core is individual species cover, as indicated.

All of the four coral species were found in the first habitat, whereas *Porites porites* was absent from the remaining two. Habitat 2 was dominated by *Siderastrea radians*, habitat 3 by *Porites astreoides*.

Total coral cover was at its highest in shallow sites, and then decreased irregularly with depth, rarely exceeding 30% (Fig. 2): the highest value, about 50% cover, was observed in the very shallow habitat 1. Relatively high values were also observed in shallow (about 2 m) sheltered sites of Pisqueiro Ti Culão (transects 1 and 10) and at intermediate depths (10-12 m) in other transects of habitat 3. Also individual species' cover tended to decrease with depth, with the only exception of *P. astreoides* which was near equally abundant down to 20 m (Fig. 2).

Calculating spatial niche breadth confirmed *Porites astreoides* as being the most widely distributed species (B = 28.9) in different habitats and depths at Sal; *Porites porites* was, on the contrary, the most localized (B = 3.3). Intermediate niche breadth values were showed by *Favia fragum* (B = 15.6) and *Siderastrea radians* (B = 14.6).

Graphical representation of the microhabitat components of the ecological niche - *i.e.*, "light" or $f(L)$ and "water movement" or $f(WM)$ - showed a certain degree of overlap between *Siderastrea radians* and *Favia fragum* and, to a lesser extent, between *Favia fragum* and *Porites astreoides* (Fig. 3). The optima of *Porites porites* were well separated from those of the remaining three species.

Calice diameters were rather similar in the case of the two *Porites* (*P. astreoides*: 0.99 ± 0.13 mm; *P. porites*: 1.30 ± 0.14 mm), producing a partial overlap in polyp sizes (Fig. 4); conspicuously larger diameters characterized *Siderastrea radians* (2.99 ± 0.23 mm) and *Favia fragum* (4.80 ± 0.24 mm).

DISCUSSION

All of the species previously recorded for Ilha do Sal (LABOREL, 1974; BOEKSCHOTEN & BEST, 1988) were found during the present study.

Porites porites was apparently confined to the shallow creek of Jorge Fonseca, whereas the remaining three species, namely *Siderastrea radians*, *Porites astreoides*, and *Favia fragum*, were widespread, co-occurring in nearly all the sites visited. According to the calculated spatial niche breadth values (ROLANDO, 1990), *P. porites* is the most specialist species, and *P. astreoides* the most generalist with respect to the habitat.

As a whole, all of the corals showed a preference for shallow depths at sheltered sites or intermediate depth at exposed sites: physical disturbance, due to strong oceanic waves beating the shallow open coasts of Sal (MORRI & BIANCHI, 1995), may be responsible for such a distribution.

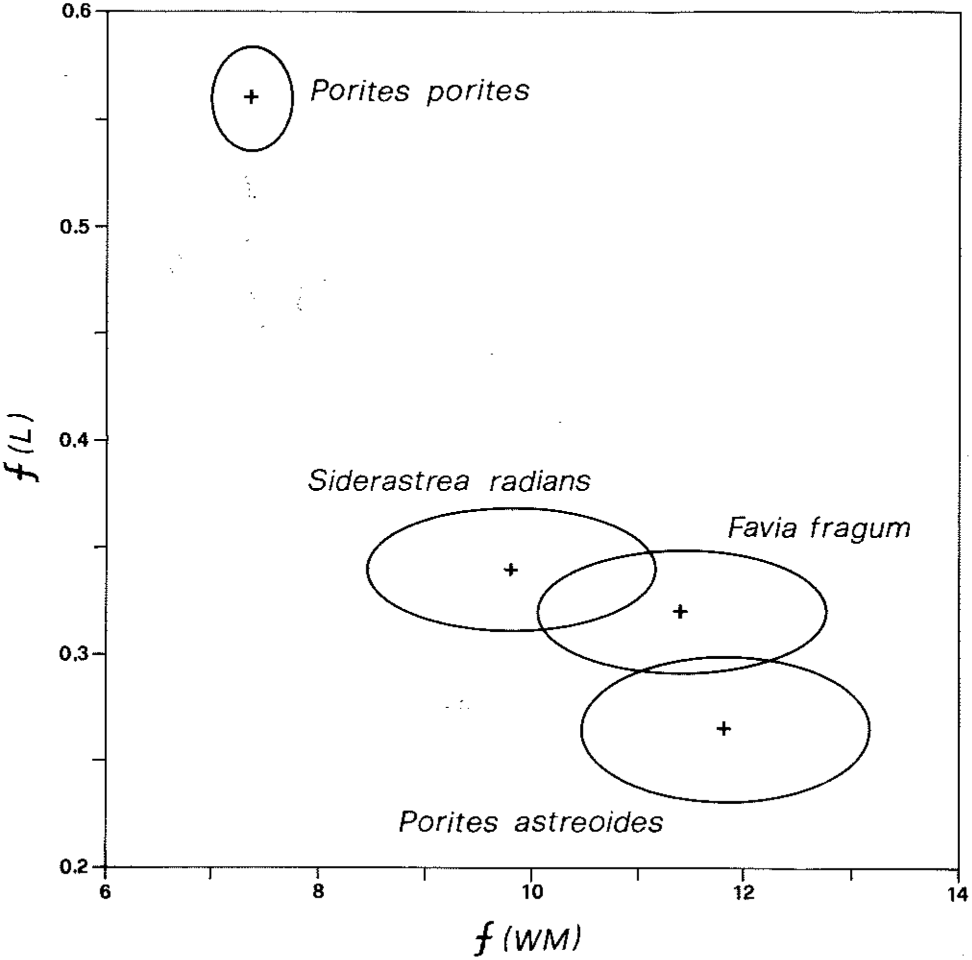

Figure 3 - Graphical representation of the individual species niches on the factorial plane formed by $f(WM)$ ("water movement") and $f(L)$ ("light") axes, measured in arbitrary units (see text). Crosses correspond to means, ellipses depict 95% confidence intervals.

Porites porites exclusively inhabited shallow, well lit habitats, where it appeared abundant on rubble and pebbles. In this habitat, moderate, wind-induced short waves easily disrupt the ramose colonies of *P. porites* and the substrate on which they grow; clonal fragments are thus dispersed locally and this probably gives the species a selective advantage (KARLSON, 1991) over the remaining species, which - having rather massive colonies - will hardly survive the overturning of the substrate on which they have settled. In Jamaica, LANG (1973) reported that *Porites porites* overgrows *Porites astreoides*, although *Siderastrea*

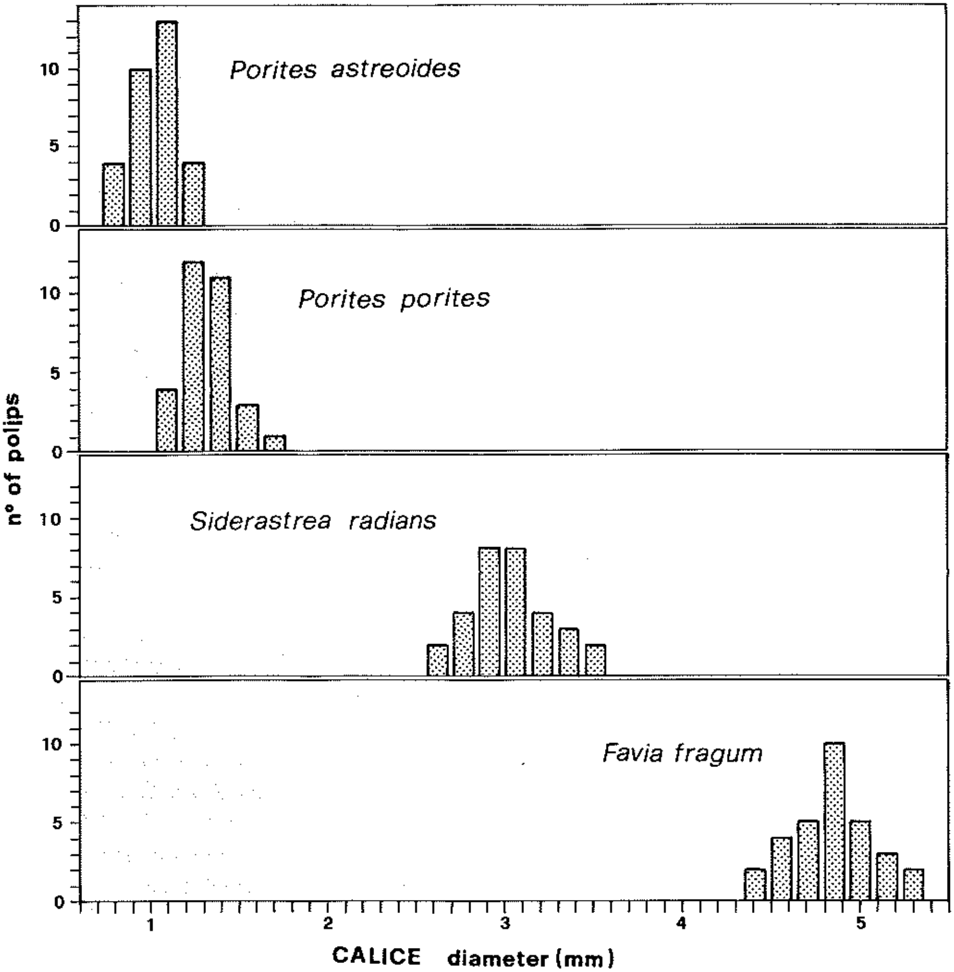

Figure 4 - Frequency distribution of calice diameters (mm) in specimens of the four coral species.

radians and *Favia fragum* should be the most aggressive (but there is geographic variation in coral aggressive behaviour: LOGAN, 1984).

On more stable substrates, *Porites astreoides* was usually the most abundant species: it showed toleration to comparatively low values of light and high values of water movement. Demographic plasticity and high regenerative capability of *P. astreoides* (HUGHES & JACKSON, 1985) probably help in enduring such conditions. *Siderastrea radians* dominated in the vicinity of sand (beach rocks, wreck, or at the base of boulder slopes); this is consistent with the fact that the species is known to have a short rejection time of sand (LEWIS, 1976) and prefers to inhabit sandy bottoms, often in lagoons (KÜHLMANN, 1980). *Favia fragum* was never abundant, and was absent in some sites: CARLON & OLSON (1993) found it suffers from high post-settlement mortality due to poor competitive ability.

Calice diameter measurements suggested sharp separation of trophic niches among the four species. Only the two *Porites* exhibited a partial overlap. However, ratio between their mean calice diameters (1.30/0.99) was 1.31, that is, a figure well corresponding to the so called "biological constant" or "HUTCHINSON's rule", commonly found among feeding structures of coexisting species (GILLER, 1984). Thus, trophic niches were sufficiently separated even in the case of the two *Porites*; moreover, it must be observed that, while *Porites astreoides* is known to primarily use zooplankton for nutrition (LEWIS & PRICE, 1975), *Porites porites* is capable of being fully autotrophic, and zooplankton ingestion can represent an insignificant component of the energy intake (EDMUNDS & SPENCER DAVIES, 1989).

Total coral cover at Sal was usually low; in addition, the life strategies of the species - which are considered r-selected species and/or first colonizers (PICHON, 1981; TOMASCIK, 1991) - indicate they are poor competitors. This suggests competition should not be of much importance in determining their distribution. Physical disturbances (such as storm damage) possibly prevent competitive interactions (CONNELL, 1976).

Nevertheless, the four coral species resulted to occupy well separated niches in terms of both microhabitat and trophic components. A further element of niche separation among the corals at Sal could be a behavioural one: indeed, the four species are known to possess different patterns of sexual reproduction (FADLALLAH, 1983; STEINER, 1991; SOONG, 1991, 1993).

As a whole, the ecological niches of the four coral species found at Sal correspond well to those that the same species have in the Western Atlantic (GOREAU & WELLS, 1967; CAIRNS, 1982; CAIRNS *et al.*, 1986; COLIN, 1988; KENNY, 1988; BOUCHON *et al.*, 1990; etc.).

At Sal, none of the four species showed significant constructional capability: the only potential reef builder is to be considered *Siderastrea radians*, which locally exhibited colonies as wide as 1 m (Jorge Fonseca, Santo Antão wreck): this agrees with observations of LABOREL (1974) and WELLS (1988), who reported slabs of living *S. radians* up to 10 m wide in Baía de Pedra de Lume, on the east coast of Ilha do Sal.

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