Biologia Geral e Experimental

Universidade Federal de Sergipe

São Cristóvão, SE 5 (1): 5-11 30.x.2004

MORPHOLOGICAL VARIATION OF *MONTASTREA CAVERNOSA* AND *SIDERASTREA STELLATA* (CNIDARIA: SCLERACTINIA) FROM THE STATES OF MARANHÃO, PARAÍBA AND PERNAMBUCO, BRASIL

Michelle Gomes Santos[1]
Fernanda Maria Duarte do Amaral[2]
Fabrício Bezerra de Sá[3]
Maria da Glória Abage de Lima[4]

ABSTRACT

In this study we examined the skeletal morphometry of five populations of the corals *Montastrea cavernosa* and *Siderastrea stellata* from the northeastern coast of Brasil. The colony shape of *S. stellata* from the state of Maranhão is predominantly flattened and the corallite diameter and columellar distance varied significantly among the populations of both species. The number of septa varied significantly in *S. stellata*. This variations may reflect the colonies' adaptations to different levels of sedimentation and different light conditions, as well as the intrinsic genetic variability of scleractinian corals.

Keywords: morphological variation, *Montastrea cavernosa*, *Siderastrea stellata*, Brasil.

RESUMO

Examinamos a morfologia esquelética em cinco populações dos corais *Montastrea cavernosa* e *Siderastrea stellata*, do litoral do nordeste do Brasil. A forma das colônias de *S. stellata* do Maranhão é predominantemente achatada, o diâmetro do coralito e a distância columelar variaram significativamente entre as populações das duas espécies. O número de septos variou significativamente para *S. stellata*. Possivelmente estas variações reflitam adaptações das colônias a diferentes condições de sedimentação e luminosidade, além da variabilidade genética intrínseca às espécies de corais escleractínios.

Palavras-chave: variação morfológica, *Montastrea cavernosa*, *Siderastrea stellata*, Brasil.

INTRODUCTION

Morphological variation is an interesting property of several sessile organisms (Bradshaw, 1965; Boardman *et al*., 1969; West *et al*., 1993), including corals (Wijsman-Best, 1974; Foster, 1977; Veron, 1981; Willis, 1985; Veron, 1995; Veron & Stafford-Smith, 2000). Coral species are identified by morphological characters of their calcareous skeleton, such as: corallite size; the number, arrangement, and structural details of the septa; colony habit (free or adhered to the substrate); coral form; and differrent aspects of the coenosteum (region between corallites). Together, these characters form the basis for the taxonomy of the order Scleractinia (Vaughan & Wells, 1943; Wells, 1956; Cairns, 1978, 1982; Zlatarski & Estalella, 1982; Zlatarski, 1990; Amaral, 1991).

At it provokes misinterpretations in studies with large temporal and spatial scales, this morphological variation is the main problem in scleractinian systematics (Wijsman-Best, 1974; Best *et al.*, 1983; Miller, 1994; Veron, 1995). The description of patterns of variation in morphological characters is necessary for the elaboration of a stable classification system

[1] Programa de Pós-Graduação em Ciências Biológicas, Universidade Federal da Paraíba, Campus I, Cidade Universitária, s/n. João Pessoa, PB. 58.059-900, siderastrea@yahoo.com.br
[2] Departamento de Biologia. Universidade Federal Rural de Pernambuco. Av. Dom Manuel de Medeiros, s/n. Dois Irmãos, Recife, PE, 52.171-900.
[3] Departamento de Morfologia e Fisiologia Animal, Universidade Federal Rural de Pernambuco.
[4] Departamento de Física e Matemática, Universidade Federal Rural de Pernambuco.

that permits increased accuracy and greater advances in ecological and evolutionary research (Knowlton *et al*., 1992; Amaral, 1994; Palumbi, 1994).

The cause of this variability has not yet been determined. It may be due to environmental factors (Foster 1977, 1978, 1980, 1983), genetic differentiation (Brakel, 1977; Carlon & Budd, 2002; Maté, 2003), or even to a combination of both (Futuyma, 1992; Knowlton *et al*., 1992). The principal environmental factors know to influence variation in zooxanthellate corals are the quantity of light (Barnes, 1973; Fricke & Schuhmacher, 1983; Willis, 1985; Amaral, 1991; Beltrán-Torres & Carricart-Ganivet, 1993; Amaral, 1994; Antônio-de-Souza & Amaral, 2001), hydrodynamics (Foster, 1980), and sedimentation levels (Barnes & Lough, 1999; Todd *et al.*, 2001). Environmental effects have been investigated in studies involving the translocation of colonies, although the heterogeneity of reef environments may conceal the relative importance of each physical variable (Gattuso, 1985; Miller, 1994; Bruno & Edmunds, 1997).

Whereas differences in qualitative characters have been described (Laborel, 1970; Mayal & Amaral, 1990), quantitative approaches are necessary to identify the more variable characters (Foster, 1980; Amaral, 1994). The aim of the present study was to describe, both qualitatively and quantitatively, the variation in morphological characters of the skeletons of different populations of *Montastrea cavernosa* (Linnaeus, 1767) and *Siderastrea stellata* Verrill, 1868 from northeastern Brasil.

MATERIAL AND METHODS

Localities

Samples were collected in three northeastern Brasilian localities: Manuel Luiz Coral Banks and Picãozinho, Paraíba; Tamandaré, Pernambuco. The Manuel Luiz Coral Banks are part of a State Marine Park (Parque Estadual Marinho do Parcel do Manuel Luiz) located on the continental shelf, at 00º 50’S and 44º 15’W, 86 km from the coast of the Brasilian state of Maranhão and 180 km from the city of São Luís. The reefs are pinnacle shaped, covering an area of 69 km^2. The temperature is approximately 28ºC (Rocha, 1999), and the cnidarian fauna is composed of twelve species of corals and four species of calcified hydroids, as well as some species of gorgonians (Amaral *et al*., 2000; Castro & Pires, 2001).

The reefs of Picãozinho (between 06º42’05”/ 07º07’30”S and 34º48’37”/ 34º50’00”W), are located at the city of João Pessoa, in the Brasilin state of Paraíba. They are composed of small rectangular platforms of no more than 300 m in extension, aligned parallel to the coast at a distance of 700 to 1,600 m from the beach. The annual temperature of this locality varies from 24º to 27ºC. The cnidarian fauna is composed of six species of corals, as well as some species of calcified hydroids and zoanthids (Young, 1984; Vuelta, 2000).

The region of Tamandaré (08º47’02”S and 35º06’45”W) is located approximately 110 km south of the city of Recife, in the Brasilian state of Pernambuco. A considerable coral fauna grows on beachrocks parallel to the coast. The temperature is approximately 24ºC in the rainy season (“winter”) and 35ºC in the dry season (“summer”), and visibility varies from 1 to 20 m according to the season, precipitation, winds, and currents (Maida & Ferreira, 1997; Amaral, 1998; Castro & Pires, 2001).

Field studies

The field studies took place between June 1999 and July 2000. Five colonies of *Montastrea cavernosa* (Figure 1) were collected from Picãozinho and Tamandaré, and five colonies of *Siderastrea stellata* were collected in each of the three localities (Figure 2). The specimens were collected at a depths of 25m in Maranhão and up to 5m in Paraíba and Pernambuco. The colonies were removed with the aid of a hammer and chisel, at locations at least 2m apart, in order to avoid collecting clones (Foster, 1980).

The specimens were deposited in the Cnidaria

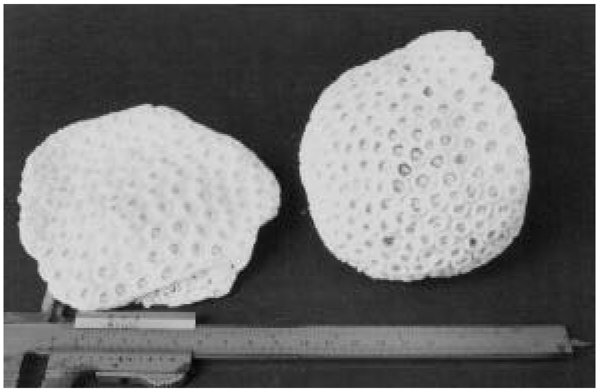

Figure 1. *Montastrea cavernosa:* Skeleton from Tamandaré.

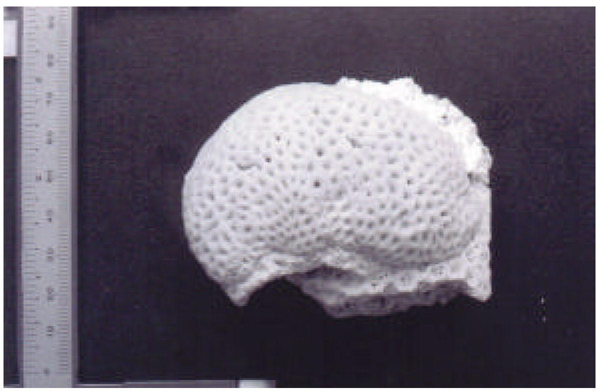

Figure 2. *Siderastrea stellata*: Skeleton from Manuel Luiz Coral Banks.

collection of the Reef Environment Laboratory of the Universidade Federal Rural de Pernambuco (LAR/UFRPE) with the following numbers: *M. cavernosa* – LAR/UFRPE 029; 109; 185; 161; 173; 448; 449; 450; 451; 452 and *S. stellata* – LAR/UFRPE 012a; 012b; 012c; 012d; 012e; 020; 022; 063; 175; 160; 453; 454; 455; 456; 457.

Laboratory study

The sample's soft parts were removed with a 30% solution of sodium hypochlorite, and then washed in distilled water and allowed to dry naturally. Skeleton characters were measured with a caliper (0.05 mm) and a stereoscopic microscope. The following qualitative and quantitative characters were recorded: colony shape, corallite shape, corallite diameter, columellar distance, and number of septa per corallite. Ten corallites per colony, chosen randomly, were measured and had their septa counted (Amaral, 1994).

Statistical analysis

In this study, the term population refers to all the colonies collected at same locality (Foster, 1980). The significance of the variations between populations of *M. cavernosa* was tested using the Student's t test for independent samples, and ANOVA among populations of *S. stellata*. Before applying ANOVA, variance homogeneity was ascertained using Levene's test, and posterior analyses were undertaken using Tukey's test (Zar, 1999). A p=0,05 significance level was used, and all tests were run on Statistica, version 4.0.

RESULTS

Montastrea cavernosa

The colonies of *M. cavernosa* were hemispheric and flattened in shape in Picãozinho and Tamandaré. Corallites were predominantly rounded. Corallite diameters of *M. cavernosa* from Tamandaré (Table 1) were significantly larger than those of Picãozinho ($t=6.69$; $t_{0.05(2)98}=1.98$; $p<0.05$), and columellar distances were significantly smaller ($t= -3.58$; $t_{0.05(2)98}=1.98$; $p<0.05$). The number of septa did not vary significantly between the two populations ($t = -0.86$; $t_{0.05(2)98} = 1.98$; $p>0.05$).

Siderastrea stellata

Most of the *S. stellata* colonies collected from the Manuel Luiz Coral Banks were flattened in shape, whereas those from Picãozinho and Tamandaré were mostly hemispheric. Corallites were predominantly rounded. Corallite diameter varied significantly among populations ($F=21.05$; $F_{0.05(2)147}=3.78$; $p<0.05$), with the colonies from the Manuel Luiz Coral Banks and Picãozinho differing significantly from those of Tamandaré (Tables 2 and 3).

The columellar distance, which refers to the

Table 1. *Montastrea cavernosa:* Descriptive statistics of the skeletal characteriss at Picãozinho and Tamandaré.

Locality	N	Character	A	x	s	V	I(x)
Picãozinho	50	a *	4.60 – 6.90	5.62±0.07	0.52	0.27	5.47 – 5.77
		b *	6.50 – 9.70	7.90±0.12	0.84	0.71	7.67 – 8.14
		c	32 – 51	41.82±0.67	4.78	22.84	40.46 – 43.18
Tamandaré	50	a *	5.10 – 8.30	6.46±0.10	0.72	0.51	6.25 – 6.66
		b *	5.90 – 9.10	7.31±0.12	0.83	0.69	7.07 – 7.54
		c	31 – 49	41.02±0.64	4.51	20.39	39.74 – 42.30

a = corallite diameter; b = columellar distance; c = number of septa; (*) = measurements in millimeters; N = number of corallites; A = amplitude; x = mean ± standard error; s = standard deviation; V = variance; I(x) = confidence limits of mean (95%).

Table 2. *Siderastrea stellata:* Descriptive statistics of the skeletal characters at Manuel Luiz Coral Banks, Picãozinho and Tamandaré.

Locality	N	Character	A	x	s	V	I(x)
Manuel Luiz Coral Banks	50	a *	2.40 – 4.70	3.50±0.06	0.46	0.21	3.36 – 3.63
		b *	2.60 – 4.50	3.51±0.07	0.47	0.22	3.37 – 3.64
		c	30 – 55	43.04±0.68	4.79	22.98	41.68 – 44.40
Picãozinho	50	a *	2.40 – 4.70	3.56±0.06	0.45	0.20	3.43 – 3.69
		b *	2.60 – 4.50	3.07±0.06	0.43	0.19	2.94 – 3.19
		c	30 – 55	43.18±0.97	6.86	47.01	41.18 – 45.13
Tamandaré	50	a *	1.90 – 3.80	3.01±0.07	0.47	0.22	2.88 – 3.15
		b *	1.60 – 3.90	2.60±0.07	0.48	0.23	4.46 – 2.73
		c	29 – 50	38.80±0.89	6.33	40.08	37.00 – 40.60

a = corallite diameter; b = columellar distance; c = number of septa; (*) = measurements in millimeters; N = number of corallites; A = amplitude; x = mean ± standard error; s = standard deviation; V = variance; I(x) = confidence limits of mean (95%).

space between the colony's corallites, differed significantly among the populations of *S. stellata* ($F=48.83$; $F_{0.05(2)147}=3.78$; $p<0.05$). The columellas of the specimens from Maranhão were significantly more widely spaced in comparison with the other populations (Tables 2 and 4). The total number of septa also varied significantly ($F=8.44$; $F_{0.05(2)147}=3.78$; $p<0.05$), with the Manuel Luiz Coral Banks and Picãozinho having a similar number, significantly larger than that recorded at Tamandaré (Tables 2 and 5).

DISCUSSION

Colonies of *Montastrea cavernosa* were both hemispheric and flattened in Pernambuco and Paraíba, suggesting shape heterogeneity in shallow environments. Several studies link the flattened form to deep environments (Laborel, 1970; Barnes, 1973;

Table 3. *Siderastrea stellata*: Tukey's test for corallite diameter.

Locality	m	N
Manuel Luiz Coral Banks	3.50	50
Picãozinho	3.56	50
Tamandaré	3.01	50

m = mean; N = number of corallites.

Table 4. *Siderastrea stellata:* Tukey's teste for the columellar distance.

Locality	m	N
Manuel Luiz Coral Banks	3.51	50
Picãozinho	3.07	50
Tamandaré	2.60	50

Table 5. *Siderastrea stellata:* Tukey's test for the number of septa per corallite.

Locality	m	N
Manuel Luiz Coral Banks	43.04	50
Picãozinho	43.18	50
Tamandaré	38.80	50

Fricke & Schuhmacher, 1983; Amaral, 1994; Bruno & Edmunds, 1997), although a species can exhibit several patterns within a single type of environment (Brakel, 1977; Maÿal & Amaral, 1990; Veron, 1995; Carlon & Budd, 2002). There are no records of *M. cavernosa* corallite shape in Brasil (Laborel, 1970; Amaral, 1991, 1994) and in this study we observed predominantly rounded corallites.

The significant differences between-localities in corallite diameter and columellar distance indicate the plasticity of these characters in *M. cavernosa*. However, the absence of variation in the number of septa per corallite suggests stability in this character. It might also indicate similarity in the deposition of calcium in the two populations given that, according to Beltrán-Torres & Carricart-Ganivet (1993), this last character directly reflects calcification effort.

Considering the geographic proximity and physical similarity of the reef environments of Picãozinho and Tamandaré, this explanation for the sililarity in the number of septa is plausible despite other factors that influence calcium deposition. Nevertheless, the marked variability in *M. cavernosa* corallite diameter corroborates the observations of Amaral (1991, 1994) at bothe intra and interpopulational levels. This author indicated that this character, along with septa thickness, exhibits relatively high plasticity.

Siderastrea stellata appears to adopt the general colony form described by Barnes (1973) and Fricke & Schuhmacher (1983), with predominantly hemispheric colonies in shallow waters, and more flattened colonies at greater depths. As for *M. cavernosa* the corallite was invariably rounded.

The significant variation in corallite diameter, columellar distance, and number of septa indicates that the skeletal morphometry of *S. stellata* can vary considerably at the interpopulational level. Todd *et al*. (2001) noted that large polyps are characters of *Favia speciosa* (Dana, 1846) colonies from shallow environments near the coast, where the levels of water turbidity is often high. However, *S. stellata* was characterizes by significantly smaller corallites at Tamandaré in comparison with Manuel Luiz, located in deep water far from the coast. Despite the lack of quantitative data for the studied areas' environmental variables, the results of this study suggest that *S. stellata* may not follow the morphological pattern of *F. speciosa*.

The columellar distance differed significantly among all populations of *Montastrea cavernosa* and *Siderastrea stellata.* The differences in the distance between columellas occur due to the colony's adaptations to light intensity (Barnes, 1973; Foster, 1980; Amaral, 1994). We observed a tendency for increasing mean columellar distance in a south-north direction in both species. In *S. stellata*, the largest mean distance was recorded in Maranhão. In deep areas, the need to improve the exposure of tissue (and, consequently, of zooxanthellae), is translated into flattened colonies with distant columellar centers, which generates a larger coenosteum.

Foster (1977, 1980) relates variations in *Montastrea annularis* to factors such as light and nutrient availability, and Lasker (1979, 1981) points to behavioral differences that influence morphology in *M. cavernosa*. Sunlight may be equally abundant at the two *M. cavernosa* study localities, and thus may not influence the variation in columellar distance, although no data are available on the quantity of sediment particles in the water.

We consider that the considerable variability in the morphological characters of *M. cavernosa* and *S. stellata* may reflect the combined action of environmental stimuli and the genetic potential of these species. The unique characteristics of Brasilian reef environments and the endemic condition of *S. stellata* indicate a need for more detailed studies, with a view to creating a profile of variation in this species.

Acknowledgements: We thank Dr. Nancy Knowlton for revising the manuscript; Andrea Q. Steiner, Eduardo Esteves, and Cristiane F. Costa for their suggestions; and PIBIC/CNPq for granting a fellowship to the first author.

REFERENCES

Amaral, F. D. 1991. **Variação morfológica dos esqueletos de *Montastrea cavernosa* (Linnaeus, 1767) e *Favia gravida* (Verrill, 1868) (Cnidaria: Scleractinia).** Dissertação (Mestrado em Zoologia). Museu Nacional do Rio de Janeiro, UFRJ 120 p.

Amaral, F.D. 1994. Morphological variation in the reef coral *Montastrea cavernosa* in Brazil. **Coral Reefs** 13: 113-117.

Amaral, F.D. 1998. Recifes de corais e de arenitos do Brasil. **Res. XIII Simpósio de Biologia Marinha**, USP – CEBIMar p. 5.

Amaral, F.D., M.M. Hudson & M.C. Coura, 2000. New findings on coral and hydrocorals from the Marine Park of Manuel Luiz Parcel (Maranhão State). **Proc. 9th International Coral Reef Symposium** 115(3):294.

Antônio-de-Souza, C. & F.D. Amaral, 2001. Variação morfométrica de algumas espécies de corais Mussidae (Cnidaria: Anthozoa) do Brasil. **Tropical Oceanography** 29(2):81-95.

Barnes, D.J. 1973. Growth in colonial scleractinians. **Bulletin of Marine Science** 23 (2):280-298.

Barnes, D.J. & J.M. Lough, 1999. *Porites* growth characteristics in a changed environment: Misima Island, Papua New Guinea. **Coral Reefs** 18:213-218.

Beltrán-Torres, A.U. & J.P. Carricart-Ganivet, 1993. Skeletal morphologic variation in *Montastrea cavernosa* (Cnidaria: Scleractinia) at Isla Verde Coral Reef, Veracruz, Mexico. **Revista de Biologia Tropical** 41 (3):559-562.

Best, M.B., G.J. Boekschoten & A. Oosterbaan, 1983. Species concept and ecomorph variation. **Paleontographica Americana** 54:70-79.

Boardman, R.S., A.H. Cheetham & P.L. Cook, 1969. Intracolony variation and the genus concept in Bryozoa. **Proc. North American Paleontological Convention** 294-320.

Bradshaw, A.D. 1965. Evolutionary significance of phenotypic plasticity in plants. **Advances in Genetics** 13:115-155.

Brakel, W.H. 1977. Corallite variation in *Porites* and the species problem in corals. **Proc. 3rd International Coral Reef Symposium** 3:393-398.

Bruno, J.F. & P.J. Edmunds, 1997. Clonal variation for phenotypic plasticity in the coral *Madracis mirabilis*. **Ecology** 78(7):2177-2190.

Cairns, S.D. 1978. New genus and species of ahermatipic coral (Anthozoa: Scleractinia) from the Western Atlantic. **Proc. Biological Society of Washington** 91(1):216-221.

Cairns, S.D. 1982. Stony corals (Cnidaria: Hydrozoa: Scleractinia) of Carrie Bow Cay, Belize. **Smithsonian Contributions to the Marine Sciences** 12: 271-301.

Carlon, D.B. & A.F. Budd, 2002. Incipient speciation across a depth gradient in a scleractinian coral? **Evolution** 56 (11):2227-2242.

Castro, C & D.O. Pires, 2001. Brazilian coral reefs: what we already know and what is still missing. **Bulletin of Marine Science** 69(2):357-371.

Foster, A.B. 1977. Patterns of small-scale variation of skeletal morphology within the Scleractinian corals, *Montastrea annularis* and *Siderastrea siderea*. **Proc. 3rd International Coral Reef Symposium** 2: 409-415.

Foster, A.B. 1978. **Morphologic variation within three species of reef corals (Cnidaria, Anthozoa, Scleractinia).** PhD Thesis. Johns Hopkins University 278 p.

Foster, A.B. 1980. Environmental variation in skeletal morphology within the Caribbean reef corals *Montastrea annularis* and *Siderastrea siderea*. **Bulletin of Marine Science** 30 (3):678-709.

Foster, A.B. 1983. The relationship between corallite morphology and colony shape in some massive reef-corals. **Coral Reefs** 2:19-25.

Fricke, H.W. & H. Schuhmacher, 1983. The depth limits of Red Sea stony corals: an ecophysiological problem (a deep diving survey by submersible). **Marine Ecology** 4 (2):163-194.

Futuyma, D.J. 1992. **Biologia evolutiva**. Sociedade Brasileira de Genética & CNPq, 2ª ed., São Paulo, 646 p.

Gattuso, J.P. 1985. Features of depth effects on *Stylophora pistillata*, an hermatypic coral in the Gulf of Aqaba (Jordan, Red Sea). **Proc. 5th International Coral Reef Congress** 6:95-100.

Knowlton, N., E. Weil, L.A. Weigt & H.M. Guzmán, 1992. Sibling species in *Montastrea annularis*, coral bleaching and coral climate record. **Science** 255:330-333.

Laborel, J. 1970. Madreporaires et hydrocoralliaries récifaux des cotes brésilienes. Systematique, écologie, répartition geographique. **Résultats Scientifiques des Campagnes de la "Calypso"** 9(5):171-229.

Lasker, H.R. 1979. Ligth dependent activity patterns among reef corals: *Montastrea cavernosa*. **Biological Bulletin** 156:196-211.

Lasker, H.R. 1981. Phenotypic variation in the coral *Montastrea cavernosa* and its effects on colony energetics. **Biological Bulletin** 160:292-302.

Maida, M. & B.P. Ferreira, 1997. Coral Reefs of Brazil: an overview. **Proc. 8th International Coral Reef Symposium** 1:263-274.

Maté, J.L. 2003. Ecological, genetic, and morphological differences among three *Pavona* (Cnidaria: Anthozoa) species from the Pacific coast of Panama. **Marine Biology** 142:427–440.

Maÿal, E. & F. Amaral, 1990. Ecomorfose em alguns escleractínios da costa pernambucana. Universidade Federal de Pernambuco. **Trabalhos Oceanográficos** 21:239-251.

Miller, J.K. 1994. Morphological variation in the coral genus *Platygira*: environmental influence and taxonomic implications. **Marine Ecology Progress Series** 110:19-28.

Palumbi, S.R. 1994. Genetic divergence, reproductive isolation, and marine speciation. **Annual Review of Ecology and Systematics** 25:547-572.

Rocha, L.A. 1999. **Composição e estrutura da comunidade de peixes do parque estadual marinho do Parcel do Manuel Luiz – Maranhão, Brasil.** Dissertação (Mestrado em Zoologia), Universidade Federal da Paraíba 147 p.

Todd, P.A., P.G. Sanderroo & L.M. Chou, 2001. Morphological variation in the polyps of the scleractinian coral *Favia speciosa* (Dana) around Singapore. **Hydrobiologia** 444:227-233.

Vaughan, T.W. & J.W. Wells, 1943. Revision of the suborders, families, and genera of the Scleractinia. Geological Society of America. **Special Papers of Washington Museum** 44:1-363.

Veron, J.E.N. 1981. The species concept in Scleractinia of Eastern Australia. **Proc. 4th International Coral Reef Symposium** 2:183–186.

Veron, J.E.N. 1995. **Corals in space and time**. Comstrock/ Cornell – Ithaca. New York 321 p.

Veron, J.E.N. & M. Stafford-Smith, 2000. **Corals of the world.** Australian Institute of Marine Science (AIMS), Townsville MC, Queensland, Australia 3 vol.

Vuelta, C.B. 2000. **Influência do turismo sobre a ictiofauna do Recife do Picãozinho, Paraíba, Brasil.** Dissertação (Mestrado em Zoologia), Universidade Federal da Paraíba 102 p.

Wells, J.W. 1956. Scleractinia, pp. 328-344. *In*: **Treatise on Invertebrate Paleontology** (Moore, R.C. Ed.). Geological Society of America, New York.

West, J.M., C.C. Harvell & A.M. Walls, 1993. Morphological plasticity in a gorgonian coral (*Briareum asbestinum*) over a depth cline. **Marine Ecology Progress Series** 94(1):61-69.

Wijsman-Best, M. 1974. Habitat-induced modification of reef corals (Faviidae) and its consequences for taxonomy. **Proc. 2nd International Coral Reef Symposium** 2:217-228.

Willis, B.L. 1985. Phenotypic plasticity stability in the reef corals *Turbinaria mesenterina* and *Pavona cactus*. **Proc. 5th International Coral Reef Congress** 4:107-112.

Young, P.S. 1984. **Análise qualitativa e quantitativa da fauna associada aos corais hermatípicos *Mussismilia harttii*, *M. hispida* e *Siderastrea stellata* (Coelenterata: Scleractinia) nos recifes de João Pessoa, PB.** Dissertação (Mestrado em Zoologia). Universidade Federal da Paraíba 180 p.

Zar, J.H. 1999. **Biostatistical analysis**. 4th edition. Prentice Hall.

Zlatarski, V.N. 1990. *Porites colonensis*, new species of stony coral (Anthozoa: Scleractinia) of the Caribbean coast of Panama. **Proc. Biological Society of Washington** 103(2):257–264.

Zlatarski, V.N. & N.M. Estalella, 1982. **Les Scléractiniaires de Cuba**. Éditions de l'Académie Bulgare des Sciences, Sofia 471 p.

Aceito: 2.iii.2004