Status of knowledge of the Indo-Pacific soft coral genus *Sinularia* May, 1898 (Anthozoa: Octocorallia)

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ABSTRACT

The distribution of the octocoral genus *Sinularia* has been examined using the latest revision of the genus and all subsequent publications.

Keywords *Sinularia*, Octocorallia, Anthozoa, Distribution.

Introduction

The Indo-Pacific genus *Sinularia*, with 128 nominal species, is the largest zooxanthellate shallow-water soft coral genus. Its species show highly variable growth forms, from encrusting with small knobs or ridges to tall and abundantly lobed. They occur in shallow water of less than 1 m down to 35 m and are represented at various reef habitats. Colonies can be a few cm to several meters in diameter. Some species may even dominate vast regions of the reef. However, much research has to be done before most species are well known. Nevertheless, thanks to the latest revision of the genus (Verseveldt 1980), specimens of *Sinularia* can be identified with reasonable certainty.

Methods

In order to examine species diversity patterns for *Sinularia* in the Indo-Pacific, species numbers of 30 areas were counted using Verseveldt's (1980) revision. Additionally, all subsequent publications dealing with taxonomy were checked. All together, 27 papers were found (Li 1982, Verseveldt and Alderslade 1982, Verseveldt 1983, Verseveldt and Benayahu 1983, Alderslade 1987, Alderslade and Baxter 1987, Chang et al. 1988, Humes 1990, Malyutin 1990, 1992, Alderslade and Shirwaiker 1991, Imahara 1991, 1997, Ofwegen and Vennam 1991, 1994, Ofwegen and Benayahu 1992, Benayahu 1993, 1995, 1997, Ofwegen and Slierings 1994, Vennam and Parulekar 1994, Ofwegen 1996, Benayahu and Schleyer 1996, Jayasree et al. Parulekar 1996, Vennam and Ofwegen 1996, Jayasree and Parulekar 1997, Benayahu yet al.1998). Because Verseveldt did not include all of his own publications in his revision dealing with *Sinularia*, ten additional relevant previous papers of Verseveldt had to be included as well (Verseveldt 1971, 1972, 1974a, 1974b, 1976, 1977a, 1977b, 1977c, 1978, Verseveldt and Benayahu 1978).

The result of this count is presented in Table 1 and Fig. 1 and should be considered a first attempt to sort out the distribution of *Sinularia* species. Some species descriptions are of such a poor quality that their recognition is hardly possible (i.e. Li 1982). Many more species await description and several of the presently recognised species probably will be synonymised after more material has been examined.

For comparison, the designated regions used by Hoeksema (1989) for the distribution of mushroom corals (Scleractinia: Fungiidae) have been adopted for the *Sinularia* distribution. That study showed a concentration of species in the Indo-Malayan region, including New Guinea, around the centre of which the diversity decreases in both longitudinal and latitudinal directions.

Results

Since Verseveldt's revision, 35 new species have been described. The four most widespread *Sinularia* species proved to be *S. leptoclados* (18 areas), *S. polydactyla* (17 areas), *S. brassica* (16 areas), and *S. flexibilis* (12 areas); all of which were already described in the 19th century. It is remarkable that of these apparently common species, with regard to the Indian Ocean, the easily recognisable *S. flexibilis* was only reported from the Andamans (Jayasree et al. 1996).

So far, only eight species have been recorded in ten or more areas. Of the 128 nominal species, no less than 49 were each found in a single area only. Of these 49 species, 13 were described from the Red Sea area only. From four regions no *Sinularia* species have been recorded, i.e., Galapagos + Cocos Islands, Mexico, Easter island, and the Persian Gulf. The easternmost record for the distribution of the genus is the Tuamoto Archipelago + Marquesas area. The Persian Gulf clearly needs more research with regard to its octocoral fauna as it would be expected that the genus occurs in that region.

The distribution of *Sinularia* is somewhat similar to that of other tropical shallow-water animals in the Indo-Pacific, showing a decrease of species number towards America, Japan and Australia (Fig. 1), but the highest number of recorded species is not found in the central Indo-Pacific. Instead, most records are for the Red Sea and the Seychelles-Mauritius Plateau (both 38 species), and eastern Africa (33 species), although the Indonesian Archipelago (28 species) and New Guinea (32 species) score rather well. The Philippines, on the other hand, with only seven species, seems to be depauperate, but it is obvious that very few papers about Philippine octocorals have been published relative to those for the Red Sea and the Seychelles. It seems, therefore, that the known distribution of *Sinularia* is highly biased by the amount of research performed in each area. The Great Barrier Reef, for example, is very rich in *Sinularia* species (Alderslade, pers. com.), but the data is yet to be published.

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Table 1 Areas in the Indo-Pacific and their number of recorded species of *Sinularia*. Verseveldt (1980) suspected that *S. microclavata* Tixier-Durivault, 1970, is synonymous with *S. mayi* Lüttschwager, 1914. Pending re-examination of the type material of *S. mayi* they are here united under *S. mayi/microclavata* without mentioning authors. All records after Verseveldt's revision are in bold.

Area	RS (Red Sea)	EL (E-Africa)	MA (Madag.)	PG (Persian G.)	SM (Seychell.)	CL (Chag/Mal)	IS (SE India)	AS (Andaman)	SC (S China S.)	IA (Indonesia)	Ph (Philippines)	TW (Taiwan)	WA (W Austr)	JA (Japan)	WC (W Carol)	MB (Marianas)	NS (New Guin)	EC (E Carol)	GB (GBR)	VN (New Cal.)	MG (Marshal)	FT (Fiji+Tonga)	SP (Samoa)	HA (Hawai)	Li (Line I.)	CS (Cook I.)	TA (Tuamoto)	Ea (Easter I)	Me (Mexico)	GP (Galap)	Number of areas
Sinularia species																															
S. abhishiktae van Ofwegen & Vennam, 1991		**1**				**1**																									2
S. abrubta Tixier-Durivault, 1970		**1**			1	**1**	**1**		1					**1**		**1**									1						8
S. acetabulata Verseveldt & Tursch, 1979																	**1**														1
S. andamanensis (Thomson & Simpson), 1909								1																							1
S. anomala Verseveldt & Benayahu, 1983	**1**																														1
S. arborea Verseveldt, 1970			1						1							**1**															3
S. asterolobata Verseveldt, 1977																			**1**												1
S. barcaformis Verseveldt & Benayahu, 1983	**1**																														1
S. brassica May, 1898	1	**1**	1		**1**	1	**1**			1	1		1	1	1	**1**	1	1	1	1											16
S. candidula Verseveldt & Benayahu, 1983	**1**																														1
S. capillosa Tixier-Durivault, 1970									1					**1**																	2
S. capitalis (Pratt, 1903)					**1**	1				1																					3
S. ceramensis Verseveldt, 1977										**1**																					1
S. compacta Tixier-Durivault, 1970		**1**										**1**								**1**								**1**			4
S. compressa Tixier-Durivault, 1945	1															**1**															2
S. conferta (Dana, 1846)																							**1**								1
S. conferta var. *gracilis* Macfadyen, 1936																	**1**		**1**												2
S. corpulenta Li, 1982									**1**																						1
S. crassa Tixier-Durivault, 1945			**1**		**1**				1							**1**				**1**								**1**			6
S. cristata Tixier-Durivault, 1969					**1**					**1**						**1**				**1**								**1**			5
S. cruciata Tixier-Durivault, 1970	**1**				**1**				1	**1**							**1**														5
S. crustaformis Verseveldt & Benayahu, 1983	**1**																														1
S. dactyloclados Verseveldt & Benayahu, 1983	**1**																														1
S. deformis Tixier-Durivault, 1969																												**1**			1
S. densa (Whitelegge, 1897)					**1**	**1**						**1**							**1**		**1**	**1**		**1**	**1**						8
S. depressa Tixier-Durivault, 1970								**1**	**1**	**1**																					3
S. discrepans Tixier-Duriuvault, 1970																**1**				**1**											2
S. dissecta Tixier-Durivault, 1945	1				1	**1**	**1**													**1**											5
S. elongata Tixier-Durivault, 1970						**1**														**1**											2
S. erecta Tixier-Durivault, 1945	1	**1**	1		**1**		**1**									**1**															6
S. exilis Tixier-Durivault, 1970					1		**1**		1			**1**																			4
S. facile Tixier-Durivault, 1970						**1**			1			**1**																			3
S. fibrillosa Li, 1982									**1**																						1
S. firma Tixier-Durivault, 1970		**1**	1		**1**												**1**			**1**											5
S. fishelsoni Verseveldt, 1970		**1**			**1**																										2
S. flabelliclavata Verseveldt & Benayahu, 1983	**1**																														1
S. flexibilis (Quoy & Gaimard, 1833)								**1**	1	1	1	**1**		1	1		**1**		1	**1**		1	1								12
S. flexuosa Tixier-Durivault, 1945	1	1	1																												3
S. foveolata Verseveldt, 1974																				**1**											1
S. frondosa Verseveldt, 1978																		**1**													1
S. fungoides Thomson & Henderson, 1906		1	1														**1**														3
S. gardineri (Pratt, 1903)	**1**	**1**				1								1		**1**																5
S. gaveshaniae Alderslade & Shirwaiker, 1991						1																									1
S. gaweli Verseveldt, 1978						1										**1**															2
S. gibberosa Tixier-Durivault, 1970		**1**			1		1	1	1	1		1		1		**1**															9
S. grandilobata Verseveldt, 1980		1					1				1	1					**1**														5
S. granosa Tixier-Durivault, 1970							1	1	1	1		1																			5
S. gravis Tixier-Durivault, 1970		**1**			1	1								1		**1**	1		1	1								1	1			10
S. grayi Tixier-Durivault, 1945	1		1																										1		3
S. gyrosa (Klunzinger, 1877)	1																														1
S. halversoni Verseveldt, 1974											1									1											2
S. heterospiculata Verseveldt, 1970	1	1	1		1					1							1														6
S. hirta (Pratt, 1903)	1	1			1	1	1	1		1							1														8
S. humesi Verseveldt, 1968	1		1		1					1						1	1														6
S. incompleta Verseveldt & Benayahu, 1983	1																														1
S. inelegans Tixier-Durivault, 1970	1					1			1																						3
S. inexplicita Tixier-Durivault, 1970									1			1							1												3
S. inflata Tixier-Durivault, 1970																				1											1

S. intacta Tixier-Durivault, 1970							1			1										1												3
S. jasminae Alderslade & Shirwaiker, 1991						1																										1
S. kavarattiensis Alderslade & Shirwaiker, 1991						1				1																						2
S. lamellata Verseveldt & Tursch, 1979																	1															1
S. laminilobata Malyutin, 1990									1																							1
S. larsonae Verseveldt & Alderslade, 1982																	1		1													2
S. leptoclados (Ehrenberg, 1834)	1	1	1		1	1	1	1		1	1		1	1		1	1		1	1	1				1		1					18
S. licroclados Verseveldt & Benayahu, 1983	1																															1
S. lochmodes Kolonko, 1926					1	1			1	1	1	1		1			1		1	1												10
S. loyai Verseveldt & Benayahu, 1983	1																															1
S. macrodactyla Kolonko, 1926	1	1	1		1					1			1								1											7
S. macropodia (Hickson & Hiles, 1900)			1		1				1					1		1	1		1	1		1					1					10
S. mammifera Malyutin, 1990									1																							1
S. manaarensis Verseveldt, 1980					1		1	1																								3
S. marenzelleri (Wright & Studer, 1889)	1	1	1				1		1								1			1	1											8
S. mauritiana Vennam & Parulekar, 1994					1																											1
S. maxima Verseveldt, 1971		1	1		1			1						1		1	1															7
S. megalosclera Alderslade, 1987												1																				1
S. mayi/S. microclavata			1		1									1						1												4
S. minima Verseveldt, 1971	1		1													1																3
S. mira Tixier-Durivault, 1970									1																							1
S. molesta Tixier-Durivault, 1970		1					1			1										1												4
S. mollis Kolonko, 1926	1										1	1		1																		4
S. molokaiensis Verseveldt, 1983																									1							1
S. monstrosa Li, 1982									1																							1
S. muqeblae Verseveldt & Benayahu, 1983	1																															1
S. muralis May, 1899		1			1	1	1			1		1																				6
S. nanolobata Verseveldt, 1977										1				1																		2
S. notanda Tixier-Durivault, 1966	1	1			1					1				1		1																6
S. numerosa Txier-Durivault, 1970			1		1	1						1		1		1				1								1				8
S. ornata Txier-durivault, 1970							1							1			1			1								1				5
S. ovispiculata Tixier-Durivault, 1970					1			1	1	1				1			1															6
S. papillosa Li, 1982									1																							1
S. parulekari Alderslade & Shirwaiker, 1991						1																										1
S. parva Tixier-Durivault, 1970									1																							1
S. paulae Benayahu, 1997																1																1
S. pavida Tixier-Durivault, 1970									1			1		1																		3
S. peculiaris Tixier-Durivault, 1970		1														1	1			1												4
S. pedunculata Tixier-Durivault, 1945			1		1				1											1				1								5
S. platylobata van Ofwegen & Benayahu, 1992		1																														1
S. platysma Alderslade & Baxter, 1987												1																				1
S. polydactyla (Ehrenberg, 1834)	1	1	1		1		1	1	1	1		1		1	1	1	1			1	1	1	1									17
S. portieri Verseveldt, 1980	1	1																														2
S. prattae Verseveldt, 1974							1																									1
S. procera Verseveldt, 1977										1														1								2
S. prodigiosa Verseveldt, 1977																			1													1
S. querciformis (Pratt, 1903)	1	1			1	1				1			1	1	1	1			1													10
S. ramosa Tixier-Durivault. 1945					1				1							1			1													4
S. recurvata Verseveldt & Benayahu, 1983	1																															1
S. rigida (Dana, 1846)	1	1			1					1						1				1	1											7
S. robusta Macfadyen, 1936					1											1		1														3
S. rotundata Tixier-Durivault, 1970		1																	1													2
S. sandensis Verseveldt, 1977							1									1				1												3
S. scabra Tixier-Durivault, 1970								1			1			1																			3
S. schleyeri Benayahu, 1993		1																														1
S. schuhmacheri Verseveldt & Benayahu, 1983	1																															1
S. slieringsi van Ofwegen & Vennam, 1994										1																						1
S. sobolifera Verseveldt & Tursch, 1979																1																1
S. tenella Li, 1982									1																							1
S. terspilli Verseveldt, 1971	1	1	1		1																											4
S. triangula Tixier-Durivault, 1970		1														1			1													3
S. variabilis Tixier-Durivault, 1945		1				1				1			1		1				1						1							7
S. venusta Tixier-Durivault, 1970					1										1	1			1	1												5
S. verseveldti van Ofwegen, 1996																1																1
S. vervoorti Verseveldt, 1977															1																	1
S. vrijmoethi Verseveldt, 1971	1		1					1						1																		4
S. whiteleggei Lüttschwager, 1914	1		1		1				1	1										1	1					1						8
S. yamazatoi Benayahu, 1995														1																		1
Total number of species per area	38	33	23	0	38	23	17	14	32	28	7	17	4	25	5	26	32	2	13	32	8	7	4	2	3	1	12	0	0	0		
Area	RS	EL	MA	PG	SM	CL	IS	AS	SC	IA	Ph	TW	WA	JA	WC	MB	NS	EC	GB	VN	MG	FT	SP	HA	Li	CS	TA	Ea	Me	GP		

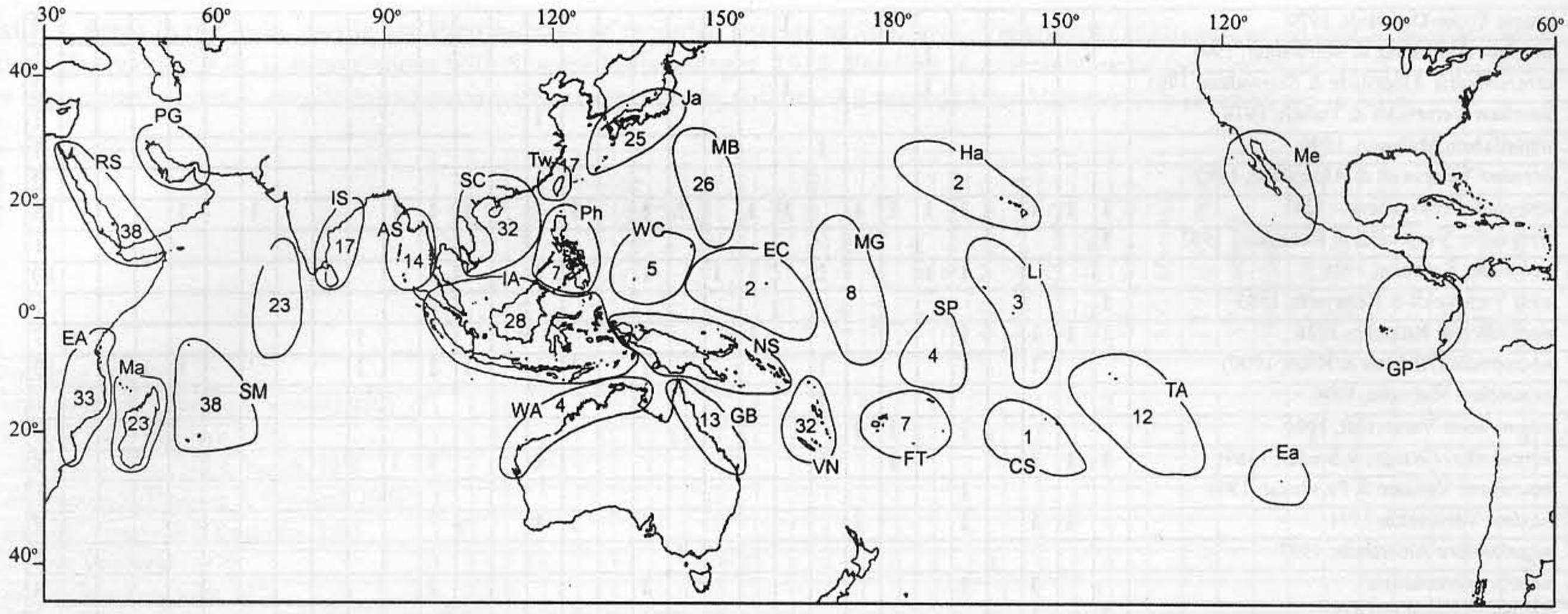

Fig. 1. Areas in the Indo-Pacific and their number of recorded species of *Sinularia*: AS = Andaman Sea; CL = Chagos-Laccadive Plateau; CS = Cook Is. + Society Is.; EA = Eastern Africa; Ea = Easter I.; EC = East Carolines; FT = Fiji + Tonga Is.; GB = Great Barrier Reef; GP = Galapagos + Cocos Is. + Gulf of Panama; Ha = Hawaii Is.; IA = Indonesian Arch.; IS = SE India + Sri Lanka; Ja = Japan; Li = Line Is.; Ma = Madagascar; MB = Marianas + Bonin Is.; Me = Mexico; MG = Marshall + Gilbert Is.; NS = New Guinea + Solomon Is.; PG = Persian Gulf; Ph = Philippines; RS = Red Sea; SC = South China Sea; SM = Seychelles- Mauritius Plateau; SP = Samoa + Phoenix Is.; TA = Tuamoto Arch. + Marquesas; Tw = Taiwan; VN = Vanuatu + New Caledonia; WA = Western Australia; WC = West Carolines (after Hoeksema, 1989).

Conclusions and further study

The presently known distribution of the *Sinularia* does not match the known distribution of other groups of tropical shallow-water animals. Especially, the central Indo-Pacific, Western Australia, and the Great Barrier Reef deserve more research. In order to test the influence of the amount of research performed in a certain area, the number of specimens examined per publication could be counted. Unfortunately, this is not always possible as sometimes only species lists are given without mentioning the material examined. Therefore, in the future, reports planned on recently collected material from the, Seychelles, Indonesia and Philippines will have the number of species per area related to the total number of specimens examined. All this material has been collected using similar collecting methods, facilitating comparison.

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