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Affinities of the marine flora of the Revillagigedo Islands, Mexico

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Abstract

The benthic algal flora reported for the Revillagigedo Islands comprises 205 specific infraspecific taxa: 42 Chlorophyta, 29 Phaeophyta and 134 Rhodophyta. This insular flora shares 131 taxa (54%) with other regions of the Mexican Pacific and 74 (36%) are restricted apparently to the islands. One hundred three taxa (50%) are shared with areas of the Mexican tropical Pacific, 69 (34%) with warm temperate Pacific Mexico and 66 (32%) with La Paz, the transitional zone between tropical and warm temperate Pacific Mexico. Considering more general regions, the Revillagigedo Islands flora includes apparently restricted distribution (34 spp., 16.6%), exclusively tropical (51 spp., 25%) and widely distributed eastern Pacific (33 spp., 16%) taxa. Even though we consider that the inventory of the Revillagigedo Islands and to a lesser degree the eastern tropical Pacific flora is still incomplete and in need of further taxonomic study, the floristic comparison shows a greater affinity of the Revillagigedo Islands flora with the Mexican tropical Pacific than with any other part of Mexico.

Introduction

The Revillagigedo Islands are of great interest for various scientific disciplines because of their specific physiographic, climatic and biological characteristics related to their insular condition and to their geographical situation at the confluence of two major oceanic currents (Adem et al., 1960; Gallegos et al., 1988). They comprise four islands (Socorro, Clarion, San Benedicto and Roca Partida), located between 18°20′ and 19°20′ N lat., 110°45′ and 114°50′ W long., and are included in the Mexican tropical Pacific region. These islands are subject to the influence of the North Equatorial Current during the summer and beginning of autumn, especially in October, and to the California Current in winter and beginning of spring, especially in April (Gallegos et al., 1988; Lluch-Cota et al., in press; Figure 1). According to Llinas-Gutiérrez et al. (1993), highly changeable wind and superficial current patterns cause the annual temperature of the sea water to vary from 19.7 to 23.5 °C. Medina (1978) has recorded salinity values of 34–35 ppt.

The Revilagigedo Islands have been characterized as an area especially in need of conservation because 31% of its terrestrial plant species, about 80% of its avifauna and all the rest of its vertebrates are endemic. In comparison, the marine biota has a lower total number of species and fewer endemic species (Bautista-Romero, et al., in press; IUCN, 1980; Llinas-Gutiérrez et al., 1993).

Our knowledge of the marine flora of the Revillagigedo Islands began with the California Academy of Sciences expeditions of 1925 and 1932 (Setchell & Gardner, 1930, 1937; Setchell, 1937). The 1925 expedition was primarily concerned with the Revillagigedo Is. The botanist was H. L. Mason, who collected algae only on Clarion Is., although Socorro, San Benedicto and Roca Partida were also visited. The 1932 expedition was primarily concerned with the Galapagos Is., but the itinerary included Clarion Is., where collections were made by the botanist J. T. Howell. These two expeditions resulted in the report of 30 specific and infraspecific taxa. Shortly thereafter, Allan Hancock sent two expeditions to the Galapagos Is., in 1934 and 1939, both of which stopped at Clarion and Socorro

Is., where the botanist, W. R. Taylor, made collections. Taylor (1945) reported 67 species and infraspecific taxa from these expeditions. Following the volcanic eruption of 1952–1953, San Benedicto Is. was visited by a group from Scripps Institution (La Jolla), including E. Y. Dawson, who revisited the island two years later. Dawson (1954c, 1957) reported 53 taxa (45 determined to the specific or infraspecific level). In 1967, an expedition to Socorro and San Benedicto Is. was organized by the Sociedad de Ciencias Naturales de Jalisco. Collections of algae were made by L. Huerta and A. M. Garza-Barrientos, who reported 69 taxa (including two identified to generic level; Huerta & Garza-Barrientos, 1975). Papers that include incidental citations of species from the Revillagigedo Is. are Dawson (1944, 1946, 1949, 1953a, 1953b, 1954a, 1954b, 1959, 1960a, 1960b, 1961a, 1961b, 1962, 1963a, 1963b), Hollenberg (1942, 1948), Hollenberg & Dawson (1961), Hollenberg & Norris (1977), Hillis (1958), Abbott (1967), Abbott & Hollenberg (1976), Huerta (1978), Chávez (1980), Norris (1985), Norris & Johansen (1981) and Ortega et al. (1985).

The purpose of the present study was to determine the floristic attinities of the benthic marine algae of the Revillagigedo Islands with several continental Pacific México sites and four more extensive regions.

Materials and methods

We made an integrated list of specific and infraspecific taxa from the Revillagigedo Islands based on the 34 papers that cite collections from there. Cyanophyta (Cyanobacteria) were not considered. The resulting floristic lists of Chlorophyta, Phaeophyta and Rhodophyta were compared with previously described floras from seven sites along the continental Pacific Mexican coast (Figure 1): (1) Todos Santos Island and Bay (Aguilar, 1981, 1982; Aguilar & Bertsch, 1983; Aguilar et al., 1990) and (2) Tortugas Bay (Mendoza-González & Mateo-Cid, 1985), both Pacific Baja California, and (3) La Paz Bay (Huerta & Mendoza-González, 1985), transitional between warm temperate and tropical (Hubbs & Roden, 1964) and (4) the northern part of the Gulf of California (Norris, 1975), 1, 2 and 4 warm temperate sites (Espinoza-Avalos, 1993); (5) Nayarit, (6) Jalisco and (7) Oaxaca (Serviere-Zaragoza, 1993; León-Tejera & González-González, 1993), all tropical sites. Floristic list for all of these sites were compared with those from Dawson (1961b). Names were checked for correctness against lists in Abbot & Hollenberg (1976), Silva et al. (1987), Ramírez & Santelices (1991) and Wynne (1986).

The degree of floristic affinity between the Revillagigedo Islands and the Mexican continental sites as well as between these islands and four other regions was calculated using percentages of shared and exclusive species. The presence of species and varieties in other areas of the Pacific was determined from the literature: eastern tropical Pacific (Dawson, 1961b; Schnetter & Bula-Meyer, 1982; Taylor, 1945), western tropical Pacific (Philippines; Silva et al., 1987), North American temperate Pacific (Abbott & Hollenberg, 1976; Dawson, 1961b), South American temperate Pacific (Dawson et al., 1964; Ramírez & Santelices, 1991). The Pacific distribution of these specific and infraspecific taxa was tabulated.

Results

Floristic affinities with continental México

The recorded benthic marine algal flora of the Revillagigedo Islands totals 205 specific and infraspecific taxa, of which 42 are Chlorophyta, 29 Phaeophyta and 134 Rhodophyta (Table 1). Of these, 74 (36%) are not known from mainland México while 131 (64%) were found in at least one of the seven continental sites. Of these 131 specific and infraspecific taxa that have records in continental México, 103 (50%) are recorded also from the Mexican tropical Pacific, of which 30 (15% of the total flora) are recorded only from the Revillagigedo Is. and Nayarit, Jalisco or Oaxaca, all tropical sites. Sixty-nine taxa (34% of the total flora) are recorded from the Revillagigedo Is. and from Mexican warm temperate areas, of which 19 (9.3% of the total flora) are recorded only from the Revillagigedo Is. and Todos Santos Island and Bay, Tortugas Bay, or northern Gulf of California, all temperate sites. Sixty-six taxa (32% of the total) are recorded from these islands and La Paz, of which 5 (2.4% of the total) are recorded only from the islands and La Paz.

Considering each of the sites, the Revillagigedo Islands flora has more species and subspecific taxa in common with tropical areas, especially Nayarit (79 spp., 38.5%) and Oaxaca (74 spp., 36%), and less with warm temperate sites like Todos Santos Island and Bay (18 spp., 8.7%) and Tortugas Bay (20 spp., 10%). La Paz (63 spp., 30.7%), in the transitional zone between tropical and warm temperate Pacific México, shares a similar number of taxa with the Revillagigedo Is. flora

Table 1. Distribution of Revillagigedo Islands species on other areas of México and other regions of the Pacific. Areas of México: SA = Todos Santos Island and Bay; TO = Tortugas Bay; PA = La Paz Bay; GC = northern part of the Gulf of California; JA = Jalisco; NA = Nayarit; OA = Oaxaca. Regions of the Pacific: WP = western tropical Pacific; EP = eastern tropical Pacific; NT = northeastern temperate Pacific; ST = southeastern temperate Pacific. syn = synonyms.

Species	Areas of México							Regions			
	SA	TO	PA	GC	JA	NA	OA	WP	EP	NT	ST
CHLOROPHYTA											
Acetabularia parvula Solms-Laub. v. *americana* Taylor	0	0	0	0	0	0	0	0	0	0	0
Bryopsis galapagensis Taylor	0	0	0	0	0	1	0	0	1	0	0
Caulerpa fastigiata Montagne	0	0	0	0	0	0	0	1	0	0	1
Caulerpa peltata (Turner) Lamour.	0	0	0	0	0	0	1	0	1	0	0
Caulerpa racemosa (Forssk.) J. Ag.	0	0	0	0	1	1	1	1	1	0	0
Caulerpa racemosa (Forssk.) J. Ag. v. *laetevirens* (Mont.) W.-v. Bosse	0	0	0	0	0	1	0	1	1	1	0
Caulerpa racemosa (Forssk.) J. Ag. v. *occidentalis* (J. Ag.) Boerg.	0	0	0	0	0	0	0	1	1	0	0
Chaetomorpha antennina (Bory) Kuetzing	0	0	1	1	1	1	1	1	1	1	1
Chaetomorpha exposita (Boerg.) Daws.	0	0	1	0	0	0	1	0	1	0	0
Chaetomorpha gracilis Kuetzing	0	0	0	0	0	0	1	1	1	0	0
Chlorodesmis comosa Harv. et Bail.	0	0	0	0	0	0	0	1	0	0	0
Chlorodesmis mexicana Taylor	0	0	0	0	0	1	1	0	1	1	0
Cladophora gracilis (Griffiths) Kuetzing f. *expansa* Farlow	0	0	0	0	0	0	0	0	0	0	0
Cladophora inserta Dickie	0	0	0	0	0	0	0	1	0	0	0
Chladophora perpusilla Skottsberg et Levring	0	0	0	0	0	0	1	0	1	0	0
Cladophoropsis membranacea (C. Ag.) Boerg.	0	0	1	0	0	0	0	1	1	1	0
Codium decorticatum (Woodw.) Howe	0	0	0	0	0	1	0	0	1	0	0
Codium isabelae Taylor	0	0	0	0	0	1	0	0	1	0	0
Codium longiramosum Setch. et. Gardn.	0	0	0	1	0	0	0	0	1	1	0
Codium simulans Setch. et Gardn.	0	0	0	1	0	0	0	0	0	1	0
Dictyosphaeria australis Setch.	0	0	0	0	0	0	0	0	1	1	0
Dictyosphaeria versluysii W.-v. Bosse	0	0	0	1	0	0	0	1	0	1	0
Enteromorpha clathrata (Roth) Grev.	0	0	1	1	0	1	1	1	1	1	1
Enteromorpha fleuxosa (Wulfen) J. Ag. syn *E. tubulosa* (Kuetz.) Kuetz.	0	0	1	0	1	1	1	1	1	1	0
Enteromorpha lingulata J. Ag.	0	0	1	0	0	0	1	1	1	1	1
Enteromorpha marginata J. Ag.	0	0	0	0	0	0	0	0	0	1	0
Enteromorpha plumosa Kuetz.	0	0	0	0	0	1	0	1	1	0	0
Ernodesmis verticillata (Kuetz.) Boerg.	0	0	1	1	0	0	0	1	0	1	0
Halimeda discoidea Decaisne	0	0	1	1	1	1	1	1	1	1	0
Halimeda opuntia (L.) Lamour.	0	0	0	0	0	0	0	1	0	1	0
Halimeda tuna (Ellis et Solander) Lamour.	0	0	0	0	0	0	0	1	0	0	0
Neomeris vanbosseae Howe	0	0	0	0	0	0	0	1	0	0	0
Ostreobium quequetii Born. et Flah.	0	0	0	0	0	0	0	0	0	1	1
Ostreobium reincekei Born.	0	0	0	0	0	0	0	1	0	1	0
Phaeophila engleri Reinke	0	0	0	0	0	0	1	0	1	0	0
Pilinia maritima (Kjellman) Rosenv. f. *pacifica* Thivy	0	0	0	0	0	0	0	0	0	0	0
Polyphysa parvula (Solms-Laub.) Schnetter et Bula-Meyer	0	0	0	0	0	1	1	1	1	0	0
Pseudobryopsis hainensis Tseng	0	0	0	0	0	0	0	0	0	0	0
Rhizoclonium kochianum Kuetz.	0	0	0	1	0	0	0	1	1	0	0
Rhizoclonium riparium (Roth) Harv. syn *R. kerneri* Stockm.	0	0	1	0	0	1	0	1	1	1	1
Siphonocladus tropicus (Crouan et Crouan) J. Ag.	0	0	0	0	0	0	0	0	0	0	0

Table 1. Continued.

Species	Areas of México								Regions		
	SA	TO	PA	GC	JA	NA	OA	WP	EP	NT	ST
Ulva lactuca L.	1	0	1	1	1	1	1	1	1	1	1
PHAEOPHYTA											
Aglaozonia canariensis Sauv.	0	0	0	0	0	0	0	0	0	0	0
Chnoosopora minima (Hering) Papenf.											
syn *C. pacifica* J. Ag.	0	0	1	0	1	1	1	1	1	0	0
Colpomenia sinuosa (Mert. ex Roth) Derb. et Sol.	1	1	1	1	0	0	0	1	1	1	1
Dictyopteris delicatula Lamour.	0	0	1	0	0	1	1	1	1	0	0
Dictyota crenulata J. Ag.	0	0	1	0	1	1	1	0	1	0	0
Dictyota dichotoma (Huds.) Lamour.	0	0	1	1	1	1	1	1	1	1	1
Dictyota divaricata Lamour.	0	0	1	1	1	1	1	1	1	1	0
Dictyota masonii Setch. et Gardn.	0	0	0	0	0	0	0	0	1	0	0
Dictyota vivesii Howe	0	0	0	0	0	0	0	0	0	0	0
Feldmannia indica (Sonder) Womers. et Bail.	0	0	0	0	0	1	1	1	1	1	0
syn *Giffordia duchassaigniana* (Grun.) Taylor											
Feldmannia irregularis (Kuetzing) Hamel	0	0	0	1	0	0	0	1	0	1	0
Hincksia breviarticulata (J. Ag.) Silva	0	0	1	0	1	0	1	1	1	1	0
Hincksia mitchelliae (Harvey) Silva	0	1	1	1	0	0	1	1	1	1	1
Lobophora variegata (Lamour.) Womers.	0	0	0	0	1	1	1	1	1	0	0
syn *Poccokiella variegata* (Lamour.) Papenf.											
Macrocystis pyrifera (L.) C. Ag.	1	1	0	0	0	0	0	0	0	1	1
Masonophycus paradoxus Setch. et Gardn.*	0	0	0	0	0	0	0	0	0	0	0
Neurocarpus delicatulus (Lamour.) O. Kuntze	0	0	0	0	0	0	0	0	0	0	0
Padina crispata Thivy	0	0	0	0	1	1	1	0	1	0	0
*Padina durvillei*Bory	0	1	1	1	1	1	1	0	1	1	1
Ralfsia californica Setch. et Gardn.	0	0	0	1	1	0	1	0	1	1	0
Ralfsia hancockii Daws.	0	0	0	0	0	0	1	0	1	0	0
Ralfsia pacifica Hollenb.	0	0	0	1	1	1	0	0	1	1	1
syn *R. occidentalis* Hollenb.											
Rosenvingea intricata (J. Ag.) Boerg.	0	0	1	1	1	1	0	1	1	1	0
Sargassum howellii Setch.	0	0	1	0	1	1	0	0	1	0	0
Sargassum palmeri Grun.	0	0	1	0	0	0	0	0	0	1	0
Sphacelaria californica (Sauvageau) Setch. et Gardn.	0	0	0	0	1	0	0	0	1	1	0
syn. *S. hancockii* Daws.											
Sphacelaria masonii Setch. et Gardn.	0	0	0	0	0	0	0	0	0	0	0
Sphacelaria mexicana Taylor	0	0	1	0	0	0	1	0	1	0	0
Sphacelaria rigidula Kuetz.	0	0	1	1	1	1	1	1	1	1	1
syn *S. furcigera* Kuetz.											
RHODOPHYTA											
Acrochaetium daviesii (Dillw.) Naeg.	0	0	0	1	0	0	0	0	0	1	0
Acrochaetium eastwoodiae (Setch. et Gardn.) Papenf.	0	0	0	0	0	0	0	0	0	0	0
Acrochaetium variabile (Drew) G. M. Smith	0	0	0	0	0	0	0	0	1	1	1
Agardhiella subulata (C. Ag.) Kraft et Wynne	0	0	0	0	0	0	0	0	1	1	1
syn *A. tenera* (J. Ag.) Schmitz											
Ahnfeltia plicata (Huds.) Fries	0	1	0	0	1	1	0	0	1	1	1
Ahnfeltiopsis concinna (J. Ag.) Silva et DeCew	0	0	0	0	1	1	1	1	1	0	1
Ahnfeltiopsis gigartinoides (J. Ag.) Silva et DeCew	1	0	0	0	0	1	1	0	1	1	0
Ahnfeltiopsis serenei (Daws.) Masuda	0	0	0	0	1	1	1	0	1	0	0
Amphiroa beauvoisii Lamour.	0	0	0	0	1	1	1	1	1	0	1
syn *A. droueti* Daws.											
syn *A. crosslandii* Lem.											
Amphiroa dimorpha Lem.	0	0	1	1	1	1	1	0	1	1	1
Amphiroa misakiensis Yendo	0	0	0	0	1	1	1	0	1	0	0

*Kuhlenkamp & Muller (1985) suggest the type specimen shows *Felmannia* characteristics.

Table 1. Continued.

Species	Areas of México								Regions		
	SA	TO	PA	GC	JA	NA	OA	WP	EP	NT	ST
Amphiroa rigida Lamour.	0	0	1	0	1	1	1	1	1	0	0
syn *A. taylorii* Daws.											
Amphiroa valonioides Yendo	0	0	0	1	0	1	0	1	1	1	0
syn *A. annulata* Lem.											
Asparagopsis taxiformis (Delile.) Trevisan	1	0	1	1	1	1	1	1	1	1	0
syn *A. sanfordiana* Harv.											
Asparagopsis taxiformis f. *amplissima* Setch. et Gardn.	0	0	0	0	0	0	0	0	0	0	0
syn *A. sanfordiana* Harv. f. *amplissima* Setch. et Gardn.											
Botryocladia pseudodichotoma (Farl.) Kylin	1	0	0	0	0	1	0	0	1	1	1
Callithamnion pacificum Taylor	0	0	0	0	0	0	0	0	0	0	0
Callithamnion paschala Boerg.	0	0	0	1	0	0	0	0	0	1	0
Callithamnion soccoriense Taylor	0	0	0	0	0	0	0	0	0	0	1
Carpopeltis clarionensis (Setch. et Gardn.) Daws.	0	0	0	0	0	0	0	0	0	0	0
Centroceras clavulatum (C. Ag.) Mont.	1	1	1	1	1	1	1	1	1	1	1
Ceramium clarionense Setch. et Gardn.	1	0	1	0	0	1	1	0	1	1	0
Ceramium flaccidum (Harv. ex Kuetz.) Ardiss.	0	0	1	1	1	1	1	1	1	1	0
syn *C. gracillimum* v. *byssoideum* (Harv.) G. Mazoyer											
Ceramium mazatlanese Daws.	0	0	0	1	0	0	1	1	1	1	0
Ceramium sinicola Setch. et Gardn.	1	1	1	1	0	0	0	1	1	1	0
Ceramium vagans Silva	0	0	0	1	0	0	0	1	1	1	0
syn *C. vagabundum* Daws.											
Champia parvula (C. Ag.) Harv.	0	0	1	1	1	1	1	1	1	1	0
Chondria clarionensis Setch. et Gardn.	0	0	0	0	0	0	0	0	0	1	0
Choreonema thuretii (Born.) Schmitz	0	0	0	0	0	0	0	0	1	1	0
Chroodactylon orgatum (C. Ag.) Basson	0	0	1	0	0	0	0	0	0	1	0
syn *Asterocytis ramosa* (Thwaites) Gobi											
Clarionea masonii Setch. et Gardn.	0	0	0	0	0	0	0	0	0	0	0
Colacodasya sinicola Setch. et Gardn.	0	0	0	0	0	0	0	0	0	0	0
Crouania attenuata (C. Ag.) C. Ag.	0	0	0	1	0	0	0	1	0	1	0
Cruoriella dubyi Crouan	0	0	0	0	0	1	0	0	1	0	0
Cryptonemia angustata (Setch. et Gardn.) Daws.	0	0	0	1	0	0	0	0	1	1	1
Cryptonemia taylorii Abbott	0	0	0	0	0	0	0	0	0	0	0
Dasya sinicola (Setch. et Gardn.) Dawson v. *abyssicola* (Daws.) Daws.	0	0	0	0	0	0	0	0	1	0	0
Dasya stanfordiana Farlow	0	0	0	0	0	1	0	0	1	1	0
Dermatolithon pustulatum (Lamour.) Fosl. f. *ascripticium* Fosl. syn *D. ascripticium* (Fosl.) Setch. et Mason	0	0	0	0	1	0	0	0	1	0	0
Dermonema frappieri (Mont. et Millard.) Boerg.	0	0	1	0	1	0	1	1	1	0	0
Digenea simplex (Wulfen) C. Ag.	0	0	1	1	0	1	0	1	1	1	0
Erythrocystis saccata (J. Ag.) Silva	1	1	0	0	0	0	0	0	0	1	0
Erythrotrichia biseriata Tanaka	0	0	0	1	0	0	1	1	1	1	0
Erythrotrichia carnea (Dillw.) J. Ag.	0	0	1	1	1	1	1	0	1	1	1
Fosliella farinosa (Lamour.) Howe	0	0	1	1	1	1	1	1	1	1	1
Galaxaura filamentosa Chou	0	0	0	0	0	0	0	1	1	0	0
Galaxaura subfruticulosa Chou	0	0	0	0	0	0	0	0	0	0	0
Gelidiella acerosa (Forssk.) Feldm. et Hamel	0	0	1	0	1	1	0	1	1	0	1
Gelidiella adnata Daws.	0	0	0	0	0	0	0	1	1	0	0
Gelidiopsis tenuis Setch. et Gardn.	0	0	1	0	1	1	1	0	1	0	0
Gelidium okamurae Setch. et Gardn.	0	0	0	0	0	0	0	0	0	0	0
Gelidium pusillum (Stackh.) Le Jolis	0	0	1	1	1	1	1	1	1	1	1
Gelidium sclerophyllum Taylor	0	0	0	0	1	1	1	0	1	0	0

Table 1. Continued.

Species	Areas of México								Regions		
	SA	TO	PA	GC	JA	NA	OA	WP	EP	NT	ST
Gracilaria crispata Setch. et Gardn.	0	0	1	1	1	1	1	0	1	1	1
Gracilaria tenuifolia Taylor	0	0	0	0	0	0	0	0	0	0	0
Gracilaria veleroae Daws.	1	0	1	1	1	1	1	0	1	1	0
Gracilaria verrucosa (Huds.) Papenf. syn *G. confervoides* (L.) Grev.	0	0	1	1	0	1	1	1	1	1	1
Gracilariopsis rhodotricha Daws.	0	0	0	0	0	0	0	0	0	0	0
Grateloupia versicolor (J. Ag.) J. Ag.	0	0	0	1	1	1	1	0	1	1	1
Grateloupia versicolor (J. Ag.) J. Ag. v. *prostrata* Daws.	0	0	0	0	0	0	0	0	0	0	0
Griffithsia ovalis Harv.	0	0	0	0	0	0	0	1	0	0	0
Griffithsia pacifica Kylin	0	1	0	1	0	0	1	0	1	1	1
Gymnogongrus johnstonii (Setch. et Gardn.) Daws.	0	0	0	1	1	1	1	0	1	1	0
Gymnogongrus martinensis Setch. et Gardn.	0	0	0	0	1	1	0	0	1	1	0
Gymnogongrus sinicola (Setch. et Gardn.) Daws	0	0	0	0	0	0	0	0	0	0	0
Gymnothamnion elegans (Schous. ex C. Ag.) J. Ag.	0	0	0	0	0	0	0	1	0	1	1
Halymenia actinophysa Howe	0	0	0	1	0	0	0	0	1	1	0
Herposiphonia secunda (C. Ag.) Ambr.	0	0	1	0	0	0	1	1	1	0	0
Herposiphonia secunda (C. Ag.) Ambr. f. *tenella* (C. Ag.) Wynne syn *H. tenella* (C. Ag.) Ambr.	0	1	1	1	1	1	1	1	1	1	0
Hildenbrandia rubra (Sommerf.) Menegh. syn *H. prototypus* Nardo	0	0	1	1	1	1	1	0	1	1	1
Hydrolithon conicum Daws.	0	0	0	0	0	0	0	0	0	0	0
Hydrolithon reinboldii (W.v.Bosse et Fosl.) W.-v.Bosse	0	0	0	0	0	0	0	1	1	0	0
Hypnea cervicornis J. Ag.	0	1	1	1	0	0	1	1	1	1	0
Hypnea johnstonii Setch. et Gardn.	0	1	0	1	1	1	0	0	1	1	0
Hypnea musciformis (Wolfen) Lamour. v. *esperi* J. Ag. syn *H. esperi* Bory	0	0	0	0	0	0	0	0	1	0	1
Hypnea pannosa J. Ag.	0	1	1	1	1	1	1	1	1	1	0
Hypnea spinella (C. Ag.) Kuetz.	0	1	1	0	1	1	1	1	1	1	0
Jania adhaerens Lamour.	0	0	1	1	1	1	1	1	1	1	0
Jania tenella (Kuetz.) Grun.	1	0	1	0	1	1	1	1	1	1	0
Jantinella sinicola (Setch. et Gardn.) Kylin	0	0	0	0	0	0	0	0	0	0	0
Jantinella verrucaeformis (Setch. et McFadd.) Kylin	0	0	0	0	0	0	0	0	0	1	0
Kallymenia tenuifolia Taylor	0	0	0	0	0	0	0	0	0	0	0
Laurencia clarionensis Setch. et Gardn.	0	0	0	0	0	0	1	0	1	0	0
Laurencia decidua Daws.	0	0	1	0	1	1	0	0	1	1	0
Laurencia hancockii Daws.	0	1	1	0	0	1	0	0	1	1	0
Laurencia humilis Setch. et Gardn.	0	0	0	0	0	0	0	0	0	0	0
Laurencia richardsii Daws.	0	0	0	0	1	1	0	0	1	0	0
Laurencia scrippsensis Daws.	0	0	0	0	0	0	0	0	0	1	0
Laurencia sinicola Setch. et Gardn.	1	1	1	1	0	0	0	0	0	1	0
Litholepis accola Fosl.	0	0	0	0	0	0	0	1	0	0	0
Lithophyllum bracchiatum (Hedr.) Lem.	0	0	0	0	0	0	0	0	1	0	0
Lithophyllum decipiens (Fosl.) Fosl.	0	0	0	0	0	0	0	0	1	1	0
Lithophyllum divaricatum Lem.	0	0	0	0	0	0	0	0	1	0	0
Lithophyllum grumosum (Fosl.) Fosl.	0	0	0	0	0	0	0	0	0	1	0
Lithophyllum imitans Fosl.	0	0	1	1	1	1	1	0	1	1	1
Lithophyllum lichenare Mason	0	0	0	0	1	1	0	0	1	1	0
Lithophyllum lithophylloides Heydr.	0	0	1	1	0	1	1	0	1	1	0
Lithoporella pacifica (Heydr.) Fosl.	0	0	0	0	0	0	0	0	0	0	0

Table 1. Continued.

Species	Areas of México								Regions		
	SA	TO	PA	GC	JA	NA	OA	WP	EP	NT	ST
Lithothamnion australe (Fosl.) Fosl.	0	0	1	1	1	1	1	1	1	1	0
Lithothamnion indicum Fosl.	0	0	0	0	0	0	0	0	1	0	0
Lithothamnion pacificum Fosl.	0	0	0	0	0	0	0	0	0	1	0
Lithothamnion validum Fosl.	0	0	0	0	0	0	0	0	1	0	1
Lomentaria baileyana (Harv.) Farl.	0	0	0	0	0	0	0	1	1	0	0
Lophosiphonia macra (Harv.) Falkenb.	0	0	0	0	0	0	0	0	0	0	0
Lophosiphonia mexicana Daws.	0	0	0	1	0	0	0	0	0	1	0
Melobesia marginata Setch. et Fosl.	1	0	0	0	0	0	0	0	1	1	1
Melobesia membranacea (Esper) Lamour.	0	0	0	0	0	0	0	0	0	0	0
Neogoniolithon trichotomum (Heydr.) Setch. et Gardn.	0	0	1	1	1	1	1	0	1	1	0
syn *Lithophyllum trichotomum* (Heydr.) Lem.											
Peyssonnelia calcea Heydr.	0	0	0	0	0	0	0	1	1	0	0
Peyssonnelia clarionensis Taylor	0	0	0	0	0	0	0	0	0	0	0
Peyssonnelia rubra (Grev.) J. Ag.	0	0	0	0	0	0	0	1	0	1	0
Peyssonnelia rubra (Grev.) J. Ag. f. *orientalis* W.-v.Bosse	0	0	0	1	1	1	0	1	1	1	0
Phyllophora clevelandii Farl.	0	0	0	0	0	0	0	0	0	1	0
Platythamnion pectinatum Kylin	0	0	0	1	0	0	0	0	0	1	0
Platythamnion pectinatum Kylin v. *laxum* Taylor	0	0	0	0	0	0	0	0	0	0	0
Plocamium cartilagineum (L.) Dixon	1	1	0	1	0	0	0	0	0	1	1
syn *Plocamium coccineum* (Huds.) Lyngb. v. *pacificum* (Kylin) Daws.											
syn *Plocamium pacificum* Kylin											
Polysiphonia beaudettei Hollenb.	0	0	1	0	0	0	0	1	1	1	0
Polysiphonia eastwoodae Setch. et Gardn.	0	0	0	0	0	0	0	0	0	0	0
syn *P. snyderae* Kylin											
Polysiphonia flaccidissima Hollenb.	0	0	0	1	0	1	1	0	1	1	1
Polysiphonia homoia Setch. et Gardn.	0	0	1	0	0	0	0	0	0	1	0
Polysiphonia simplex Hollenb.	0	0	1	1	1	1	1	0	1	1	0
Polysiphonia sonorensis Daws.	0	0	0	1	0	0	1	0	1	1	0
Predaea masonii (Setch. et Gardn.) De Toni	0	0	0	1	0	0	0	0	0	1	0
Prionitis clarionensis (Setch. et Gardn.) Kajimura	0	0	0	0	0	0	0	0	0	0	0
Pterocladia capillacea (S. G. Gmel.) Born. et Thur.	1	0	1	0	1	1	0	1	1	1	1
det *P. pyramidalis* (Gardn.) Daws.											
Pterocladia musciformis (Taylor) Daws.	0	0	0	0	0	0	0	0	1	0	0
Pterosiphonia dendroidea (Mont.) Falkenb.	1	1	0	1	0	0	0	0	1	1	1
Sahlingia subintegra (Rosenv.) Kornm.	0	0	1	1	0	0	1	0	1	1	1
Smithoria naiadum (C. L. Anders.) Hollenb.	1	1	0	0	1	0	0	0	1	1	0
Spongites fruticulosus Kuetz.	0	0	0	0	0	0	1	0	1	0	0
syn *Lithothamnion fruticulosum* (Kuetz.) Fosl.											
Spyridia filamentosa (Wulfen) Harv.	0	0	1	1	0	1	0	1	1	1	0
Stenogramma interrupta (C. Ag.) Mont.	0	0	0	0	0	0	0	0	0	1	1
Stylonema alsidii (Zanardini) Drew	0	1	1	1	1	1	1	0	1	1	1
syn *Goniotrichum alsidii* (Zanardini) Howe											
Wurdemannia miniata (Sprengel) Feldm. et Hamel	0	0	1	0	1	1	0	1	1	0	0

as does the tropical site of Jalisco (62 spp., 30.2%). The northern part of the Gulf of California (67 spp., 32%) has the highest value for a warm temperate site.

Floristic affinities with other Pacific regions

Of the 205 species and infraspecific taxa of benthic marine algae recorded from the Revillagigedo Islands,

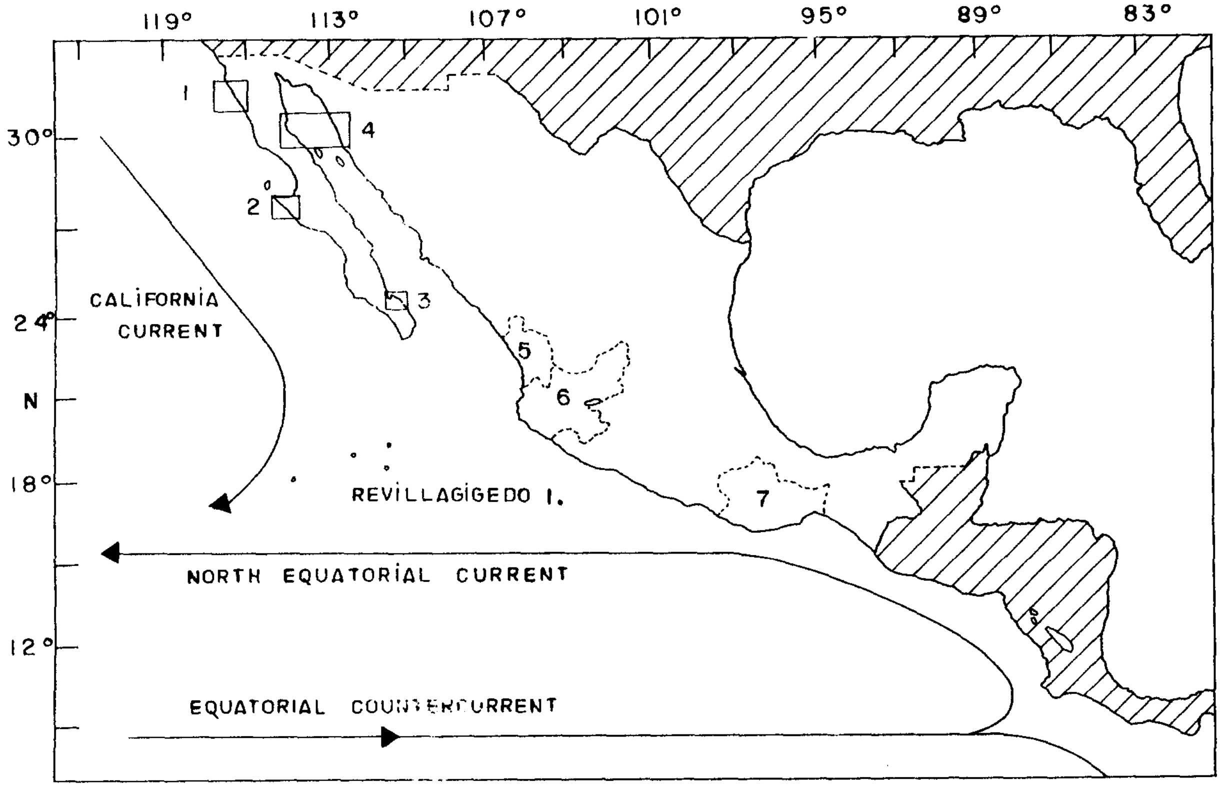

Figure 1. Map showing the location of the Revillagigedo Islands and the continental Mexican areas compared. 1. Todos Santos Island & Bay; 2. Tortugas Bay; 3. La Paz Bay; 4. northern Gulf of California; 5. Nayarit; 6. Jalisco, 7. Oaxaca; 8. Revillagigedo Islands.

34 (16.6%) are not known from any of the Pacific regions used for comparison; 13 (6.3%) are known from all four regions; 33 (16%) are found in all three eastern Pacific regions, 23 (11%) only from the temperate regions considered and 51 (25%) occur only in the two tropical regions. Concerning exclusive distributions between pairs of regions, 18 were found only in the northeastern Pacific region, one only in the southeastern temperate region, six in the western tropical Pacific (Philippines) and 27 in the eastern tropical Pacific region.

Discussion

The present state of our knowledge of the benthic marine algae of the Revillagigedo Islands indicates greater affinity with the three tropical sites of continental Pacific México considered than with the warm temperate ones. Concerning the more general regions included here, this insular flora shows also more taxa in common with the eastern tropical Pacific region than with the other three regions. Whether completion of the inventory of this incompletely studied area will continue to support these floristic relationships remains to be seen.

The presence in the Revillagigedo Islands of taxa with affinities to distant regions may be explained, as suggested by Llinas-Gutiérrez et al. (1993), by the position of the islands in a zone of confluence of two major oceanic currents. The California Current could account for the North American temperate affinity whereas the North Equatorial Current could account for the eastern tropical and South American temperate affinities. These currents are considered important in establishing varying temperature regimes at different times of the year and/or transporting propagules.

Another hypothesis, used to explain the colonization of eastern Pacific reefs from the Indo-Pacific and supported by Dana (1975) and Grigg (1988), is that tectonic movements in the Pacific plate produced several islands that served as 'bridges'. Bautista-Romero et al. (in press) suggest that once the Indo-Pacific species have reached the central Pacific Islands, the routes for the colonization of the Revillagigedo Is. could include either the Galapagos Is. and Central America by way of the Equatorial Countercurrent and the North Equatorial Current, or more directly via Clipperton I. considering that part of the Equatorial Countercurrent passes Clipperton I., then the Revillagigedo Is. during several months of the year (Wyrtki, 1965).

The eastern tropical Pacific, particularly the Mexican tropical Pacific, has been characterized as having an impoverished flora (Lüning, 1990; Silva, 1992), with fewer than 400 species reported. Althoug this situation has not yet been explained satisfactorily, Silva (1992) suggested that "it may be related to the cyclical shift in latitude of the major oceanic current system, a phenomenon called El Niño, which results in a particular area being subjected to unusually high or low temperatures periodically". Although this suggestion applies to the Mexican tropical Pacific as a whole, it has only minor effects over the Socorro I. area (Lluch-Cota et al., in press). Recent reports (González-González, 1992; León-Tejera & González-González, 1993; Serviere-Zaragoza, 1993) have increased the number of specific and infraspecific taxa in the Mexican tropical Pacific to more than 500, suggesting that the number of macroalgal species in the area may be higher than previously assumed.

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