OCTOCORALS IN THE GALAPAGOS ISLANDS

By: Odalisca Breedy[1], Cleveland P. Hickman, Jr[2] & Gary C. Williams[3]

[1]Centro de Investigación en Ciencias del Mar y Limnología (CIMAR), Universidad de Costa Rica 2060, San José, Costa Rica
[2]Department of Biology, Washington & Lee University, Lexington, VA 24450, U.S.A.
[3]Department of Invertebrate Zoology and Geology, California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118, U.S.A.

SUMMARY

The Galapagos octocorals were almost unknown until recent years. Of the three orders within the subclass Octocorallia (Anthozoa, Cnidaria), the Pennatulacea (sea pens) and Alcyonacea (soft corals and gorgonians) occur in the Galapagos. Recent collections and research bring the total known octocorallian fauna to three sea pens (*Virgularia galapagensis, Ptilosarcus undulatus* and *Cavernulina darwini*) and 15 gorgonians. Of the 13 gorgonians that we have collected, several are new species. *Pacifigorgia* is widely distributed in the archipelago, with four named species (*P. dampieri, P. symbiotica, P. rubripunctata*, and *P. darwinii*), three of them recently described, and two others yet to be described. The genus *Muricea* contains three widely distributed undescribed species, one of which appears in three chromotypes, and one deep-water species that has not been collected recently. Two species of *Heterogorgia* occur in the central archipelago, *H. verrucosa* and the recently described and widely distributed *H. hickmani.* The remaining gorgonians are *Eugorgia daniana, Leptogorgia alba* and *Adelogorgia telones.*

RESUMEN

Octocorales en las Islas Galápagos. Hasta hace pocos años, los octocorales de las Islas Galápagos eran muy poco conocidos. De los tres órdenes que comprende la subclase Octocorallia (Anthozoa, Cnidaria), los Pennatulacea (plumas de mar) y Alcyonacea (corales suaves y gorgonias) aparecen en las Galápagos. Por medio de investigación y recolectas recientes se ha encontrado que la fauna de octocorales está compuesta por tres plumas de mar (*Virgularia galapagensis, Ptilosarcus undulatus* y *Cavernulina darwini*) y por 15 gorgonias. Nosotros hemos recolectado 13 gorgonias y de ellas, algunas son especies nuevas. El género *Pacifigorgia* con cuatro especies descritas (*P. dampieri, P. symbiotica, P. rubripunctata* y *P. darwinii*), tres de estas descritas recientemente, más dos probablemente nuevas, se encuentra ampliamente distribuido en el archipiélago. El género *Muricea* contiene tres especies que no se han descrito y que están ampliamente distribuidas, de las cuales una presenta tres cromotipos, más una especie de profundidad que no ha sido recolectada recientemente. Del género *Heterogorgia*, dos especies aparecen en el archipiélago central, *H. verrucosa* y *H. hickmani*. Esta última, ha sido descrita recientemente y se encuentra ampliamente distribuida. Las otras gorgonias son *Eugorgia daniana, Leptogorgia alba* y *Adelogorgia telones.*

INTRODUCTION

The marine faunas of oceanic islands are of great biogeographical interest, providing insights into endemism, dispersal patterns, and evolution through comparisons with mainland faunas (Quammen 1996, Hickman 2009). There are five main oceanic islands or archipelagos in the tropical E Pacific: Cocos Island, Costa Rica; Malpelo Island, Colombia; the Revillagigedo Islands, Mexico; Clipperton Island, France; and the Galapagos, Ecuador. Each is separated from the mainland by at least 435 km (Malpelo) and up to 1300 km (Clipperton), and also by abyssal depths (Kaiser & Bryce 2001). Numerous expeditions have yielded a considerable literature on certain taxonomic groups on these islands. However some groups of marine invertebrates, including the Octocorallia, have received little attention. Although several octocoral species have been photographed and collected from these islands, published records exist only from Cocos and Galapagos. The Galapagos are the largest group of islands in the tropical E Pacific, and the subject of considerable research, but the marine fauna, especially the octocorals, was almost unknown until recently. This paper summarises our knowledge of the octocorals of Galapagos.

THE OCTOCORALS

The subclass Octocorallia (class Anthozoa) comprises sedentary, mostly colonial marine animals, distinguished from the true, or stony, corals by their octoradial symmetry, pinnate tentacles, and skeletal elements of calcium carbonate, called sclerites, in their tissue. Many taxa also have proteinaceous and calcified axial skeletons. The Octocorallia comprise three orders: Helioporacea (blue corals), Pennatulacea (sea pens), and Alcyonacea (soft corals and gorgonians). Sea pens and gorgonians occur in the Galapagos.

The Pennatulacea have colonies formed by a very large primary polyp called the oozooid, on the wall of which the coenenchyme spreads with numerous small (secondary) polyps. The primary polyp may be additionally supported by a horny axis, and part of it forms the peduncle that anchors the colony in sand or soft substrates. The other part of the oozooid forms the rachis, which bears other kinds of polyps: autozooids and siphonozooids. In some species the emergent part looks like a feather (thus the name sea pens) (Williams 1990, Fabricius & Alderslade 2000).

Alcyonacean soft corals have not been reported in the Galapagos. Gorgonians, the most abundant octocorals in the Galapagos, include sea rods, sea whips, sea candelabra, sea feather plumes and sea fans. They present very diverse growth forms: encrusting colonies, upright fans and bushes with slender branches, or simple whips. Gorgonian colonies have a central axial skeleton composed of a collagenous matrix called gorgonin, and calcifications within the collagen interstitial spaces (Jeyasuria & Lewis 1987). A layer of coenenchyme with sclerites and polyps surrounds it.

There are an estimated 2900 species of octocorals worldwide although new species and even genera continue to be described at a rapid rate. In Galapagos, nine shallow-water (<50 m) and one deep-water octocoral species have been reported in the literature and eight more shallow-water species are reported here (Table 1). The species listed in the table, except *Adelgorgia telones*, which has not been collected since it was described by Bayer (1978), are described in more detail, with photographs, in Hickman (2008).

Main identification sources are Bayer (1981) and Williams (1995). There is also a key to octocoral families, complete bibliography of octocoral literature and listing of current genera by G. Williams at http://www.calacademy.org/research/izg/isg_researchl_ink.htm. Octocoral species are identified by colony morphology

Table 1. Distribution of shallow-water (< 50 m) octocoral species in the Galapagos Islands. * indicates records not previously published.

Species	Sites
Order Pennatulacea:	
Cavernulina darwini Hickson 1921 (Veretillidae)	San Cristóbal.
Virgularia galapagensis Hickson 1930 (Virgulariidae)	Isabela (Tagus Cove). Santiago (James Bay).
Ptilosarcus undulatus (Verrill 1865) (Pennatulidae)	Wolf, Isabela (Tagus Cove).
Order Alcyonacea: Suborder Holaxonia: Family Gorgoniidae:	
Pacifigorgia dampieri Williams & Breedy 2004[1]	Darwin, Wolf, Roca Redonda.
Pacifigorgia darwinii (Hickson 1928)[1]	Isabela (Cuatro Hermanos islets, Tagus Cove, Punta Moreno, Punta Vicente Roca), Fernandina (Punta Espinosa), Floreana (La Botella rock), San Cristóbal (and Kicker Rock), Pinzón.
Pacifigorgia symbiotica Williams & Breedy 2004[1]	Darwin, Wolf, Isabela (Caleta Iguana, Cabo Rosa).
Pacifigorgia rubripunctata Williams & Breedy 2004[1]	Bartolomé, Española, Rábida, Nameless, Santiago, Floreana (Gardner islet), Isabela (Cuatro Hermanos islets), Genovesa.
**Pacifigorgia* sp. 1 (*P.* cf. *symbiotica*)[1]	Wolf.
**Pacifigorgia* sp. 2 (*P.* cf. *rubripunctata*)[1]	Nameless.
**Eugorgia daniana* Verrill 1868	Genovesa, Nameless, Pinzón.
Leptogorgia alba (Duchassaing & Michelotti 1864)	Darwin, Wolf.
Order Alcyonacea: Suborder Holaxonia: Family Plexauridae:	
Adelogorgia telones Bayer 1979[1]	San Cristóbal (Kicker Rock).
**Muricea* cf. *fruticosa* Verrill 1868	Isabela (Cuatro Hermanos islets, Punta Vicente Roca), Nameless, San Cristóbal (Punta Pitt, Whale Rock), Darwin.
**Muricea* sp. 1[1]	Fernandina (Cabo Douglas), Isabela (Punta Albermarle, Punta Vicente Roca, Tagus Cove, Tortuga islet), Nameless, Pinzón, Floreana (La Botella rock, Gardner islet), Santiago (Bainbridge Rocks), San Cristóbal (Kicker Rock).
**Muricea* sp. 2 purple variety[1]	Darwin, Genovesa.
**Muricea* sp. 2 yellow/orange variety[1]	Darwin, Genovesa, Floreana (Devil's Crown islets).
**Muricea* sp. 2 white variety[1]	Darwin, Floreana (Devil's Crown islets), Santa Fe (NW), San Cristóbal (Whale Rock).
Heterogorgia hickmani Breedy & Guzman 2005[1]	Pinzón, Floreana (La Botella rock, Devil's Crown islets), San Cristóbal (Kicker Rock, Five Fingers rocks), Isabela (Las Marielas islets, Caleta Black, Tagus Cove and south of there, Punta Albemarle, Caleta Iguana, Tortuga islet), Santa Fe (NW), Rábida, Santa Cruz (Gordon Rocks), Española.
**Heterogorgia verrucosa* Verrill 1869	Santa Cruz (Gordon Rocks).

[1]Known only from Galapagos.

(branching pattern, colour and shape) and sclerite morphology (sizes, colours, forms and abundance of the different types of sclerite). However, morphological characteristics can be modified by the environment, and intergrading forms may confound some identifications (Breedy & Guzman 2003, 2007). For identification and molecular studies, specimens ideally should be collected complete and preserved in 70–95% ethanol (never formalin as this dissolves the sclerites). However, most octocorals can be identified on sclerite morphology using a much smaller sample, as little as a few polyps. For the study of sclerites, fragments from colonies are treated with sodium hypochlorite to dissociate sclerites from tissue, washed several times in distilled water, dehydrated with 100% ethanol, then air or oven dried and prepared for scanning electron microscopy or light microscopy. For further details of the methodology, see Breedy & Guzman (2002) and http://www.calacademy.org/research/izg/OctoResearchTech.htm.

RESULTS

The first octocoral specimen from Galapagos was a fragment of probably *Pacifigorgia darwinii* collectedby Charles Darwin in 1835 (Hickson 1921, 1928), which was deposited in the University Museum of Zoology, Cambridge, U.K. Unfortunately this specimen was misplaced or lost (R. Preece pers. comm.). Two species of Pennatulacea and three species of *Pacifigorgia* (under the name *Gorgonia*) were reported from the C. Crossland S.Y. St George voyage (Hickson 1928, 1930, Stiasny 1941, 1943), and one alcyonacean, described as *Muricea galapagensis*, came from the Presidential Cruise of 1938 (Deichmann 1941). Bayer (1978) described *Adelogorgia telones* from collections by W.D. Hope in 1978. Several specimens collected during the R.V. Anton Bruun Cruise in 1966 were deposited in the Museum of Comparative Zoology of Harvard University and later identified as *Pacifigorgia rubripunctata* (Williams & Breedy 2004). Collections made by the 1986 Harbor Branch Oceanographic Institution expedition to the Galapagos, Cocos, and Pearl Islands contain a number of octocorals from deep waters that may yield new species. Collections made by the 1994 California Academy of Science Marine Expedition to the Galapagos, periodic marine surveys by the Charles Darwin Research Station, Galapagos, and numerous collections by CPH from 1996 to 2007 have produced three new species of *Pacifigorgia* (Williams & Breedy 2004), one new species of *Heterogorgia* (Breedy & Guzman 2005), specimens of the pennatulid *Ptilosarcus*, one species of *Eugorgia*, one of *Leptogorgia*, and probably three or four species of *Muricea*. Several are expected to represent species new to science (Table 1).

Geographic distribution of Galapagos shallow-water species is shown in Table 1. In addition to the species in the table, *Muricea galapagensis*, a deep-water species (> 50 m) collected in 1938 at Isabela Island (Deichmann 1941), has not been reported since.



Figure 1. *Leptogorgia alba*, Darwin´s Arch, Darwin Island. Photograph: CPH.

Although sea pens were believed to have disappeared from Galapagos following the 1982–3 El Niño event, all three species have been observed recently at depths below 40 m (S. Banks pers. comm.).

Among the Gorgoniidae, *P. dampieri*, *P. symbiotica* and *Leptogorgia alba* (Fig. 1) have been found at the northernmost islands of Darwin and Wolf. A species similar to *P. symbiotica* was also found at these islands but its status is not yet resolved. *P. rubripunctata* was found mostly at the central and eastern islands, while a similar species, *Pacifigorgia* sp. 2 was found coexisting with *P. rubripunctata* at Santa Cruz. *P. darwinii* (Fig. 2) was found throughout the central and western archipelago. It is the species with the widest range, but is not reported for Darwin and Wolf. *Eugorgia*



Figure 2. *Pacifigorgia darwinii*, Roca Onan, Pinzón Island. Photograph: Angel Chiriboga.



Figure 3. *Eugorgia daniana*, Darwin Bay, Genovesa Island. Photograph: CPH.



Figure 4. *Muricea* cf. *fruticosa*, Cuatro Hermanos islets, Islabela. Photograph: CPH.

daniana (Fig. 3) was found at Genovesa, Pinzón and Nameless.

Of the Plexauridae, two of the *Muricea* spp. are probably new to science. *Muricea* sp. 2 comprises three chromotypes (purple, yellow/orange, and white), found together in Darwin. *M.* cf. *fruticosa* (Fig. 4) is distributed throughout the archipelago, while *Muricea* sp. 1 is restricted to the central and southern archipelago. *Heterogorgia hickmani* occurs throughout the central and southern archipelago, while *H. verrucosa* has been reported only from Santa Cruz. No specimens of *Adelogorgia telones* have been recovered since the initial report by Bayer (1978).

DISCUSSION

Studies of octocoral diversity at other E Pacific oceanic islands are scarce; only records from Cocos are available for comparison, where only three species of gorgonians have been reported, in shallow waters: *Pacifigorgia curta* (Breedy & Guzman 2003), *Leptogorgia alba* (Breedy & Guzman 2007) and a new, unnamed species of *Leptogorgia*. Only *L. alba*, which is a widespread species, is present in both Cocos and Galapagos. The pennatulid *Ptilosarcus undulatus* that was reported for Cocos (Deichmann 1941) needs validation, owing to an inadequate description of the Cocos specimen. Because Galapagos has a wider range of biotopes and is much larger than Cocos, its diversity is higher, at least in shallow waters.

The Galapagos octocoral fauna includes more species than reported from Ecuador's mainland coast. The few published records for the mainland include two species of *Leptogorgia* and two of *Eugorgia* (Bielschowsky 1929), although many others have been observed in recent explorations (S. Luna, D. Ruiz, pers. comm.). At present, all of the thirteen largest islands and many of the smaller islands of the Galapagos have been searched for shallow water species of octocorals, but other sites remain to be explored and new records and new species are expected. Meaningful comparison of gorgonian diversity in Galapagos, the Ecuador mainland and other oceanic islands will only be possible when comprehensive surveys equivalent to those in the Galapagos are completed.

ACKNOWLEDGMENTS

We are especially grateful to the Charles Darwin Research Station whose sustained support of CPH's research over the years has made possible the collections that formed a large part of OB's taxonomic research on Galapagos octocorals. Although many people assisted in the field, we are especially grateful to Angel Chiriboga, Bill Ober and Fred Liss for assistance in sample collection, and the captain and crew of the *Tip Top IV* during the 2007 collections. We also are grateful to Jorge Cortés who read and offered helpful comments on this manuscript. The authors would like to thank the U.K. Department for Environment, Food and Rural Affairs' Darwin Initiative Project 14-048 *Galapagos Coral Conservation: Impact Mitigation, Mapping and Monitoring* for supporting the 2006–7 expeditions to the northern islands of Galapagos, where some of the recent specimens were collected.

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