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Three new species of pennatulacean octocorals with the ability to attach to rocky substrata (Cnidaria: Anthozoa: Pennatulacea)

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Abstract

All sea pens have been thought to anchor in soft sediment using a basal, sausage-shaped, muscular peduncle. Based on underwater images and examination of specimens, we report an adaptation of the proximal portion of the peduncle for attachment to solid surfaces. We document four species with this adaptation, three new, *Anthoptilum lithophilum* **sp. nov.** (California, 669–700 m), *A. gowlettholmesae* **sp. nov.** (Tasmania, 729–1803 m), and *Calibelemnon francei* **sp. nov.** (the Bahamas, 1969 m), and one known, *A. decipiens* Thomson & Henderson, 1906 (Sri Lanka, 925 m). The peduncle of a colony with this adaptation is greatly expanded by an outgrowth of the coenenchyme that forms a sucker-like structure, beneath which a conical mass of tough tissue surrounds the proximal end of the internal axis. We infer this structure affects suction, increasing or decreasing the strength of adhesion to the substratum, and discuss the systematics and functional morphology of this new ecological phenomenon—pennatulaceans fastened to hard substrata. We alter the definition of the genus *Anthoptilum* to accommodate this morphology, reporting on specimens of the type species, *A. grandiflorum*; compare the two sea pen families—Anthoptilidae and Scleroptilidae— and the two genera; and present a key to the known rock-inhabiting species.

Key words: Octocorallia, Anthoptilidae, Scleroptilidae, new taxa, sea pens, benthic adaptation, rocky substrata

Introduction

Recent advances in deep-sea exploration technology have allowed for discoveries and observations not previously possible. In deep ocean research, the use of remotely operated vehicles (ROVs) has led to the ability to select individual deep sea organisms for collection and photography (both video and still images) (Williams and Lundsten, 2009), and permitted organisms on hard substrata (such as deep reefs and rocky outcrops) to be carefully collected in contrast to the severe limitations of bottom trawls, dredges, and bottom grabs in such habitats. Until now, sea pens (Pennatulacea) have been characterized by a basal muscular peduncle that has evolved to anchor them only in soft sediments (Williams, 1999), but in the past decade ROVs have enabled observations and collections to be made of pennatulacean octocorals attached to rocks or stones, sometimes covered in a thin layer of sediment (seen in images from the ROV *Jason*), from a depth range of 670–2060 m. These sea pens, which have been found in Australia, New Zealand, Hawai'i, central California in the Pacific, and the Bahamas in the western Atlantic (Chave & Malahoff 1998; below in this paper) are able to attach to rocky substrata by a remarkable morphological modification of the proximal portion of the peduncle.

The discovery and recognition of this structure is significant regarding evolutionary biology and ecology, in that sea pens are now known to have developed an adaptation and capability to live on rocky substrata permitting them to colonise habitats other than the soft sediments to which they were considered to be restricted.

Several octocoral genera are known to occupy both hard and soft substrata:

1. Some species of *Dendronephthya* can attach to hard reef material while others have short basal stolons to attach to small grains and gravel in sediments (e.g. hard substrate, *D. koellikeri* and *D. habereri* Kükenthal,

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