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NEW HOST RECORD FOR THE CALIFORNIA MUSSEL *MYTILUS CALIFORNIANUS* (BIVALVIA, MYTILIDAE), EPIBIOTIC ON THE PACIFIC SAND CRAB *EMERITA ANALOGA* (DECAPODA, HIPPIDAE) FROM MONTEREY BAY, CALIFORNIA (U.S.A.)

BY

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ABSTRACT

Sea mussels form dense aggregations on temperate rocky shores; however, in the absence of such firm substrates, biogenic surface such as the calcified integument of crustaceans may become settlement sites for their larvae. In this paper we present the first report on the association between the California mussel *Mytilus californianus* Conrad, 1837 and the Pacific sand crab *Emerita analoga* (Stimpson, 1857), collected from a sandy beach in Monterey Bay, California, U.S.A. We examined 63 crabs, and three had epibiotic mussels attached on their lateroventral surfaces. The organisms were measured and photographed. Such low incidence rate is tied to the collection site, as sandy beaches are considered atypical habitats for this bivalve species. The occurrence of epibiotic *M. californianus* suggests a random and non-obligatory relationship with *E. analoga*.

RESUMEN

Los mejillones forman densas agregaciones en zonas rocosas litorales de mares templados. Sin embargo, en ausencia de tales sustratos, las superficies biogénicas tales como el tegumento calcificado de los crustáceos puede permitir el asentamiento de sus larvas. En este trabajo, presentamos por primera vez la asociación del mejillón de California *Mytilus californianus* Conrad, 1837 y el cangrejo de arena del Pacífico *Emerita analoga* (Stimpson, 1857), recolectados en una playa de Monterey Bay, California, U.S.A. Examinamos 63 cangrejos, y tres tenían mejillones en su superficie lateroventral. Los ejemplares fueron medidos y fotografiados. La baja frecuencia está asociada a la zona de muestreo, ya que las playas de arena no son el habitat común de los mejillones. La aparición epibiótica de *M. californianus* sugiere una relación al azar y no obligatoria con *E. analoga*.

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INTRODUCTION

In marine intertidal zones, larvae of sessile organisms routinely settle on exposed hard substrates and compete for attachment space (Connell & Keough, 1985). However, in the absence of such resource in a soft bottom environment, these organisms frequently become epibionts on various benthic fauna (Wahl, 1989). Decapod crustaceans, whose calcified exoskeleton acts as suitable substrate, harbour epibionts like ciliates, sponges, hydroids, polychaetes, bryozoans, barnacles and ascidians (Becker, 1996; Fernandez-Leborans, 2010, and references therein).

There are several reports available on the epibiotic associations between bivalves and decapods, such as the kelp scallop *Leptopecten latiauratus* (Conrad, 1837) on the pelagic red crab *Pleuroncodes planipes* (Stimpson, 1860) (Coan et al., 2000), the variegated scallop *Mimachlamys varia* (Linnaeus, 1758) on the squat lobster *Galathea strigosa* (Linnaeus, 1761) (Albano & Favero, 2011), the zebra mussel *Dreissena polymorpha* (Pallas, 1771) on the rusty crayfish *Orconectes rusticus* (Girard, 1852) (Brazner & Jensen, 2000), the golden mussel *Limnoperna fortunei* (Dunker, 1857) on the anomuran crab *Aegla platensis* Schmitt, 1942 (Lopes et al., 2009), as well as the South American freshwater crab *Trichodactylus borellianus* Nobili, 1896 (Molina & Williner, 2013) and the bisexual mussel *Semimytilus algosus* (Gould, 1850) on the Pacific sand crab *Emerita analoga* (Stimpson, 1857) (Villegas et al., 2006).

This paper reports on the finding of the mussel *Mytilus californianus* Conrad, 1837 as an epibiont on *Emerita analoga*. This mussel is found in large aggregations on rocks and other hard substrates along the west coast of North America, extending from Alaska to Northern Mexico (Shaw et al., 1988). *Emerita analoga* is a common, sand-burrowing decapod of the swash zone and is widely distributed along the Pacific coasts of North and South America (Contreras et al., 1999). Although both are extremely common species with an overlapping geographical range, our finding represents the first record of their association.

MATERIAL AND METHODS

Specimens were collected during receding tides in the swash zone of Del Monte Beach in Monterey Bay, California (36.80°N 121.90°W) between August and October 2014. The sand on this beach is quartzitic, of fine to medium texture, and very well sorted (Rohrbough et al., 1964), thus providing an ideal habitat for *Emerita analoga* (cf. Efford, 1976). While examining sand crabs under a dissecting scope for other studies, we encountered three individuals of *Mytilus californianus* as epibionts on the sand crabs. Organisms were measured in millimetres using a

digital calliper and photographed with a digital camera. Mussel individuals were carefully removed from their hosts, fixed with 70% ethanol, and deposited as voucher specimens at the Santa Barbara Museum of Natural History, California under the accession number 2016-025, catalogue number SBMNH 461254.

RESULTS AND DISCUSSION

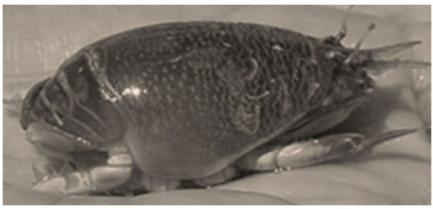
We examined a total of 63 crabs, of which 51 (81%) were females. Crabs ranged in size from 10.2 to 26.7 mm; males and females' sizes ranged between 10.2-14.4 mm and 10.2-26.7 mm, respectively. Three crabs harboured *Mytilus californianus*; this resulted in an epibiotic incidence rate of 4.8%. Mussels were found attached to ventral sides on female crabs, which measured approximately 24 mm (table I). These mussels were considered juveniles, as adults are known to attain sizes exceeding 250 mm (Coan et al., 2000). Only one mussel was observed per crab host (fig. 1).

The epibiosis phenomenon is vital for certain aquatic organisms in areas where hard substrates are lacking. The body surfaces of crustaceans are one of the few hard substrates available for colonization, especially in the unstable marine sediments as seen in sandy beaches. For example, 56 specimens of the mussel *M. varia* were found on a single *Galathea strigosa* squat lobster from the North Adriatic Sea, which features a soft substrate (Albano & Favero, 2011). The congeneric mussel *M. edulis* (Linnaeus, 1758) forms vast beds in soft-bottom sediment consisting primarily of clay and organic matter (Frandsen et al., 2015) and also colonizes a variety of substrates, including crabs (Williams & McDermott, 2004; Dvoretsky & Dvoretsky, 2008); however, this has not been reported for *M. californianus*. Our study site was an exposed beach without rocky outcrops for several miles from our sampling area. The exoskeleton of the sand crab provided a suitable substrate for settling by the veliger larva, which then transformed into juvenile mussels. While studying the larval settlement behaviour of *M. californianus* in Oregon, Petersen (1984) found them to settle on many

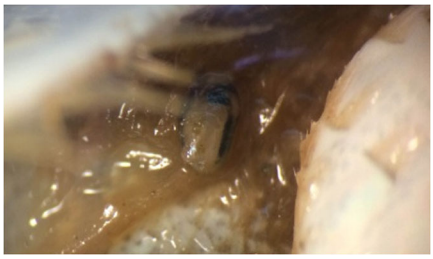
TABLE I

Details of the host-epibiont record of *Mytilus californianus* Conrad, 1837 and *Emerita analoga* (Stimpson, 1857): host size (CL, carapace length) and sex, and total length (TL) of bivalves

	Host CL (mm)	Host sex	Epibiont TL (mm)
Crab 1	23.74	Female	1.0
Crab 2	24.15	Female	1.0
Crab 3	24.67	Female	1.8



(A)



(B)

(C)

Fig. 1. Specimen of *Mytilus californianus* Conrad, 1837 and *Emerita analoga* (Stimpson, 1857): A, dorsal view of crab; crab size 24.7 mm; B, mussel attached to the lateroventral surface between the first and second pereopods; C, mussel detached from the crab; mussel size 1.8 mm. This figure is published in colour in the online edition of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/journals/15685403.

different substrates, like several species of algae, *M. trossulus* Gould, 1850 beds, *M. californianus* beds, and bare rock with scattered barnacles. Such flexibility in substrate selection may explain the use of the crab's exoskeleton as an alternative settlement site for the veliger larva.

An epibiotic association was reported between *Emerita analoga* and the mussel *Semimytilus algosus* from southern Peru (Villegas et al., 2006). Beyond this reporting, we are unaware of any other mussel taxa forming an epibiotic relationship with this sand crab species. The low incidence rate of 4.8%, with one mussel per host, and the presence of juvenile mussels on the ventral surface of the crabs that we report here somewhat matches with the findings by Villegas et al.

(2006). In the latter investigation, 7.3% of *E. analoga* were fouled by mostly single juveniles of *S. algosus*, with the majority of epibionts attached to the crabs' ventral sides. With regards to the settlers' body size, Albano & Favero (2011) reported that 86% of epibionts on the squat lobster were mussel juveniles measuring $\leqslant$3 mm.

The low epibiotic frequency may be attributed to several reasons. Firstly, our collection site was a soft bottom community, an uncharacteristic habitat for veliger larva or juvenile mussels. Secondly, many of the crabs we examined had soft exoskeletons; it is likely that epibionts, if present on their exuviae, were detached during moulting. Other investigators have reported that older specimens and females are more densely colonized than newly-moulted individuals (Abelló et al., 1990; Abelló & Macpherson, 1992; Shields, 1992). And thirdly, sand crabs bury themselves in the sediment and consequently may reduce the susceptibility to settling stages of epibionts. Becker (1996) compared colonization densities on exposed (oysters, etc.) and non-exposed (crabs) surfaces and showed that exposed ones became more densely colonized.

We found the larger-sized crabs, which were all females, to host the molluscs. It is likely that the larger hosts offered more surface area for attachment compared to the smaller ones. Larger crabs of other genera have also been shown to be more susceptible to fouling by epibionts (McGaw, 2006; Dvoretsky & Dvoretsky, 2009).

While it is interesting to observe the association between *M. californianus* and *E. analoga*, it remains unclear whether the crab and/or the mussel may gain benefits or suffer disadvantages as a result of this relationship. In a related study involving the mussel *Limnoperna fortunei* and the crab *Trichodactylus borellianus* from Argentina, where two crabs were seen harbouring one mussel each, the latter most likely benefitted by the movement of their crab hosts expanding their filter feeding opportunities (Molina & Williner, 2013).

In conclusion, the presence of the mussel *M. californianus* as an epibont on *E. analoga* represents a new host record for this mollusc species. This finding is not too surprising as their geographic distribution overlaps along the west coast of North America. The species interaction noted here may imply an accidental and facultative association.

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