Symbiosis (2013) 60:85–90
DOI 10.1007/s13199-013-0239-x

SHORT COMMUNICATION

First record of the association between *Malmgreniella cf. variegata* (Polychaeta, Polynoidae) and *Ophionereis annulata* (Echinodermata, Ophionereididae) in the Mexican Pacific

Rebeca Granja-Fernández · Paulina Hernández-Moreno · Rolando Bastida-Zavala

Received: 14 October 2012 / Accepted: 5 April 2013 / Published online: 18 April 2013

Abstract An association between the scale-worm *Malmgreniella cf. variegata* and the ophiuroid *Ophionereis annulata* is reported for first time in the Mexican Pacific. The relationship was found in five localities across a total of 22 sites where *O. annulata* was collected. The polynoids collected were similar to the Western Atlantic scale-worm *Malmgreniella variegata*, which was previously recorded as commensal of *O. annulata* on the Pacific side of Panama, although they differ in colour pattern and the presence of notochaetae with a unidentate tip. The prevalence of infestation was 5 % and the intensity was 1.20. Experimental observations suggest that the behaviour of the scale-worm on *O. annulata* could be affected by light conditions, and that the commensal had a preference for its host over other ophiuroid species. More studies should be carried out to determine the taxonomic status of *M. cf. variegata* in the Eastern Pacific and to further elucidate the commensal–host relationship between this scale-worm and *O. annulata*.

R. Granja-Fernández (✉)
Programa de Posgrado, Facultad de Ciencias Naturales,
Universidad Autónoma de Querétaro,
Av. de las Ciencias s/n, col. Juriquilla,
76230 Querétaro, Mexico
e-mail: beckygranja@gmail.com

P. Hernández-Moreno · R. Bastida-Zavala
Laboratorio de Sistemática de Invertebrados Marinos (LABSIM),
Universidad del Mar, Campus Puerto Ángel,
Ciudad Universitaria, Apdo. Postal 47,
70902 Puerto Ángel, Oaxaca, Mexico

P. Hernández-Moreno
e-mail: paulinahzd@msn.com

R. Bastida-Zavala
e-mail: rolando@angel.umar.mx

Keywords Association · Intensity · Mexico · Ophiuroid · Prevalence · Scale-worm

1 Introduction

Polychaeta is one of the marine groups with the highest number of symbiotic species. There are 292 species of commensal polychaetes involved in 713 different commensal relationships (Martin and Britayev 1998); of these, the highest number corresponds to relationships with echinoderms (ca. 150 species) because echinoderms provide effective protection for polychaetes (Martin and Britayev 1998; Wisshak and Neumann 2006). Among the echinoderms, the class Ophiuroidea is, after the class Asteroidea, the group with the highest number of relationships with polychaetes (Martin and Britayev 1998).

Almost 55 % of commensal polychaetes are members of the scale-worm family Polynoidae (Clark 1956; Martin and Britayev 1998). Polynoids are common in intertidal and shallow-water on all substrata, including stones, crevices, and coral reefs, and most are carnivorous, feeding on other polychaetes, molluscs, crustaceans and echinoderms (Hartman 1971; Fauchald and Jumars 1979; Pettibone 1986, 1993). Worldwide, there are approximately 40 associations between scale-worms (e.g. genera *Hermenia*, *Hololepidella*, *Lepidonopsis*, *Malmgrenia*, *Malmgreniella*, *Subadyte*) and ophiuroids (e.g. genera *Acrocnida*, *Amphiodia*, *Amphioplus*, *Macrophiothrix*, *Microphiopholis*, *Orphiarthrum*, *Ophiocoma*, *Ophionephthys*, *Ophionereis*, *Ophiophragmus*, *Ophiopsila*, *Ophiothrix*). Of these, *Malmgreniella* and *Ophiocoma* are the polychaete and ophiuroid genera with the highest number of relationships (Pettibone 1993; Hendler et al. 1995; Martin and Britayev 1998).

In the tropical Eastern Pacific, the family Polynoidae is represented by almost 100 species (Salazar-Vallejo and Londoño-Mesa 2004), while the class Ophiuroidea is represented by 186 species (Stöhr et al. 2012); the Polynoidae and Ophiuroidea in the Mexican Pacific are represented by 61 and 63 species, respectively (Salazar-Silva 2006; Honey-Escandón et al. 2008). Despite this, the association between commensal polynoids and ophiuroids in the Eastern Pacific is poorly studied, with only three documented associations (none in the Mexican Pacific): *Malmgreniella baschi* Pettibone, 1993 with *Ophiopsila californica* A.H. Clark, 1921 from Santa Catalina Island, California; *Malmgreniella macginitiei* Pettibone, 1993 with *Amphiodia (Amphispina) urtica* (Lyman, 1860) from Santa Monica Bay, California; and *Malmgreniella variegata* (Treadwell, 1917) with *Ophionereis annulata* (Le Conte, 1851) from Perlas Islands, Gulf of Panama (Pettibone 1993). Previously, in the Western Atlantic, several *Malmgreniella* species have been documented as commensals of ophiuroids: *M. galetaensis* Pettibone, 1993 with *Amphiura kinbergi* Ljungman, 1872, and *Ophiophragmus septus* (Lütken, 1859); *M. hendleri* Pettibone, 1993 with *A. kinbergi*, and *Ophionephthys limicola* Lütken, 1869; *M. maccraryae* Pettibone, 1993 with *Amphioplus (Amphioplus) sepultus* Hendler, 1995 and *Microphiopholis gracillima* (Stimpson, 1854); *M. panamensis* Pettibone, 1993 with *Ophiopsila cf. polysticta*; *M. pierceae* Pettibone, 1993 with *A. kinbergi*; *M. puntotorensis* Pettibone, 1993 with *Amphiodia trychna* H.L. Clark, 1918, *O. limicola*, *Ophiophragmus cubanus* (A. H. Clark, 1917), *Ophiophragmus pulcher* H.L. Clark, 1918 and *O. septus* (Lütken, 1859); *M. taylori* Pettibone, 1993 with *Microphiopholis atra* (Stimpson, 1852) and *M. gracillima*; *M. variegata* with *Ophionereis reticulata* (Say, 1825) (Millott 1953; Pettibone 1993; Hendler et al. 1995; de Santa-Isabel et al. 1996).

The main goal of this paper is to document the association between a pair of scale-worms and an ophiuroid species for the first time in the Mexican Pacific.

2 Materials and methods

This work is part of a much larger-scale study regarding ophiuroid biodiversity in shallow-waters along the Pacific coast of Mexico, where a total of 36 localities from Nayarit to Oaxaca were sampled between 2007 and 2012. The sampling was carried out by SCUBA diving in different substrate (dead and live stony corals, gorgonians, sand, rock, algae) from the intertidal zone to a depth of 26 m. When detected, the associated polynoids were collected; the scale-worms were gently pulled away from the host and were immediately placed in individual containers.

To prevent autotomy of the elytra, the collected polynoids were relaxed using 7–8 % magnesium chloride buffered seawater, and were fixed posteriorly with 10 % formalin. Both polynoids and ophiuroids were preserved in 70 % ethanol. Ophiuroid specimens were identified according to Le Conte (1851), and Fell (1960), while the scale-worms being identified according to Treadwell (1917), Pettibone (1993), and Salazar-Silva (2006). The ophiuroids and polynoids were deposited in the Colección de Referencia del Laboratorio de Sistemática de Invertebrados Marinos, at the Universidad del Mar, Oaxaca, Mexico.

We estimated the "prevalence of the commensal" as the number of infested hosts divided by the total number of hosts collected, and the "intensity" as the number of commensals recorded on a single infested host (Margolis et al. 1982; Bush et al. 1997).

We conducted a series of preliminary experiments to investigate host preference by the scale worm. One collected pair of *Malmgreniella cf. variegata* and *Ophionereis annulata*, as well as two specimens each of *Ophiocoma aethiops* Lütken, 1859 and *Ophiocoma alexandri* Lyman, 1860 (from Copalita, Oaxaca), were transported in individual plastic bags to the laboratory. We used the genus *Ophiocoma* because it is among the most common in the study area and co-occurs with *O. annulata* (R. Granja-Fernández unpublished data). In the laboratory, the specimens were placed into a 5 l aquarium with running seawater. Due to the scarcity of the material, we conducted a limited number of behavioural observations. We conducted three simple behavioural observations on the 5 l aquarium: 1) the scale-worm was exposed to the host from which it was collected under different light conditions (natural light, 10 % of incident light); 2) the scale-worm was exposed against two specimens of *O. aethiops* and *O. alexandri* at different times; and 3) we exposed the scale-worm to its host (*O. annulata*), two specimens of *O. aethiops* and two specimens of *O. alexandri*. We conducted each observation five times. After each run, the specimens were removed and the water was replaced. Each run was separated by a delay of 5 min. In every case, we initiated each run by putting the scale-worm and the ophiuroid at opposite sides of the aquarium.

3 Results

Although the ophiuroid species *Ophiactis savignyi* (Müller & Troschel, 1842), *Ophiactis simplex* (Le Conte, 1851), *Ophiolepis pacifica* Lütken, 1856, *Ophiocnida cf. hispida*, *Ophiocoma aethiops*, *Ophiocoma alexandri*, *Ophiothela mirabilis* Verrill, 1867, *Ophiothrix (Ophiothrix) rudis* Lyman, 1874, *Ophiothrix (Ophiothrix) spiculata* Le Conte, 1851, *Ophioderma cf. teres*, and *Ophioderma panamensis* Lütken, 1859, were routinely collected along the Mexican Pacific coast, only *Ophionereis annulata* was found with associated scale-worms. The scale-worm *Malmgreniella cf. variegata* was

always found attached to *O. annulata*. The ophiuroid *O. annulata* was found in 22 localities from a total of 36 in the Mexican Pacific; 103 specimens were collected, all of which were buried in sand from the intertidal zone to a depth of 12 m. The association between *O. annulata* and *M. cf. variegata* was found only in five localities: Cuastecomatito, Jalisco (one commensal, 6 m); Caleta de Chón, Guerrero (one commensal, 5 m); Estacahuite, Oaxaca (two commensals, 12 m); Maguey, Oaxaca (one commensal, 7 m); and Copalita, Oaxaca (one commensal, 9.1 m). So, approximately 5 % of the population of *O. annulata* in the Mexican Pacific host *M. cf. variegata* and normally host a single individual (Table 1).

In the field, *Malmgreniella cf. variegata* appear to be cryptically coloured on *Ophionereis annulata*, with white and black pattern on the elytra (Fig. 1). The colour pattern was the same in the different hosts. The collected scale-worms were firmly attached to the aboral side of the disc of the ophiuroids but when manipulated, they moved to the arms and the oral side of the disc.

We observed two different behaviours in the aquarium when the scale-worm was exposed to the host from which it was collected, which were dependent on the light conditions. In the presence of natural light, the scale-worm immediately

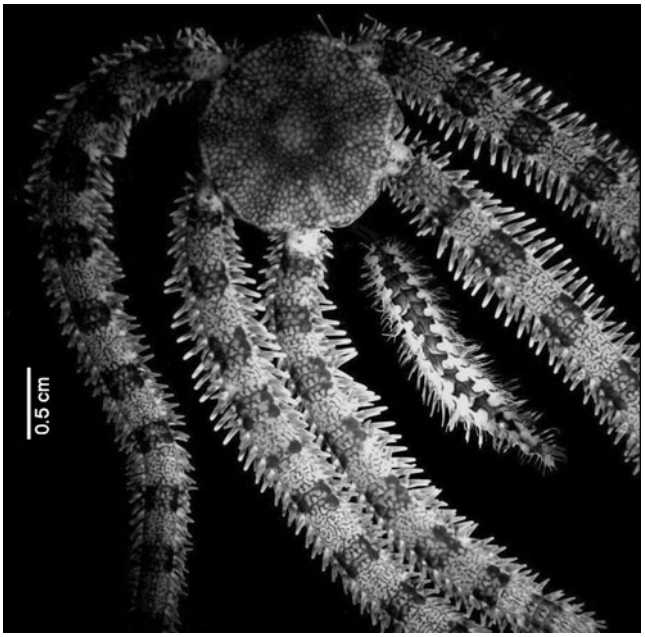

Fig. 1 *Malmgreniella cf. variegata* and its host *Ophionereis annulata*, from Caleta de Chón, Guerrero, Mexico

Table 1 Intensity and prevalence of infestation of *Malmgreniella cf. variegata* on *Ophionereis annulata* in the Mexican Pacific

Locality	State	Latitude (N)	Longitude (W)	*Ophionereis* N	Infested ophiuroids N	Commensals N	Int	Prev
La Pajarera	Jal	19°33′23.87″	105°06′28.44″	2	0	0	0	0
Cuastecomatito	Jal	19°13′58.66″	104°45′15.37″	1	1	1	1	1
Punto B	Col	19°05′55.10″	104°23′24.43″	1	0	0	0	0
Sacramento	Gro	17°37′57.74″	101°36′34.07″	1	0	0	0	0
Manzanillo	Gro	17°37′14.32″	101°31′26.24″	5	0	0	0	0
Caleta de Chón	Gro	17°36′54.72″	101°33′17.71″	8	1	1	1	0.13
Morros de Potosí	Gro	17°31′58.43″	101°29′26.60″	1	0	0	0	0
Puerto Angelito	Oax	15°51′24.85″	97°04′26.69″	1	0	0	0	0
El Faro	Oax	15°51′24.38″	97°03′58.63″	5	0	0	0	0
Santa Elena	Oax	15°46′55.43″	96°56′07.65″	3	0	0	0	0
Mazunte	Oax	15°39′35.31″	96°33′17.12″	9	0	0	0	0
Boquilla	Oax	15°40′53.94″	96°27′57.70″	3	0	0	0	0
La Mina	Oax	15°40′24.60″	96°28′38.61″	6	0	0	0	0
Estacahuite	Oax	15°40′06.14″	96°28′52.44″	21	1	2	2	0.05
San Agustín	Oax	15°41′14.56″	96°14′13.49″	1	0	0	0	0
Tijera	Oax	15°41′15.12″	96°26′31.47″	2	0	0	0	0
Dos Hermanas	Oax	15°42′04.82″	96°12′36.42″	3	0	0	0	0
Isla Cacaluta	Oax	15°43′12.05″	96°09′47.85″	2	0	0	0	0
Maguey	Oax	15°43′48.50″	96°08′54.20″	1	1	1	1	1.00
Órgano	Oax	15°44′12.82″	96°08′38.57″	1	0	0	0	0
Manzanilla	Oax	15°46′00.03″	96°05′57.11″	2	0	0	0	0
Copalita	Oax	15°46′51.98″	96°03′35.02″	24	1	1	1	0.04
				103	5	6	1.20	0.05

Jal Jalisco; *Col* Colima; *Gro* Guerrero; *Oax* Oaxaca; *Int* intensity; *Prev* prevalence

sought the ophiuroid; when the polynoid located the host, it climbed to the dorsal arm plates, then moved to the ventral arm plates and finally to the oral side of the ophiuroid disc (with its mouth near to the ophiuroid mouth). With 10 % of incident light, the scale-worm stayed away from the ophiuroid for a period of time (5–10 min), following which it sought the host, climbed to the dorsal arm plates and moved to the dorsal side of the disc, where it remained.

The second aquarium observations consisted of exposing the scale-worm to *Ophiocoma aethiops* and *O. alexandri* at different times. The scale-worm showed the same behaviour in the presence of both species: the scale-worm approached the ophiuroids, but when they established physical contact either the scale-worm ignored the potential hosts or moved away. Finally, we placed the species *O. aethiops*, *O. alexandri* and *O. annulata* together; in every observation the scale-worm ignored the *Ophiocoma* species but move towards and attached to *O. annulata*, where it remained.

4 Discussion

From 2007 to the present day we have collected numerous ophiuroids (~3,500 specimens) along 36 localities in the Mexican Pacific; however, this is the first time that we have found an association between a polychaete and an ophiuroid in the region. *Ophionereis annulata* represents one of the most common ophiuroids in the Mexican Pacific, together with *Ophiocoma aethiops* and *O. alexandri* (R. Granja-Fernández unpublished data). Members of the genus *Ophiocoma* as *O. anaglyptica* Ely, 1944, *O. brevipes* Peters, 1851, *O. dentata* Müller & Troschel, 1842, *O. doederleini* de Loriol, 1899, *O. echinata* (Lamarck, 1816), *O. erinaceus* Müller & Troschel, 1842, *O. pumila* Lütken, 1856, and *O. scolopendrina* (Lamarck, 1816) have associations with different polychaetes worldwide, such as the syllid *Branchiosyllis exilis* (Gravier, 1900), the hesionid *Gyptis ophiocomae* Storch & Niggemann, 1967, and the polynoids *Hermenia verruculosa* Grube, 1856, and *Hololepidella nigropunctata* (Horst, 1915) (Pettibone 1993; Hendler et al. 1995; Martin and Britayev 1998). Despite this, we found no polychaete species on *O. aethiops* or *O. alexandri* during the course of this study; similar results were obtained by Hendler and Meyer (1982) on the Pacific side of Panama.

The scale-worms collected during this work have morphological characteristics which coincide perfectly with the genus *Malmgreniella* and appear to be most closely allied to the scale-worm from the Western Atlantic, *Malmgreniella variegata*. The specimens examined in this study were identified as *Malmgreniella cf. variegata* because they share the semi-spherical microtubercles and the bidentate neurochaetae with the nominal species, but differ in the colour pattern of the elytra (dark and light brownish in nominal species, black and white in *M. cf. variegata*), and the presence of notochaetae with unidentate tip in *M. cf. variegata*, while the nominal species has only blunt tips. *Malmgreniella variegata* has been widely recorded in the Gulf of Mexico and the Caribbean Sea associated with *O. variegata*, and there is one report from the Pacific side of Panama of association with *Ophionereis annulata* (Pettibone 1993). It will be necessary to review the populations of *M. variegata* and *Ophionereis* spp. from both sides of Panama in order to clarify the identity of the species in that area.

All of the scale-worms were initially found on the aboral side of the disc of the ophiuroids, when the specimens were manipulated the scale-worms migrated to the arms and the oral side of the disc. A similar behaviour was observed in the aquarium observations, which suggested that the behaviour of *Malmgreniella cf. variegata* on *Ophionereis annulata* could be affected by light conditions, or may be mediated by chemical signals. In our preliminary observations, in the presence of light, the scale-worm stayed "protected" on the oral side of the ophiuroid but with only 10 % of incident light it stayed on the dorsal side; however, more studies need to be carried out to determine whether light is a primary factor determining the position of the scale-worm on the host. Other authors record that *M. variegata* from the Western Atlantic and Panama were found on the aboral side of the disc and moved to the oral side (near the mouth) and towards the arms of *O. reticulata* (Millott 1953; Pettibone 1993; de Santa-Isabel et al. 1996). Devaney (1967) suggests that species that bury themselves in sand (such as *O. annulata*) only expose their aboral side, which is the reason why the commensal only attached to this part of the ophiuroid. A different behaviour has been observed in other species of polychaetes, such as *Hololepidella nigropunctata* and *Branchiosyllis exilis*, which were located mostly on the arms and the oral side of their host; the location of the commensals on these parts is related to physical protection and the availability of food (Devaney 1967; Hendler and Meyer 1982).

Our preliminary observations suggested that *M. cf. variegata* had a preference for its host *Ophionereis annulata* over *Ophiocoma* species. This is consistent with data from our collections. The literature (e.g. Davenport 1950, 1953; Dimock and Davenport 1971) suggests that commensal polychaetes seem able to distinguish their host from other related species; they are probably even capable of recognising and responding to some specific chemical signal emanating from their hosts.

The prevalence of infestation in this study was 5 %, while other reports of polychaete-ophiuroid relationships reported a prevalence of 11–100 % (Hendler and Meyer 1982; Alvà and Jangoux 1989; Martin and Britayev 1998). Despite the fact that our prevalence of infestation is low in comparison with other studies, there are several independent evidence lines that suggest that the observed relationship is not fortuitous or due to chance. We have collected ophiuroids in approximately 1,500 km across the Mexican Pacific (from Nayarit to Oaxaca) and found the relationship in three different

geographical areas (Jalisco, Guerrero, Oaxaca) with a distance between them of 380–600 km. Similarly, inventories of polychaetes have been carried out in the South Mexican Pacific and no *Malmgreniella cf. variegata* have been found free living, on or in any substrata. Although we routinely collected 12 species of ophiuroids in shallow-water in the Mexican Pacific, we only found *M. cf variegata* associated with *Ophionereis annulata*. Finally, the matching of the colour pattern in both species could suggest a specific mimicry, moreover, our behavioural observations at the aquarium bear out that *M. cf variegata* has a preference for its host (*O. annulata*) over other ophiuroid species.

Pettibone (1993) recorded two specimens of *Malmgreniella variegata* associated with one *Ophionereis annulata* on the Pacific side of Panama, while Millot (1953) also reported a similar observation for the species *M. variegata* and its host *O. variegata* from Jamaica. Nevertheless, our data suggests an intensity of 1.20, and that a single commensal scale-worm per host is more common in the Mexican Pacific. The relationship of one commensal per host is common in other polynoid–ophiuroid symbiotic relationships (Davenport 1953; Pettibone 1993; Martin and Britayev 1998) and may be related to the aggressive behaviour that the polynoids had displayed when two or more individuals are close together (Devaney 1967).

Polychaetes and ophiuroids represent two of the most important macroinvertebrate groups in marine ecosystems because they contribute an important quantity of biomass to the benthos, and also represent two main groups in the food chain (Salazar-Vallejo 1981; Lawrence 1987). This study is the first to report an association between a polynoid and an ophiuroid species in the Mexican Pacific. Due to the ecologic relevance of these taxa, further physiological and morphological studies should be undertaken to enable a better understanding of these relationships in the Eastern Pacific.

Acknowledgments We thank Andrés López-Pérez, Ronald Zepeta-Vilchis (UMAR, Puerto Ángel) and Francisco Solís-Marín (ICML-UNAM, Mexico City) for collecting specimens; and Gordon Hendler (NHM of LA County) and Luis Calderón (CICESE) for providing valuable information. The study of ophiuroids was supported by a grant from CONACYT (80228) and CONABIO (HJ029), and the study of the polynoids by a grant from CONACYT-SEMARNAT (FOSEMARNAT 2004-01-92) and a fellowship to one of the authors (PHM). While this work was done, RGF was supported by a scholarship for CONACYT.

References

Alvà V, Jangoux M (1989) Sur les symbioses entre Polychètes et Ophiures avec la description d'un nouveau cas de commensalisme. In: Régis MB, Segui A, Frasson C, Escoubet P, Riva A (eds) Echinodermes: actuels et fossiles. Actes du VIe Séminaire International sur les Echinodermes, Aix-Marseille III: CERAM, Faculté des Sciences et Techniques de Saint-Jérôme, Foundation Océanographique Ricard, pp 185–192

Bush AO, Lafferty KD, Lotz JM, Shostak AW (1997) Parasitology meets ecology on its own terms: Margolis *et al*. revisited. J Parasitol 83(4):575–583

Clark RB (1956) *Capitella capitata* as a commensal, with a bibliography of parasitism and commensalism in the polychaetes. Ann Mag Nat Hist Ser 12:433–448

Davenport D (1950) Studies in the physiology of commensalism. I. The polynoid genus *Arctonoë*. Biol Bull 98(2):81–93

Davenport D (1953) Studies in the physiology of commensalism. III. The polynoid genera *Acholoe*, *Gattyana*, and *Lepidastenia*. J Mar Biol Assoc U K 32:161–173. doi:10.1017/S0025315400011486

de Santa-Isabel LM, Pinto-Cerqueira WR, de Souza-Alves OF (1996) Associação entre *Ophionereis reticulata* (Say) (Ophiuroidea, Ophionereididae) e *Malmgreniella variegata* (Treadwell) (Polychaeta, Polynoidae) das Praias de Salvador, Bahia, Brasil. Rev Bras Zool 13(1):137–142

Devaney DM (1967) An ectocommensal polynoid associated with Indo-Pacific echinoderms, primarily ophiuroids. Occas Pap Bernice P Bishop Mus 23:287–304

Dimock RV Jr, Davenport D (1971) Behavioural specificity and the induction of host recognition in a symbiotic polychaete. Biol Bull 141:472–484

Fauchald K, Jumars PA (1979) The diet of worms: a study of polychaete feeding guilds. Oceanogr Mar Biol 17:193–284

Fell HB (1960) Synoptic keys to the genera of Ophiuroidea. Zool Publ Victoria Univ N Z 20:1–44

Hartman O (1971) Abyssal polychaete annelids from the Mozambique Basin off southeast Africa, with a compendium of abyssal polychaetous annelids from world-wide areas. J Fish Res Board Can 28:1407–1428. doi:10.1139/f71-219

Hendler G, Meyer DL (1982) An association of a polychaete, *Branchiosyllis exilis*, with an ophiuroid, *Ophiocoma echinata*, in Panama. Bull Mar Sci 32:736–744

Hendler G, Miller JE, Pawson DL, Kier PM (1995) Sea stars, sea urchins, and allies. Echinoderms of Florida and the Caribbean. Smithsonian Institution, Hong Kong

Honey-Escandón M, Solís-Marín FA, Laguarda-Figueras A (2008) Equinodermos (Echinodermata) del Pacífico Mexicano. Rev Biol Trop 56(3):57–73

Lawrence J (1987) A functional biology of echinoderms. The Johns Hopkins University Press, Baltimore

Le Conte JL (1851) Zoological notes. Proc Acad Nat Sci Phila 5:316–319

Margolis L, Esch GW, Holmes JC, Kuris AM, Schad GA (1982) The use of ecological terms in parasitology (report of a committee of the American Society of Parasitologists). J Parasitol 68:131–133

Martin D, Britayev TA (1998) Symbiotic polychaetes: review of known species. Oceanogr Mar Biol Annu Rev 36:217–340

Millott N (1953) A remarkable association between *Ophionereis reticulata* (Say) and *Harmothoe lunulata* (Delle Chiaje). Bull Mar Sci Gulf Caribb 3(2):96–99

Pettibone MH (1986) Review of the Iphioninae (Polychaeta: Polynoidae) and revision of *Iphione cimex* Quatrefages, *Gattyana deludens* Fauvel, and *Harmothoe iphionelloides* Johnson (Harmothoinae). Smithson Contrib Zool 428:1–43

Pettibone MH (1993) Scaled polychaetes (Polynoidae) associated with ophiuroids and other invertebrates and review of species referred to *Malmgrenia* McIntosh and replaced by *Malmgreniella* Hartman, with descriptions of new taxa. Smithson Contrib Zool 538:1–92

Salazar-Silva P (2006) Scaleworms (Polychaeta: Polynoidae) from the Mexican Pacific and some other Eastern Pacific sites. Investig Mar 34(2):143–161

Salazar-Vallejo SI (1981) La importancia de los poliquetos (Annelida: Polychaeta) en el medio marino. Bol Centro Invest Biol UANL 11:3–4

Salazar-Vallejo SI, Londoño-Mesa MH (2004) Lista de especies y bibliografía de poliquetos (Polychaeta) del Pacífico Oriental Tropical. An Inst Biol UNAM 75(1):9–97

Stöhr S, O'Hara TD, Thuy B (2012) Global diversity of brittle stars (Echinodermata: Ophiuroidea). PLoS One 7(3):e31940. doi:10.1371/journal.pone.0031940

Treadwell AL (1917) Polychaetous annelids from Florida, Porto Rico, Bermuda, and the Bahamas. Carnegie Inst Wash Publ 251:257–268

Wisshak M, Neumann C (2006) A symbiotic association of a boring polychaete and an echinoid from the Late Cretaceous of Germany. Acta Palaeontol Pol 51(3):589–597