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# HABITAT CHARACTERISTICS AND OCCURRENCE OF THE SPIONID *PSEUDOPOLYDORA* SP. ON THE TUBE-CAPS OF THE ONUPHID *DIOPATRA BILOBATA* (POLYCHAETA: SPIONIDAE, ONUPHIDAE)[1]

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**Hwey-Lian Hsieh and Kun-Hsiung Chang** (1991) Habitat characteristics and occurrence of the spionid *Pseudopolydora* sp. on the tube-caps of the onuphid *Diopatra bilobata* (Polychaeta: Spionidae, Onuphidae). *Bull. Inst. Zool., Academia Sinica* **30**(4): 331-339. The habitat characteristics of the spionid polychaete *Pseudopolydora* sp. and the changes of its population density were examined in an intertidal flat in Hsin-Chu, Taiwan, from 1990 to 1991. Four habitats bare sand areas, the vicinity of oyster culture supports and the tubes of the onuphid *Diopatra bilobata* Imajima and of the terebellid *Amphitrite* sp. were surveyed. *Pseudopolydora* sp. showed a preference for the tube-caps of *D. bilobata*. As a biogenic structure the tube-caps of *Diopatra* serve as a habitat which provides the persistency and stability of a substratum and harbors silt and debris for *Pseudopolydora* sp. to construct tubes and feed upon. The population densities of *Pseudopolydora* sp. peaked in the fall of 1990 with 53 to 71 individuals per tube-cap but dropped in the winter and spring to a low of two to three individuals per tube-cap. This decrease in density may be related to low winter temperatures.

**Key words:** Biogenic structure, *Diopatra* tube-caps, *Pseudopolydora*.

In marine systems biogenic structures serving as habitats for plants and animals have been well documented in coral reefs (Lewis, 1981), mussel beds (Paine and Levin, 1981), macroalgal forests (McRoy and Lloyd, 1981), seagrasses (Heck, Jr. and Wetstone, 1977) and polychaete tubes (Woodin, 1978). Biogenic structures differ markedly in spatial and temporal scales but provide similar functions. These functions are to provide structural persistency and refugia from predators or physical stress, to serve as brooding sites and to trap food particles (Mangum *et al.*, 1968; Brenchley, 1976; Bell, 1985).

The architecture of the tubes of the onuphid polychaete *Diopatra* is relatively complicated, compared to other polychaete tubes. *Diopatra* constructs parchment-like tubes which penetrate the substratum

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vertically to a depth of over 30 cm. Above the substratum, tubes protrude several centimeters and bend like a chimney. The above ground portions, referred to as tube-caps (Mangum *et al.*, 1968), are decorated with fragments of shells, plant materials and other debris. *Diopatra* tube-caps have been found to be a habitat rich with microfloral and meiofaunal communities. On the east coast of the United States, *Diopatra cuprea* (Bosc) serves as a habitat for more than 14 phyla and 69 species (Mangum *et al.*, 1968; Bell and Coen 1982a, b). It is worth noticing that in this habitat-habitant system, the tube-dwelling spionid polychaete *Polydora ligni* Webster were found on the *D. cuprea* tube-caps but not in adjacent sediments (Bell and Coen, 1982a). This suggests the persistent nature of *Diopatra* habitats and the possibility of habitat preference by the spionid larvae.

*Pseudopolydora* sp.(1) is a small spionid. An adult worm has about 25 segments and a total length of about 4mm. Larvae newly releasd from brood capsules have 3–4 setigers, spend 3 weeks or so in the plankton and metamorphose with 12–14 setigers at 22–26°C, 30–35‰ salinity and fed with alga *Tetraselmis chuii* (personal observations). *Pseudopolydora* sp. has life style characteristics similar to *Polydora ligni*: such as both construct sand or mud tubes and brood until reaching three setigers, then larvae become planktotrophic. Preliminary studies showed that larval *Pseudopolydora* were often collected by plankton nets at the study site, however, the adults were not found in sediment samples. According to Bell and Coen (1982a, b), *Polydora ligni* prefers to live on the tube-caps of *Diopatra cuprea.* Since *Diopatra bilobata* Imajima are common in the present study site and *Pseudopolydora* sp. has a similar life style to that of *Polydora ligni*, it is reasonable to propose that the habitat-habitant system found on the east coast of the United States may also occur in Taiwan. The purpose of this study was to address the following questions: 1) Whether *Diopatra bilobata* is a possible habitat for adult *Pseudopolydora* sp., 2) What are the physical characteristics of *Diopatra bilobata* tube-caps, 3) What is the seasonal occurrence of *Pseudopolydora* sp. on *Diopatra bilobata* tube-caps.

## MATERIALS AND METHODS

### The study site

The study site is an intertidal sand flat at Hsiang-Shan (24° 50′N, 120° 54′E), Hsin-Chu, northern Taiwan. The flat consists of sand with only a few small patches being vegetated by seagrass *Halodule uninervis*. On the southwest side of the flat oysters are cultured, supported above the sediment by bamboo sticks. Tubes of onuphid *Diopatra bilobata*, the terebellid *Amphitrite* sp. and chaetopterids are the most obvious polychaete tubes seen on the flat.

### The habitat of the spionid *Pseudopolydora* sp.

Distributions of adult *Pseudopolydora* sp. were investigated by examining various habitats on the sandy intertidal flat from February to May, 1990. The habitats surveyed included bare sand, tubes of two polychaetes, *Amphitrite* sp. and *Diopatra bilobata*, and the vicinity of oyster culture supports. The upper 10 cm long portions of *Diopatra* and terebellid tubes were clipped and enclosed separately in containers with clean sea water. Sediment samples from the surrounding bare sand and the vicinity of oyster culture supports were collected by PVC corers with a surface area of

(1) It is a new species currently being described elsewhere.

5.31 $cm^2$ or 0.78 $cm^2$ to a depth of 10 cm. All samples were brought to the laboratory fresh and sieved through 295 $\mu$m mesh or 53 $\mu$m mesh using sea water. *Pseudopolydora* sp. was sorted out with a dissecting microscope and its abundance was recorded.

**Grain size analyses**

Grain size compositions of bare sand, sediment associated with *Diopatra* tube-caps, terebellid tubes and *Pseudopolydora* tubes were analyzed from April to June, 1990. Bare sand samples were taken using PVC corers with 2.6 cm in inner diameter. The *Diopatra* tube-caps analyzed had less than two *Pseudopolydora* individuals living on them, in order to diminish the confounding of grain composition betweed the two tube dwellers. Three samples were taken for each of the above. All samples were fixed in 10% formalin in the field and wet sieved through a series of screens with mesh openings from 1 mm to 0.053 mm in the laboratory. Grains of worm tubes were shaken off by using ultrasonic cleaners (Bransonic 5200) for 10 min before sieving. Silt-clay proportions were analyzed using pipette methods (Buchanan and Kain, 1971) with a slight modification to eliminate salts contained in the samples. Salts were washed away using deionized water while sediment was pipetted onto a Whatman glass microfibre filter (opening about 1.2 $\mu$m). Therefore, distributions of grain sizes greater than 1.2 $\mu$m were analyzed. Grain size distributions of *Pseudopolydora* tubes were analyzed using a particle counter (Elzone 180 XY). Granulometric parameters were calculated following Folk (1966).

**Persistency of tube-caps of *Diopatra bilobata***

Relative persistency of the tube-caps of *Diopatra bilobata* were compared between different aged tubes. Tubes were collected in November 1990 and in February 1991, brought back to the laboratory fresh and kept in aerated sea water. Comparisons were made between four month old tubes and two week old tubes. Pull forces were applied to the tubes and the weight which caused tubes to break was recorded. Three tubes were tested for each of the two age treatments. Persistency was expressed as pull forces in grams per tube.

**Temporal changes of density in *Pseudopolydora* sp.**

Temporal changes of density in *Pseudopolydora* sp. were examined from March, 1990 to February, 1991. Thirteen to 18 *Diopatra bilobata* tubes were haphazardly collected monthly and brought back to the laboratory fresh. The number of *Pseudopolydora* sp. per tube-cap was recorded.

## RESULTS

**The occcurrence of *Pseudopolydora* sp. on *Diopatra bilobata* tube-caps**

*Pseudopolydora* sp. was abundant on the tube-caps of *Diopatra bilobata* but rare in the bare sand. None were found on the terebellid tubes, nor in the vicinity of oyster cultre supports (Table 1). Average density of *Pseudopolydora* was five individuals per *Diopatra* tube-cap and 0.01 individual per $cm^2$ in the bare sand, indicating that this species has specialized habitat requirements and prefers the *Diopatra bilobata* tubes.

**Granulometry of bare sand and worm tubes**

Grain size distributions and granulometric parameters of the tubes of *Diopatra bilobata*, *Amphitrite* sp. and *Pseudopolydora* sp., and the surrounding sand are shown in Table 2 and Fig. 1. The median

Table 1
The abundance of *Pseudopolydora* sp. found in different habitats at the study site. *=per cm², ♯=per tube

| Habitat | Abundance of *Pseudopolydora* | | |
|---|---|---|---|
| | Number of samples | Mean | Standard deviation |
| Tube-caps of *Diopatra bilobata* | 32 | 5.06♯ | 5.28 |
| Bare sand | 31 | 0.01* | 0.03 |
| Tubes of *Amphitrite* sp. | 14 | 0.00♯ | 0.00 |
| Vicinity of oyster culture supports | 3 | 0.00* | 0.00 |

Table 2
Granulometric parameters of bare sand, the *Diopatra bilobata* tube-caps and the *Amphitrite* sp. tubes. a, b, c=replicates

| Habitat | | Median particle size | | Modal particle size | | Sorting | Skewness | Silt-Clay |
|---|---|---|---|---|---|---|---|---|
| | | (φ | mm) | (mm | % dry weight) | coefficient | | (% dry weight) |
| Bare sand | a | 2.5 | 0.18 | 0.15 | 28.2 | 0.57 | +2.26 | 1.6 |
| | b | 2.4 | 0.18 | 0.21 | 30.1 | 0.60 | +2.02 | 1.5 |
| | c | 2.6 | 0.17 | 0.15 | 35.4 | 0.57 | +2.31 | 1.7 |
| *Diopatra* tube | a | 2.3 | 0.21 | 1.00 | 38.0 | 2.45 | +1.16 | 19.1 |
| | b | 2.2 | 0.21 | 1.00 | 38.6 | 2.37 | +1.28 | 17.8 |
| | c | 2.2 | 0.25 | 1.00 | 45.2 | 2.45 | +1.15 | 19.6 |
| *Amphitrite* tube | a | 0.6 | 0.72 | 1.00 | 44.7 | 0.72 | +1.11 | 0 |
| | b | 0.5 | 1.00 | 0.50 | 39.4 | 0.66 | +1.09 | 0 |
| | c | 0.6 | 0.80 | 0.50 | 42.2 | 0.75 | +1.11 | 0 |

grain sizes of the bare sand ranged from 0.17–0.18 mm in diameter with modal grain sizes ranging from 0.15 to 0.21 mm in diameter. These values characterized the study site as a fine sand flat (Buchanan and Kain, 1971). Sorting coefficients ranged from 0.57 to 0.60, indicating that this site is moderately well sorted (Folk, 1966).

The tubes produced by *Diopatra bilobata* and *Amphitrite* sp. showed distinct differences in particle size composition from the surrounding sand (Fig. 1 and Table 2). On *Diopatra* tube-caps median particle sizes were from 0.21 to 0.25 mm in diameter, whereas modal particles were larger than 1.00 mm and weighed over 38% of total dry weight. In the *Amphitrite* tubes median particles ranged from 0.72 to 1.00 mm in diameter, with modal sizes from 0.50 to 1.00 mm, weighing over 39% of total dry weignt. The majority of the particles in both the *Diopatra* tube-caps and *Amphitrite* tubes were larger than that in the surrounding sand, indicating that both species select larger particles for tube construction. Particles selected by *Diopatra bilobata* were not uniform in size, since sorting was very poor (coefficients were 2.37 to 2.45). In contrast, particles were much better sorted by *Amphitrite*, with coefficients from 0.66 to 0.75, moderately well sorted composition of particle sizes.

Silt-clay proportions were also markedly different among habitats. *Amphitrite*

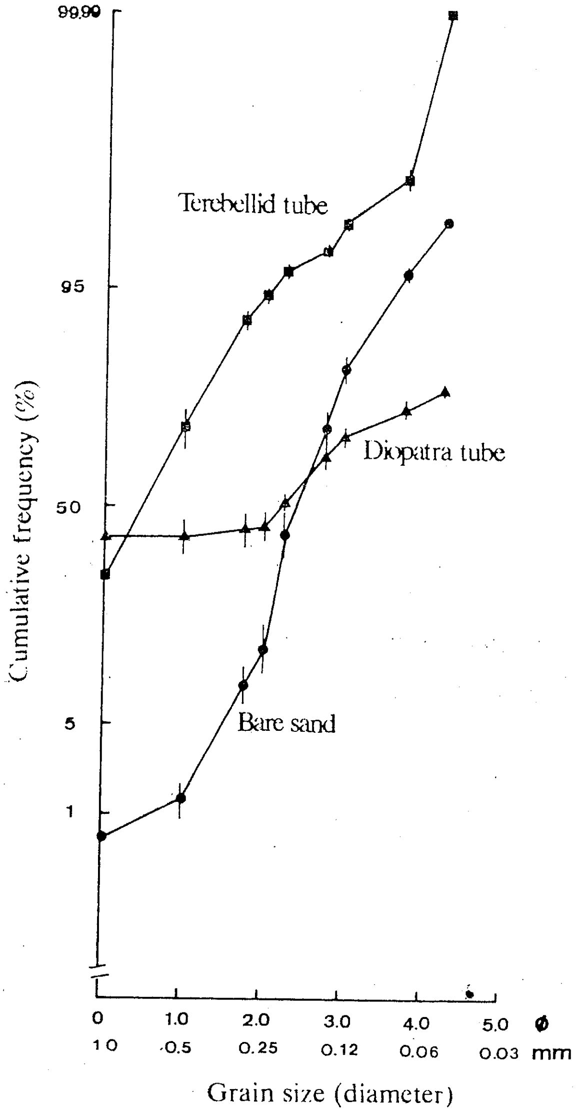


Fig. 4. The frequency distributions of grain compositions in bare sand, tube-caps of *Diopatra bilobata*, and tubes of the terebellid *Amphitrite* sp.

tubes did not contain silt and clay, whereas the surrounding sand contained very little, generally less than 2% dry weight of the sand bulk. In contrast, on the *Diopatra* tube-caps silt and clay comprised from 18 to 19% of total dry weight.

*Pseudopolydora* tubes had particle sizes ranging from 4.6 to 27.9 $\mu$m with modal sizes from 4.6 to 15.7 $\mu$m (Table 3). The particle sizes of *Pseudopolydora* tubes fell in the silt-clay range, indicating that *Pseudopolydora* demands an environment which can provide sufficient silt and clay for them to build tubes.

**Persistency of *Diopatra bilobata* tube-caps**

The forces needed to break the tube-caps of *Diopatra bilobata* were 80.8 grams (s. d. = 5.8) for tubes kept in laboratory for two weeks and 41.7 grams (s. d. = 6.3) for those kept for four months. These values suggest that over a four-month period the tubes still retained half of their initial strength.

**Temporal changes of density in *Pseudopolydora* sp. on the *Diopatra bilobata* tubes**

The proportions of the *Diopatra bilobata* tube-caps inhabited by *Pseudopolydora* sp. increased from 53% in March 1990 to 100% in May 1990, decreased a little in July and August, reached 100% again after September and then decreased again in February 1991 (Table 4). Monthly

Table 3
The particle size analyses of grains making up *Pseudopolydora* sp. tubes

| Replicate | Particle size ($\mu$m) 27.9-15.7 Count | % | 15.7-4.6 Count | % | Total counts |
|---|---|---|---|---|---|
| a | 29 | (0.83) | 3471 | ( 99.17) | 3500 |
| b | 1 | (0.33) | 295 | ( 99.66) | 296 |
| c | 0 | (0) | 842 | (100.00) | 842 |

Table 4
Monthly density changes of *Pseudopolydora* sp. on *Diopatra bilobata* tube-caps. Units of mean and s.d. are individuals per tube-cap

| Date | Total *Diopatra* tube-caps checked | *Diopatra* tube-cap inhabited by *Pseudopolydora* | | *Pseudopolydora* abundance on *Diopatra* tube-cap | | |
|---|---|---|---|---|---|---|
| | N | N | % | Total | Mean | S.D. |
| 1990 Mar | 15 | 8 | 53.33 | 29 | 1.93 | 2.52 |
| Apr | 18 | 14 | 77.78 | 51 | 2.83 | 2.55 |
| May | 15 | 15 | 100.00 | 125 | 8.33 | 5.56 |
| Jul | 13 | 11 | 84.62 | 74 | 5.69 | 5.36 |
| Aug | 15 | 14 | 93.33 | 141 | 9.40 | 8.14 |
| Sep | 15 | 15 | 100.00 | 152 | 10.13 | 6.28 |
| Oct | 15 | 15 | 100.00 | 785 | 52.33 | 29.70 |
| Nov | 13 | 13 | 100.00 | 849 | 65.31 | 40.11 |
| Dec | 13 | 13 | 100.00 | 928 | 71.38 | 31.39 |
| 1991 Jan | 14 | 14 | 100.00 | 575 | 41.07 | 44.00 |
| Feb | 14 | 12 | 85.71 | 280 | 20.00 | 21.42 |

changes in density of *Pseudopolydora* on *Diopatra* tube-caps showed another trend (Table 4). The lowest density (two *Pseudopolydora* per tube-cap) appeared in March 1990; density gradually increased to ten individuals per *Diopatra* tube-cap in September 1990, sharply increased to 53 individuals per tube-cap in October, and remained as high as 71 individuals per tube-cap in December. In January 1991 the density of *Pseudopolydora* sp. decreased to 42 individuals per tube-cap and further dropped to 20 individuals per tube-cap in February 1991. During the study period mature males and females and brooded larvae were present in almost all monthly samples, inicating that *Pseudopolydora* sp. living on the tube-caps of *Diopatra bilobata* is a viable population.

## DISCUSSION

Tube-caps of *Diopatra bilobata* are made of a mucopolysaccaride matrix (onuphic acid) secreted by the worms and decorated with a great deal of exogenic materials (fragments of oyster and other bivalve shells, sand dollar tests and plant twigs and leaves) (Mangum *et al.*, 1968; Bell, 1985). The mucopolysaccaride matrix is arranged in a lamellar form. The internal side of the tube is smooth, but the external surfaces of the tubes look shredded after attached materials are removed. This irregular layering is due to the arrangements of the lamellae. Some lamellae run parallel, some across and others diagonal in direction relative to the axis of the tube-caps. These lamellae are where *Diopatra* incorporate and adhere foreign fragments and where fine grains accumulate. As a result, crevices are created between the complexes of incorporated fragments. More importantly, *Pseudopolydora* sp. was found building their own tubes in the crevices where clay, silt, debris or fine sand had accumulated (see Results).

The present study shows that the tube-caps of *Diopatra bilobata* are a habitat preferred by the spionid *Pseudopolydora* sp. In this habitat mature individuals and developing larvae were consistently present in monthly samples, indicating that the tube-caps of *Diopatra bilobata* are utilized as an effective habitat where the habitants can survive, grow and reproduce. The current results are consistent with those examined along the Altantic coast of the U.S. (Bell, 1985; Bell and Coen, 1982 a, b). In both systems, although the constituents are different (*Diopatra cuprea—meiofaunal* communities and *Polydora ligni* along the Atlantic U.S. coast; *Diopatra bilobata—Pseudopolydora* sp. on the coast of Taiwan), the functions that the biogenic structure provides are basically identical. The ornamentation of *Diopatra* tube-caps has been related to predator detection and avoidance (Brenchley, 1976). From the meiofaunal prespectives, tube-caps have been proposed to be an extension of sedimentary habitats, but with the unique feature of being a stationary substratum with constant water flowing over it. In such a habitat food can be trapped, physical stress can be prevented and brooding sites can be protected (Mangum *et al.*, 1968; Bell and Coen, 1982 a; Bell, 1985).

Ornamentation of *Diopatra* tube-caps reinforces the above-ground tube segment (Brenchley, 1976). Tubes also can be repaired or rebuilt quickly by worms if damaged (Brenchley, 1976; Woodin, 1978). Furthermore, tubes lacking worms were not worn out and still retained 50% of their strength for at least four months (see Results). Four months is long relative to the generation time of *Pseudopolydora* sp. (the latter completes one generation in one and half to two months, personal observations). These features suggest that *Diopatra* tubes bear the important characteristics of a habitat, *i.e.*, stability and persistency.

The tubes of *Diopatra bilobata* consist of higher proportions of silt and clay than the other substrata examined in this study. A higher content of silt and clay presented in tube-caps is consistent with the prediction of the hydrodynamic principles (Butman, 1987). The protrusion of tube-caps above the sediment surface slows down bottom current flowing over the tube-caps; moreover, decorations on the tubes further diminish flow speed. Thus tube-caps trap more fine sediments or detrital materials than bare sand areas or terebellid tubes. The tubes of *Pseudopolydora* sp. are composed of silt and clay (see Table 3). *Pseudopolydora* sp. were observed to ingest the same materials used for their own tube construction. As a habitat, *Diopatra* tube-caps provide their habitants not only potential food but also the silt-clay and detrital materials necessary for the tube construction.

Since *Pseudopolydora* sp. is a tube dwellers, once metamorphosed, its ability to move around is restricted. Therefore, if there are any habitat choices, the selection must be made at the settling stage. *Pseudopolydora* sp. showed differential preference for tube-caps of *Diopatra bilobata* against bare sand and/or terebellid tubes, suggesting that *Pseudopolydora* larvae may actively select the habitat at settlement. Experimental studies on such habitat selection are under investigation.

The present study showed that densities of *Pseudopolydora* sp. on the tube-caps of *Diopatra bilobata* were low in winter and spring (see Table 4). It is proposed here that low winter temperatures may be an important factor causing the decreases in densities. In the laboratory larval survivorship was very poor when the culture temperatures were below 15°C (personal observations), suggesting that *Pseudopolydora* larvae can not tolerate low temperatures. In the field the air temperatures in January and February averaged around 14°C (Tsay, 1990). The question of whether or not low temperatures also affect the field adult population needs further investigation.

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# 棲息在歐努菲蟲管上的海稚蟲之棲所特徵及其族羣變化

謝蕙蓮　張崑雄

民國 79 到 80 年間調查分布在臺灣新竹香山潮間帶地區海稚蟲（*Pseudopolydora* sp.）成體的棲所。比較沙地、牡蠣架周圍的沙地、歐努菲蟲（*Diopatra bilobata*）以及蟄龍介蟲（*Amphitrite* sp.）的棲管等四種可能的棲所，發現海稚蟲主要分布在歐努菲蟲所築的管子上。再經由棲所之粒度組成（granulometry）及持效性（persistency）分析，結果顯示歐努菲蟲的棲管堆積較多的粉泥（silt-clay）並且棲管本身不易解體，具有穩定性及持效性。粉泥爲海稚蟲築管所需，亦爲其食物來源之一。海稚蟲族羣密度在冬及春兩季有下降趨勢，推測與冬季低溫有關。