Proc. Arthropod. Embryol. Soc. Jpn. 52, 19–21 (2019)

ISSN 1341–1527

[SHORT COMMUNICATION]

Outline of the Life History and Postembryonic Development in a Pycnogonid, *Nymphopsis muscosa* (Pycnogonida, Ammotheidae) at Izu Oshima Island, Japan

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Pycnogonids, or sea spiders are a small group of marine arthropods usually classified in the class Pycnogonida. A recent comprehensive review of the developmental pathways of pycnogonids (Brenneis et al., 2017) disclosed that the accumulation of information on the life history and postembryonic development of pycnogonids was still incomplete.

Nymphopsis muscosa Loman, 1908 is an ammotheid pycnogonid recorded from Malaysia to Sagami Bay at 12 to 300 meters depth (Nakamura and Child, 1991), and more recently also from Papua New Guinea and Vanuatu [datasets from OBIS (Ocean Biogeographic Information System)]. In the present study, the authors outline the life history and postembryonic stages of *N. muscosa* based on semi-monthly collections and/or underwater observations.

Specimens at various postembryonic stages were collected and photographed by one of the authors (OH) during scuba activities from 20–30 m depth off Akinohama-Beach, Izu Oshima (Fig. 1). Sampling sites were about 100–150 m distant from the shore entry point. These sites were visited several days in every month from April 2017 to March 2018 except for November when the sites were temporarily covered by mud-like contamination. In total 112 specimens were collected by hand. Many specimens were photographed underwater by a Nikon D810 with a close-up lens, INON UCL-67 or Nauticam SMC-1. All specimens were found on the hydroids, *Dentitheca hertwigi* and *Plumularia* sp. (all months), or *D. habereri* covered by a zoanthid, *Parazoanthus gracilis* (from December to March).

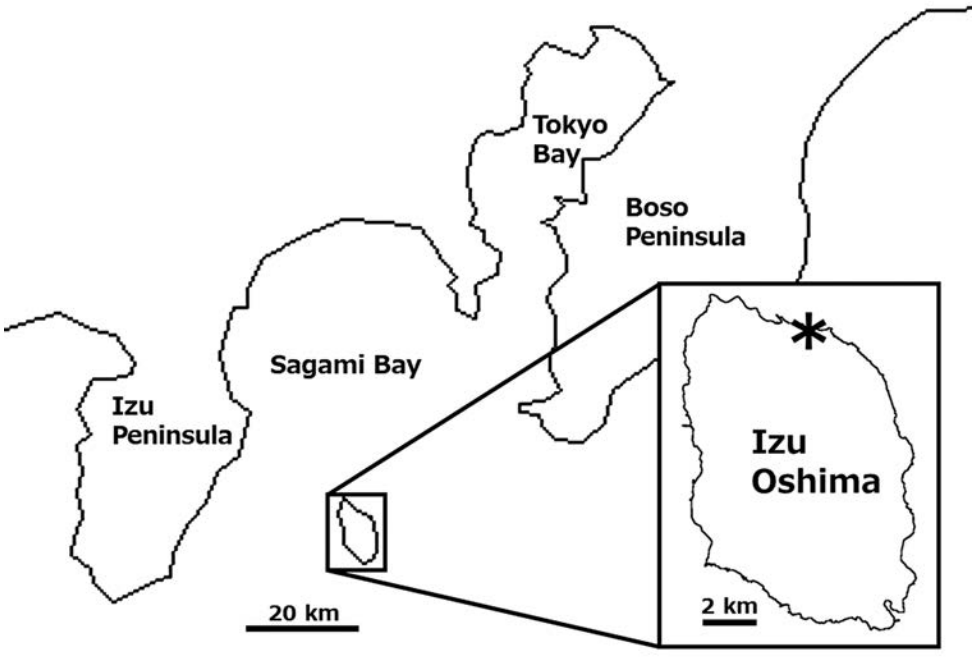

Fig. 1 Sampling locality of *Nymphopsis muscosa* specimens examined. Asterisk indicates the location of Akinohama-Beach.

Table 1 Appendicular article number and morphological features in each stage of *Nymphopsis muscosa*.

Stage	Appendages							Morphological features
	app1 (ch)	app2 (pa)	app3 (ov)	wl1	wl2	wl3	wl4	
A	3	la	la	–	–	–	–	la: in same size and proportion
B	3	la	–	–	–	–	–	
C	3	la	–	lb	–	–	–	
D	3	la	–	7	lb	–	–	wl1: femur and 1st tibia undivided; tarsus and propodus undivided
E	3	la	–	9	7	lb	–	wl2: same as wl1 of Stage D
F	3	3	–	9	9	7	lb	wl3: same as wl1 of Stage D
G	3	3	–	9	9	9	7	wl4: same as wl1 of Stage D
H	3	5	lt	9	9	9	9	wl length: 1=2=3>4
I	3	6	rs	9	9	9	9	wl length: 1=2=3=4, genital pores absent
Adult	3	9	10	9	9	9	9	genital pores present

app: appendage, ch: chelifore, la: larval appendage, lb: limb bud, lt: low tubercle, ov: oviger, pa: palp, rs: rod-shaped, wl: walking leg.

Specimens at various stages of postembryonic development were found clinging firmly to the hydroids by their chelifores and later also by walking legs following their appearance.

Collected specimens were observed under stereoscopic- or biological light microscope, and nine postembryonic stages (Stage A–I) were distinguished based on the article numbers of each appendage and other morphological features (Table 1). The size and the proportion of the "Stage A" specimens correspond closely to the previous figures by Loman (1908) and to SEM photographs by Nakamura (1987) of the hatching larvae (protonymphon larvae) of *N. muscosa*. Compared with the previous studies on the postembryonic development in other ammotheids (Morgan, 1891; Okuda, 1940; Gillespie and Bain, 2006; Mochizuki and Miyazaki, 2017), the incomplete number of palp articles and the still non-articled ovigers at "Stage I" suggest further one or more stages before reaching adult stage. The type of hatching larvae (protonymphon larvae), the pattern of walking leg development (sequential), and its mode of life (parasitic on hydroids) show that the mode of postembryonic development in *N. mucosa* corresponds to the "Type 1" of Brenneis et al. (2017). This type of development is widely reported not only in the Ammotheidae but also in the families Endeidae, Nymphonidae and the Pycnogonidae (Brenneis et al., 2017).

In *N. muscosa*, the newly developed walking legs are made up of seven articles in the Stages D to G (Table 1). The fourth article subsequently divides to form the femur and the first tibia, and the sixth article to form the tarsus and the propodus. The nine-articled leg is then complete. This progressive pattern of walking leg development is completely concordant with that shown in the genus *Tanystylum* (Morgan, 1891; Gillespie and Bain, 2006).

The various developmental stages were easily observed in close-up photographs. The monthly data provided a good outline of the life history of *N. muscosa* over a twelve-month period (Table 2). Three cycles from the earliest to the latest developmental stages are suggested a year in the Izu-Oshima population during the period (April to March). Significantly, no adult specimens were collected during the present study. There is no reported association between adult *N. muscosa* and hydroids (Loman, 1908, 1911; Stock, 1953, 1954; Utinomi, 1959; Nakamura, 1987), suggesting that specimens would leave their host hydroids prior to maturity and reproduce elsewhere. Adults may move unexpected distances far away, as the adult walking legs of *N. muscosa* are provided with numerous long spine-like projections, which would enhance their ability to rise into the water column utilizing a strong kicking action thereby to be carried by the tides while remaining suspended.

Table 2 *Nymphopsis muscosa* collected in each month.

Month	Stage									
	A	B	C	D	E	F	G	H	I	Adult
April 2017	2	11	11							
May							10	1		
June	11									
July			11	10	2		2			
August							1	4		
September							1	15	3	
October		☆								
November				No data (no dives).						
December			☆							
January 2018					☆	☆				
February					2	15				
March						☆	☆	☆		

☆: developmental stage identified by close-up photographs.

Acknowledgments: The authors thank Dr. Masakazu Aoki of Tohoku University for his providing an opportunity to start the present study. Thanks are also due to Dr. David A. Staples of Museum Victoria, Australia, for the English editing, Dr. Hiroshi Namikawa of National Museum of Nature and Science, Tokyo for the identification of host hydroids, and Dr. Yoshie Takahashi of Hokurei Junior and Senior High School for providing some literature.

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