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Naupiar Development of *Nitocra spinipes* Boeck, 1865 (Copepoda, Harpacticoida, Ameiridae) Reared in the Laboratory

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Abstract

The larvae of *Nitocra spinipes* Boeck, 1865 were reared at 20℃ and 33.3‰ in the laboratory.

These species passed through six nauplii stages and the first copepodid appeared in 8-10 days.

Nauplii of *N. spinipes* is distinguished by characteristics of the appendage setation and caudal setae. The number of segments of antennal and mandibular exopodites in harpacticoida is discussed within the familial level.

Key words – Copepoda, Harpacticoida, *Nitocra spinipes*, naupliar development

Introduction

Nitocra spinipes Boeck, 1865 occurs at the Tongbak Island in Pusan, the south coast of Korea.

Within the Ameiridae, the nauplius and copepodite development of *N. spinipes* were studied by Abraham & Gopalan [1]. But their descriptions are not enough to make a comparision. Thus the present study is to describe the external morphology of all naupliar stages of *N. spinipes* in detail. All the nauplii of *N. spinipes* are compared with the previously described harpacticid nauplii, in the respect of the morphology of the segment of antennal and mandibular exopodites in harpacticoida.

Materials and Methods

Ovigerous females were reared individually in petri dish (50 mm diameter×15 mm depth) containing with filtered seawater of 33.3‰ until hatching. Newly hatched larvae were separated into 5 groups of 10 larvae per petri dish (containing 25 ml filtered seawater) and kept at 20℃ in a culture chamber with a light regime of 14 : 10 hr L : D. Diatom, *Skeletonema costatum* was provided as food with daily.

Exuviae, dead larvae and some representatives for each larval stage were preserved in 5~7% neutral formalin.

A Nikon F XII light microscope was used for examination at magnification of 400X -1000X. Drawings were made with the aid of a camera lucida. Seta counts and measurements were based on 10 specimens for each larval stage.

Measurements of larvae and tabular presentation of appendage setations followed the format of Dahms [5].

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Results

First nauplius (Figs. 1, N1; 2, N1; 3, N1; 4, N1)

Red eye appearing as a round spot.

Body (Fig. 1, N1). Length 79.9 μm long, width 84.4 μm.

Caudal armature (Fig. 1, N1). With a pair of simple

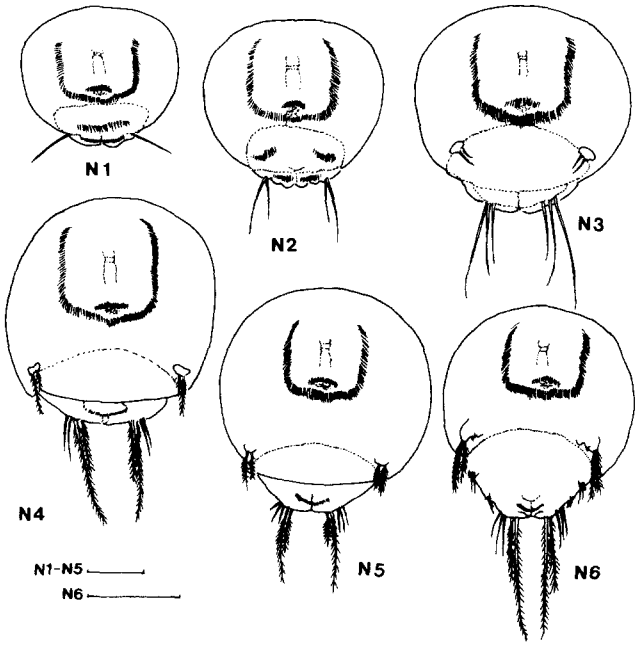

Fig. 1. *Nitocra spinipes.* Naupliar stages 1 to 6 in ventral view. Scale bars = 50 ㎛

setae. Ventrocaudal crest of spinules present between 2 caudal setae.

Labrum (Fig. 1, N1). With setules laterally and distally.

Antennule (Fig. 2, N1). Three-segmented: basal segment naked, second segment with 3 setae, third segment with 3 setae + 1 aesthetasc.

Antenna (Fig. 3, N1). Coxa with masticatory process with spinules on inner margin. Basis with 2 spinulose setae. Endopodite 2-segmented: basal segment with a simple seta on middle, second segment with a claw and tiny seta. Exopodite 3-segmented: basal segment with a spinulose seta, second segment with a seta, distal segment with 2 setae.

Mandible (Fig. 4, N1). Coxa with a spinulose seta. Basis with a spinulose seta and a simple seta. Endopodite with 3 claws and 3 genticulate setae on outer field. Exopodite 2-segmented: basal segment with 2 setae, second segment with 3 setae.

Second nauplius (Figs. 1, N2; 2, N2; 3, N2; 4, N2)

Body (Fig. 1, N2). Length 96.7 ㎛, width 97.7 ㎛.

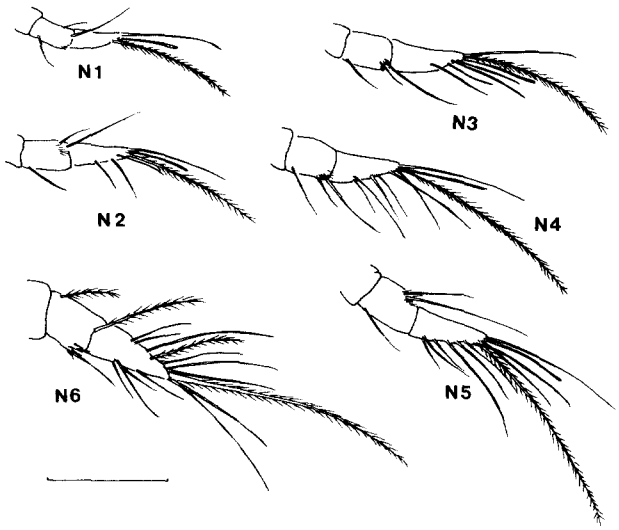

Fig. 2. *Nitocra spinipes.* Development of naupliar antennules. Scale bar = 50 ㎛

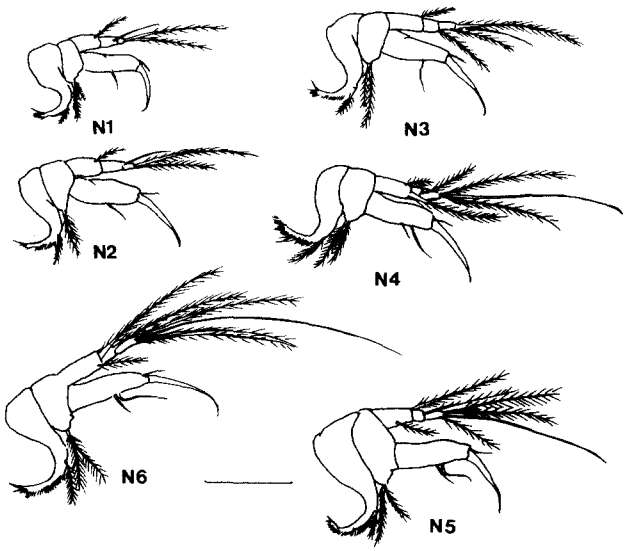

Fig. 3. *Nitocra spinipes.* Development of naupliar antennae. Scale bar = 50 ㎛

Caudal armature (Fig. 1, N2). With 2 spinulose setae on each side.

Antennule (Fig. 2, N2). Distal segment with 3 more setae.

Antenna (Fig. 3, N2). Masticatory process with a spinulose seta.

Mandible (Fig. 4, N2). Basis with 2 spinulose setae. Endopodite with a more geniculate seta.

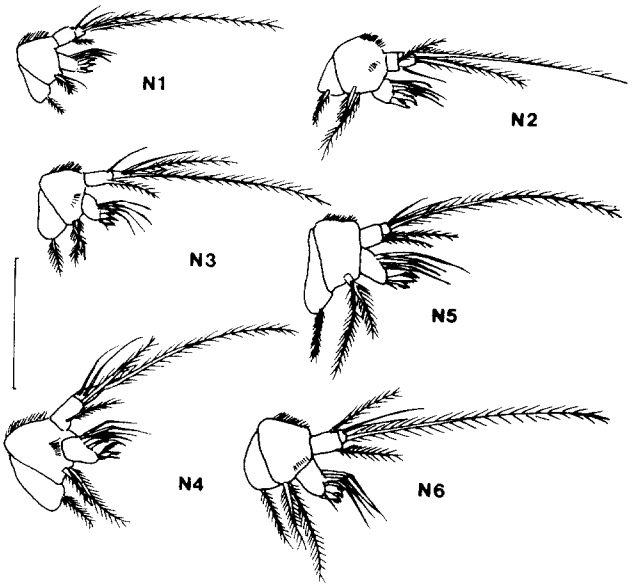

Fig. 4. *Nitocra spinipes*. Development of naupliar mandibles. Scale bar = 50 ㎛

Third nauplius (Figs. 1, N3; 2, N3; 3, N3; 4, N3)

Body (Fig. 1, N3). Length 117.9 ㎛, width 121.4 ㎛.

Caudal armature (Fig. 1, N3). With 3 setae on each side.

Maxillule (Fig. 1, N3). With 2 simple setae.

Antennule (Fig. 2, N3). Distal segment with a more seta.

Antenna (Fig. 3, N3). Exopodite with a more seta on distal segment.

Mandible (Fig. 4, N3). Endopodite with a more small seta.

Fourth nauplius (Figs. 1, N4; 2, N4; 3, N4; 4, N4)

Body (Fig. 1, N4). Length 131.5 ㎛, width 132.0 ㎛.

Caudal armature (Fig. 1, N4). With 2 inner spinulose setae and 2 outer simple setae on each side.

Maxillule (Fig. 1, N4). With 2 spinulose setae.

Antennule (Fig. 2, N4). Distal segment with 2 more setae.

Antenna (Fig. 3, N4). Endopodite with a more seta at middle of basal segment. Exopodite with a more seta on basal segment.

Fifth nauplius (Figs. 1, N5; 2, N5; 3, N5; 4, N5)

Body (Fig. 1, N5). Length 143.4 ㎛, width 137,8 ㎛.

Caudal armature (Fig. 1, N5). With 5 setae on each side.

Maxillule (Fig. 1, N5). With more setules.

Antennule (Fig. 2, N5). Distal segment with 2 more setae.

Antenna (Fig. 3, N5). Exopodite with a more seta on distal segment.

Sixth nauplius (Figs. 1, N6; 2, N6; 3, N6; 4, N6)

Body (Fig. 1, N6). Length 170.3 ㎛, width 141.1 ㎛.

Caudal armature (Fig. 1, N6). With 5 setae on each side.

Maxillule (Fig. 1, N6). As a bilobed, with a spine and 2 spinulose setae.

P1 (Fig. 1, N6). With 2 small setae on inner and a spine on outer lobe.

P2 (Fig. 1, N6). With 2 small setae on lobe.

Antennule (Fig. 2, N6). Distal segment with 3 more setae.

Mandible (Fig. 4, N6). Basis with spinules on surface.

Key to the nauplius stages of *Nitocra spinipes*

1. Caudal armature with 2 setae N1
- Caudal armature with more than 2 setae 2
2. Caudal armature with 4 setae;maxillule absent .. N2
- Caudal armature with 6-10 setae; maxillule present 3
3. Caudal armature with 6 setae N3
- Caudal armature with 8-10 setae 4
4. Caudal armature with 8 setae N4
- Caudal armature with 10 setae 5
5. Maxillule with 2 setae; P1 and P2 absent N5
-Maxillule with 4 setae; P1 and P2 with 2 setae ... N6

Discussion

The naupliar stages of *Nitocra spinipes* by Abraham & Gopalan and Dahms are compared with those of the present study [1,7]. The body length of our material is

Table 1. Nauplius development of *Nitocra spinipes* Boeck, 1865

	NI	NII	NIII	NIV	NV	NVI
A1 seg.	3	3	3	3	3	3
set.	0-3-3 (Ae)	0-3-6 (Ae)	0-3-7 (Ae)	0-3-9 (Ae)	0-3-11 (Ae)	0-3-14 (Ae)
A2 coxa	mast.proc.+1spls.	mast.proc.+1spls.	mast.proc.+1spls.	mast.proc.+1spls.	mast.proc.+1spls.	mast.proc.+1spls.
basis	2spls.	2spls.	2spls.	2spls.	2spls.	2spls.
enp						
med	1s.	1s.	1s.	2s.	2s.	2s.
term	1claw+1s.	1claw+1s.	1claw+1s.	1claw+1	1claw+1s.	1clow+1s.
exp						
seg.	3	3	3	3	3	3
set.	1-1-2	1-1-2	1-1-3	2-1-3	2-1-4	2-1-4
Md coxa	1spls.	1spls.	1spls.	1spls.	1spls.	1spls.
basis	1spls.+1s.	2spls.	2spls.	2spls.	2spls.	2spls.
enp						
proc.	3claw	3claw	3claw+1small s.	3claw+1small s.	3claw+1small	3claw+1small s.
outer field.	3 genic.	4 genic.	4 genic.	4 genic.	4 genic.	4 genic.
exp.						
seg.	2	2	2	2	2	2
set.	2-3	2-3	2-3	2-3	2-3	2-3
Mx 1			2s.in lobe	2spls.in lobe	2spls.in lobe	2s.+2spls. (bilobed)
P 1						2s.+1sp.
P 2						2s.
Hindbody	2	4	6	8 (2spls.)	10 (1spls.)	10 (2spls.)

A1, antennule; A2, antenna; Md,mandible; Mx1, maxillule; Mx2, maxilla; P1 and 2, legs one and two; seg, segment; set., setation; enp, endopodite; exp, exopodite; sp, spine; s., Seta; spls., spinules; med, medium

larger than that of Abraham & Gopalan's [1]. The maxillule appears in the nauplius IV stage in the present study, whereas it appears from the nauplius V stage according to Abraham and Gopalan. Legs 1 and 2 have 2 setae, whereas legs 1 and 2 have 4 and 3 setae, respectively, in the Dahms's description [7].

In the Table 2, the number of segments of antennal and mandibular exopodites in Harpacticoida is compared. In swimming mode, Tisbidae bears a 4-segmented antennal exopodites, whereas 2 or 3-segmented mandibular exopodite. In creeping mode, Harpacticoidae and Ameiridae bear 2 or 3-segmented antennal exopodite, whereas 1 or 2-segmented mandibular exopodite. Consequently, the creeping mode of locomotion is directly correlated with a trend to join the antennal and mandibular exopodites. The swimming mode of locomotion is related to the multi-segmented exopodite of antenna and mandible, which must have been developed secondarily. Whereas Ameiridae, *N. spinipes* has 3-segmented antennal and 2-segmented mandibular exopodite nauplii is belong to intermediated mode of locomotion.

This study indicated that some characters of developmental stages could give valuable insights into the relationships at various familial levels. Detailed descriptions of larval stages are needed to certify the phylogenetic relationships within Harpacticoida.

Table 2. Comparision of the segmental number of antennal and mandiblular exopodite in Harpacticoida nauplii.

	segment of antennal exopodite	segment of mandibular exopodite
AMEIRIDAE		
Nitocra spinipes[1]	3	2
N. spinipes (present study)	3	2
HARPACTICIDAE		
Harpacticus nipponicus[3]	2	1
H. littoralis[2]	3	1
H. uniremis[7]	3	1
Zaus unisetosus[4]	2	1
Z. spinatus[7]	2	1
TISBIDAE		
Tisbe holothuriae[9]	4	3
T. cucumariae[8]	4	2
T. gracilis[6]	4	3

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초록 : 요각류, *Nitocra spinipes* Boeck, 1865의 노우플리우스 유생 발생

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실험실에서 부화한 *Nitocra spinipes* Boeck, 1865 의 유생을 수온 20℃, 염분 농도 33.3‰에서 사육하고 그 유생발생단계를 자세히 기술 및 도시 하였다. 본 종은 6개의 nauplius 유생기를 가지며, 부화후 8-10일 후에 copepodid 1기가 되었다.

이 종의 각 유생기는 제1작은 턱다리, 가슴다리의 발달시기, 그리고 caudal setae의 수 등의 특징에 따라 구별되었다. 또한 이미 연구된 Harpacticoida 내의 유생의 제 2, 3촉각의 외지의 체절을 비교하여 과 수준에서의 특징을 밝혔다.