

# OBSERVATIONS OF EARLY DEVELOPMENTS OF THE ANTARCTIC KRILL, *Euphausia superba* DANA

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**Abstract:** During two cruises of R. V. KAIYO MARU for Antarctic expeditions, raising experiments of the Antarctic krill, *Euphausia superba* DANA, were conducted in order to observe its early developments. The krill were collected in the Indian sector of the Antarctic Ocean by a 0–36 m oblique tow using the KOC-A net on January 24, 1980 and by a 0–103 m oblique tow using the KYMT net on January 22, 1981. Water temperature was kept at  $+0.4^{\circ}\text{C}$  throughout the 1980 experiments, and about  $0.0\sim-1.0^{\circ}\text{C}$  in 1981. The post-hatching developments toward the metanauplius stage were observed in 1980 while the cleavages of two- to 64-cell stages were observed in 1981. In 1980 only the starting time of each stage from nauplius I to metanauplius was obtained because each time range could not be examined. It took about 9.3–10.3 hours for the released eggs to start cleavage, seven days for hatching and 25 days to reach the metanauplius stage. Metanauplius was the most developed stage obtained in this study since all larvae died at this stage. The developmental rate of the eggs and larvae observed in this study was relatively slower, being about 4–9 hours for the two-cell stage, about 4 days for hatching and about 15 days for the metanauplius stage, than that found by McWHINNIE and DENYS (Antarct. J. U. S., **13**, 133, 1978).

## 1. Introduction

The general characteristics of the reproductive biology in several euphausiid species have been described mainly on the basis of the analysis of population structures (*e.g.*, RUUD, 1932; BARGMANN, 1937, 1945). Embryological studies using the rearing technique, however, have been very few (TAUBE, 1909, 1915; PONOMAREVA, 1969; GOPALAKRISHNAN, 1973; LE ROUX, 1973, 1974; McWHINNIE and DENYS, 1978), and the developmental processes of euphausiid, especially of earlier stages, are known only in a few species (*e.g.*, GOPALAKRISHNAN (1973) on *Nematoscelis difficilis*, LE ROUX (1973) on *Nyctiphanes couchii* and LE ROUX (1974) on *Meganyctiphanes norvegica*). In *E. superba* the early developments were observed by McWHINNIE and DENYS (1978). Raising matured *E. superba* at Palmer Station in 1977/78, they found the rate of developmental advance after spawning to the metanauplius stage. However, the developments of this species, with detailed morphological illustrations of each stage, have been recorded rather poorly. The present author had an opportunity to keep *E. superba* alive during two Antarctic-bound cruises of R. V. KAIYO MARU of the Fisheries Agency in 1979/80 and 1980/81, and krill eggs were successfully raised on board the ship. This paper describes morphological changes of *E. superba*

through its earlier developments from the start of cleavage to the metanauplius stage.

## 2. Materials and Methods

The raising experiments on *E. superba* aboard R. V. KAIYO MARU for Antarctic expeditions were conducted twice; the first was from January 24 to February 25 in 1980 and the second was from January 22 to 29 in 1981. The krill in the 1979/80 season were collected by a 0–36 m oblique tow using the KOC-A net (The KAIYO MARU Opening and Closing Acoustic, mesh aperture 5.6 mm, frame size  $3 \times 3$  m, length from frame to cod end 16 m) at  $64^{\circ}45.5' \text{ S}$ ,  $114^{\circ}04.0' \text{ E}$  on January 24, and the latter case was by a 0–103 m oblique tow using the KYMT net (The KAIYO MARU Midwater trawl, mesh aperture 3.4 mm, frame size  $3 \times 3$  m, length from frame to cod end 16 m) at  $64^{\circ}00.0' \text{ S}$ ,  $39^{\circ}59.4' \text{ E}$  on January 22, 1981.

Immediately after the sampling, several tens of sexually matured females were sorted out and were kept in a plastic container ( $40 \times 50 \times 30$  cm) filled with 30 l of surface sea water. In order to acclimatize the krill under an artificial condition on the ship, the container was placed in a chilled fish hold under total darkness. The water temperature during the experiments was kept at about  $+0.4^{\circ}\text{C}$  in the 1980 experiments and  $0.0^{\circ} \sim -1.0^{\circ}\text{C}$  in 1981. In order to make the female spawn, each of the matured females acclimatized was transferred into smaller vessels with the capacity of 0.2–3.0 l in the cruise of 1980, but in 1981 only 3.0 l vessels were used. The fish hold where these vessels were kept throughout experiments was illuminated for 2–3 hours once or twice a day for the observations. Throughout the rearing, the rearing water was changed at intervals of one or two days, using surface sea water, and the krill was fed on phytoplankton obtained by towing a net of 0.99 mm mesh apertures. Krill spawned three to eight days after the sampling. Average number of eggs laid by six krill in 1980 and by 20 krill in 1981 was 1309 and 1526, respectively. After the spawning, the released eggs were transferred into other vessels, and the raising was continued to observe subsequent developments. Several eggs and larvae laid by one female were picked up randomly from every vessel and were used for the observations under the microscope. The diameter of ten eggs and the body length of ten larvae in each stage were measured and the average value was obtained. After the microscopic observations some eggs and larvae were fixed by formalin. The cleavages after the egg release to the early gastrula stage were observed in 1981, and the developments from the hatching to the metanauplius stage were observed in 1980. The photographs taken in the 1980 experiments were based on the formalin-fixed materials, but in 1981 the photographs were taken while the eggs or animals were alive.

## 3. Results and Discussion

### 3.1. Cleavage and developments of egg

The spawned egg began to develop toward the first cleavage after 9.3–10.3 hours, and continued developments quite normally up to the metanauplius stage. The

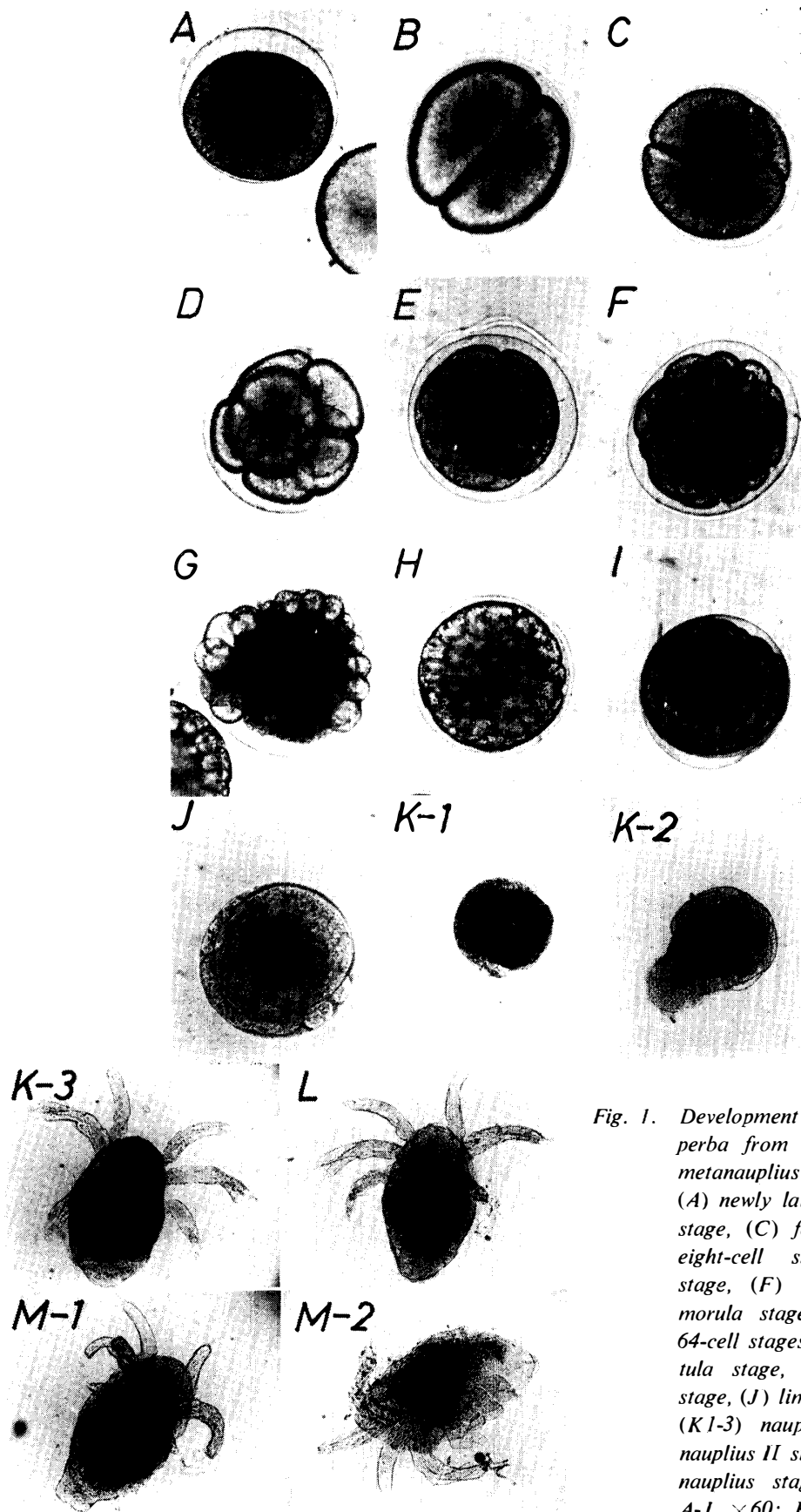


Fig. 1. Development of *Euphausia superba* from newly laid egg to metanauplius stage.

(A) newly laid egg, (B) two-cell stage, (C) four-cell stage, (D) eight-cell stage, (E) 16-cell stage, (F) 28-cell stage, (G) morula stage (including 32 to 64-cell stages), (H) early blastula stage, (I) early gastrula stage, (J) limb primordia stage, (K1-3) nauplius I stage, (L) nauplius II stage, (M1-2) metanauplius stage. Magnification: A-J,  $\times 60$ ; K1-M2,  $\times 40$ .

following thirteen stages of developments were observed and pictured as shown in Figs. 1A–1M along with the morphological notes. The developmental stages from nauplius I to metanauplius are after the definition by FRASER (1936). The morphological characteristics after the nauplius I stage observed in the rearing experiments are in accord with the description by FRASER (1936). The cleavage of eggs proceeded with considerable uniformity, and there were no notable changes in egg size during the first ten cleavage stages.

1) Newly laid egg: The fertilized egg was about 0.52 mm in diameter. The fertilization membrane, the perivitelline space, the cytoplasmic membrane and the cytoplasm are clearly visible. (Fig. 1A)

2) Two-cell stage: 9.3–10.3 hours old egg. (Fig. 1B)

3) Four-cell stage: 13.5–14.5 hours old egg. (Fig. 1C)

4) Eight-cell stage: 18.3–19.3 hours old egg. (Fig. 1D)

5) 16-cell stage: 26.9–30 hours old egg. (Fig. 1E)

6) 28-cell stage: 32–33 hours old egg. (Fig. 1F)

7) Morula stage: 36–37 hours old egg including 32 to 64-cell stages. (Fig. 1G)

8) Early blastula stage: 45–54 hours old egg. (Fig. 1H)

9) Early gastrula stage: 64–67 hours old egg. (Fig. 1I)

10) Limb primordia stage: Five days old egg. The embryo begins to rotate and forms a pair of the first and the second antennae. (Fig. 1J)

11–1~3) Nauplius I stage: 858 of 1688 eggs hatched out. Seven days old larva (B.L. 0.62 mm), showing formation of the first and the second antennae and mandibular legs. (Fig. 1K-3). Figs. 1K-1 and 1K-2 show slightly earlier stages in hatching. The breakage of egg membrane.

12) Nauplius II stage: 21 days old larva (B.L. 0.90 mm), showing a pair of the second antennae and biramous mandibular legs. Formation of bristles at the posterior edge of the body is clearly visible. The number of individuals at this

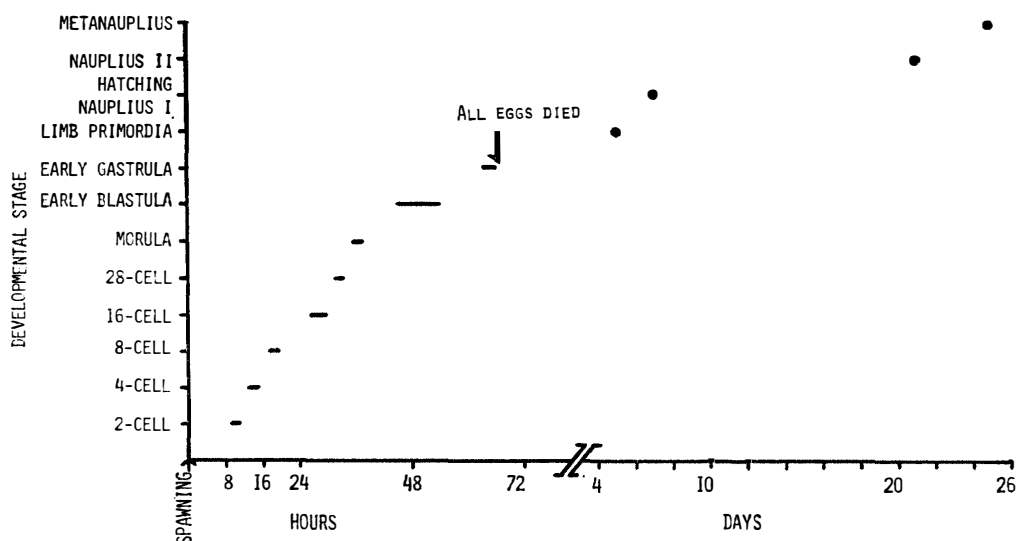


Fig. 2. Developmental advance of *Euphausia superba* from egg to metanauplius stage.

stage was not counted. (Fig. 1L)

13-1~2) Metanauplius stage: 25 days old larva (B.L. 0.90 mm). The segmentation of the second antennae, the reduction of second maxillae, the projection of abdomen from carapace with several spines at the terminal of telson. (Figs. 1M-1 and 1M-2). Only 25 nauplii developed to this stage (KIKUNO, 1981).

### 3.2. Rate of developmental advance

The rate of developmental advance was estimated on the basis of the passage of each developmental stage (Fig. 2). The developmental rate of the eggs and larvae obtained in this study was relatively slower, being about 4-9 hours for the two-cell stage, about 4 days for hatching and about 15 days for the metanauplius stage, than that found by McWHINNIE and DENYS (1978). Since McWHINNIE and DENYS (1978) did not mention the water temperature in the raising experiments, it is uncertain whether the difference in the developmental rates has resulted from different experimental conditions.

### Acknowledgments

The author would like to express his appreciation to Dr. A. KAWAMURA of Hokkaido University for giving advice and criticism in preparing the manuscript. Thanks are due to chief investigators, Drs. K. NASU and Y. KOMAKI of the Far Seas Fisheries Research Laboratory for their encouragement throughout Pre-FIBEX and FIBEX expeditions. Dr. S. SAWAMOTO of Tokai University and Mr. J. SUGAI of Tokyo University of Fisheries helped him with the laboratory work during the cruises. He is also indebted to the officers and the crew of R. V. KAIYO MARU for their co-operation.

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(Received March 31, 1982; Revised manuscript received April 30, 1982)