On the Pelagic Eggs of Copepoda*

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Abstract: There are two types in the pelagic eggs of copepods. One is spherical in shape but is wanting in floating devices. This type of egg is common in pelagic eggs. A typical example is seen in the eggs of *Calanus*, with the exception of the eggs of *Calanus hyperboreus* and *Undinula vulgaris*. The other type of pelagic eggs is provided with floating devices as are observed in the eggs of *Eucalanus*, *Centropages* and *Tortanus*. Copepods which lay the eggs with floating devices are more evolutive those without such the devices.

1. Introduction

In general copepods do not lay eggs freely but carry their eggs in the sac or in the egg string attached to the genital segment of the abdomen. In *Mycophilus*, a notodelphoid copepod parasitic within ascidians, the eggs are deposited separately. However, some copepods deliver pelagic eggs freely. Most of calanoid copepods have this character, but these pelagic eggs have been seldom observed in natural conditions.

The developments of eggs of copepods have been demonstrated by the following authors: GROBBEN (1881) first described the post-embryonal development of egg and the changes occurring internally up to the early copepodite stage of *Calanus finmarchicus*. He gives the size of the egg as 0.17 mm in diameter. The egg of *Centropages hamatus* was described by OBERG (1906), that of *Calanus hyperboreus* by SØMME (1934), that of *Tortanus discaudatus* by JOHNSON (1934), those of *Calanus finmarchicus* etc. by MARSHALL and ORR (1955), and that of *Centropages abdominalis* by KOGA (1960).

The material dealt within this paper was obtained by servation of oviparous females by myself or by citing the examples described by previous authors.

2. Description of the pelagic eggs

The pelagic eggs of copepods are divided into two groups: (1) eggs without floating de-

vices and (2) eggs with floating devices.

(1). The eggs of the following species belong to the first group.

Calanus finmarchicus (GUNNERUS)

Plate I, Fig. 1.

Calanus helgolandicus (CLAUS)

Plate I, Fig. 3.

According to MARSHALL and ORR (1955), *Calanus* usually lay down about 200–300 eggs. In a few minutes after laying the eggs separate singly and round off. The eggs retain a faint pinkish colour for some hours. The egg of *Calanus finmarchicus* resembles that of *Calanus helgolandicus*, and measures about 0.16 mm in diameter, which is smaller in size than that of *helgolandicus*. SØMME (1934) gives the egg-size of *Calanus finmarchicus* as 0.15 mm to 0.16 mm, but GROBBEN (1881) gives the size as 0.17 mm. Thus there is no appreciable difference in eggs between *Calanus finmarchicus* and *C. helgolandicus*, but according to MARSHALL, ORR and REES (1953) it has also been shown that the eggs of *helgolandicus* are bigger (av. 0.172 mm, 0.165–0.18 mm in diam.) than those of *finmarchicus* (av. 0.145 mm, 0.135–0.155 mm in diam.).

MARSHALL, ORR and REES (1953) found a species intermediate between *C. finmarchicus* and *C. helgolandicus* at Tromsø Sound in the spring of 1952. The species differs from either of them in the shape of coxa on the fifth pair of feet. The egg of this species has a variable space between the inner and outer membranes which appears shortly after the egg is laid. With the membranes the diameter of the egg may reach 0.195 mm as against 0.172 for that

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of *C. helgolandicus* (Plate I, Fig. 2).

Calanus hyperboreus (KRØYER)

Plate I, Fig. 4.

According to SØMME (1934), the number of eggs varies greatly. In some specimens they have 65 eggs, in others 180 and in certain cases they have more than 400 eggs. The egg is surrounded by a thin egg membrane like that of *C. finmarchicus*. For some hours after laying in groups the eggs fall away each other. The eggs in the oviducts are markedly orange coloured, and also retain this colour after spawning. Unlike the eggs of *C. finmarchicus* the eggs show a marked variation in diameter. SØMME (1934) gives the size of fresh eggs as 0.21 to 0.34 mm in the longest diameter, as 0.20 to 0.29 mm in the shortest diameter.

Undinula vulgaris (DANA)

Plate I, Fig. 5.

Unlike the egg of *Calanus finmarchicus* which is pinkish, and the egg of *Calanus hyperboreus* which is orange in colour, the egg of this species is colourless. The egg is covered by a gelatinous case which is semi-permeable in nature. The embryo of egg resembles that of *Calanus finmarchicus*. The egg is sphere-shaped, about 0.16 mm in diameter.

Temora discaudata GIESBRECHT

Plate I, Fig. 6.

The egg of *Temora discaudata* is translucent, sphere-shaped and about 0.065 mm in diameter.

Labidocera acuta (DANA)

Plate I, Fig. 7.

The egg of *Labidocera acuta* is sphere-shaped, about 0.1 mm in diameter, and black in colour.

Pontellopsis yamadae MORI

Plate I, Fig. 8.

The egg of *Pontellopsis yamadae* is sphere-shaped, about 0.135 mm in diameter, colourless and translucent.

(2). The eggs of the following species belong to the second group with floating devices.

Eucalanus elongatus (DANA)

Plate I, Figs. 9, 10.

The egg of *Eucalanus elongatus* is contained in a transparent case specially adapted for floating. The case is filled with a gelatinous substance and is translucent, sphere-shaped and

about 1.5 mm in diameter. The egg in the case is sphere-shaped and is about 0.24 mm in diameter.

Eucalanus crassus GIESBRECHT

Plate I, Figs. 11, 12.

The egg of *Eucalanus crassus* resembles that of *Eucalanus elongatus*, but the case is smaller and oval.

Centropages abdominalis SATO

Plate I, Fig. 15.

KOGA (1960) described the egg of *Centropages abdominalis*. It is sphere-shaped, about 0.075 mm in diameter. The egg has a number of spines on the surface, which keeps the egg drifting in the water. The length of spines is 0.02 mm to 0.04 mm and the spines are sometimes separated into small spines on the distal end. The egg is translucent and light green in colour.

Centropages yamadae MORI

Plate I, Fig. 14.

The egg of *Centropages yamadae* is sphere-shaped, about 0.067 mm in diameter; it is provided with numerous spines on the surface like that of *Centropages abdominalis*, but the length of spines is smaller than those of *C. abdominalis*; they measured about 0.01 mm in length.

Centropages hamatus (LILLJEBORG)

Plate I, Fig. 13.

According to OBERG (1906), the egg of *Centropages hamatus* has the small spinous cyst which looks like verrucae. The egg is about 0.075 mm in diameter.

Centropages furcatus (DANA)

Plate I, Fig. 16.

The egg of *Centropages furcatus* is kept within a strong thick spinous cyst which is translucent, and sphere-shaped. The egg proper is about 0.08 mm in diameter. The egg has a space between the embryo and the cyst. The spinous cyst is transparent, about 0.1 mm in diameter. The processes on the surface of cyst measure about 0.06 mm in length, split at the terminal end, and are less in number than those of *Centropages yamadae* and *Centropages abdominalis*.

Tortanus discaudatus (J. C. THOMPSON
and A. SCOTT)

Plate I, Figs. 17, 18.

According to JOHNSON (1934), the egg of *Tortanus discaudatus* is 0.11 mm in diameter,

In contrast to the old egg which is kept in a floating case, a newly laid egg is spherical in shape and has no drifting device. This disc-like case is formed some time after spawning. The first indication of its development is seen in the appearance of a number of small blister-like structures covering the egg's surface. The egg is contained in the flat disc surrounding the equator of a egg. The disc is 0.08 mm in depth, and 0.27 mm in diameter. The egg is granulous and is opaque due to the large amount of deuteroplasm; the case is semi-transparent and has very fine reticulations on the disc. One side of the case is provided with a fissure.

3. Key to the pelagic eggs of copepods

I. The egg without the special floating devices.

- 1a. The egg without the blister-like case.
 1. The spherical egg is about 0.145 mm (0.135–0.155 mm) in diameter.
.....*Calanus finmarchicus*.
 2. The spherical egg is about 0.172 mm (0.165–0.18 mm) in diameter.
.....*Calanus helgolandicus*.
 3. The oval egg is 0.21 to 0.34 mm in the longest diameter; as 0.20 to 0.29 mm in the shortest diameter.
.....*Calanus hyperboreus*.
 4. The spherical egg is about 0.065 mm in diameter.*Temora discaudata*.
 5. The spherical egg is about 0.1 mm in diameter, and black in colour.
.....*Labidocera acuta*.
 6. The spherical egg is about 0.135 mm in diameter, colourless and translucent.*Pontellopsis yamadae*.
- 2a. The egg with the small blister-like case.
 1. The spherical egg is about 0.16 mm in diameter.*Undinula vulgaris*.
 2. The diameter of spherical egg including the membrane reaches about 0.195 mm.*Calanus finmarchicus*: Tromsø form.

II. The egg with the special floating devices.

- 1a. The egg with the transparent case

filled with colloidal substances.

.....*Eucalanus elongatus*, *E. crassus*.

2a. The egg with the spinous cyst on the surface.

1. The egg is about 0.075 mm in diameter. The spine of cyst is 0.02 to 0.04 mm in length.*Centropages abdominalis*.
2. The egg is about 0.067 mm in diameter. The spine of cyst is 0.01 mm in length.*Centropages yamadae*.
3. The egg is about 0.075 mm in diameter. The egg has the small spinous cyst with verrucae.
.....*Centropages hamatus*.
4. The egg proper is about 0.08 mm in diameter. The strong thick processes on the surface of cyst split at the terminal end and are less in number than those of *Centropages yamadae* and *Centropages abdominalis*.
.....*Centropages furcatus*.
- 3a. The egg is contained in the case with flat disc surrounding equator of a egg. The egg proper is about 0.11 mm in diameter.*Tortanus discaudatus*.

4. Discussion

Crustaceans are divided into two groups according to the behaviour after spawning: Namely, the first group is characterized by the protective activity to their eggs. The animals belonging to this group take care of the eggs in the sac attached to or near the genital pore. On the other hand, the second group does not take care of their eggs but lays their eggs freely in the water. For that reason the second group appears to be more primitive than the first group which places the eggs under their protection.

Among Malacostraca most of Mysidacea, some of Isopoda and Amphipoda, and a greater part of Decapoda belong to the first group with some exceptions of Euphausiacea and shrimps. While most of Entomostraca belong to the second group, but copepods, an important member of Entomostraca, do not cast their eggs freely in the water, and carry their eggs in the thin-walled sacs suspended from the ge-

nital pore. There may be one sac, as is seen in many of Calanoida and Harpacticoida, or two sacs as in most of Cyclopoida. In Monstrilloidea, the female carries two egg filaments attached on the ventral side of the genital segment. In Caligidae the female carries an egg string attached to both sides of the genital segment. The adult female of the parasitic copepods which fixes herself to the host produces the egg strings of various kinds on or near the genital pore. In Notodelphidea, *Notodelphys* and *Dorophygus* possess the eggs contained within the brood pouch, and *Ertericola* possesses elongated egg strings. Some parasitic copepods, such as Choniostmatidae produce six or eight egg sacs.

Generally speaking copepods which lay their eggs in water freely are phylogenetically more primitive than those which carry the eggs in the sac attached to the genital segment. The eggs of Centropagidae which are provided with various spinous cyst show a quite good example of adaptation for drifting in the water. The egg of Eucalanidae is kept within the case containing colloidal substances which will afford a condition like that in the egg sac. Therefore, the egg of Eucalanidae is the most highly evolutive one among the copepods which lay their eggs freely in the water. On the other hand, most of the spherical eggs of Calanoida which

drift in the water without floating devices, such as the spinous cyst or the case, are the most primitive in advancement.

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References

- GROBBEN, C. (1881): Die Entwicklungsgeschichte von *Cetochilus septentrionalis* GOODSIR. Arb. Zool. Inst. Univ. Wien, **3**, 1-40.
- JOHNSON, M. W. (1934): The life history of the copepods *Tortanus discaudatus* (THOMSON and SCOTT). Biol. Bull., **67**, 182-200.
- KOGA, F. (1960): The nauplius larvae of *Centropages abdominalis* SATO. Bull. Jap. Soc. Scienc. Fish., **26** (9), 877-881.
- MARSHALL, S. M. and A. P. ORR (1955): The biology of a marine copepod. OLIVER & BOYD. London 188 pp.
- MARSHALL, S. M., A. P. ORR and C. B. REES (1953): *Calanus finmarchicus* and related forms. Nature Lond., **171** (4365), 1163-1164.
- OBERG, M. (1906): Die Metamorphose der Plankton-Copepoden der Kieler Bucht. Wiss. Meeresuntersuch. Abt. Kiel, **9**, 37-175.
- SØMME, J. (1934): Animal plankton of the Norwegian coast waters and the open sea. 1. Fishkeridir. Skr. Havundersøk., **4** (9), 1-163.

橈脚類の浮遊性卵について

古 賀 文 洋

要旨 橈脚類には他の甲殻類にみられるように産卵後、卵塊や卵囊を体の一部に付着させる種類と水中に浮遊性卵を産出するものがある。

本論では橈脚類の浮遊性卵について C. GROBBEN, J. SØMME, S. M. MARSHALL etc. によって記載された *Calanus* 類, M. OBERG による *Centropages*, M. W. JOHNSON による *Tortanus* の卵などに著者が観察した

数種類の卵を記載し考察を加えた。

浮遊性卵には特別な浮遊適応をしたものと、しないものがある。浮遊適応をしない卵で典型的なものは *Calanidae* の卵である。浮遊適応をした卵には膠質状のケースの中にある *Eucalanus*, 刺やいぼ状の突起を持つ *Centropages* や赤道面が平板状になったケースを持つ *Tortanus* の卵などがある。

Plate I. The eggs which the copepods did cast freely in the water.

1. <i>Calanus finmarchicus</i> .	9, 10. <i>Eucalanus clongatus</i> .
2. <i>Calanus finmarchicus</i> , Tromsø form.	11, 12. <i>Eucalanus crassus</i> .
3. <i>Calanus helgolandicus</i> .	13. <i>Centropages hamatus</i> .
4. <i>Calanus hyperboreus</i> .	14. <i>Centropages yamadai</i> .
5. <i>Undinula vulgaris</i> .	15. <i>Centropages abdominalis</i> .
6. <i>Temora discaudata</i> .	16. <i>Centropages furcatus</i> .
7. <i>Labidocera acuta</i> .	17, 18. <i>Tortanus discaudatus</i> (egg and case,
8. <i>Pontellopsis yamadai</i> .	viewed from above and side).