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Hatching Time of *Acartia clausi* (Copepoda) Eggs isolated from the Seawater in Maizuru Bay[1),2)]

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Abstract

Acartia clausi eggs isolated from the seawater in Maizuru Bay were incubated to determine the time required for hatching after being collected, and, for comparative purpose, the development time of the eggs newly spawned in the laboratory was determined under the same condition. The laboratory-spawned eggs hatched almost synchronously around 23 h after spawning. In contrast, the hatching time required for the seawater-isolated eggs after sampling greatly varied; some of them hatched in a few hours after sampling. Two series of the incubations of the seawater-isolated eggs showed that cumulative numbers of the hatched nauplii increased almost linearly with time after sampling, indicating that the sampled eggs consisted of various developmental stages in similar proportions. In Maizuru Bay, it can not always be assumed that most eggs spawned in the water sink to the bottom before hatching.

Acartia clausi is one of the calanoid copepods, the biology of which has been relatively well known both in field and laboratory. This species spawns eggs freely in the water. However, since the eggs are slightly denser than the seawater, it has been assumed that, in a shallow water, most of them sink to the bottom before hatching unless strong upwelling occurs (LANDRY 1978, UYE 1980).

In Maizuru Bay, the Japan Sea coast of the mainland Japan, *A. clausi* occurs abundantly from winter to early summer (UEDA 1978) and its floating eggs in the water column are also abundant in the reproductive season. In the present work, to test the above assumption, the time required to hatch for the eggs collected from the seawater in the bay was determined and compared with that for the eggs newly spawned in the laboratory.

Materials and Methods

Experiments on hatching time of seawater-isolated eggs were made repeatedly on 31 May and 1 June, 1978. At 1100 hours of the former day, 10-liter seawater was sampled with a Van Dorn water sampler from a 5 m deep layer at a station in Maizuru Bay, 13 m deep off the Fisheries Research Station, Kyoto University. Immediately after sampling, the seawater was filtered with a 132 μm mesh cloth to remove adult females of *Acartia clausi*, and eggs (ca. 75 μm in diam.) contained in the filtrate were collected into a bottle by filtering with a 46 μm mesh cloth. After immediate transport to the laboratory, 28 eggs were isolated with a pipette and placed into nine watch glasses containing the seawater filtered with a 46 μm mesh cloth;

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[2)] 舞鶴湾の海水より採取した *Acartia clausi* (橈脚類) 卵の孵化時間

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each glass contained three or four eggs. Then they were incubated at 20°C, nearly equivalent to the temperature of the surface water at the sampling station. Illumination was continuous but its intensity was not controlled specially. The numbers of hatched nauplii and unhatched eggs were counted under a dissecting microscope at 4.5, 7, 10.5 and 21.5 h after sampling.

The experiment started on 1 June was made largely by the same procedure as on the previous day, but two samples of seawater were taken at 1000 and 1100 hours from a 4 m deep layer at the floating pier of the Station. This sampling station is about 6 m deep and 21 m offshore. The numbers of the eggs isolated from these water samples were 15 and 21, respectively. They were incubated separately in groups of three eggs in a total of 12 watch glasses. Hatching to nauplii was monitored at 1–3 h intervals until 36 h after sampling for the eggs collected at 1000 hours and 35 h for those collected at 1100 hours.

At night on 1 June, 1978, in order to obtain the newly spawned eggs, a number of *A. clausi* females were collected with a bucket, using an underwater fish lamp, at the floating pier. They were then kept in a 2-liter beaker for a period of 1 h from 2030 to 2130 hours, and were removed by filtering with a 132 μm mesh cloth. Twelve eggs were pipetted from the filtrate into four watch glasses in groups of three eggs and incubated under the same condition as that of the experiments above. Hatching was monitored at 1–6 h intervals untill 40 h after spawning; herein, the time of spawning is designated as the median time (2100 hrs.) of the 1 h spawning period of females.

Results

In the experiment started on 31 May, one eggs had already hatched at the first observation of 4.5 h after sampling (Fig. 1), and then the cumulative number of hatched nauplii increased linearly with time until the final observation of 21.5 h. At the final observation, about 90% of the initial eggs had hatched to nauplii.

The experiment on hatching of the seawater-isolated eggs collected on 1 June showed that the first hatching of the eggs occurred between 1 and 2 h after sampling. Hatching to nauplii was observed until 21 h, at which 78% of the initial eggs had hatched, but no subsequent hatching was observed until the final observation. Some of these unhatched eggs at the final observation were apparently dead and coated with fungi, and the others were presumably not viable because their color was faded and differed from that of the eggs under the normal development. Although most hatchings of the eggs collected at 1000 hours were observed after 11 h, the hatchings of those collected at 1100 hours occurred more randomly in a period of 20 h following sampling and, in the latter case, the cumulative number of hatched nauplii increased more or less proportionally to time after sampling.

The eggs newly spawned in the laboratory did not hatch until 20 h after spawning except for one egg, which hatched between 5 h and 6 h. LANDRY (1975a) indicated that there was little individual variability in development time of *Acartia clausi* eggs and that the interval of hatching closely paralleled the interval of egg laying. If this is true in the present eggs, those spawned during a period of 1 h would hatch over a period of about 1 h. In this ex-

periment, because the wild eggs that were captured with the bucket together with females were considered to be much fewer than the eggs spawned by the females in the laboratory, I did not pay any care to prevent the contamination of these wild eggs into the experimental vessels. Therefore, the hatching occurred between 5 h and 6 h was presumably due to an accidental contamination of a wild egg.

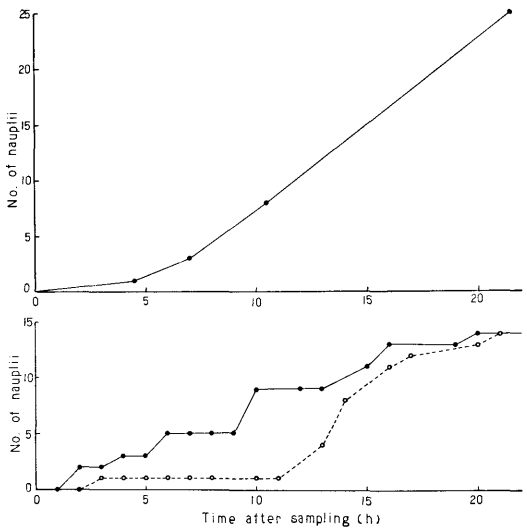

Fig. 1. Cumulative numbers of *Acartia clausi* nauplii hatched from the seawater-isolated eggs collected at 1000 hours of 31 May (top) and at 1000 (--○--) and 1100 (—•—) hours of 1 June (bottom) in Maizuru Bay in 1978.

Of the remaining 11 eggs, seven nauplii hatched before the subsequent observation of 26 h after spawning. Thereafter, no hatching occurred until the final observation of 40 h, at which all the unhatched eggs seemed to have been dead. Consequently, the development time after spawning to hatch at 20°C was roughly determined around 23 h (20–26 h). This is somewhat shorter than those (29.3–31.2 h) of *A. clausi* eggs at the same temperature obtained by LANDRY (1975b) but almost agrees with that (19.9 h) obtained by UYE (1980); the latter author's value is obtained by calculating from the Bělehrádek equation, parameters of which were determined by him.

Discussion

Maizuru Bay is geographically divided into two parts, Eastern-bay and Western-bay. According to Maizuru Marine Observatory (1960), the tidal current at 2 m depth in the bay was generally less than 15 $cm \cdot s^{-1}$ and there was almost no current at 10 m depth in Eastern-bay, in which the sampling stations were located. There were not so windy conditions inducing turbulence of the water for several days before egg samplings. Thus, because of the stationary condition of the bottom water in Eastern-bay, it is likely that the eggs settled on the bottom were

not resuspended into the water column. It is also likely that they were not resuspended by the water turbulence induced by the descending sampler, because the sampler was kept far from the bottom. Therefore, it is safe to consider that the seawater-isolated eggs used in the experiments did not contain those resuspended from the bottom.

LANDRY (1978) noted that *Acartia clausi* eggs sank approximately 3 $m \cdot h^{-1}$ in the laboratory experiment. UYE (1980) stated that the sinking rate of the eggs in still water at 18°C was 1.28 $m \cdot h^{-1}$. The former author considered that most eggs would have to hatch from the sediment because the water he studied was shallow and the duration of the egg stage greater than one day. If eggs sank at these rates throughout the water column in Maizuru Bay, those collected from a 4 m deep layer on 1 June would be younger than 3 h old and, considering that the development time from spawning to hatching is around 23 h, they would not hatch until about 20 h after sampling. However, in contrast with the synchronous hatching of the eggs spawned in the laboratory, the experiments on hatching of the seawater-isolated eggs revealed wide variations in their hatching time after sampling; some of them hatched only in a few hours after sampling. This apparently indicates that *A. clausi* eggs in the bay do not necessarily sink at the same rate as those obtained in still water in laboratory, and that some eggs hatch to nauplii while floating. In fact, in the 10-liter seawater sampled on 31 May, 35 hatched eggs (cast testae) of *A. clausi* were observed together with 55 unhatched ones. This observation lends further evidence of the hatching of floating eggs in the bay.

Because, as mentioned above, it is hard to think that settled eggs on the bottom were resuspended into the water in Eastern-bay, the short hatching time of the seawater-isolated eggs suggests long floating time after spawning in nature. If there are only slight water movements as found in Maizuru Bay, some eggs may be able to keep floating until hatching even in a shallow water. Although this does not necessarily deny that some eggs sink to the bottom before hatching, we observed in the present experiments the linear increase of the cumulative numbers of hatched nauplii during incubations, which were indicating that the seawater-isolated eggs consisted of various stages in similar proportions. Therefore, at least in Maizuru Bay, the eggs that keep floating until hatching is not so few as compared with those sinking to the bottom before hatching.

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