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Hatching mechanism and delayed hatching of the eggs of three broadcast spawning euphasiid species under laboratory conditions

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Three different egg hatching mechanisms were observed under laboratory conditions in *Euphausia pacifica* Hansen, *Thysanoessa spinifera* Holmes and *Thysanoessa inspinata* Nemoto: backward, forward and flipping. In all broadcast spawning euphasiids, the species usually hatch as nauplius with the same orientation before the embryo takes on a slightly oval shape. When ready to hatch, the N1 pushes against the chorion with the posterior part of the abdomen producing a protuberance. No spine or egg tooth is present to break the chorion. The pressure breaks the chorion, and the nauplius pushes itself backwards with the first and second antennae and mandible to slide from the chorion. After about three quarters of the body is outside, the nauplius brings all the appendages together to move backward without touching the egg after the hatching. This is the backward hatching mechanism. Hatching takes 5–20 s, and most of the eggs in a clutch hatch during <2 h. Several eggs of *E. pacifica* hatched as meta-nauplii (MN) (>200 h after spawning) or as calyptopis 1 (C1) stage (>232 h), rather than as N1. Delayed hatching of embryos also was observed in *T. spinifera* as nauplius 2 (N2) (>120 h) or as MN stage (>180 h), and in *T. inspinata* as N2 (106 h) after spawning. Eggs with larvae in stages of development beyond N1 have not been observed from preserved zooplankton samples. However, eggs spawned in the field and incubated in the laboratory also had extended development and late hatching but with low frequency (<0.06%). It is proposed that, if the backward hatching mechanism fails, alternate hatching mechanisms can be used by the euphasiid. There is high flexibility in their hatching modes. The N2 and MN break the chorion by flipping of the abdomen, searching the chorion for hatching and then C1 hatching uses the forward and flipping mechanisms. Delayed hatching was associated with low hatching success in comparison with the backward hatching mechanism.

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