Massive mortality of euphausiids caused by lethal endoparasitic apostomatic ciliates

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ABSTRACT: During June 2001 a deployment of a ROV video-system in the bottom off Astoria Canyon, Oregon USA recorded thousands of carcasses of the euphausiid *Euphausia pacifica* laying on the seafloor. This massive mortality event was caused by the highly virulent endoparasitic apostomatid ciliate *Collinia beringensis* Capriulo and Small. This is the first large-scale epidemic infestation reported in euphausiids that resulted in a massive mortality. During several oceanographic cruises conducted between 2000 and 2002, 70 infected euphausiids (*E. pacífica, Thysanoessa spinifera*, and *T. gregaria*) were collected alive and observed under laboratory conditions. This ciliate also infects *Thysanoessa inermis* in the Gulf of Alaska. Adults infected with the ciliates have a swollen cephalothorax with bright red/orange coloration. The ciliates feed osmotrophically on the organs and muscles of the euphausiids. They increase their biovolume due to growth and reproduction to such a point that in 85% of the infected euphausiids the body cavity ruptures in a dramatic burst, releasing thousands of ciliates into the surrounding water. The rest of the infested animals did not burst, but died due to the heavy ciliate infestation eating the body completely. The carcasses on the seafloor of Astoria Canyon and animals killed by the ciliates in the ship-board incubations exhibit the same symptoms. Both had ciliates within their body cavity and the analysis of the ROV video showed sinking euphausiids close the bottom of the canyon. This ciliate infestation is a hitherto unknown source of mortality that affects the euphausiid secondary productivity in coastal upwelling ecosystems.

(A) Distribution of the euphausiids infected with the ciliate *Collinia beringensis* along the Oregon coast from July 2000 to August 2002. During three cruises conducted in 2002, infected animals were collected at 6.6% of the stations (MOCNESS and 1-m mouth nets, n=316) distributed mostly near the shelf-break . The map also shows the location of the Astoria Canyon, where a massive mortality of *Euphausia pacifica* Hansen was discovered. (B) Fledermaus visualization of high-resolution multibeam bathymetry, facing southeast looking up Astoria canyon with ROV navigated dive tracks superimposed. Depth ranges 150 m (red) to 2200 m (blue). (C) Carcasses recorded with the ROV video-system on the seafloor of the dive R596 (June 28, 2002). (D) Abundance (mean ± SE) of euphausiid carcasses on the seafloor and depth of the ROPOS along the R596 ROV track about 2 km long. Gray shading indicates the presence of live euphausiids in the vicinity of the bottom, and areas of high-density swarms are shown in a darker shade of gray.

The obligate killing parasite grows inside the host and converts host biomass into parasite transmission stages. When the host breaks open (In 85% of the hosts, n=70) millions of long lived transmission stages are released into the environment.

Healthy looking euphausiids turned cream-orange with a swollen carapace between 12-24 h after incubation at 10°C. In the initial infestation stage, the euphausiids have a pale cream-orange spot below the gonad and posterior to the stomach. The ciliates feed osmotrophically. Ciliates increase in size and the euphausiid cephalothorax swells, then the coloration changes to a bright red-orange.

In 85% of the hosts the ciliates escape from the host breaking apart the body between the posterior part of the cephalothorax and first abdominal segment.

Specimens of *E. pacifica* that burst

Astoria canyon   **Onboard incubated**
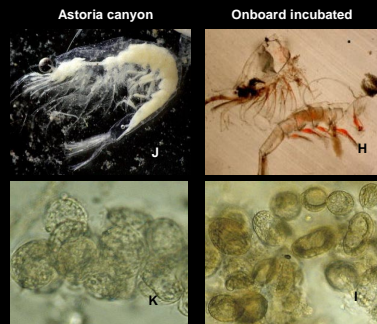
Comparison of infected *Euphausia pacifica* collected from the seafloor of Astoria Canyon (Dive 596: at 600 m depth) using the ROV suction system (J), and euphausiid killed during ship incubation (H) showing the *C. beringensis* inside each host (K & I)

Other species infected by the endoparasitic ciliates

Thysanoessa gregaria
Oregon coast

Meganyctiphanes norvegica
North Atlantic
Uwe Kils picture copy rights ©

We found a specimen of *Thysanoessa gregaria* infected by *C. beringensis*. Uwe Kills took a picture of a *Meganyctiphanes norvegica* that perhaps also is infected by a parasitic ciliate because it shows orange coloration.

Evolution of the infestation in two euphausiid species

The average time between early ciliate infestation and the death of the euphausiid by bursting was 40.6 h (S_x=9.3 h, n=9) and those that did not burst died within 76.8 h (S_x=7.7 h, n=9) after infestation.

Euphausia pacifica   *Thysanoessa spinifera*
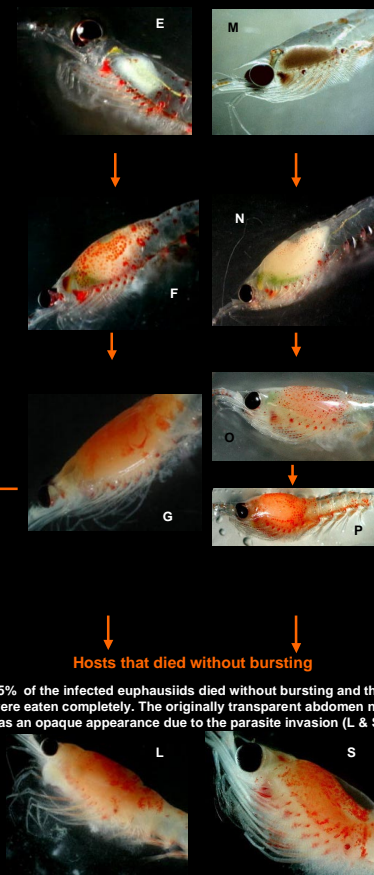
Hosts that died without bursting

15% of the infected euphausiids died without bursting and they were eaten completely. The originally transparent abdomen now has an opaque appearance due to the parasite invasion (L & S).

Ciliate morphology and life history

Several hours before causing the death of the euphausiid, the trophont stage (feeding osmotrophic stage) secretes a cyst wall and begins to differentiate into a tomont stage (reproductive stage).

Collinia beringensis

Ciliates in a trophont stage were recovered in the beginning of the infestation and stained via the Protargol staining technique showing 20-22 rows of kineties (ciliates rows).

### Reproduction of *Collinia beringensis* by palintomy

Tomont   Protomite   Tomite

Palintomy is the division of the ciliate without growth. (W) Tomont stage inside the euphausiid host (90 μm), (X) the Protomite stage starts the cell-division, (Y_1 & Y_2) division in advanced stage, and (Z) new tomite daughter cells (45 μm), (dispersal stage).
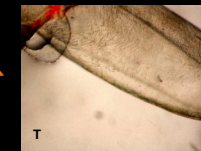
Hosts that died bursting

Infestation under laboratory conditions
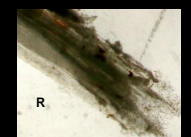
Healthy euphausiid incubated along an infected host with free-swimming *C. beringensis*, clustered in the telson and abdominal spines and trying to enter the new host through its wounds.
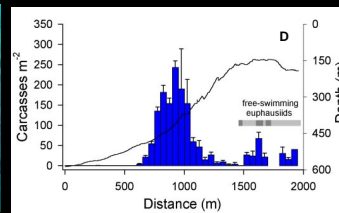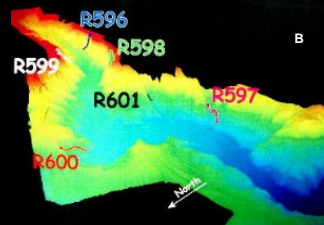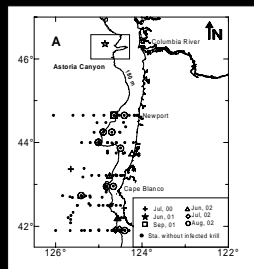
The ciliates invade the entire euphausiid body

The ciliates invade and digest all of the body leaving the empty exoskeleton