First report of epizoic diatom *Pseudohimantidium pacificum* on copepod *Corycaeus affinis* from North Eastern Arabian Sea

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Marine epizoic diatom, *Pseudohimantidium pacificum* Hustedt and Krasske 1941, on copepod *Corycaeus affinis* is reported for the first time in North Eastern Arabian Sea. It was found attached exclusively to copepod *C. affinis*. Light Microscope and Scanning Electron Microscopic studies were made to examine the frustule morphology. With the present report from the North Eastern Arabian Sea, the biogeographic boundary of this species can be extended to the Indian waters.

Keywords: *Pseudohimantidium pacificum*; epizoic diatoms; Copepod; *Corycaeus affinis*, Northern Arabian Sea

Introduction

Copepods are the most common crustacean mesozooplankton enjoying cosmopolitan distribution and their exoskeleton constitutes a convenient habitat for a variety of epizoic microorganisms such as bacteria, microalgae mainly diatoms and protozoans. Giesbrecht reported first time about the stalked epizoic diatom on planktonic copepod *Corycaeus* sp. in the Adriatic Sea. Since then there have been several reports of epizoic diatoms from different regions of the world. The main epizoic diatom genera reported are *Falcula*, *Licmophora*, *Protoraphis*, *Pseudohimantidium* and *Sceptronema*. These epizoic diatoms are mainly described for marine taxa ( pennate diatoms) that live exclusively on certain species of crustacean copepods, showing high degree of host-specificity. For example, *Pseudohimantidium pacificum* has been recorded associated to the genus *Corycaeus* Dana and *Falcula hyalina* shows preference by hosts of the genus *Acartia*. Epizoic diatoms get a number of benefits from epizoic mode of life, such as protection against grazing, enhanced photosynthesis due to the near-surface distribution of copepods during the day time, nutritional advantage, as the epibiontic microalgae can exploit the host catabolites and CO₂ supply for their growth. Moreover, microalgae may also benefit from having an elevated position avoiding the sediment resuspension. In contrast, copepods may suffer from negative impacts due to the diatom attachment, such as loss of energy due to increased drag in swimming and feeding; greater susceptibility to visual predators due to increasing apparent volume and also interfere the host mating. The present paper briefly describes the occurrence of epizoic diatom *Pseudohimantidium pacificum* on cyclopoid copepod *Corycaeus affinis* based on our recent investigations carried out in North Eastern Arabian Sea.

Materials and Methods

Cyclopoid copepod infested with epizoic diatom was observed in the surface mesozooplankton samples collected from open ocean waters of North Eastern Arabian Sea (NEAS, Lat. 21°00'36" N; Long. 68°00'16"E) (Fig.1) onboard *FORV Sagar Sampada* during early spring intermonsoon of 2013 (March 2013). Mesozooplankton samples were collected using Bongo net with 300 µm mesh size and the unreserved sample was observed using a stereomicroscope to detect copepod with epizoic diatoms. Copepods infested with epizoic diatoms were picked up and preserved in 5% neutralized formaldehyde solution for further analysis and identification. The diatom cells and the copepods were washed in distilled water followed by cleaning of diatom frustules from the organic matter according to the technique of Hasle and Fryxell. Permanent slides were mounted using Canada Balsom (refractive index= 1.535) as a mounting medium. For light

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Results and Discussion

Epizoic diatoms on the body surface of copepods were detected in the mesozooplankton samples collected from NEAS. By both LM and SEM analysis the epizoic diatom on copepod Corycaeus affinis was identified as Pseudohimantidium pacificum. P. pacificum has been reported as a stalked epizoic diatom, assigned to the family Protoraphidaceae and was only found in epizoic association with planktonic copepods in tropic to temperate waters.

The epizoic diatom P. pacificum were found infested to copepod species Corycaeus affinis by means of a clear, flexible, mucilaginous stalk (Fig. 2, 3 and 4). Species is rather easily identifiable by the valve shape, the axial area and the row of labiate processes on both valve ends. Stalks were attached to the diatoms at one end of each cell below a curved groove on the valve mantle. P. pacificum was found adhered almost all the available copepod exoskeleton, especially the locomotory appendages, antennae and the dorsal and ventral surfaces of carapace. Diatom valves are arcuate with subrostrate apices. Valves are dorsiventral (sickle or crescents shaped), and have almost straight transapical striae, 30-40 in 10 µm. Length 32-51 µm, breadth 7-14 µm. Numerous small chloroplasts are distributed throughout the cell. Apical axis 39-46 µm, transapical axis 9-13 µm. Striae are uniseriate, 30-40 in 10 µm, parallel at the valve center, becoming radiate toward the apices; poroids are elongate, 2-3 in 1 µm. Each apex has several striae composed of smaller poroids (Fig. 5). Sternum is narrow, strongly curved at the apices to form a hook-like shape, aligned with the rimoportulae at one apex, and bend in the other (Fig. 5). Rimoportulae placed parallel to the ventral side and the external openings are fused each other in a common groove. Biometrical data of present P. pacificum specimen from the NEAS agree well with the original

Mesozooplankton samples collected from NEAS contain a number of copepod genus (Calanus, Paracalanus, Corycaeus etc.) and other crustaceans (Cladocerans, Lucifer, Amphipods), but the epizoic
diatoms shows some degree of preference to the copepod hosts of genus *Corycaeus*. This type of host specificity of *P. pacificum* on copepod *Corycaeus* was first suggested by Ikeda. Around 40% of the copepod *Corycaeus* was infected with *P. pacificum*. Male animals were consistently more abundant than females in the mesozooplankton samples and the *P. pacificum* infestations were much higher in males than in females. Male infections are much higher than females. Male *C. affinis* carried around 50-60 cells of *P. pacificum* per animals than the females.

Free living *P. pacificum* cells were not observed in the micro algal samples collected from the study area and this supports Russell and Norris findings that these epizoic diatoms can grow only as epibionts on copepods. They tried to culture the epizoic diatom *P. pacificum* in an enriched seawater medium, but that was not successful. This suggests that these epizoic diatoms cannot grow anywhere but on copepods, and indicates that they require some essential nutrients heterotrophically which could necessitate the interaction between the epizoic diatoms and their hosts. This would apparently be advantageous for diatom survival during periods of nutrient depletion which might periodically occur in the natural environment. The assumption is that the diatom cells could derive some ecological benefit by their attachment to a moving host i.e. replenish their nutrient supply because of the host’s movements.

Table 1 shows the summary of previous informations on the epizoic diatom *P. pacificum* on copepods from the world oceans. So far there is no published report of these interesting epizoic diatoms for the Arabian Sea. This is the first report of *P. pacificum* from the NEAS. The biogeographic boundary of this species can be extended to the NEAS based on the present study.

**Table. 1 Summary of previous informations on the epizoic diatom *Pseudohimantidium pacificum***

<table>
<thead>
<tr>
<th>Author</th>
<th>Host copepod</th>
<th>Location</th>
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<tbody>
<tr>
<td>Giesbrecht, 1892</td>
<td><em>Corycaeus elongatus</em></td>
<td>Adriatic Sea</td>
</tr>
<tr>
<td>Steuer, 1910</td>
<td><em>C. rostratus</em>, <em>C. brehmi</em>, <em>C. obstrusus</em></td>
<td>Adriatic Sea</td>
</tr>
<tr>
<td>Fruchtl, 1924</td>
<td><em>C. gibulius</em></td>
<td>Adriatic Sea</td>
</tr>
<tr>
<td>Klevenhusen, 1933</td>
<td><em>C. speciosus</em>, <em>C. lautas</em>, <em>C. flaccus</em></td>
<td>South Atlantic Ocean</td>
</tr>
<tr>
<td>Motoda, 1963</td>
<td><em>C. crassiusculus</em></td>
<td>Hawaiian waters</td>
</tr>
<tr>
<td>Gibson, 1978</td>
<td><em>C. speciosus</em>, <em>C. gracilis</em>, <em>C. Subulatus</em>, <em>C. giesbrechti affinis</em></td>
<td>Western North Atlantic Ocean</td>
</tr>
<tr>
<td>Russell and Norris, 1971</td>
<td><em>C. affinis</em></td>
<td>Puget Sound region</td>
</tr>
<tr>
<td>Rivera et al., 1986</td>
<td><em>Corycaeus sp.</em></td>
<td>Southern Pacific Ocean</td>
</tr>
<tr>
<td>Lee et al., 1993</td>
<td><em>C. affinis</em></td>
<td>Korean coastal waters</td>
</tr>
<tr>
<td>Fernandes and Feres, 2012</td>
<td><em>C. amazonicus</em>, <em>Euterpina acutifrons</em>, <em>cypris larva</em></td>
<td>Brizilian waters</td>
</tr>
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**References**


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