ALTERACIONES MORFOLOGICAS EN Keratella spp. (MONOGONONTA: BRACHIONIDAE) DEL LAGO DE PATZCUARO, MICHOACAN

RESUMEN. Recientemente se registró en la zona del Embarcadero del Lago de Pátzcuaro, Michoacán, que algunos rotíferos del género Keratella presentaron alteraciones morfológicas. Se cuantificó que el 0.019% de la población de Keratella cochlearis y el 0.008% de Keratella americana presentaron alteraciones morfológicas en distintas espinas y ninguna presentó huevos. Estas anormalidades pudieran estar relacionadas con diferentes tipos de contaminantes en el Embarcadero, por lo que podrían ser consideradas como bioindicadores de toxicidad.

Espinosa-Rodríguez C. A., Huerto-Delgadillo, R. Jr., Torres-Sánchez C. E., Martínez-Miranda D. M., Rivera-De la Parra L. & Lugo-Vázquez A. 1*, 2Grupo de Investigación en Limnología Tropical, UICSE, FES Iztacala, Universidad Nacional Autónoma de México. Av. De los Barrios 1, Col. Los Reyes Iztacala, Tlalnepantla, Estado de México. CP 54090. México. 3Subcoordinación de Hidráulica Ambiental, Instituto Mexicano de Tecnología del Agua, Paseo Cuauhnáhuac 8532, Progreso, Jiutepec, CP 62550, Morelos, México. 4Laboratorio de fisiología vegetal, L-204, FES Iztacala, Universidad Nacional Autónoma de México. Av. De los Barrios 1, Col. Los Reyes Iztacala, Tlalnepantla, Estado de México. CP 54090. México. *Corresponding autor: alugva@gmail.com

Keratella is one of the most common genera of rotifers found in freshwater systems in Mexico: it shows high plasticity and a rigid ornamented lorica with anterior and posterior spines (Sarma & Nandini, 2017). The posterior spine presents high morphological variations ranging from its total absence to a large and rigid spine (Segers & De Smet, 2008). The factors related to this variation are temperature, trophic conditions, mutation accumulation, and predator presence (Stemberger & Gilbert, 1987; Galkovskaja & Mityanina, 1989; Bielanska-Grajner, 1995; Cieplinski et al., 2018). However, recent studies have demonstrated that some pollutants can cause a variety of morphological and reproductive effects on different groups of zooplankton (Elmooor-Loureiro, 2004; Zurek, 2006; Alvarado-Flores et al., 2015; 2019; Pérez-Yáñez et al., 2019). Moreover, lake Pátzcuaro has been strongly affected by anthropogenic contamination, which could be damaging its associated biota (Chacón, 1993; Mijangos-Carro et al., 2008; Hansen, 2012). Recent samplings at Embarcadero site of Pátzcuaro lake, registered some individuals of Keratella cochlearis with morphological alterations. This fact has motivated more detailed studies on this organism to quantify the population percentage with morphological changes, similarities of the alterations, and if they modify the reproduction success of Keratella.

Environmental selected variables (Tables 1 and 2) were measured at the Embarcadero site in Pátzcuaro lake (Fig. 1). Zooplankton collected in April 2017 was obtained filtering 80 L of water through a plankton net. Organisms were identified and quantified at the laboratory using a Sedgwick-Rafter chamber, a NIKON ECLIPSE TS 100 inverted microscope, and specialized taxonomic keys (Koste, 1978; Sarma & Nandini, 2017). Fifteen replicates were used for quantification. The three identified species of Keratella were: Keratella americana, Keratella cochlearis and Keratella tropica. For Keratella the total percentage of morphologically altered females was 0.019%, while in Keratella americana was 0.008%, and Keratella tropica did not show any alteration. These abnormalities consisted of atypical posterior spines and forewings (Figs. 2, 3). Some individuals of Keratella americana also showed morphological alterations that have not been reported previously, where just the posterior spine had curvatures (Fig. 4). Every not normal organism had a twist on the posterior spine (Fig. 3). Some individuals of Keratella americana also showed morphological alterations that have not been reported previously, where just the posterior spine had curvatures (Fig. 4). Environmental variables measured at the Embarcadero site of Lake Pátzcuaro. Temperature (T), conductivity (Cond.), dissolved oxygen (DO), transparency (Tran.), depth (Depth), total alkalinity (Alk.), biochemical oxygen demand (BOD), total suspended solids (TSS).

<table>
<thead>
<tr>
<th>Variables</th>
<th>T °C</th>
<th>Cond. µS.cm⁻¹</th>
<th>DO mg.L⁻¹</th>
<th>Tran. m</th>
<th>Depth m</th>
<th>Alk. mg.L⁻¹ CaCO₃</th>
<th>BOD mg.L⁻¹</th>
<th>TSS mg.L⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2017</td>
<td>19.2</td>
<td>1010</td>
<td>3.36</td>
<td>0.07</td>
<td>1.47</td>
<td>840</td>
<td>5.8</td>
<td>148</td>
</tr>
</tbody>
</table>

Embarcadero, Lake Pátzcuaro.

Fecha de recepción: 30 de agosto de 2019        Fecha de aceptación: 18 de julio de 2020
Table 2. Environmental variables measured at the Embarcadero site of Lake Pátzcuaro. Hardness (Hard.), ammoniacal nitrogen (N-NH3), N-nitrates (N-NO3), total coliforms (TC), fecal coliforms (FC), turbidity (Turb.), fats and oils (F. and O.).

<table>
<thead>
<tr>
<th>Variables</th>
<th>pH</th>
<th>Hard. mg.L-1</th>
<th>N-NH3 mg.L-1</th>
<th>N-NO3 mg.L-1</th>
<th>TC MPN/100 ml</th>
<th>FC MPN/100 ml</th>
<th>Turb. NTU</th>
<th>F. and O. mg.L-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2017</td>
<td>6.1</td>
<td>142</td>
<td>0.759</td>
<td>0.822</td>
<td>230</td>
<td>430</td>
<td>160</td>
<td>9.07</td>
</tr>
</tbody>
</table>

Although it is not the first record of aquatic organisms with morphological alterations, it is the first existing record for *K. americana* in natural conditions. Some works of this nature have carried out laboratory experiments with different contaminants using other species of invertebrates; however, the observed alterations differ from those found here (Alvarado-Flores et al., 2015, 2019; Pérez-Yáñez et al., 2019). Gilbert and Kirk (1988) observed a high degree of polymorphism in *Keratella cochlearis* exposed to predator allelochemicals. *K. cochlearis* could change its size and rigidity, or generate longer spines to avoid predation. In our study, the registered malformations do not resemble those that developed in the presence of predators; instead, it presents some variations that differ from these (Segers & De Smet, 2008). Cieplinski et al. (2018) investigated the life history of *Keratella cochlearis*, and found that some individuals presented deformations in their lorica; however, they reported that the culture conditions may have accumulated deleterious mutations.

On the other hand, in a reservoir associated with a sulfur mine Zurek (2006) found that 0.1% of the *Keratella cochlearis* population showed deformations in its spines, which was associated with sulfides and other derivatives. Other studies have demonstrated that morphological alterations in aquatic organisms may not only be related to water pollutants, as is the case of two deformed species of *Testudinella* described from an unpolluted lake (Coelho et al., 2019). Opposite, there are studies where the cause of some morphological alterations found in various organisms is still unknown. Elmoor-Loureiro (2004) found that 40% of *Ilyocryptus spinifer* population presented morphological abnormalities in the anal spines of the postabdomen, and she inferred that it could be due to the presence of some toxic in the environment. In the case of the present study, we also assumed that deformations could be attributed to some toxic, but further studies are necessary to determine this situation.
MORPHOLOGICAL ALTERATIONS IN ROTIFERS

Figure 2. Frequency of spines abnormalities of *Keratella cochlearis* and *Keratella americana*.

Figure 3. Morphological alterations in spines of *Keratella cochlearis*. 1. Typical structure of anterior and posterior spines. 2-11. Abnormal structure of the posterior spine clearly showing a type of branching at the end of the spine. 2,8,12-13. Abnormally curved anterior spines.
Due to the presence of several pollutants, water bodies deteriorated to such a degree that they are risky for human health and other organisms, as it is currently the case in Lake Pátzcuaro. These pollutants came from different sources or activities, such as the mismanagement of untreated sewage, agriculture, livestock, microplastics, etc. Sewage discharges also have a large contribution to diffuse pollution in the form of phosphorous and nitrogen compounds that favor the growth of cyanobacteria populations and the increase of cyanotoxin concentrations (Mijangos-Carro et al., 2008; Tomasini et al., 2016). Hansen (2012), analyzed the content of metals in sediment cores extracted from Lake Pátzcuaro and found that the concentration of lead became very high in the 70’s decade and decreased in recent years. Other metals such as chromium, arsenic, mercury, and nickel did not show high concentrations.

Embarcadero site at Pátzcuaro is a boating zone which has much transit of gasoline motorboats, and this situation could be associated with the presence of specific pollutants in the water; however, this needs a corroboration. Furthermore, the layer of gasoline and oil present at the surface of the water could modify CO₂ concentrations and pH (Cerdeña et al., 2014). Even the cause of morphological alterations found in Keratella spp. is still unknown, the factors previously mentioned have to be considered in future studies. Besides, deformed structures of this rotifer species could be used as bioindicators for toxicity measurements in water quality analysis.

ACKNOWLEDGEMENTS

CAER thanks CONACYT (SNI 75527), to the Environmental Hydraulic Subcoordination of IMTA and the Gonzalo Río Arronte Foundation for financial support. To Dr. SSS Sarma, Dr. Nandini Sarma and Dr. María del Rosario Sánchez-Rodríguez for comments on this paper. M. Sc. Mónica Chico Avelino drew the Fig.1 map.

REFERENCES


