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MORPHOLOGICAL ALTERATIONS IN *Keratella* spp. (MONOGONONTA: BRACHIONIDAE) FROM LAKE PATZCUARO, MICHOACAN

Alteraciones morfológicas en *Keratella* spp. (Monogononta: Brachionidae) del Lago de Pátzcuaro, Michoacán.

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 *K. 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.

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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 (Elmoor-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: *K. americana*, *K. cochlearis* and *K. tropica*. For *K. cochlearis* the total percentage of morphologically altered females was 0.019%, while in *K. americana was* 0.008%, and *K. tropica* did not show any alteration. These abnormalities consisted of atypical patterns showed by anterior and posterior spines that have not been described before (Fig. 2). 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). Organisms of *K. americana* and *K. cochlearis* without deformed spines showed a female/egg ratio of 0.19 and 0.015 $egg.female^{-1}$, respectively. In contrast, individuals with altered spines did not show any presence of eggs.

Table 1. 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).

Variables	T °C	Cond. $\mu S.cm^{-1}$	DO $mg.L^{-1}$	Tran. m	Depth m	Alk. $mg.L^{-1}$ $CaCO_3$	BOD $mg.L^{-1}$	TSS $mg.L^{-1}$
April 2017 Embarcadero, Lake Pátzcuaro.	19.2	1010	3.36	0.07	1.47	840	5.8	148

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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.).

Variables	pH	Hard. mg.L-1 CaCO3	N-NH3 mg.L-1	N-NO3 mg.L-1	TC MPN/100 ml	FC MPN/100 ml	Turb. NTU	F. and O. mg.L-1
April 2017 Embarcadero, Lake Pátzcuaro.	6.1	142	0.759	0.822	230	430	160	9.07

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.

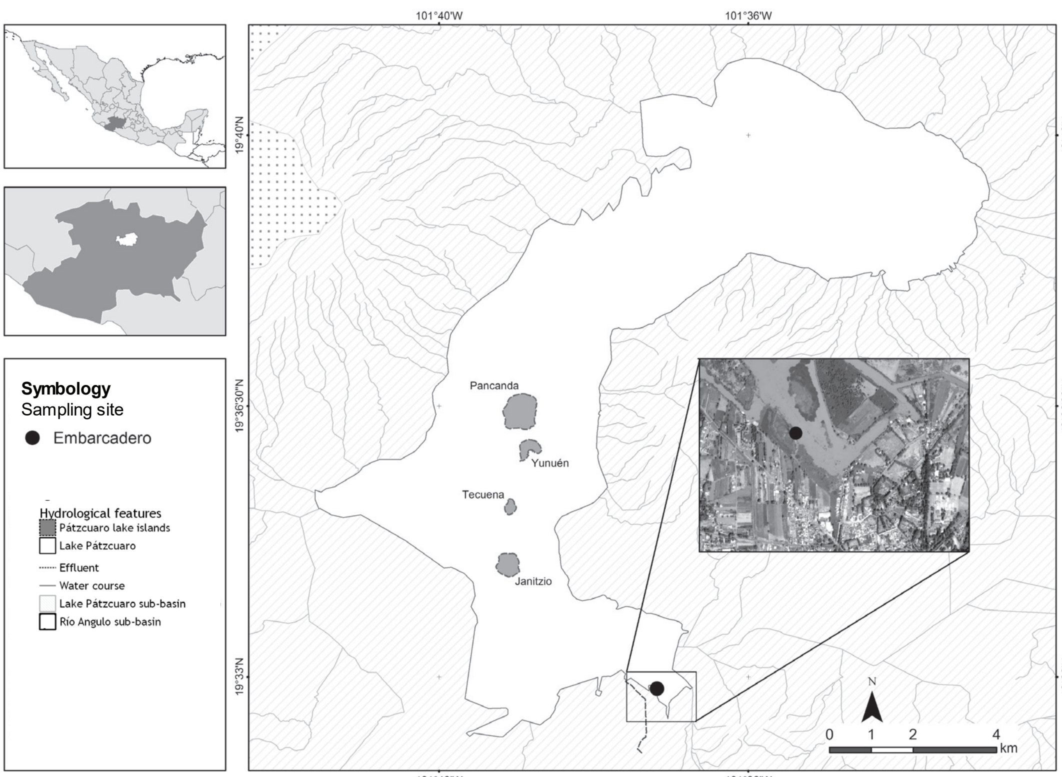

Figure 1. Location of the Embarcadero site at lake Pátzcuaro.

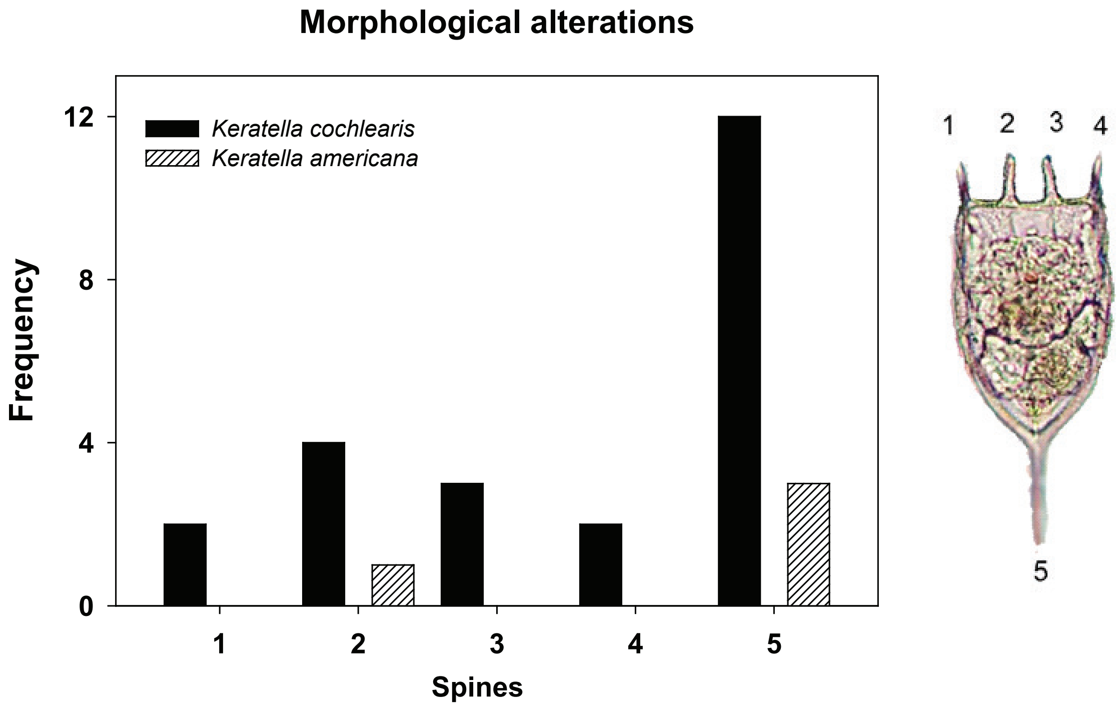

Figure 2. Frequency of spines abnormalities of *Keratella cochlearis* and *Keratella americana*.

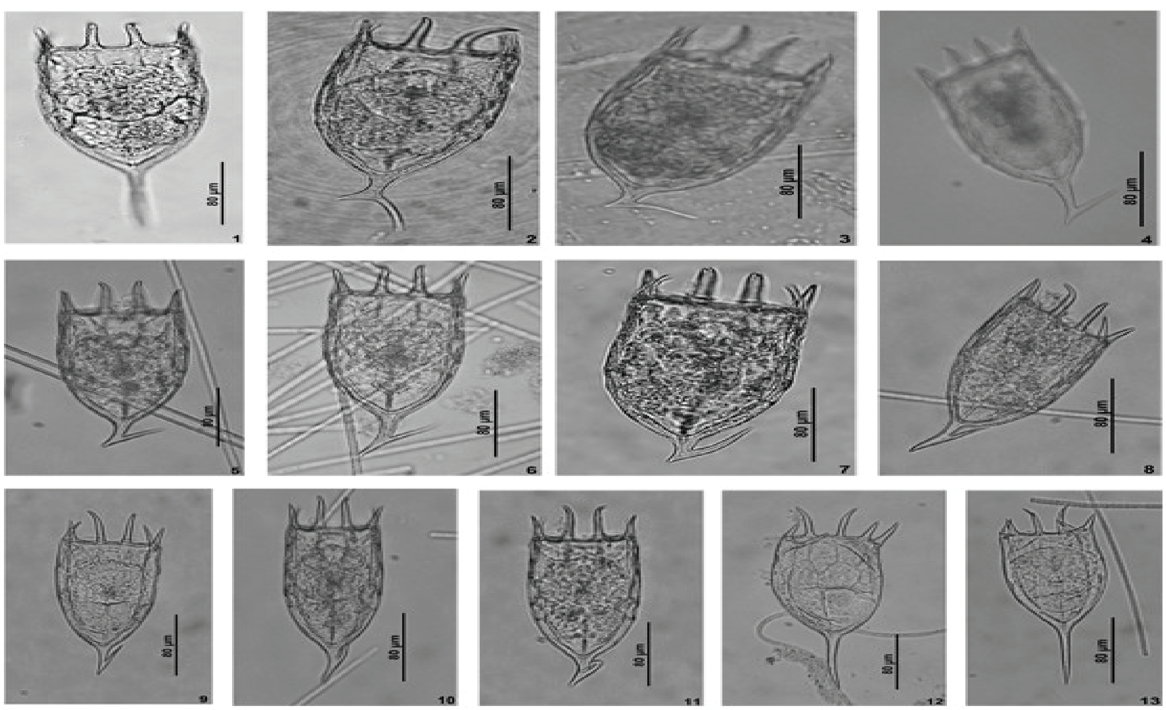

Figure 3. Morphological alterations in spines of *Keratella cochlearis*. 1. Typical structure of anterior and posterior spines. 2-11. Abnormal structure of the posterior spine clearly showing a type of branching at the end of the spine. 2,8,12-13. Abnormally curved anterior spines.

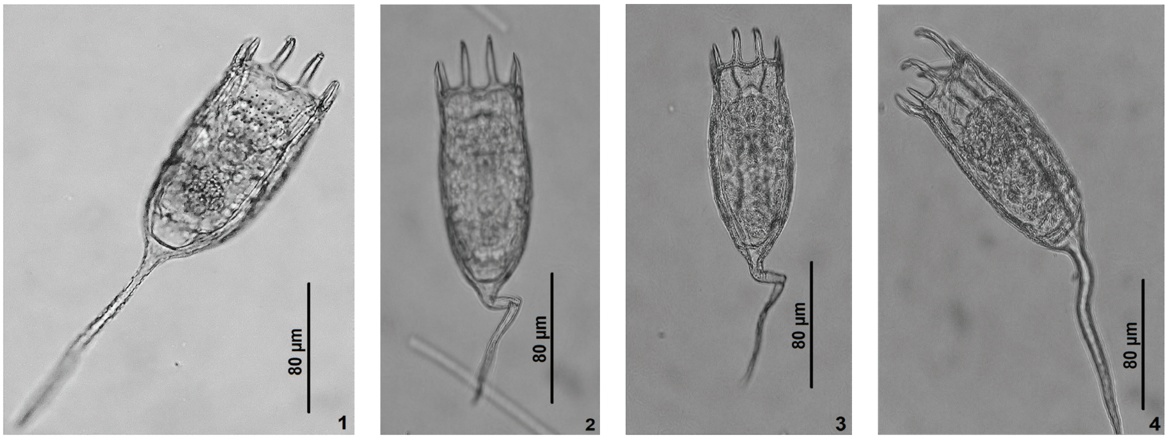

Figure 4. Morphological alterations in spines of *Keratella americana* registered at Embarcadero of Pátzcuaro. 1. Typical structure of *Keratella americana*. 2-4. Alterations of the posterior spines.

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 CO_2 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.

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REFERENCES

Alvarado-Flores, J., R. Rico-Martínez, A. Adabache-Ortíz & M. Silva-Briano. 2015. Morphological alterations in the freshwater rotifer *Brachionus calyciflorus* Pallas 1766 (Rotifera: Monogononta) caused by vinclozolin chronic exposure. *Ecotoxicology,* 24: 915-925. https://doi.org/10.1007/s10646-015-1434-8

Alvarado-Flores, J. & R. Rico-Martínez. 2019. Effects of waterborne luteinizing hormone and follicle-stimulating hormone on reproduction of the rotifer *Brachionus calyciflorus* (Monogononta: Brachionidae). *Annales de Limnologie-International Journal of Limnology,* 55(10). https://doi.org/10.1051/limn/2019008

Bielanska-Grajner, I. 1995. Influence of temperature on morphological variation in populations of *Keratella cochlearis* (Gosse) in Rybnik Reservoir. *Hydrobiologia*, 313/314: 139-146. https://doi.org/10.1007/BF00025943

Cerdeña, C., W. Reyes-Lázaro & A. Vásquez-Matute. 2014. Contaminación de las aguas del río Itaya por las actividades portuarias en el puerto Masusa, Iquitos, Perú. *Ciencia Amazónica (Iquitos)*, 4(1): 100-105. http://doi.org/10.22386/ca.v4i1.73

Chacón, T.A. 1993. Lake Pátzcuaro, Mexico: watershed and water quality deterioration in a tropical high-altitude Latin American Lake. *Lake and Reservoir Management*, 8: 37-47. https://doi.org/10.1080/07438149309354457

Cieplinski, A., U. Obertegger & T. Weisse. 2018. Life history traits and demographic parameters in the *Keratella cochlearis* (Rotifera, Monogononta) species complex. *Hydrobiologia,* 811: 325-338. https://doi.org/10.1007/s10750-017-3499-2

Coelho, P.N., S. Magalhães, A. Lansac-Tôha & R. Henry. 2019. Ocurrence of concavities on the lorica of two species of *Testudinella* (Rotifera, Monogononta, Testudinellidae). *Biota Neotropica*, 19(02). https://doi.org/10.1590/1676-0611-bn-2018-0633

Elmoor-Loureiro, L.M.A. 2004. Morphological abnormalities in the Cladoceran *Ilyocryptus spinifer* (Apipucos Reservoir, Pernambuco state, Brazil). *Brazilian Journal Biology*, 64(1): 53-58. https://doi.org/10.1590/S1519-69842004000100007

Gagneten, A.M. 2002. Efectos del herbicida Paraquat sobre el zooplancton. *Iheringia Série Zoologica*, 92(3): 47-56. https://doi.org/10.1590/S0073-47212002000300005

Galkovskaja, G.A. & I.F. Mityanina. 1989. Morphological structure and functional patterns of *Keratella cochlearis* (Gosse) populations in stratified lakes. *Hydrobiologia*, 186/187: 119-128. https://doi.org/10.1007/978-94-009-0465-1_14

Gilbert, J.J. & K.L. Kirk. 1988. Escape response of the rotifer *Keratella*: Description, stimulation, fluid dynamics, and ecological significance. *Limnology and Oceanography*, 33: 1440-1450. https://doi.org/10.4319/lo.1988.33.6part2.1440

Hansen, A.M. 2012. Lake sediment cores as indicators of historical metal(loid) accumulation – A case study in Mexico. *Applied Geochemistry*, 27: 1745-1752. https://doi.org/10.1016/j.apgeochem.2012.02.010

Koste, W. 1978. *Rotatoria*. Die Radertiere Mitteluropsas. Vol. 1 y 2. Borntraeger, Bristol and Konigstein. Berlin y Stuttgart.

Mijangos-Carro, M., J. Izurieta-Dávila, A. Gómez-Balandra, R. Hernández-López, R. Huerto-Delgadillo, J. Sánchez-Chávez & L. Bravo-Inclán. 2008. Importance of diffuse pollution control in the Pátzcuaro lake basin in Mexico. *Water Science and Technology*, 58: 2179-2186. http://doi.org/10.2166/wst.2008.820.

Pérez-Yáñez, D., D.K. Soriano-Martínez, M.E. Damian-Ku, E. Cejudo-Espinosa & J. Alvarado-Flores. 2019. Cadmium and morphological alterations in the rotifer *Philodina* cf. *roseola* (Bdelloidea: Philodinidae) and the worm *Aeolosoma hemprichi* (Annelida: Aeolosomatidae). *Revista de Biología Tropical*, 67: 1406-1417. http://doi.org/10.15517/RBT.V67I6.35981

Sarma, S.S.S. & S. Nandini. 2017. Rotíferos Mexicanos (Rotifera) Estado de México. Manual de Enseñanza. Facultad de Estudios Superiores Iztacala. Universidad Nacional Autónoma de México. México

Segers, H. & W. De Smet. 2008. Diversity and endemism in Rotifera: a review, and *Keratella* Bory de St Vincent. *Biodiversuty and Conservation,* 17: 303-316. https://doi.org/10.1007/s10531-007-9262-7

Stemberger, R.S. & J.J. Gilbert. 1987. Multiple-species induction of morphological defences in the rotifer *Keratella testudo*. *Ecology,* 68(2): 370-378. https://doi.org/10.2307/1939268

Tomasini-Ortiz, A.C., L.B. Bravo-Inclán, J.J. Sánchez-Chávez & G.E. Moeller-Chávez. 2016. Monitoreo de descargas de aguas residuales y su impacto en el Lago de Pátzcuaro, México (2006-2011). *Revista AIDIS de Ingeniería y Ciencias Ambientales: Investigación, desarrollo y práctica* 9(1): 61-74. http://dx.doi.org/10.22201/iingen.0718378xe.2016.9.1.50113

Zurek, R. 2006. Response of rotifers to hydrochemical and biotic factors. *Oceanological and Hydrobiological Studies*, 35(2): 121-139.