

Occurrence of *Notodiaptomus maracaibensis* Kiefer, 1954 (Copepoda: Calanoida, Diaptomidae) from an ephemeral pond in northern Colombia

Presencia de *Notodiaptomus maracaibensis* Kiefer, 1954 (Crustacea: Copepoda: Calanoida, Diaptomidae) en una charca temporal al norte de Colombia

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Abstract

Key words:
copepods; diaptomids;
freshwater zooplankton;
La Guajira; taxonomy

The freshwater Neotropical planktonic copepod *Notodiaptomus maracaibensis* Kiefer, 1954 was found in a small temporal pond in northern La Guajira. Hitherto, it had been reported in Venezuela and Colombia, mainly in the Caribbean region. This article is the first documented, illustrated record confirming its presence in Colombia and La Guajira department. Our specimens from La Guajira have a combination of diagnostic features of *N. maracaibensis* as reported in both the original description and subsequent taxonomical accounts, including 1) segment 15 of male right antennule with no spinous process, 2) inner margin of male right P5 basipodite smooth, 3) male right P5 endopod short, 4) male right P5 exopod 2 nearly 2.5 times as long as wide; 5) lateral spine of male P5 exopod 2 inserted subdistally; 6) lateral wings of female pediger 5 asymmetrical, 7) inner margin of female lateral wings with a spinules row, 8) left lateral wing with both sensilla inserted closer to each other than on right wing; 9) female genital double-somite 1.5 times as long as wide, 10) both sensilla of genital double-somite arranged perpendicularly to the body axis. *Notodiaptomus maracaibensis* superficially resembles *N. henseni*, also reported in Colombia. These two species can be easily confused with each other; so, we provide crucial morphological details to distinguish these species. A key to the *Notodiaptomus* species found in Colombia is also provided.

Resumen

Palabras claves:
copépodos; diaptómidos;
zooplancton de agua dulce;
La Guajira; taxonomía

El copépodo planctónico de agua dulce *Notodiaptomus maracaibensis* Kiefer, 1954 fue encontrado en un pequeño estanque temporal al norte de La Guajira, Colombia. Hasta ahora, se había registrado solamente en Venezuela y Colombia. Este es el primer registro ilustrado y documentado que confirma su presencia en Colombia y en el departamento de La Guajira. Los especímenes de La Guajira presentan una combinación de caracteres diagnósticos propios de *N. maracaibensis*, tal como se consigna tanto en su descripción original como en los trabajos taxonómicos posteriores, incluidos 1) segmento 15 de la anténula derecha del macho sin proceso espinoso, 2) margen interno del basipodito de la P5 derecha del macho liso, 3) endopodito de la P5 derecha del macho corto, 4) segundo segmento exopodal de la P5 derecha del macho casi 2,5 veces tan largo como ancho; 5) espina lateral del segundo segmento exopodal de la P5 derecha del macho insertada subdistalmente; 6) procesos laterales del pedígero 5 de la hembra ligeramente asimétricos; 7) borde posterior de los procesos laterales del pedígero 5 de la hembra con una hilera de espínulas; 8) proceso lateral izquierdo del pedígero 5 de la hembra con ambas sensilas insertadas más cerca una de la otra que en el lado derecho; 9) doble somita genital 1,5 veces más largo que ancho, 10) ambas sensilas del somita genital dispuestas perpendicularmente al eje del cuerpo. *Notodiaptomus maracaibensis* se parece superficialmente a *N. henseni*, también presente en Colombia, y ambas podrían confundirse con facilidad; por ello, se presentan algunos detalles que permiten diferenciarlas. También se proporciona una clave para las especies de *Notodiaptomus* que se encuentran en Colombia.

Introduction

The genus *Notodiaptomus* was proposed by Kiefer (1936) to include eleven species originally placed in *Diaptomus* Westwood, 1836 *sensu lato* (Santos-Silva *et al.*, 1999). This genus has the widest distribution of freshwater calanoids in the Neotropical region (Santos-Silva *et al.*, 1999; 2013). Members of this genus can be found both in lentic and lotic ecosystems (Previattelli *et al.*, 2013) and are restricted to the Neotropical region (Walter and Boxshall, 2021). The diversity of *Notodiaptomus* is the greatest among the calanoid copepod family Diaptomidae; it currently comprises 36 valid species (Suárez-Morales *et al.*, 2020). Of these, *Notodiaptomus coniferoides* (Wright, 1927), *N. echinatus* (Lowndes, 1934), *N. henseni* (Dahl, 1894), *N. maracaibensis* Kiefer, 1954, *N. simillimus* Cicchino, Santos Silva & Robertson, 2001 have been known to occur in Colombia (Kiefer, 1956; Cicchino *et al.*, 1989; Atencio *et al.*, 2005; Álvarez, 2010; Jaramillo-Londoño and Aguirre-Ramirez, 2012; Dussart, 1984; Rivera-Rondón *et al.*, 2010; Villabona-González *et al.*, 2011). Furthermore, Gaviria and Aranguren (2019) recorded seven species of *Notodiaptomus* in Colombia and added *N. linus* (Brandorff, 1973) and *N. dilatatus* Dussart, 1984, but these two species are currently considered members of *Diaptomus* (Suárez-Morales *et al.*, 2020). This manuscript follows the criterion of the latter authors.

Notodiaptomus maracabiensis was originally described by Kiefer (1954) in Lago de Maracaibo, Venezuela. Hitherto, this species has been recorded in both the Caribbean and Pacific regions in Colombia, having a wide distribution in the former (Gaviria and Aranguren, 2019) This paper aims to document the first finding of *N. maracabiensis* in the La Guajira Department. Unlike previous regional and national records, our report includes a brief description of the specimens examined, illustrations of relevant taxonomic traits of this species, and a comparative analysis concerning its closest congener in the country. A key for identifying the species of *Notodiaptomus* found in Colombia is also provided.

Materials and methods

Biological samples were taken from a small temporary pond at Ebanal farm, northern sector of La Guajira-Colombia, (11°45'23.37" N; 72°25'10.97" W). Qualitative surveys were performed during October and November 2018. Environmental parameters were measured with a WTW 3111 conductivity meter gear. Water samples were collected using a bucket of 25 L, sieved through a standard zooplankton net (55 µm mesh) until

to obtain concentrates of 500 ml that and fixed in 96 % ethanol. In the laboratory, samples were concentrated to 50 ml and stained with Bengal rose. The copepods were sort and count using a Bogorov chamber and with the aid of a stereomicroscope; they were taxonomically examined in toto under a compound optical microscope in a drop of glycerol-formaldehyde mixture. Specimens were measured in ventral position, from the anterior end of the cephalothorax to the posterior margin of the caudal ramus and then they were dissected to examine the taxonomically relevant appendages, which were mounted in semi-permanent slides. The appendages with taxonomic relevance were drawn using a drawing tube and also photographed with a Kodak Easy Share C140 digital camera adapted to a compound microscope at 1000x magnification. The identification of this species was based on the original description and illustrations by Kiefer (1954, 1956); we also followed the taxonomic key by Suárez-Morales *et al.* (2020). Our morphologic remarks and complementary description followed Huys and Boxshall's (1991) terminology. The following abbreviations are used in the text: P1-P6 = first to sixth legs; EXP = exopod; ENP = endopod.

Voucher specimens of *N. maracaibensis* were deposited at the Centro de Colecciones Biológicas Universidad del Magdalena, Colombia (CBUMAG: MEI: 0825 and CBUMAG: MEI: 0826) where they are available for consultation or further examination.

Results

Order Calanoida Sars G.O., 1903
 Family Diaptomidae Baird, 1850
 Subfamily Diaptominae Kiefer, 1932
 Genus *Notodiaptomus* Kiefer, 1936
Notodiaptomus maracaibensis Kiefer, 1954

Material examined: Seven adult females and five adult males from an ephemeral pond located in La Guajira, Colombia (11°45'23.37" N; 72°25'10.97" W), collected using a plankton net, October - November 2018, coll. JMF-R.

Morphology

Female. Body length = 1064–1092 µm (n = 7, average length = 1075 µm) (figure 1A). Antennules symmetrical, 25-segmented, reaching beyond caudal rami (figure 1A), pediger 5 wings asymmetric, with one pair of sensillae on each side; left side with both sensilla inserted closer to each other than on right side, inner sensilla thinner (figure 2A); posterior margin ornamented with small spinules (figure 1C, D). Urosome 3-segmented

(figures 1B, 2B, C). Genital double-somite symmetrical, weakly produced ventrally (figures 1A, 2C), about 1.4 times as long as wide (figures 1A, 2C), longer than the other urosomites lengths

combined (figure 1B). Somite with laterally directed sensillum on each side (figure 2A, C). Caudal rami symmetrical, about 1.6 times as long as wide (figure 2C).

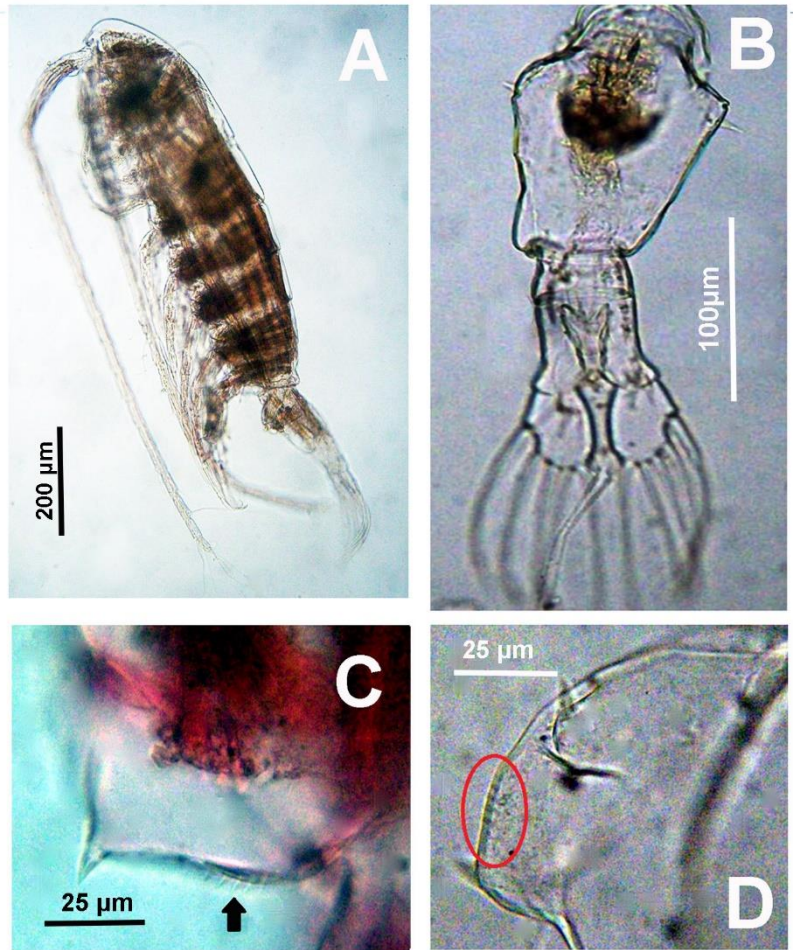


Figure 1. *Notodiptomus maracaibensis* Kiefer, 1954 from La Guajira, Colombia. Adult female. A. habitus, lateral view. B. urosome, ventral view. C. left wing of pediger 5 showing spinule ornamentation. D. same, right wing.

P1–P4 with 3- segmented EXPs and ENPs, except for 2- segmented P1ENPs (figure 3A-D). P5 symmetrical (figure 2D), coxa with sensilla on outer margin, basis subtriangular with short outer basipodal seta (figures 2D, 5B). EXP 3-segmented. EXP1 robust, about 2.4 times as long as wide, with a small subdistal sensilla (figures 2E, 3C). EXP2 represented by a stout terminal claw with small denticles along lateral margins, with small outer spine in the proximal position (figures 2E, 5C). EXP3 small, subquadrate, armed with two stout terminal setal elements, outer shorter than inner (figure 2E). ENP 1-

segmented, reaching about mid length of EXP1 (figures 2D, 5B) with a brush of short spinules apically (figure 2F).

Male: Body length = 938 – 980 µm (n = 5, average length = 969 µm). Left antennule as in female. Right antennule geniculate, with segments 14-19 modified, expanded, bearing spinous processes on segments 9, 11, 12, 14, 16, and 17 (figures 4B). Antepenultimate segment with short, acute process on distal position, not reaching proximal margin of succeeding segment (figure 4A).

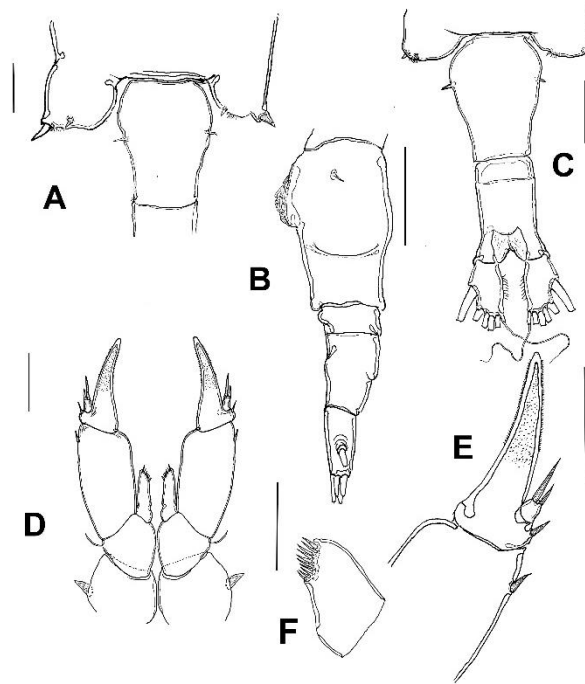


Figure 2. *Notodiaptomus maracaibensis* Kiefer, 1954 from La Guajira, Colombia. Adult female. A. pediger 5 and genital double-somite, dorsal view. B. urosome, lateral view. C. same, dorsal view. D. fifth leg. E. right fifth leg, distal segment. F. apical end of endopodite. Scale bars: A-C= 60 μ m, D, E= 25 μ m, F= 10 μ m.

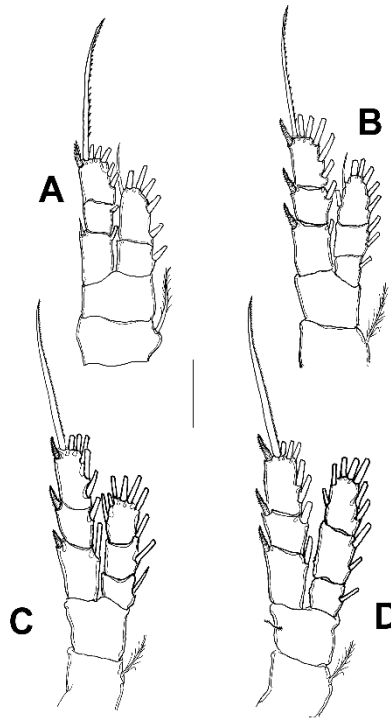


Figure 3. *Notodiaptomus maracaibensis* Kiefer, 1954 from La Guajira, Colombia. Adult female. A. leg 1. B. leg 2. C. leg 3. D. Leg 4. Scale bars: A-D= 50 μ m.

P1-P4 as in female, P5 biramous, strongly asymmetrical (figure 4C). Right P5. Coxa with large conical process (figure 4C). EXP 2-segmented; first segment with a short acute process on outer distal margin and small distal sclerotized process projecting over second exopodal segment (figure 4C); second segment with a lateral spine inserted subdistally; terminal claw strong, curved (figure 4C). ENP short, 1-segmented, with a row of spinules on inner margin (figure 4C).

subrectangular, with short outer basipodal seta. EXP 2-segmented, EXP1 robust, about half as long as basipodite, with curved outer margin; inner margin with small thumb-like process ornamented with setules. EXP2 with inner margin expanded into subtriangular lamella ornamented with a inner row of spinules; outer corner with small distal seta. Distal half of EXP2 tapering distally into pair of chitinized digitiform processes (figure 4D). ENP wide, conical, 1-segmented, with a row of spinules on the inner margin, ENP almost reaching the distal end of EXP2 (figure 4C, D).

Left P5. Leg barely reaching right leg EXP1. Basipodite robust,

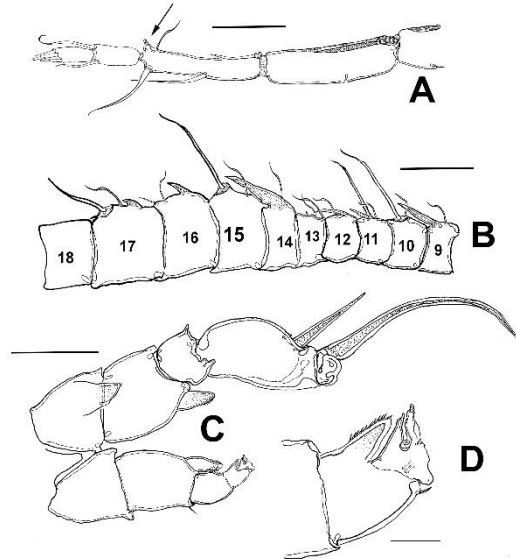


Figure 4. *Notodiaptomus maracaibensis* Kiefer, 1954 from La Guajira, Colombia. Adult male. A. antepenultimate segment of male right antennule showing acute process (arrow). B. right antennule segments 9-18. C. fifth leg. D. detail of terminal exopodal segment of left fifth leg. Scale bars: B= 50 μ m, C= 60 μ m, D= 10 μ m.

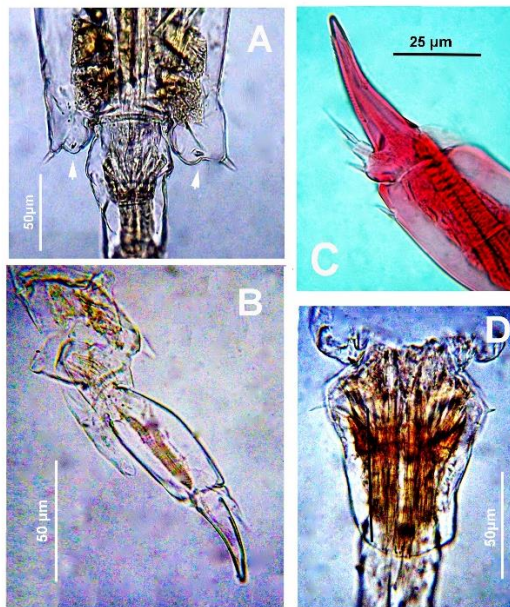


Figure 5. *Notodiaptomus maracaibensis* Kiefer, 1954 from La Guajira, Colombia. Adult female. A. fifth pediger lateral wings and genital double-somite, dorsal view. B. fifth leg. C. detail of fifth leg. D. genital double-somite, dorsal view.

Discussion

The morphology of the seven adult female and five male specimens from La Guajira, Colombia agrees with previous descriptions and illustrations of *N. maracaibensis* (Kiefer, 1956; Suárez-Morales *et al.*, 2020).

Notodiaptomus maracaibensis can be separated from its closest congeners by a unique combination of characters including: 1) segments 13 and 15 of male right antennule lacking spinous process (figure 4B), 2) inner margin of male right P5 basipodite smooth, 3) male right P5 endopod short, 1-segmented, 4) male right P5 EXP2 almost 2.5 times as long as wide, 5) lateral spine (aculeus) of male right P5 EXP2 inserted subdistally; 6) female lateral wings of pediger 5 weakly asymmetrical, 7) inner margin of female lateral wings with row of spinules, 8) left lateral wing with both sensilla inserted closer to each other than on right wing, 9) genital double-somite 1.5 times as long as wide, 10) both sensilla on genital double-somite arranged perpendicularly to the body axis. These distinctive traits are present in our Colombian specimens. In his original description of this species, Kiefer (1956) depicted the antepenultimate segment of the male right antennule as having a weak distal expansion (Kiefer, 1956, fig. 16), whereas a strong, acute process is present in the specimens examined (arrow in figure 4A).

The genus *Notodiaptomus* was divided by Wright (1935) into two distinct groups: the nordestinus-complex containing 13 species and the genus *Notodiaptomus* by Kiefer, comprising the remaining species (Santos-Silva *et al.*, 2013). *Notodiaptomus maracaibensis* is included in the latter.

In Colombia, *N. maracaibensis* superficially resembles *N. henseni* and which could be easily confused. These two species can be distinguished by several subtle characters including: 1) *N. maracaibensis* has small denticles on the inner margin of the female lateral wings (Kiefer, 1954, Abb. 5; Kiefer 1956, Abb. 10; Suárez-Morales *et al.*, 2020, figure 21.8K, GS, present data, figures 1C-D, 2A, C); this ornamentation is absent in *N. henseni* (Santos-Silva *et al.*, 2013, Suárez-Morales *et al.*, 2020); 2) distal portion of last pediger with spinules in *N. henseni* (Santos-Silva *et al.*, 2013; Suárez-Morales *et al.*, 2020), vs. smooth surface in *N. maracaibensis* (Kiefer, 1954, Abb. 5; Kiefer, 1956, Abb. 10; Suárez-Morales *et al.*, 2020, present data, figures 1C-D, 2C, 3) segment 13 of male antennule without spinous process in *N. maracaibensis* (Kiefer, 1954, Abb. 7; Kiefer, 1956, Abb. 12; Suárez-Morales *et al.*, 2020; present data, figure 4B) vs. such segment with a spine in *N. henseni* (Santos-Silva *et al.*, 2013, Suárez-Morales *et al.*, 2020).

Distribution

So far, *Notodiaptomus maracaibensis* is exclusively distributed in the Neotropical region and has been recorded in two countries: Venezuela (Kiefer, 1954) and Colombia (Gaviria and Aranguren, 2019). In the latter, it has been recorded in different areas (Atencio *et al.*, 2005; Álvarez, 2010; Gaviria and Aranguren, 2019; Villabona-González *et al.*, 2011), but illustrations and morphologic comparisons of the Colombian populations have not been yet provided for this species. This paper becomes first documented, illustrated record confirming its presence in Colombia and La Guajira.

Only three Neotropical diaptomid species were included as threatened in the 1996 Red List (Reid *et al.*, 2002). Currently, *Notodiaptomus maracaibensis* is considered to be threatened (Daga *et al.*, 2020) and included at the IUCN Red species (Baillie and Goombridge, 1996). Our finding from ephemeral ponds in northern Colombia suggests that its conservation status should be reviewed.

Key to the *Notodiaptomus* species recorded in Colombia

- 1A. Lateral spine of right P5 Exp2 less than 1/5 (20 %) length of terminal claw.....2A
- 2A. Left side of genital double-somite with a additional semicircular inflated area, without dorsal hump on female fourth pediger, modified seta on segment 13 of male right antennule small, reaching midlength of segment 14.....*Notodiaptomus simillimus* Cicchino, Santos-Silva & Robertson, 2001.
- 2B. Left side of genital double somite lacking an additional semicircular inflated area, with dorsal hump on female fourth pediger, modified seta on segment 13 of right male antennule long, reaching the distal end of segment 14.....*Notodiaptomus coniferoides* (Wright, 1927)
- 1B. Lateral spine of right Exp2 P5 more than 1/5 (20 %) the length of terminal claw.....3A
- 3A. Lateral spine of right EXP2 P5 inserted distally, last segment of female urosome lacking a strong hump.....4A
- 3B. Lateral spine of right EXP P5 inserted medially, last segment of female urosome with a strong hump.....*Notodiaptomus echinatus* Lowndes 1934.

4A. Distal portion of the last pediger without spinules, small denticles on the end edge of lateral wings females, segment 13 of male antennule without spine.....
Notodiaptomus maracaibensis Kiefer, 1954.

4B. Distal portion of the last pediger with spinules, without small denticles on the end edge of lateral wings females, segment 13 of male antennule with spine.....
Notodiaptomus henseni (Dahl, 1894).

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