

On the taxonomical status of *Arctodiaptomus dampfi* Brehm (Crustacea: Copepoda: Diaptomidae) with comments on *A. dorsalis* (Marsh)

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ABSTRACT

Arctodiaptomus dampfi Brehm is a diaptomid copepod described from Lake Petén, in Guatemala. Due to the fact that the type material is lost and no additional material was available, the taxonomical status of this species remained unclear for more than 65 years. *Arctodiaptomus dampfi* has been advanced as a synonym of *A. dorsalis* and some authors followed this position; instead, others recognized this species in regional checklists. We collected zooplankton samples at Lake Petén, *A. dampfi* type locality, and compared this material with confirmed museum specimens and material from Louisiana, the type locality of *A. dorsalis*. Our observations with light microscopy and SEM allowed us to state that *A. dampfi* is in fact a synonym of *A. dorsalis* and should be excluded from regional lists. This was concluded after examination and comparison of the taxonomically relevant structures in both groups of specimens. Differences between both groups of specimens were slight. We found significant size differences between the Guatemalan population and the other neotropical and nearctic ones, the former being the smallest sized populations known throughout the known distributional range of *A. dorsalis*.

Key words: copepods, freshwater, taxonomy, Mexico, zooplankton

1. INTRODUCTION

The neotropical freshwater copepod fauna of Mexico, Central America, and adjacent areas has been surveyed by several authors and a few faunistic checklists are available (Smith & Fernando 1982; Collado *et al.* 1984; Reid 1990; Suárez-Morales & Reid 1998; Suárez-Morales *et al.* 2000). However, due to the fact that regional copepod surveys started during the first decades of the century, several of the early records are dubious (Reid 1990). Attempts have been made to correct previous misidentifications of Neotropical freshwater copepods, mainly in southeastern Mexico and in Central America (Rocha & Hakenkamp 1993; Fiers 1995; Suárez-Morales *et al.* 1996).

The diaptomid copepod species *Arctodiaptomus dampfi* was described twice by Brehm (1932 and 1939) from material collected in the Guatemalan Lake Petén. Overall, he described it very briefly, in the first paper he gave a short diagnosis in German without illustrations, and in the second, published in Spanish, he included drawings of a few appendages. Additionally, the type material is lost. Based on the German description, this species was later on speculated to be a synonym of *A. dorsalis* (Marsh 1907) by Wilson (1959), and Bowman (in litt.). However, more recently, Reid (1990) listed it as *Acanthodiaptomus dampfi*, distributed in Guatemala and Panama. Suárez-Morales *et al.* (1996) proposed the new synonymy as well, but suggested that material from the type locality for *A. dampfi* should be reviewed and compared in order to present a conclusive statement. The fact that diaptomids tend to show restricted dis-

tributional patterns (Dussart & Defaye 1995) and the finding of endemic species of Diaptomidae in southeast Mexico (Suárez-Morales & Elías-Gutiérrez 2000) made this controversy a more interesting issue. Hence, we decided to disentangle this problem and made a sampling trip to Lake Petén, Guatemala where we obtained zooplankton material from various sites of the limnetic zone. The samples collected in this area contained several adult males and females of diaptomid copepods. In this work we compare confirmed museum material of *Arctodiaptomus dorsalis* from the type locality and from sites within its known distributional range, and available figures (Wilson 1959; Collado *et al.* 1984; Suárez-Morales *et al.* 1996; Silva-Briano & Suárez-Morales 1998) with the specimens collected in Lake Petén, the type locality for *A. dampfi*.

2. MATERIALS AND METHODS

Specimens of diaptomid calanoid copepods were collected during a zooplankton survey carried out on August 4th, 1999 at Lake Petén, Guatemala, Central America. Sampling was performed within an area comprised between the following coordinates: 16°55'57"-16°57'25" N and 89°52'40"-89°54'35" W. Zooplankton samples were collected using a plankton net with a 0.05 mm mesh performing both vertical and oblique hauls. The material was fixed in a 4% sugar-formalin solution. All copepods were sorted and then transferred to a 70% ethanol solution with a drop of glycerin, for preservation. Adult male and female specimens were sorted from the samples under a stereomicroscope and then processed for examination. Several other adult

male and female specimens were prepared for SEM analysis.

The Lake Petén specimens were compared with type material of *Arctodiaptomus dorsalis* from Louisiana, USA, and with USNM confirmed specimens of *A. dorsalis* collected in Mexico and the USA. Observations were based on whole and dissected specimens mounted in glycerin, and on SEM analysis. SEM comparisons of *A. dampfi* were made with the geographically closest population of confirmed *A. dorsalis*, that of the Yucatan Peninsula, southeastern Mexico. A one-way ANOVA test was performed to detect length differences in both males and females of the populations available to us.

3. MATERIAL EXAMINED

Arctodiaptomus dorsalis. - Slides. Smithsonian Institution, National Museum of Natural History. Seven ♂♂ syntype specimens (USNM 296403), Guzman, Louisiana, United States. D. Marsh collection, deposited at the NMNH, Washington, D.C.: slide 3128 (one adult ♀, dissected), Slidell, Louisiana; slide 3571 (one ♂, one ♀), no locality on label; slide 3680 (two ♂♂, one ♀), Middle Lake, Florida; slide 3681 (four ♂♂, one egg-carrying ♀), no locality on label; slide 3723 (one ♂, dissected), no locality on label. National Museum of Natural History, Washington, D.C., ethanol-preserved material: USNM 140776, Caribbean Sea, Cuba, Las Villas Province, Cayo Caguanes, Lago Marti (18 ♀♀, 5 ♂♂); USNM 122758 United States, Florida, Pensacola, Santa Rosa Island, Fort Pickens State Park Ponds (10 ♀♀, 11 ♂♂); USNM 122757 United States, Florida, Pensacola, Santa Rosa Island, Fort Pickens State Park Ponds (11 ♀♀, 5 ♂♂); USNM 250571 Mexico, Quintana Roo, Sian Ka'an Biosphere Reserve, sinkhole (1 ♀♀, 2 ♂♂); USNM 250590 Mexico, Quintana Roo, Cenote Catedrales (4 ♀♀); USNM 211198 United States, California, Sacramento River at Hood (3 ♀♀); USNM 211197 United States, California, Sacramento River at Rio Hood (4 ♂♂). Collection of the Universidad Autónoma Metropolitana (UAM-Mexico), Campus Iztapalapa, Mexico City, Mexico: Ethanol-preserved material: MORE92, Mexico, Jiutepec, Morelos State, coll. September 21, 1992 (50 ♀♀, 14 ♂♂); CENTLA99, Mexico, Centla Swamps, Frontera Municipality, Tabasco State, Biological Station "Tres Brazos", collected June 3, 1999 (147 ♀♀, 23 ♂♂). Additional material: one adult ♀ from Puente Milagros II, Quintana Roo, México, March 9, 1997 (ECO-CHZ-00560); several adult ♂♂ and ♀♀ mainly from cenotes of Quintana Roo, Mexico, deposited in the El Colegio de la Frontera Sur (ECOSUR), Chetumal, Mexico, and in the National Museum of Natural History (USNM 259684; USNM 259690; USNM 259696). Several ♂♂ and ♀♀ from central Mexico, Miacatlán Municipality, Morelos State, Coatetelco Lagoon. Several ♂♂ and ♀♀ from central Mexico, Puente de Ixtla, Morelos State, Emiliano Zapata Dam.

Arctodiaptomus dampfi. Specimens from Lake Petén, Guatemala: Two adult ♂♂, two adult ♀♀ collected near Flores town, vertical tow, June 4, 1999 (ECO-CHZ-00897) and remaining material on original samples (+50 ♂♂ and ♀♀) deposited in the Zooplankton Collection of El Colegio de la Frontera Sur, Chetumal, Mexico. Four adult ♂♂, one adult ♀♀, same date and locality, deposited in the Muséum National d' Histoire Naturelle, Paris, Cp-1909.

4. RESULTS AND DISCUSSION

Diaptomus dorsalis Marsh, 1907: 387, 389-399, 406, 408, 467-469, 473, Pl. XXIII, Figs 8, 9, Pl. XXIV, Figs 2, 3, 5, 6.

Diaptomus (Arctodiaptomus) dorsalis - Light, 1939: 476.

Arctodiaptomus dorsalis - Dussart & Defaye, 1983: 66, 212.

Arctodiaptomus (Arctodiaptomus) dorsalis - Reed, 1994: 671, 676.

Diaptomus (Arctodiaptomus) dorsalis - M.S. Wilson in Wilson & Yeatman, 1959: 739, 778, Figs 29, 62.

Diaptomus (Arctodiaptomus) dorsalis - Smith & Fernando, 1980: 11, 12, Figs 4L-J.

Diaptomus alter - Herbst; Dussart & Defaye, 1983: 64, synonym of *D. proximus*

D. proximus - Dussart & Fernando, 1985b: 204-206, Figs 15-23.

Arctodiaptomus dorsalis- Reid, 1990a: 178.

Diaptomus dorsalis - Suárez-Morales, 1991: 250.

Arctodiaptomus dorsalis - Suárez-Morales *et al.* 1996: 98-100, Figs 18a-h.

Diaptomus Dampfi Brehm, 1932: 64-65 (new synonymy)

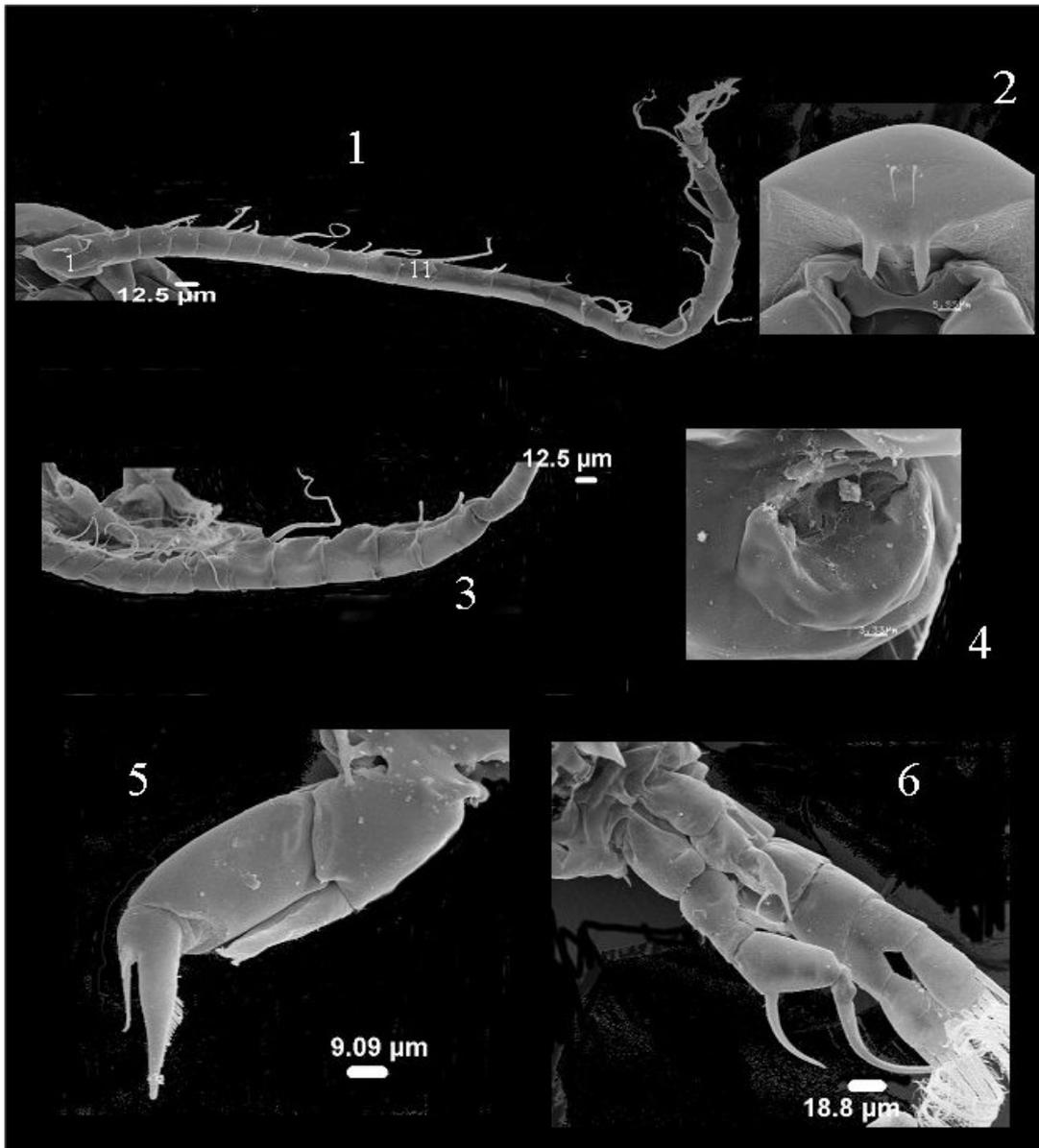
Diaptomus Dampfi Brehm, 1939: 175-177.

Acanthodiaptomus dampfi - Reid, 1990: 178.

Arctodiaptomus dorsalis - Reid, 1990: 178.

4.1. Comparisons

The most relevant characters for the identification of diaptomid copepod were evaluated in order to determine the species to which the Lake Petén specimens belong. The Petén specimens were placed under the genus *Arctodiaptomus sensu* Reed (1994) by a combination of characters: one seta on antennule segment 11, a sensorial spine on segment 8 of the male right antennule, a hyaline lamella on the inner margin of the basipodite on the male right fifth legs, male left fifth leg ending in a pair of pincer-like processes, male rostrum with two triangular processes, and a short female fifth leg endopodal ramus without apical setae, only with a subapical row of hairs. At this stage, we speculate that the American *Arctodiaptomus* could belong to an undescribed genus. The main reason for this statement relies on the fact that according to recent descriptions of *Arctodiaptomus* s. str. (Reddy 1994; Dussart & Defaye 1995), all the Old World species have two setae on antennule segment 11



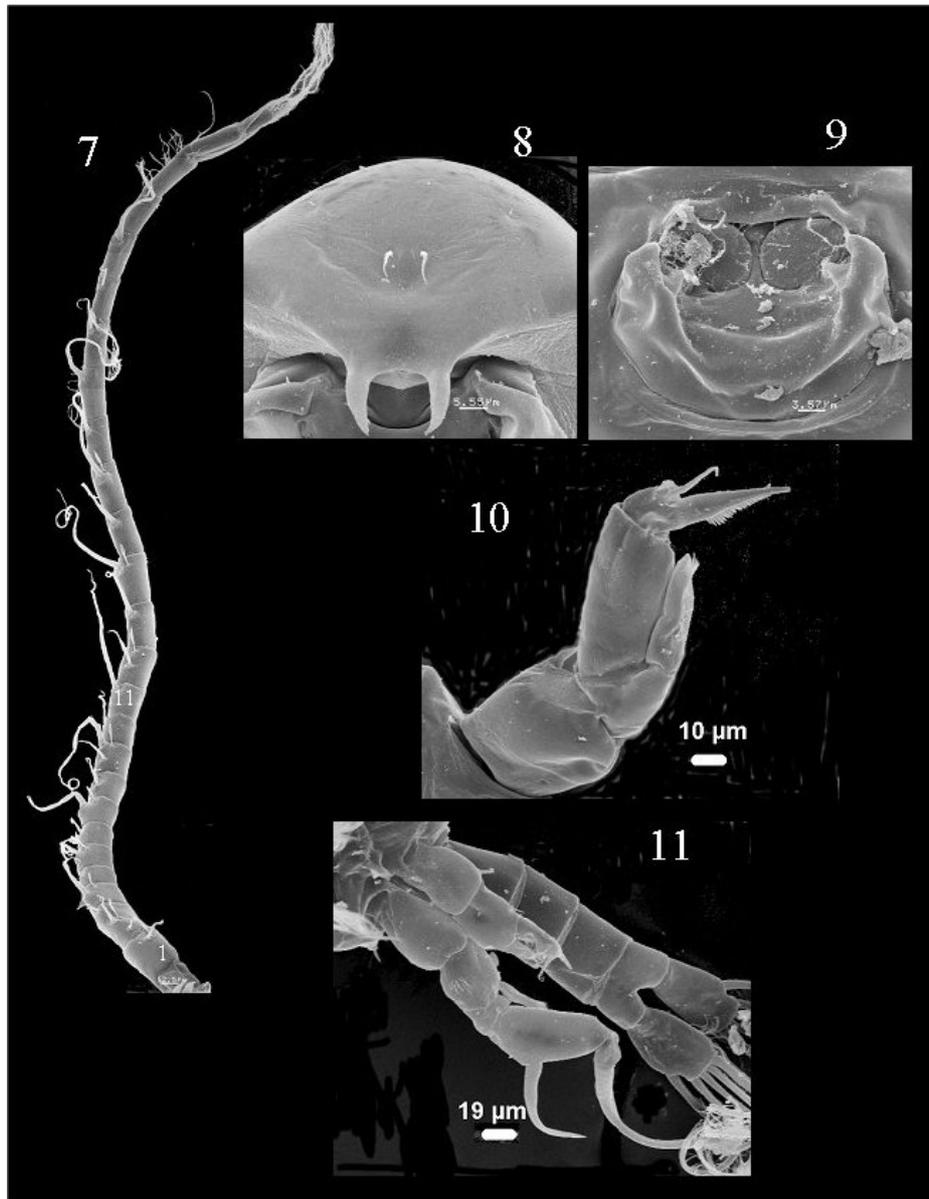
Figs 1-6. *Arctodiaptomus dorsalis* (formerly *A. dampfi*) from Lake Petén (coll. June 4, 1999) (1-2,4-5 female; 3-6 male), SEM photographs. 1. Antennula; 2. Rostral points; 3. Right antennula; 4. Genital opening; 5. Fifth leg, right side; 6. Fifth leg, right and left sides.

of females and left male antennule. Conversely, the American species have one seta only (Wilson 1959; Reed 1994). In order to have a better overview about this genus identity, there is an urgent need to study the type species *A. wierzejskii* Richard, 1888 and compare it with all the American taxa assigned to *Arctodiaptomus*.

The specimens of Lake Petén, Guatemala were identified as *Arctodiaptomus dorsalis*. This was concluded after comparison and evaluation of the most important taxonomical characters used to separate species of this genus (see Reed 1994). Among others, characters used to identify this species were the relative length of the antennules, the hyaline processes on the male fifth leg as described and depicted by Marsh (1907), and the

very long and curved lateral spine on second exopodal segment of the right fifth leg of the male. In fact, our Lake Petén specimens key down to this species in the most recent key to the New World species of *Arctodiaptomus* (Reed 1994).

Collado *et al.* (1984) made an accurate description of the history of *A. dorsalis* synonyms, including *A. proximus* and *A. alter* as well. They considered that changes of the morphology of taxonomically important appendages can be artificially produced by the preparation and mounting of the specimens for study. A comparison is presented here based on taxonomically relevant structures. The Petén specimens showed slight differences with respect to *A. dorsalis*.



Figs 7-11. *Arctodiaptomus dorsalis* from Cenote Catedrales, Yucatan Peninsula (coll. November, 1987) (7-10 female; 11 male), SEM photographs. 7. Antennule; 8. Rostral points; 9. Genital opening; 10. Left fifth leg; 11. Left and right fifth legs.

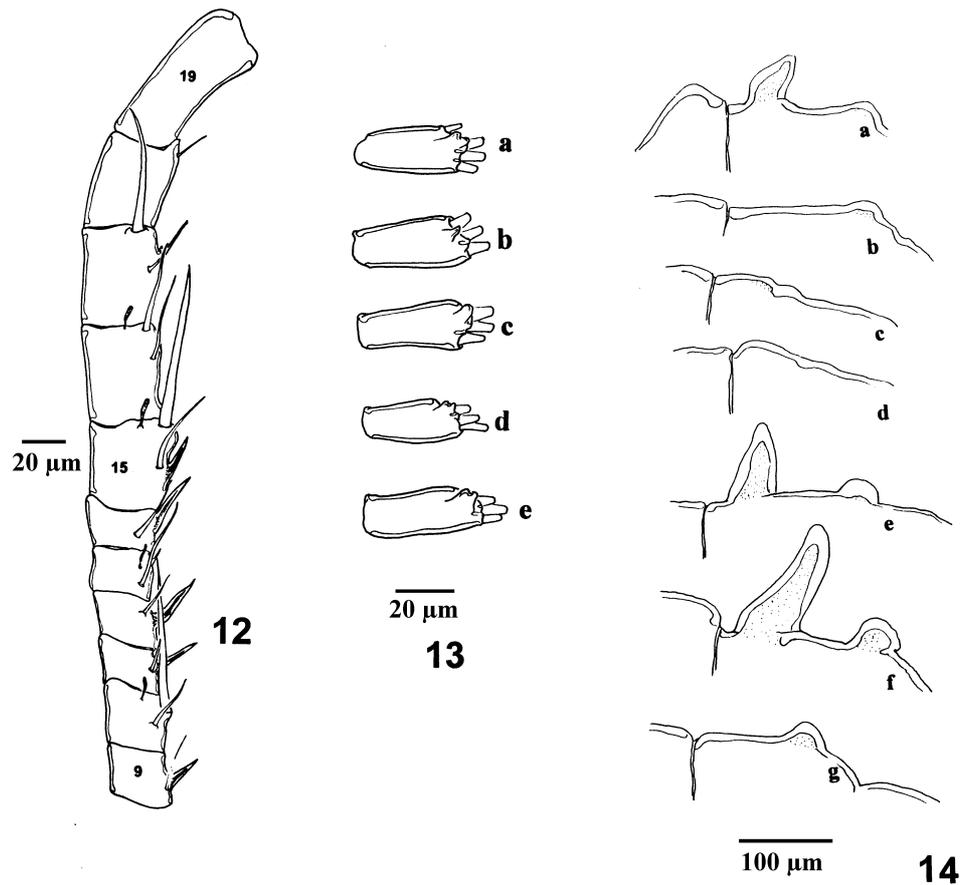
4.1.1. Male

Lake Petén specimens. Mean body length: 0.78 mm; range = 0.72-1.05 mm. Yucatan specimens ranged between 0.9 and 1.06 mm. In both cases, body slender, with a typical diaptomid shape. Rostral filaments present, rostrum represented by two robust, heavily chitinized projections with the usual process at the base, process shows the same structure in both groups compared, although they are slightly curved inwards in *A. dorsalis* from the Yucatan (Figs 2, 8).

Both groups of specimens with pediger 4 and 5 partially fused, tapering posteriorly. Pediger 5 asymmetrical, armed in each side with a spiniform process, the

right one being more acute. Urosome symmetrical, five-segmented. First urosomite slightly asymmetrical, posterior half of left lateral margin slightly protuberant. Caudal rami 1.5 times longer than wide in *A. dorsalis* from Yucatan, 1.6 in the Petén specimens. Inner and outer margins smooth, with 5 terminal caudal setae subequal in length and width, plus the dorsal one, subterminally inserted (Figs 6, 11). Caudal setae finely plumose, non-articulated, relatively short, about 2.5 times length of caudal rami. Inner and outer margins of caudal rami naked in both groups compared.

Right antennule 23-segmented (Fig. 12); segment 9 with one spine and one seta; 10 with one long seta, a short one and an aesthetasc; 11 and 12 with a spine and



Figs 12-14. *Arctodiaptomus dorsalis*. 12. Male right antennule, specimen from Yucatan; 13a-e. *Arctodiaptomus dorsalis*, male right antennule, variation of process on last segment in specimens from different localities: a. Florida, USNM 122758 ; b. Centla, state of Tabasco, Mexico; c. syntype specimen 1, USNM 296403, Guzman, Louisiana, USA; d. Lake Petén, Guatemala; e. syntype specimen 2, USNM 296403, same locality; 14a-g. Variation in shape and number of dorsal keels, a-d. population from Cuba, April 29, 1969, USNM 140776; e. from Florida, USNM 122758; f. from Sacramento USNM 211198; g. from Petén, Guatemala.

one seta; 13 with a small spine, one seta, and one aesthetasc; 14 with a strong spine and a seta; 15 with a spine, an aesthetasc and one seta; segment 16 with two setae and one aesthetasc; segment 17 with two setae. Antepenultimate segment with curved process. This process has the same structure in both cases. Last segment with small fang-like process (Figs 13a-e), similar to that known in *Acanthodiaptomus* (see Dussart 1995).

Right fifth leg (Figs 6, 11): Basis as long as first exopodal segment and slightly smaller than that of left leg; with semicircular hyaline cuticular process on anterior surface plus a small hyaline lamella on inner margin. Outer margin of exopod 1 straight, with no particular projections. Inner margin smooth, with low rounded protuberance. Exopod 2 *ca* 3 times the length of exopod 1, with cuticular hyaline process on anterior surface. Lateral spine broadly curved and borne on proximal 2/3 of segment, slightly slenderer than endopod, almost 1.4 length of exopod 2. Terminal claw relatively slender, curved, inner margin with a row of small denticles on middle portion. Claw about 2.2 times

longer than exopod 2. Endopod 1-segmented reaching about half the length of exopod 1.

Left leg 5 (Figs 6, 11) reaching about one-third of inner margin of right second exopodal segment. Coxa with small spiniform process on left antero-lateral margin. Basis with short lateral seta on outer margin. First exopodal segment almost as long as segment 2, with row of short hair-like setae on inner margin. Second exopodal segment ending in elongated digitiform process. An inner long seta is opposite to this process, and both structures form a pair of pincers. Inner margin of distal pad with a patch of hair-like setae. Endopod one-segmented, reaching midlength of exopod 2. Tip of endopod with row of short hairs inserted subterminally.

4.1.2. Female

Lake Petén specimens, mean length 0.90 mm; range = 0.77-1.08 mm. Pedigers 4 and 5 fused, pediger 5 with short wings with spiniform processes, both sides with about the same development. Urosome with two so-

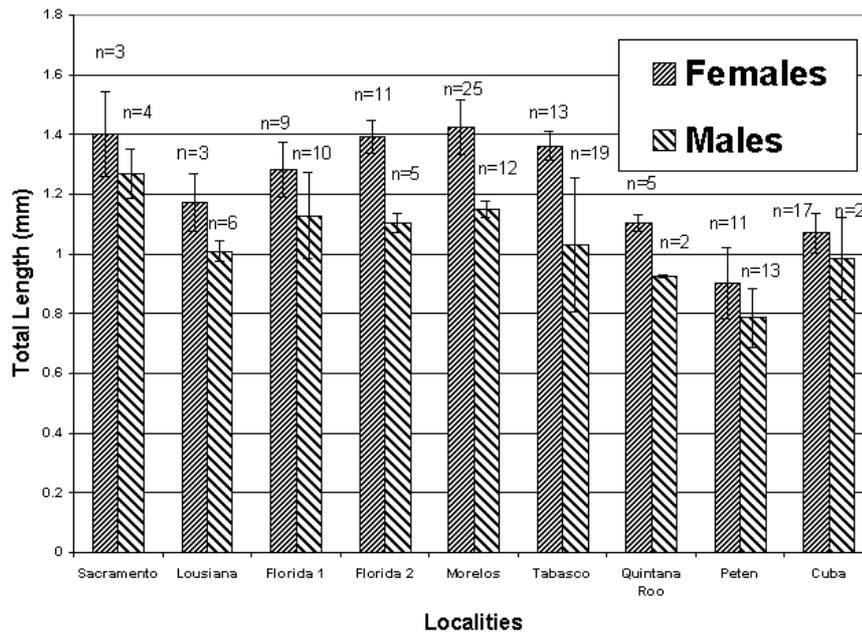


Fig. 15. Size average comparison of male and female specimens from different sites of the known distributional range of *A. dorsalis*, including material from Lake Petén, Guatemala.

mites, relative lengths of each being: 71:29 = 100. Genital double somite asymmetrical in dorsal view, with lateral protuberance on left margin with a sensilla. Genital double somite ventrally expanded, with genital openings as shown in figure 4 for the Yucatan and in figure 9 for the Petén specimens. Anal somite very short. Furca and caudal setae similar to male. Rostral points represented by two strong projections as shown in figures 2, 8. Antennules 25-segmented (Figs 1, 7), reaching beyond posterior margin of caudal rami. Segment 11 with one seta, ornamentation of segments identical on both specimens groups.

Leg 5 (Figs 5, 10): Coxa with seta on outer margin. Basis with inner margin straight. Endopod one-segmented, relatively wide, reaching almost distal margin of first exopodal segment; tip pointed, partly covered with short hairs, which are inserted subterminally (Figs 5, 10). First exopodal segment about 1.2 times longer than exopod 2, with smooth margins. Inner margin of claw armed with row of hairs along distal half. Exopod 3 reduced, with one short, strong spine and a long spini-form seta reaching beyond distal end of claw.

Habitat: Lake Petén is located in central Guatemala. It is a large meso-oligotrophic tropical lake. General conditions during sampling were: temperature of water: 30.5 °C, air temperature: 29-31 °C, Secchi disc transparency: 3.5-5.6 m, depth: 44 m.

5. TAXONOMIC REMARKS

Arctodiaptomus dampfi was described in two different documents (as *Diaptomus dampfi*) by the same

author (Brehm 1932, 1939). In the first paper, V. Brehm did not publish drawings, in the second one he depicted the male fifth leg and the right male antennule. For the female, he presented the fifth leg and the urosome in ventral view. In both papers the author compared this purported new species with the Cuban *Arctodiaptomus asymmetricus* (Marsh 1907) only, based exclusively on the fact that both species showed an Antillean distribution. Although it is evident that he used Marsh's (1907) paper, he overlooked most of the taxonomically relevant structures of *A. dorsalis* and compared his *A. dampfi* with the clearly distinct *A. asymmetricus*. He commented briefly on *A. dorsalis* in one paragraph of the Spanish paper:

"...pero las dos especies se distinguen fácilmente por las diferencias en la quinta extremidad de la hembra y porque *D. dampfi* carece de la característica protuberancia dorsal, que da al *D. dorsalis* su nombre."

This means that he separated the new species from *A. dorsalis* by differences on the female fifth leg and the absence of a dorsal keel. He did not specify which differences he found in the female fifth legs; furthermore, our observations of the dorsal keel in *A. dorsalis* support the idea that it is not a reliable specific character. The dorsal keel has a wide variability in this species, we have observed adult individuals with one, two or none dorsal protuberances in the same population (see Fig. 14). Other Mexican diaptomids with dorsal keel, such as *Mastigodiaptomus montezumae*, also show

a wide range of variation in this structure (Dussart & Defaye 1995; Dos Santos Silva *et al.* 1996). Furthermore, a comparison of the male and female fifth legs of the Petén material with that of *A. dorsalis* from different localities did not show any significant difference (see Figs 5, 6, 10, 11). In fact, Bowman (in litt.) suggested that *A. dampfi* could represent a "...*keeless population of A. dorsalis*...". Brehm (1932) did not mention or figure the spine on segment 9 of the right male antennule, which is a relevant generic character; this spine is present in the Petén specimens. The relative proportion of the spines on segments 10-15 found in both the Yucatan and Petén specimens is coincident with the depiction of this structures by Brehm (1939). He also noticed the very long lateral spine on the second exopodal segment of the male right fifth leg and mentioned it as a character shared with *A. dorsalis* but did not make additional comments on this species. Reddy (1994) outlined the relevance of the structure of the male rostral points to separate species in *Arctodiaptomus*. This structure showed no differences between the compared specimens of both localities (Figs 2, 8).

The Petén population of *A. dorsalis* showed a significant size difference (one-way ANOVA, $p > 0.001$) with respect to the specimens from other geographic localities, it represents the smallest size within all the known distributional range of *A. dorsalis* both for males and females (see Fig. 15). The largest size recorded in this work corresponded to specimens of central Mexico (Morelos) and of California (Sacramento) (Fig. 15).

We consider that there is no morphological or taxonomical justification to keep *A. dampfi* as a valid species anymore. The new synonymy documented here solves a problem not dealt with for a long time (over 65 years) due to the lack of type material. Hence, previous synonymizations were only suggested upon the brief description text and draft illustrations by Brehm (1932, 1939), and the biogeographic affinity known for *A. dorsalis*. This finding of *A. dorsalis* complements its known regional distributional range, which includes currently Costa Rica, Cuba, Hispaniola, Nicaragua, Puerto Rico, Mexico (Yucatan Peninsula, states of the Gulf of Mexico coast, and central Mexico), and southern United States, from the west to the east coast (Reid 1990; Suárez-Morales 1991; Suárez-Morales *et al.* 1996; Alvarez-Silva 1999; Gutiérrez-Aguirre & Suárez-Morales, in press). There is one previous record of this species in Guatemala (Reid 1990).

ACKNOWLEDGMENTS

We thank Janice Clark and Chad Walter (USNM) for providing material of *A. dorsalis* from the type locality (Louisiana) and from many other localities in the United States through loans 381720 and 2016644. Janet W. Reid and T.E. Bowman (in 1988) confirmed the identification of this species in the Yucatan samples.

Carlos Alvarez-Silva, Universidad Autónoma Metropolitana (UAM-Iztapalapa) and José Luis Gómez-Márquez, Universidad Nacional Autónoma de México (UNAM-Zaragoza) sent us material from the Mexican states of Morelos and Tabasco, respectively. Danielle Defaye deposited specimens of *A. dorsalis* from Lake Petén in the MNHN-Paris and provided the catalog number. Field work was supported by El Colegio de la Frontera Sur (ECOSUR), Unidad Chetumal. Guadalupe Nieto, from ECOSUR-Tapachula, kindly assisted us with SEM photographs.

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Received: November 2000

Accepted: January 2001