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Original Article

New records of two cladoceran species (Branchiopoda: Anomopoda) from Northeastern Brazil: the importance of studies in temporary ponds

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Abstract

Temporary ponds are heterogeneous aquatic environments, in which hydrodynamics and richness of macrophytes may increase the diversity of zooplankton and other invertebrate communities. Cladocerans are common residents of these ecosystems, showing great variability of forms. During a faunistic survey in temporary ponds under the influence of riparian vegetation, in the Camucim Forest Protected Area, Pernambuco Endemism Center, Brazil, the cladocerans *Moina dumonti* Kotov, Elías-Gutiérrez and Granado-Ramírez, 2005 and *Chydorus nitidulus* (Sars, 1901) were found. These are their first records in the Oriental Northeast Atlantic hydrographic region, and the second record of *M. dumonti* in Brazil. The present study raises Cladocera species richness in Pernambuco State to 73 and also 16 in the Pernambuco Endemism Center.

Keywords

Chydoridae, Moinidae, Neotropical, Pernambuco Endemism Center, zooplankton

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Introduction

Temporary pond ecosystems are abundant and occur around most of the globe, frequently threatened by human impacts and periodically exposed to water stress during the dry seasons (Williams and Hynes, 1977; De Meester *et al.*, 2005; Williams, 2005; Medeiros *et al.*, 2019). In such periods, evaporation processes reduce the volume of water bodies, affecting the availability of resources and the aquatic population dynamics (Junk, 2002; Lake, 2003). Even so, they host particularly diverse communities, sometimes exclusively, and they play an important role in the distribution of aquatic species and provide essential ecosystem services (Blaustein and Schwartz, 2001; Diniz *et al.*, 2013; Fuentes-Reinés *et al.*, 2019). The presence of riparian vegetation and macrophytes in temporary aquatic environments enhances local heterogeneity and preserves its biotic/abiotic integrity. It also promotes thermal stability, shade, shelter, and food sources for a number of animal groups, especially zooplanktonic organisms (Arcova and Cicco 1999; Thomaz and Cunha, 2010; Medeiros *et al.*, 2019).

Cladocerans are common planktonic and/or phytophilous microcrustaceans in continental aquatic ecosystems and are highly diversified in the Neotropical region. Moinidae Goulden, 1968 and Chydoridae Dybowski and Grochowski, 1894 emend. Frey, 1967 are prominent families in this region, with high endemism rates (50 % and 57.3 %, respectively) (Forró *et al.*, 2008). The Moinidae, particularly the genus *Moina* Baird, 1850, are opportunistic, thermal stress-tolerant, and typical pelagic components in temporary water bodies (Petrusek, 2002; Farias *et al.*, 2017). On the other hand, the Chydoridae are very specialized organisms, with limited ability for dispersion, which results in high endemism rates (Fryer, 1968). Herein, we report two new records of the cladocerans *Moina dumonti* Kotov, Elías-Gutiérrez and Granado-Ramírez, 2005 and *Chydorus nitidulus* (Sars, 1901) for Northeastern Brazil, briefly discuss some of their morphological traits and the environmental context in which they were found.

Material and Methods

The specimens were sampled in May 2018 during zooplankton biodiversity assessments in temporary ponds under the influence of riparian vegetation. The surveys were carried out in the Camucim Forest Protected Area, near Tapacurá Ecological Station, in São Lourenço da Mata municipality, part of the Oriental Northeastern Atlantic Basin (Fig. 1, Tab. 1).

Figure 1. Distribution records of *Moina dumonti* Kotov, Elías-Gutiérrez and Granado-Ramírez, 2005 and *Chydorus nitidulus* (Sars, 1901) in Neotropical regions.

Table 1. New and previous records of *Moina dumonti* Kotov, Elías-Gutiérrez and Granado-Ramírez, 2005 and *Chydorus nitidulus* (Sars, 1901) in Neotropical regions. Abbreviations for Brazilian States: BA = Bahia; GO = Goiás; MG = Minas Gerais; MS = Mato Grosso do Sul; MT = Mato Grosso; PA = Pará; PE = Pernambuco; PR = Paraná; RJ = Rio de Janeiro; SC = Santa Catarina; SP = São Paulo.

Species / Locality	Habitat	Coordinates	Reference
Moina dumonti			
Felipe Carrillo Puerto, México	Temporary pond	19°23'37.9"N 88°37'12.1"W	Kotov *et al.*, 2005
Playa de Guanabo, Cuba	Temporary pond	23°09'40.2"N 82°07'21.3"W	Kotov *et al.*, 2005
Rio de Janeiro, RJ, Brazil	Permanent pond	23°01'24.80"S 43°28'17.93"W	Farias *et al.*, 2017
Camucim Forest Protected Area, PE, Brazil	Temporary pond	08°01'59.8"S 35°12'03.8"W	Present study
Camucim Forest Protected Area, PE, Brazil	Temporary pond	08°02'18.2"S 35°12'2.97"W	Present study
Camucim Forest Protected Area, PE, Brazil	Temporary pond	08°02'5.07"S 35°11'57.38"W	Present study
Chydorus nitidulus			
Camucim Forest Protected Area, PE, Brazil	Temporary pond	08°02'24.8"S 35°11'48.5"W	Present study
Camucim Forest Protected Area, PE, Brazil	Temporary pond	08°02'18.2"S 35°12'2.97"W	Present study
Mata da Pimenteira, PE, Brazil	Temporary pond	07°53'48.96"S 38°18'14.30"W	Diniz *et al.*, 2013
Brígida River, PE, Brazil	River	08°05.183'S 39°34.694'W	Diniz *et al.*, 2020
Santa Rita, BA, Brazil	Reservoir	14°11'14"S 39°42'27"W	Macêdo *et al.*, 2021
Bom Sucesso Farm, BA, Brazil	Reservoir	14°10'25"S 39°44'19"W	Macêdo *et al.*, 2021
Pedra do Cavalo Dam, BA, Brazil	Reservoir	12°35'51.9"S 39°00'16.4"W	Macêdo *et al.*, 2021
Formosa lagoon, GO, Brazil	Permanent lagoon	15°09'15.8"S 47°28'04.7"W	Elmoor-Loureiro, 2007
Flores do Goiás swamp, GO, Brazil	Temporary swamp	14°18'23.9"S 46°57'34.0"W	Elmoor-Loureiro, 2007
Baía do Castelo, MS, Brazil	Permanent pond	18°31'36.0"S 57°34'54.3"W	Hollwedel *et al.*, 2003
Lago Buritizinho, MS, Brazil	Permanent pond	18°25'33.1"S 54°49'39.2"W	Güntzel *et al.*, 2010
Lago Ribeirão, MS, Brazil	Permanent pond	18°25'14.7"S 54°50'31.6"W	Güntzel *et al.*, 2010
Rio Taquari, MS, Brazil	Permanent pond	18°25'19" S 54°50'41"W	Panarelli *et al.*, 2013
Lago Souza Lima, MT, Brazil	Permanent pond	15°43'27.3"S 56°06'52.4"W	Neves *et al.*, 2003
Lagoa dos Patos, MS, Brazil	Permanent pond	22°49'S 53°33'W	Serafim-Júnior *et al.*, 2003
Represa Paraibuna, SP, Brazil	Reservoir	23°26'53"S 45°33'44"W	Rocha *et al.*, 2011
Represa Itaiquara, SP, Brazil	Reservoir	21°35'05"S 46°44'52"W	Rocha *et al.*, 2011
Lagoa do Peixe, SP, Brazil	Permanent pond	21°37'25"S 47°48'24"W	Rocha *et al.*, 2011
Represa Mogi, SP, Brazil	Reservoir	22°22'44.7"S 46°53'17.3"W	Rocha *et al.*, 2011
Lago Fazenda Socorro, SP, Brazil	Permanent pond	20°57'49"S 48°40'45"W	Rocha *et al.*, 2011
Lago Fazenda Brazil, SP, Brazil	Permanent pond	20°45'46"S 49°32'58"W	Rocha *et al.*, 2011
Lago Marechal Rondon, SP, Brazil	Permanent pond	21º11'44"S 50º53'52"W	Rocha *et al.*, 2011
Lago marginal, Rio Aguapeí, SP, Brazil	Permanent pond	21º42'24"S 50º30'48"W	Rocha *et al.*, 2011
Reservatório Chavantes, SP, Brazil	Reservoir	23°08'27"S 49°42'24"W	Rocha *et al.*, 2011; Perbiche-Neves and Nogueira, 2010
Vicentinópolis, SP, Brazil	Temporary pond	20°56'00"S 50°20'51"W	Castilho-Noll *et al.*, 2010
Macaubal, SP, Brazil	Permanent pond	20°44'40"S 49°56'13"W	Castilho-Noll *et al.*, 2010
Novo Horizonte, SP, Brazil	Permanent pond	21°30'10"S 49°18'29"W	Castilho-Noll *et al.*, 2010
Represa Promissão, SP, Brazil	Reservoir	21°25'33"S 49°29 59"W	Castilho-Noll *et al.*, 2010
Planalto, SP, Brazil	Permanent pond	21°00'54"S 49°58'41"W	Castilho-Noll *et al.*, 2010
União Paulista, SP, Brazil	Permanent pond	20°54'28"S 49°55'17"W	Castilho-Noll *et al.*, 2010
Magda, SP, Brazil	Permanent pond	20°32'00"S 50°11'43"W	Castilho-Noll *et al.*, 2010
Matão, SP, Brazil	Permanent pond	21°36'18"S 48°33'12"W	Castilho-Noll *et al.*, 2010
Matão 3, SP, Brazil	Permanent pond	21°36'25"S 48°30'33"W	Castilho-Noll *et al.*, 2010
Represa Jurumirim, SP, Brazil	Permanent pond	23°31'40.7"S 48°38'10.5"W	Debastiani-Júnior *et al.*, 2016
Rio Itajaí-Açu, SC, Brazil	River	26°53'27.5"S 49°14'05.4"W	Serafim-júnior *et al.*, 2006
Represa do Iraí, PR, Brazil	Reservoir	25°23'44.8"S 49°06'10.7"W	Ghidini and Santos-Silva, 2009
Reservatório Salto Grande, PR, Brazil	Reservoir	22°56'43"S 49°57'60"W	Rocha *et al.* 2011
Lago dos Patos, MG, Brazil	Permanent pond	19°48'19.9"S 42°32'12.7" W	Maia-Barbosa *et al.*, 2014

Table 1. Cont.

Species / Locality	Habitat	Coordinates	Reference
Lago Dom Helvácio, MG, Brazil	Permanent pond	19°46'55.7''S 42°35'28.9''W	Maia-Barbosa *et al.*, 2014
Rio Xingu, PA, Brazil	River	01°55'29.1''S 52°13'53.8''W	Matsumura-Tundise *et al.*, 2015
Lago Batata, PA, Brazil	Permanent pond	01°30'S 56°20'W	Sodré *et al.*, 2017
Laguna Navio Quebrado, Colombia	Saline lagoon	11°25'N 73°05'W	Fuentes-Reinés, 2014
Maicao, Colombia	Temporary pond	11°23'04.63"N 72°16'31.10"W	Fuentes Reinés *et al.*, 2019
Santa Elena, México	Temporary pond	18°04'45''N 92°01'32''W	Elías-Gutiérrez *et al.*, 2006
Chicanná, México	Temporary pond	18°30'50''N 89°28'50''W	Elías-Gutiérrez *et al.*, 2006

This area is located within the Atlantic Forest Biome, and precisely in the Pernambuco Endemism Center (Silva and Casteleti, 2003). The climate is categorized as Tropical with dry summer (Köppen's classification criteria: "As"), with annual average temperature varying from 24 to 26 °C, and annual rainfall at about 1200 mm, from March to July (Alvares *et al.*, 2013).

Six ponds were chosen for sampling in this area (see Medeiros *et al.*, 2019). Environmental data were obtained through a multiparameter water-quality meter, Horiba-U50. For each station, a minimum of 10 liters of water were filtered using a 20 µm net, and the organisms retained were fixed in 4 % neutral formalin. Specimens were identified under a light microscope, according to literature (*e.g.*, Elmoor-Loureiro, 1997; Farias *et al.*, 2017), and deposited in the Zooplankton Collection of the Federal Rural University of Pernambuco (vouchers CZ-UFRPE: 18008, 18010, 18011, 18019, 18029, 18034).

Systematics

Class Branchiopoda Latreille, 1817

Order Anomopoda Sars, 1865

Suborder Aradopoda Kotov, 2013

Family Moinidae Goulden, 1968

Genus *Moina* Baird, 1850

***Moina dumonti* Kotov, Elías-Gutiérrez and Granado-Ramírez, 2005**
(Fig. 2)

Material examined. 1 ind. (CZ-UFRPE 18010), Camucim Forest Protected Area, São Lourenço da Mata, Pernambuco, 8°02'18.2''S 35°12'2.97''W (WGS84), 09 May 2018, colls. R.F. de Oliveira and F.A. Santos; 7 ind. (CZ-UFRPE 18011), 4 ind. (CZ-UFRPE 18029), Camucim Forest Protected Area, São Lourenço da Mata, Pernambuco, 8°02'14''S 35°12'01''W, 09–10 May 2018, colls. R.F. de Oliveira and F.A. Santos; 1 ind. (CZ-UFRPE 18019), Camucim Forest Protected Area, São Lourenço da Mata, Pernambuco, 8°01'59.8"S 35°12'03.8"W, 10 May 2018, colls. R.F. de Oliveira and F.A. Santos.

Specimens. All *M. dumonti* specimens have morphological characters corresponding to the original description (Kotov *et al.*, 2005) (Fig. 2); with body structures of parthenogenetic females (Fig. 2a) and males (Fig. 2b), although it was not possible to observe the presence of ocellae at the base of the first antenna. Females show short and practically cylindrical antennae, with an aesthetasc tip of similar size (Fig. 2c); whereas males showed long and slightly curved antennae, distally with four similar hook-like setae (Fig. 2d). Postabdomen with terminal claw showing basal pecten with five spines in females (Fig. 2e) and four in males (Fig. 2f). All males showed the same set of spines on the basal pecten. This morphological character easily distinguishes this species from its congeners. The setulated hook in the dorsal portion of the posterior valve observed by Farias *et al.* (2017) does not exist in females (Fig. 2g) or males (Fig. 2h) sampled in the present study.

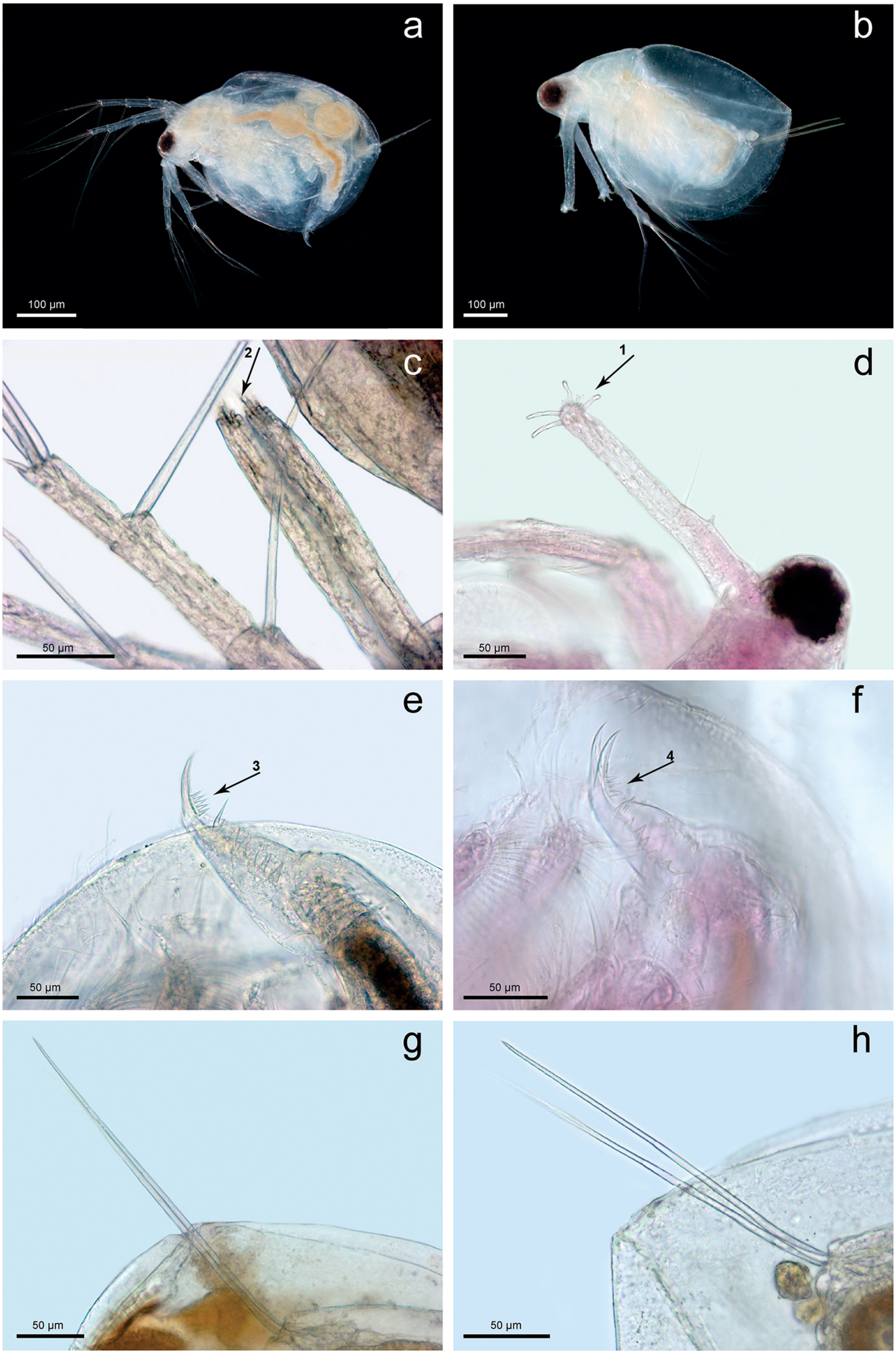

Figure 2. Specimens of female (**a, c, e, g**) and male (**b, d, f, h**) of *Moina dumonti* Kotov, Elías-Gutiérrez and Granado-Ramírez, 2005 from Camucim Forest Protected Area, Pernambuco, Brazil. **a**, Parthenogenetic female; **b**, male; **c**, antenna I, aesthetasc of similar size (Arrow-2 setae); **d**, antenna I, Arrow-1 points to four hook-like setae; **e**, postabdomen (Arrow-3: set of teeth - n: 5); **f**, postabdomen (Arrow-4: set of teeth - n: 4); **g, h**, back of the dorsal valve of female and male, respectively.

Ecology and habitat. Parthenogenetic females, ephippials and males were collected in two distinct environments: two ponds with riparian vegetation and a predominance of the macrophyte *Lemna* on the waterline; and one pond without riparian vegetation and a predominance of the macrophyte *Azolla*. These environments showed population densities of 27,208 ind/m^3 and 833 ind/m^3, respectively. The influence of riparian vegetation on the zooplanktonic communities of these ponds was described by Medeiros *et al.* (2019), who associated the occurrence of *M. dumonti* with low water turbidity (45.81 ± 27.84 NTU), high oxygenation (5.17 ± 2.10 mg L^{-1}), and variable *a*-chlorophyll concentrations (23.31 ± 28.07 μg L^{-1}).

Distribution. Since its description, *M. dumonti* has been recorded in three environments in the world: two temporary habitats in Mexico and Cuba (Kotov *et al.*, 2005) and one perennial lagoon in Rio de Janeiro, Brazil (Farias *et al.*, 2017). In this study, the specimens were recorded in a habitat similar to its type-locality, temporary ponds, for the first time in the Brazilian Northeast region (Fig. 1). Thus, this species is now recorded in Southeast Atlantic (SE) and Oriental Northeast Atlantic (NOr) hydrographic regions of Brazil.

Suborder Radopoda Dumont and Silva-Briano, 1998

Family Chydoridae Dybowski and Grochowski, 1894 emend. Frey, 1967

Subfamily Chydorinae Dybowski and Grochowski, 1894 emend. Frey, 1967

Genus *Chydorus* Leach, 1816

***Chydorus nitidulus* (Sars, 1901)**
(Fig. 3)

Material examined. 1 ind. (CZ-UFRPE 18008), Camucim Forest Protected Area, São Lourenço da Mata, Pernambuco, 8°02’24.8”S 35°11’48.5”W (WGS84), 09 May 2018, colls. R.F. de Oliveira and F.A. Santos; 12 ind. (CZ-UFRPE 18010), 2 ind. (CZ-UFRPE 18034), Camucim Forest Protected Area, São Lourenço da Mata, Pernambuco, 8°02’18.2’’S 35°12’2.97’’W (WGS84), 09 and 11 May 2018, colls. R.F. de Oliveira and F.A. Santos.

Specimens. The specimens of *C. nitidulus* show characters similar to their latest descriptions (Elmoor-Loureiro, 1997). In Fig. 3a, the body structure of a parthenogenetic female is represented, with oval body and postabdomen exposed. Arrow indicates the naked and elongated labral keel, which is diagnostic for this species. Details of postabdomen are typical, showing terminal claw chitinized and curved, with two basal spines of different sizes (Fig. 3b). Valves have one denticle in the posteroventral corner (Fig. 3c).

Ecology and habitat. Parthenogenetic females of *C. nitidulus* were recorded in environments limnologically distinct from those of *M. dumonti*, although both species were collected in stations dominated by *Lemna*. The specimens sampled in the present study occurred in ponds with both degraded and preserved riparian vegetation, which show high turbidity (132 ± 96.55 NTU), low oxygenation (3.57 ± 2.73 mg L^{-1}) and low *a*-chlorophyll concentration (14.24 ± 13.76 μg L^{-1}).

Distribution. *Chydorus nitidulus* is a Neotropical species, previously recorded in Venezuela (Rey and Vásquez, 1886; Vásquez and Rey, 1989), Argentina (Paggi, 1972), Brazil (Elmoor-Loureiro, 1997), Mexico (Elías-Gutiérrez *et al.*, 2006), and Colombia (Fuentes-Reinés, 2014; Fuentes-Reinés *et al.*, 2019). In Brazil, this species was mainly recorded in the hydrographic regions of Amazonia (AM), Paraguay (PG), Paraná (PR), São Francisco (SF), East (AL), South (SA) and Southeast Atlantic (SE), and Tocantins/Araguaia (TA) (see Fig. 1 and Tab. 1, for references). Thus, this study expands the distribution of *C. nitidulus* to the Oriental Northeast Atlantic hydrographic region (NOr) and to Atlantic forest ponds in Northeastern Brazil.

Discussion

In Northeastern Brazil, most studies on Cladocera were performed in large water bodies, such as reservoirs, rivers, and shallow lakes (Sousa *et al.*, 2009; Soares and Elmoor-Loureiro, 2011; Medeiros and Melo Júnior, 2016; Cabral *et al.*, 2020). This is in contrast with studies on smaller and temporary aquatic environments (*e.g.*, ponds and pools), which are rare (Diniz *et al.*, 2013; Melo and Medeiros, 2013).

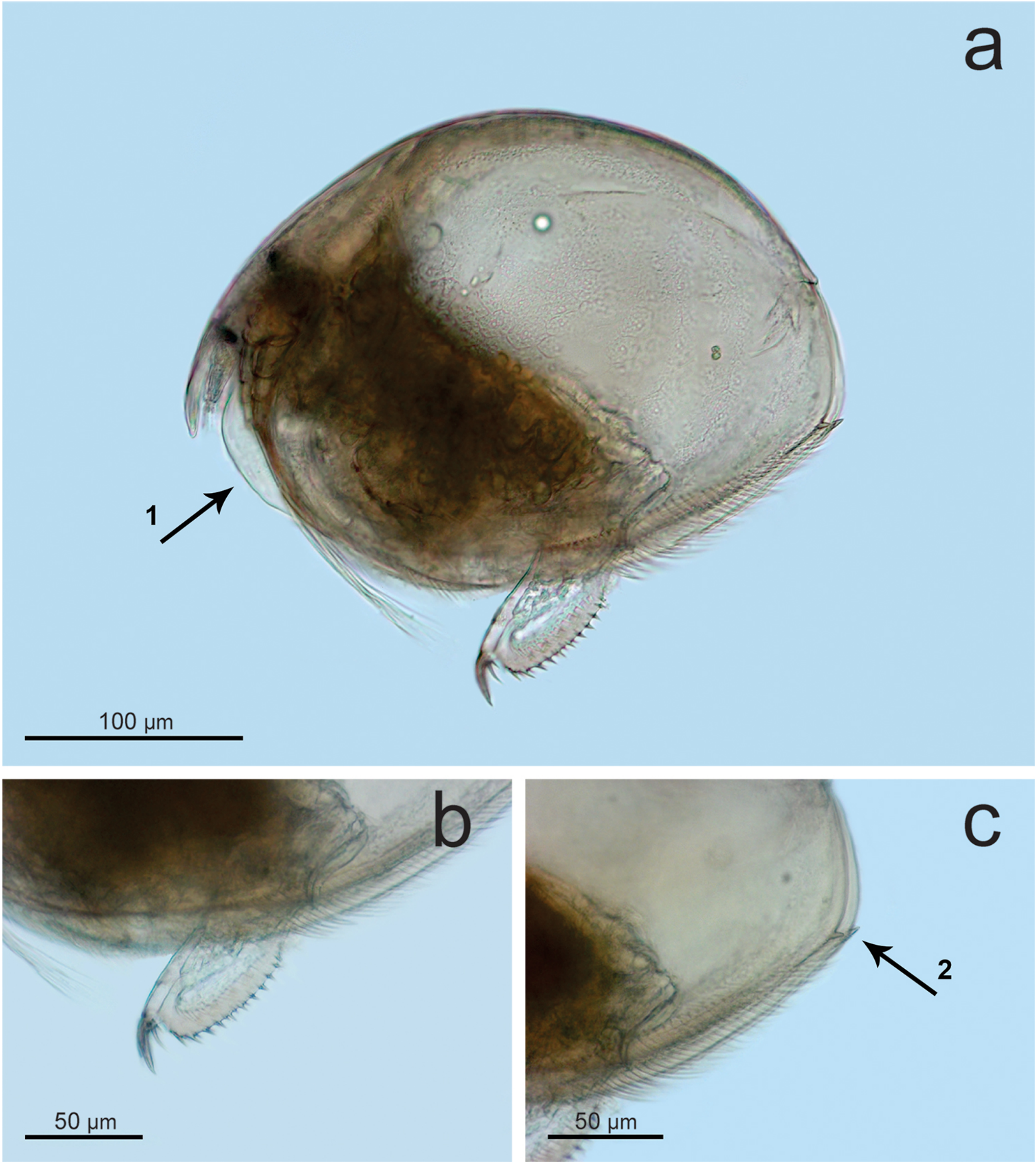

Figure 3. Specimen of *Chydorus nitidulus* (Sars, 1901) from Camucim Forest Protected Area, Pernambuco, Brazil. **a**, Habitus of a female (Arrow-1: labral keel); **b**, postabdomen; **c**, valves (Arrow-2: denticle in the posteroventral corner).

These latter ecosystems are numerous, heterogeneous, and important to conservation, because they are highly dynamic and hold highly specialized species (De Meester *et al.*, 2005). Cladoceran species are very diversified in these habitats, because their structure and dynamics are affected by fluctuations in biotic and abiotic conditions (Crispim and Freitas, 2005; Diniz *et al.*, 2013). However, this aquatic community is often threatened because temporary habitats are more susceptible to human impacts. Pollution, trampling by cattle, eutrophication, the introduction of exotic species, and deepening to a permanent state are the most common impacts (Wiliams and Hynes, 1977; De Meester *et al.*, 2005).

This study fills a latitudinal gap in the distribution of *M. dumonti* between the tropical north and the subtropical southern hemispheres (Kotov *et al.*, 2005; Farias *et al.*, 2017). The previously disjointed distribution is attributed to its early description (Kotov *et al.*, 2005) but also reveals how poorly studied the habitats are that this species inhabits (*e.g.*, temporary ponds). This study records for the second time the occurrence of this cladoceran species in Brazil. On the other hand, although *C. nitidulus* has been recorded in a wide variety of aquatic habitats in Northeastern Brazil (Tab. 1), a similar situation occurs with this species, which has hitherto only had two records in temporary ponds (Diniz *et al.*, 2013). With the inclusion of *M. dumonti*, this study expands to 73 the list of Cladocera species registered in Pernambuco State. The region now features four species of Moinidae and 43 of Chydoridae (Soares and Elmoor-Loureiro, 2011; Diniz *et al.*, 2013; Sousa *et al.*, 2015a; 2015b; Medeiros and Melo-Júnior, 2016; Medeiros *et al.*, 2019; Diniz *et al.*, 2020). Our results also reinforce the importance of performing further research and inventories in temporary environments to expand the knowledge about associated aquatic diversity, especially in the remnants of the Brazilian Atlantic Forest.

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