Estudos de
BIOLOGIA Ambiente e Diversidade

ORIGINAL PAPER

Swarmings of *Moina micrura* Kurz, 1874 (Cladocera: Crustacea) in a semi-arid Brazilian temporary pool

Agrupamentos de Moina micrura Kurz, 1874 (Cladocera: Crustacea) em um lago temporário no semi-árido brasileiro

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Abstract
Temporary aquatic environments are dependent on the rainfall distribution and form after extended periods of drought. The occurrence of groups of the cladoceran Moina micrura Kurz, 1874 was recorded in a temporary pool studied is located in the municipality of Monte Alegre de Sergipe, Sergipe State, Brazil. The mean abundance for each group was of 2,670 ± 2,089 individuals. Compared to other studies, we found a higher numbers of males (26 ± 6 individuals) and of ephippial females (30 ± 20 individuals). Therefore, the presence of males and ephippial females points to reproductive function of these groups, due to the dryness processes of these small pools

Keywords: *Caatinga. Environmental stress. Ephippial eggs*

Resumo
Ambientes aquáticos temporários dependem da distribuição de chuvas e se formam depois de extensos períodos de seca. A ocorrência de grupos de cladóceros Moina micrura Kurz 1874 foi observada em uma pequena lagoa na região do semi-árido, no município de Monte Alegre de Sergipe, Sergipe, Brasil. A abundância média entre três grupos analisados foi de 2.670 ± 2.089 indivíduos. Comparado a populações de outros estudos, um número alto de machos (26 ± 6 indivíduos) e de fêmeas com ovos de resistência (30 ± 20 indivíduos) foi encontrado. Esses resultados permitem inferir que a elevada abundância de indivíduos machos e fêmeas com efípios nos grupos de cladóceros aponta para a função reprodutiva, acionado pelo sequente ressecamento dessas pequenas lagoas.

Palavras-chaves: Caatinga. Estresse ambiental. Ovos de resistência. Machos.

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Introduction

Studies in water pools allow a better understanding of the aquatic systems, because they have small and simple hydrodynamics, when compared to a man-made lake, and they are often temporary. These characteristics, possibly, inhibit the interest of many researchers, and nowadays there are few studies in this type of environment, as Crispim & Freitas (2005) and Diniz *et al*. (2013). Moreover, temporary pools can bring about important discoveries. Several microcrustaceans species have been described in these environments (Brehm, 1933; Dodson, 1985; Paggi, 2011), they can tolerate wide ranges of water temperature, for example. The ecological dynamics in these environments is also differentiated, especially by receiving environmental stresses such as the extended dry season or freezing (Perbiche *et al.*, 2011).

The cladocerans populations are usually only constituted by female individuals, which reproduce by parthenogenesis (Forró, Korovchinsky, Kotov, & Petrusek, 2008). The presence of males in the population is usually associated with some environmental stress, such as drought and/or drying, or predator presence. These individuals appear in order to form resistant eggs or ephippia, which ensure population maintenance after hatching, when the environment is once more favorable. Figuerola and Green (2002) also indicate that resistant eggs can exert a passive dispersion function, since they typically resist the passage through the digestive tract of birds, and probably also other animals.

Cladocerans behavior is complex (Kotov, 2000) and swarming patterns can be related to different reasons. De Meester, Maas, Dierckens and Dumont (1993), Young, Watt, Grover and Thomas (1994), Pijanowska and Kowalczewski (1997), and Kotov (2000) reported aggregation for some cladocerans species and attribute the fact to a behavioral response to avoid predation. Kotov (2000) also found cladocerans swarmings in the littoral zone of a lake in Russia, but he did not find ephippia resistant eggs or males, discarding the reproductive function of these swarmings. Cuddington and McCauley (1994) observed patches of *Ceriodaphnia dubia* Richard, 1984 and *Daphnia pulex* Leydig, 1860 for feeding and for movement. Only for *Daphnia magna* Straus, 1820 sexual swarming patterns are known (Young, 1978), but in general the patch formation for reproduction is little known worldwide (Ratzlaff, 1974) – the records for cladocerans are presented in this paper, and there is no record of this behavior in Brazil.

The aim of this study is to report the occurrence of groups of *Moina micrura* Kurz, 1874 in a temporary environment in the drying process, presumably with reproductive functions, as indicated by the relatively high presence of males (0.1%) and females with resistant eggs and ephippia.

Material and methods

The temporary pool studied is located in the municipality of Monte Alegre de Sergipe, in the margin of the highway SE-206 in the northern extreme of the Brazilian state of Sergipe (09º58’306”S and 37º35’439”W). This area is located within the Caatinga morphoclimatic domain, as defined by Ab'Saber (1974). The temporary pool had approximated an area of 600m^2, it also had semi-circular shape, and maximum approximated depth of 70cm (Figure 1a). At the moment of sampling, the pool had an estimated area of 300m^2 and was 30cm deep, clearly demonstrating that it was going through the drying process.

The climate of the region is characterized by relatively reduced and infrequent rainfall, with annual precipitation of approximately 500 mm, distributed mainly between April and

August, the period locally known as the winter. Rainfall is minimal during the remaining months, although the quantity and distribution of precipitation may vary considerably among years. Temperatures are relatively high throughout the year, with means around 30 °C during the dry season, but there is also an accentuated diurnal temperature range.

Cladocerans sampling was carried out in depressions of 20cm in July 26th, 2012. In three locations around of the pool (Figure 1a), cladocerans patches were fully collected by aspiration of the organisms. The patches were measured with a single rule in its diameter (cm).The samples were preserved in 70% alcohol. Cladocerans were identified (Elmoor-Loureiro, 1997) and quantified under an optical microscope. The samples of cladocerans groups were quantified to estimate the abundance of individuals and after a mean was made. The final density was expressed in ind.m^{-3}. The organisms were classified into parthenogenetic females, parthenogenetic females with embryo, ephippial females with resistant egg and males.

Results

Swarming of *Moina micrura* was found in the depressions of the temporary pool about 20 cm in diameter each (Figure 1b, c). The animals were actively swimming. A mean of 2.670 ± 2.089 individuals was found per patch, a very high concentration compared to other studies (see discussion).When performing a density estimate, we registered400,000 ind.m^{-3}. We found an average of 1.402 ± 1.081 (mean ± standard deviation) parthenogenetic females (=52.5% of total), 1.211 ± 1.023 parthenogenetic females with embryo (=45.3%), 30 ± 20 ephippial females (1.12%), and 26 ± 6 males by patch (=0.97%). All individuals presented a red coloration. Besides cyclopoid copepods and Insecta larvae, no vertebrate predators (i.e., fish) were found.

Discussion

The species *Moina micrura* patches observed in this study reinforce the idea that cladocerans exhibit complex behaviors, as stated by Young (1978) and Kotov (2000).Since the drying process of the pool sampled was at beginning, cladocerans performed sexual reproduction with male individuals, resulting in the formation ofresistant eggs, repeating a cycle that is possibly normal for this kind of environment.

The absence of animals with significant potential for predation, probably contributed the swarming of these organisms in large numbers than other studies, which pointed swarming by predators influence (Chang & Hanazato, 2003; Kotov, 2000; Pijanowska & Kowalczewski, 1997; Young *et al*., 1994). These swarming, would possibly be an easy target for visual predators such as fish, due to conspicuity provided by the large number of organisms and their red coloration. Swarming detected by other authors such as Kotov (2000), showed lower abundances than the ones observed in the present study, although in this case, they were only monospecific. One sample period could be contribute to found only one species. Probably there are few species of Cladocera in the present temporary lake, no more than 3, in contrast to another shallow lake – but almost ten times larger - located 215km far from the North, at Pernambuco State, with 22 species (Diniz et al., 2013). Cladocerans patches had a diameter of about 20cm, not exceeding 20 cm in depth. Thus, the estimated abundance was very high, exceeding values found in other semiarid pools (Diniz et al., 2013), reservoirs of different trophic levels (Nogueira *et al*., 2008), and eutrophic environments (Ghidini *et al*., 2009).

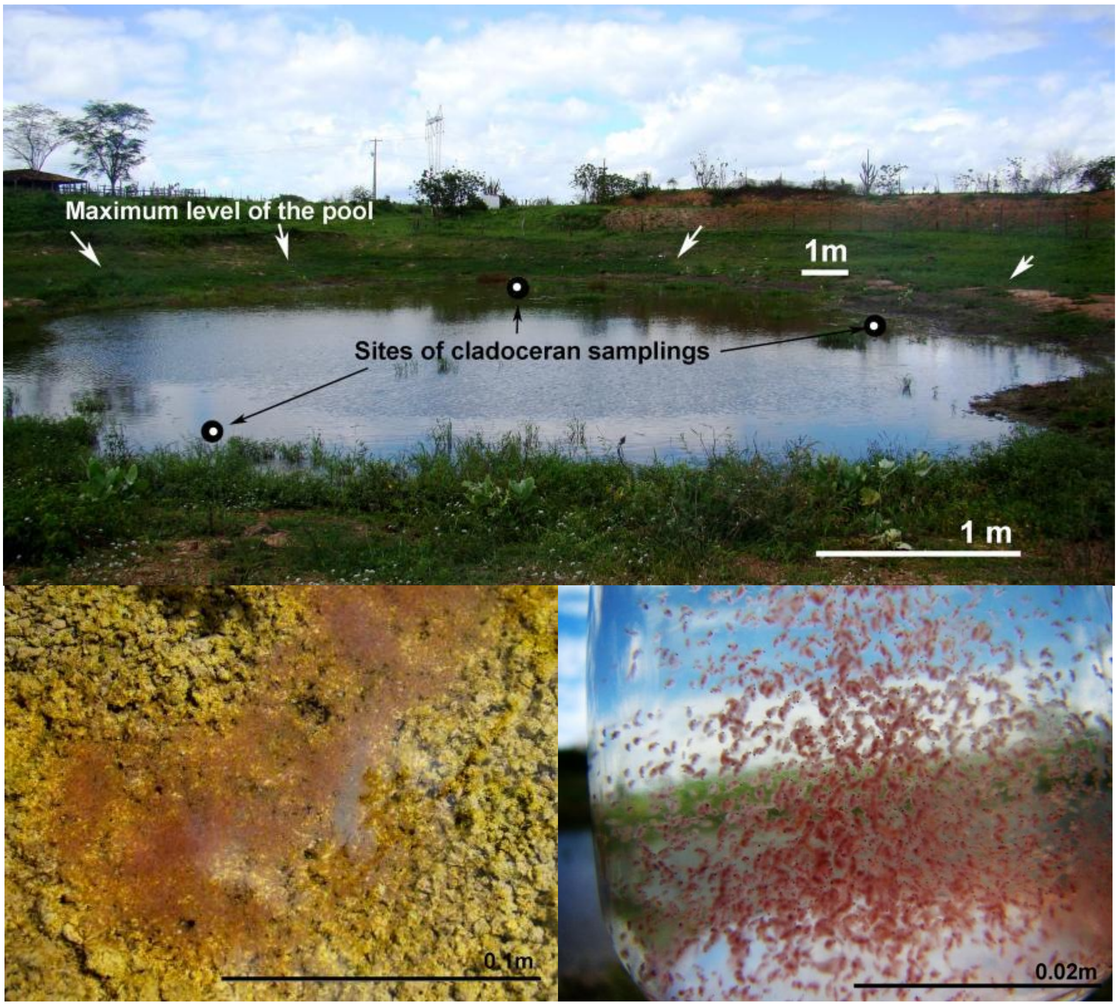

Figure 1. (upper) Overview of the temporary pool. The arrows indicate the maximum height reached by the water during the rainy season, with 1m of depth; (lower left) Photo showing the formation of patches of *Moina micrura* in the temporary pool; (lower right) *M. micrura* alive after sampling, emphasizing the high concentration of individuals and their red coloration. For all figures the scales are in meters (m). Source: composition of the author

The red color detected in the organisms is possibly due to molecules such as carotene or some other homologous to hemoglobin (Green, 1957). These pigments may have protective function against solar radiation, due to the low depth of the pool and also due to water transparency, or they allow tolerance to low concentrations of dissolved oxygen in water (Hansson, 2000; Landon & Stasiak, 1983; Pirow *et al*., 2001). However, the pigmentation in micro crustaceans increases their vulnerability to visual predators (Hansson, 2004; Tollrian & Heibl, 2004), typically the production of carotene or hemoglobin is reduced in the presence of predators (Hansson, 2004; Hylander *et al*., 2012; Landon & Stasiak, 1983; Tollrian & Heibl, 2004). Thus, the absence of visual predators in the pool would have favored the intense red coloration of the organisms, as observed by Landon and Stasiak (1983) and Engle (1985).

In the present study, due to drying stress in semiarid pools, reproductive individuals at different stages were found, including females with resistant eggs and also males, a clear signal of stress in the environment because cladocerans are typically parthenogenetic (Elmoor-Loureiro, 1997).These results contrast with other studies previously cited about predation effects and suggest that the aggregation found may be related to reproductive adaptive strategies characteristics of the species, being the first record of this fact in Brazil and in the Neotropical region.

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