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Relict populations of *Diaphanosoma* (Cladocera: Ctenopoda) in the Chadian Sahara, with the description of a new species

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Abstract

We record two species of *Diaphanosoma* from Ounianga and Tibesti in Northern Chad, the first ctenopods to be found in the Sahara desert. One species, from a freshwater guelta on the south flanks of the Tibesti (*D. excisum*) is tropical; the second species, found in a freshwater lake in a largely saline environment (the Ounianga plateau) is new to science (*D. bopingi* **sp.nov**.) and is here described, with special attention to some previously unnoticed structures on the postabdomen. Its relatives are northern species that may transgress into the tropics but largely live outside of them. They are also more salt-tolerant than the tropical *D. excisum*. The latter is considered a relict of Megachad times, while the new species is considered a relict of more humid but also cooler times in the desert.

Key words: Ctenopods, cladocerans, Tibesti mountains, Ounianga plateau, climate change, relicts, green Sahara

Introduction

The south-eastern Sahara offers several peculiarities. Not only is it one of the desert's driest zones, with mean precipitation extremely low (around 5 mm *per annum* at Ounianga Kebir, around 12 mm *per annum* at Bardai, 1200m asl, but up to 100–150 mm *per annum* above 2000 m and not exceptionally snowfall in winter), and a record potential evaporation of about 6 m *per annum.* Paradoxically, this same area stands out by the presence of a series of permanent lakes, varying in salinity between hypersaline and fresh on a plateau, Ounianga, at altitudes of just over 300m. These lakes have recently become a focus of faunal and palaeolimnological research (Kröpelin *et al*, 2008; Van Bocxlaer *et al*, 2011; Eggermont *et al*., 2008). One of these water bodies, the (almost) freshwater Lake Bokou is the first subject of the present study (Fig 1). In this lake, rich in fish species, the first lungfish population of the Sahara was recently discovered (Trape *et al*., 2013). Finally, west of Ounianga the mountains of Tibesti are found, a sandstone and lava area ca 100,000 km^2 in size, with the Emi Koussi volcano rising to 3400+ m, the highest mountain peak of the Sahara.

Apart from the Ounianga lakes, surface water is exceedingly scarce and restricted to a few privileged places where either springs discharge on the floor of deep canyons (as at Yebbi Bou), or rainwater supplemented or not by groundwater forms lakelets, called gueltas, mostly in deep canyons, protected from evaporation. Totous is the second environment that will be dealt with here. It is an area of sandstone rock, deeply dissected into canyons called oued or enneri, in this case the Enneri Douar. Along this riverbed, a series of lakelets or pools are to be found, called the gueltas of Totous. The largest guelta, enclosed between the steep sandstone walls of a narrow side valley, is barely 10 m wide, but runs over a length of several hundreds of meters. Smaller gueltas are found in the more open situation of Enneri Douar, and include guelta Io (Fig 2). All gueltas of Totous abound in fish. They are among the classical stations for fish in the Sahara (Lévêque, 1990).

Between 4 and 18 March 2014, one of us (H.J.Dumont) participated in a hydrobiological expedition to the Ounianga-Tibesti area that had been closed for research for most of the period since the independence of Chad, and is now one of the least explored parts of the desert. A list of localities sampled for zooplankton can be found in the article by Dumont (2014) dealing with the Odonata recorded during the trip.

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rudimentary spine of the A2, even if this is a little bigger than in true *brachyurum*), or, alternatively, as *D. mongolianum*, on account of the armature of the ventral valve rim. For the same reason, even *D. orghidani* might have been considered as its closest relative. Now, all we can say is that *D bopingi* **sp. nov**. is derived from an ancestry that should be looked for at the shores of the Mediterranean or even further north. In view of the extremely slow evolution of the ctenopods (Kotov, 2007) it is, furthermore, quite unlikely that it is a product of local speciation. The lakes at Ounianga have surely survived millennia of climate change (Kröpelin et al., 2008), but the species may be much older than this, and perhaps the Ounianga population is just a relict of a (north African?) range that used to be much larger than today's. It is interesting to see that that in this area of great variation in salinity within and among lakes, the local ctenopod is of a group (*brachuyrum*-group in a broad sense) that tolerates wide fluctuations in water salinity, and is occasionally found in water of up to 15 g/L (Korovchinsky, 1992). In the second species, *D. excisum,* so far only found in Totous, this tolerance is about ten times less (1.5 g/L). No doubt, the time of the "green Sahara" during the early to mid-Holocene (Kröpelin et al., 2008), was also a time of enormous expansion of Lake Chad, currently half-dried out, and situated more than 1,000 km south. The cladocerans of Lake Chad have been studied by Rey & St Jean (1968, 1969), and two species have been recorded, viz. *D. excisum* and *D. sarsi.* While their illustrations of *D. excisum* leaves no doubt as to the identity of the animal, save that the eye is rather big, that of *D. sarsi* could either be that species, or the form of *excisum* with a large eye we found at Totous. This leads to the suggestion that the Totous population is a relict of Lake Megachad, while the Ounianga species is a relict of a greener but cooler Sahara.

The peculiar structure of the postabdomen revealed by SEM is difficult to comment upon, since this is the first time that a belt flanking the postabdomen, arising from the base of the end-claws has been described. A discussion of its significance will have to await a comparison with other species of the genus.

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