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A new cichlid fish in the Sahara: The Ounianga Serir lakes (Chad), a biodiversity hotspot in the desert

Un poisson Cichlidae nouveau au Sahara : les lacs d'Ounianga Sérir (Tchad), un point chaud de la biodiversité dans le désert

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ABSTRACT

In the rare perennial bodies of water of the Sahara desert, only a few fish species have survived to increasing aridification since the end of the last humid period at the Holocene, approximately 5000 years BP. Here, I report the occurrence of an undescribed haplochomine cichlid fish in Lake Boukou, one of the seven Ounianga Serir lakes (Chad). These lakes are located in one of the most arid areas of the Sahara desert, but they persist by virtue of subsurface inflow of fresh groundwater from a large fossil aquifer. *Astatotilapia tchadensis* sp. nov. is characterized by a black bar between eye and corner of mouth, rounded orange spots on anal fin, scales ctenoid, lower limb of first gill arch with 7–8 gill rackers, dorsal fin with 13–14 spines and 9–11 soft rays, anal fin with 3 spines and 8–9 soft rays, 29 or 30 lateral line scales, and lower pharyngeal dentition with enlarged molariform teeth. The new species is easily distinguished from *A. desfontainii* and *A. flaviijosephii*, the northernmost haplochromine species currently isolated from its other group members, and appears close to an unnamed species of Lake Chad basin. Ounianga Serir lakes and especially Lake Boukou present a remarkable diversity of fish, the highest known in the Sahara desert with a total of at least six fish species belonging to six genera and three families. They also constitute an exceptional natural landscape inscribed on the UNESCO world heritage list in 2012 and a biodiversity hotspot for desert vertebrate species.

Mots clés :
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RÉSUMÉ

Dans les rares points d'eau permanents du désert du Sahara, seules quelques espèces de poissons ont survécu, malgré l'aridification croissante depuis la fin de la dernière période humide à l'Holocène, il y a environ 5000 ans. Cet article rapporte la présence d'un poisson cichlidé haplochrome nouveau dans l'un des sept lacs d'Ounianga Sérir (Tchad), le lac Boukou. Ces lacs sont situés dans l'une des régions les plus arides du Sahara, mais ils persistent grâce à une alimentation souterraine en eau douce issue d'une grande nappe aquifère fossile. *Astatotilapia tchadensis* sp. nov. est caractérisé par une barre noire entre l'œil et la commissure des lèvres, des taches arrondies de couleur orange sur la nageoire anale, des écailles cténoides, 7–8 branchiospines sur la partie inférieure du premier arc branchial, une nageoire dorsale avec 13–14 épines et 9–11 rayons mous, une nageoire

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anale avec 3 épines et 8–9 rayons mous, 29 ou 30 écailles en ligne latérale et une dentition pharyngienne inférieure avec des dents élargies en forme de molaires. La nouvelle espèce est facilement distinguable d'*A. desfontainii* et d'*A. flavijosephi*, les plus septentrionales des espèces d'haplochromes actuellement isolées des autres membres de leur groupe, et elle apparaît proche d'une espèce non dénommée du bassin du lac Tchad. Les lacs d'Ounianga, et particulièrement le lac Boukou, présentent une remarquable diversité en poissons, la plus grande connue au Sahara, avec un total d'au moins six espèces appartenant à six genres et trois familles. Ils constituent aussi un paysage naturel exceptionnel inscrit au patrimoine mondial de l'Unesco depuis 2012 et un point chaud de la biodiversité pour les espèces de vertébrés du désert.

1. Introduction

Few fish species have survived the increasing aridity of the Sahara since the last humid period at the Holocene, approximately 5000 years BP [1]. Almost all perennial bodies of water—springs, guelta, pounds, sebkhras or lakes—where the occurrence of fishes has been reported since the first Saharan exploration expeditions in the early 20th century, are located in mountainous massifs, rarely elsewhere, and fish diversity is low [2–4]. Currently, 20 species of fish are known in the Sahara, most of them in a very low number of watering places, often in a single spring or guelta [4].

The fish fauna of Chad has been investigated since 1904 following the first expedition Chevalier–Decorse to Lake Chad and Chari River [5]. The first studies on fishes collected in Saharan areas of northern Chad were published by Pellegrin [6,7] who described *Tilapia borkuana* (= *Sarotherodon galilaleus borkuanus*) from Ounianga Serir and *Labeo tibestii* (= *L. parvus* Boulenger, 1902) from Enneri Debassa in the Tibesti. This author also mentioned the presence of *Labeo horie* [= *L. niloticus* (Forsskål, 1775)], *Barbus anema* (= *B. macrops* Boulenger, 1911) and *Clarias lazera* [= *C. gariepinus* (Burchell, 1822)] in Totous guelta (Tibesti), *Hemichromis bimaculatus* Gill, 1862, in Ounianga Serir, *Barbus deserti* (= *Barbus macrops*) in Archei guelta (Ennedi), and *Tilapia zilli* (Gervais, 1948) in Archei and Totous gueltas [6]. He also mentioned the presence of *Barilius louti* [= *Raiamas senegalensis* (Steindachner, 1870)] in Yezei (Tibesti), where *T. zilli* and *B. macrops* were also recorded, the latter species being also collected in Zouarke pool (Tibesti) [6]. Another collection of fishes from northern Chad was studied by Estève [8], who reported the occurrence of *Aplocheilus marni* [= *Epiplatys spilargyreius* (Duméril, 1861)] in Tigui (Borkou), *L. parvus*, *B. deserti* (= *B. macrops*) and *T. zilli* in Archei, and *H. bimaculatus* and *S. g. borkuanus* in Ounianga Kebir. *S. g. borkuanus* was also collected in Fada (Ennedi) by Fowler [9]. Further studies of new collections of fishes from Tibesti, Borkou and Ennedi were made by Daget [10,11], who also re-examined the previous collections deposited in Paris, and by Monod [12]. These authors reported *Barbus batesi* (= *Barbus bynni occidentalis* Boulenger, 1911) from Totous, *S. g. borkuanus* from Enneri Maro (Tibesti), *Barbus apleurogramma* Boulenger, 1911, from Aoue guelta (Ennedi), and *L. parvus* from various additional Tibesti and Ennedi gueltas. The taxonomic status of the whole species of fish that were recorded from Sahara was reviewed by Lévêque [2]. Recently, I reported the occurrence of *Polypterus senegalus* Cuvier, 1829, and *Poropanchax normani* (Ahl, 1928) in Lake Boukou at Ounianga Serir [4].

In central and southern Chad, after the first studies by Pellegrin [5,13–15] and those by Chabanaud [16] and Fowler [17], the most important work was the monography by Blache [18] which included 175 species from the Lake Chad basin and provided meristic and biological data for the specimens collected. More recently, the fish fauna from the Chad basin was included in the monography of Paugy et al. [19] on the fresh and brackish water fishes of West Africa.

Haplochromine cichlid fishes represent some of the most species-rich adaptive radiations known and are famous for their astonishingly fast rates of speciation [20–22]. Paradoxically, although thousands of haplochromine species are known from central, eastern, and southern Africa [20–26], they are virtually absent from Chad and West Africa, where only a single species has been currently reported [19]. During two zoological surveys in northern Chad in 2013 and 2014, fishes, reptiles, amphibians, and invertebrates were collected in various areas of Borkou, Ennedi and Tibesti [4,27–30]. Among the fishes collected in Lake Boukou at Ounianga Serir, several specimens belonged to an undescribed haplochromine cichlid species. Here I describe the new species from Lake Boukou, which adds to the unique relict fish fauna of Ounianga lakes, one of the most remarkable hotspot for biodiversity in the Sahara desert.

2. Material and methods

The Ounianga lakes consist of two main groups of lakes located between the Tibesti and Ennedi mountains in northeastern Chad (Fig. 1). They are among the very few permanent aquatic ecosystems currently existing in the most arid parts of the Sahara desert [31]. Although in this area, average annual rainfall is less than 5 mm and annual evaporation exceeds 6000 mm, these lakes are maintained by an inflow of fossil groundwater from a large sandstone aquifer that was last recharged during the Early Holocene [32–35]. The four Ounianga Kebir lakes are all hypersaline, with freshwater restricted to a creek and a few springs on the shore of the main lake. At Ounianga Serir, which

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