



Ecology/Écologie

A study of the relict fish fauna of northern Chad, with the first records of a polypterid and a poeciliid in the Sahara desert



Une étude de la faune relique des poissons du Nord du Tchad, avec les premiers signalements d'un Polypteridae et d'un Poeciliidae dans le désert du Sahara

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ABSTRACT

Seventeen species and sub-species of fishes belonging to four families (Cyprinidae, Clariidae, Aplocheilidae, Cichlidae) were known to occur in perennial bodies of water in the Sahara desert. The study of fishes collected in Lake Boukou near Ounianga Serir (Borkou, northern Chad) shows, for the first time, the occurrence in the Sahara desert of relict populations of *Polypterus senegalus* (Polypteridae) and *Poropanchax normani* (Poeciliidae). The Cichlidae *Tilapia zilli* was also collected in this lake. With these new records, the relict fish fauna currently known in lakes and gueltas of the Borkou plateaus comprises six species. In the Ennedi Mountains, where the specific status of *Barbus* populations was unclear, *B. macrops* was collected in Bachikere guelta. The toad *Amietophrynus regularis* was collected in Ounianga Kebir.

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R É S U M É

Dix-sept espèces et sous-espèces de poissons appartenant à quatre familles (Cyprinidae, Clariidae, Aplocheilidae, Cichlidae) étaient connues pour être présentes dans des collections d'eau pérennes du Sahara. L'étude de poissons collectés dans le lac Boukou près d'Ounianga Sérir (Borkou, Nord du Tchad) montre, pour la première fois, la présence dans le désert du Sahara de populations reliques de *Polypterus senegalus* (Polypteridae) et de *Poropanchax normani* (Poeciliidae). Le Cichlidae *Tilapia zilli* a aussi été collecté dans ce lac. Avec ces nouveaux signalements, la faune de poissons reliques actuellement connue dans les lacs et gueltas des plateaux du Borkou comprend six espèces. Dans les montagnes de l'Ennedi, où le statut spécifique des populations de *Barbus* était incertain, *B. macrops* a été collecté dans la guelta de Bachikéré. Le crapaud *Amietophrynus regularis* a été collecté à Ounianga Kebir.

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1. Introduction

The presence of relict fish populations in several regions of Central Sahara was recognized during the first Saharan expeditions in the early 20th century [1–6]. Most of the

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rare perennial bodies of water where fish populations have survived since the end of the last humid period at the Holocene, approximately 5,000 years ago, correspond to springs, gueltas, or pools located in the main Saharan mountains massifs: the Ahaggar, Mouydir and Tassili-n-Adjer in southern Algeria, the Adrar in Mauritania, and the Tibesti and Ennedi in northern Chad [7]. In total, seventeen species and sub-species of fishes are currently known to occur in these areas [7–9], including nine Cyprinidae: *Barbus macrops* Boulenger, 1911, *Barbus pobeguini* Pellegrin, 1911, *Barbus deserti* Pellegrin, 1909, *Barbus bynni occidentalis* Boulenger, 1911, *Barbus callensis biscarensis* Boulenger, 1911, *Barbus apleurogramma* Boulenger, 1911, *Labeo parvus* Boulenger, 1902, *Labeo niloticus* (Forsskål, 1775), and *Raiamas senegalensis* (Steindachner, 1870); two Clariidae: *Clarias anguillaris* (Linnaeus, 1758) and *Clarias gariepinus* (Burchell, 1822); one Aplocheilidae: *Epiplatys spilargyreus* (Duméril, 1861); and five Cichlidae: *Hemichromis bimaculatus* Gill, 1862, *Sarotherodon galilaeus galilaeus* (Linnaeus, 1758), *Sarotherodon galilaeus borkuanus* (Pellegrin, 1919), *Astatotilapia desfontainesi* (Lacépède, 1803), and *Tilapia zilli* (Gervais, 1948). Species richness differ depending on the massif, ranging from only three species in the Ahaggar (*B. c. biscarensis*, *B. macrops*, *T. zilli*) and the Mouydir (*B. c. biscarensis*, *A. desfontainesi*, *T. zilli*), to four species in the Adrar (*B. pobeguini*, *B. macrops*, *C. anguillaris*, *S. g. galilaeus*), five species in the Tassili-n-Ajjer (*B. c. biscarensis*, *B. deserti*, *C. gariepinus*, *H. bimaculatus*, *T. zilli*), seven species in the Ennedi (*B. apleurogramma*, *B. macrops*, *L. parvus*, *L. niloticus*, *C. gariepinus*, *S. g. borkuanus*, *T. zilli*), and eight species in the Tibesti (*B. b. occidentalis*, *B. macrops*, *L. parvus*, *L. niloticus*, *R. senegalensis*, *C. gariepinus*, *S. g. borkuanus*, *T. zilli*). Several species have been reported from only a single body of water for the whole Sahara, e.g. *S. g. galilaeus* in Molohmar guelta (Adrar), *A. desfontainesi* in Arak (Mouydir), *E. spilargyreus* in Tigui spring (Borkou), *B. bynni occidentalis* in Totous guelta (Tibesti), *Raiamas senegalensis* in Yezei guelta (Tibesti), and *B. apleurogramma* in Aoue guelta (Ennedi) [3,7,10,11].

The first studies on fishes collected in northern Chad were published in 1919 by Pellegrin [2,3], who described *Tilapia borkuana* (= *Sarotherodon galilaeus borkuanus*) from Ounianga Serir in northeastern Borkou [2] and *Labeo tibestii* (= *L. parvus*) from the Enneri Debassa in the Tibesti [3]. This author also mentioned the presence of *Labeo horie* (= *L. niloticus*), *Barbus anema* (= *B. macrops*) and *Clarias lazera* (= *C. gariepinus*) in Totous guelta (Tibesti), *Hemichromis bimaculatus* in Ounianga Serir, *Barbus deserti* (= *B. macrops*) in Archei guelta (Ennedi), and *Tilapia zilli* in Archei and Totous gueltas [2]. He also mentioned the presence of *Barilius louti* (= *Raiamas senegalensis*) in Yezei (Tibesti), where *T. zilli* and *B. macrops* were also recorded, the later species being also collected in Zouarke pool (Tibesti) [3]. Another collection of fishes from northern Chad was studied by Estève [11], who reported the occurrence of *Aplocheilus marni* (= *Epiplatys spilargyreus*) in Tigui (Borkou), *L. parvus*, *B. deserti* (= *B. macrops*) and *T. zilli* in Archei, and *H. bimaculatus* and *S. g. borkuanus* in Ounianga Kebir (Borkou). *S. g. borkuanus* was also collected in Fada (Ennedi) by Fowler [12]. Further studies of new

collections of fishes from Tibesti, Borkou and Ennedi were made by Daget [13,14], who also re-examined the previous collections deposited in Paris. This author reported *Barbus batesi* (= *B. bynni occidentalis*) from Totous, *S. g. borkuanus* from Enneri Maro (Tibesti), *Barbus apleurogramma* from Aoue guelta (Ennedi), and *L. parvus* from Totous, Enneri Maro, and four additional Ennedi gueltas: Kordi, Bimé, Michero and Ouro Gale. In Bachikele guelta (Ennedi), two poorly preserved *Barbus* sp. specimens were collected [14]. Several other gueltas in the Tibesti [3] and Ennedi [15] are known to be home of fishes but have never been studied. The taxonomic status of the whole species of fish that were recorded from Sahara was reviewed by Lévêque [7].

Here I present new records of fishes from northern Chad, including the first records of a Polypteridae and a Poeciliidae, two families of fishes new for Sahara.

2. Study area and methods

In March 2013, the occurrence of fishes was investigated in lakes and springs of Ounianga Kebir (19°03'N, 20°23'E) and Ounianga Serir (18°55'N, 20°52'E) in the northeastern part of the Borkou plateaus, and the gueltas of Bachikele (16°30'N, 22°20'E) and Archei (16°54'N, 21°46'E) in the Ennedi Mountains, northern Chad.

The Borkou is one of the most arid areas of Sahara, with mean annual precipitations of only 3 mm in Ounianga Kebir [16]. Due to the rarity of rains and intense evaporation, it is the inflow of ground water from the Nubian sandstone aquifer that accounts for the existence of perennial lakes located in depressions at the altitude of ca 380 m for Ounianga Kebir and 350 m for Ounianga Serir (Fig. 1). Some of these lakes are among the largest for Sahara, with a surface up to 370 ha, and up to 25 m depth [17,18].

The Ennedi Mountains have a north-Saharan climate in their southern part, with mean annual precipitations of 94 mm in Fada, almost exclusively concentrated between May and September [16]. There are at least twenty perennial or semi-perennial springs, gueltas and pools, all of them of small size, with a maximum length rarely exceeding a few dozen of meters during the dry season [15].

Fish sampling was conducted both by day and by night, using a landing-net, and additional observations in Ounianga Kebir and Ounianga Serir were made by snorkelling. Most fishes collected were released after rapid identification and some voucher specimens were preserved in alcohol and deposited at the Museum national d'histoire naturelle (MNHN), Paris.

3. Results

3.1. Ounianga Kebir

There are two main lakes (Lake Yoa and Lake Katam), two small lakes and a few perennial pools in this area (Fig. 2). All lakes and pools are saline, but perennial freshwater springs are located on the banks of Lake Yoa and several freshwaters streams run a few dozen of meters before joining the saline waters of this lake (Fig. 3).

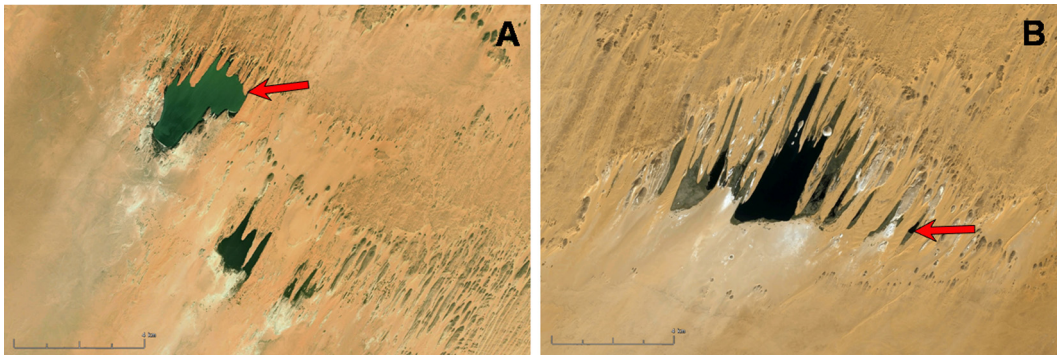


Fig. 1. Satellite view (Google Earth) of the Ounianga Kebir Lakes (A) and the Ounianga Serir Lakes (B). The red arrows indicate the location of the freshwater spring investigated near Lake Yoa (A) and the location of Lake Boukou (B). Color online.



Fig. 2. General view of Lake Yoa at Ounianga Kebir. Color online.

H. bimaculatus and *S. g. borkuanus* were observed in one of these springs located at 19°03'31"N, 20°31'14"E. These two species were previously reported by Estève [11] from a similar spring on the banks of Lake Yoa. Among other zoological records of interest on the edge of Lake Yoa, the toad *Amietophrynus regularis* and the skink *Chalcides ocellatus* were observed.

3.2. Ounianga Serir

There are a dozen of lakes and pools of various sizes. The largest one, Lake Elime, is saline, but at least four lakes have freshwater and are known to be home of fishes according to local villagers. In Lake Boukou (18°54'N, 20°54'E), the deepest of these lakes (depth not measured, several meters, Fig. 4), five species were collected: *Polypterus senegalus*, *Poropanchax normani*, *H. bimaculatus*, *S. g. borkuanus*, and *T. zilli*. Only *H. bimaculatus* and *S. g. borkuanus* were previously known from Ounianga Serir [2,7,13]. *P. senegalus* and the three species of Cichlidae were easy to observe and to collect only by night, when some individuals moved to the rare shallow waters of the bank of the lake that are relatively free of *Typha*. *P. normani* was abundant and easy to observe both by day and night (Fig. 5).

3.3. Bachikele guelta

The Bachikele canyon and guelta are considered as among of the most ecologically significant areas of the



Fig. 3. Spring on the banks of Lake Yoa home of *Hemichromis bimaculatus* and *Sarotherodon galilaeus borkuanus*. Color online.

Ennedi Mountains, due to the presence of a relict Sudano-Guinean flora unknown in other areas of the Sahara and Sahel [19] (Fig. 6). Only one species of fish has been reported from Bachikele guelta, based on two specimens of *Barbus* sp. that were studied by Daget [14]. These specimens were poorly preserved, preventing precise determination, but this author mentioned that they were different from *B. macrops* and *B. apleurogramma*, the two species of *Barbus* currently known in the Ennedi Mountains [7,14]. All specimens collected in Bachikele guelta in 2013



Fig. 4. General view of Lake Boukou at Ounianga Serir. Color online.

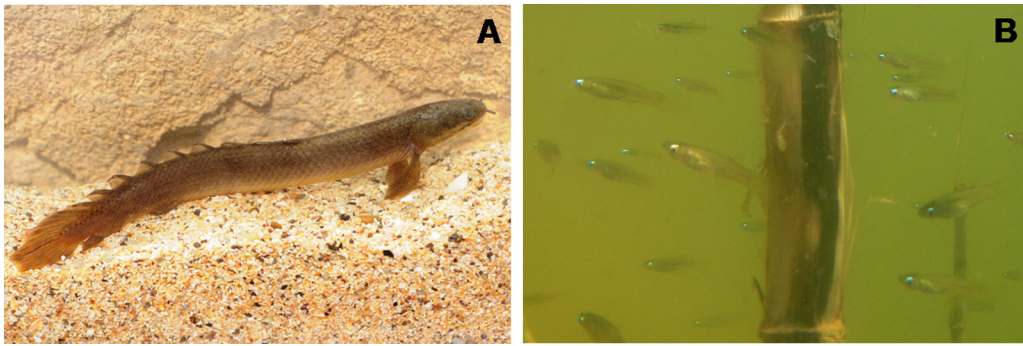


Fig. 5. *Polypterus senegalus* (A) and *Poropanchax normani* (B) from Lake Boukou. *P. senegalus* was collected by night and the *P. normani* specimens of the figure were photographed in the lake. Color online.



Fig. 6. The Bachikele guelta. Color online.



Fig. 7. *Barbus macrops* from Bachikele guelta. Color online.

were clearly attributable to *B. macrops*, both according to meristic data and colour pattern (Fig. 7). No other species of fish was observed in this guelta.

3.4. Archei guelta

The Archei guelta is well known for its local economic importance (several thousand of dromedaries come daily to drink in this guelta during the dry season) and the small relict population of crocodiles that survive in this place (Fig. 8). Four species of fishes are known in this guelta: *B. macrops*, *L. parvus*, *T. zilli*, and *S. g. borkuanus* [2,11,14]. During a short visit to Archei, juveniles of *L. parvus* were collected (Fig. 9) and two crocodiles were observed.

4. Discussion

Northern Chad has remained poorly studied due to less accessibility than most other Saharan regions, and major past and present security issues including severe climatic conditions, Tubu rebellions, war with Libya, frequent banditry, and the large number of areas that have remained heavily mined. This explains why the scientific literature on Borkou, Ennedi and Tibesti is so scarce, despite the huge interest of these regions in many domains, from anthropology [20] and social sciences to bio-geography and earth sciences [21,22].



Fig. 8. The Archei guelta. Color online.



Fig. 9. *Labeo parvus* from Archei guelta. Color online.

issued from the Tibesti Mountains and additional lacustrine and fluviatile formations in this area [27,28]. The pathway from Nile to Chad was the Bahr el Ghazal lying between the Tibesti and Ennedi [29]. At present, the nearest known populations are located approximately 800 km to the south in Lake Chad and 1,200 km to the east in the Nile in Sudan [23–25,30]. *P. normani*, a small but relatively deep-bodied “Lampeye” species, also inhabits many river systems in West and Central Africa, including the Chad basin [31]. The nearest known population is from Lake Chad at Hadjer El Hamis [30,31]. Thus, it is another valuable relict of the past connections between Lake Chad and Ounianga lakes.

The Cichlidae *Tilapia zilli* was also unreported from Ounianga lakes, but is well known from several pools and gueltas in various areas of Sahara, including Ahaggar, Tassili, Tibesti, Ennedi and northern Sahara from Morocco to Tunisia [7]. The fact that three species of fishes out of five are reported here for the first time from Ounianga Serir lakes suggests that only rapid investigations were carried out in this area by Bruneau de Miré when he conducted the only collection of fishes from Ounianga Serir lakes studied in the literature [11], and also probably that Lake Boukou, the easternmost of these lakes, was not sampled during this expedition.

Interestingly, the toads collected in Ounianga Kebir represent the first confirmed report of *A. regularis* in northern Chad (Fig. 10). Since the revision of Tandy et al. [32], most early records of this species in Saharan regions are now attributed to *A. xeros*, which is also the most widespread toad in the Sahel. *A. xeros* has red markings on the thighs that were absent in the several dozens of specimens from Ounianga Kebir examined. *A. regularis* is widely distributed in tropical Africa and along the Nile valley in Egypt, but is less common in the Sahelo-Saharan areas, where its distribution is often associated with main perennial rivers and lakes, e.g. Senegal River in Mauritania and northern Senegal, Niger River in northern Mali and western Niger, and Lake Chad in central Chad. Early records of *A. regularis* from the oases of Djanet (Algeria) and Gat (Libya) were first confirmed by Tandy et al. [33], but these specimens also are now attributed to *A. xeros* [34]. It is possible that the distribution of *A. regularis* reach the Tibesti Mountains, since the occurrence of undetermined toads has been mentioned in this area [35]. The skink *C. ocellatus* was previously known in several areas of Central Sahara, where its distribution also seems associated with perennial bodies of water [36].

These new data on the relict fish fauna of northern Chad and the additional herpetological observations highlight the considerable bio-geographical interest of this region of Sahara and, more generally, the interest of the study of relict distribution patterns of aquatic animals to evaluate climate changes in the Sahara and Sahel [29]. Despite extreme aridity, the perennial bodies of water that have persisted since the Holocene in northern Chad remain the home of the richest fish fauna of the Sahara desert, with 13 species belonging to six families currently known. This fauna is clearly Afrotropical, with all species also distributed in the Lake Chad basin except *B. apleurogramma*, which is a species nowadays only known from Lake Victoria and the connected river systems [7]. Further investigations in the numerous springs, gueltas, pools or lakes that have never been studied will probably confirm that our knowledge of the relict fauna of northern Chad remains largely incomplete.



Fig. 10. *Amietophrynus regularis* from Lake Yoa. Color online.

Disclosure of interest

The author declares that he has no conflicts of interest concerning this article.

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