

Chapter 24

Amphibian conservation in Mauritania

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Only eleven species of amphibians (all anurans) have been found in Mauritania so far. Nonetheless, large areas of the country remain unexplored and the taxonomic status of several species remains uncertain, suggesting that additional species may be found in the future, especially in the Sahel savannahs of the southern part of the country. Within the Saharan realm, amphibians occur in isolated springs, “wadis” (temporary streams), and “gueltas” (ponds) in montane regions (Adrar and Tagant plateaus), while the Sahel savannahs contain innumerable bodies of water where all species listed in the country have been recorded despite only a small portion of the area having been sampled. No information on population trends is available, but the Sahel is threatened by intensive wood harvesting, agro-pastoral utilization, and uncontrolled use of pesticides. Mountain populations in the Sahara are isolated and likely small, with high vulnerability to drought and global warming. Priority research needs include: (1) data on distribution and diversity for action by local conservation agencies; (2) determination of environmental change and the effect of population dynamics on genetic diversity and local populations; and (3) clarification of the taxonomic status of existing populations and the identification of reservoirs of genetic diversity.

Key words: amphibians; conservation; decline; distribution; Mauritania.

Conservación de anfibios en Mauritania. Hasta la fecha sólo once especies de anfibios (todas ellas anuros) han sido citadas en Mauritania. Sin embargo, todavía quedan en el país áreas extensas sin explorar y el estatus taxonómico de algunas especies es incierto, lo que sugiere que en el futuro podrían sumarse más especies, sobre todo en las sabanas del Sahel en la parte sur del país. En el área del Sáhara, los anfibios aparecen en manantiales aislados, “wadis” (arroyos temporales) y “gueltas” (charcas) en zonas de montaña (mesetas de Adrar y Tagant), mientras que las sabanas del Sahel contienen numerosas masas de agua en las que se han hallado todas las especies presentes en el país pese a que sólo se ha muestreado una pequeña parte de este área. No hay información disponible acerca de las tendencias poblacionales, pero el Sahel está amenazado por la explotación maderera intensiva, el uso agro-pastoral y la aplicación incontrolada de plaguicidas. Las poblaciones montañosas en el Sáhara aparecen aisladas y probablemente son pequeñas y con una elevada vulnerabilidad a la sequía y el calentamiento global. Las necesidades prioritarias en cuanto a investigación incluyen: (1) toma de datos de distribución y diversidad para promover acciones por parte de las agencias locales de conservación, (2) determinación de cambios ambientales y del efecto de las dinámicas poblacionales sobre la diversidad genética y las poblaciones locales, y (3) aclaración del estado taxonómico de las poblaciones existentes e identificación de reservorios de diversidad genética.

Key words: anfibios; conservación; declive; distribución; Mauritania.

Three quarters of Mauritania's one million square kilometers belong to the Sahara Desert, which translates into low amphibian diversity relative to adjacent areas such as the Mediterranean and the Sahel. Only eleven widely-distributed anuran species have been so far recorded for the country (Table 1) (NICKEL, 2003; PADIAL & DE LA RIVA, 2004), and all of them are categorized as species of Least Concern by the IUCN (2013). Large areas of the Mauritanian territory remains, however, poorly explored, especially in the north, east, and south of the country. Considering the distribution of amphibians in adjacent areas of neighbouring countries, at least 17 additional species might occur in these unexplored areas of Mauritania. In addition, the taxonomy of some species currently considered broadly-distributed, including those cited for Mauritania (*Ptychadena* spp. [Ptychadenidae], *Hoplobatrachus occipitalis* [Dicroglossidae], *Tomopterna* spp. [Pyxicephalidae], and *Phrynobatrachus* spp. [Phrynobatrachidae]), is often unreliable. Resolution of taxonomic problems may change the composition of the species-list and some species currently considered widely-distributed may eventually be found to consist of species complexes, each component species of which exhibiting a more restricted distribution.

Saharan Mauritania harbours relict populations of some Afrotropical species, several hundred kilometres distant from the closest area with large populations of such species, the Senegal basin. These now-isolated populations were likely connected to source populations as recently as 4000 years ago when more benign conditions

supported continuous savannah extending further north to southern Morocco, Western Sahara, and northern Mauritania, and where the now-relict anuran populations dwelled among elephants, giraffes, and lions (LE HOUÉROU, 1997). As relatively recent, and extremely rapid, climatic change led to desertification (GASSE, 2000; FOLEY *et al.*, 2003), most large mammals disappeared from arid areas, while some amphibian, reptilian, and fish populations became isolated along basins of retreating rivers and interior water courses, forming pockets of local survivors (PADIAL & DE LA RIVA, 2004; PADIAL, 2006; TRAPE, 2009; BRITO *et al.*, 2011). At least 20 localities within the Mauritanian Sahara, many connected by fossil river basins that may have acted as corridors for exchange of individuals during wet periods, are still inhabited by two to three anuran species. Anurans inhabiting other localities, particularly those on the Adrar and Tagant plateaus, are completely isolated by dunes or expanses of rock from conspecific populations. These areas constitute a natural laboratory for studying effects of climatic change on natural populations (DUMONT, 1982). Topics such as the effect of population size and degree of isolation on genetic diversity and survival, the effect of species-specific physiological plasticity to environmental change, and the effect of allopatry and local adaptation in diversification, could be optimally studied in Saharan isolates (WARD, 2009).

Biodiversity is usually managed at the level of nations and more inclusive administrative units (PLEGUEZUELOS *et al.*, 2010) and it is therefore important to maintain as

Table 1: Geographical areas (see also Fig. 1) and taxonomic status of anuran species recorded from Mauritania. Nomenclature and classification follow FROST (2013); taxonomic status follows RÖDEL (2000).

Family	Species	Distribution and population status	Taxonomic status
Bufonidae	<i>"Bufo" pentoni</i>	Scattered localities across the Sahelian savannah; locally abundant.	Stable.
	<i>Amietophrynus regularis</i>	Scattered localities across the Sahelian savannah and along the coast; locally abundant.	Unstable; several synonyms across its broad distribution, coupled with large genetic divergence between East Africa versus Central and West Africa (VASCONCELOS <i>et al.</i> , 2010) present the possibility of future change in status.
	<i>Amietophrynus xeros</i>	Most Saharan bodies of water; locally abundant.	Unstable; several synonyms across its broad distribution present the possibility of future change in status.
Dicroglossidae	<i>Hoplobatrachus occipitalis</i>	Most Saharan bodies of water and across the Sahelian savannah; locally abundant but possible local extirpations have occurred.	Unstable; possible species complex.
Hyperoliidae	<i>Kassina senegalensis</i>	Scattered localities across the Sahelian savannah; scarce.	Unstable; possible species complex.
Phrynobatrachidae	<i>Phrynobatrachus natalensis</i>	Known only from a single locality in the Sahelian savannah; no data on abundance.	Unstable; possible species complex.
Ptychadenidae	<i>Ptychadena bibroni</i>	Known from two localities in the Sahelian savannah; no data on abundance.	Stable.
	<i>Ptychadena mascareniensis</i>	Known only from a single locality in the Sahelian savannah; no data on abundance.	Unstable; possible species complex.
	<i>Ptychadena trinodis</i>	Known from two localities in the Sahelian savannah; no data on abundance.	Stable.
Pyxicephalidae	<i>Pyxicephalus edulis</i>	Scattered localities across the Sahelian savannah; probably locally abundant.	Unstable; possible species complex.
	<i>Tomopterna cryptotis</i>	Scattered localities across the Sahelian savannah; also recorded from the coast and in some Saharan bodies of water; rare.	Unstable, possible species complex.

much genetic diversity as possible within national borders. Recent surveys of fishes in central Mauritania indicate that localities supporting populations of several species in the 1950s (DEKEYSER & VILLIERS, 1956) have now completely dried, leading to local

extirpations (TRAPE, 2009). Although anurans are more tolerant than fish to periods of drought, populations of some anurans may have been extirpated while others may have already crossed the population size threshold necessary for long-term survival.

DIVERSITY AND DISTRIBUTION

All species occurring in Mauritania are present in the Sahelian savannah (Table 1; Figs. 1-2), a pattern partially explained by humidity and temperature conditions. Species present in Saharan isolates occur along springs, “wadis” (temporary streams), and “gueltas” (ponds) in montane regions, and are also generally abundant and widely-distributed in the Sahel (Fig. 1), a pattern also explained by humidity and temperature but coupled with elevation. This simple pattern suggests that the Saharan populations are not Saharan in origin but are instead the product of colonization from the Sahelian savannah. In contrast to the situation of other Saharan massifs further north, such as Hoggar or Tassili N’Ajjjer, no amphibian species of Mediterranean affinities reaches Mauritania.

Within the Saharan realm of Mauritania, *H. occipitalis* (Dicroglossidae) and *Amietophrynus xeros* (Bufonidae) are the most conspicuous representatives, although *Tomopterna cryptotis* (Pyxicephalidae) can also be found in a few Saharan localities. *Amietophrynus regularis*, *A. xeros* (Bufonidae), and *T. cryptotis* are also found along the Saharan Atlantic coast, although large populations occur only in the Sahelian wetlands of Diawling National Park, near the mouth of the Senegal River. *Kassina senegalensis* (Hyperoliidae), *Phrynobatrachus natalensis* (Phrynobatrachidae), *Ptychadena mascareniensis*, *Ptychadena trinodis*, *Ptychadena bibroni* (Ptychadenidae), and *Pyxicephalus edulis* (Pyxicephalidae) are restricted to the Sahelian savannah (Fig. 2) of southern Mauritania.

Important areas for Saharan populations are on the Adrar and Tagant plateaus (Fig. 1), where rocky areas form networks of seasonal

“wadis”) with many temporary and permanent springs and small pools (“gueltas”) along streams (CAMPOS *et al.*, 2012) (Fig. 3). The Adrar plateau contains more than 20 such permanent bodies of water (Fig. 1). The Tagant plateau, situated south of the Adrar plateau, is transitional between Saharan and Sahelian environments. This mountainous area of about 2000 km² forms an inner drainage that empties into a marshland formed by Gabou Lake (Fig. 3c) and other minor lakes, or into several “wadis” in the Senegal River basin. This area harbours more suitable sites for amphibians than does the Adrar, and includes typical components of the Sahelian savannah such as *K. senegalensis*. Many other montane areas remain poorly explored in Mauritania. Sampling has been most intense in the Adrar and Tagant areas, especially because they are more easily accessible by car. Nonetheless, other montane areas of Mauritania have been comparatively less sampled than the Tagant and the Adrar and may contain important populations of amphibians. The Assaba and Afollé Mountains, located south and east of the Tagant, respectively, also hold important populations of *H. occipitalis*, *A. xeros*, *K. senegalensis*, and *T. cryptotis*.

The savannah in southern Mauritania contains innumerable bodies of water (CAMPOS *et al.*, 2012) (Fig. 3). In addition to the eleven species recorded from this most diverse area of the country, PADIAL & DE LA RIVA (2004) suggested that several species were expected to occur in the country because they had been reported in neighbouring areas of Mali or Senegal. While none of these species has yet been recorded for Mauritania, we report this (taxonomically updated) list of expected species here:

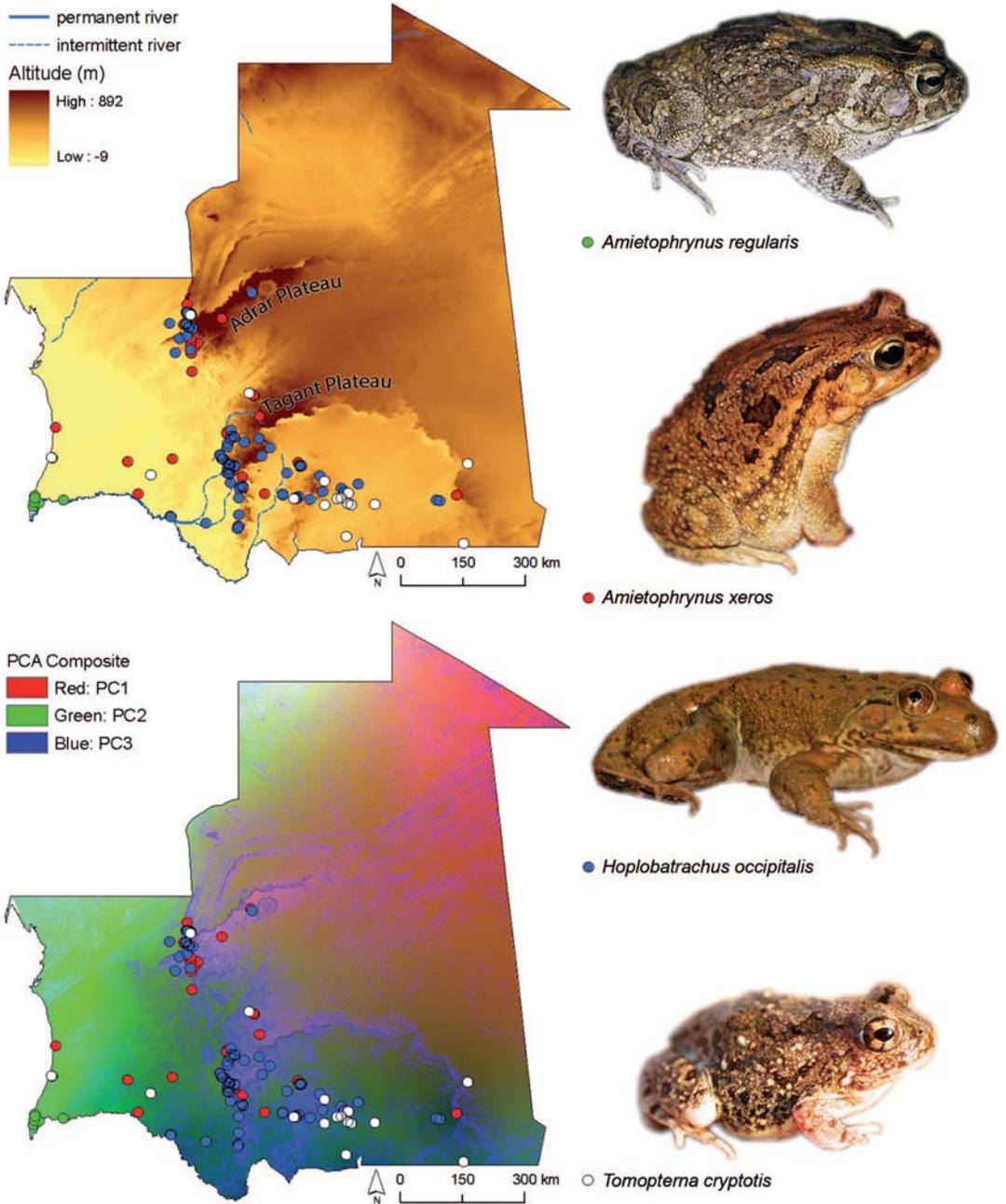


Figure 1: Localities for Mauritanian anurans occurring in both Saharan isolates and Sahelian savannahs depicted over (top) elevation, and (bottom) environmental variability derived by Principal Components Analysis, where PC1 (red; 48.1% of variation): annual average temperature and maximum temperature of the hottest month; PC2 (green; 20.7%): minimum temperature of the coldest month; and PC3 (blue; 16.4%): slope. Environmental factors from Worldclim database (www.worldclim.org) at 2.5 arc-second resolution. Photograph of *Amietophrynus regularis* courtesy of Mark-Oliver Rödel.

Hemisotidae (*Hemisus marmoratus*); Hyperoliidae (*Afrixalus fulvovittatus*, *Afrixalus weidholzi*, *Hyperolius spatzi*, *Kassina cassinoides*, and *Kassina fusca*); Arthroleptidae (*Leptopelis bufonides*); Microhylidae (*Phrynomantis microps*); Pipidae (*Xenopus muelleri*); Ranidae (*Hylarana galamensis*); Phrynobatrachidae (*Phrynobatrachus latifrons*, *Phrynobatrachus francisci*, and *Phrynobatrachus natalensis*); Ptychadenidae (*Ptychadena schillukorum*, *Ptychadena oxyrhynchus*, *Ptychadena pumilio*, and *Ptychadena tellinii*).

CONSERVATION STATUS

Although amphibians are declining worldwide, and amphibian extinctions are a major source of concern in many tropical countries (STUART *et al.*, 2004), none of the anurans currently known in Mauritania is considered globally endangered (IUCN, 2013). This conclusion is, however, based on an incomplete survey of most African regions, and utilizes incomplete taxonomic knowledge. There is evidence suggesting that many African nominal species of the genera *Ptychadena*, *Tomopterna*, and *Phrynobatrachus* could in fact constitute species complexes (VENCES *et al.*, 2004; PICKERSGILL, 2007; RÖDEL *et al.*, 2009). Future taxonomic research may well lead to changes in the perception of the level of endemism and, hence, in the conservation needs of many species, including those occurring in Mauritania.

Although no evidence was found to indicate any population decline of anurans in Mauritania due to human pressure, an adequate assessment cannot be made because the relevant data are lacking. Some populations in the Sahel might be suffering negative effects

from intense harvesting of wood and from agro-pastoral use, two activities that enhance desertification, as well as from the uncontrolled use of pesticides (NATIONAL RESEARCH COUNCIL, 1981). Other important consequences for amphibians of agro-pastoral use in Mauritania could be the contamination of water by cattle faeces and the exploitation of bodies of water. Availability of many bodies of water within the Sahel Plateau (CAMPOS *et al.*, 2012), however, should continue to provide refuge for healthy populations of anurans, at least in the short term.

Most Saharan populations are nonetheless vulnerable to extirpation. In fact, there has been a decline of relict fish populations in the Adrar Mountains related to intense drought (35% reduction in precipitation) since the 1970s (FOLEY *et al.*, 2003), and some of them already have disappeared (TRAPE, 2009), suggesting that some local Saharan anuran populations may also be declining. While one might expect that a much higher tolerance to aridity would help anurans survive episodes of severe drought, and that metapopulation connectivity may be enhanced during favourable years, Saharan isolates of *H. occipitalis*, *A. xeros*, and *T. cryptotis* should be considered locally endangered, as well as other water-dependent reptiles and mammals (BRITO *et al.*, 2011; VALE *et al.*, 2012). Especially vulnerable are the northernmost populations of the Adrar Plateau. In fact, the permanent and deep (5 m) Guelta of Molomhar (near Atar) dried completely in March 2008, an unprecedented event according to local guides. This “guelta” had been historically inhabited by *A. xeros*, *H. occipitalis*, and at least three species of fish (*Clarias anguillaris*, *Afropuntio pobeguini*, and *Tilapia zillii*); all may have disappeared.

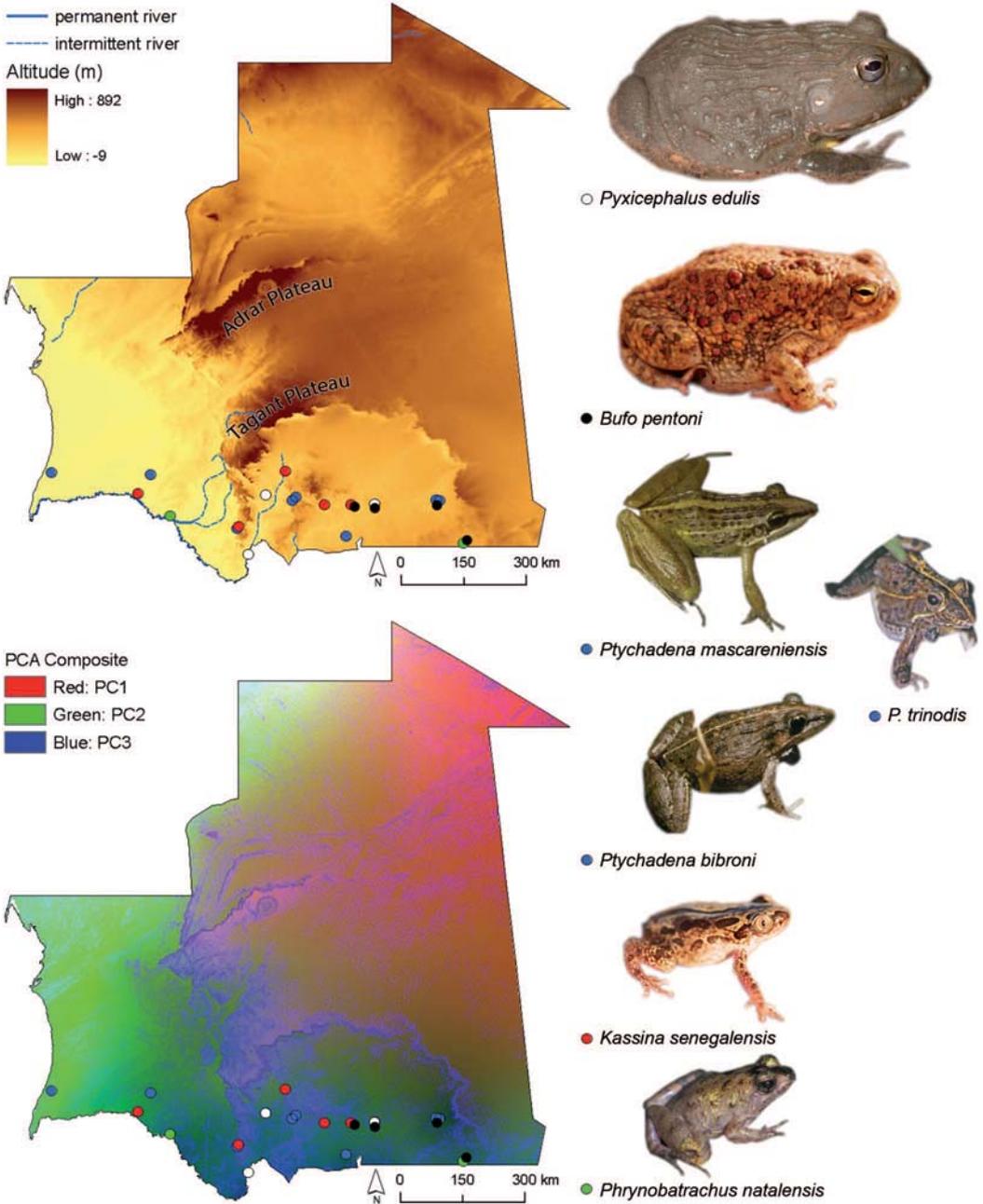


Figure 2: Localities for Mauritanian anurans occurring exclusively in the savannahs of the Sahel. See Fig. 1 for an explanation of Principal Components Analysis. All symbols for *Ptychadena* species are in blue because identifications in the literature are ambiguous.

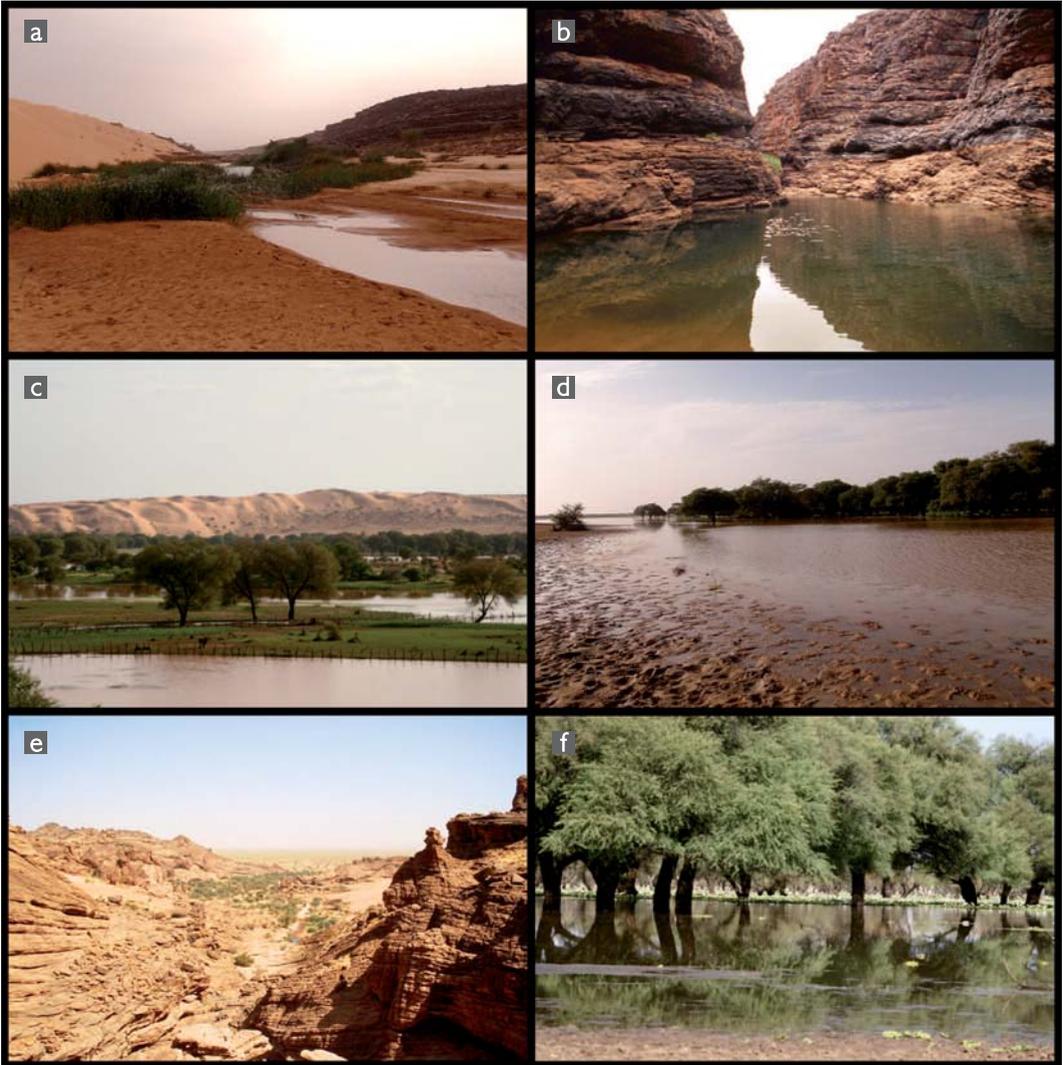


Figure 3: Representative localities occupied by anurans in Mauritania. (a) Guelta Toumbahjît (Adrar) supports relict populations of *Amietophrynus xeros* and *Hoplobatrachus occipitalis*. (b) Guelta Molomhar (Adrar), previously supported *A. xeros* and *H. occipitalis* but was found to be completely dry in March 2008 (see text). (c) Gabou Lake (Tagant) contains populations of *A. xeros*, *H. occipitalis*, *Tomopterna cryptotis*, and *Kassina senegalensis*. (d) Tâmoûrt Goungel (Hodh el Gharbi) where *H. occipitalis*, *K. senegalensis*, *Ptychadena* spp., and *T. cryptotis* are frequently found. (e) Mountainous areas of the Sahel south of Kiffa (Assaba), and Guelta Oumm Lebare where *Ptychadena trinodis* was found. (f) Tamourt Bougari (Assaba), a swamp inhabited by *A. xeros* and *H. occipitalis*, and probably *Amietophrynus regularis*, *T. cryptotis*, and *K. senegalensis*.

The major factor determining survival of Saharan amphibian populations is their capacity to resist episodic drought and their chance to experience occasional episodes of

populational connectivity during favourable years. Use of water by humans, especially for watering cattle, may increase the risk of local extirpation, especially during extremely dry

periods. The most effective conservation measure in this case is the provision of guidance for better management of water resources in oases, “wadis”, “gueltas”, and springs. Human populations have been historically living in close contact with anuran populations, and despite the intense droughts of the 1970s some amphibian populations survived. Nonetheless, human populations are increasingly relying on ground water for agriculture, including the raising of cattle, and for domestic use, which may eventually reduce the impact they may have had to date on some surface water.

Conservation measures for Saharan populations may be desirable because they present an ideal scenario for studying and testing hypotheses on effects of on-going environmental change on survival, local adaptation, and genetics of small and isolated populations. The Sahara Desert has probably suffered gradual xerification (with intermediate wet periods) since the Holocene, that, when considered along with more recent episodes of dramatic climatic change (GASSE, 2000; FOLEY *et al.*, 2003), could be behind the current genetic and population structure of water-dependent organisms. Comparing the genetic structure of anurans in Saharan isolates with those of more continuously distributed populations in the Sahel should provide information about the role of population size, population dynamics, distance among populations, and time since separation, on the genetic structure of species in isolated populations. The current scenario available in Mauritania provides a perfect opportunity to study how population size, gene flow, species-specific characteristics, and environmental change affect local adaptation and extinction.

RECOMMENDATIONS

A list of localities important to anurans in Mauritania is provided in Table 2. The conservation status and population trends of this fauna are currently unknown but we list the following series of actions that should lead to better understanding of the situation of amphibian populations and provide a frame-

Table 2: Important localities for anurans in Mauritania (coordinates in decimal degrees [WGS84 datum]).

Locality	Coordinates	
Wilaya Adrar		
Guelta Handoum	N20.323193	W13.142101
Guelta Molomhar	N20.580946	W13.136361
Guelta Toungâd	N20.061001	W13.132806
Iriji	N20.516667	W13.050000
Kanoal, Oued Séguelil	N20.303600	W13.197283
Terjît	N20.252804	W13.088188
Toumbahjît	N20.236826	W13.004978
Wilaya Assaba		
Aouïnet Nanâga	N17.152482	W12.199115
Bou Blei'îne	N17.126067	W10.990067
Bougari	N16.546667	W10.792333
Guelta Oumm Lebare	N16.579150	W10.704550
Guelta Metraucha	N16.538033	W10.741550
Oumm Icheglâne	N17.070297	W12.207848
Wilaya Brakna		
Aleg	N17.053333	W13.916117
Wilaya Hodh Ech Chargui		
Mahmûdé Lake	N16.499483	W7.715183
Wilaya Hodh El Gharbi		
Ain El Berbera	N16.691103	W9.716622
Chegg el Mâleh source	N16.515562	W10.452908
Guelb Samba	N16.654987	W9.707835
Tâmchekket	N17.249855	W10.667613
Tâmoûrt Goungel	N16.403148	W9.559860
Wilaya Tagant		
Gabou Lake	N18.260000	W12.360000
Guelta el Gheddiya	N17.834850	W11.557833
El Housseïniya	N17.737962	W12.245253
Guelta Fanar	N18.015850	W12.174967
Guelta Garaouel	N17.451667	W12.394850
Guelta Matmata	N17.887298	W12.110844
Wilaya Trarza		
Diawling National Park	N16.440000	W16.340000

work for defining future research and conservation priorities: (1) evaluate the status of Saharan isolates, especially the more vulnerable northern populations (i.e. Adrar and historical localities in Tiris Zemmour), and extend field surveys to Saharan localities having a potential for supporting amphibian populations, e.g., Wilayas Assaba, Brakna, Guidimaka, Gorgol, Hodh El Gharbi, Hodh Ech Chargui, and Trarza in the Senegal basin and, especially, in the mountain ranges of Assaba and Gorgol in the Sahel, regions suspected of having the highest anuran diversity in Mauritania; (2) inventory amphibian populations, with special emphasis on exploration of poorly known areas (eastern Atar, Tagant, Tiris Zemmour, and Hodh Ech Chargui), and provide resultant data regarding anuran distribution and diversity to national and international conservation agencies for use in future proposals regarding wildlife management and conservation; (3) conduct assessments of water quality and threats to populations, particularly in populations restricted to isolated montane pools; (4) from all populations collect tissue samples for molecular studies aimed at (a) assessing the effect of environmental change and population dynamics on genetic diversity and local extinction, (b) evaluate the phylogeographic structure of all anuran species present in Mauritania in order to identify large-scale patterns of genetic diversity, isolation, and gene flow, and (c) clarify the taxonomic status of Mauritanian populations through integration of Mauritanian samples into systematic studies of African anurans. In addition, a conservation measure that could potentially have an important impact on the conservation of amphibians would consist of the pro-

vision of guidance to local inhabitants for better management of water resources in oases, "wadis", "gueltas", and springs.

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