AMPHIBIAN CONSERVATION IN MAURITANIA

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I. INTRODUCTION

Three quarters of Mauritania's one million square kilometers is Sahara desert; Mauritania does not have high amphibian diversity. Only eleven widely-distributed anuran species have been recorded for the country (Table 1; Nickel 2003; Padial & De la Riva 2004), and all are categorized as species of least concern by the IUCN (2009). Mauritanian territory is largely unexplored, however, and it is likely that some of the 19 anuran species recorded from adjacent areas of neighboring countries could occur within its borders. In addition, the taxonomy of most broadly-distributed anuran species in Africa, including those cited for Mauritania (*Ptychadena* spp. [Ptychadenidae]; *Amietophrynus* spp. [Bufonidae]; *Tomopterna* spp. [Pyxicephalidae]; and *Phrynobatrachus* spp. [Phrynobatrachidae]), is incomplete and unreliable.

Broadly-distributed species could eventually be found to be representative of unique, and currently-undescribed, species with restricted distributions. Several Afrotropical anurans have relictual populations in Mauritania and most of these populations are several hundred kilometers distant from the Senegal basin, the closest area of extensive distribution for their "parent" populations. Origins of these relictual populations date at least to 4000 years ago when benign conditions supported continuous savanna habitat and anurans dwelled along with elephants, giraffes and lions (Le Houérou 1997). When relatively recent, and extremely rapid, climate change lead to desertification (Gasse 2000; Foley et al. 2003) amphibian populations became isolated along retreating rivers and interior water basins. Large mammals widely disappeared, but some anuran populations resisted extinction and became true local survivors from the African savanna. At least 20 localities within the Mauritanian Sahara, many of which are connected by fossil river basins that may act as corridors for the exchange of individuals during wet periods, are

inhabited by two or 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 populations of conspecifics. Areas such as these constitute a natural laboratory for studying effects of climate change on natural populations (Dumont 1982), effects of population size on genetic diversity and survival, and effects of allopatry on local adaptation and diversification (Ward 2009).

Because biodiversity is managed at national and local levels (Pleguezuelos et al. 2009), it is important to maintain as much genetic diversity as possible within national borders. Recent surveys for 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 extinction (Trape 2009); this may have been the fate of some anurans as well.

II. DIVERSITY AND DISTRIBUTION

All species occurring in Mauritania are present in the Sahel savanna (Table 1, Figures 1–2), in a pattern partially explained by humidity and temperature. Species present in Saharan isolates are generally abundant and widely-distributed in the Sahel (Fig.1). This latter pattern suggests Saharan isolates are not originally of Saharan origin but are instead the product of colonization by Afrotropical species. Afrotropical species in Mauritania occur in isolated springs, wadis (temporary streams) and gueltas (ponds) in montane regions of the Sahara; *Hoplobatrachus occipitalis* (Dicroglossidae) and *Amietophrynus xeros* are the most conspicuous representatives, although *Tomopterna cryptotis* can also be found in a few Saharan localities. *Amietophrynus regularis*, *A. xeros*, and *T. cryptotis* are also found along the Saharan Atlantic coast, although important populations occur only in the Sahelian wetlands of Diawling National Park near the mouth

of the Senegal River. *Kassina senegalensis* (Hyperoliidae), *Phrynobatrachus natalensis*, *Ptychadena mascareniensis*, *P. trinodis*, *P. bibroni*, and *Pyxicephalus edulis* (Pyxicephalidae) are restricted to the Sahel savanna (Fig. 2).

The most important areas for Saharan amphibians are on the Adrar and Tagant plateaus (Fig. 1) where rocky areas form networks of seasonal rivers (wadis), and where there are many temporary and permanent springs and small pools (gueltas) along stream beds (Fig. 3). The Adrar plateau contains more than 20 water bodies (Fig. 1). The Tagant plateau, situated south of the Adrar plateau, can be considered a transitional area between Saharan and Sahelian environments. This mountainous area of around 2, 000 Km^2 forms an inner drainage that empties into either an interior marshland formed by Gabou Lake (Fig. 3C) and other minor lakes, or into several wadis in the Senegal River basin. This area harbors more available sites for amphibians than the Adrar, and includes components (such as *Kassina senegalensis*) from the Sahel savanna.

The Sahel savanna in southern Mauritania contains innumerable water bodies (Fig. 3) that presumably harbor amphibians but that have not yet been sampled, or for which data have not been published. This area is undoubtedly the richest area of the country in plant and animal species diversity. Besides the eleven species already reported for that region Padial and De la Riva (2004) produced a list containing 19 species expected to occur because they have been found in adjacent Mali or Senegal: Hemisotidae: *Hemisus marmoratus;* Hyperoliidae: *Afrixalus fulvovittatus*, *A. weidholzi*, *Hyperolius nitidulus*, *H. viridiflavus*, *Kassina cassinoides*, *K. fusca*, *Leptopelis bufonides*; Microhylidae: *Phrynomantis microps*; Pipidae: *Xenopus muelleri*; Ranidae: *Hylarana galamensis*, *Phrynobatrachus latifrons* (as *P. accraensis*), *P. francisci*, *P. latifrons*, *P. natalensis*, *Ptychadena schillukorum* (as *P. floweri*), *P. oxyrhynchus*, *P. pumilio,* and *P. tellinii*.

III. 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 for Mauritania is considered globally endangered (IUCN 2009). 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 species of the genera *Ptychadena, Tomopterna* and *Phrynobatrachus* could, in fact, be species complexes containing cryptic or unrecognized species (Vences et al. 2004; Pickersgill 2007; Rödel et al. 2009). Future taxonomic research may well lead to changes in our perception of the level of endemicity and, hence, the conservation needs of many species.

In general, we have found no evidence indicating population decline of anurans in Mauritania due to human pressure but there are, unfortunately, no data about population trends of anurans in Mauritania. Some populations in the Sahel might be suffering negative effects from intense wood harvesting and agro-pastoral use, as well as from the uncontrolled use of pesticides, but availability of many water bodies within the Sahel Plateau should continue to provide refuge for healthy populations of anurans, at least in the short term.

Evidence presented concerning the decline of relictual fish populations in the Adrar Mountains (intense drought since the 1970s, resulting in a 35% reduction in precipitation; Foley et al. 2003; Trape 2009), suggests that some local Saharan anuran populations may also be at risk of extinction due to environmental factors. While we might expect that

tolerance to aridity would help anurans survive episodes of severe drought, Saharan isolates of *Hoplobatrachus occipitalis*, *Amietophrynus xeros* and *Tomopterna cryptotis* should be considered locally endangered because of small population size and extreme isolation.

Population decline of anurans could be the case at the permanent (and deep [5m]) Guelta of Molomhar (near Atar), which was completely dry in March, 2008 (P. Geniez, pers. obs.). Known to be inhabited by *A. xeros*, *H. occipitalis*, and at least three fish species, this guelta had never been seen dry by local guides and it is not known for certain how its fauna was affected by this exceptional drying event. Isolated populations of *A. xeros* from other Sahelian regions (Guelta of Timia, Niger) have dorsal skin ulcers probably related to parasitic as well as fungal, viral or secondary opportunistic infections, suggesting that isolated populations may have increased vulnerability to extinction (Brito et al. 2005) but whether these infections also occur in Mauritania is not known.

The major factor determining survival of Saharan amphibian populations is their capacity to resist episodic drought. Human use of water, especially for watering cattle, may increase the risk of local extinction, especially during extremely dry periods. The most effective conservation measure in this case is providing guidance for better management of water resources in oases, wadis, gueltas and springs. Human populations have been living in close contact with anuran populations since, at least, the 1950s, and during intense droughts of the 1970s, with no indication of human-induced decline. Human populations are increasingly relying on ground water for agriculture, including raising cattle, and domestic use, which may eventually reduce the slight impact they have had to date on some surface water bodies.

Conservation of Saharan anuran isolates is especially desired because these populations constitute ideal natural situations for studying and testing hypotheses and

provide general models for the study of population genetics. 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), sculpted the current genetic and population structure of water-dependent organisms. Comparing the genetic structure of anurans in Sahara isolates with that of more continuously-distributed populations in the Sahel should provide information regarding the role of population size, population dynamics, distance, and time since separation, on isolated populations. The current scenario available in Mauritania provides a perfect opportunity to study how population size and gene flow affect local adaptation to dry conditions.

IV. RECOMMENDATIONS

In Table 2 we provide a list of localities important to anurans in Mauritania. Conservation status and population trends of this fauna are currently unknown but we list a series of actions we consider necessary for improving basic understanding of Mauritanian amphibians. These recommended actions can provide a framework for defining future priorities for conservation and management:

- Evaluate status of Saharan isolates and extend field surveys to Saharan localities having potential for supporting amphibian populations, such as Wilayas Assaba, Brakna, Guidimaka, Gorgol, Hodh El Gharbi, Hodh Ech Chargui, and Trarza in the Senegal basin and, especially, in the Sahelian mountain ranges of Assaba and Gorgol regions which are suspected of having the highest anuran diversity in Mauritania,

- Provide anuran distribution and diversity data to conservation agencies that may use them for future proposals regarding conservation,
- Collect tissue samples from all populations for molecular studies aimed at discovering the effect of environmental change and population dynamics on genetic diversity and local extinction,
- Evaluate the phylogeographic structure of Mauritanian anurans to identify Evolutionary Significant Units, and
- Contribute to taxonomic and phylogenetic analyses of African species with representatives in Mauritania to clarify the taxonomic status of Mauritanian populations.

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Table 1. Geographical areas (see also Figure 1) and taxonomic status of anuran species recorded from Mauritania. Nomenclature and classification follow Frost (2009); taxonomic status follows Rödel (2000) and Frost (2009).

SPECIES	DISTRIBUTION AND POPULATION STATUS	TAXONOMIC STATUS
Bufonidae		
"Bufo" pentoni	Scattered localities across the Sahel savanna; locally abundant.	Stable.
Amietophrynus regularis	Scattered localities across the Sahel savanna and along the coast; locally abundant.	Stable; several synonyms across its broad distribution present the possibility of future status change.
Amietophrynus xeros	Most Saharan water bodies; locally abundant.	Stable; several synonyms across its broad distribution present the possibility of future status change.
Dicroglossidae		
Hoplobatrachus occipitalis	Most Saharan water bodies and across the Sahel savanna; locally abundant but possible local extinctions have been reported.	Stable.
Hyperoliidae *Kassina senegalensis*	Scattered localities across the Sahel savanna; scarce.	Unstable, possible species complex.

Phrynobatrachidae		
Phrynobatrachus natalensis	Known only from a single locality in the Sahel savanna; no abundance data.	Unstable, possible species complex.
Ptychadenidae		
Ptychadena bibroni	Known from two localities in the Sahel savanna; no abundance data.	Stable.
Ptychadena mascareniensis	Known only from a single locality in the Sahel savanna; no abundance data.	Unstable, possible species complex.
Ptychadena trinodis	Known from two localities in the Sahel savanna; no abundance data.	Stable.
Pyxicephalidae		
Pyxicephalus edulis	Scattered localities across the Sahel savanna; probably locally abundant.	Unstable, possible species complex.
Tomopterna cryptotis	Scattered localities across the Sahel savanna, also recorded on the coast and in some Saharan water bodies; rare.	Unstable, possible species complex.

Table 2. Important localities for anurans in Mauritania (Coordinates in decimal degrees [WGS84 projection]).

Locality	Coordinates	
Wilaya Adrar		
Guelta Handoum	N20.323193	W13.142101
Guelta Molomhar	N20.580946	W13.136361
Guelta Toûngâd	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		
Aouînet Nanâga	N17.152482	W12.199115
Bou Bleïîne	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		

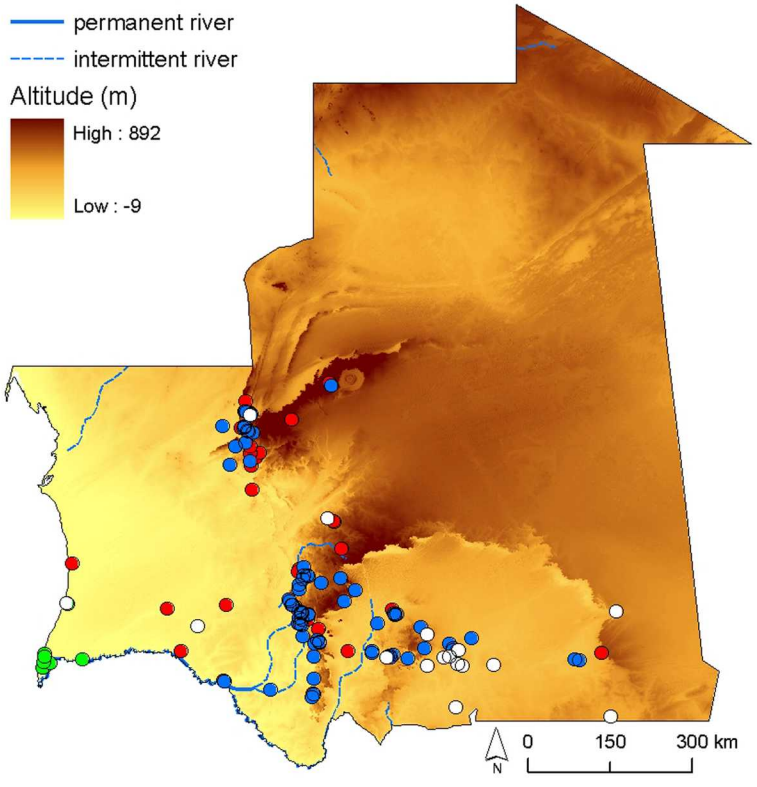
Ain El Berbera	N16.691103	W9.716622
Chegg el Mâleh source	N16.515562	W10.452908
Guelb Samba	N16.654987	W9.707835
Tâmchekket	N17.249855	W10.667613
Tâmoûrt Goungel	N16.403148	W9.559860
Wilaya Tagant		
Gabou Lake	N18.260000	W12.360000
Guelta el Gheddiya	N17.834850	W11.557833
El Housseînîya	N17.737962	W12.245253
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

Figure 1. Localities for Saharan isolates and for Mauritanian anurans occurring in Sahel savannas. Altitude (above) and environmental variability (below) represent the first three axes (red, green and blue, respectively, explaining 85.1% of total variance) calculated when importance of altitude, slope, annual precipitation, precipitation of the wettest month, annual average temperature, minimum temperature of the coldest month and maximum temperature of the hottest month were assigned by Principal Components Analysis. (*A. regularis* photograph courtesy of Mark-Oliver Rödel).

Figure 2. Mauritanian amphibians occurring exclusively in Sahel savannas. All symbols for *Ptychadena* species are blue because literature identifications are ambiguous. Altitude (above) and environmental variability (below) represent the first three axes (red, green and blue, respectively, explaining 85.1% of total variance) calculated when importance of altitude, slope, annual precipitation, precipitation of the wettest month, annual average temperature, minimum temperature of the coldest month and maximum temperature of the hottest month were assigned by Principal Components Analysis. (*A. regularis* photograph courtesy of Mark-Oliver Rödel).

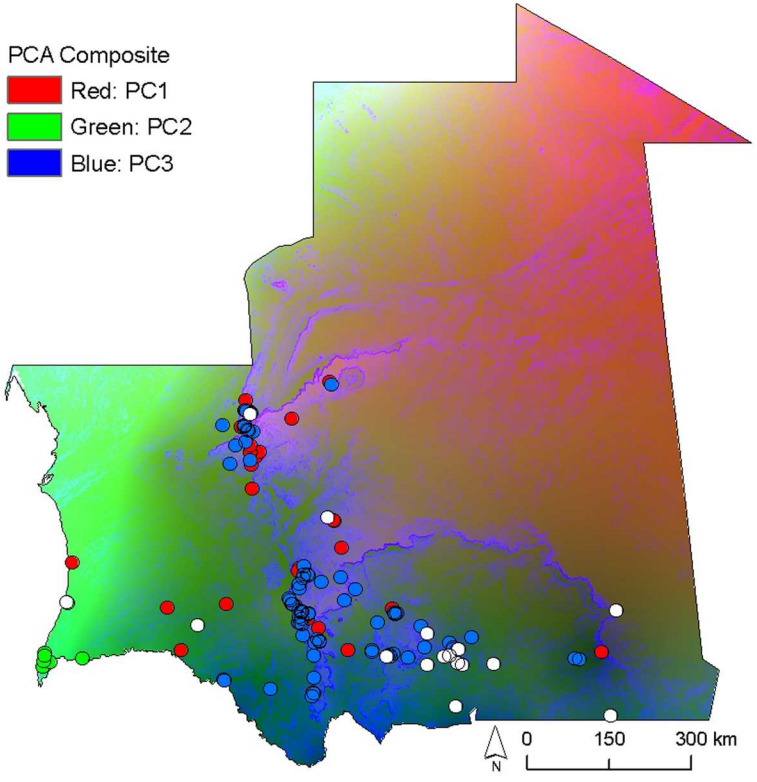
Figure 3. Representative localities occupied by anurans in Mauritania. A. Guelta Toumbahjît (Adrar) supports relict populations of *Amietophrynus xeros* and *Hoplobatrachus occipitalis*; B. Guelta Molomhar (Adrar), supported *A. xeros* and *H. occipitalis* but was found to be completely dry in March, 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 *Hoplobatrachus occipitalis*, *Kassina senegalensis*, *Ptychadena* spp. and *Tomopterna cryptotis* are frequently

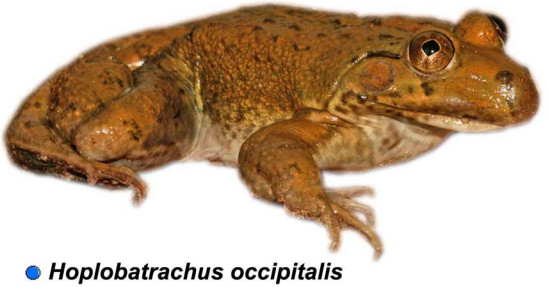
found; E. Mountain areas of the Sahel south of Kiffa (Assaba) and Guelta Oumm Lebare where *Ptychadena trinodis* was found; F. Tamourt Bougari (Assaba), a swamp inhabited by *A. xeros*, *H. occipitalis* and probably *A. regularis*, *T. cryptotis* and *K. senegalensis*.



● ***Amietophrynus regularis***

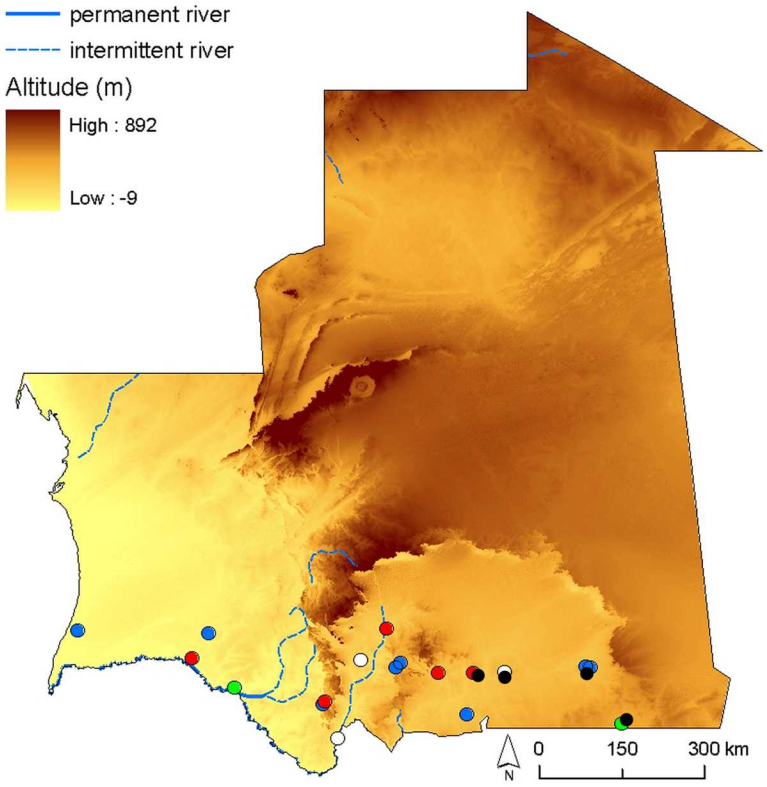
● ***Amietophrynus xeros***





● ***Hoplobatrachus occipitalis***

○ ***Tomopterna cryptotis***



○ ***Pyxicephalus edulis***

● ***Bufo pentoni***

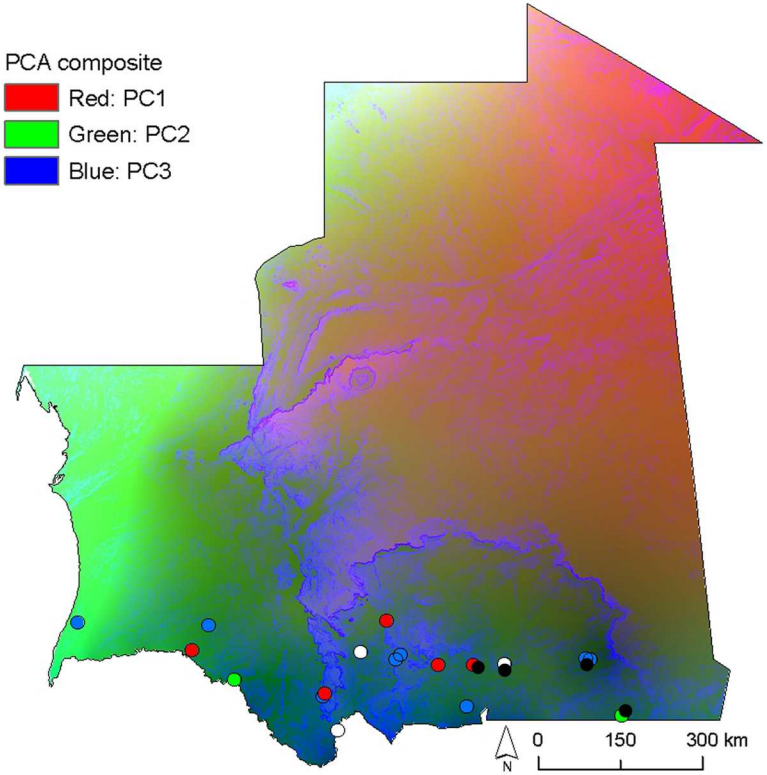
● ***Ptychadena mascareniensis***

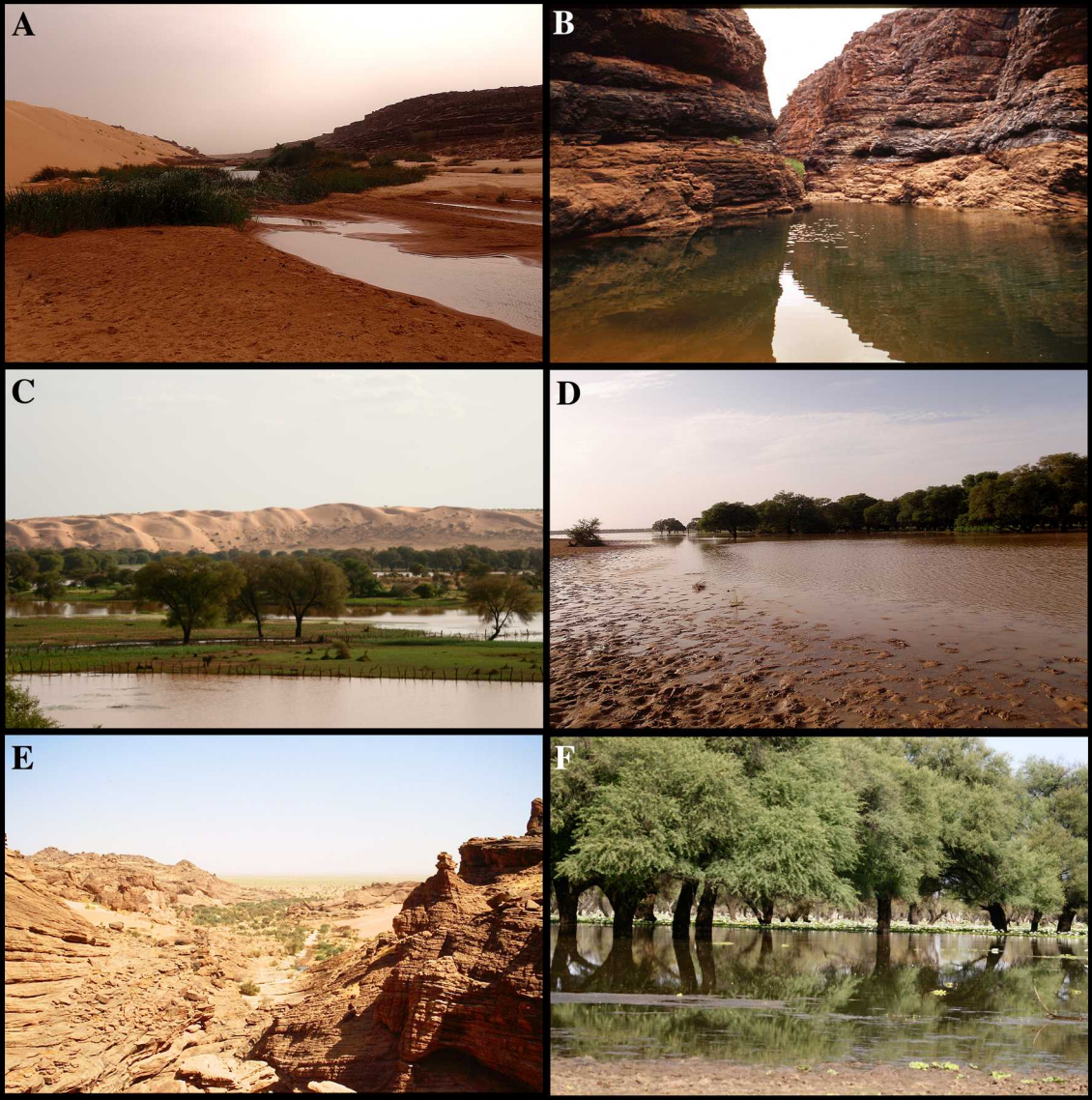
● ***P. trinodis***

● ***Ptychadena bibroni***

● ***Kassina senegalensis***

● ***Phrynobatrachus natalensis***

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