Short Communication

Crocodiles *Crocodylus niloticus* as a focal species for conserving water resources in Mauritanian Sahara

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Abstract A survey on the Tagant Plateau, Mauritania, to design a reserve for the crocodile *Crocodylus niloticus* revealed that the area is occupied by a crocodile population larger than expected. Crocodiles occur in lakes and pools along seasonal rivers that form an inner hydrographical network. Reported movements of individuals during the summer floods suggested that it is necessary to protect the whole 700 km-long hydrological network to preserve inter-pool connectivity. However, the basin is occupied by 40,000 people that are completely dependent on water from the hydrological network. Thus it was important to propose a reserve network that would reconcile both the protection of biodiversity and human use of water resources. Considering the symbolic role of crocodiles for many Mauritanians, the acceptance of their presence by the people of Tagant, and the increasing use by tourism agencies of some pools for crocodile-watching, the species may be a good focal species for promoting the conservation of the whole hydrological network of the Tagant Plateau.

Keywords *Crocodylus niloticus*, desert, focal species, Mauritania, reserve design, Sahara, water management.

The status of crocodiles in the Sahara is a matter of conservation concern. Although they are now extinct in the northern Sahara, they still survive in some isolated locations in the south (Smet, 1999). West African crodiles were long considered a subspecies of the nominal form *Crocodylus niloticus* but, based on molecular evidence, the resurrection of the old name *Crocodylus suchus* has been proposed (Schmitz *et al.*, 2003; Geniez *et al.*, 2004; Padial, 2006). Mauritanian crocodiles were considered to be extinct until their rediscovery in isolated pools in south-east Mauritania (Behra, 1994; Shine *et al.*, 2001). The northernmost populations are known from the Tagant Plateau (Behra, 1994; Shine *et al.*, 2001; Padial, 2006). Based on published (Behra, 1994) and informal data collected in the area, the Ministry of Development and Environment realized the need to offer protection for this species, and we were asked to prepare a Ramsar Convention Site proposal for conserving Matmata, the crocodile site most visited by tourists to the Tagant Plateau.

A preliminary survey suggested that Matmata pool belongs to a large, isolated hydrographical network draining to the north-west in Gabou Lake, an interior marshland surrounded by desert. Thus we hypothesized that crocodiles were probably distributed in isolated pools across the whole Gabou basin. If so, based on metapopulation theory (Hanski, 1998), conservation of crocodiles would require the preservation of between-pool connectivity by protecting the seasonal rivers that periodically connect pools and lakes during the rainy season. However, this region is occupied by *c.* 40,000 people that depend on the hydrological network's water resources (Padial, 2002). Thus, it appeared necessary to design a reserve that would reconcile both crocodile protection and human use of water resources.

The Tagant Plateau is a 2 million ha area ranging in altitude from 90 m at Gabou Lake to >500 m in the highest mountains. Annual rains are scarce and seasonal (100-150 mm in July-October) but flow on impermeable slopes into seasonal rivers (*oued* in Arabic). There are temporary and permanent small pools (*guelta*) along the stream beds and some permanent lakes (Fig. 1). Highlands are covered by desert steppe (with vegetation dominated by *Acacia ehrenbergiana, Acacia tortilis, Balanites aegyptiaca* and associated species) and occupied by nomadic herdsmen who rear goats, sheep, camels, donkeys and cows. Lowlands are covered by trees (especially *Acacia nilotica*) and marshlands that are used to produce vegetables and/or date palm *Phoenix dactylifera* by sedentary farmers.

During November 2006 and February 2007 we travelled 1,500 km across the Tagant Plateau to assess the distribution of potential habitat for crocodiles. Given logistical difficulties of moving within the region, we sampled a set of pools located in the low, middle and high sectors of river beds. We used satellite imagery provided by Google Earth (2006), conventional maps, and local guides for detecting

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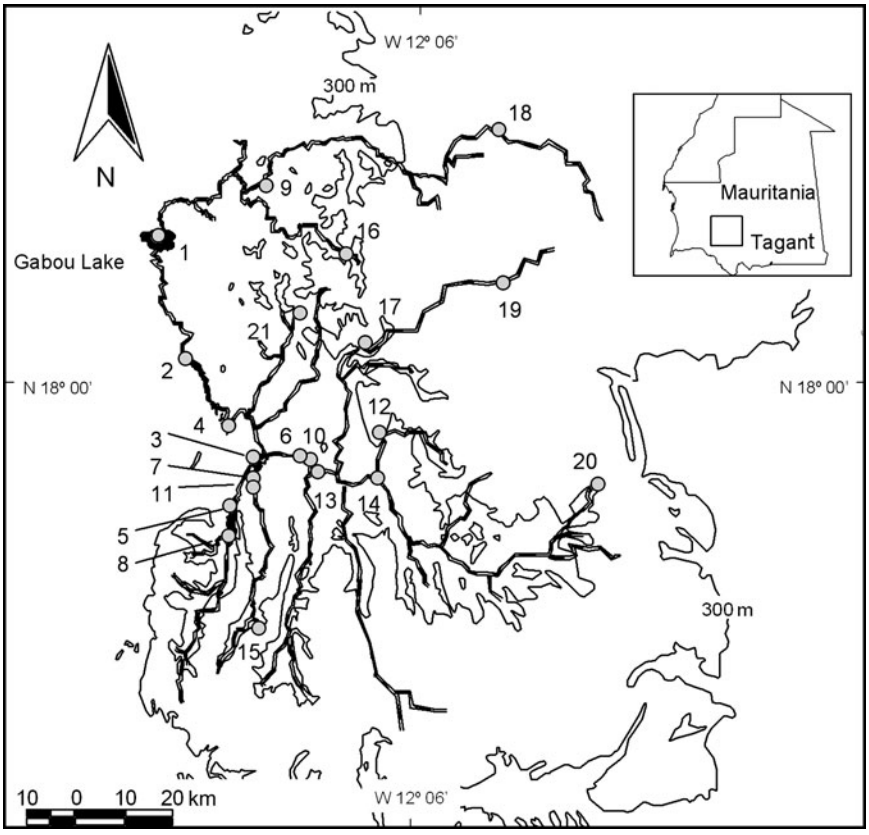

FIG. 1 The Tagant Plateau in Mauritania showing the structure of the hydrographical network that drains into Gabou Lake. Dots show the localities in which crocodiles were recorded (see Table 1). Guelta Fanar (21) has been included based on data provided by Padial (2006). The rectangle on the inset indicates the location of the main figure in West Africa.

pools. We also interviewed the local heads of 30 villages and camps. In this way we gathered information on crocodiles and the use of water resources by people. Spatial data were geo-referenced with a global positioning system and processed by the geographical information system *ArcView v.* 3.2 (ESRI, Redlands, USA). At each site where we located crocodiles we measured the surface area covered by water, noted whether the water was permanent or seasonal, and assessed any overuse by herdsmen. At each site we assessed the presence of crocodiles by visual inspection from suitable spots using binoculars and a telescope for 2-5 hours. In addition, we always looked for tracks on muddy substrata around pools and crevices and, when camped near a pool, we used headlamps (light range: 0.25 lumens m^{-2} at 45 m) to search for crocodiles at night.

We recorded crocodiles in 20 localities (Table 1). These findings, with the addition of Guelta Fanar (18°09' N 12°10' W) cited in Padial (2006), indicate that crocodiles are distributed across the whole Gabou basin (Fig. 1). We also recorded new sites with crocodiles outside the basin (Guelta Silimbo 17°49' N 12°16' W and Toueijikjit 17°25' N 12°25' W). These localities, together with Guelta Laout (17°15' N 11°58' W) on the southern slopes of the Plateau (Padial, 2006) suggest that individuals in the Gabou basin may be connected with other, southern populations (Shine *et al.*, 2001; Nickel, 2003). After assessing the surface of permanent lakes (Table 1) and evaluating the area covered by seasonal rivers and small pools (700 km long and *c.* 50 m wide beds that account for *c.* 3,500 ha) we calculated that the suitable habitat for crocodiles in the Gabou basin is *c.* 9,500 ha.

Crocodiles seemed to be active year-round in permanent pools but, when water disappears in seasonal pools, they retire to crevices (Shine *et al.*, 2001; Nickel, 2003). According to the local herdsmen this retreat occurs early in pools overexploited by domestic animals, particularly in the most elevated sectors of the basin. People in N'Beika reported the detection and the regular killing (Smet, 1999) of 2-3 crocodiles during summer rainy periods, and people of N'Beika, Guelta Kaimel and Motoboul referred to movements of crocodiles along the river beds during flooding.

Our survey and analysis supports the view that crocodiles are broadly distributed across the Gabou basin, making this the northernmost population of this species in West Africa. We cannot discard the possibility that there is some genetic exchange with the nearby populations of the Senegal River Basin (Guelta Silimbo in the Senegal basin and Husseiniya in the Gabou basin are 10 km apart). We did not assess the size of the crocodile population in Gabou basin but the localities we have identified account for 40% of the known localities of Mauritanian desert crocodiles (Shine *et al.*, 2001; Nickel, 2003; Padial, 2006).

The reported movements of individuals during summer floods suggest that potential extinctions in small pools (usually occupied by 1-3 crocodiles) could be compensated

TABLE 1 Localities and characteristics of the 20 sites in which crocodiles were recorded (Fig. 1).

Locality[1]	Coordinates	Water surface (ha)	Distance to basin (km)	Altitude (m)	State[2]	Overuse[3]
1. Gabou (L)	18°17' N 12°18' W	2,500	0	83	P	N
2. Dekla (L)	18°04' N 12°18' W	1,500	0	99	P	N
3. Marshra (L)	17°53' N 12°11' W	1,000	0	86	P	N
4. T.Naaj (L)	17°56' N 12°15' W	200	0	105	P	N
5. Bouraga (L)	17°47' N 12°13' W	1,000	0	110	P	N
6. Jabara (P)	17°53' N 12°06' W	<1	8	110	S	N
7. Suklan (P)	17°50' N 12°11' W	*	3	114	S	N
8. Husseiniya (P)	17°44' N 12°14' W	<1	1	116	S	N
9. Daal (P)	18°23' N 12°09' W	0.006	34	144	S	N
10. Matmata (P)	17°53' N 12°05' W	0.5-1	10	148	P	N
11. Tkhsutin (P)	17°49' N 12°11' W	0.075	4	155	P	N
12. Bajai (P)	17°50' N 12°04' W	0.05	37	164	P	N
13. Guelta (P)	17°51' N 12°01' W	0.2	13	180	P	N
14. Kabda (P)	17°50' N 11°57' W	0.65	27	256	P	N
15. Daber (P)	17°34' N 12°10' W	0.06	37	259	P	Y
16. Kaimel (P)	18°15' N 12°01' W	0.03	62	288	P	Y
17. TinOudin (P)	18°06' N 11°59' W	0.001	50	344	S	Y
18. Motoboul (P)	18°29' N 11°44' W	*	97	369	S	*
19. Iguevane (P)	18°12' N 11°44' W	0.006	89	383	P	Y
20. El Giya (P)	17°50' N 11°33' W	0.15	92	398	P	Y

[1]L, lake; P, pool
[2]P, permanent; S, seasonal
[3]Y, yes; N, no
*Dry season pool that was difficult to assess

by the arrival of individuals moving along river beds. In this context, permanent lakes in the bed of the basin may be refuges for transient individuals moving between *oueds*. This could explain the recolonization of some pools. For instance, we detected crocodiles in El Giya, which is 90 km from any permanent lakes (Table 1), in which the species disappeared after the strong drought of the 1970s (Smet, 1999). This is an example of why it is important to protect the whole hydrological network and not just particular isolated pools or lakes.

Such a proposal is related to the management of water resources in the whole Gabou basin (*c.* 1 million ha), something that will also reinforce the conservation of other water dependent, threatened wildlife (e.g. *Gazella rufifrons*, *Gazella dorcas*) and other relict populations of Afrotropical species associated with water (e.g. *Clarias anguillaris*, *Varanus niloticus*, *Python sebae*). Because of the critical role of water resources for the human population of this arid area, any conservation plan for the whole hydrological network will require the commitment of both the Tagant people and the relevant government authorities.

Considering the symbolic role of crocodiles for many Mauritanians, the pacific way people accept their presence, and the increasing use by tourism agencies of some pools (e.g. Matmata) for crocodile-watching, the species seems to be a potential focal species for promoting the conservation of the whole hydrological network of the Tagant Plateau (Lindenmayer & Fischer, 2003). This is reinforced by the fact that, according to local herdsmen, crocodiles rarely predate domestic animals and are consequently not perceived as a problematic species. The crocodiles depend on permanent or seasonal water pools and their future is strongly related to sustainable management of this resource. This use of crocodiles as a focal species for conserving water resources is the modern approach to a traditional belief. Shine *et al.* (2001) reported that Mauritanian villagers living near wetlands believe that if crocodiles are killed water will disappear with them and bad luck will befall the village.

Despite the apparent absence of any negative human-crocodile interactions we did, however, detect some indirect threats related to human use of water. Over-exploitation by herdsmen of the highest pools in the basin (where scarce runoff prevents the easy refilling of pools) produces rapid reduction of the water table during the dry season and the early retreat of crocodiles. This generates, in addition to strong faecal contamination by domestic animals, a concomitant increase in human activity to excavate pools or to pump water. This situation can be particularly hazardous for crocodiles and other wildlife using waterholes (Wakefield & Attum, 2006). In addition, some herdsmen reported that upstream construction of small barrages is affecting the refill of downstream pools, increasing the pervasive effects of overuse. These impacts, together with the mechanized pumping of water in some highland villages (from more than 40 m deep in some cases,

e.g. in Rachid) can affect the aquifers. Farms at the margins of lowland lakes have drastically reduced the suitability of many places for crocodiles and, probably, the best places for nesting. Given the permanent availability of water and the potential central role of lakes in the dynamics of the Tagant crocodile population, it seems critical to preserve some sites at the borders of lakes to improve crocodile protection.

These findings were used to prepare a report that was sent to the Ministry of Environment of Mauritania (Tellería *et al.*, 2007). It was used for completing an Information Sheet on Ramsar Wetlands that, after being approved by the local authorities of Tagant, in November 2007, was submitted to the Ramsar Convention Secretariat by the Government of Mauritania in January 2008.

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References

Behra, O. (1994) Crocodiles on the desert's doorstep. *Crocodile Specialist Group Newsletter*, 13, 4–5.

Geniez, P., Mateo, J.A., Geniez, M. & Pether, J. (2004) *The Amphibians and Reptiles of Eastern Sahara. An Atlas and Field Guide*. Edition Chimaira, Frankfurt am Maim, Germany.

Google Earth (2006) Http://earth.google.com/ [accessed 1 November 2006].

Hanski, I. (1998) Metapopulation dynamics. *Nature*, 396, 41–49.

Lindenmayer, D.B. & Fischer, J.F. (2003) The focal species approach: sound science or social hook. *Landscape and Urban Planning*, 62, 149–158.

Nickel, H. (2003) *Ökologische Untersuchungen zur Wirbeltierfauna in südöstilichen Mauretanien. Zwei Fallstudien unter besonderer Berücksichtigung der Krokodile*. GTZ, Echborn, Germany.

Padial, J.M. (2002) *Basis for the Establishment of Biosphere Reserves in The Islamic Republic of Mauritania*. Unpublished Report, Spanish Cooperation Agency-Man et Nature, Nouadhibou, Mauritania.

Padial, J.M. (2006) Commented distributional list of the reptiles of Mauritania (West Africa). *Graellsia*, 62, 159–178.

Schmitz, A., Mansfeld, P., Hekkala, P., Shine, T., Nickel, H., Amato, G. *et al.* (2003) Molecular evidence for species level divergence in African Nile crocodiles *Crocodylus niloticus* (Laurenti, 1786). *Comptes Rendus Palevol*, 2, 703–712.

Shine, T., Böhme, W., Nickel, H., Thies, D.F. & Wilms, T. (2001) Rediscovery of relict populations of the Nile crocodile *Crocodylus niloticus* in south-eastern Mauritania, with observations on their natural history. *Oryx*, 36, 260–262.

Smet, K. de (1999) Status of the Nile crocodile in the Sahara desert. *Hidrobiología*, 391, 81–86.

Tellería, J.L., El Mamy Ghaillani, H., Fernández-Palacios, J.M., Bartolomé, J. & Montiano, E. (2007) *Propuesta para la declaración de Sitio Ramsar de la cuenca del Lago Gabou, Meseta de Tagant (Republica Islámica de Mauritania)*. Conservación Medica Canarias-Sahel, Tuineje, Fuerteventura, Spain.

Wakefield, S. & Attum, O. (2006) The effects of human visits on the use of waterholes by endangered ungulates. *Journal of Arid Environments*, 65, 668–672.

Biographical sketches

José Luis Tellería is interested in vertebrate biology and conservation, and has conducted studies on the distribution of Iberian vertebrates, bird migration and the ecology of vertebrate communities in fragmented landscapes. Hamoud El Mamy Ghaillani has expertise in medical missions and environmental studies in the Sahara and is the manager of Cooperación Médica Canarias Sahel in Mauritania. José María Fernández-Palacios is a plant ecologist interested in island biogeography and ecology, forest dynamics and environmental sciences. Juan Bartolomé has expertise in medical missions and environmental studies worldwide, particularly in the management of health standards under catastrophic events. Emilio Montiano works in health and environment programmes in Mauritania and other West African countries.