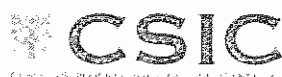


PROYECTO PARA EL REFORZAMIENTO DE LA POBLACIÓN DE GACELA DAMA MHORR EN SENEGAL

(Segundo año)

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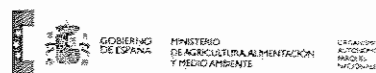


Foto de portada: Hembra de Nanger dama mhorrr capturada en Guembeul (junio 2012).
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Con el presente documento se pretende dar cumplimiento al Artículo 1.8 del Contrato firmado entre la UNESCO y en CSIC para la realización del proyecto "Reforzamiento de la población de *Gazella dama mhor* en Sengal", Segundo año, en el que se señala que es preceptivo la realización de un Informe de Seguimiento para su aprobación, en el que se reflejen las actividades realizadas durante cada misión de los miembros del equipo de investigación a Senegal.

En Almería, a 12 de octubre de 2012

Fdo: Eulalia Moreno Mañas
PROFESORA DE INVESTIGACIÓN DEL CSIC

ÍNDICE

- Preámbulo 5
- Elaboración de un trabajo científico sobre el efecto de la estructura del hábitat de Guembeul en la distribución y abundancia de la gacela mohor reintroducida en esa Reserva de Fauna 5
- Captura de gacelas Mohor en Guembeul para toma de muestras genéticas y parasitológicas 8
- Conclusiones..... 14

APÉNDICE 1

PREÁMBULO

De acuerdo con el Plan de Trabajo presentado para el segundo año de este proyecto la primera misión a Senegal debería haber sido realizada entre febrero y marzo de 2012. Por motivos ajenos a nuestra voluntad (elecciones presidenciales en el país) nos hemos visto obligados a retrasar nuestra primera misión hasta en dos ocasiones, habiéndola llevado a cabo definitivamente entre los días 26 de junio y 2 de julio del año en curso.

Al regreso de nuestra primera misión, y dados los cambios políticos acontecidos, entre otros el que afectaba al nombramiento de un nuevo Director General de Parques de Senegal, solicitamos al OAPN retrasar la elaboración de este informe hasta tener información verificable de los cambios que podrían afectar a gestión de la Reserva de Fauna de Guembeul y, en su caso a la de Ferlo Norte. Nuestro objetivo era poder relatar en este informe no sólo el cumplimiento de sus objetivos, sino también ofrecer una visión de su futuro en el nuevo contexto que para dichas Reservas se quiere ofrecer relativos a su conservación y manejo. Es por ello que emitimos este informe con un retraso de dos meses según lo estipulado en el contrato firmado con la UNESCO.

A continuación exponemos los resultados de los objetivos alcanzados según se expusieron en el Plan de Trabajo presentado a la UNESCO para la firma del Contrato en vigor.

1. ELABORACIÓN DE UN TRABAJO CIENTÍFICO SOBRE EL EFECTO DE LA ESTRUCTURA DEL HÁBITAT DE GUEMBEUL EN LA DISTRIBUCIÓN Y ABUNDANCIA DE LA GACELA MOHOR REINTRODUCIDA EN ESA RESERVA DE FAUNA.

Recordemos que una de las hipótesis que nos planteábamos al comienzo de este proyecto (véase Plan de Trabajo del primer contrato y Primer Informe del año 2011) para explicar la disminución en el tamaño de población de la gacela Mohor durante los últimos años en Guembeul estaba relacionada con un posible cambio en la estructura del hábitat de esta Reserva de Fauna. Durante las dos misiones realizadas en 2011 tomamos los datos de campo necesarios para verificar esta hipótesis y a lo largo de los primeros meses de este segundo contrato los hemos analizado y elaborado un trabajo científico que ha sido publicado en la revista ANIMALS (Open Access). Dicho trabajo se presenta en toda su extensión como Apéndice 1 de este Informe. Sus conclusiones más relevantes las resumimos a continuación:

- 1) La Reserva de Fauna de Guembeul no es homogénea en cuanto a estructura del hábitat. Su parte oriental representa un hábitat más abierto, donde las especies arbóreas y los cactus del género *Opuntia* son menos abundantes (cobertura media de árboles = 38.6%; cobertura media de *Opuntia* = 0.48%)

que en su parte occidental (cobertura media de árboles = 71.43%; cobertura media de *Opuntia* = 17.85%). La altura de la vegetación es significativamente menor en la parte oriental (altura media = 35 cm; en Guembeul occidental la altura media es 56.9 cm).

- 2) Todas las gacelas Mohor censadas se han localizado en la zona oriental de Guembeul. El número de individuos es de 10 (mismos resultados obtenidos los dos días de censo), distribuidos como sigue: un grupo reproductor compuesto por un macho y 7 hembras, y dos machos solitarios. En la parte occidental no se han detectado gacelas Mohor ninguno de los dos días de censo.
- 3) Se han censado, igualmente, los Oryx de cuernos de cimitarra. Su distribución en Guembeul es más o menos homogénea en ambas partes de la Reserva. Se han registrado un total de 70 individuos, 46 en la parte oriental y 24 en la occidental. Generalmente forman grupos familiares, aunque se ha detectado también un gran grupo liderado por un macho dominante.

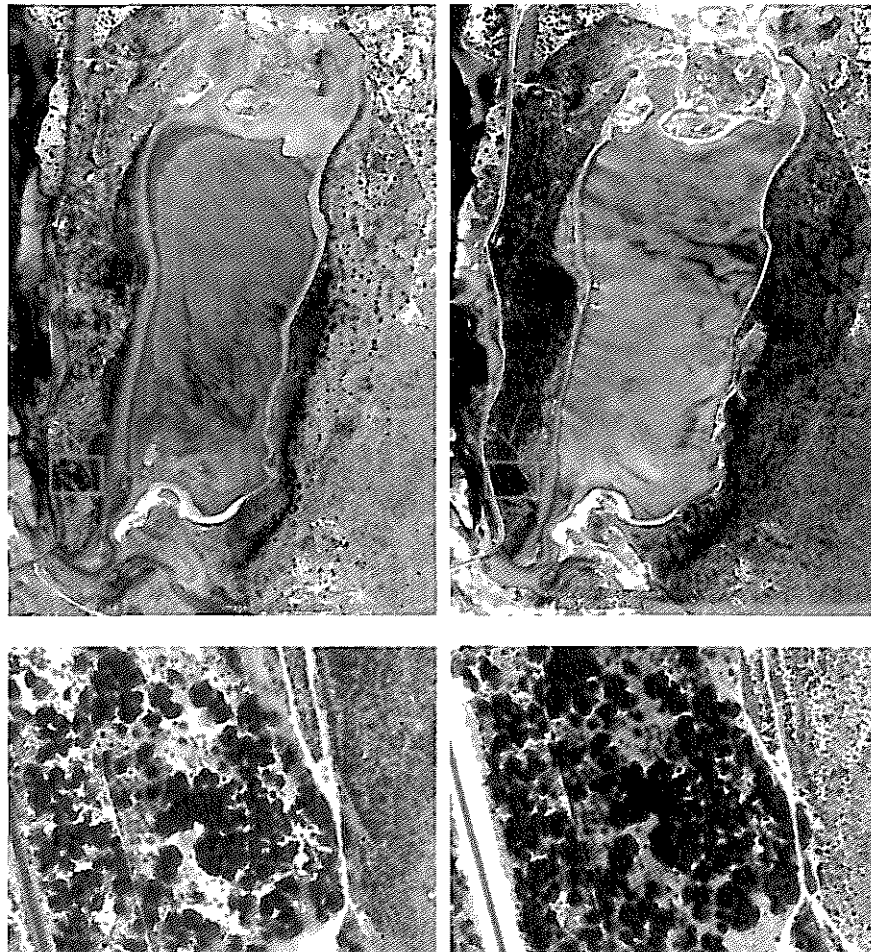


Figura 1.- Fotos donde se muestran los cambios ocurridos en la estructura de la vegetación en la RF Guembeul: las fotos de la izquierda están tomadas en marzo de 2003; las de la derecha en abril de 2011. Arriba, vista general; el detalle de los cuadrados rojos se muestra abajo más ampliada. Las fotos se han tomado de Google©; fecha de acceso 28 de mayo de 2012.

4) Existe una asociación entre presencia de gacelas Mohor y hábitat simples: cobertura vegetal y dosel arbóreo menos espeso y hierba de menor altura. Estos resultados nos hacen sugerir la posibilidad de que a lo largo del tiempo, y después de la delimitación de la Reserva que ha impedido la entrada de ramoneadores, se ha producido un cambio en la estructura de la vegetación en Guembeul, cambio que ha reducido la cantidad de hábitat óptimo para la gacela Mohor, que prefiere hábitats más abiertos donde los depredadores puedan ser divisados a larga distancia. La comparación de las imágenes de satélite de la Reserva de Fauna de Guembeul entre 2002 y 2011 apoyan esta hipótesis (Fig. 1), dado que a lo largo del tiempo la estructura de la vegetación se ha modificado hacia un hábitat más complejo y una mayor cobertura vegetal, sobre todo en la parte oriental de la Reserva. La proliferación de la especie invasora *Opuntia tuna* (Fig. 2) en este período de tiempo ha desempeñado un papel primordial en este cambio estructural, pues actualmente es muy abundante en toda la reserva, convirtiendo algunas zonas en impracticables para la fauna ungulada.



5) En este trabajo hemos identificado al menos una de las posibles causas que han traído como consecuencia la disminución de la población de gacela Mohor reintroducida en Guembeul en 1984. Y a la luz de nuestros resultados podemos sugerir que el mantenimiento de esta especie en esta Reserva de Fauna en el largo plazo pasa por el mantenimiento de una cantidad mínima de hábitat óptimo para la especie. Es necesario un clareo intensivo de la vegetación y la eliminación de la invasora *Opuntia* para poder asegurar una razonable viabilidad de esta especie en Guembeul. Sugerimos una política proactiva de las autoridades senegalesas favoreciendo la realización de estas actividades de clareo y mantenimiento de la vegetación por parte de los habitantes de la zona en esta área protegida. Creemos que este tipo de iniciativas produciría un aumento en la efectividad de la labor de conservación por cuanto los habitantes verían la reserva como un elemento que les proporciona trabajo a la vez que los involucraría en una actividad sostenible para el entorno.

2.- CAPTURA DE GACELAS MOHOR EN LA RF GUEMBEUL PARA TOMA DE MUESTRAS GENÉTICAS Y PARASITOLÓGICAS

Durante los días 27, 28, 29 y 30 de junio se realizó el trabajo de campo en la RF Guembeul. Considerando los cambios que había habido unas semanas antes a nuestra visita en la Dirección-Conservación de la Reserva, junto con el gran despliegue de medios humanos que era necesario para la captura de las gacelas Mohor, el día 27 de junio mantuvimos una reunión en el Ecomuseo de Guembeul con las autoridades y técnicos de la Reserva, para ultimar todos los detalles del operativo. A esa reunión, que estuvo presidida por el nuevo director-conservador, Sr. Bocar Thiam, asistió también el director-conservador de la RF de Ferlo Norte (Sr. Jacques Gomis), Joaquín Sanz-Zuasti, y el responsable de la empresa con la que se había contratado la captura, el Sr. Agustín Sánchez.



Figura 2.- Reunión en la RF Guembeul el 27 de junio de 2012. Foto J. Sanz-Zuasti

Los días 28 y 29 de mayo eran las fechas previstas para las capturas. A las 06:00 hora local, comenzó el trabajo de campo. Es de destacar el enorme número de personas involucradas en este trabajo (Fig. 3), necesarias debido al método de captura que se iba a utilizar: ojeo de los animales en batida hasta hacerlos llegar a una zona perimetrada, que terminaba en un embudo (Fig. 4) donde se capturaba al animal con la propia red. En estos trabajos han estado involucrados cada día entre 30 y 40 personas, que, en su mayoría, fueron reclutadas por la empresa contratada para las capturas entre los habitantes de la villa de Guembeul. También formaron parte del equipo de captura numerosos técnicos de la DPN venidos desde San Luis, Dakar y Ferlo Norte.

El día 28 se hicieron dos ojeos; en ninguno de ellos se logró atrapar a ningún animal. Los ojeos permitieron llevar a los animales hasta la zona perimetrada, pero al alcanzar la zona más cercana al embudo, y de forma imprevista, usaron como vía de escape el lago central de la Reserva.

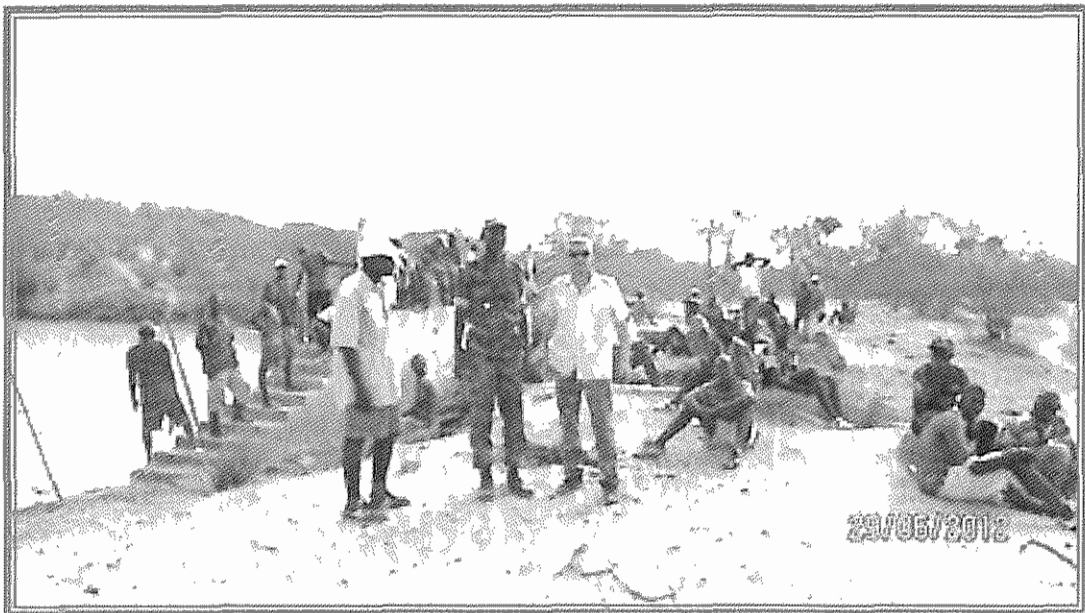


Figura 3: Participantes del equipo de captura en las inmediaciones de lo zona perimetrada al finalizar uno de los ojeos. En la foto inferior, el conservador de RF Guembeul, Sr. Bocor Thiam, y Joaquín Sanz-Zuasti. Foto J. Sanz-Zuasti.



Figura 4: Parte final (embuda) del recinto perimetrado construido para la captura de las gacelas. Foto E. Moreno.

El día 29 de junio se realizó un nuevo ojeo que tuvo como resultado la captura de un único individuo de gacela Mohor. Se trataba de una hembra adulta, de edad aproximada (calculada basándonos en la morfología y tamaño de sus cuernos) entre los 5-6 años (Fig. 5).

El protocolo veterinario (Fig. 6) que se llevó a cabo tras la captura consistió en primer lugar en la administración de maleato de acepromacina (Calmo Neosan®), un sedante del grupo de las fenotiacinas que actúa disminuyendo el posible estado de agitación y excitación derivado de la captura, junto con una dosis de vitamina E y selenio (Hipravit-Se®), como método profiláctico para evitar una posible miopatía postcaptura. Posteriormente, y una vez tomadas las muestras biológicas pertinentes, se le administró un antiparasitario, ivermectina (Ivomec®), a la vez que perfenazina enantato (Trilafon®), un sedante de larga duración (al menos 7 días) para facilitar tanto la adaptación al cercado en el que se le iba a recluir, como para disminuir el estrés de una posible nueva captura (e.g., para devolverlo de nuevo a su hábitat en Guembeul).

El examen en el momento de su captura nos demostró que el animal presentaba un acusado estado de adelgazamiento (Fig. 7), así como mal aspecto del pelo, sintomatología que nos hizo pronosticar algún estado infeccioso sin identificar. Pese a todo, su grado de hidratación era el idóneo.



Figura 5.- Gacela Mahor recién capturada. Foto E. Moreno.



Figura 6.- Intervención veterinaria inmediatamente después de la captura. Foto E. Moreno.



Figura 7.- Aspecto general de la gacela Mahor capturada en Guembeul. Nótese la prominencia de las ancas, indicativo de su estado de delgadez. Foto I. Malina.

La gacela fue marcada mediante crotal con el número 1 (código de color: amarillo-amarillo). Desde el momento de la captura hasta la suelta en el cercado se midieron de forma rutinaria las constantes vitales del animal (pulso, respiración y temperatura). En ningún momento de la manipulación éstas fueron patológicas. En el momento de la suelta se le administró una dosis del antibiótico amoxicilina (Clamoxyl LA®) como tratamiento al posible proceso infeccioso que se le había diagnosticado.

Las muestras biológicas tomadas fueron: sangre (en frotis para estudio de parásitos y en vial para estudio genético) y ectoparásitos (se encontraron 4 garrapatas, aparentemente todas de la misma especie, que están siendo identificadas en la Univ. de Murcia). No fue posible la toma de muestras de heces, pues todas las veces que se intentó, el animal tuvo el tracto rectal vacío.

Aproximadamente a las 10:00 horas de ese día 29 la gacela capturada se liberó en el cercado construido el año pasado para este efecto. Su estado era, aparentemente, bueno (Fig. 8). Desde el momento de su reclusión en el cercado y hasta el anochecer, el animal estuvo vigilado por dos personas de nuestro equipo, ante la posible eventualidad de algún efecto secundario de los distintos

tratamientos o de la propia cautividad. Nada anormal ocurrió durante todo el tiempo transcurrido en el cercado.



Figura 8.- Gacela Mohor en el cercado de la RF de Guembeul el 29 de junio de 2012. Foto E. Morena.

Después de tres intentos de capturar a las gacelas (días 29 y 30 de junio), los miembros de nuestro equipo, de acuerdo con las autoridades de la DPN y con Joaquín Sanz-Zuasti y Agustín Sánchez, decidimos no hacer nuevos intentos de captura. Las razones fundamentales fueron dos: 1) los animales estaban aprendiendo el método que usábamos en el ojeo, y eludían cada vez más fácilmente al ojeador; 2) dado que el estado sanitario de la gacela capturada no era óptimo, no creímos conveniente continuar estresando a los animales con más ojeos, pues si el resto de las gacelas no capturadas estaban en condiciones similares, era probable que una elevación del estrés pudiera provocar perjuicios no contemplados a priori (bajada de respuesta inmunitaria, shock postraumático por la captura,...).

Como consecuencia, el día 30 de junio la gacela Mohor capturada el día anterior fue de nuevo liberada en la misma zona de la RF Guembeul donde mayoritariamente se han avistado a estos animales en los últimos dos años: alrededor del mirador que existe en la parte oriental de la Reserva. El animal

salió trotando, sin signos aparentes de afección por la captura o por las 24 horas que estuvo cautivo en el cercado.

El día 30 de junio por la tarde me reuní, a petición suya, con el nuevo Director de Parques Nacionales de Senegal, el Sr. Soulèye Ndiaye. Le acompañaba el director-conservador de la RF Guembeul, Sr. Bocar Thiam. En dicha reunión relato los objetivos de este proyecto en los casi dos años que lleva en marcha, así como los resultados obtenidos hasta ese momento. Igualmente le informo de los resultados de la presente misión, así como de las expectativas que tenemos para el futuro y de los compromisos espero se realicen por parte de la DPN para alcanzar el fin último de este proyecto: lograr identificar las causas del declive de la población de gacela Mohor reintroducida en Guembeul y reforzar esa población con animales provenientes de Almería una vez subsanadas las causas que pueden haber determinado dicho declive (ver más abajo Conclusiones).

3. CONCLUSIONES

Los trabajos realizados hasta la fecha en la RF Senegal nos permiten tener una idea bastante fiable de las causas que han podido llevar al declive poblacional de la gacela Mohor en la RF Guembeul en los últimos años. Su remediación sería posible con un reforzamiento de animales provenientes del EEP (Programa Europeo de Cría en Cautividad) coordinado desde la EEZA-CSIC de Almería, a la vez que con la colaboración de las autoridades senegalesas que debieran velar porque las causas que han llevado a este declive no vuelvan a reproducirse y promover activamente el mantenimiento y conservación de la población reforzada. En este momento nuestras conclusiones y recomendaciones serían las siguientes:

1.- La población de gacela mhorr (*N. d. mhorr*) cuenta en la actualidad con 10 individuos. **La modificación del hábitat** de Guembeul hacia una estructura más compleja parece estar desempeñando un papel importante en su declive de los últimos 10-15 años (véase Apéndice 1).

2.- Según señalamos en el Informe anterior, la **pérdida de variabilidad genética** también se desprende de nuestros resultados como causa probable del declive. Los datos de pedigrí señalan una pérdida de líneas maternas ocurridas alrededor de los años 90, lo que muy probablemente haya aumentado el nivel de consanguinidad de la población, y con ella, haya elevado los problemas de supervivencia a medio y largo plazo. Esperamos poder confirmar esta hipótesis cuando dispongamos de los análisis de ADN del ejemplar capturado.

3.- No debemos excluir la posibilidad de **competencia con el Oryx** de cuernos de cimitarra. Esta especie, que fue reintroducida en Guembeul en los años 90, parece competir en condiciones de dominancia con la gacela Mohor.

4.- Es necesaria la **colaboración de autoridades y técnicos senegaleses en el mantenimiento de instalaciones y animales**. En nuestra reunión con el Sr. Soulèye Ndiaye le expusimos la necesidad de que se actuara sobre la vegetación de la Reserva antes de proceder al reforzamiento de la Mohor. Es imprescindible el clareo de algunas especies arbustivas autóctonas a la vez que una erradicación de la invasiva *Opuntia*. Le indicamos igualmente de la necesidad de reparación que tiene la valla perimetral, con el fin de eliminar la intrusión de posibles depredadores (chacales y perros asilvestrados, fundamentalmente). También le indicamos que es requisito imprescindible el mantenimiento higiénico-sanitario de los animales en los cercados de aclimatación cuando se capturen los de Guembeul y/o lleguen los del reforzamiento. Esto lo señalamos como consecuencia de haberse detectado al menos un caso de salmonelosis en uno de los rebaños de *Gazella dorcas* que hay en la Reserva, y que ha provocado varios abortos en los últimos meses (uno de ellos ocurrió en la tarde del 29 de junio, estando presente los miembros de nuestro equipo).

Aunque aparentemente existe interés por parte de las autoridades senegalesas en seguir adelante con este proyecto y recibir nuevos animales que refuercen la población de Mohor, como ya comentamos en el Informe anterior, es necesario que en la práctica las actuaciones por parte de Senegal sean vistas lo antes posible. En este proyecto hemos llegado al punto en el que ahora han de actuar ellos. Nosotros tenemos ya una diagnosis fiable del problema y sabemos cómo ponerle remedio. Pensamos que los cambios políticos ocurridos este año en Senegal pueden ser responsables parciales del retraso en estas actuaciones, pero cualquiera que sea su causa, lo cierto es que en estos momentos no podemos avanzar más en la RF Guembeul.

Además, surge la posibilidad de que la RF Guembeul vea modificada su actividad. Según nos comenta el Sr. Soulèye Ndiaye, existe una iniciativa para aumentar la superficie de la Reserva, perimetrarla con fondos provenientes de la cooperación con otros países, y reconducirla hacia una reserva similar a la de Bandia, al este de Dakar. Mientras este punto se clarifica nuestra actuación según nuestro Plan de Trabajo no parece puede proseguir su curso, o al menos no en esta Reserva.

5.- Contemplamos la posibilidad de **hacer el reforzamiento en la Reserva de Ferlo Norte**. Los datos que obtuvimos en nuestro primer viaje, así como la información que hemos recibido tanto del Sr. Sanz-Zuasti como de las propias autoridades senegalesas en los últimos meses nos sugieren que esta es una alternativa plausible y alternativa a la de hacerla en Guembeul.

APÉNDICE 1

Changes in Habitat Structure May Explain Decrease in Reintroduced Mohor Gazelle Population in the Guembeul Fauna Reserve, Senegal

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Article

Changes in Habitat Structure May Explain Decrease in Reintroduced Mohor Gazelle Population in the Guembeul Fauna Reserve, Senegal

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Simple Summary: The reintroduction of plants and animals to the wild is an important technique to save endangered species from extinction. To perform post release monitoring is crucial to evaluate reintroduction outcomes. A Mohor gazelle reintroduction programme took place in Senegal in 1984. We attempt to explain why the size of the reintroduced gazelle population has diminished in recent years. We suggest that changes in habitat structure occurred over time and have very likely reduced the amount of suitable habitat for this species.

Abstract: Reintroduction is a widespread method for saving populations of endangered species from extinction. In spite of recent reviews, it is difficult to reach general conclusions about its value as a conservation tool, as authors are reluctant to publish unsuccessful results. The Mohor gazelle is a North African gazelle, extinct in the wild. Eight individuals were reintroduced in Senegal in 1984. The population grew progressively, albeit slowly, during the first 20 years after release, but then declined dramatically, until the

population in 2009 was estimated at no more than 13–15 individuals. This study attempts to determine the likelihood of gazelle-habitat relationships to explain why the size of the gazelle population has diminished. Our results show that the Mohor gazelle in Guembeul is found in open habitats with less developed canopy where the grass is shorter, suggesting the possibility that changes in habitat structure have taken place during the time the gazelles have been in the Reserve, reducing the amount of suitable habitat. Reintroduction design usually concentrates on short-term factors that may affect survival of the released animals and their descendants (short-term achievement), while the key factors for assessing its success may be those that affect the long-term evolution of the population.

Keywords: evaluation of reintroduction; habitat structure; *Nanger dama mhorh*; post release monitoring; Senegal

1. Introduction

Reintroduction has emerged as a widespread method for saving endangered species from extinction, representing a particularly suitable conservation strategy when *in situ* and *ex situ* measures have been shown to be insufficient. However, published research on its outcome has been limited [1], as most authors prefer to publish their “successful” results than to report failures or even uncertainties. In recent years reintroduction reviews have been increasing [2–5]. Most of them strongly recommend carrying out periodically post-release monitoring as well as reporting of results, as differences over time in the known and unknown outcomes of reintroduction programs (success, failure, and uncertain) have been shown. Reviews also show that reintroduction programs do not have high success rates (26% of success reported by Fischer & Lindenmayer [1]; 42% of success reported by Germano & Bishop [4]; 46% of success reported by Sheean and co-workers [5]), particularly when captive-bred animals are used. Captive breeding seems to induce significant evolutionary changes in ways that compromise fitness in natural environments [6,7].

The Mohor gazelle (*Nanger dama mhorh* Bennett, 1833) is the largest gazelle species known (males: 40–75 kg; females: 35–40 kg [8]). It is a North African species believed to be extinct in the wild [8]. Its range coincided more or less with the oceanic and suboceanic Atlantic Sahara, a cold-current coastal attenuated desert comprising a sublittoral zone where steppes and acacia woodlands abound. The species inhabited areas with sparse vegetation [8], grazing gramineous or non-graminid herbaceous plants, and browsing the foliage of ligneous species, which played a particularly important role in the ecological requirements of this species [9]. Two more subspecies are widely recognized within *N. dama*: *N. d. dama* (in the western and central Sahel) and *N. d. ruficollis* (in the eastern Sahel; see [8] for a review). In Senegal, the Mohor gazelle has been known since at least the 18th century in the Sahelian zone [10]. Sournia & Dupuy [11], however, thought that it was only a dry season visitor (see also [12]). An *ex situ* conservation programme began at “La Hoya” Experimental Field Station (EEZA-CSIC) in Almería (Spain) in 1971, and its world’s captive population is currently about 180 individuals [13]. This species was first reintroduced in Senegal in 1984 [14]. Eight individuals (2 males: 6 females) were taken from Almería to the Réserve Spéciale de Faune de Guembeul (RF Guembeul) in Senegal. The population grew gradually to around 49 individuals in 2002 [15]. But due to unknown causes, the population has

declined dramatically in last ten years, the species having disappeared from the western part of the Reserve according to information provided by rangers. In 2009, the population size was 15 individuals [16], some authors having recommended a reinforcement of the species [8]. Along with the Mohor gazelles, a small group (1 male: 2 females) of dorcas gazelles were moved from La Hoya Experimental Field Station to RF Guembeul in 1984 as well, but all of them died from traumatic accidents during the first two days after arrival [17].

Another reintroduction attempt took place in Senegal in 1999, when eight (3 males: 5 females) Scimitar-horned Oryx (*Oryx dammah*) from the Hai Bar Zoo Reserve in Israel were transferred to RF Guembeul [18]. In 2002, two males and two females were added to this founder population from the Vincennes Zoo in Paris [19]. Contrary to the Mohor gazelles, the Scimitar-horned oryx population at the Reserve appears to be growing, albeit slowly, with normal births each year [20], and was comprised of 40 individuals in 2009 [16]. Comparison of the outcomes of the two reintroduction initiatives made the need to investigate the likely causes of the decline in the Mohor population evident. In 2010, the “Organismo Autónomo Parques Nacionales” (a dependency of the Spanish Ministry of Agriculture and Environment) and UNESCO funded a project to investigate the likely reasons for the decrease in the Mohor gazelle population observed in RF Guembeul, in agreement with the Senegalese “Direction des Parcs Nationaux” (DPN).

Many factors have been shown to have an effect on the success/failure of reintroduction projects [7,21–23], such as availability of suitable habitat to cover the vital requirements of animals [24–27]. In this paper we examined gazelle-habitat relationships in the Réserve Spéciale de Faune de Guembeul. As the species used to live in Sahelian grasslands, savanna and sub-desert steppes, where the presence and density of trees appears to condition its distribution [28], we presently test the hypothesis that Mohor gazelle habitat preferences could partially explain its distribution (presence vs. absence) in Guembeul, a hypothesis which would provide a plausible explanation for the current decline of the species observed in this Reserve. We suggest that it is very likely paralleled by changes in habitat structure at RF Guembeul in the last 9–10 years. If this hypothesis is true, we would expect Mohor gazelles to be absent from the most vegetated, covered areas in Guembeul, the species preferably inhabiting its simplest structured habitat.

2. Methods

The RF Guembeul (a 720-ha fenced off area; 15°55'N; 16°28'W) is about 12 km south of Saint Louis (Sahelian zone in northern Senegal). Created in 1983, it is one of the three connected reserves in the network of lagoons and creeks which follow the Senegal River to its mouth. It was set aside primarily to protect a variety of resident and migrant water birds. In 1986, it was designated as a Ramsar Wetlands. The centerpiece of the Reserve (about 1/3 of its total area) is a large lagoon which divides RF Guembeul in two (called “West” and “East” for the purposes of this study, Figure 1). It is in a shallow depression with sandy shores surrounded by thorn-bush savannah dominated by *Acacia* sp. and *Balanites aegyptiaca* [29], and scattered *Boscia senegalensis*, *Salvadora persica* and *Commiphora africana* shrubs, among others. *Opuntia tuna* thickly covers some parts of the Reserve. In the eighties, it was restricted to a small area in the southwest [14], but as an exotic weed, this cactus species has become more widespread, especially in the West where it appears quite evenly distributed.

Figure 1. Map of the Reserve of Fauna of Guembeul showing plots where habitat structure has been sampled (15°55'N; 16°28'W). The central lagoon divides the Reserve into a western part and an eastern part, each of them containing seven sampling plots (1W–7W; 1E–7E). The white line around denotes a perimetral fence. Photo taken from Google©.



Reintroduced Mohor gazelles were part of the species EEP (European Endangered Species Programme), and were identified with the following studbook numbers [13]: ND176, ND229 (males), ND39, ND114, ND172, ND191, ND241, ND247 (females). Female ND247 died during transport. Upon arrival, a breeding group was placed in a 400-m² pen (male ND176 and all of the females), and the remaining male (ND229) was kept alone in a 100-m² pen. Details of the evolution of the stock released until 1992 can be found in [14].

We made a thorough review of the literature in an attempt to find out as much information as possible on how the released stock has evolved since its reintroduction in 1984. However, published information is scattered and sometimes contradictory, with gaps for which there is no information at all. Published information on the evolution of the Scimitar-horned oryx reintroduced in RF Guembeul was also reviewed for purposes of comparison.

Fieldwork was undertaken in 2011. To study habitat structure, 14 plots were selected (Figure 1). Seven were located in the West of the Reserve and seven in the East, where

the remaining population of gazelles has been observed by rangers in recent years. Plots were sampled twice (once in January and once in November). Every plot consisted of a square 25 m per side separated from the closest plot by about 500 m. Each plot was geo-referenced (information available upon request). The following predictor variables were taken for each plot: tree cover (percentage), grass cover (percentage), *Opuntia tuna* cover (percentage), bare ground cover (percentage), mean tree height, mean grass height, minimum browsing height and species richness (defined as the number of different species of trees and ligneous bushes inside the plot). Data on gazelles were collected in two censuses on different days (16 and 17 November) beginning at 06:00 AM by means of a “census party” of nine people moving together from south to north over East RF Guembeul. They were distributed horizontally from the shore of the lagoon to the outer (perimetral) fence (about 600 m wide). Each person was separated from his neighbour by a distance such that each could see the one on both right and left. We were therefore sure that all animals were seen by at least one person in the census party. We recorded the number of individuals seen (Mohor gazelle or Scimitar-horned oryx), the GPS coordinate where it was observed, and whether they were solitary or in a group.

The Mohor gazelle is considered to be absent from the West of Guembeul, as none have been observed by RF Guembeul rangers in the last few years. Counts of Scimitar-horned oryx were made on 16–17 November in one-day drives and walking (another day), always at dusk. As East and West Guembeul were completely separated by the central lagoon in November, we were sure that individuals counted early in the morning in the East were different from those counted at dusk in the West, because they are unable to cross the water. In accord with previous rangers’ information, we found no Mohor gazelle in West RF Guembeul.

We performed a General Discriminant Analysis to test for differences in habitat structure between East and West RF Guembeul. To control the probability of a sampling date effect (January vs. November), we included this variable as a categorical predictor. To check for lack of relationships between sampling date and significant continuous predictors (plot variables), we tested their interactions. For reaching normalization, variables taken as percentages were arcsine transformed and linear variables were log-transformed. Analysis was performed using Statistica 7.0 [30].

3. Results and Discussion

Table 1 shows the evolution of the Mohor gazelle and Scimitar-horned oryx populations in RF Guembeul according to published information. The gazelle population grew from 7 to 13 individuals (6 males: 7 females) from 1984 to December 1992. Eighteen deaths were recorded during this eight year period (see [14] for more details on yearly evolution of the population and herd management). From 1992 to 2002 the Mohor gazelle population seemed to grow gradually to 49 [15]. The Senegalese DPN took advantage of the increased population of this gazelle at RF Guembeul to transfer nine of them (2 males: 7 females) to the Réserve de Faune du Ferlo Nord in 2003 (482.000 ha of protected Sahel in Northern Senegal [20,31]). In 2005, only 20 Mohor gazelles were left in RF Guembeul [20] representing the population’s first recorded decrease. We have been unable to find published information on the evolution of the Mohor population in RF Guembeul from 2005 to 2009, when, as we were informed by DPN technicians, only 13–15 gazelles were left in the Reserve (see also [16]).

Table 1. Evolution of the Mohor gazelle and Scimitar-horned oryx populations at RF Guembeul since their respective years of reintroduction (1984 and 1999) according to published information. References are included.

Species	Date	Population size	Reference
<i>N. d. mhorr</i>	1984	8	[14]
	1992	13	[14]
	2001	44	[32]
	2002	49	[15]
	2003	(40) 9 individuals to Ferlo	[16,20]
	2005	20	[20]
	2009	15	[16]
	2011	10	Current study
<i>O. dammah</i>	1999	8	[18,19]
	2001	14	[19]
	2002	23	[15]
	2003	26	[18,19]
	2003	(18) 8 individuals to Ferlo	[20]
	2004	18	[19]
	2005	18	[20]
	2009	40	[16]
	2011	70	Current study

Available information on the reintroduction of the Scimitar-horned oryx in RF Guembeul tells a different story. It started 15 years later than the Mohor; reinforcement (2:2 individuals) took place after initial reintroduction (3:5); the population has progressively evolved up to now even though eight individuals (2:6) were taken from RF Guembeul to Ferlo Nord in 2003 within the broad DPN initiative for reintroducing Sahel Saharan antelopes there, including the Mohor gazelle.

We found that West and East RF Guembeul had different habitat structures (Table 2). Tree cover, *Opuntia* cover and grass height were significantly different whether sampled in January or in November (no significant interaction). East RF Guembeul is a more open habitat, where trees and *Opuntia* are less abundant (mean tree cover = 38.6%; mean *Opuntia* cover = 0.48%) than in the West (mean tree cover = 71.43%; mean *Opuntia* cover = 17.85%), and the canopy is significantly less developed. Grass height is also lower in the East (mean grass height = 35 cm; in West Guembeul mean grass height = 56.9 cm). The discriminant function correctly classified 100% of plots sampled in East RF Guembeul and 97% in the West.

We found the same Mohor gazelle population size on both census days. In the East there are 10 individuals distributed as follows: one breeding group formed by one adult male and seven females, and two solitary males. The Scimitar-horned oryx population, on the other hand, was composed of 46 individuals in this part of RF Guembeul; most of them in a large herd (n = 37) with a dominant male, several younger males and many females and their calves. We also detected two family groups of five and three individuals respectively, and one solitary male. In the West, we counted up to 24 individuals, all included in a single herd. This means that the Scimitar-horned oryx population at RF Guembeul had grown to 70 individuals by November 2011.

Table 2. Results of the General Discriminant Analysis performed to test for differences in habitat structure between East and West RF Guembeul. The interaction between sampling dates (January vs. November) and the three significant variables are also shown.

Variable	F	Effect df	Error df	<i>p</i>
Species richness	0.072	1	18	0.792
Bare Ground	1.612	1	18	0.220
<i>Opuntia</i> cover	21.289	1	18	<0.001
Tree cover	12.849	1	18	0.002
Grass cover	2.207	1	18	0.155
Tree height	0.021	1	18	0.886
Grass height	18.981	1	18	<0.001
Minimum browsing height	3.316	1	18	0.085
Sampling date (January vs. November)	0.904	1	18	0.354
Sampling date* <i>Opuntia</i> cover	0.026	1	20	0.873
Sampling date* Tree cover	0.002	1	20	0.969
Sampling date* Grass height	0.008	1	20	0.930

The Mohor gazelle population that was reintroduced in RF Guembeul has experienced a decline in recent years after a post-release increase up to 2002–2003. This gazelle is a desert/semi-desert species [8]. The presence and density of trees appears to condition its distribution throughout its range. Numerous observations have been made in the Atlantic-Sahara desert, mostly in open habitats [33–35]. In Niger, its strong preference has been documented for the major “wadis” and their flood plains, secondarily for the steppes in zones of water movement and the dunes invading the “wadi” beds [28]. In Termit Massif it occupies rocky, open areas and sandy fields of barkhan with green pastures and other annual plants [36]. As predicted from its ecological preferences, we found Mohor gazelles currently absent in those zones of RF Guembeul with denser canopy, and where grass is taller, occupying preferably areas characterized by more open, simpler habitats with shorter grass height. This result led us to suggest the possibility that there have been changes in habitat structure during this time in Guembeul, which have reduced the amount of suitable habitat for this gazelle in the Reserve.

A few months after creation, RF Guembeul was completely fenced off to protect the area from livestock grazing. At that time, it was a rather impoverished sandy habitat due mainly to overgrazing. However, fencing promoted recovery of vegetation, and four years later important changes in its landscape were reported [14]: In 1984 “*Acacia* spp shoots about 25–30 cm high were scattered around the Reserve, with very few mature trees”. In 1988 “the acacias and other trees had grown to a height of 3–5 m and were distributed fairly evenly some 6–10 m apart” and “a small area to the south-west is thickly covered by *Opuntia tuna*”. This has also changed with time, and this cactus is much more widely extended, especially in the West where it appeared in all plots sampled (Table 3). Unfortunately there is no quantified data available on habitat structure in the RF Guembeul in the past that would provide an accurate image of the hypothesized habitat changes over the past years, and which presumably could explain Mohor gazelle decline parallel to an increase in vegetation cover. However, by using historical as well as current Google© images of the Reserve (Figure 2), we can observe changes in the extent of the canopy roughly by comparing pictures taken in 2003 and pictures taken in 2011, and this change is much more pronounced in West Guembeul,

very likely associated with the expansion of *Opuntia* in this part of the Reserve. Remote sensing techniques could probably be used in a future follow up study to underpin our current results.

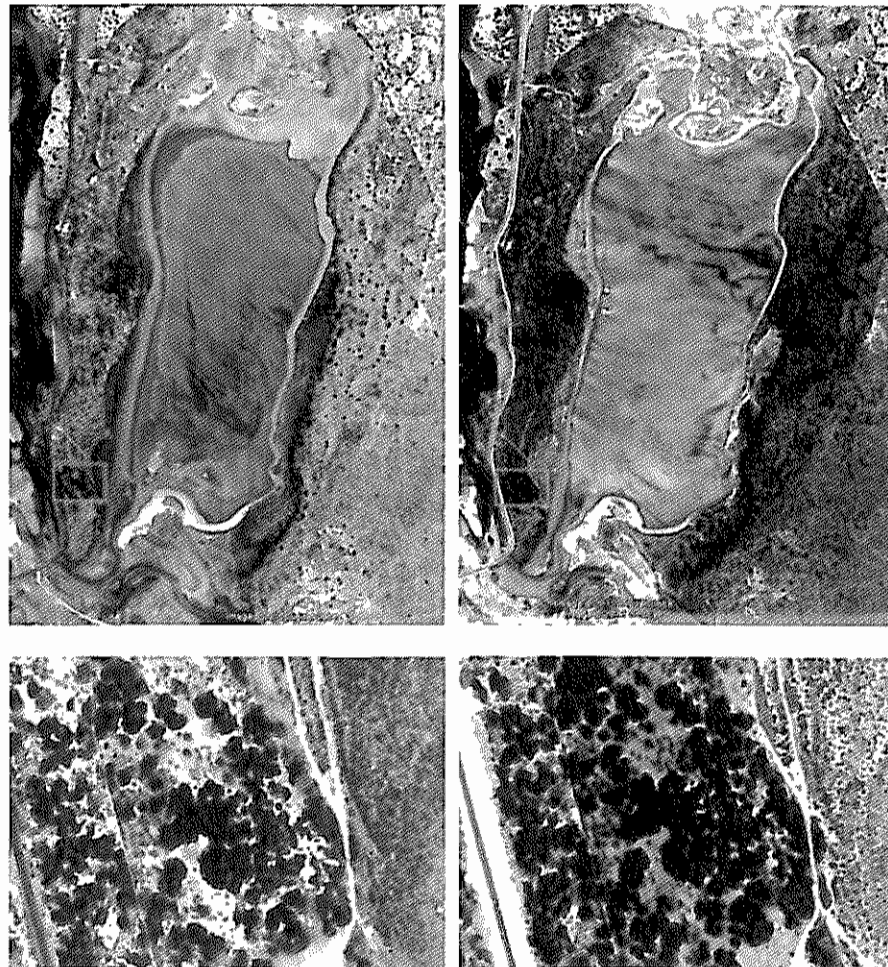
Table 3. Main tree and thorn-bush species found within the sampled plots. Plots are coded as in Figure 1 (1E–7E, eastern part of RF Guembeul; 1W–7W western part). Abbreviations: OT, *Opuntia tuna*; Asp, *Acacia* sp; BA, *Balanites aegyptiaca*; GT, *Grewia tenax*; CP, *Cocculus pendulus*; AD, *Adansonia digitalis*; PJ, *Prosopis juliflora*; SP, *Salvadora persica*; EB, *Euphorbia balsamifera*; CA, *Commiphora africana*; BS, *Boscia senegalensis*; TS, *Tamarix senegalensis*.

Plot	OT	Asp	BA	GT	CP	AD	PJ	SP	EB	CA	BS	TS
1E	X						X		X			
2E		X	X	X						X		
3E		X		X		X	X	X	X	X		
4E												X
5E		X				X	X	X		X	X	
6E		X		X			X	X				X
7E	X	X					X	X				
1W	X	X					X		X			
2W	X	X	X				X					
3W	X	X	X		X			X		X		
4W	X	X	X						X	X		
5W	X	X	X				X	X		X		
6W	X	X		X			X	X				X
7W	X	X					X			X		

It is of interest to analyse the likely causes explaining differences in outcomes of the Scimitar-horned oryx reintroduction relative to the outcomes of the Mohor gazelle reintroduction. Contrary to the latter species, the reintroduced Scimitar-horned oryx population has been increasing progressively in RF Guembeul since 1999. This arid grassland species occupies the same ecological zones as the Mohor gazelle, and the ecology of both species was very similar when sharing their historical range [8]. However, changes observed in habitat structure in our study site do not seem to have had effects on the Scimitar-horned oryx population. One likely explanation is competition. The fact that the Mohor gazelle population decline occurs roughly in parallel to the Scimitar-horned oryx population increase seems to support this explanation. Theory suggests that species that share ecological features may compete. Competing species are expected to develop ways to limit competitive interactions, e.g., niche shift [37]. The Scimitar-horned oryx being much bigger (150–165 kg, [38]), might have taken advantage displacing the smaller Mohor gazelle from their most preferred sites in RF Guembeul, the latter species responding to the presence of the competitor by restricting its niche to a smaller subset (*i.e.*, West Guembeul) of the habitat than it would otherwise do (*i.e.*, the whole Reserve). Alternatively, competing species may reduce interactions by partitioning the available resources (niche partitioning, [39]). Although there does not seem to be any first-hand information on the precise ecology of the Scimitar-horned oryx in its entire ecological zone, but rather that it has been described by extrapolation of the Sahelian information combined with other sparse data

[8], it seems that in Niger this species assures shade (an essential element of its habitat during the hot months) by accessing thickly wooded sites. Here *Commiphora africana*, various acacias, and several other Sahelian trees form fairly dense woods in its preferred zones of occupation [8]. Moreover, contrary to Mohor gazelle, during the dry season the Scimitar-horned oryx can feed on succulent plants as a water provider [8]. It is plausible to argue that under a niche partitioning scenario to avoid competition, Mohor gazelle and Scimitar-horned oryx could coexist at Guembeul in the past, populations of both species growing in accordance with their respective ecological demands. However, habitat changes reported in this study, very likely has facilitated the Scimitar-horned population increase and impeded to some extent that of the Mohor gazelle. If this were the case, changes in habitat structure occurred in RF Guembeul in the last 9–10 years could be still claimed as the proxy of the Mohor population decline.

Figure 2. Photos showing changes occurred in vegetation cover in RF Guembeul: left side pictures taken in 13 March 2003; right side pictures taken in 5 April 2011. General view is shown above; details of plots in red, below. Photos have been taken from Google©; accessed on 28 May 2012.



There are other, non-mutually exclusive possibilities for explaining Mohor gazelle decline in Guembeul that might exist: inbreeding, diseases, stochastic effects, and drought together with the inability to move to follow sporadic rainfall in the fenced area of Guembeul, predation. Very likely, there is not one sole factor affecting its decline,

and all these alternative hypotheses should be tested to establish the precise causes of its population decrease. High standard data sets to test them all are not available yet. However, this study is only intended to be the very first step of a post-release monitoring agenda that should be developed to gather those key parameters enabling us to evaluate the outcome of the Mohor reintroduction programme which took place in Senegal in 1984.

4. Conclusions

Among the number of complex dilemmas faced by conservationists and managers of reintroduction programmes, the definition of “success” is of major importance. There is no agreement on what constitutes successful reintroduction, although several definitions have been discussed [40], including breeding by the first wild-born generation [41], a three-year breeding population with recruitment exceeding adult death rate [42], and an unsupported wild population of at least 500 individuals [43] among others. Following IUCN Guidelines [44], a reintroduction project attempts to re-establish species within their historical ranges through the release of wild or captive-bred individuals following extirpation or extinction in the wild. As the re-establishment of the species is its final goal, for the purpose of this study we consider reintroduction to be successful if it achieves establishment of a self-sustaining population [45], even if it takes a long time [46]. Accordingly, the reintroduction of the Mohor gazelle in RF Guembeul cannot yet be considered successful, as its population size is presently declining. Our current study is a post-release initiative to investigate the likely reasons for that decline in the interest of bringing the reintroduction programme initiated in 1984 to a successful end. Although reinforcement of the population at RF Guembeul has been recommended elsewhere [8], the likely causes of failure must be identified so that, as strongly recommended by the IUCN [44], those causes may be removed first. In the light of our results, it seems that a key to the long-term survival of the Mohor gazelle in the Reserve is maintenance of a minimum area of suitable habitat in it, avoiding distinct changes in the extent of vegetation cover. Clearing vegetation by periodically cutting down some trees might be an appropriate management policy in Guembeul. These actions could represent a community-based initiative that would significantly increase the effectiveness of biodiversity conservation in Guembeul as for people living around the Reserve its value would be enhanced for them as a job provider. For local authorities this could also be a way to promote sustainable livelihoods for resident populations as well as improve local involvement in management of protected areas.

Reintroduction should not be undertaken purely as a management practice, but be designated to meet research objectives as well [3], testing hypotheses associated with reintroduction [47–50]. While reintroduction design usually gives much more attention to short-term factors that may affect survival of the released animals and their descendants (short-term achievement), the key factors for assessing its success may be those that affect the long-term evolution of the population (e.g., the observed changes in habitat structures in RF Guembeul). Most reintroduction projects take place in protected areas, many of them after the area has been fenced in to protect it from livestock grazing. By doing this, wild vegetation is recovered, assuring food resources for animals. However, sometimes protection also has detrimental effects, as is the case of the excessive development of canopy in our Senegalese study area.

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Conflict of Interest

The authors declare no conflict of interest.

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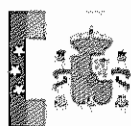
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