2024 Annual Report

Chad Oryx Reintroduction Project

A joint initiative of the Government of Chad and the Environment Agency Abu Dhabi, implemented in Chad by Sahara Conservation

Edited by Sahara Conservation

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Environment Agency - ABU DHABI

SAHARA CONSERVATION

ZSL Zoological Society of London

SMITHSONIAN'S NATIONAL ZOO & CONSERVATION BIOLOGY INSTITUTE

FOSSIL RIM WILDLIFE CENTER

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Executive summary

This report provides an overview of activities and results through 2024 of the Scimitar-horned Oryx Reintroduction Project taking place in Ouadi Rimé-Ouadi Achim Faunal Reserve, Chad. A joint initiative of the Environment Agency Abu Dhabi (EAD) and the Government of Chad, Sahara Conservation implements this unique and highly ambitious program in-country with assistance from the Direction de la Faune et des Aires Protégées (DFAP).
The report integrates data, information, and observations collected by the project team, including valuable data on the behavior, social structure, calving performance, and survival of the oryx reintroduced. It draws on data from all project partners, including EAD, the DFAP, Sahara Conservation (SC), the Smithsonian's National Zoo & Conservation Biology Institute (NZCBI), and the Zoological Society of London (ZSL).

Cover photo: Addax, Dama gazelle and Scimitar-horned Oryx, in Chad - © Marc Dethier

Acknowledgements

This project would never have happened without the vision, the leadership, the resources, the skills and the animals of the Environment Agency - Abu Dhabi and its leaders. The partnership between EAD, the Government of Chad, and Sahara Conservation has ensured the project's success in many ways. The initiative is not only one of the most ambitious wildlife reintroductions ever undertaken but also a glowing example of what can be done to save Africa's imperiled wildlife if we all pull together.

Abbreviations and acronyms

AP	African Parks
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement (Center for International Cooperation in Agricultural Research for Development)
DFAP	Direction de la Faune et des Aires Protégées (Directorate of Wildlife and Protected Areas)
EAD	Environment Agency - Abu Dhabi
ENCR	Ennedi National and Cultural Reserve
FRWC	Fossil Rim Wildlife Center
GPS	Global Positioning System
IRED	Institut de Recherche en Élevage pour le Développement (Chad Livestock Research Institute for Development)
MEPDD	Ministère de l'Environnement, la Pêche et du Développement Durable (Ministry of the Environment, Fisheries and Sustainable Development)
NZCBI	Smithsonian's National Zoo & Conservation Biology Institute
OBC	Oryx Base Camp
Oryx	Scimitar-horned oryx (*Oryx dammah*)
Oryx Project	Chad Oryx Reintroduction Project (also "reintroduction project")
POROA	Ouadi Rimé-Ouadi Achim Project (project to support the development of the Réserve de Faune de Ouadi Rimé-Ouadi Achim)
OROAFR	Ouadi Rimé-Ouadi Achim Faunal Reserve
RZSS	Royal Zoological Society of Scotland
SC	Sahara Conservation
VHF	Very High Frequency
ZSL	Zoological Society of London

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INTRODUCTION

The Ouadi Rimé-Ouadi Achim Faunal Reserve (OROAFR), located in central Chad, was established by decree No. 135/PR/EFP/PNR of 10 May 1969 to protect Sahelo-Saharan antelopes, cheetahs, and ostriches. It covers a surface area of 7,795,000 hectares.
The reserve straddles five Provinces: Batha, Borkou, Bahr el Ghazal, Wadi Fira, and Ennedi-Ouest.
Unfortunately, the years of conflict and drought that the country experienced during the 1970s and 80s had negative consequences on Chad's wildlife. The scimitar-horned oryx (*Oryx dammah*) became extinct in the wild in the 1980s, but the reserve still supported populations of wild dorcas gazelles, bustards, and dama gazelles.
In September 2014, the Chadian Minister of Environment and the Environment Agency – Abu Dhabi (EAD) signed an agreement to reintroduce the scimitar-horned oryx into OROAFR. The NGO Sahara Conservation was entrusted to implement the activities on the ground in Chad. A new phase of the initiative was renewed in 2019, expanding the reintroduction efforts to include addax (*Addax nasomaculatus*) and dama gazelles (*Nanger dama*), as well as scimitar-horned oryx.

On October 28, 2024, the Ministry of Environment, Fisheries and Sustainable Development of Chad and the Environment Agency of Abu Dhabi renewed their partnership to launch the third phase of the Scimitar-horned Oryx Reintroduction Project in Chad. Sahara Conservation is in charge of implementing the project in Chad.

Key outcomes in 2024 included the reinforcement of the Oryx population in Chad, the first pilot release of Dama gazelles, strengthened ecological monitoring, and enhanced collaboration with local communities. Despite challenges, notably elevated mortality during the extreme hot season, the project continues to move forward with confidence, consolidating progress made in earlier phases while preparing for the new objectives of Phase III.

Section I. *IN SITU* MANAGEMENT

Marc Dethier

Project Director – Sahara Conservation

Mahamat Hassan Hatcha

Ouadi Rimé–Ouadi Achim Faunal Reserve Coordinator - Direction de la Faune et des Aires Protégées - Ministère de l'Environnement, la Pêche et du Développement Durable

1. Human resources

1.1 Staff

As the Oryx Project enters its third phase (2024–2029), twenty people are currently employed full-time on the Project: 15 at the reintroduction site and five in the Chadian capital, N'Djamena, providing administrative and logistical support to the Project, in addition to the Sahara Conservation (SC) team based in France.

Permanent staff - December 2024	
Name	**Position**
Marc Dethier	Project Director
Honoré Todjibaye Midjigue	Cook
Dieudonné Kephas Doldiguim	Cook
Evariste Djibkibeng Malbe	Mechanic
François Madjitigal	Tractor driver/Driver
Yacoub Hassaballah Hagry	Driver
Abdourassoul Mahamat	Tractor driver / Driver
Djiddi Aklabach Ali	Tractor driver
Oumar Annadif	Head animal keeper and ecological monitoring officer
Kher Issakha Kher	Animal keeper and ecological monitoring officer
Loutfallah Ali	Animal keeper
Habib Ali Hamid	Ecological monitoring officer
Taboye Abdelkarim	Ecological monitoring team leader
Mahamat Ali Adoum Hassane	Ecological monitoring officer
Hissein Gadeye	DFAP permanent escort guard
Ahmat Anour	Driver
Delphine Gossumta	N'Djamena office housekeeper
Dana Mahamat	N'Djamena office security
Debi Ali	N'Djamena office security
Takadji Nanga Yanga	N'Djamena office security

In addition to the project's permanent staff, SC's administrative, financial, and logistical services in N'Djamena also support the Project activities. The project also employs temporary staff to cover tasks not directly related to the reintroduction of the oryx (mainly to tackle bushfires).

1.2 Staff activities

Marc Dethier, Project Director, oversees and supports all field activities at the Oryx Base Camp (OBC), with assistance from the administrative and logistical team in N'Djamena.
All staff based at the OBC are provided with accommodation and meals, and have access to electricity, running water, internet, and television.

Culinary team

Honoré Todjibaye Midjigue and Dieudonné Kephas Doldiguim are the cooks at the OBC. They manage the food supply by organizing the purchase of provisions from nearby towns. Having two cooks allows the ecological monitoring team to stay in the field for several days without needing to return frequently to OBC.

Maintenance and transport

Evariste Djibkibeng Malbe and François Madjitigal are responsible for the maintenance and repair of vehicles. Yacoub Hassaballah Hagry and Abdoulrassoul Mahamat drive light vehicles, while Djiddi Aklabach Ali exclusively operates tractors. Ahmat Anour is a driver in N'Djamena.

Animal care in enclosures and monitoring

Oumar Mahamat Annadif and Kher Issakha monitor the diets of animals in the enclosures and participate in field monitoring activities. Loutfallah Ali and Djiddi Akhabach Ali provide daily food and water for the animals.

The animal keepers start their day around 5 a.m., closing the drinking troughs in the enclosures to prevent attracting birds during the day. They give the appropriate food for various species, including oryx, addax, dama gazelles, and North African ostriches. At 3 p.m., they reopen the water troughs while remaining on-site to deter birds that pollute the water and distribute food. They also assist with other various activities at OBC.

Ecological monitoring

Habib Ali Hamit, Taboye Abdelkerim (who left in July 2024) and Ali Mahamat (since 2024) conduct ecological monitoring of the free-ranging animals. They are in constant contact with the teams from the Zoological Society of London (ZSL) and the Smithsonian's National Zoo & Conservation Biology Institute (NZCBI) and go into the field daily to observe the behavior of the oryx and addax. Two outings are scheduled per day, one in the morning to observe distant groups and another in the afternoon for the groups closer to the camp.

When it is needed, all staff members may be called upon to participate in occasional activities:

- Extinguishing bushfires;
- Coordination and logistics of oryx and addax transfers between Abéché and the reintroduction site.

Administrative support

In N'Djamena, Daniel Nahodjingar, Administrative and financial manager, and Sylvie Ndohoko Yoram, Administrative officer, handle all administrative and financial aspects of SC in Chad, under the supervision of Oualbadet Magomna, Country director. Four staff members handle security and maintenance at the Sahara Conservation office: Ali Debi, Takadji Nanga Yanga, Dana Mahamat as security, and Delphine Gossumta as a housekeeper.

The staff is under contract, and the contracts have been formalized by the *Office National de Promotion de l'Emploi*. All staff members are employed by Sahara Conservation and registered with the National Social Security Fund.

1.3 The rest period system

Given the staff's distance from their homes, a system has been set up to allow them to reunite with their families during their leave of absence. In accordance with labor regulations, each Sunday worked counts as a day gained for leave purposes.

Following a consultation in 2022, staff were granted 20 working days of rest after every two months (60 days) spent at OBC. Thus, over the 12 calendar months, the staff works for seven months, allowing for an annual leave period of five months.

1.4 The Directorate of Wildlife and Protected Areas escort guard

For all journeys between N'Djamena and OBC, the guard Hissein Abderahim Gadaye, assigned to the project by the Ministry of the Environment, Fisheries and Sustainable Development (MEPDD) (Memorandum No. 004/PR/PM/MEP/SG/DPELCB/2017), escorts the vehicles.

1.5 Temporary staff

Rambo team

The Rambo team creates firebreaks and fights bushfires (from October 2024 to May 2025). They have also manufactured fire bats, which are a better alternative to the branches cut by nomads and allow for more effective bushfire control.

Fig. 1. Manufacture of fire bats and their use by transhumants

The team is composed of six people: Mahamat Moumine, alias Rambo, Hamdan Ibrahim, Haroun Oumar, Mahamat Moussa, Mahamat Zen and Nassour Bechir.

They were involved in the work on the dama gazelle enclosure in May and June 2025.

Fig. 2. Gathering between EAD and Rambo teams

Tango team

The high number of transhumants in the reserve at the end of the rainy season highlights the importance of organizing awareness missions on bushfire prevention. The Oryx project has set up a partnership with the *Association de sensibilisation anti-braconnage et de lutte contre les feux de brousse* (anti-poaching and bushfire prevention awareness association), based in Arada, to reach out to the transhumants. The association has formed a rotating team of four people, the "Tango team," which has been traveling the region to meet nomadic groups since October 2024.

Fig. 3. Some members of the Tango team: Khadidja Mahamat Djode, Mahamat Ahmat Acyle, Abakar Mahamat Manay, Hamid Mahaye Abdhallah, Ali Abdellatif Hassan, Sadia Rozi, Alhadi Mahamat Issa, Abderamane Mahamat

The team is permanently based in the field and provides weekly reports on its activities. Beyond providing recommendations to prevent bushfires, the association asks the transhumants to position themselves appropriately in relation to the firebreaks and to make use of them during their movements. Not only is travel along the firebreaks easier than through tall grasses, but some transhumants also set up their camps there for greater safety, avoiding tall grass, cram-cram, and scorpions.

Fig. 4. Awareness-raising and use of the firebreaks by the transhumants

Others

Two additional tractor drivers were hired due to the scale of the firebreak work: Adam Mahamat Issackha for four months and Tahir Kabaché, Djombo for two months.

1.6 Interns

During the 2024-2025 period, the Project supervised several interns:

- Amné Abderahim (Degree 2 in Biology of Plant Organisms at the University of Abéché),
- Reine Balamon Mandeba (Master 2 in Plant Biology, University of N'Djamena). At the end of her internship, Reine returned in July-August 2024 to complete her master's thesis, which she defended in December 2024.
- Rachida Nassingar (4th year of Veterinary Medicine at Alexandria University, N'Djamena).

All three conducted research on woody vegetation in the same 28 km^2 area around OBC.

- Alamine Abderahim (student in the Department of Geography at the Faculty of Human and Social Sciences at the University of N'Djamena) conducted a one-month research project at the OBC since December 2024 on the following theme: natural reserves and their roles in biodiversity conservation. Ouadi Rimé–Ouadi Achim is presented as a model reserve for biodiversity conservation between 2013 and 2023.
- Tchinbibe Bang-Djobe completed a 2-month internship (November 2024 to February 2025) studying the relationship between the communities living in or passing through the Ouadi Rimé - Ouadi Achim Faunal Reserve (OROAFR) and vultures.

- Abdoulaye Zayed, a field assistant in the biodiversity department at Zakouma National Park, completed a one-month observation internship at the OBC.

1.7 Oryx Project staff training

Bushfire Training

Habib Ali Hamid participated in a bushfire training course provided by the ALBIA project in Arada, from May 13 to 17, 2024.

Necropsy

The ecological monitoring team attended a training course on best practices in necropsy, delivered by veterinarian Dr. Jon Llona Minguez.

Ornithology

In September 2024, the members of the ecological monitoring team were trained by Alain Jacot and Gabriel Marcacci from the Swiss Ornithological Institute. They learned how to install acoustic devices to record bird songs and use software for call recognition. From February 1 to 13, 2025, Habib Ali Hamid went to Zakouma National Park to attend an ornithology training class provided by ornithologists from La *Tour du Valat* and the French Office for Biodiversity, in collaboration with the DFAP of Chad.

Parasitology

In November 2024, Mr. Mouhktar Aldjibert (*Institut de Recherche en Élevage pour le Développement* in Chad) conducted a training session for the ecological monitoring team about the "digitization of digestive parasite eggs."

GIS

Mahamat Ali completed a six-week online training course on GIS, mapping, and geospatial data analysis, delivered by Maya Digit, a firm based in Burkina Faso.

2. Infrastructure management and maintenance

Fig. 5. Aerial view of the reintroduction site facilities

OBC (left), the rangers' camp (bottom right), and the pre-release enclosures (background). The base is located in a remote area, 70 km from Arada, the nearest town.

Fig. 6. Oryx Base Camp

2.1 Water management

Two water bladders, totaling 500 m³, have been installed inside the OBC to meet human needs, as well as for the animals present in the enclosures.

Due to the high costs of renting tank trucks in Arada (350,000 FCFA) to transport 20 m³ of water, it is more cost-effective to use our own truck equipped with a tank. Thus, a 17.85 m³ tank was manufactured in N'Djamena. It can be mounted and dismounted from the truck as needed.

Fig. 7. Tank and filling of water bladders

From October 3 to November 20, a 24 m³ truck-mounted water bowser supplied water to OBC on two occasions, completing 21 journeys (150 km round trip) between Arada and OBC.
The truck made 17 trips to supply 306 m³ of water in January 2025 and 12 trips for 214 m³ of water in May. The truck is also used to fill the water bladders at the guards' camp.
Monitoring water consumption at the base reveals that an average of 70 liters of water is consumed per day by one person to meet their needs.

2.2 Electricity management

OBC is equipped with 93 450-watt solar panels, providing a total output of 41,850 watts.
Electricity consumption amounted to 24,551 kWh from May 2024 to May 2025, but the actual consumption is higher since the monitoring system was not operational in October and November 2024 (see graph).

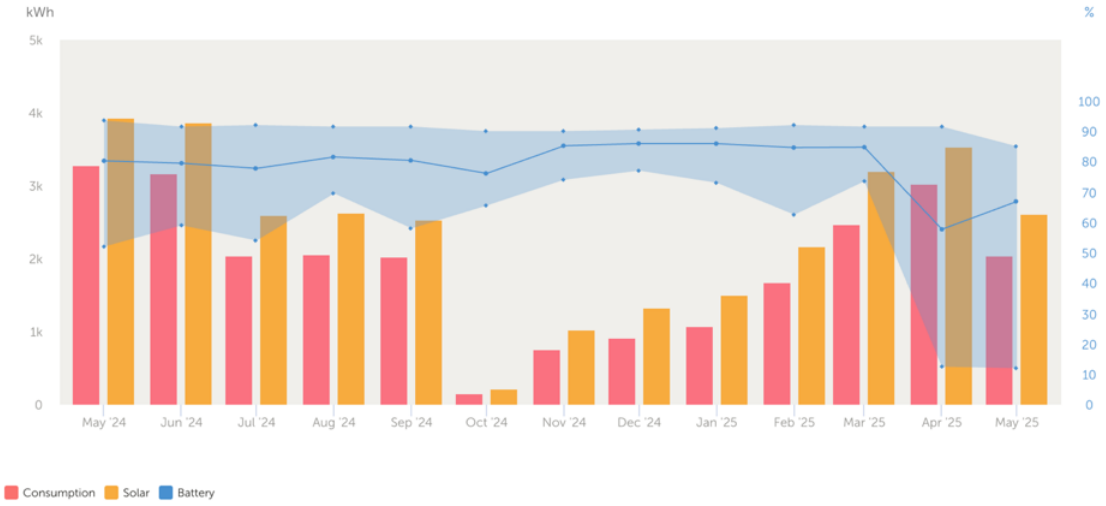


Fig. 8. Electricity consumption at OBC

With the price of electricity in N'Djamena ranging from 100 to 150 FCFA per kWh, the cost ranges between 2,455,100 and 3,682,000 FCFA.
Electricity consumption is higher during the hot months of the year (April to July) and during Ramadan, when air conditioners run for several hours a day.

At night, the 3,000 W wind turbine charges the batteries to cover permanent needs such as refrigeration/freezing, internet access, computer operation, lighting, and cooling fans for equipment.

2.3 Internet connection management

Vsat is crucial for the Project's operations. It enables the monitoring of animals fitted with GPS collars (oryx, addax) and is the only reliable means of communication with the outside world.
The Project now has two Starlink antennas, one fixed at the OBC and the other mobile. The mobile antenna, transported in the vehicle by the team when traveling to remote areas from the base, provides internet access.

2.4 Vehicle management

Small vehicles

The Oryx Project operates:

- 4 Toyota twin-cab pick-ups,
- 2 Toyota single-cab pick-ups,
- 1 Toyota V8 station wagon.

All vehicles are in good working order and properly insured.

Fig. 9. Oryx Project motor vehicle fleet

The Toyota twin-cab 18C4107TT is currently assigned to the ecological monitoring team and has an average annual mileage of 31,000 km, primarily for observing oryx and addax. During the year 2024-2025, it traveled 9,432 km

The single-cab pickup 18C4213TT is used for logistics at OBC, transporting personnel to and from the enclosures, and was extensively used for bushfire control (creating firebreaks, bushfire interventions). This year, the round-trip to the enclosure totaled 5,729 km.

The Toyota Land Cruiser V8, 18C4484TT (donated by EAD in July 2017), facilitates trips between N'Djamena and OBC (1,200 km) but is primarily stationed in N'Djamena. In May 2025, it recorded 115,752 km, supporting EAD personnel on missions in Chad.

As the activities expanded, the Project acquired three new vehicles: one “single-cab” and two “twin-cabs” from CFAO in N'Djamena. The single-cab 18C5208TT and one twin-cab 18C5206TT are used for logistical support, while the second twin-cab 18C5207TT is dedicated to the monitoring team. They respectively totaled 19,567 km and 27,901 km over the period.
The double-cabin vehicle 18C5207TT is used by the monitoring team and has traveled 37,393 km this year.

VEHICLES	PURCHASE DATE	MAIN USE	MILEAGE IN KM May 2024	MILEAGE IN KM May 2025
Land Cruiser twin-cab 18C4107TT	August 2015	Ecological monitoring	276,812	286,244
Land Cruiser single-cab 18C4213TT	January 2016	Animal care in enclosures	162,514	168,243
Land Cruiser twin-cab 18C4328TT	August 2016	Ostrich ecological monitoring / Firebreaks logistics	273,712	281,433
Land Cruiser V8 18C4484TT	July 2017	EAD N’Djamena/ OBC	101,009	115,752
Land Cruiser twin-cab 18C5206TT	May 2021	Long distance trips logistics	139,799	167,700
Land Cruiser twin-cab 18C5207TT	May 2021	Ecological monitoring	97,240	134,633
Land Cruiser single-cab 18C5208TT	May 2021	Logistics / infrastructures maintenance	77,128	96,695
Land Cruiser twin-cab 18C4882TT	March 2024 (POROA/OBC)	Logistics / Tango team	130,910	159,007
Land Cruiser twin-cab 18C4883TT	March 2024 (POROA/ OBC)	Logistics	130,040	158,775

In March 2024, for security reasons, the two double-cabin vehicles of the POROA Project were stationed at the OBC. The Toyota Land Cruiser DC 18C4882TT traveled 28,097 km. It was used by the Tango team from October 2024 to June 2025 for bushfire awareness missions. The second double-cabin 18C4883TT vehicle covered 28,735 km.

Each vehicle is equipped with a GPS/InReach system, ensuring real-time movement tracking, driver safety, and text communication, including the transmission of the coordinates of collared animals to field teams.

Tractors

At the moment, five tractors and plows are used for creating firebreaks and controlling bushfires. All the related operating costs are covered by the Oryx Project (fuel, maintenance, repairs, etc.).

- John Deere 6100D
- John Deere 5503
- John Deere. 5500 (made available to the Oryx Project by the ALBIA Project in February 2025.)
- John Deere 6100D (lent by the PREPAS Project)
- Erdvark G40B motor graders (2)

The graders are pulled by 6100D tractors. The blade width of these G40 graders is 3.1 meters, which is more efficient than the disc plows. They are ideal for creating and maintaining firebreaks.

Fuel consumption

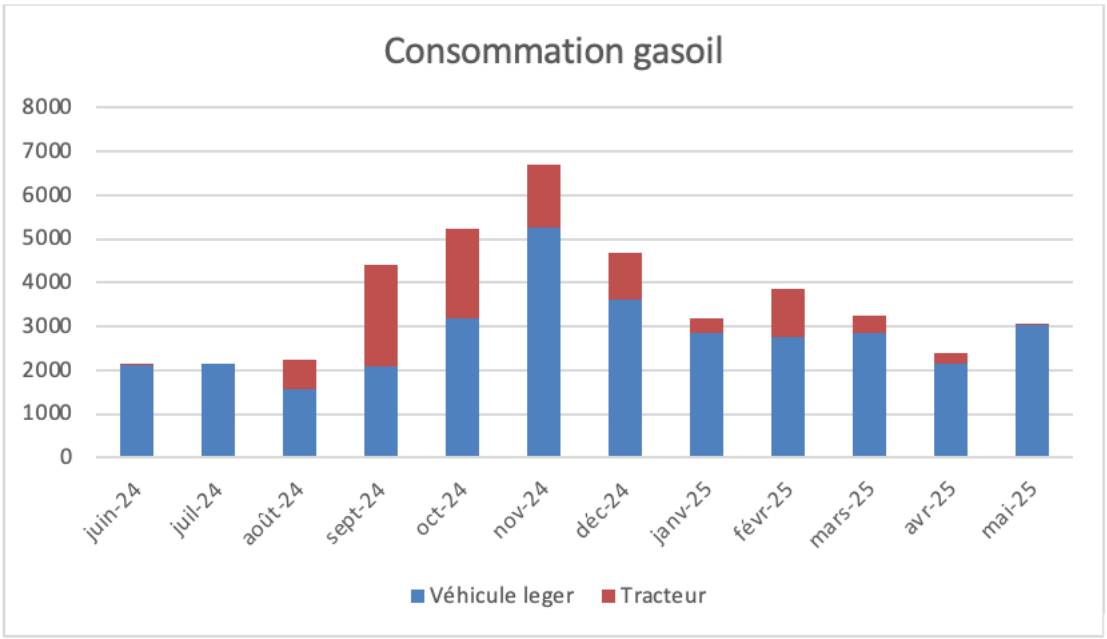


Fig. 10. Fuel consumption over 11 months

From June 1st 2024, to May 31st 2025, the Oryx Project used 43,302 liters of fuel (33,616 for light vehicles and 9,686 for tractors). The average consumption is 3,609 L/month.

2.5 Food management

We mainly buy food in the neighboring towns of Biltine and Abéché, and from time to time in N'Djamena, and fresh produce and meat from the weekly markets in Arada and Biltine or from nearby herders. Food is stored in the refrigerators and freezer installed in the kitchen.
On average, 16 people are constantly present at the OBC, with major increases when hosting various missions, such as the oryx and addax arrivals.

2.6 Enclosure infrastructures management

Oryx enclosure

An additional 20-foot container was purchased to store animal feed.

Addax/Dama enclosures

Modifications to the dama gazelle enclosure began in May 2025. The plan designed by the EAD team includes the creation of a 1.5-meter-wide corridor and an exchange area between animal groups at the center of the enclosure.

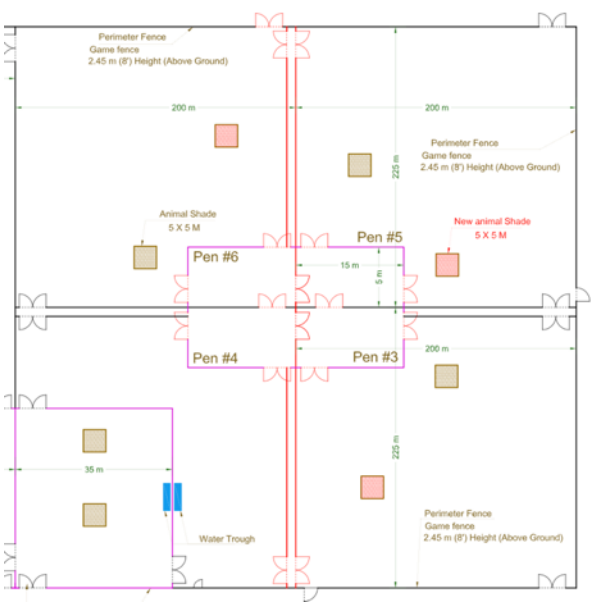
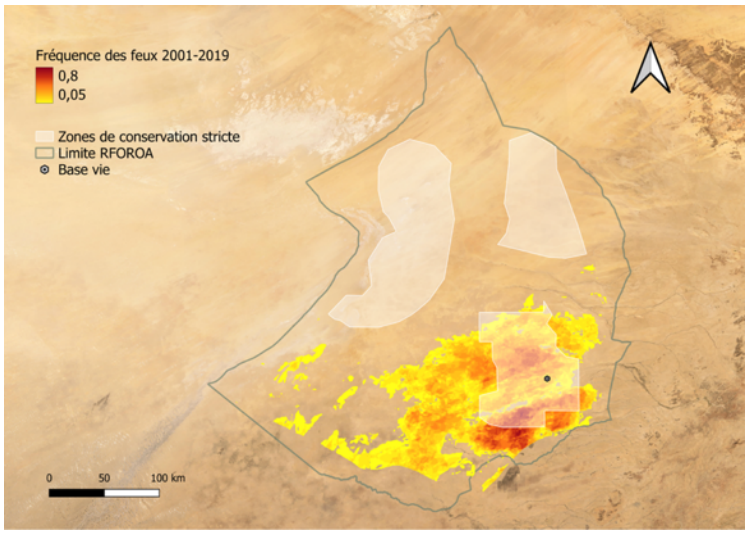


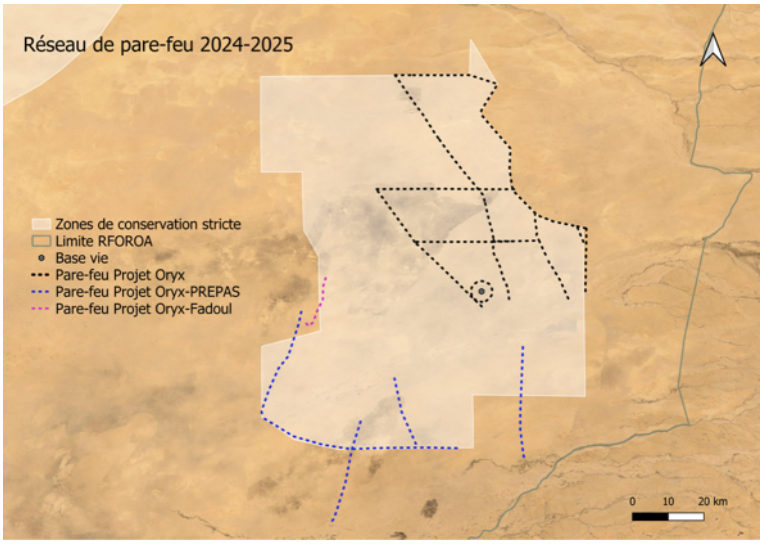
Fig. 11. Modifications of the dama gazelle enclosures

2.7 Firebreak network

To protect the Project's facilities, along with the reintroduced animals and their grazing, we have opened a network of firebreaks, which also benefits local herders and their livestock.
A partnership agreement was signed with the PREPAS project, which focuses on supporting livestock farming in various provinces of Chad. The map below shows the frequency of fires in the OROAFR and highlights the "strategic" locations where firebreaks should be opened.



Considering the frequency of fires since 2001 and the prevailing North-East/South-West wind direction, in areas close to the range of the released animals, the teams have opened 315 km of firebreaks (black lines) by clearing two parallel strips of soil about 30 meters apart. The "Rambo" team (six people) burns the grass between these strips of overturned soil.



At the request of the canton chief, the tractor of the ALBIA Project was lent to the Donki Fadoul community, enabling them to create 18 km of firebreaks (brown line). The partnership agreement with the PREPAS project led to the creation of an additional 185 km (blue lines) in the southern part of the OROAFR.
In total, approximately 520 km of firebreaks were established.

Fig. 12. Creating firebreaks

2.8 Aerial support

A compacted earth landing strip has been created in OROAFR, located 8 km south of OBC. Maintaining the strip involves grading the surface twice a season to remove vegetation and to level the hoofprints left by domestic livestock during the wet season. Because of temporary flooding, the strip cannot be used during the rainy season unless there are at least two days between consecutive rain showers, allowing sufficient time for the surface to dry.

The strip is 1,200 meters long. Aircraft such as Cessna 172 (Wings for Conservation), Cessna 182 (African Parks, MAF), and Cessna Caravan (MAF, AVMAX) land there. The strip is marked out and equipped with a regulatory windsock.

In November 2023, the Minister's delegation came to OBC aboard an AVMAX Caravan aircraft.
In June 2024, Philip Gibbs, Zakouma National Park's pilot, conducted a 1,617 km aerial survey in a Savannah ultralight aircraft over the mortality area of oryx and addax.
On February 18th, 2025, Zakouma's microlight aircraft was forced to return to the runway during its journey to the Ennedi Natural and Cultural Reserve (ENCR).

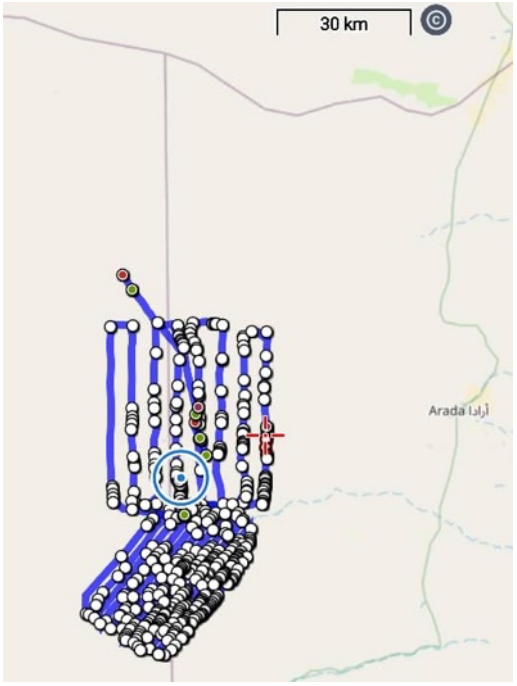


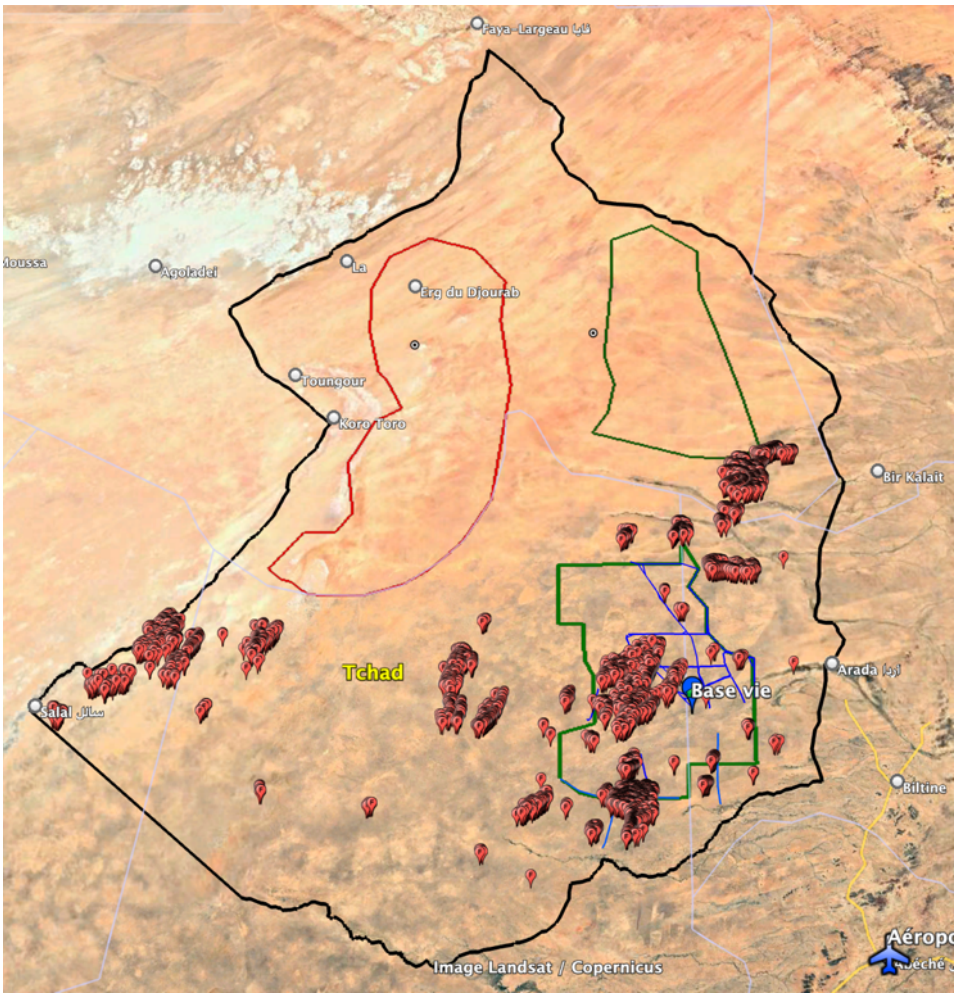
Fig. 13. Microlight aircraft and flight path of aerial transects (June 2024)

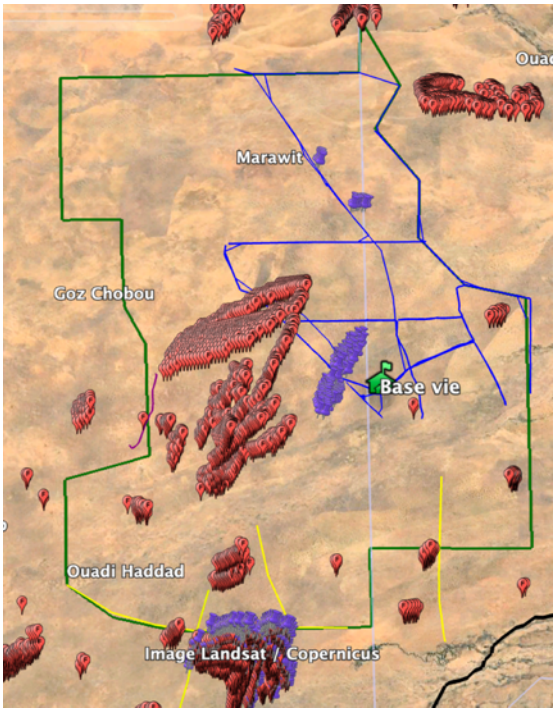
2.9 Other offices

The project rents a villa in N'Djamena, divided into several offices.
A house in nearby Arada is also rented.

3. Bushfires

From June 2024 to May 2025, we recorded 58 bushfires within the OROAFR, burning an estimated area of 2,800 km².





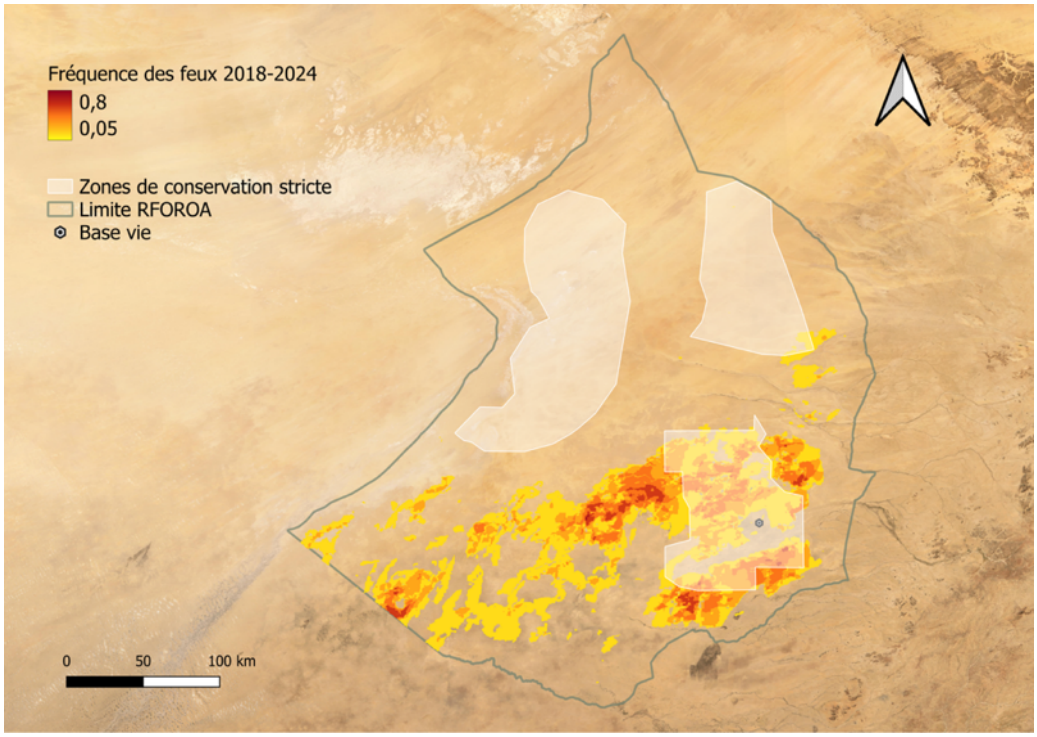
Within the strict conservation zone defined in the OROAFR management plan, except for one fire caused by a vehicle, all other fires were accidentally started by herders.

The firebreaks helped stop the spread of eight fires (purple dots).

In the south, in the herders' grazing area, a firebreak slowed the fire over a distance of 18 km.

Month	Bushfire/month
September 2024	0
October 2024	11
November 2024	12
December 2024	2
January 2025	8
February 2025	5
March 2025	8
April 2025	8
May 2025	4
Total	**58**

Fig. 14. Fire stopped by a firebreak



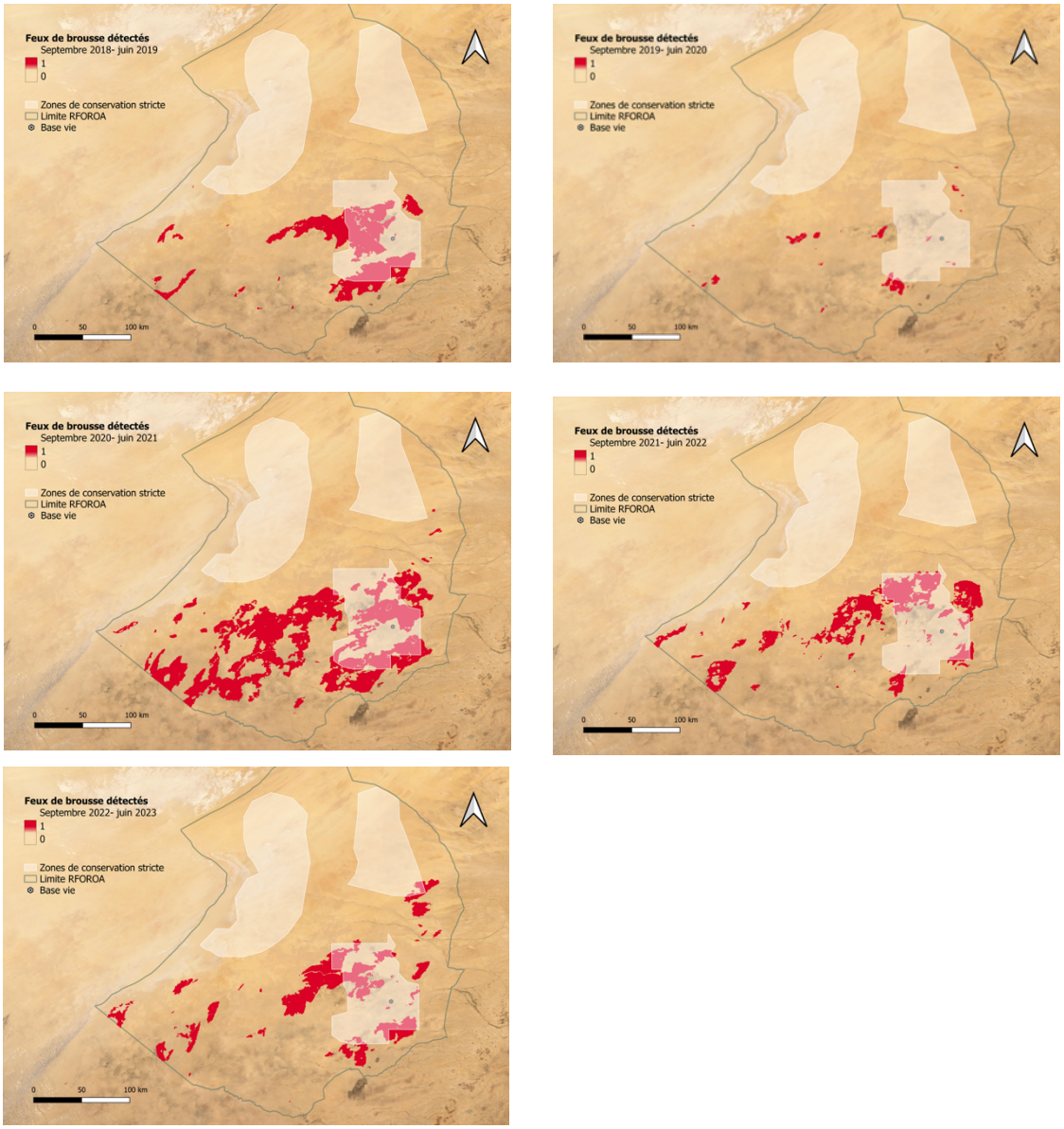


Fig. 15. Area burned per year in OROAFR (2018–2023)

4. The different species in the enclosures

4.1 Scimitar-horned oryx

Three groups of scimitar-horned oryx arrived from Abu Dhabi this year. With the flight route of the Ilyushin aircraft now being longer, the animals reach Abéché airport in the morning and are then transported by truck during the day to the enclosures. They are released either the same evening or the following morning, depending on the arrival time at the OBC.
In June 2025, there were nine oryx in captivity.

Fig. 16. Nine oryx in the pre-release pen

As a reminder:

Date	Number of founders	Release date
16 March 2016	25	14 August 2016
14 November 2016	25	21 January 2017
18 January 2017	25	3 August 2017
11 February 2018	25	6 August 2018
15 February 2018	25	6 August 2018
18 February 2018	25	6 August 2018
25 February 2019	25	17 September 2019
11 November 2019	25	17 December 2019
3 March 2020	25	22 September 2020
8 November 2021	25	5 December 2021
14 March 2022	20	17 August 2022
7 November 2023	15	17 January 2024
12 November 2024	25	11 December 2024
17 November 2024	25	10 December 2024
23 February 2025	10	In the enclosures in May 2025
Total	**345 individuals**	

4.2 Addax

Fifteen addax arrived on February 23, 2025, and are still in the quarantine enclosure.

As a reminder:

Date of arrival in Abéché	Number of founders	Release date
13 November 2019	15	January 2020
6 March 2020	25	7 September 2020
15 November 2021	25	12 December 2021
7 March 2022	25	24August 2022
14 November 2023	25	16 January 2024
23 February 2025	15	In the enclosures in May 2025
TOTAL	**130 individuals**	

Fig. 17. Fifteen addax in the pre-release pen

4.3 Dama gazelles

From May 2024 to May 2025, the number of dama gazelles in captivity increased from 23 to 36 individuals. Of the 15 births recorded in the enclosures, 13 calves survived. One of these calves fell into a hole and could not get out, and another was found dead after a few days, for unknown reasons.
An adult male, which had most likely ingested the toxic plant datura (*Datura stramonium*), was found dead at the end of March 2024. This plant was present in the capture area but absent from the grazing areas within the enclosure. Introduced from an undetermined source, it was also abundant outside

the enclosure near the containers. The plant was removed and the external area where it had spread was burned.

The diet of the dama gazelles is based on pellets and hay imported from Abu Dhabi, supplemented with peanut plant tops purchased locally, as well as *balanite* fruits and colocynth collected within the reserve.
By the end of May 2025, 36 dama gazelles were present in the enclosure:

- Manga Group: 17 animals, including 10 adults (1♂ and 9♀) and 7 newborns.
- Andrea/EAD Group: 19 animals, including 11 adults (1♂ and 10♀) and 8 newborns.

Fig. 18. Nineteen dama gazelles, EAD group

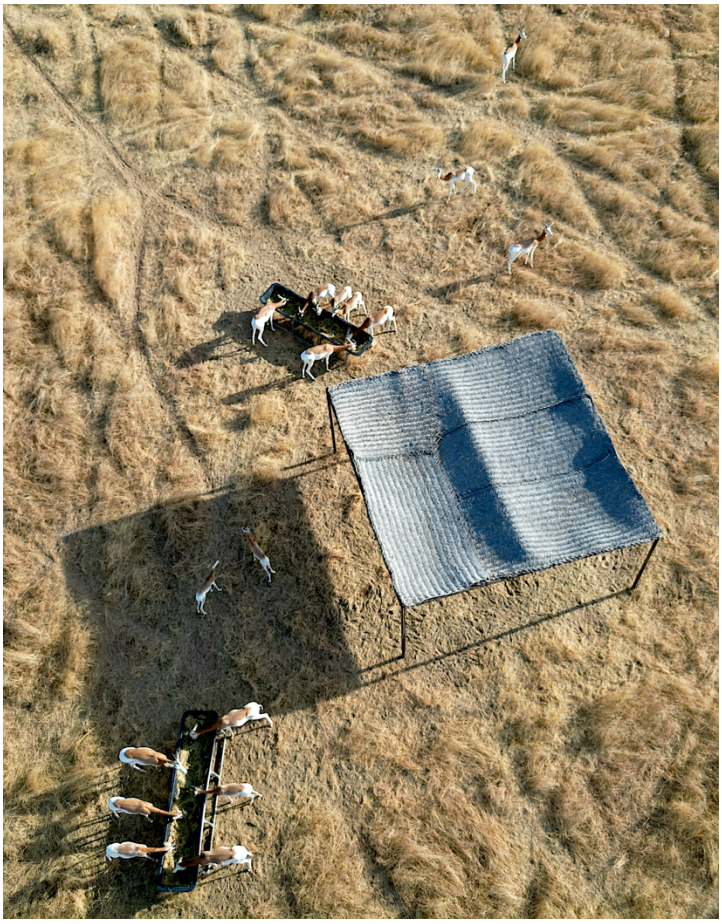


Fig. 19. Seventeen dama gazelles, Manga group

It is worth noting that a group of four free-ranging dama gazelles, consisting of three gazelles released in January 2023 and a wild male, regularly approaches the enclosures.

5. Partnerships and events

Partnership with African Parks

Collaboration with African Parks (AP) continued throughout the year at various levels:

- **Regional Management**: Erik Mararv (Regional Director) visited the OBC several times and invited the Oryx Project team to Fada to observe the operations room of the ECNR.
- **ENCR Team**: Regular exchanges took place at the OBC with Issakha Gonney Guirki (Park Manager) and Jonas Eriksson (Conservation Manager) regarding the reintroduction of addax into the ENCR. Equipment from the OBC was made available for the addax capture mission in February 2025.
- **Zakouma/Siniaka Minia Team**: From June 20 to 24, Philip Gibbs, piloting the Savannah microlight, followed the transect lines provided by Katherine Mertes and Tim Wacher. Three days of flights were conducted to survey wildlife, livestock, and human activities during the hot dry season in the reserve.
- **Knowledge Sharing**: Members of the ENRC and Zakouma Park had the opportunity to participate in training and practical internships with the OBC teams.
- Since November 2024, SC staff have benefited from free use of AP's transit house in Abéché.

Relations with national and international veterinarians

- Mahamat Issa, Head of the Wadi Fira sector of the Ministry of Livestock and Animal Production, based in Biltine, worked with Dr. Jon Llona Minguez during the episode of high mortality affecting both wildlife and domestic livestock in June 2024.
- Dr. Jon Llona Minguez provided guidance on veterinary care for the addax remaining close to the OBC. Four addax were captured and treated following his recommendations.
- In October, a meeting involving Victoria Barrios, John Newby, Dr. Jon Llona Minguez, Dr. Philippe Chardonnet, Dr. Tim Wacher, and Marc Dethier discussed and subsequently recommended practices to address parasitic diseases affecting wildlife.
- Veterinarians from the Ministry of Livestock and Animal Production were present during the arrivals of animals from Abu Dhabi (November 2024 and February 2025).
- In November, Mr. Adljibert Moukthar, a researcher at IRED, provided training in parasitology to members of the ecological monitoring team.

Partnership with the Swiss Ornithological Institute

- September 25 to October 3, 2024: Mission with the Swiss Ornithological Institute in the OROAFR to assess and better understand the status of bustards in the reserve and to develop appropriate conservation actions.
- A follow-up mission is scheduled for September 2025.

Partnership with ESAFRO

- ESAFRO (*Éducation et Santé sans Frontière*) conducted two missions this year: in the Wadi Fira Province in September 2024 and in the Batha Province in February 2025. Dr. Anne Vilaseca, Luc Barbier, along with Chadian doctors and nurses, met with nomadic and transhumant populations traveling more than 35 km from the nearest health center. On each occasion, they were accompanied by facilitators from the ALBIA Project.
- Another mission is scheduled for December 2025 in both provinces.

Relationships with local authorities

- In November 2024 and February 2025, the authorities of the Wadi Fira Province were invited to participate in the release of animals into the enclosures. The General Secretary of Biltine Governorate, accompanied by a delegation including the Delegate of the Ministry of Environment, Fisheries and Sustainable Development (MEPDD) and the monitoring/evaluation officer of the Ministry of Livestock and Animal Production of Wadi Fira, was welcomed at the OBC. The prefect of Albiher and nine canton chiefs also attended.
- In December 2024, Mr. Gal Ahmat Goukouni Mourali, Governor of Batha, attended the opening of the enclosure gates and the release of the oryx, accompanied by the provincial delegate for the environment. On the same occasion, a delegation from the Ouaddaï Province, composed of Mahamat Ahmat Hassaballah, Provincial Delegate of the MEPDD, and His Majesty the Abbasid Sultan of Dar-Ouaddaï, Cherif II Abdel-Hadi Mahdi, arrived from Abéché. Around forty people were present for the release of the captive oryx.

Partnership with the PREPAS program (*Programme de renforcement de l'élevage pastoral dans les régions du Batha, de l'Ennedi et de Wadi Fira*)

- A 16-month memorandum of understanding was signed on December 6, 2024, with the technical and fiduciary coordination unit of the pastoral livestock strengthening program, based in Abéché. This agreement covers joint activities related to bushfire control and the provision of a tractor.

Partnership with the "*Association de sensibilisation anti-braconnage et de lutte contre les feux de brousse*"

- On October 8, 2024, a collaboration agreement was signed with the Association for Anti-Poaching and Bushfire Awareness (ASBLCFB). The agreement aims to raise awareness among nomadic herders about the causes of bushfires and the protection of grazing areas. This agreement is effective until June 7, 2025.
- In early January 2025, the ASBLCFB organized an information and awareness session at the SC office in Arada attended by administrative and local authorities. The meeting focused on the activities carried out by the Tango team with the herders and the results obtained. Twenty-four people attended, including various canton chiefs from Wadi Fira and administrative authorities from the Al Biher prefecture.

SSIG (Sahel & Sahara Interest Group) Tozeur, Tunisia, May 7 to 9 2025

During the annual conference of the Sahel & Sahara Interest Group, two members of the ecological monitoring team gave presentations:

- Oumar Annadif: *"Conservation of the Scimitar-horned Oryx: Update on the Reintroduction Project in the Ouadi Rimé–Ouadi Achim Faunal Reserve, Chad"*
- Ali Mahamat: *"Monitoring of Lappet-faced and Rüppell's Vultures in the Ouadi Rimé–Ouadi Achim Faunal Reserve, Chad: Perspectives for Conservation"*

The president of the ASBLCFB also presented a talk on: "Challenges of Bushfires in the Ouadi Rimé - Ouadi Achim Faunal Reserve in Chad.

6. Project management

6.1 Administrative documents

The Ministry of Environment, Fisheries and Sustainable Development, through the DFAP, plays the following roles:

- Provide all the permits required for the arrival of the animals and the Project's activities (CITES, veterinary, aircraft overflight and landing permits, planning permissions, etc.);
- Provide and help obtain any official permits for staff and operators working on the Oryx Project (invitation letters to obtain visas, residence permits, travel permits, etc.);
- Issue export permits for samples taken from reintroduced animals;
- Facilitate authorizations for documentary filming in the reserve.

6.2 Project staff security

To ensure the safety of the Project's staff, the guards' responsibilities include:

- escorting project vehicles during travels between towns and OBC,
- escorting the ecological monitoring team on field missions,
- guarding aircraft involved in project activities,
- maintaining control over the three-kilometer firebreak around OBC to prevent domestic animals from straying into the area or unauthorized campsites from being set up.

6.3 Law enforcement

Monitoring the reserve and enforcing the law is the responsibility of the government.
Patrol efforts primarily focus on areas where reintroduced animals are found. Due to limited resources, patrols are concentrated in these key areas rather than across the entire reserve. Patrols are conducted by vehicle, with teams of six to seven guards operating in the field on ten-day rotations.

In 2024, an attempted poaching of an oryx was observed, six cases of poaching of dorcas gazelles, and one case of poaching of an Arabian bustard were recorded. The poachers were arrested, presented to the local authorities and handed over to the justice system.

6.4 Fight against bushfires

At the end of each rainy season, bushfires usually occur, often triggered by human activities, such as vehicle exhaust or herding activities.

In 2024, the guards intervened in six cases of bushfires, alongside the Project teams.

6.5 Raising awareness amongst the pastoralist community

The reserve is a livestock area, home to two distinct categories of herders:

- transhumant herders who come up from the South at the start of the rainy season and leave once the seasonal pools dry up,
- local herders who reside in the reserve year-round.

During patrols, the rangers engage with both groups, raising awareness about the reintroduced species, the dangers of bushfires, the illegal poaching of wildlife, and the unchecked spread of portable water bladders and boreholes that are leading to overgrazing.

6.6 Recommendations

- Organize more regular steering committee meetings in accordance with the Project's needs;
- Recruit a local veterinarian for the medical monitoring of released animals, in cooperation with veterinarians in Abu Dhabi and Europe;
- Provide sufficient vehicles and fuel to enhance surveillance of the reserve;
- Provide the necessary means of communication (including Iridium) and personal equipment for the rangers;
- Build adequate housing and amenities at the rangers' camp;
- Recruit enough guards for the reserve.

Section II. FIELD-BASED POST-RELEASE MONITORING

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Introduction

Routine post-release monitoring of reintroduced oryx and addax populations was maintained in the field by the monitoring team throughout 2024. External support to the team on data management, particularly supervision of breeding records and coordination of monthly report editing, was remotely provided by the Zoological Society of London (ZSL) through regular email contact. ZSL staff also made three visits to Chad to join the monitoring team in the field and support a variety of project activities:

- 20 Feb 2024 to 26 Mar 2024
- 07 Jul 2024 to 28 Jul 2024
- 22 Sep 2024 to 24 Nov 2024

1. Reintroduced antelope monitoring activities

- Routine supervision of the ecological monitoring team, operating with four core members through most of 2024. Habib Ali, Oumar Annadif and Kher Issakha Kher were joined by Mahamat Ali, recruited following his successful camera trapping student project at the OBC in late 2023.
- Regular real-time communication updating discoveries of births or deaths among reintroduced antelopes was maintained between monitoring team members and ZSL throughout the year.
- The CyberTracker sequence was regularly updated to reflect changes in the status and numbers of tagged individuals, including the provision of identity codes in anticipation of future wild-caught tagging events for oryx and addax.
- Every month, data verification was conducted on the identification records of tagged oryx and addax, alongside maintaining monthly resighting histories for each living (or potentially alive) individual.
- Updating and maintaining monthly matrices indicating the presence or absence of functioning satellite collars for every collared oryx, addax and dama since August 2016.
- Dedicated time in the field with individual members of the monitoring team, refreshing methods and use of the Cybertracker sequence, reviewing data management practices and reinforcing the daily monitoring routine.
- To support the project's goal of shifting from strong dependence on collared individuals to a more population-based approach, the team was asked to dedicate time each month for missions to distant parts of the reserve, especially the north-west and south. These missions aim to observe and record wildlife, and also to build awareness by documenting interactions with the local population using existing Cybertracker menus.
- Maintenance of the Dropbox photographic library for all founder oryx and tagged calves, organized by release group. These images are accessible to colleagues at DFAP, EAD, SC & SNZCBI, with a particular emphasis on imagery of the original founders from the earliest release groups.
- Planning, execution and full reporting of two line-transect surveys, including a special survey in July 2024, adapted to assess the abundance of 'fresh' carcasses of all ungulate species, wild and domestic, that accumulated because of the unusually harsh late dry season conditions encountered in the reserve from March to June 2024 (see summary reports below).

- Delivering training theory and practice in survey methods to survey participants. Presentation of the objectives of the work and results of previous surveys, key methods and individual responsibilities to be followed by survey team members. Also, provision of photographic reminders of key distinguishing features of commonly confused species (foxes, cats, bustards, vultures) likely to be encountered. Associated refreshment training on GPS settings and use while navigating transect surveys.
- Preparation and circulation to partners of internal reports with full analysis and results of the July 2024 carcass survey, and a large-scale conventional wildlife and livestock distribution survey in November 2024.
- Documentation of the first estimated drop in the mean oryx population size estimate from c. 600 individuals down to c. 450, following the early-year mortalities in 2024. All data are presented in relation to all surveys conducted by Sahara Conservation since 2011, showing additional trends in density estimates for dorcas and three species of large bustards, as well as trends in contemporary livestock encounter rate and distribution information.
- In collaboration with ZSL colleague Raj Amin, a 5-year analysis (Jan 2020 -Aug 2024), using the monthly resighting history matrices created from the daily field monitoring records and known mortality records for all tagged addax, was used to provide first estimates of post-release annual survivorship/mortality and detectability estimates accounting for the presence of functioning satellite collars. This is complementary to a similar set of estimates provided for oryx in 2023 (see reports below).
- The resighting matrices are updated each month and reanalysis of vital rates, using the most recent information available, will be a key component of a planned Population Viability Assessment (PVA) meeting.
- Work on a manuscript covering translocation management and performance (over 97% survival from capture to release, 2-6 months later, among 263 oryx moved from EAD Deleika to OROAFR) and subsequent oryx survivorship rates post-release continued through 2024.

2. Dama gazelles monitoring activities

- A database summarizing daily numbers, pen management organisation, births, deaths and origin of all captive dama held at OBC, was maintained at ZSL, based on monitoring team reports. Sample sizes for age at first calving for males and females, and a preliminary calving interval frequency distribution have been extended. Preliminary steps applying this information to Vortex PVA modelling have been used to examine the potential impact of periodic reinforcement releases of dama from the captive group to the wild.
- The pilot release group of six dama gazelles from the captive group, undertaken in January 2024, involved an adult pair captured from the wild in OROAFR and four of their offspring, born in the pen system, creating a group of 3.3 individuals. Thus, all were of 100% OROAFR origin. The youngest animal was 95 days old at release.
- The progress of the released dama was closely followed by the monitoring team, establishing that all released animals contacted wild dama post-release. However, none of the three older animals (2.1) fitted with transmitter units (2 collared, 1 horn-mounted), survived the 2024 dry season. All three younger animals (1.2) fitted with small ear tags only were alive and well at the end of the year. They were known to have travelled up to 50 km north-west of OBC following the rains and returned to the vicinity of the release pens subsequently. Although they spent a lot of time adjacent to the fence lines in late 2024, the movements of these young gazelles broadly replicated the seasonal patterns previously reported for wild dama gazelles.
- The discovery of four wild dama gazelle carcasses during the difficult 2024 dry season (in addition to the three released dama lost) out of a projected total population of around 65 individuals (based on the late 2023 total aerial counts) was followed by a reduction in encounter rates with wild dama for most of 2024. This emphasized both the high vulnerability of the wild population and the growing importance of the captive group at OBC.
- The captive group had a successful year despite the harsh conditions. The project held 27 individuals in the pens at the start of 2024. Six were released on 22nd January 2024. Successful calvings in the pens meant these six had been replaced by late August 2024, and the group had grown to 32 individuals by the end of December 2024, continuing to increase in 2025.
- The Dropbox photographic libraries of captive and released dama, accessible to DFAP, EAD, SC and SNZCBI colleagues, were maintained with folders containing chronologically sorted images for every captive and released individual dama.

3. Other activities

- ZSL worked with SC on a second round of vulture tagging in November 2024 and contributed to planning a systematic study of nesting success among local Lappet-faced and Rüppell's vulture pairs through the 2024-2025 nesting season. Nesting data were collected using the Cybertracker sequence, originally developed by ZSL in 2023 and adapted with input from SC staff.
- Tim Wacher also supported SC during an introductory visit by a team from the Swiss Institute of Ornithology with a view to developing formal studies of large bustard species in the OROAFR and investigating the use of automatic sound recording units, particularly to study migrant passerines.
- In addition to reports, data and information on the status of oryx, addax, and dama were routinely supplied in response to requests and questions from EAD and SC's staff.

4. Ungulate mortality survey - July 2024

Following high mortalities between February and June 2024, an ungulate carcasses survey was conducted from 16th – 20th July 2024. Thirteen transects were driven by two teams through the core survey block (2,275 km^2) for a total survey distance of 449 km.
The distributions of recent wild ungulate and livestock carcasses observed and measured from transect lines (confirming larger carcasses detected at longer distances) are shown in Fig. 1 to 4.
The total numbers of fresh carcasses of the year seen (n=593, all species combined) are summarised with the resulting total carcass estimates by species in Table 1.

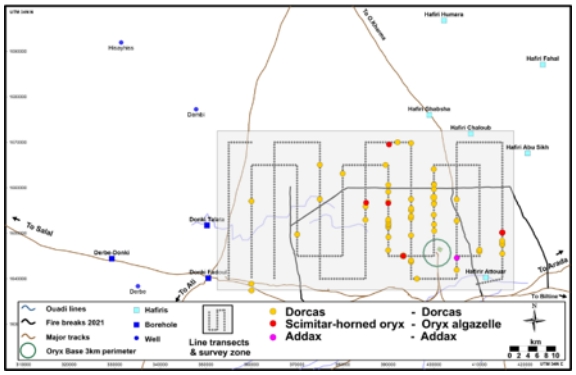

Fig. 1 Location of wild ungulate carcasses detected on transects, 16–20 July 2024

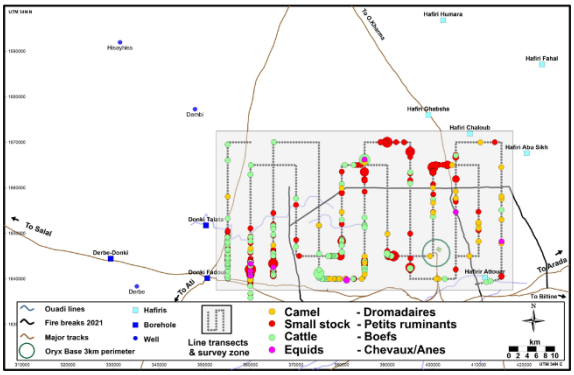

Fig. 2 Location of domestic livestock carcasses detected on transects, 16–20 July 2024

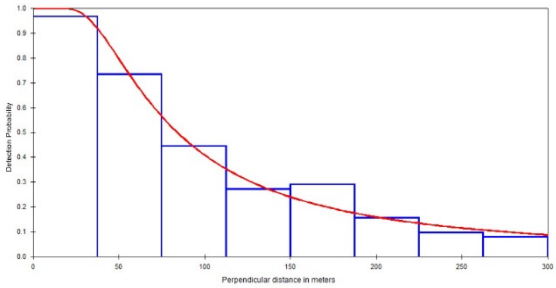

Fig. 3 Global detection function based on 157 recent carcasses 'groups' used to estimate numbers of dead camels, cattle & equids, July 2024

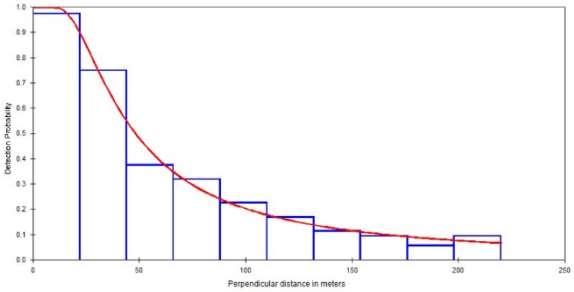

Fig. 4 Global detection function derived from 169 recent carcass 'groups' used to estimate the number of dead oryx, addax & sheep, July 2024

Table 1. Ungulate count and distance sampling results for numbers of carcasses observed and estimated in the survey block, 16–20 July 2024.

SPECIES	LIVE ANIMALS COUNTED (n groups)	CARCASSES OF THE YEAR SEEN	Carcasse groups (after truncation)	ESTIMATED TOTAL CARCASSES +/- 95% c.i.
Small stock / Petit ruminants	10665 (119)	325	164	**10,646** (6398 - 17714)
Cattle / Boefs	3170 (101)	151	109	**3270** (1826 - 5856)
Camels / Dromadaires	6466 (162)	42	40	**888** (546 - 1444)
Donkey / Ane	238 (58)	9	7	**145** (55 - 383)
Horse / Cheval	67 (43)	1	1	**22** (4 - 135)
Dorcas	1240 (243)	61	47	**4671**(2388 - 9137)
Oryx	35 (12)	6	4	**182** (55 - 606)
Addax	6 (5)	1	1	**36** (6 - 225)
Dama	4 (2)	0	0	?

4.1 Environmental conditions associated with mortality events – 2024

- All 69 oryx deaths detected directly in 2024 occurred during the late dry season, a period of exceptional and persistent maximum temperatures, peaking in May and June (Fig. 5).
- Rainfall in the previous wet season (2023) was neither unusually high nor low, being close to the annual average experienced by the project (Fig. 6).
- During the survey carried out in November 2023, pasture coverage was already very low, and the grazing impact was noticeably high even before the harsh 2024 dry season (Fig. 7 & 8).
- The records suggesting poor pasture condition in November 2023 followed the highest ever encounter rates with livestock recorded in the September 2023 survey (Fig. 9), but the role of fire in depressing food resources should also be investigated.

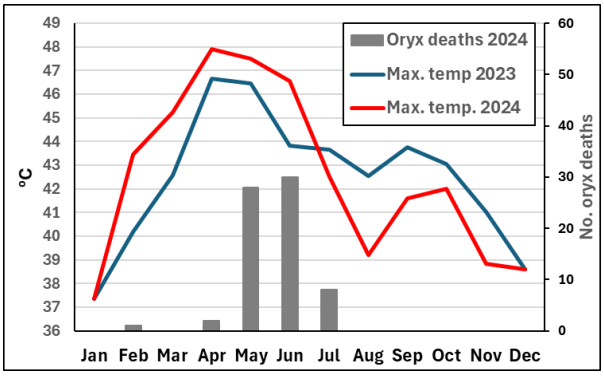

Fig. 5. Maximum temperatures 2023 & 2024 and timing of discovered oryx mortalities

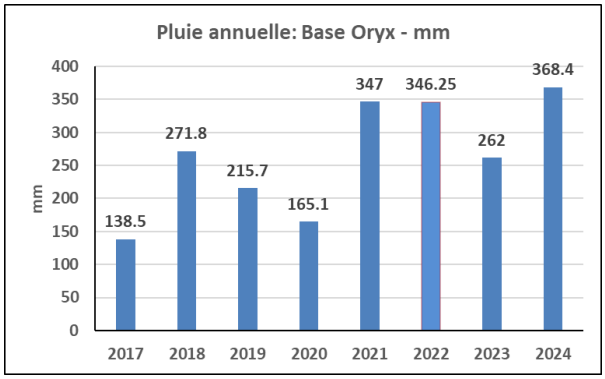

Fig. 6. Total annual rainfall at oryx base camp, 2017 - 2024

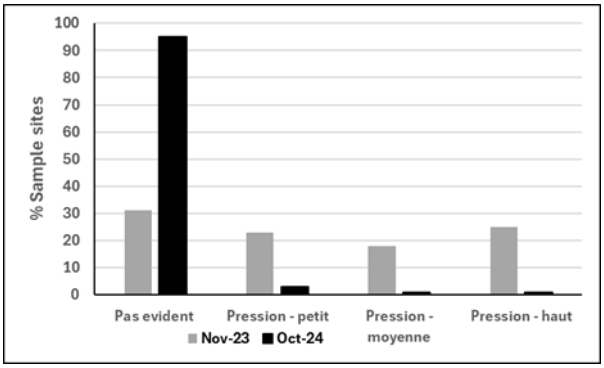

Fig. 7. Visually assessed grazing pressure scores, Nov. 2023 and Oct. 2024

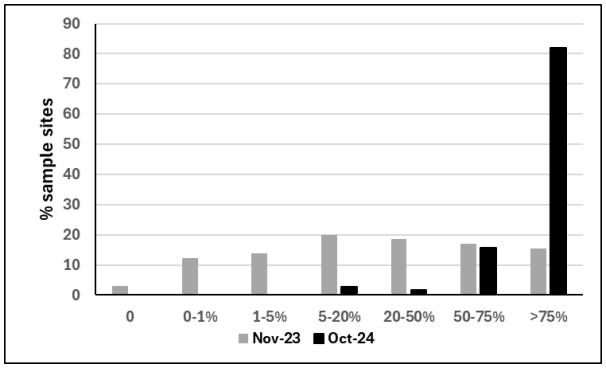

Fig. 8. Visually assessed vegetation ground cover scores, Nov. 2023 & Oct. 2024

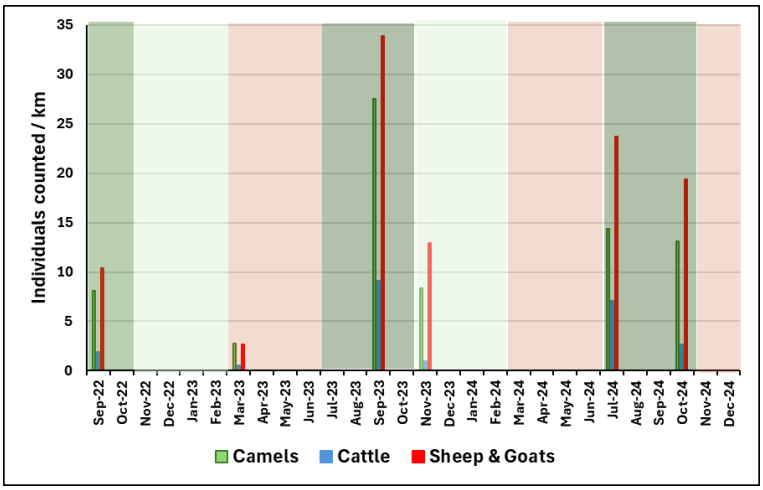

Fig. 9 Livestock encounter rates over 6 transect surveys, Sep. 2022-Oct.2024

4.2 Wildlife and livestock survey: October 2024

From October 28th to November 1st, 2024, a line transect equal-effort sample survey was conducted to record the distribution and numbers of wildlife and livestock in the oryx re-introduction core zone. Two teams drove twenty-nine sample transects, covering a combined length of 815 km, through the original core zone with contiguous extensions to the west and north, resulting in a survey area of 4075 km² that encompassed major parts of the known oryx distribution.
The distributions of Oryx, Dorcas, Addax and dama gazelle sightings are shown in relation to the transect lines, survey zone, livestock and pastoralist camps in Figs. 10 to 13. Large bustards sightings are shown in Fig. 14 and 15.

Habitat: Following high rainfall in 2024 and a reduction in the number of livestock encountered, pasture cover in October 2024 was much higher than in September 2023, and grazing pressure was perceived to be much less heavy (Fig. 6-9).

Livestock and pastoralists: Encounter rates with livestock and pastoralist camps in October 2024 were close to half the rate recorded in September 2023 (Fig. 9).

Oryx population estimate: Based on 72 groups across 11 surveys. Results were severely influenced by sampling effects, principally an observation of a herd of 91 oryx (Fig. 10). Inclusion of this herd results in an unrealistically high population estimate (879, 95% c.i. 249-3106; 85% of the variance attributed to group size). Re-analysis without the 91, but then increasing the formal result by 91, produces an estimate of 429 oryx (95% c.i. 125-868; 74% of the variance attributed to group size). The very low precision of both estimates and the unorthodox treatment of the latter mean that neither result is reliable. But the lower estimate does correspond to the degree of change that might be expected when comparing the estimates obtained in 2023 with the results of the carcass survey (Table 1 and Fig. 16).

Addax: Encounters are still insufficient for constructing a detection function for distance analysis (21 groups seen across eight surveys with addax present). The ratio between the proportion of tagged and untagged addax observed during all field work in October 2024 implies a naïve estimate of 103 addax, representing a decline similar to that experienced by the oryx population (Fig. 17).

Dama gazelle: Technically, encounters on transect are still insufficient for distance analysis (37 groups recorded across 16 surveys since 2011). But in the absence of alternatives, distance analysis has been

run on the available dataset. Results show loose agreement with results of aerial total counts in 2023 when c. 60 were believed present, but suggest around half that number in 2024. This accords with general field experience in 2024 (Fig. 18). The status of dama in the reserve remains critical and the importance of the captive group at OBC is strongly underlined.

Dorcas gazelle: Population estimate within the survey block, 21,995 (95% c.i. 15808 -30601). Density 5.4 dorcas / km^2 (95% c.i. 3.9 – 7.5). Based on the global detection function from 6,959 groups recorded over 16 surveys since 2011.

Arabian bustard density: 0.19 / km^2 (95% c.i. 0.12 – 0.31), Fig. 14 & 20.

Nubian bustard density: 0.09 / km^2 (95% c.i. 0.01 – 0.16), Fig. 15 & 21.

Denham's bustard density: 0.06 / km^2 (95% c.i. 0.02 – 0.18), Fig. 15 & 22.

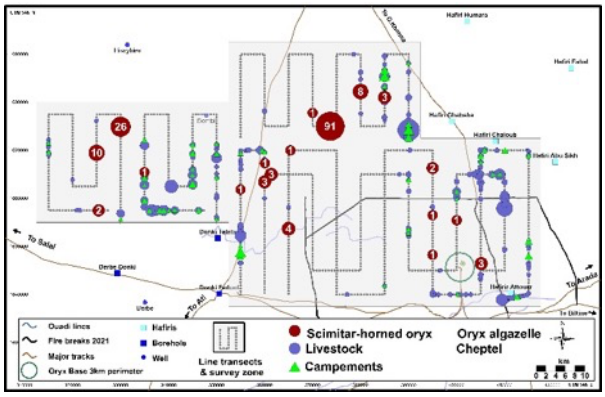

Fig. 10. Distribution of oryx groups with combined livestock and encampments, Oct. 2024

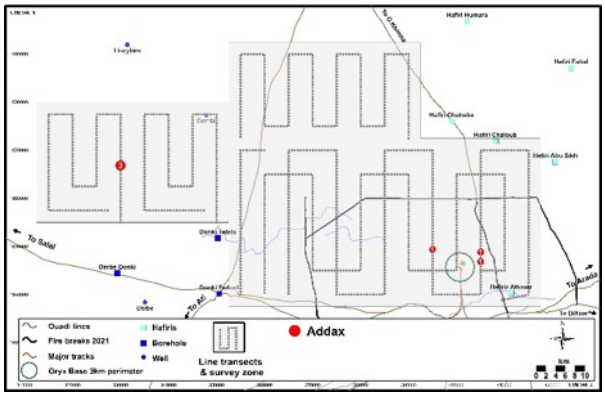

Fig. 11. Distribution of addax groups observed from transects, Oct. 2024

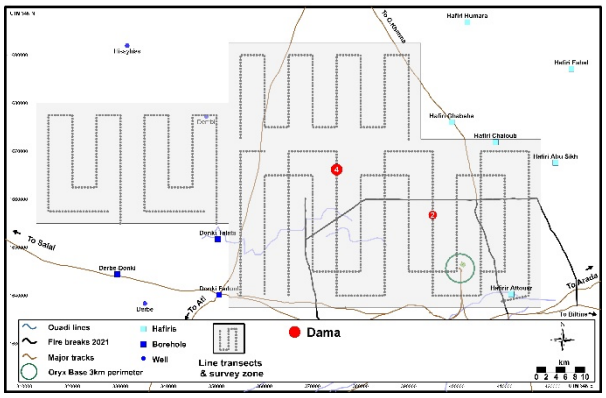

Fig. 12. Distribution of dama groups observed from transects, Oct. 2024

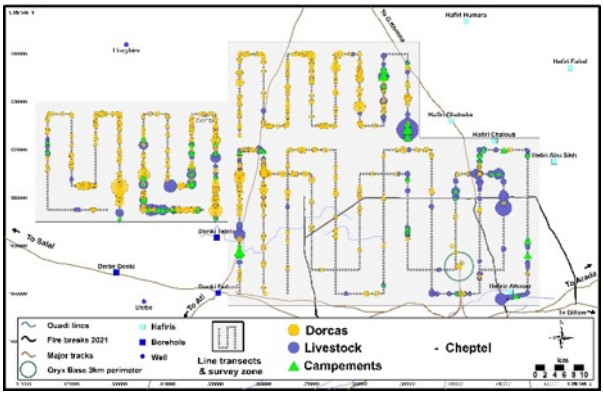

Fig. 13. Distribution of dorcas groups with combined livestock and encampments, Oct. 2024

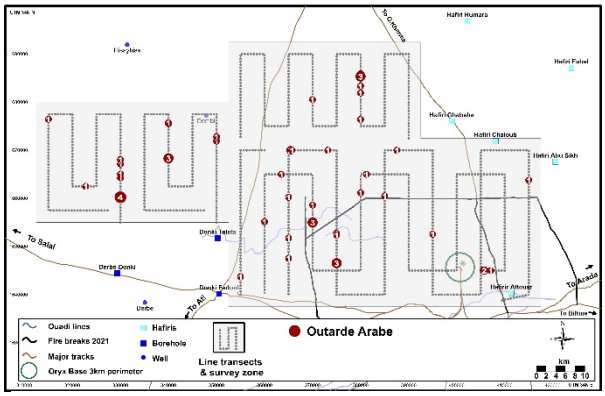

Fig. 14. Distribution of Arabian bustard groups observed from transects, Oct. 2024

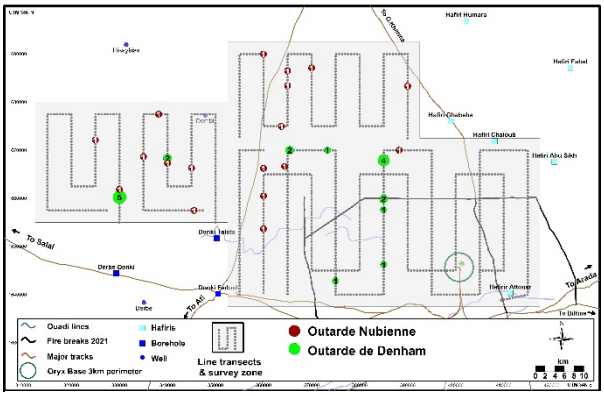

Fig. 15. Distribution of Nubian bustard and Denham's bustard groups observed from transects, Oct. 2024

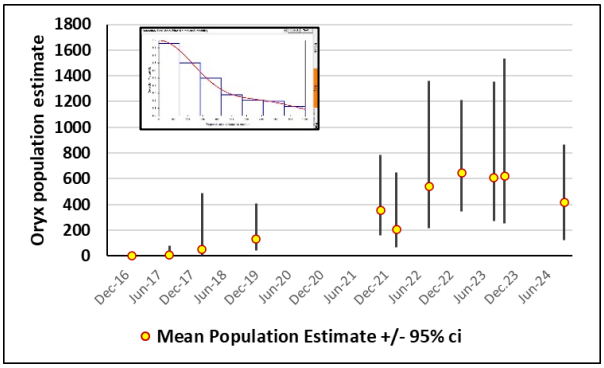

Fig. 16. Scimitar-horned oryx population estimates - OROAFR, 2016-2024

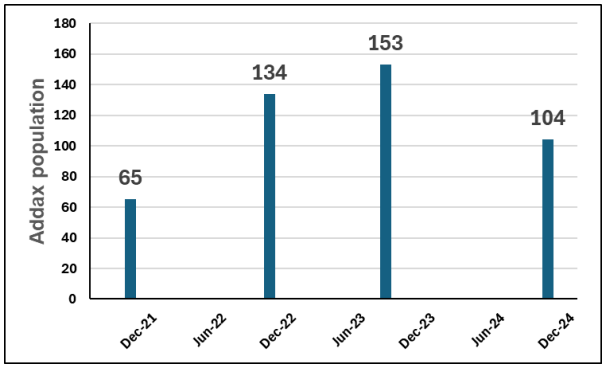

Fig. 17. Addax population estimates - OROAFR, 2020-2024

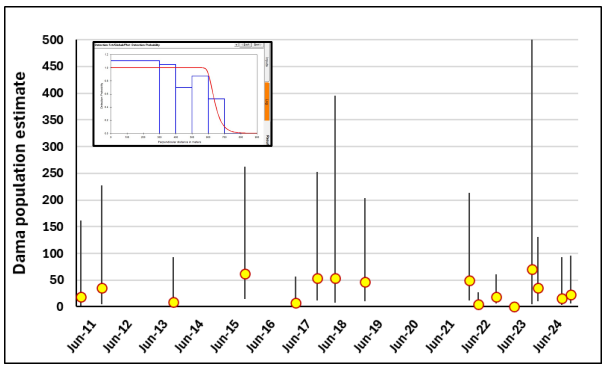

Fig. 18. Dama gazelle population estimates from sample surveys – OROAFR, 2011-2024

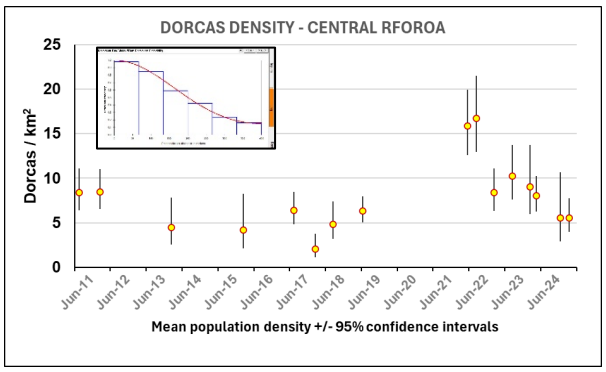

Fig. 19. Dorcas gazelle density estimates from sample surveys - Central OROAFR, 2011-2024

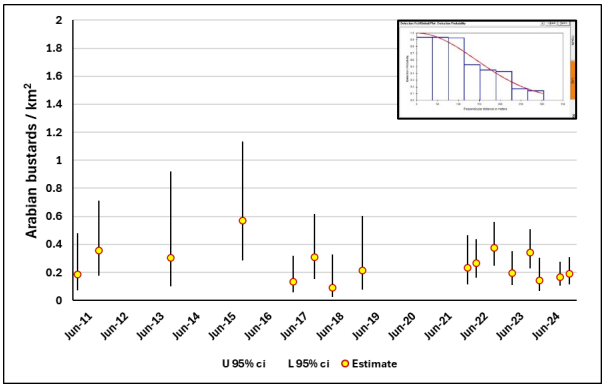

Fig. 20. Arabian bustard density estimates - Central OROAFR, 2011-2024

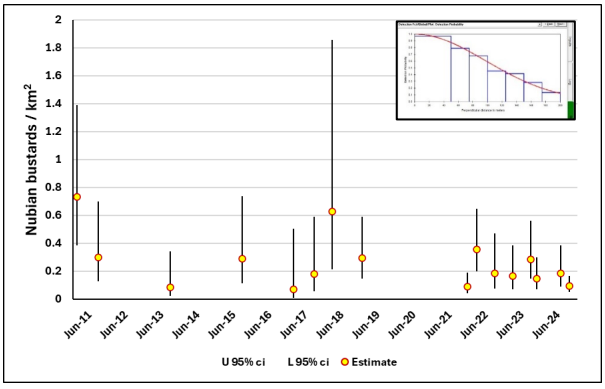

Fig. 21. Nubian bustard density estimates - Central OROAFR, 2011-2024

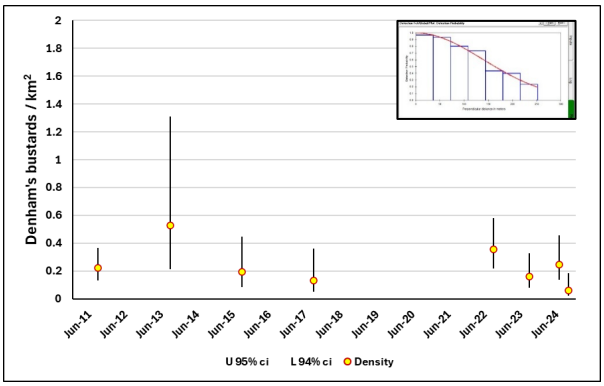

Fig. 22. Denham's bustard density estimates - Central OROAFR, 2011-2024

4.3 Oryx and addax survivorship - Preparation for population viability analysis

In preparation for a proposed Population Viability Analysis (PVA), the post-release monitoring data collected by the monitoring team at the OBC were analyzed to provide estimates of post-release survival and mortality for oryx and addax. The method includes the use of covariates enabling comparisons, for example, between founders and wild-born individuals, males and females, release groups and seasons, and seasons of birth. Provisional application of these data to Vortex PVA models has been illustrated. The input data are updated monthly, so a reanalysis at the time of the planned PVA meeting will ensure that participants have the most recent data available. Here we present provisional results to illustrate examples.

Data analysis

We used the program JAGS (Just Another Gibbs Sampler) to code a Bayesian Cormack-Jolly-Seber (CJS) live-encounter-dead recovery model estimating survivorship.

- Example data for oryx currently runs from August 2016 to August 2023, comparing 263 founders (all collared and ear-tagged), 20 pen-born and 118 ear-tagged wild-born calves.
- The example addax data set runs from January 2020 to February 2025, involving 115 founders (all collared and ear-tagged) and 73 ear-tagged wild-born calves.

For both species, we created monthly resighting matrices (for a given month, 1= observed; 0= not observed; -1=known mortality) and monthly satellite collar status matrices (1= collar functional; 0= collar not transmitting or detached), to account for the effect of satellite tracking on detectability. The individual resighting histories were tagged with covariates, including sex, release group, year, and origin (wild or founder). We made assumptions that identities are recorded correctly and tags are not lost.

The CJS model was fitted to the live-encounter and dead-recovery data and covariates through the R Statistical Software (v4.0.4; R Core Team 2022) using the package RJAGS. We used three Markov chains with 65,000 iterations, removed the first 5,000 iterations as burn-in, and thinned every third iteration to ensure that posterior distributions were adequately characterized. We examined trace and density plots for each model parameter and the Gelman-Rubin statistic R-hat to confirm chain convergence and assessed the precision of model parameters by confirming that the Monte Carlo Standard Error (MCSE) was less than 5%.

The oryx data set incorporates information on an episode of elevated mortality related to disease and management issues in the wet season of 2018, but does not yet extend to a period of elevated mortality related to exceptionally harsh dry season conditions experienced in 2024. Similarly, the addax data set, which begins only in 2020, is managed to examine the impact of the harsh 2024 dry season. Deciding the best options to organise the analysis of these events will be a discussion point in the planned PVA.

Model fit

The trace and density plots for all the model parameters showed convergence, indicating acceptable fits to the data.

Scimitar-horned oryx: comparison of founder survivorship between release groups 1-9

Adult survival varied considerably for release groups (Figure 23). Notably, the first release group has returned the highest annual survivorship of (0.93, HDI 0.888-0.974). Other groups have not performed as well. It is known that the low survivorship observed in Group 4 (0.649, HDI 0.575-0.719) was associated with a wet season disease outbreak shortly following their release, which was also unusual

for involving >70 individuals with associated impact on pre-release diet. But reasons behind the poor annual survivorship returned by Group 9 (0.594, HDI 0.388-0.79) are less clear and require further investigation.

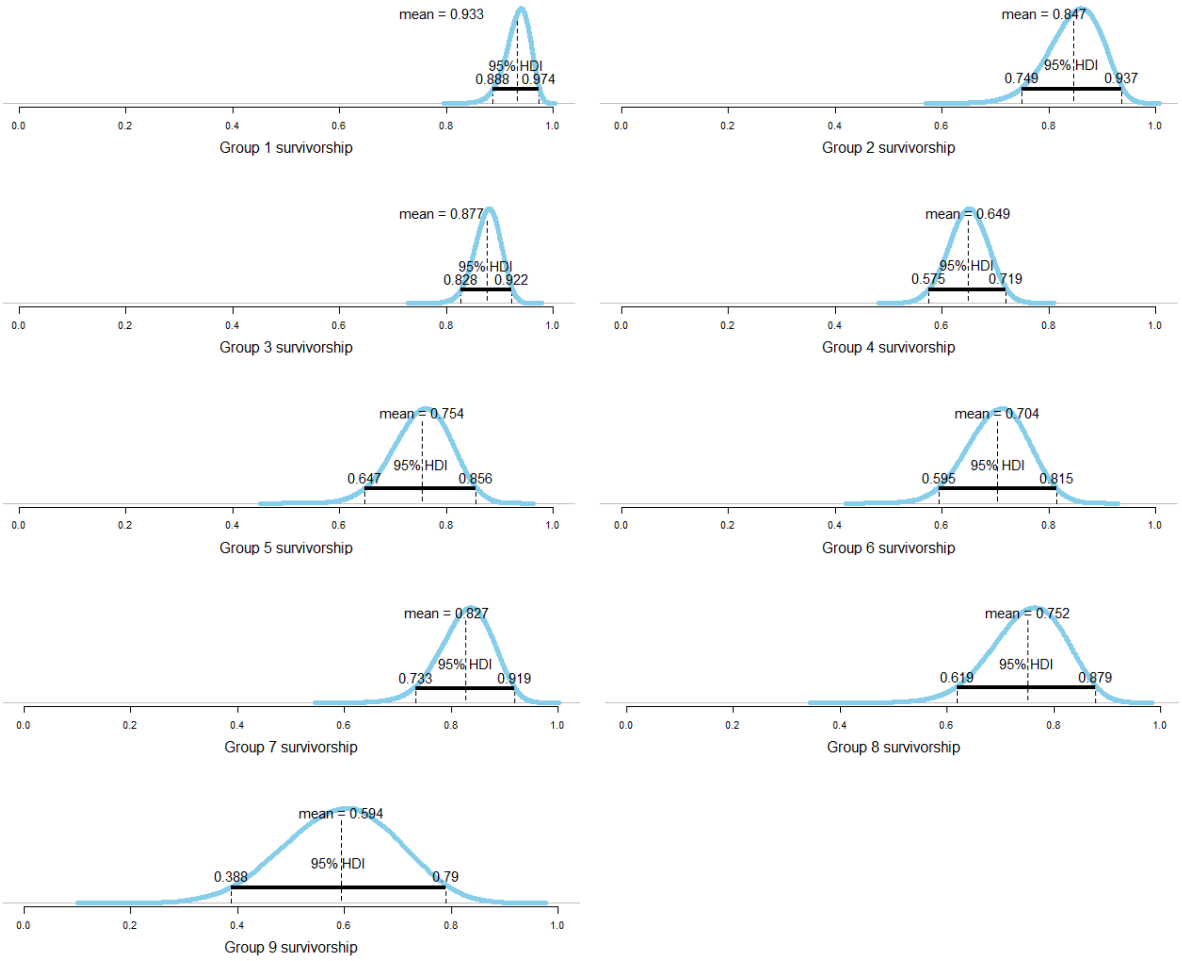

Fig. 23. Annual survivorship estimates for nine scimitar-horned oryx founder release groups - Aug 2016 -Aug 2023

Effect of season on survival probability: scimitar-horned oryx and addax

Survivorship probability by season is compared for oryx and addax in Figs. 24 & 25. In this analysis, resighting histories for all tagged oryx and addax, founder and wild-born combined, have been grouped by a covariate for season (1=Wet season, July-October; 2 = early dry season, November to February; 3 = late dry season, March to June). Additional evidence that these periods are biologically significant to the oryx has been derived independently from analysis of satellite tracking movement patterns (Mertes et al. in prep.).

In both species, the probability of survival has been highest in the early dry season and lowest in the late dry season, notwithstanding the current absence of oryx data for the late dry season of 2024. Although the differences between oryx and addax are not statistically significant, it can be noted that oryx survivorship is higher than that of addax in every season.

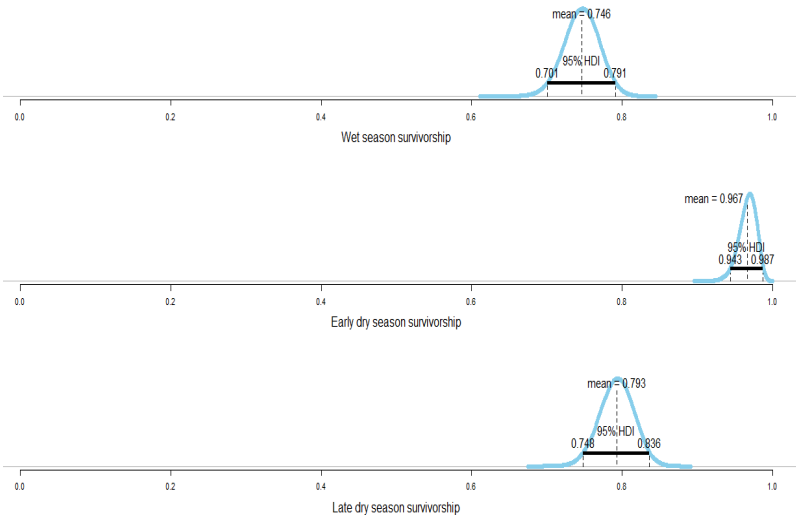

Fig. 24. Survivorship by season for founder and Chad-born scimitar-horned oryx (n=401), August 2016-August 2023

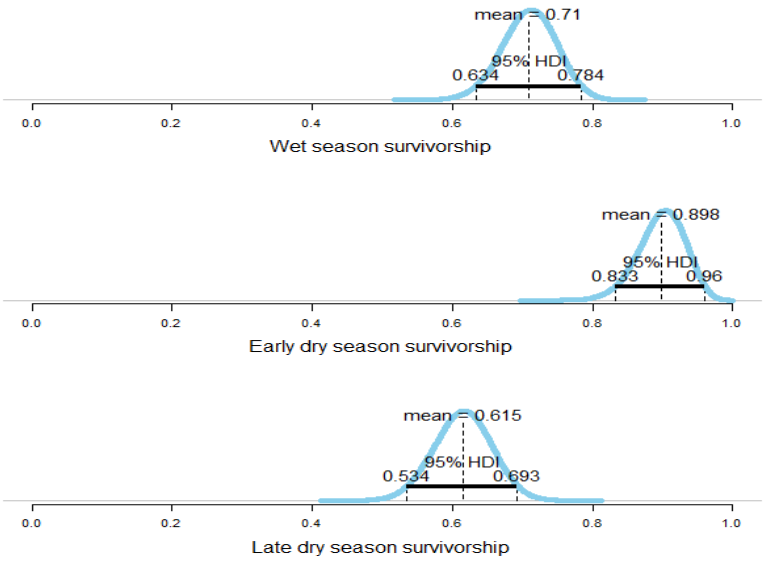

Fig. 25. Survivorship by season for founder (n=114) and wild-born (n=69) addax. (Wet season=Jul-Oct; Early dry season=Nov-Feb; Late dry season=Mar-Jun)

5. Summary

The major feature of the monitoring year in the reserve was an episode of elevated mortalities in the late dry season (March-June) 2024, affecting both oryx and addax as well as dorcas gazelles, dama gazelles and all livestock.

The monitoring work showed that the mortalities occurred over a 3–4-month period in March to June, a period of exceptionally high temperatures, associated with poor grazing availability.

Importantly, the monitoring outputs demonstrated that livestock and other wild species were equally affected, and carcasses were discovered more or less in proportion to the relative abundance of each species. Heaviest losses were among small livestock and dorcas gazelles.

A July 2024 carcass survey produced an estimate of c. 180 oryx lost. A conventional wildlife survey in November 2024 produced an estimate of c. 450 oryx, reflecting a decrease from c. 600 in surveys throughout 2023. For comparison, the July 2024 survey indicated c. 4,600 dorcas and 10,600 small stock carcasses in the same area, as well as camels, cattle and equids.

No estimates are available for the impact on the very small wild dama gazelle population, but the discovery of seven dama carcasses out of a population believed to number no more than 60-70 individuals underlines the vulnerability of the wild group, and the importance of the *in situ* captive group, which increased in number through the year. There were 27 captive dama at the beginning of the year; 6 were released, followed by a recovery from 21 to 32 by the end of the year.

This was the second episode of unusual mortality experienced by the project, but differed in character and likely causes from the first, when some 40 oryx died in 4-5 weeks from combined effects of diseases and diet management, during release at the end of the rains in September 2018.

6. Recommendations

- The experience of the 2024 late dry season underlines the need already discussed by project partners to anticipate harsh conditions in advance. Reserve management could benefit from the capacity to implement an integrated approach in the early dry season of each year. Use of remote sensing data to assess plant biomass (NDVI), rainfall (satellite models weighted by an improved network of automatic weather stations across the reserve) & fire extent (NASA.FIRMS), together with livestock numbers (field survey data), specifically to anticipate probable late dry season food availability, could help assess possible support needs for reintroduced species in some years.
- The difference in late dry season outcomes between 2024 (animals returning to pens in poor condition, searching for food and water, many dying of natural causes) and 2025 (almost no animals returning to pens, most in good to very good condition, with the only detected mortality due to human interference) should provide a useful comparative study of the factors listed above to understand the ecological dynamics in the reserve.
- For dama reinforcement releases, it is recommended to explore options for designing much lighter satellite tracking units (ideally avoiding large ear tags or horn mounts) and to conduct the releases much sooner after the end of the rains, in late September or October.
- A Population Viability Analysis workshop is recommended to provide insight into prospects and consensus on management options for future releases of oryx, addax and dama gazelles.

Section III. REMOTE MONITORING OF ORYX AND DAMA GAZELLES

Katherine Mertes

Postdoctoral Research Fellow - Smithsonian's National Zoo & Conservation Biology Institute

1. Summary

1.1 Key findings

- A mark-recapture analysis of monthly detection histories for reintroduced oryx released during 2016-2023 found that annual cohort-level survival varied from 0.49-1.0, with a minimum difference of 0.1.
- A sample size of n=42 had 80% power (at α=0.1) to detect the minimum difference in annual survival observed between cohorts of oryx with typical vs. elevated survival rates. A 15% attrition rate to account for mortality due to unrelated causes and device malfunctions yielded a minimum sample size of n=50. Thus, tracking at least n=25 animals in each release group, and n=50 animals across as many segments of the oryx population as possible, represents a minimum target to maintain the potential to detect elevated mortality in an unknown sub-group of the reintroduced oryx population (i.e., during a future massive mortality event).
- Compared to other oryx released during the cool dry season, R11 oryx traveled further each day until ca. 45 days after release. After this time, R11 exhibited similar daily distances traveled, daily net displacements, and seasonal space use to other groups released in December and January (i.e., R6, R8, and R10).

1.2 Management applications

- In December 2024, NZCBI team members coordinated the purchase and delivery of 20 GSat Solar GPS / Globalstar solar-powered tracking devices. Three devices were transported to the OROAFR for testing, and five were attached to oryx at Deleika Wildlife Center in Abu Dhabi. All devices have maintained at least 50% battery charge and reported the expected number of GPS positions since deployment.
- NZCBI, Fossil Rim Wildlife Center (FRWC), and Tarleton State University are collaborating to test lightweight GPS / Globalstar tracking devices on dama gazelle at Fossil Rim.

1.3 Products

- In November 2024, EAD and NZCBI team members fit 35 oryx with GPS / Iridium collars and horn-mounted GPS / Iridium tags at Deleika Wildlife Center in Abu Dhabi. These animals were translocated to the OROAFR and released on December 10-11, 2025.
- NZCBI personnel circulated the Phase III monitoring strategy for review and comment by project partners, and are developing revised monitoring protocols for seasonal transect, in situ monitoring, and vegetation sampling activities.
- NZCBI and ZSL personnel collaborated on a 7-year analysis of survivorship among marked oryx of different age classes. This analysis is currently in prep for submission to project partners for review.
- NZCBI personnel maintained an EarthRanger site to visualize real-time tracking data from reintroduced oryx, addax, and dama on a secure online platform, as well as FIRMS notifications to indicate potential bushfires.
- NZCBI personnel collaborated with Dr. Elena Pesci, Dr. Fayiz Abakar of IRED, and Dr. Latifa Sikli of Agence Nationale des Eaux et Forêts, Morocco, on a literature review of diseases relevant to Sahelo-Saharan antelope in range states with active reintroductions. This manuscript, which compiled historical records of relevant diseases and elaborated potential disease exposure concerns for these species, has been reviewed at EcoHealth and is undergoing minor revisions.

2. Animal tracking activities – November 2024 to May 2025

On November 7, 2024, EAD and NZCBI personnel fitted 21 adult oryx at Deleika Wildlife Center in Abu Dhabi with GPS / Iridium tracking devices (Fig. 1). Sixteen female and three male oryx were fitted with Vertex Plus 2D collars manufactured by Vectronic Aerospace and 0.2 oryx were fitted with 80g solar-powered tracking devices manufactured by Savannah Tracking, which were attached to horns using nylon straps and keratin-specific adhesives (Fig. 2). Four male oryx in the same management groups were not fit with tracking devices. On November 8, another 10.2 oryx were fit with Vectronic collars, 0.2 oryx were fit with Savannah Tracking horn tags, and 5.6 oryx were not fit with tracking devices. All oryx were briefly restrained in a drop-floor restraint device (i.e., a TAMER Jr) and carefully monitored for elevated respiration rate, overheating, and other potential signs of stress. Each oryx was restrained for less than ten minutes in total, and no animal exhibited undue stress during or after restraint.

During November 11-16, 2024, the 50 oryx selected for translocation to the OROAFR and processed on Nov 7-8 were loaded into individual crates, transported by road to the Al Ain airport, flown to Abéché, Chad, transported by road and track to the project's release site in the OROAFR, and released into the acclimation pens (Fig. 3). These animals were released into the wild as Group 11 (on December 11) and Group 12 (on December 10).

Fig. 1. Preparations to fit 30 x Vectronic Plus 2D GPS / Iridium collars and 4 x horn-mounted Savannah Tracking solar-powered GPS / Iridium tags to scimitar-horned oryx at Deleika Wildlife Center on Nov 7, 2024

Fig. 2. Savannah Tracking GPS / Iridium tag fit to the horn of adult female oryx Y616- C6215F in the acclimation pens at the project's release site in the OROAFR, Chad

Fig. 3. Oryx translocated from Deleika Wildlife Center, Abu Dhabi, to the acclimation pens at the project's release site in the OROAFR, Chad, on November 14, 2024

3. Post-release movements by R11 and R12 Oryx

After their release in December 2024, oryx in releases 11 and 12 moved further from the release site than other oryx released at a similar time of year (Fig. 4). While oryx from Release 6 (released on 12/12/2019) and Release 10 (1/9/2024) remained within 5 km of the release site during the cool dry season in which they were released, and oryx from Release 8 (12/5/2021) remained within 20 km, oryx from Releases 11 and 12 moved much further from the release site. In particular, oryx R58-Y613F moved more than 100 km from the release site by January 2025, eventually crossing the Western boundary of the OROAFR and remaining more than 250 km from the release site since February 2025 (Fig.5).

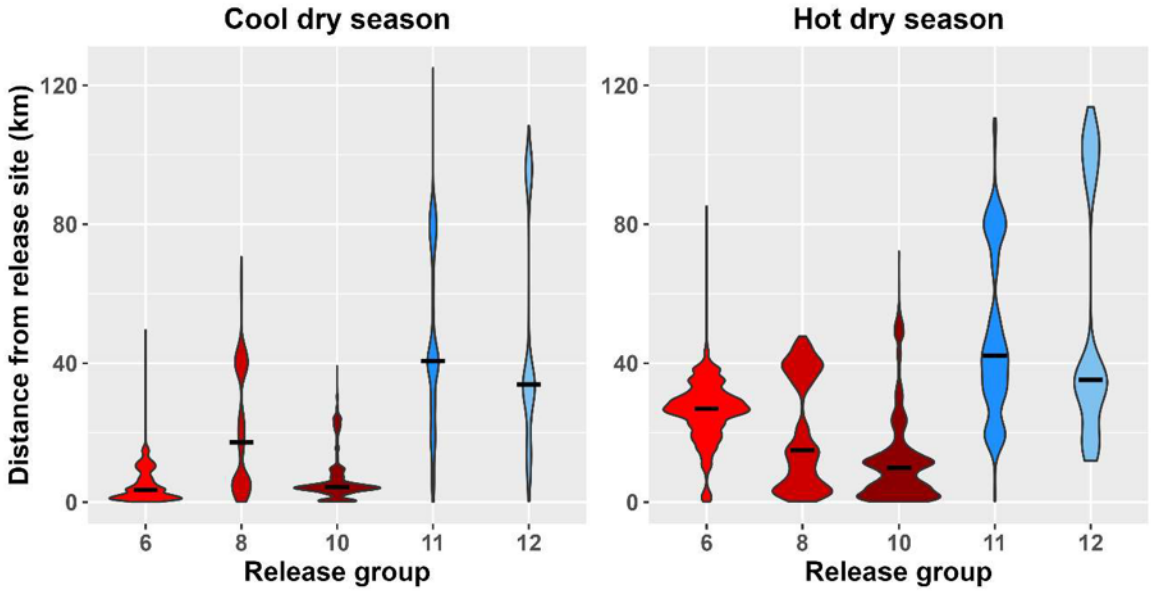

Fig. 4. Dispersal by oryx released in December / January. Violin plots contain median daily straight-line distances between oryx and the release site during the cool dry season of their release (left) and their first hot dry season in the OROAFR (right). Black lines show group-level median daily dispersal distance

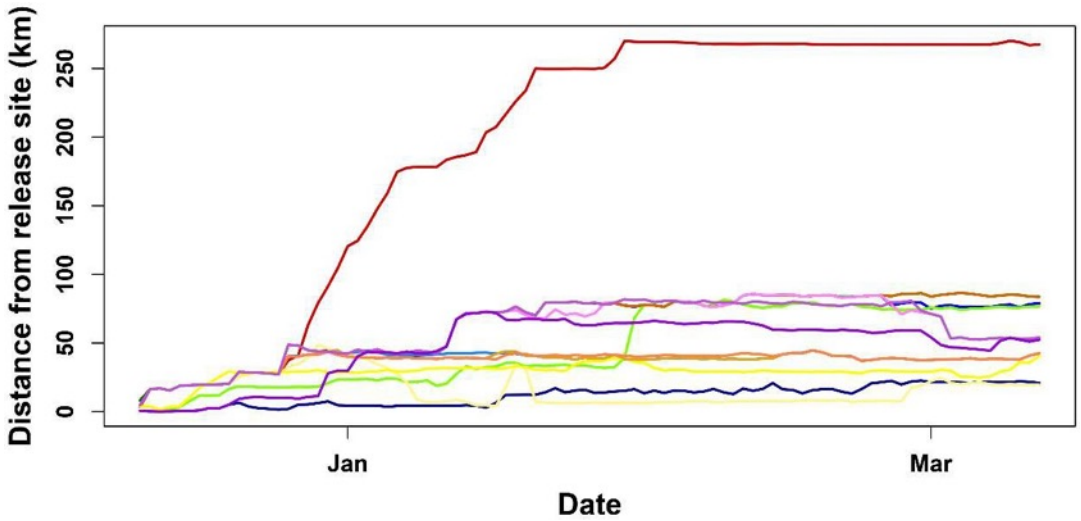

Fig. 5. Dispersal by oryx released on December 11, 2024. Red line indicates R58-Y613F, which crossed the OROAFR boundary; each color indicates a different oryx in R11

The rapid dispersal by R11 oryx is also reflected in their space use (Fig. 6). During the cool dry season of their release, R11 and R12 oryx moved over much larger areas than other oryx released during the cool dry season. However, after dispersing relatively quickly, R11 and R12 oryx decreased their overall space use, similar to most other oryx released in the cool season and experiencing their first hot dry season in the OROAFR (except R6; Fig. 6).

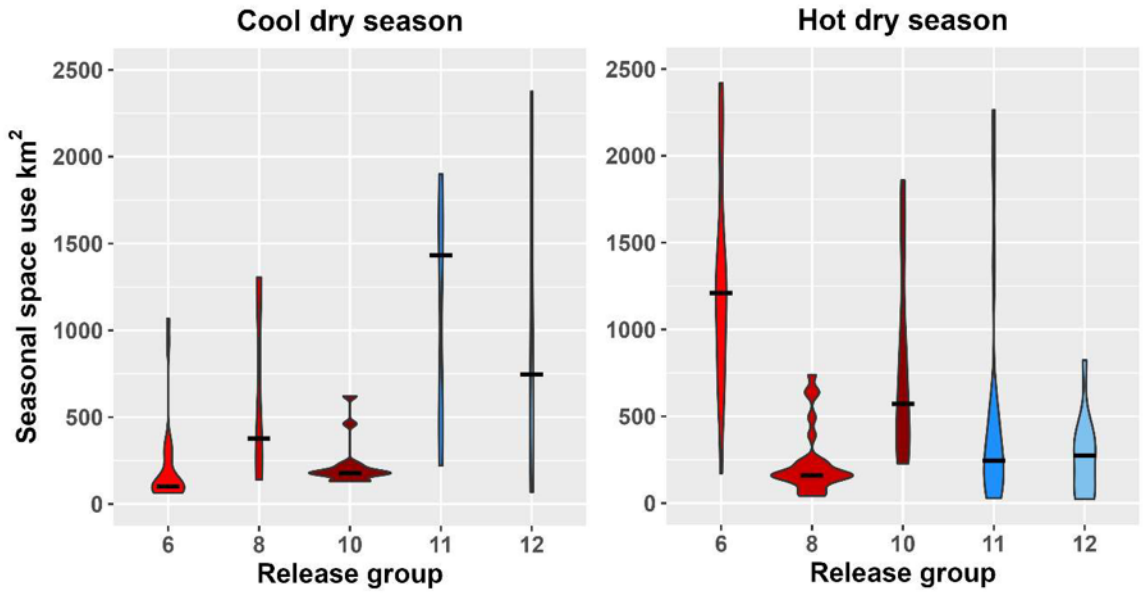

Fig. 6. Space use by oryx released during the cool dry season. Violin plots contain the area (km2) of minimum convex polygons (97.5%) encompassing movements by individual oryx during the cool dry season of their release (left) and the following hot, dry season (right). Black lines show median seasonal space use by each group

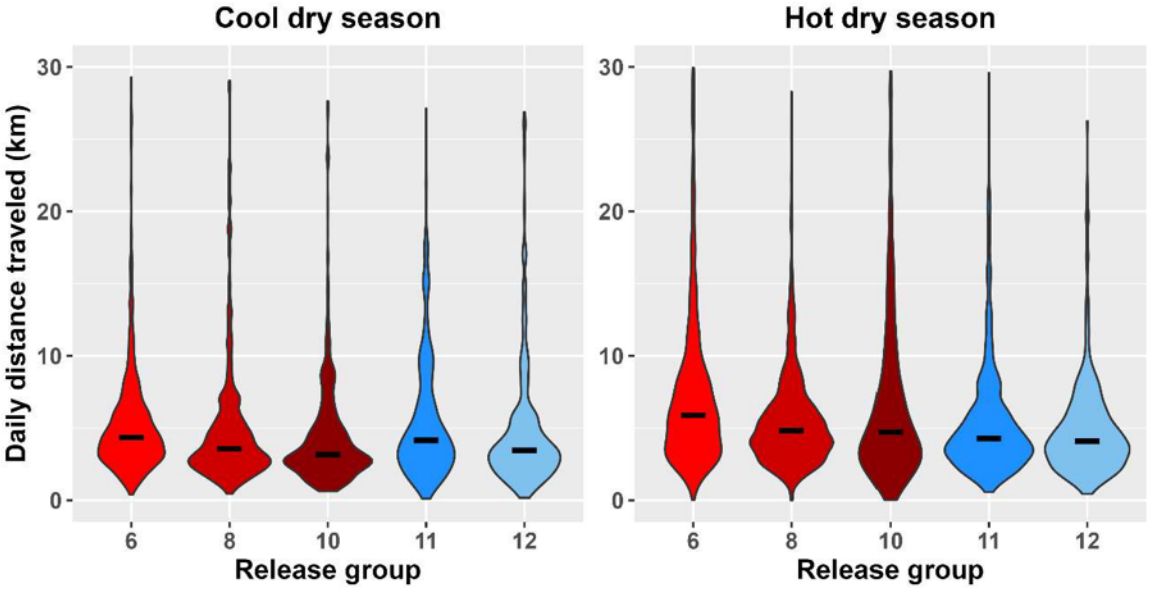

Fig. 7. Daily total distance moved by oryx released during the cool dry season. Violin plots contain along-track distances moved each day by individual oryx during the cool dry season of their release (left) and the following hot dry season (right). Black lines show the group-level median

Investigating finer movements by R11 oryx reinforces this inference. On average, oryx in R11 and R12 moved 15-25 km during the first three days after release, similar to the 20-50 km traveled by R8 oryx, and in contrast to the 0-2 km moved by R6 and R10 oryx, over the initial days after release. However, R11 oryx continued to travel slightly further each day (1-15 km) compared to other oryx released in the cool dry season (except for occasional longer-distance movements by R6 and R10) until ca. 45 days after release (Fig. 8). After this time, oryx released in December 2024 exhibit similar daily distances traveled (Fig. 7), space use, and daily net displacement (i.e., straight-line distance traveled; Fig. 9) to other oryx released in the cool dry season.

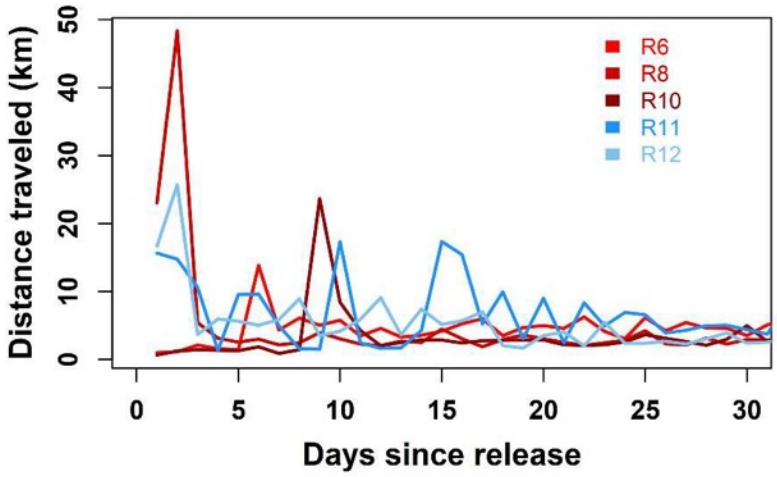

Fig. 8. Median daily distances traveled by oryx released in the cool dry season. Colored lines show the median of total distance traveled along the movement track, across each release group, each day after release into the OROAFR

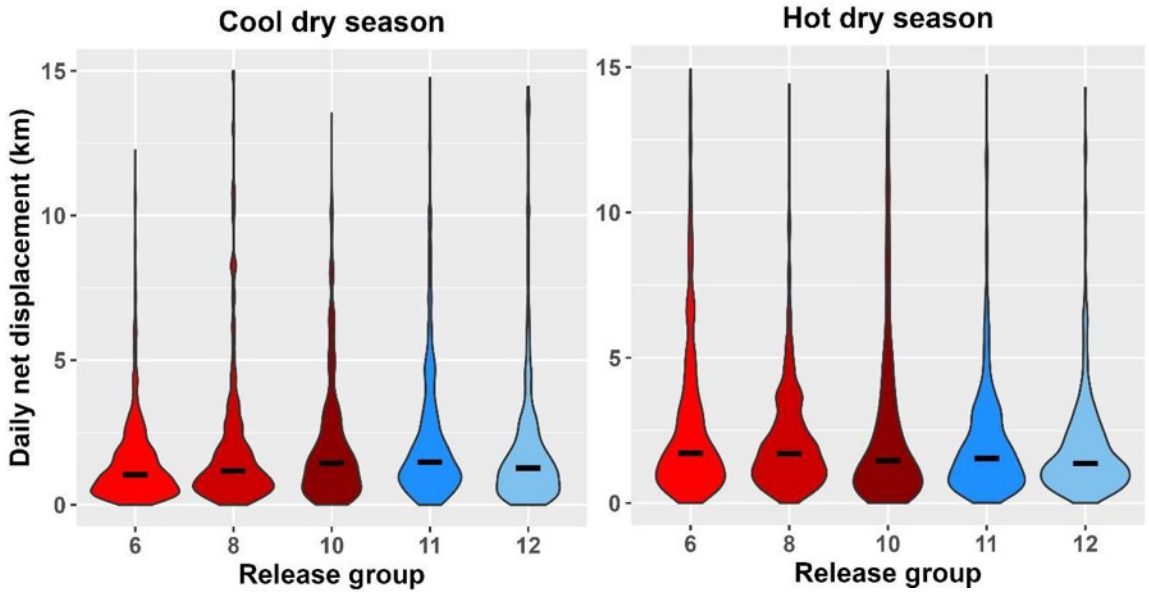

Fig. 9. Daily net displacement by oryx released during the cool, dry season. Violin plots contain daily straight-line distances moved by individual oryx during their season of release (left) and the following hot dry season (right). Black lines show the group-level median

4. Estimating sample sizes for tracking activities during Phase III

Even as the reintroduced oryx population in the OROAFR continues to grow, maintaining the capacity to detect variation in survival remains an important objective for the project. However, anticipated reductions to the monitoring budget during Phase III require revisions to the strategies previously used to achieve this objective. In addition, encounter rates for reintroduced oryx are highly variable during monitoring activities not based on recent tracking data, and group sizes are also highly variable, due to the species' fission-fusion social structure. For example, across 11 sets of distance transects conducted since 2017, 72 groups of oryx were encountered, which ranged in size from 1-91 animals (Wacher et al. 2024). Thus, maintaining the capacity to detect variation in survival rates will continue to rely, at least in part, on animal tracking data.

To quantify variation in annual survival rates for reintroduced oryx, we compiled field observations of marked translocated and Chad-born oryx from 2016 to 2023 into monthly detection histories. We then used Cormack-Jolly-Seber models to estimate annual survival for each release group (treating wild-born oryx as a separate group), including a collar presence variable to account for the effect of a tracking device on detectability. This approach assumes that animal identities are always correctly recorded and that animal markings (i.e., ear tags) are not lost. These results (Table 1) represent realistic ranges of cohort-level annual survival rates for free-roaming oryx in the OROAFR. This analysis also captured a realistic scenario of elevated mortality for reintroduced oryx: the disease outbreak of August-October 2018, which resulted in the survival of only 49% of Release 4. The exceptionally severe dry season of 2024, which depressed the survival of Release 10 to 27%, represents a second plausible scenario that may result in elevated annual mortality rates for reintroduced oryx.

Release	2017	2018	2019	2020	2021	2022	2023
1	1	1.00	0.97	0.97	0.97	0.96	0.93
2	1	0.95	0.98	0.98	0.99	0.91	0.91
3	-	1.00	0.99	0.98	0.95	0.94	0.89
4	-	0.49	0.99	0.98	0.97	0.93	0.89
5	-	-	0.97	0.95	0.94	0.87	0.84
6	-	-	-	0.96	0.98	0.92	0.84
7	-	-	-	1.00	0.98	0.96	0.94
8	-	-	-	-	-	0.98	0.97
9	-	-	-	-	-	0.95	0.96
Wild	-	-	0.95	0.98	0.98	0.88	0.91

Table 1. Estimated annual survival of oryx reintroduced into the OROAFR in 2016-2023.
The 2018 survival rate for Release 4 was modified based on known mortalities (0.49)

For this analysis, we considered oryx survival over one year a dichotomous variable: "survival" or "mortality," with a null hypothesis of no difference in survival rates among sub-groups within the reintroduced population. While this approach assumes that (i) survival and mortality are independent among animals and (ii) survival probability is constant over the analysis period – dramatically simplifying the complex environmental, social, and anthropogenic factors affecting the reintroduced oryx population – such assumptions are ubiquitous across power analysis methods. To estimate the sample size required to detect an elevated mortality rate in a sub-group of the reintroduced oryx population (e.g., a particular cohort or phenotype), we performed two- proportion z-tests of (i) the minimum estimated annual survival

rate across release cohorts unaffected by extreme scenarios (0.84), and (ii) the estimated survival rate for Release 4 in 2018 (0.49) and Release 10 in 2024 (0.27). We varied significance levels (i.e., the probability that the observed outcome was due to chance) from 0.01 to 0.1, and power criteria (i.e., the chance of correctly rejecting the null hypothesis of no difference in survival between sub-groups) from 0.6 to 1.0.

This power analysis identified that a sample size of n=42 animals has 80% power to detect the minimum difference between elevated and non-elevated annual survival rates at a significance level of 0.1. Because tracking devices are affected by electronic, software, and other malfunctions (over the course of the reintroduction project, 8-12% of deployed devices are typically affected by some kind of malfunction each year) and some tracked animals may die due to causes unrelated to an elevated mortality scenario, we increased this estimate by 15% to account for potential device and animal attrition. Thus, the estimated minimum sample size to detect a plausible difference in annual survival rates between two groups of reintroduced oryx is n=50 animals. Notably, this approach also assumes that sampled animals are evenly distributed between the sub-group with elevated mortality and the unaffected portion of the reintroduced population, which is unlikely in the context of an unknown massive mortality event. Thus, we consider n=50 animals a minimum guideline for tracking coverage.

Given these results, it is likely that tracking at least n=25 animals in each release group will maintain the capacity to detect an elevated mortality rate among recently released animals. In contrast, estimated annual survival rates for Chad-born oryx ranged from 0.88 to 0.98 and were not significantly different from estimates for founder oryx (0.84-1.0), indicating there is not an urgent need to track a minimum sample size of this segment of the reintroduced oryx population. Instead, distributing at least n=50 tracking devices across as many segments of the reintroduced population as possible is necessary to maintain a reasonable potential to detect elevated mortality rates in an unknown subgroup during a future massive mortality event.

5. Next-generation tracking devices for reintroduced antelopes

In late 2023, the Globalstar satellite network expanded, bringing service to Chad for the first time (Fig. 10). Modems that communicate with Globalstar satellites can currently be manufactured smaller and more cheaply than modems for Iridium satellites. Of available Globalstar tracking devices, NZCBI selected the GSat Solar tag for potential use on antelopes released into the OROAFR (Fig. 11). These devices are built using an ST-100 chipset and IoT (i.e., "internet of things") transmitter, weigh ca. 40g, and cost ca. USD$200, representing a substantial savings compared to GPS / Iridium collars (typically $1500 refurbished - $2500 new). A Yale University study investigating bovine tuberculosis in Kruger National Park attached more than 500 GSat Solar tags to Cape buffalo, returning relatively short deployment periods (ca. 70 days). The Giraffe Conservation Foundation has deployed GSat Solar devices on 47 giraffes in Angola, Namibia, Rwanda, and Zimbabwe, which have performed well under field conditions for at least 1 year and transmitted the programmed number of fixes (except for devices in Rwanda).

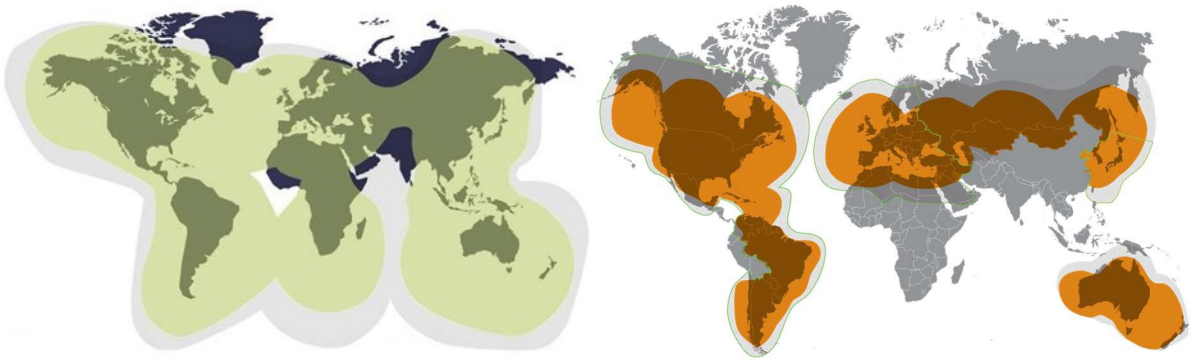

Fig. 10. Coverage of the Globalstar satellite network in 2022 (left) and 2023 (right)

Fig. 11. Example deployments of GSat Solar tracking devices as ear tags on terrestrial mammals. (A) Two-pin ear tag on a giraffe in Akagera National Park, Rwanda by the Giraffe Conservation Foundation (GCF). (B) One-pin ear tag on black rhino in Karingani Game Reserve, Mozambique by African Parks. (C) One-pin ear tag on a domestic cow. (D) Two-pin ear tag on a giraffe in Namibia by GCF during June-July 2023

In March 2025, three GSat Solar tags were transported to the project's base camp in the OROAFR and attached to the fence line (Fig. 12). These tags have consistently reported at ca. 2-hour intervals and maintained at least 50% battery power (Fig. 12), indicating these tags achieve acceptable satellite communication and solar charging in the OROAFR.

Fig. 12. GSat Solar tags deployed in Chad. The left image shows the geographic location of the tags; the right image shows one tag attached to the base camp fence line

On April 10, 2025, EAD personnel attached five GSat Solar tags to the ears of oryx at Deleika Wildlife Center in Abu Dhabi (Fig. 13). To test the device's recharge capability under solar exposure conditions similar to Chad, three tags were attached with the solar panel facing "backward" (Fig. 13 left) and two with the panel facing "forward" (Fig. 13 center). Daily observations and photographs are collected by Deleika animal care staff, and tagged oryx are assessed regularly by EAD veterinarians.

Fig. 13. Trial of GSat Solar tracking devices at Deleika Wildlife Center. Left and center images show tags attached to two of five scimitar-horned oryx tagged in April 2025; right image shows GPS positions reported by three example tags

Also in April 2025, personnel from NZCBI and FRWC continued an ongoing collaboration to trial lightweight tracking devices on captive dama gazelle. This device test is also a collaboration with Dr. Luke Linhoff of Tarleton State University (Stephenville, TX), whose students will follow behavioral observation protocols developed during trials at NZCBI and FRWC to collect behavioral data before and after tags are attached in late June 2025.

6. Assessing the conservation status of critical sites for reintroduced oryx

Since 2023, NZCBI personnel have collaborated with Dr. Emily Naylor of James Madison University (Harrisonburg, VA), a specialist in biomechanics and behavioral ecology, to use hidden Markov models (HMMs) to classify movements by reintroduced oryx into behavioral states (Fig. 14) and evaluate oryx behavior budgets across seasons and years of post-release experience. This project was recently presented as a senior thesis, and is currently *in prep* for review by project partners and submission to a scientific journal.

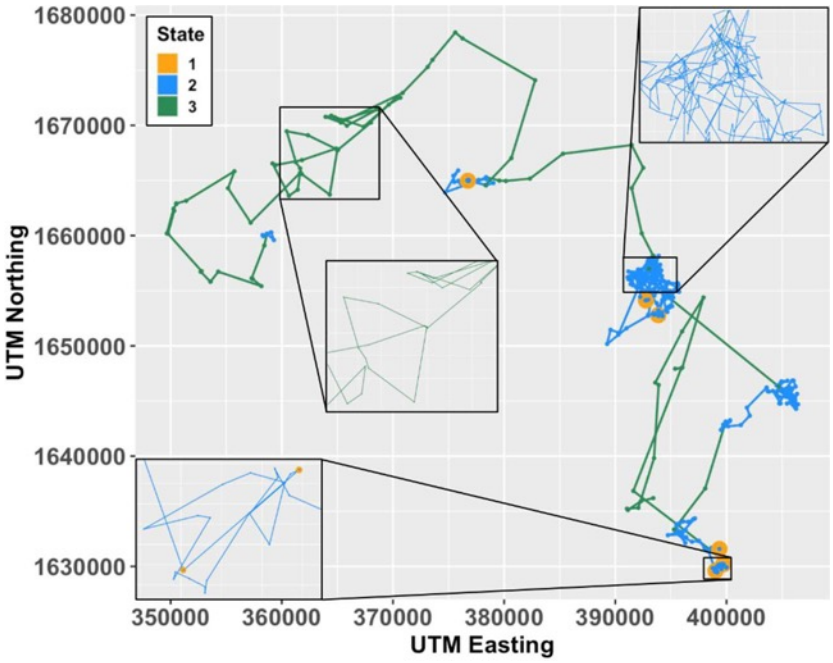

Fig. 14. Example oryx movement path classified into behavioral states. The trajectory of R6 oryx 21811.2 during the 2020 rainy season is colored according to the behavioral state assigned by a hidden Markov model, where State 1 represents resting behavior, State 2 captures foraging, and State 3 travelling. Note: insets are displayed at different spatial scales

As presented at the May 2025 Sahelo-Saharan Interest Group meeting (SSIG), NZCBI personnel have extended HMM-assigned behavioral states to investigate where in the OROAFR oryx perform certain behaviors, and assess the conservation status of potential "hotspots" of critical behaviors, such as foraging. In general, reintroduced oryx use the area within 30 km of the release site extensively and year-round (Fig. 15), with an additional highly used area emerging ca. 100km to the Northwest during the rainy season (Fig. 15 center). Reintroduced oryx exhibit the highest relative revisitation at the largest number of sites during the hot dry season (Fig. 15 left), when specific areas may offer particularly good shade or remnant palatable vegetation. In contrast, reintroduced oryx exhibit lower relative revisitation distributed across a larger number of sites during the rainy season (Fig. 15, center), potentially due to the generally high availability of nutritious forage across the reserve during this period.

We also assessed where reintroduced oryx frequently performed foraging behaviors across the first five years of the reintroduction project (Fig. 16). Because most tracked oryx, and the majority of field observations, occur within 30km of the project's release site, and a designated conservation zone fully encompasses the release site, most foraging behaviors performed during this period occurred within a region of the OROAFR identified as a strict conservation zone. While the protection of critical oryx foraging areas is a desired and

beneficial outcome, two aspects require further investigation. First, a finer temporal analysis may enable the separation of areas that contain high-quality foraging resources from those that are simply located near the release site. Second, conservation zones may receive greater physical protection in the future, such as boundary markers and added enforcement operations, which may influence oryx space use. We plan to continue the analysis of critical behavior sites for reintroduced oryx through 2025.

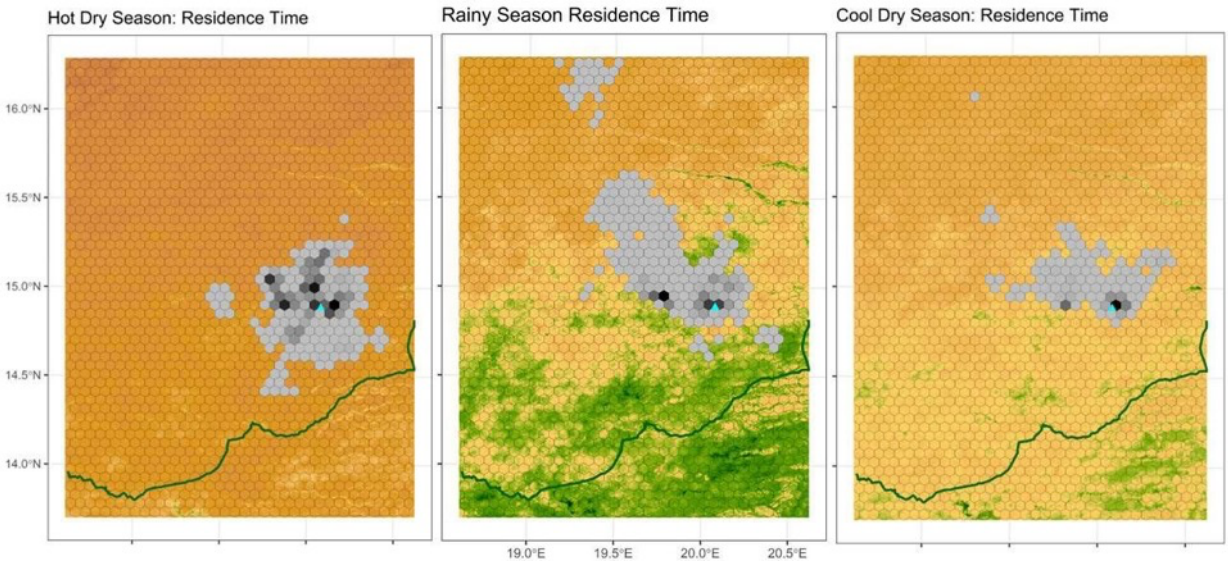

Fig. 15. Relative residence time in sites highly revisited by reintroduced oryx. Lower relative residence time within a season is shown in light gray, and higher in dark gray. The base map shows productive vegetation from no cover (tan) to dense cover (dark green). The OROAFR boundary is shown as a dark green line

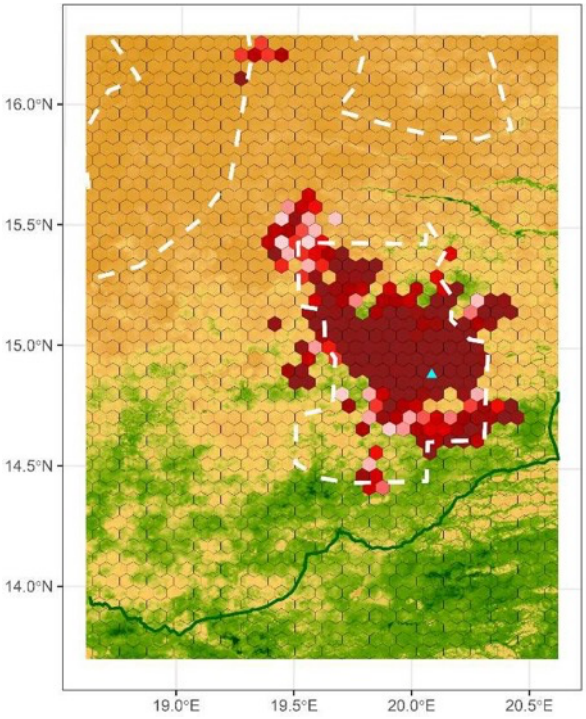

Fig. 16. Critical foraging sites for reintroduced oryx. Sites where reintroduced oryx performed foraging behaviors (as classified by a seasonal HMM covering the period 2016-2023) less frequently are shown in light red, and sites where oryx performed foraging behaviors very frequently are shown in dark red. Base map shows productive vegetation from no cover (tan) to dense cover (dark green) and the OROAFR boundary as a dark green line.

7. Ouadi Rimé – Ouadi Achim Faunal Reserve One Health Project

The *Centre de coopération internationale en recherche agronomique pour le développement* (CIRAD, Montpellier, France) has been collaborating with NZCBI to assess the extent to which free-roaming livestock in the OROAFR are exposed to regionally important pathogens relevant to oryx, addax, and dama gazelle, including: Trypanosomosis, Contagious Bovine Pleuropneumonia (CBPP), Heartwater, Q fever, Bluetongue, Sheep pox & goat pox, Crimean-Congo haemorrhagic fever (CCHF), Foot and Mouth Disease, Lumpy Skin Disease, peste des petits ruminants (PPR), and Rift Valley Fever. CIRAD received ca. 400 samples collected from sheep, goats, cows, and camels in September-October 2022, and tested them for the presence of genetic material or antibodies against these diseases. Serology results could be obtained for the target pathogens for 94% of samples. CIRAD detected antibodies for all target pathogens in at least one sample, except for CBPP (Table 2). Most animals were seropositive for more than one disease, suggesting they had been in contact with multiple target pathogens during their lifetime.

Disease/species	Bovine	Caprine	Ovine	Camelids
Heartwater	11%	11%	-	11%
CCHF	100%	24%	34%	97%
RVF	26%	12%	2%	50%
PPR	22%	54%	51%	6%
Trypanosomosis	61%	-	-	65%
Q fever	20%	39%	35%	34%
Capripox	10%	13%	24%	-
CBPP	0%	-	-	-
Bluetongue	88%	96%	72%	-
CCPP	-	19%	-	-
FMD	77%	29%	27%	0%

Table 2. Percentage of seropositivity by pathogen. Values indicate the proportion of serum samples in which each pathogen was detected, by livestock species. Samples for which status was assessed as "doubtful" according to laboratory protocols are not included.

While no samples tested positive for the presence of Rift Valley Fever virus by molecular methods (i.e., Reverse Transcription quantitative PCR; RT-qPCR), the relatively high level of RVF seroprevalence in camels and cows – especially in camels, a species for which an RVF vaccine is not currently available – indicates past RVF infections in the OROAFR. Similarly, that CCHFv-specific IgG antibodies were detected in high proportions of multiple livestock, particularly cows (100%) and camels (90%), indicates high levels of exposure to CCHF, because there is no commercially available vaccine for this pathogen. In addition, the role of wild mammals in the natural ecology of CCHF is not well known. Test results also showed that CCPP is circulating in goats at all sampled sites, representing a clear risk to reintroduced antelope, which are susceptible to this pathogen.

Further sampling of wildlife and livestock for serological testing, ideally distributed spatially and temporally randomly across the OROAFR, could help characterize the level of contact that reintroduced antelope experience with diseases that may represent threats to their survival.

8. Conclusions and recommendations

8.1 Protect seasonal habitats and movements

Multiple lines of evidence indicate that reintroduced oryx and addax, and wild dama and dorcas gazelle, engage in directed seasonal movements to the West and Northwest of the project's release site in the OROAFR during the rainy season. Maintaining the ability of wild and reintroduced antelope to move to and from these areas with limited interference and competition from humans and livestock is emerging as a key component for establishing and maintaining viable antelope populations in the reserve.

8.2 Continue toward a "long-term monitoring group" of 50 oryx

Based on a revised power analysis, tracking n=50 animals in the free-roaming oryx population and n=25 recently released animals represents the minimum sample size with reasonable potential to detect massive mortality events. In field missions conducted between 2020 and 2024, teams efficiently captured, sampled, and collared 27 oryx in the OROAFR. However, many collars have since dropped from animals captured during these missions. Maintaining n=50 tracked oryx in the reintroduced population will strengthen the project's ability to monitor population trends and demographic parameters, and detect catastrophic events.

8.3 Restrict animal releases to the rainy season and the early cool, dry season

Based on:

- previous dispersal behavior and reliance on supplementary resources by oryx released in January 2017;
- poor body condition scores observed during the first dry season for addax released in January 2020;
- the elevated mortality rate observed in oryx and addax released in January 2024;

➔ We recommend that future releases be restricted to the rainy season and the early cool, dry season.

8.4 Conduct a field test of lightweight tracking devices in Fall 2025

Multiple tests are underway to evaluate the performance of lightweight GPS / Globalstar tracking devices on oryx, addax, and dama gazelle. Should these devices continue to perform well, we recommend that at least 25 antelopes released during the remainder of 2025 be fitted with both GPS / Iridium / VHF Vectronic collars and lightweight solar-powered GPS / Globalstar tags, for an *in situ* test of this cost-effective monitoring option of longer duration than captive trials to date.

8.5 Focus monitoring effort on marked oryx

Because the reintroduced oryx population is growing so rapidly, and because unmarked juvenile and sub-adult oryx typically cannot be individually identified, observations of unmarked oryx provide relatively limited information. In contrast, every observation of a marked Chad-born or founder oryx contributes to a timeline of survival probability, space use, and social dynamics. Thus, focusing monitoring effort on groups of oryx that contain marked animals is a more efficient strategy and will yield monitoring data of greater long-term utility.

8.6 Collect DNA samples from wild-born calves via buccal swab

The primary opportunity to collect biological samples from wild-born oryx and addax is soon after birth, when calves may be captured and ear-tagged by monitoring personnel. In March 2022, personnel from the University of Edinburgh demonstrated a protocol developed by RZSS that uses a buccal swab to collect DNA from an ear-tagged calf.
DNA samples from Chad-born calves may provide insights on parentage, population genetics, and disease exposure. These analyses may also pave the way for future monitoring using non-invasive DNA samples.

8.7 Deploy camera collars on a subset of reintroduced oryx and addax

A previous collaboration among SC, FRWC, and NZCBI showed that the additional weight of a camera attached to a GPS / satellite collar (ca. 600g) does not negatively affect oryx health. In addition, mean activity budgets captured by camera collars were equivalent to those estimated by an external human observer (overall Wilcoxon signed-rank test, p=0.24). Camera collars thus represent a cost-effective tool to assess animal behavior after release, evaluate spatial overlap with livestock and wildlife, and thereby potential human-wildlife conflict, and identify gregarious individuals that may act as vectors for infectious diseases. Camera collar data may also be used to further develop accelerometry-based models of oryx behavior. Moreover, images and videos recorded by camera collars are extremely useful for outreach, communication, and other public-facing materials. We recommend that select oryx and addax in good body condition be fit with camera collars in 2025-2026.