Celebrating 50th anniversary of the "Operación Mohor": avoiding the complete extinction of the mhorr gazelle (*Nanger dama mhorr*)

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Dedicated to the pioneers of the mhorr gazelle conservation program: Jose Antonio Valverde, Antonio Cano and Mar Cano

Origin

Very often, at the origin of the important events, people of special charisma, certain circumstances and, of course, a "little bit of luck" come together. This is the case of the so-called "Operación Mohor" (in Spanish), for which, this year 2021, we celebrate the 50th anniversary.

On the night of 14th January 1971, a group of seven mhorr gazelles (one male and six females) (*Nanger dama mhorr*) along with 17 dorcas gazelles (*Gazella dorcas neglecta*), from the Western Sahara (ex-Spanish colony) arrived at "La Hoya" farm (Figure 1), a property of the Estación Experimental de Zonas Áridas (EEZA), a research center of the National Spanish Research Council (CSIC), in Almería, southeast Spain. This was the starting point for the creation of the Saharan Fauna Park Rescue (in Spanish: Parque de Rescate de la Fauna Sahariana; PRFS), and the beginning of a captive breeding program that saved the mhorr gazelle from almost certain extinction. Later the same year, two more mhorr females joined the original group. Finally, on 14th November 1975, the last group of 10 mhorr gazelles (four males, six females) that had been kept in the military HQ in the Western Sahara, arrived at the PRFS. Joining the mhorr gazelles were more dorcas gazelles, Cuvier´s gazelle (*Gazella cuvieri*), Saharan Barbary sheep (*Ammotragus lervia sahariensis*) and other Saharan animal species which arrived and settled at the PRFS. For more detail see Valverde´s memoirs (Valverde 2004).

The people who promoted and piloted this project in the early years were Professor José Antonio Valverde, probably one of the best Spanish ecologists, mainly recognized for his role in the creation of the Doñana National Park and the Biological Station of the same name (EBD-CSIC), and Antonio Cano, curator of the museum at the EEZA. Antonio Cano was a lawyer by training but with a naturalist's heart, great skills and abilities in photography and communication and, above all, a restless person and faithful friend. When Professor Valverde suggested that he embark on the risky adventure of saving the mohor antelope, he did not hesitate.

The fortunate circumstances that accompanied this adventure were, on the one hand, the contacts and friendships that Professor Valverde had with the Spanish military in the area who were keeping some specimens of mhorr in captivity; on the other, the existence of a suitable space in "La Hoya" farm, as well as a suitable climate for the gazelles' adaptation. No other site in Europe could be more suitable. Another fortunate circumstance was that a daughter of Antonio Cano, Mar Cano, - at that time a biology student - immediately joined the project. Mar's dedication of a lifetime to the conservation of this species is well known.

Fig.1. *"La Hoya" farm (© T. Abaigar CSIC)*

First steps

The challenges taken on by these pioneers were enormous. Few people would have accepted the risk of the preservation of such an important species, one the verge of extinction, without a lack of knowledge of its most basic aspects of its biology and behavior. The first challenges came soon after, with the need to solve such basic aspects necessary to their survival as: what is the most appropriate food? how much space do they need to live in captivity? what is their gestation period? how to capture them if necessary? how many males and females to put in the same enclosure? what are their main diseases? etc. In the absence of other experience, some of these questions were resolved by comparison with domestic species (goats) and sometimes by trial-and-error. It was especially important to implement a capture system of frequent and safe use. Since these early years, the PRFS has continued using a capture system that utilizes nets for manual immobilization of gazelles. Also, the diet of gazelles, the design of enclosures and herding of gazelles, have undergone a few modifications since these early beginnings. These first years were exciting because they were so full of new knowledge of the mhorr gazelles, but some mortality also occurred during the first years. The story of the challenges that were faced in these early years can be read in Cano (1988, 1991) and De Boroviczény (1988).

But it was not only about ensuring the survival and reproduction of the mhorr gazelles. The real engagement was to establish a long-term and science-based *ex situ* conservation program for this species. In this sense, we must also recognize the success and the correct decisions of Antonio and Mar Cano in the data collection and meticulous recording of genetic and demographic information that constitutes the basis of management of any *ex-situ* conservation program. It should be noted that in the early 1970s, it was very far from that. Later the global

zoological community would establish standards of species management (EEP/ EAZA and SSP/AZA programs). When this happened, the mhorr EEP program – as well as its International Studbook - was one of the first to be approved (1986). At the beginning of the 1980s, once the first difficulties had been overcome and when the population began to grow, contacts began with national and international zoos in order to establish breeding groups in other centers, thereby assuring the survival of the species in case of a catastrophe, and providing more resources for the global *ex-situ* conservation program. The first groups of mhorr gazelle were moved to several zoos in Germany (Osnabrück, Berlin East, Munich) and to San Diego Zoo in the US in 1981 (Dolan 1981).

And from the very beginning, reintroduction of the mhorr gazelle into native areas in North Africa was a priority of the *ex situ* conservation program. The first reintroduction project of the mhorr was carried out in Senegal in 1984 (Cano et al. 1993), just 13 years after the first arrival of gazelles in Almeria.

Achievements

After 50 years, I am quite confident that the complete extinction of the mhorr gazelle has been averted. The species has fully adapted to live under the management conditions imposed by captivity, and natural reproduction is successful (Figure 2). Currently the population is around 350-400 individuals distributed in different zoological institutions in Europe, North America, and the Middle East. All these captive populations are registered in the international studbook and managed according to the standards of the European Association of Zoo and Aquaria (EAZA) and the Association of Zoos & Aquariums (AZA).

During the 50 years since the mhorr gazelle was brought into captivity, different national and international research groups have collaborated on research into the necessary knowledge on the biology, physiology and behavior. The acquired knowledge has been essential to ensure their survival and well-being in captivity. We cannot make an inventory of all the publications during the last decades, but I would like to highlight some of them on those subjects which are relevant and also common to other threatened species under similar conservation programs, such as the effects of the loss of genetic variability, the basis of their physiology of reproduction as well as implementing assisted-reproductive technologies and, the studies of their behavior as a basis for improving the well-being of individuals in captivity.

While 19 mhorr gazelles (5.14) were moved from the Western Sahara to the PRFS in Almeria, only 11 of them (2.9) left descendants (Ruiz-López et al. 2009) and Moreno et al. (2011) pointed out the possibility of just genetic five founders (1.4). The number of identified haplotypes into the captive populations was only two, although their nucleotide diversity was higher than for some wild populations of dama gazelle in Niger (Senn et al. 2014). All these studies reveal a scarcity of genetic variability which will inevitably diminish over time. The possibility of finding new founders is null.

The effects of the limited numbers of founders and the inevitable loss of genetic variability on different biological traits and functionalities has been evaluated. It is worth mentioning publications that refer to reproductive fitness (Alados and Escós 1991, Cassinello 2005, Roldán et al. 2006, Ruíz-López et al. 2010, Moreno et al. 2011), survival (Alados and Escós 1991, Cassinello 2005, Ibañez et al. 2013) and body condition (Ibañez et al. 2011). The duration of the ovarian cycles and the length of gestation of females have both hormonal and behavioral characteristics (Pickard et al. 2001, 2003), as well as semen characteristics in males (Holt et al. 1996, Cassinello et al. 1998, Abaigar et al. 1999, Garde et al. 2003, Roldan et al. 2006, Ruiz-

López et al. 2010). Assisted reproductive techniques (ARTs) and artificial insemination with frozen semen has been implemented (Holt et al. 1996, Roldan et al. 2006, Berlinguer et al. 2008). The results derived from studies related to social behavior, relationships between hierarchy and aggression and protocols of enrichments (Cano 1991, Cassinello and Pieters 2000, Rose et al. 2008) have contributed important knowledge to improve the welfare of captive mhorr gazelles.

As mentioned, the reintroduction of the mhorr gazelle into their original areas of distribution in North Africa was always a priority and the final purpose of their *ex-situ* captive conservation program. Until now, the mhorr gazelle has been reintroduced in several protected areas (PA) in Senegal in 1984 (Cano et al. 1993), Morocco in 1992 and Tunisia in 1994 (Abaigar 2018). The evolution, success and current situation of these reintroduced populations are uneven depending on intrinsic and extrinsic factors (Abáigar 2018), the management of each PA being one of the most important.

In 2015, for the first time, a group of 24 mhorr gazelles were released into the wild in southern Morocco (Abáigar et al. 2019). This unique experience has shown basic ecological aspects of the species in the wild such as the size of its areas of use, the selection of habitats and their characteristics, and the rhythms of activity (Abáigar et al. 2019, 2020), all of them essential for the success of future reintroductions.

Finally, it should be noted that the experience of these 50 years has made the EEZA a reference center in the management and conservation of endangered North African ungulates and, as such, it is an important center for training for managers and rangers of North African countries.

Fig.2. *Dama Mhorr (© T. Abaigar CSIC)*

Future

In spite of the achievements described above, during 50 years of the mhorr gazelle´s *ex- situ* conservation program, the two main objectives (ensuring survival and reintroduction in the places of origin) are still continuing and research to support the success of these objectives continues as a fundamental pillar of the program.

Increasing the existing captive population is the only way to ensure, not only the survival of the mhorr gazelles but also one of priority actions within the Conservation Strategy (2019-2028) (Al Ain Zoo et al. 2019) for the entire dama gazelle (*Nanger dama*) species. Currently, dama gazelle is one of the most threatened ungulates in Africa and is classified as "Critically Endangered" on the IUCN Red List. Increasing current populations needs more space and economic resources. In that sense, more zoological center participants in the EEP and SSP program are desirable. The captive population in Almeria is the largest (about 150 individuals). Moving the facility to a bigger area is one of the EEZA´s ambitions and priorities. Managing the population as is being done (under the standards of EEP / EAZA and SSP/AZA) is the best way to slow down the inevitable loss of genetic variability and its possible (and deleterious) consequences for long-term survival. After all, conserving a species means conserving the maximum genetic variability possible so that individuals can adapt and evolve successfully in the face of both foreseeable and unforeseeable environmental changes.

Monitoring the effects of inbreeding on natural traits and performance (reproductive success, disease resistance) are research priorities. More studies are also needed to delve deeper into the causes and consequences of stress and how it affects behavior and well-being. Finally, the survival of gazelles after release into the wild will be related to their capacity to recognize predators and threats and to respond appropriately to them. If these capacities are innate or learned and how they have been affected in animals raised for generations in captivity is something that must be investigated to increase the success of reintroductions.

Finally, more and more successful reintroductions remain a pending issue. Despite the degradation and occupation of its original habitat, there are still large areas where the mhorr gazelle could survive in complete freedom. The experiences carried out so far clearly show us which are the factors that condition the success of reintroduction projects, in areas where social and political conflict, as well as the persistence of poaching, limit the success of any conservation project. It is necessary to involve the local population in these projects, from the very beginning, making them feel that these kinds of projects are compatible with their traditional way of life, and that it will bring them benefits in the short, medium, and long term. It is also essential to have enough material, financial and human resources to carry out an exhaustive, long-term (decades) monitoring of these projects. Finally, we should support economic and social projects in range states that contribute to the autonomous economic development of these countries, to the improvement of the well-being of the entire local population and to greater education.

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