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Reintroduction strategy for the Andean Condor Conservation Program, Argentina

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The Andean condor *Vultur gryphus* is the largest bird in the world with flight capacity. For thousands of years the Andean condor has been honoured as a sacred link between space and humans by indigenous communities. In the last 100 years, the range of this emblematic species contracted rapidly and the Andean condor was pronounced extinct at both ends of its endemic South American range, in Venezuela and on the Atlantic coast of Patagonia. The Andean condor appears in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora and is listed as in 'Danger of Extinction' by the United States Fish and Wildlife Service. In addition, according to the International Union for Conservation of Nature, this species is classified as Near Threatened. In 1991, the Andean Condor Conservation Program (PCCA: Programa Conservación Cóndor Andino) was founded in Argentina. The PCCA started by performing genetic analyses and documenting the condor population in zoological institutions in a Latin American regional studbook. The PCCA then developed artificial-incubation programmes and techniques for hand rearing birds without human contact, and worked to rescue and rehabilitate wild condors. The PCCA has succeeded in rearing 57 chicks and rescuing 197 wild condors. This paper describes the strategy used by the PCCA to reintroduce 160 condors throughout South America.

El Cóndor Andino (*Vultur gryphus*) es el ave voladora más grande del mundo. Por miles de años, ha sido honrado por las comunidades originarias como un nexo sagrado entre el espacio y los humanos. En los últimos 100 años, la distribución de esta emblemática especie se redujo rápidamente y fue declarado extinto en ambos extremos de su endémica distribución Sudamericana, en Venezuela y la costa atlántica de Patagonia. El Cóndor Andino esta listado en el Apéndice I de la Convención sobre el Comercio Internacional de Especies Amenazadas de Fauna y Flora Silvestres y esta listado en Peligro de Extinción por el Servicio de Vida Silvestre y Pesca de los Estados Unidos. Además, acorde a la Unión Internacional para la Conservación de la Naturaleza, esta especie está clasificada Cercana a la Amenaza. En 1991, el Programa de Conservación Cóndor Andino (PCCA) fue creado en Argentina. El PCCA comenzó por realizar estudios genéticos y documentar la población cautiva en un Studbook Latinoamericano. Luego el PCCA desarrolló programas de incubación artificial y técnicas para criar aves en aislamiento humano, y trabajó en el rescate y rehabilitación de cóndores silvestres. El PCCA ha logrado criar 57 pichones y rescatar 197 cóndores silvestres. Este artículo describe la estrategia usada por el PCCA para reintroducir 160 cóndores en Sud América.

Key-words: Andean condor; breeding; conservation; PCCA; rehabilitation; reintroduction; rescue.

INTRODUCTION

Biological information

There are disagreements about which order the Andean condor *Vultur gryphus* belongs to (Lambertucci, 2007), but experts agree that these birds are in the family Cathartidae, a Greek term that refers to its status as a scavenger ('which cleans the environment'). The Andean condor can reach 1·20 m height, have a wingspan of 3 m and can weigh as much as 12 kg, making it the world's largest flying bird (Kasielke & Wallace, 1990; Jácome, 1995). Changes in plumage begin at around the age of 3 years, when a moult of the grey collar gives way to the condor's characteristic white neck ruff. The juvenile condor's ochre–brown plumage gradually changes to grey and

then to black, with adults becoming entirely black and white at 7–8 years of age (Wallace & Temple, 1987). Male condors possess a crest and have brown irises while females have no crest and develop red irises when they reach sexual maturity (Del Hoyo *et al.*, 1994; Donázar *et al.*, 1999). The feet of Andean condors are not prehensile but they are robust, with strong toes and relatively weak blunt nails (De la Cruz Robles & Peters, 2007). With the help of its strong beak, the condor is able to tear open the skin of large dead animals providing access to food for other scavengers as well, triggering a sequence of scavenging that optimizes the 'cleaning' of the ecosystem and avoiding the build-up of carrion that could cause the spread of disease and contamination of the local environment (Wallace & Temple, 1988; Cuesta, 2000).

Andean condors are gregarious by nature and have a strict hierarchy in which the males are dominant, followed by females of the same age, then subadults and, lastly, the young. This hierarchy is clear when the group feeds (Donázar *et al.*, 1999; Donázar & Feijóo, 2002) and also when pairs hatch or feed their chicks (Lambertucci & Mastrantuoni, 2008). In zoological institutions condors have reached 75 years of age (Speziale *et al.*, 2008). The Andean condor is a K-strategist, with a long gestation period, extensive parental care and sexual maturity is not reached until at least 9 years of age. Andean condor chicks mature slowly and adults only breed in alternate years to accommodate the extended period of parental care (Temple & Wallace, 1989; Lambertucci, 2007). The species generally forms monogamous pairs (Paz-y-Miño *et al.*, 2015).

Although condors roost and feed in groups, when pairs enter the reproductive stage they separate from the flock and select caves or well-protected ledges for nesting (Jácome & Lambertucci, 2000). The female lays a single egg and does not build any sort of protective structure for it. The pair incubates the egg for 60 days, the longest incubation period of all birds (Del Hoyo *et al.*, 1994). Once hatched, the chick remains in the roost for 5 months until it has its complete plumage and begins its first flights. A young condor will remain under the care of its parents for 2–3 years. These extensive reproductive cycles suggest that a pair will only raise one chick every 2–3 years (Wallace & Temple, 1987). In the light of this low reproductive rate, Andean condor groups need to maintain low mortality rates in order to stabilize the population. Therefore, mortality of condors as a result of human activities is of great significance and can create a lasting impact on the natural population of this iconic bird.

Range and conservation

The Andean condor is endemic to South America, and is distributed as far north as Venezuela and as far south as Tierra del Fuego and Isla de los Estados. The range of the species also extends the entire length and width of the Andean mountains, from sea level to heights exceeding 7000 m (Beltrán, 1992; Chébez, 1994; Del Hoyo *et al.*, 1994; Jácome, 1996b). The Andean condor is listed on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2016), and has been declared an 'endangered' species by the United States Fish and Wildlife Service. It is also listed as Near Threatened by the International Union for Conservation of Nature (IUCN) on *The IUCN Red List of Threatened Species* (IUCN, 2015), and as 'vulnerable' by the Ministry of the Environment and Sustainable Development of Argentina.

Reintroductions have been initiated in Venezuela, where the Andean condor has been extinct since 1965 (Jácome, 1998b). In Colombia, fewer than 50 wild condors survive and a similar number of reintroduced birds supplement that population (Lieberman *et al.*, 1993; Barrera-Rodríguez & Feliciano-Cáceres, 1994; Márquez *et al.*, 2005). In Ecuador, the national census of 2015 indicated no more than 102 surviving condors (Naveda-Rodríguez *et al.*, 2016). In Peru and Bolivia the condor population

continues to decline (Ríos-Uzeda & Wallace, 2007) even though there are more numerous populations in the adjacent Chile and Argentina. Local extinctions have already occurred, such as in the Atlantic Coast of Patagonia, where the species was extinct for over a century, although recent reintroduction efforts have resulted in the return of the condor to its historic range (Conway, 2005; Jácome *et al.*, 2005).

The main cause of this reduction in population numbers is the conflict between Andean condors and farmers, who have killed and poisoned the birds for years. Farmers believe that the birds are the cause of livestock deaths, despite their exclusive role as scavengers. At the time of writing, hunters continue to kill Andean condors, while others are victims of poisoning following ingestion of lead or the consumption of the carcasses of illegally poisoned animals, especially large carnivores that have been killed to protect livestock. Collisions with man-made structures (e.g. telephone and cable lines), disturbances in nesting and roosting areas, the decline of populations of other species that form part of the diet of condors (e.g. Red deer *Cervus elaphus*, Guanaco *Lama guanicoe*), illegal trade in feathers and body parts (Williams *et al.*, 2011), and the alteration of their natural habitat all endanger the survival of the Andean condor in South America (Cuesta, 2000).

The role of the condor in the world view of indigenous communities

The Andean condor not only occupies a vital ecological niche but also fills an irreplaceable cultural role. In pieces of Nazca ceramics (1500 years old) the condor can be found as a central figure, and in the designs and monuments of the Incas the condor has been immortalized in stone (Celis Parra, 1992).

The indigenous communities of South America have transmitted their knowledge about the Andean condor from generation to generation by word of mouth and direct experience, preserving the view that the species occupies a central role in their culture. For the nomadic communities of the south, the condor is a sacred bird. 'Janana' (i.e. the 'condor') is central in the world view of the Günün A Künnä culture (Tehuelche people). 'Yeskalaw' (i.e. the 'ordering of the world') entrusted the condor with the mission of collecting and carrying the souls of the dead to the east (i.e. the 'sea coast'). From there, the souls undertake their long journey from 'Gayawa Ashchach' (i.e. the 'river of the world'), to reach the west, where they will meet and live with their ancestors [Daniel Huircapan (spiritual leader of the Pukona Mapu community, Chubut, Argentina), pers. comm.].

From the Pacific to the Atlantic, the Mapuches (i.e. the 'people of Earth') honour the Mañke (i.e. 'condor' in Mapudungun). When an animal is slaughtered for consumption, the hunters share part of the carcass with the Andean condor, foxes *Lycalopex* sp and Pumas *Puma concolor*, while the women sing Taíles (i.e. 'sacred songs') to encourage the animals to come and take what they need from the kill. This community believes that everyone is united as brothers to the Ñuke Mapu ('our only mother earth') [Teresa Epulef (Monguel Mamuell, Viedma, Argentina), pers. comm.]. Named 'Kuntur' in Quechua or 'Mallku' in Aymaras, the condor represents the sacred bond between man and the cosmos [Tayta Ullpu (spiritual leader Mink' akuy Tawantinsuyupaq, Bolivia), pers. comm.].

With the deep connection with these sacred birds, indigenous people have not only respected the condor but also honoured it for millennia (Plate 1). These teachings remain to this day and the PCCA has integrated these beliefs into the conservation programme as a fundamental part of its strategy to safeguard the species, joining science and the cultural world view, as if they are two wings of the same condor (WAZA, 2016).

FIVE STRATEGIC PILLARS OF THE PCCA

The PCCA's strategy includes development of a comprehensive conservation plan,

Plate 1. Spiritual leaders of the Quechua and Mapuche communities share sacred Andean condor *Vultur gryphus* **feathers at the release site of Paileman, Río Negro province, Argentina. The feathers for the ceremonies are sourced from moulting birds in zoological institutions or found in the wild.** *Hernán Pepe, Fundación Bioandina Argentina.*

which brings together *ex situ* and *in situ* conservation in five main pillars (Jácome & Astore, 2016).

- Cooperative management group and regional Latin American studbook.
- Artificial incubation and rearing centre.
- Rescue and rehabilitation centre for the Andean Condor.
- Post-release tracking and population studies.
- Education and outreach.

Cooperative management group and Latin American studbook

One of the first steps of the PCCA programme was to study the genetics of the Andean condor all along its South American distribution. This study demonstrated the low genetic variability of the condor population (Hendrickson *et al.*, 2003; see also Jácome, 1996a) and made it possible to impose reproductive guidelines on the condor pairs already in zoological institutions in Argentina and, since 2007, in the whole of Latin America. The creation of the cooperative management group and the first Latin American studbook for the Andean condor, which brings together valuable scientific information on over 275 different specimens, have made it possible to develop a comprehensive conservation plan (Astore, 2015).

Artificial incubation and rearing centre

The Andean condor has a low reproductive rate and it can take > 9 years for a chick to reach sexual maturity. Therefore, each wild pair will only raise a single chick at each breeding attempt every 2–3 years (Temple & Wallace, 1989; Jácome, 1994). However, in zoological institutions it is possible to increase the reproductive capacity of a pair by removing the first egg of the season for artificial incubation and leaving the second egg to the care of the parents. This process can double the number of individuals hatched in any given season.

Eggs removed from the nests that are part of the PCCA's network are artificially incubated at the Centro de Incubación Artificial y Cría en Aislamiento Humano (Centre for Artificial Incubation and Rearing in Isolation from Humans) at Ecoparque Buenos Aires, Argentina. Once hatched, latex puppets that represent the adult birds are used to rear the chicks to ensure they do not imprint on humans (Plate 2). After 2 months, chicks of the same age group are

housed together in a single enclosure where they are socialized (through sight and sound) with adult condors that inhabit an adjacent enclosure. The chicks are socialized in these conditions at the breeding facility at least until their juvenile plumage comes in. At 6 months of age the chicks are ready to be included in release programmes around South America, using techniques for reintroduction that have been developed for condors with no flight experience.

Rescue and rehabilitation centre

The PCCA receives condors that have been victims of hunters, injured in traps or poisoned by the illegal use of toxic baits, or that have collided with high-tension wires or fallen into the hands of illegal traffickers. To provide for the needs of these condors, the Centro de Rescate del Cóndor Andino (CRCA) (Center for Rescue of the Andean Condor) was created in April of 2002. Since 2008, the Centre has been located at the Ecoparque Buenos Aires, and works to facilitate the rescue and rehabilitation of wild condors with the aim of releasing them back into their natural environment or integrating them into *ex situ* conservation plans.

The PCCA has agreements with the national parks, the Gendarmería Nacional Argentina (National Police), and the provincial and national branches of the Department of Wildlife in Argentina, all of which are responsible for providing primary aid to rescued condors. Once the injured condors have been stabilized they are sent to the CRCA at Ecoparque Buenos Aires, thanks to the support of Aerolineas Argentinas Foundation (national airline). Although it is not possible to rehabilitate all the condors brought to the Center, the majority can be rehabilitated and released. Others, because of the severity of their injuries, are kept under human care and integrated into *ex situ* conservation plans, strengthening the PCCA's breeding, education and research programmes. In the case that the condor can be returned to its natural habitat, the search for its release site begins along with initiating an intensive educational campaign directed towards the local communities, rural populations, schools and institutes of study of all educational levels as well as with extensive press campaigns in the areas of influence, followed by the post-release monitoring of rehabilitated condors.

Plate 2. 'Kallfu', an Andean condor *Vultur gryphus* chick, being hand reared with the use of a puppet. *Hernán Pepe, Fundación Bioandina Argentina.*

Post-release tracking and population studies

The PCCA uses various systems of identification and tracking, including the application of microchips, the use of vinyl wing bands, and radio and satellite transmission (Astore, 2001). The use and application of these devices not only makes it possible to monitor the movement of the birds across enormous and isolated areas, such as the Andes Mountains, but also enables a better understanding about how the birds use their environment (Sestelo, 2003). This information facilitates informed decision making regarding the relocation and reintroduction of condors, as well as how best to conserve the species.

Since December 1997, the PCCA has developed and implemented a satellite monitoring system for this species. Together with Dr Michel Wallace from the Los Angeles Zoo, CA, USA, and with support of the NASA Goddard Space Flight Center, Greenbelt, MD, USA, and Microwave Telémetry, Inc., Columbia, MD, USA, the first PTT (Platform Transmitter Terminal)-100s with solar panels were designed, which were put onto the wings of condors released in Valle Encantado, in the province of Rio Negro, Argentina (Jácome, 1998a). Since then, many PTTs have been installed and new devices have been developed (Argos/GPS Solar PTTs-100), all of which provide even more accurate information about positioning, flight direction, speed and altitude. Through the satellite-based ARGOS platform, the PCCA receives daily data sets from the tagged condors. All of this information is uploaded to a Geographic Information Systems programme specific to the species. In addition, a special program called DECOSAT (a flight simulator system), which was developed specifically for the PCCA by the Bioandina Foundation, makes it possible to visualize and understand the patterns of movement of released condors in their natural habitat by comparing demographic information, such as age, sex and place of origin (Jácome & Astore, 2016).

Education and outreach

While breeding and rescue programmes are powerful tools, education is key to producing a cultural shift in society. The PCCA has a centre specifically for outreach, La *Cabaña* Condor (The Condor Cabin) based at Ecoparque Buenos Aires. This classroom receives thousands of visitors a year, all of whom are able to look at photographs, attend lectures and study other educational media as well as having access to specific information on the scope and results of the Andean condor rescue and reintroduction programme. In addition, the PCCA carries out programmes of education with schools, residents and farmers in rural communities, as well as those in big cities, reaching thousands of students and members of the community per year. To add to this, the PCCA has published numerous brochures, educational booklets, books, videos, documentaries and educational materials, which are distributed to educational institutions and local communities.

In 2015, the PCCA released a film in conjunction with the Instituto Nacional de Cine y Artes Audiovisuales (INCAA) (National Institute of Cinema and Visual Arts), Argentina, called 'The Sky Again', reinforcing these outreach efforts. This film is played in 52 INCAA theatres around the country. A travelling exhibition, which is set up through the main scientific and cultural offices in the country, aims to disseminate the scope of the PCCA and the special relationship humans have with the Andean condor.

During the past 25 years, the PCCA has succeeded in having an impact on the conservation of this species through developing these five main areas and was recognized as one of the leading conservation programmes in Latin America (Jacome *et al.*, 2013). Certainly the reintroduction of condors to the natural environment has been one of the

greatest challenges and achievements of the programme.

METHODOLOGY OF REINTRODUCTIONS

Artificial incubation, parental rearing, isolation from human contact, and rescue and rehabilitation are effective techniques that prepare Andean condors for reintroduction into their natural habitat in South America. The PCCA uses two basic methods of reintroductions, based on the flight capacity and experience of individuals that are to be released.

Reintroduction of individuals without flight experience

Individuals without flight experience are either hatched at Ecoparque Buenos Aires or rescued from the wild as chicks. Artificial incubation and breeding programmes provide chicks for reintroductions. These chicks are unaware of natural roosting sites and how to find food, nor have they been taught their place in the condor social hierarchy as scavengers in nature. These processes would normally be learned from the parents so human assistance in such teaching must be carefully planned during the reintroduction process in order to increase the chance of survival once the chicks have been released.

It is preferable to release Andean condors in groups of three or more, rather than individually because together they can learn from each other and mutually advance their flying, foraging and roost-finding practices. Therefore, it is necessary to socialize young condors when preparing them for reintroduction. This process can start from 2 months of age onwards. Juveniles are fitted with microchips (Trovan) and banded on the wing to make it possible to identify individuals within their groups.

The PCCA looks after these groups of juvenile condors in isolation from human contact at Ecoparque Buenos Aires. The juveniles are housed in enclosures that are adjacent to adult condors that are part of the rescue and/or breeding programmes so they can establish relationships and reinforce natural behaviours with other condors. The birds are kept under these conditions until they complete their juvenile plumage at *c.* 6 months of age, when they are transferred to the reintroduction sites. Even during the transfer to the release sites the condors are kept in a crate and remain visually isolated from humans.

Upon arrival at release sites, a group of up to five condors can be housed on liberation platforms (PLTs). These PLTs are fitted with an outdoor enclosure of at least 10 m long × 5 m wide × 3 m tall, fully enclosed with 10 cm × 10 cm woven mesh. An internal wooden-construction enclosure (at least 5 m long × 5 m wide × 2 m tall) with an impermeable roof provides some shade and refuge from the weather. Both compartments have food-delivery areas and water fixtures 100 cm long × 60 cm wide × 30 cm deep, which provide a constant supply of drinking water, and the facility for individuals to bathe and clean their plumage. Five-litre capacity troughs, which are kept very clean, are used to supply water on the PLTs. The condors located in the enclosures on the PLTs are fed at least 700 g of meat per day per individual, either in the form of whole animals (sheep or goats) or in parts (meat from horses and cows). Food is also left outside the PLT enclosures to attract other scavengers so that the condors can familiarize themselves with those species.

The location of the liberation platforms is particularly important as they must suit the needs of the birds. The condors will consider these platforms their 'roosts', safe places from which they can visually explore their environment, where food and water are available, and to which they will return throughout their lives. The PLT is located in a place that permits long-range vision and has an altitude differential of more than 40 m, which allows the birds to jump into space easily and take flight. The PLTs are located in areas that already have condors

in flight, providing positive reinforcement to the newly released juveniles by attracting other scavengers (especially wild condors) to the area, facilitating adaptation to living within the local scavenger-community hierarchy.

Condors spend at least 2 months at the release site to facilitate their socialization, thus further uniting the group and making it possible for the birds to gain a better recognition of their local landscape. During this time the young condors make their first practice flights safely within the outdoor enclosure. Before they are released, the condors are fitted with radio transmitters (TXE-207W Telenax) and satellite transmitters (Argos/GPS PTTs-100), one on each wing, to ensure post-release monitoring is possible.

Prior to the reintroduction, a team implements an educational campaign, reaching out to rural schools and communities, cities and mass media, in order to enhance the educational programme of the PCCA. Before the release, the spiritual leaders of the community lead release ceremonies.

The condors are released at midday to allow the birds to take advantage of the thermals that aid their flight (Plate 3). Andean condors take a few months to master the art of flying. A process of intensive monitoring, which includes 12 hours of daily observations, is carried out for 4 months to give the birds time to master the art of flying (Astore, 2001) and begin to find food for themselves. Support, in the form of supplementary food and water, is reduced in instalments until at 1 year of age (6 months post-release) the condors are completely independent.

Reintroduction of individuals with flight experience

Rescued condors that had sufficient flying experience before they were brought into the Center can be released more easily, even individually. These birds are simply brought to the release sites in boxes (e.g. Vari Kennel 500s) and released almost immediately. Although condors cross borders during their long flights, a single province is chosen for release in order to consolidate working groups on a national level. Prior to the reintroduction, a team of educators implements a campaign across the entire area of influence, reaching out to rural schools and communities, cities and mass media, in order to enhance the educational programme of the PCCA. Again, before the release occurs, spiritual leaders of the community lead release ceremonies.

The condor's carrying case is located at a site with good height differential to facilitate initial flight. The site must also be secure enough so hundreds of people can gather in the area for the educational experience. These people are allowed to get closer to the condors than those that attend the releases of the captive-bred birds. The participants are arranged a number of metres away from the box, permitting the condor sufficient space to exit the carrying case and take flight. Given the enormous flight ranges of condors with flight experience, before release the birds are fitted with wing bands, and radio and satellite transmitters to facilitate post-release monitoring.

RESULTS

Over the course of the Andean condor breeding programme to date, 61 chicks have hatched, four (7%) of which did not survive the first few months of life. Of the remaining 57 (93%), two were transferred to *ex situ* conservation programmes and 55 were reintroduced in South America. The CRCA took part in the rescue of 197 condors (Fig. 1). To date, the PCCA has reintroduced 92 individuals with flight experience and 68 condors without flight experience. Within the framework of the binational programme, the PCCA has succeeded in releasing 28 of those condors in Chile. The PCCA has also participated in the reintroduction of three individuals in Colombia, six in Venezuela, three in Bolivia and 120 in Argentina, resulting in a total number of 160 Andean condors reintroduced in South America.

Plate 3. The release of 'Ayni', an Andean condor *Vultur gryphus* with no flight experience. The release took place in Paileman, Río Negro province, Argentina. *Silvia Peralta, Fundación Bioandina Argentina.*

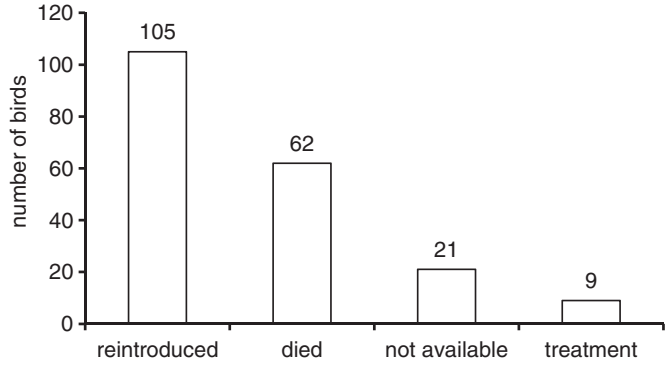

Fig. 1. The Centro de Rescate del Cóndor Andino (CRCA) (Center for Rescue of the Andean Condor) took part in the rescue of 197 Andean condor *Vultur gryphus.* Of these, 105 (53%) have been successfully rehabilitated and reintroduced to the wild, 62 (31%) have died, 21 (11%) have been unable to be reintroduced because of the gravity of their injuries and, at the time of writing, nine (5%) are being treated at the Center.

The study and monitoring of released condors has made it possible to gain a better understanding of the flight abilities of the birds and test different tracking techniques (Astore, 2001). These studies have also advanced our understanding of the preferential use of habitat demonstrated by the condors, made evident by the effectiveness of the process of socialization and by observing the aggregate behaviour of the released individuals (Sestelo, 2003). For example, in Patagonia the birds thrive in ecotonal areas between the high mountains and steppe (Cabrera & Willink, 1980; Roig, 1998; Burkart *et al.*, 1999).

Roosts were identified and the use the birds made of them was evaluated (Lambertucci *et al.*, 2008). The study of home ranges highlighted the enormous flight areas utilized by these birds, which peaked at 79 985 km^2 for juveniles and reached 159 142 km^2 for adults in just 2 months of post-release monitoring (De Martino, 2009). In addition, researchers were able to confirm the

seasonality of the condors' flights. In Patagonia, the home-range areas vary according to the season and the distribution of flights during the year is not random; for example, there are periods where the distances travelled are longer. In spring, summer and autumn, condors use approximately the same home-range area, although evidence shows that this becomes significantly smaller in winter (De Martino *et al.*, 2011).

In Argentina the PCCA has managed to reintroduce the species to the Atlantic coast of Patagonia from where it had disappeared more than a century ago. Since December 2003, thanks to an international conservation effort called 'El Retorno del Cóndor al Mar/The Return of the Condor to the Sea', it was possible to reintroduce the species to its former range (Conway, 2005; Jácome *et al.*, 2005). Since then, 48 individuals (i.e. 40% of the 120 condors released in Argentina) have been released in Paileman, Río Negro province, Argentina. Using radiotelemetry tracking systems and satellite transmission, it has been determined that 25% of these released condors (n = 12) did not survive, mainly because they were victims of poisoning from the ingestion of lead or the consumption of the carcasses of animals killed illegally using poison (Astore, 2015). Conversely, the other 75% (n = 36) are gaining flight experience every day, reaching distances of > 600 km from their release sites, linking the mountains to the sea, and their flights make it possible to identify the places that are key to the conservation of these birds.

In November 2009, the nests of condors that had been released on the Atlantic coast were discovered (Jácome, 2010). Nests have since been established in Paileman and Tembrado, two areas of the coast of Patagonia that are separated by more than 50 km. To date, the hatching of six chicks has been observed and the parental-rearing process for these individuals has been monitored. The first chicks that hatched have now reached the subadult stage.

'Quebracho', the first chick incubated and hatched within the framework of the PCCA, was released in 1997 in Valle Encantado, Río Negro, on the same latitude as Paileman, but above the mountain range. This bird has not only managed to survive 19 years but also found a mate. The pair succeeded in hatching a female chick in 2016 (O. A. Mastrantuoni, pers. comm.).

The process of tracking, based on the wing bands, radiotelemetry and transmission satellite, has made it possible to follow-up on the released condors and confirm their adaptation to the environment. At 4 months post release, the condors have mastered the art of flying well enough to find their own food, locate roosting sites, learn their place in the scavenger food chain and, after a year, are considered to be entirely independent of the PCCA's care.

On average, the PCCA releases about eight condors each year. Once they have been rehabilitated, those that have flight experience are released in the province in which they were rescued, usually in spring or autumn to avoid extremes of heat or cold temperatures. In Argentina, condors without flight experience are only released from the PLTs of Paileman where there are human and material resources that support the field camp. Early releases on the coast were carried out in December but the high temperatures made it almost impossible to work at the base camp. Since that time, September and October have been adopted as the most appropriate months to carry out releases.

CONCLUSION

The PCCA has set a regional record with the reintroduction of 160 condors in South America. The reintroduction of 92 condors with flight experience from rescue programmes has proven to be a valuable tool. These individuals are released with sufficient experience in their natural environment and often these birds are already sexually mature. The cases of mortality observed in wild condors indicate that there is still a significant impact of human activities on condor populations (Fig. 1).

The reintroduction of condors that have no flight experience, although logistically difficult and costly, permits repopulation of areas where the species had become extinct in the past, particularly because juveniles appear to be able to adapt to new environments. Andean condors hatched and reared in isolation from human contact at Ecoparque Buenos Aires, once released into the Venezuelan moorlands or Atlantic coast of Patagonia, are without difficulty able to find the ancient roosts and flight corridors of their ancestors.

Considering the length of time it takes for condors to reach maturity, being able to check the hatch and survival rates of chicks in the field entails an extensive fieldwork process that requires continuity, and many years of study and monitoring. Recent hatches of chicks from condors originally released in 1997 to repopulate certain areas, indicating that these released birds are largely independent of the PCCA, one of the greatest successes of this conservation programme.

Using tracking systems makes it possible to study and advance our understanding of key aspects of the biology of Andean condors, including flight capacity and habitat preference. Satellite data have been used to discover, study and protect (by declaring them sanctuaries) nests and roosts, areas of great importance for the conservation of the species. It is evident from the monitoring carried out to date that the principal national parks do not cover the enormous areas that condors fly across and any conservation strategy that is based exclusively on these parks will not be effective. Andean condors routinely cross borders between countries and, therefore, it is essential that international stakeholders unite to coordinate the conservation of this emblematic species.

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PRODUCTS MENTIONED IN THE TEXT

DECOSAT: flight simulator system, designed by Fundación Bioandina Argentina, Buenos Aires, Argentina.

Kennel 500: transport crate (102 cm × 69 cm × 76 cm), manufactured by Distribuidora, El Chaja 5 e/el calden y el espartillo, Ciudad Evita, Gran Buenos Aires, Argentina. *Web:* http://www.distribuidoraemp.com.ar

Microchip: individual identification transponders, manufactured by Trovan Ltd, Cologne, Germany. *Web:* http://www.trovan.com

Platform Transmitting Terminal (PTT): remote meteorological and environmental data-collection terminal, manufactured by Argos Services, Inc., Largo, MD 20774, USA. *Web:* http://www.argosinc.com

PTT-100: 50 g solar patagial satellite transmitters (reinforced antenna; maximum velocity 150 km h^{-1}, manufactured by Microwave Telemetry, Inc., Columbia, MD 21045, USA. *Web:* http://www.microwavetelemetry.com

TXE-207W: patagial radio transmitters (2·7 cm × 1·8 cm × 1·3 cm; 32 g weight; 30 km range; 11 month lifespan), manufactured by Telenax, Col. La Toscana, Playa del Carmen, Q. Roo. 77725, Mexico. *Web:* http://www.telenax.com

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