

## Should the Pyrenean wild goat be cloned?

Ricardo García-González<sup>1</sup>, Antoni Margalida<sup>2,3\*</sup>

<sup>1</sup> *Pyrenean Institute of Ecology (IPE), Spanish National Research Council (CSIC), 22700 Jaca, Spain. Tel.: (+34) 976 369 393. E-mail: rgarciag@ipe.csic.es*

<sup>2</sup> *Department of Animal Production (Division of Wildlife), Faculty of Life Sciences and Engineering, University of Lleida, 25198 Lleida, Spain. Tel.: (+34) 973 003 721*

<sup>3</sup> *Division of Conservation Biology, Institute of Ecology and Evolution. University of Bern, Baltzerstrasse 6, 3012 Bern, Switzerland.*

\*E-mail: amargalida@prodan.udl.cat

In recent years, new technology has revived the scientific debate regarding the feasibility of recovering extinct species (Stone 2013; Minter 2014). However, due to the various pros and cons of back-breeding, cloning, and genetic engineering, these techniques remain controversial (Sherkow & Greely 2013). The term 'de-extinction', used to express the restoration of extinct species, appears frequently in the literature, particularly in reference to the 'de-extinction' by cloning of the Pyrenean wild goat (*Capra p. pyrenaica*) (Folch et al. 2009; Kupferschmidt 2014). The recent extinction of this Iberian subspecies (of which the last individual died in January 2000) makes this project an attractive one for policy makers, conservationists, and hunters, because ecosystem characteristics are unchanged and the factors affecting the conservation of this subspecies are well known. Nevertheless, while these are necessary conditions to ensure the success of reintroduction, they may not be sufficient (Sherkow & Greely 2013).

After a failed attempt in 2003 (Folch et al. 2009), the same research team has recently resumed trials aimed at re-cloning the Pyrenean wild goat (Kupferschmidt 2014). However, there are a number of special circumstances that make this cloning process inadvisable.

First, cloning is very expensive (see Cottrell et al. 2014) and significant amounts of public money have been invested in this project, which leaves less funding for other conservation efforts. Some authors argue that the hypothetical reversibility of the extinction process could lead to a relaxation or deactivation of many of the programs currently under way for the recovery of other threatened species (Sherkow & Greely 2013). This will be especially true if the funds for the cloning are deducted from budgets allocated to other monitoring and conservation programs, above all given the current scenario of economic crisis in which cuts in research investment are already affecting biodiversity conservation (Margalida 2012).

Secondly, Spanish scientists have used somatic cell nuclear transfer (SCNT) and cryopreserved tissue from the last known Pyrenean wild goat to revive this extinct subspecies. However, to date this technique has only managed to produce one fetus that has survived to term, which died minutes after birth from lung abnormalities (Folch et al. 2009). Furthermore, the tissues available for this particular cloning project originate from the last known

specimen – an old, infertile, highly homozygous female, possibly suffering from hereditary heart disease (Jiménez et al. 1999; Fernández Caso et al. 2001 unpubl. report) –unlikely to provide adequate and diversified genetic material for viable individuals in their natural state. It is known that cloning produces high levels of abnormalities, deformities, and the premature death of cloned animals (Chavatte-Palmer et al. 2012).

The systematic identification of this subspecies and its relationship to neighbouring taxa are still not completely clear (García-González 2012). *C. pyrenaica* is an endemic species of the Iberian Peninsula. The few phylogenetic studies available seem to indicate a clear genetic and morphological differentiation between the extinct subspecies *C. p. pyrenaica* and the other two living subspecies *C. p. victoriae* and *C. p. hispanica*. *C. p. pyrenaica* presents an equidistant genetic position between living subspecies and *C. ibex* (a neighbouring species from the Alps) (Manceau et al. 1999), a significantly larger size and particular skeletal differences with respect to living subspecies (García-González 2011). This lack of certainty regarding the genetic identity of the Pyrenean wild goat means that any attempt at a recovery program will be risky.

Finally, a population of more than 100 individuals of another subspecies (*C. p. hispanica*) thrives in the pre-Pyrenees, just 10 km from where the last Pyrenean wild goat lived (Herrero et al. 2013). This population has been reproducing normally in the wild and has expanded into surrounding areas.

If *C. pyrenaica* must be reintroduced in the Pyrenees, alternatives to the cloning of the last Pyrenean wild goat individual do exist. An easy and economic solution could be to favour the wild goats that currently exist in the pre-Pyrenees. Their genetic distance from *C. p. pyrenaica* is probably not as distant as those of any of the currently planned genetically artificial products that may be obtained by cloning and genetic engineering (Kupferschmidt 2014). In this regard, a recent project aimed at reinforcing and reintroducing other Pyrenean megafauna such as the quasi-extinct brown bear (*Ursus arctos*) using individuals from genetically neighbouring populations from central Europe (Swenson et al. 2011) is a good model to follow. The economic investment will be less and the chances of success are likely to be significantly higher.

## Literature cited

- Cottrell, S., J.L. Jensen, and S.L. Peck. 2014. Resuscitation and resurrection: The ethics of cloning cheetahs, mammoths, and Neanderthals. *Life Sciences, Society and Policy* **10**:3.
- Chavatte-Palmer, P., S. Camous, H. Jammes, N. Le Cleac'h, M. Guillomot, and R. S. Lee. 2012. Review: Placental perturbations induce the developmental abnormalities often observed in bovine somatic cell nuclear transfer. *Placenta* **33**:S99-S104.
- Folch, J. et al. 2009. First birth of an animal from an extinct subspecies (*Capra pyrenaica pyrenaica*) by cloning. *Theriogenology* **71**:1026-1034.
- García-González, R. 2011. Elementos para una filogeografía cabra montés ibérica (*Capra pyrenaica* Schinz, 1838). *Pirineos* **166**:87-122.
- García-González, R. 2012. New Holocene *Capra pyrenaica* (Mammalia, Artiodactyla, Bovidae) skulls from the southern Pyrénées. *Comptes Rendus Palevol* **11**:241-249.
- Herrero, J., O. Fernández-Arberas, C. Prada, A. García-Serrano, and R. García-González. 2013. An escaped herd of Iberian wild goat (*Capra pyrenaica*, Schinz 1838) begins the re-colonization of the Pyrenees. *Mammalia* **77**:403–407.
- Jiménez, N., J. Folch, A. Fernández-Arias, J. Guiral, and A. Sánchez. 1999. Estudio genético mediante marcadores microsatélites de las poblaciones de cabra montés. *ITEA* **20**:300-302.
- Kupferschmidt, K. 2014. Can cloning revive Spain's extinct mountain goat? *Science* **344**:137-138.
- Manceau, V., J. P. Crampe, P. Boursot, and P. Taberlet. 1999. Identification of evolutionary significant units in the Spanish wild goat, *Capra pyrenaica* (Mammalia, Artiodactyla). *Animal Conservation* **2**:33-39.
- Margalida, A. 2012. Baits, budget cuts: a deadly mix. *Science* **338**: 192.
- Minteer, B. A. 2014. Is it right to reverse extinction? *Nature* **509**:261.
- Sherkow, J. S., and H. T. Greely. 2013. What if extinction is not forever? *Science* **340**:32-33.
- Stone, R. 2013. Fluttering from the ashes. *Science* **340**:19.
- Swenson, J. E., P. Taberlet, and E. Bellemain. 2011. Genetics and conservation of European brown bears *Ursus arctos*. *Mammal Review* **41**:87-98.