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The taxonomic status of the European mouflon in Spain

El estatuto taxonómico del muflón europeo en España

Stefan Michel[1,2], Sandro Lovari[3], Arash Ghoddousi[1,4] & Juan Herrero[1,5*]

1. IUCN/SSC Caprinae Specialist Group.
2. Nature and Biodiversity Conservation Union Germany (NABU). stefan.michel@nabu.de
3. Maremma Natural History Museum, Grosseto, Italy, and Past-chair of the IUCN Caprinae Specialist Group. sandro.lovari@gmail.com
4. Wildlife Ecology and Conservation Group, Wageningen University and Research, Wageningen, The Netherlands. arash.ghoddousi@wur.nl
5. Technical School, University of Zaragoza, 22071 Huesca, Spain.

* Corresponding author: herreroj@unizar.es

The taxonomy of the European mouflon (Bovidae: Caprinae), as reported in the updated list of Spanish mammals by Román *et al.* (2025), deserves clarification. Román *et al.* (2025) incorrectly label the mouflon found in Spain as *Ovis gmelinii* [*sic*], applying the species name of the wild Asiatic mouflon *O. gmelini* Blyth, 1841 with a spelling error. We disagree on the use of this scientific name for the Spanish mouflon population, as it disregards the evidence indicating that introduced European mouflons are descendants of domestic sheep *Ovis aries* Linnaeus, 1758. Applying the name *O. gmelini* is not only scientifically incorrect but it could also have adverse consequences for its conservation.

Context

In the Bulletin for Zoological Nomenclature (Gentry *et al.* 1996), three renowned members of the Nomenclature Commission (namely, A. Gentry, J. Clutton-Brock, C.P. Groves) raised the issue of mammal-specific names based on wild species, which are antedated by or contemporary with those based on domestic animals. The majority of domestic animals and their wild ancestors continue to share the same name but in a few cases, a tradition has arisen under which the domestic and wild forms are separately named. There are 15 mammals in which the name for the domestic form antedates or is contemporary with that of the wild ancestor. A minority of authors has thus applied the domestic names to the wild forms. The most prominent of these are Wilson & Reeder (2005), who named several species after their domestic descendants, including the Asiatic mouflon *O. gmelini* and urial *O. vignei* Blyth, 1841, which they classified together and applied to both the name of the domestic sheep *O. aries*. This caused substantial confusion, including in the application of CITES regulations for which this had been the standard taxonomic reference before being replaced in 2019. Yet, the majority of authors have not followed this approach. Gentry *et al.* (1996) had proposed that the majority usage should be confirmed by adopting of the first available specific name based on the wild population. Fortunately, the International Commission on Zoological Nomenclature (ICZN 2003) followed this proposal and confirmed the scientific names of *Capra aegagrus* Erxleben, 1777 (wild/bezoar goat) and *O. orientalis* Gmelin, 1774 (presently the Asiatic mouflon *O. gmelini*), respectively wining over *C. hircus* Linnaeus, 1758 and *O. aries* (which should actually have had priority). However, Gentry *et al.* (1996) pointed out explicitly that the Mediterranean mouflon, being a domestic sheep turned wild some 8,000 years ago or so, should keep the name *O. aries* (cf. Lovari 2004, for a synthesis).

Both the 1997 IUCN Caprinae Action Plan (Shackleton 1997) and the previous IUCN Red List of Threatened Species assessment (Valdez 2008) listed one species, *O. orientalis*, for both Asiatic mouflon and urial. The delegates of the Workshop on Caprinae Taxonomy (IUCN/SSC Caprinae Specialist Group 2000) disagreed with such classification, partly because of differences in the

number of chromosomes (i.e., Asiatic mouflon 54 and urial 58), and concluded that Asiatic mouflon and urial are different species. A molecular study (Rezaei *et al*. 2010) showed that the individuals identified as Asiatic mouflon and urial form two strongly monophyletic groups. Individuals sampled from hybrid populations appear either in the clade of urial or in that of Asiatic mouflon. Considering these two taxa as distinct species would be coherent with the morphological and genetic differences between them, as well as their past evolutionary divergence and the occurrence of a hybrid zone (Rezaei *et al*. 2010). The name *O. orientalis* has first been used to designate the red sheep, found in Iran (listed as *O. o. orientalis* on page 13 of the IUCN Caprinae Action Plan; Shackleton 1997). This sheep is considered a hybrid form, the result of interbreeding of Asiatic mouflon and urial. Therefore, the name *O. orientalis* is *nomen nudum*. Following on chronology, the next valid name for the Asiatic mouflon should be *O. gmelini* and for the urial it is *O. vignei*. This nomenclature has been adopted by IUCN in the Red List of Threatened Species (Michel & Ghoddousi 2020a, b).

Conservation implications

There are three to five recognized autochthonous wild subspecies of mouflon (IUCN SSC Caprinae Specialist Group, 2000): Armenian mouflon *O. g. gmelini*, the Esfahan mouflon *O. g. isphahanica*, and the Laristan mouflon *O. g. laristanica*. Sometimes the Anatolian mouflon *O. g. anatolica* and the Armenian mouflon *O. g. armeniana* are considered as subspecies separate from *O. g. gmelini*. However, the former classification of mouflon subspecies has been followed in the last IUCN re-assessment (Michel & Ghoddousi 2020a). The Cyprus mouflon, introduced in prehistoric times, might be a true wild sheep and separate subspecies *O. g. ophion*, and has been considered as such in the global (Michel & Ghoddousi 2020a) and European (Michel & Kassinis 2025) IUCN Red List assessments.

O. gmelini is listed globally as Near Threatened (NT) on the IUCN Red List of Threatened Species (Michel & Ghoddousi 2020a). The global population size is estimated to be at least around 16,000 mature individuals, with the main population in Iran. Due to limited geographical separation between the other subspecies or populations, only two were assessed at the subspecies level: Anatolian mouflon *O. g. gmelini* [*anatolica*] and Cyprus mouflon *O. g. ophion*, both of which are listed as Endangered (EN) (Michel & Ghoddousi 2020a). For Europe, the IUCN Red List assessment, *O. gmelini* was determined as EN (Michel & Kassinis, 2025), considering only the population of Cyprus as wild sheep. Including the introduced European mouflon in Spain, as suggested by Román *et al*. (2025), and subsequently in other parts of the world, as part of *O. gmelini* would mean adding their large numbers to the global population size of the wild species, which would obscure its actual status. With the addition of the introduced European mouflon, *O. gmelini* would globally become Least Concern (LC) at the species level, masking potential and actual declines in the species' native range.

The relevance of this concern can be illustrated by the case of the common fallow deer *Dama dama*, which was assessed as LC (Masseti & Mertzanidou 2008) because of numerous introduced populations originating from semi-domesticated individuals. Only two native populations remained, one in Telmessos National Park in Türkiye, numbering fewer than 30 individuals, and one on the Greek island of Rhodes, occupying a restricted area of 550 km² and comprising an estimated 400-800 animals (Masseti & Mertzanidou 2008). Taking into account only these true wild populations, common fallow deer would likely meet the criteria of EN.

Furthermore, classifying the introduced European mouflon as true wild sheep may hinder the necessary management or eradication of populations of this species, which is at least locally considered invasive and/or harmful to conservation and land use interests. Own experience (S. Michel and A. Ghoddousi pers. obs.) has shown that game managers sometimes use the argument that these mouflons represent the 'threatened wild mouflon' when arguing against reduction measures or complaining about the effect of returning wolves on local population size.

Origin of mouflons on Mediterranean islands

Wild sheep found on Mediterranean islands are recognized to have been introduced by humans (Shackleton 1997, Masseti 1998, Wilson & Reeder 2005), and genetic, archaeo-zoological studies and the lack of any fossil suggest that they are feral

populations of ancient domestic stocks (e.g., Vigne 1994, Hiendleder *et al*. 2002). Consequently, these taxa should be included in the domestic species *O. aries* (Gentry *et al*. 1996, Gentry *et al*. 2004, Gippoliti & Amori 2004) and not as subspecies of the wild taxon *O. gmelini*.

However, the Cyprus mouflon, in contrast to Corsican and Sardinian mouflons, might originate from (introduced) wild stock, Iran representing the most credited region as the source for its ancient introduction to Cyprus, and thus it might not be a true feral sheep (Guerrini *et al*. 2015). Also, Sanna *et al*. (2015) noted high genetic distance observed between the Cyprus mouflon and other (domestic) sheep haplogroups, including European, Corsican and Sardinian mouflons but found the Cyprus mouflon grouping exclusively with Anatolian mouflon *O. g. gmelini* [*anatolica*]. Hiendleder *et al*. (2002) suggested that mouflon populations found in Türkiye and western Iran are likely candidates for truly wild ancestors of domestic sheep; thus, genetic differentiation of feral descendants of early domesticated stock from descendants of true wild sheep is difficult. Therefore, Michel & Ghoddousi (2020a) and Michel & Kassinis (2025) included *O. g. ophion* in the IUCN Red List assessments because it is possibly a wild but not a feral sheep.

Why introduced European mouflons in Spain are *Ovis aries* but not *Ovis gmelini*?

Román *et al.* (2025) describe the introduced European mouflons in Spain as being descendants of the mouflon populations in Corsica and Sardinia. Two issues, therefore, warrant discussion. First, the taxonomic status of these mouflons, for which Damm & Franco (2014) apply the vernacular name 'Tyrrhenian mouflon'. The second issue is the extent to which the mouflons introduced to Spain and other European countries are identical to their Corsican and Sardinian counterparts.

Román *et al.* arguments solely refer to the first issue. They see the mouflons on these two islands as descendants of wild Asiatic mouflons that were transferred there from their region of origin, and argue that they should therefore be treated as introduced wild sheep, applying the scientific name for this taxon. However, this view is not supported by the available scientific evidence, including several of the papers quoted by the authors to justify their position.

Román *et al.* (2025) argue that the Tyrrhenian mouflons were introduced by Neolithic peoples around 8,500 years BCE (Garel *et al*. 2022) from animals that were still morphologically wild but under human control. Artificially selected domestic sheep first appeared 9,500-9,000 BP (Zeder *et al.* 2008, Zeder 2009). However, Román *et al.* (2025) suggest that they arrived in Europe several millennia after their initial domestication, citing Chessa *et al.* (2009) and Satta *et al.* (2021) as references.

Chessa *et al*. (2009) confirmed the link between European mouflon and wild Asiatic mouflon, showing that they are more closely related than either is to modern domestic sheep. However, they also showed that several other breeds of domestic sheep, such as the Soay sheep, share a similarly close relationship with Asiatic mouflon. These authors do not provide a clear statement on the degree of domestication of the primitive breeds or about the timing of their introduction to the Mediterranean islands and Western Europe. Zeder (2009) states that clear morphological responses to domestication are not evident until ca. 9,500-9,000 BCE, i.e., a time period substantially earlier than that indicated by Satta *et al*. (2021) and Garel *et al*. (2022) for the introduction to Corsica and Sardinia. The first study does not draw any conclusions regarding the level of domestication of the ancestors of Sardinian mouflon but it does highlight their distinctiveness from the sheep introduced later and belonging to a second wave of domestication.

The arguments presented, which are mainly based on studies of mitochondrial DNA, do not provide evidence for the wild origin of Tyrrhenian mouflon. The paper by Portanier *et al*. 2022 suggests that the Corsican mouflons may descend from the Asiatic mouflon but it does not address the level of domestication of their introduced ancestors.

The most recent genetic study (Mereu *et al.* 2025) referenced by Román *et al*. (2025) placed all the Tyrrhenian mouflons in the HPG-B cluster. This haplogroup is the most prevalent among the sampled European and Asian domestic sheep. However, only one of the wild sheep samples analysed by Mereu *et al.* (2025) fell into this haplogroup, a specimen from Kazakhstan. As neither *O. gmelini* nor European mouflons do naturally occur in this country, the sample must originate from a non-native individual, from a domestic sheep or from a hybrid with a domestic sheep in its maternal ancestry, as Mereu *et al.* (2019, quoted in Portanier *et al*. 2022) speculated. All wild

sheep samples from Iran fell into other haplogroups, whereas the samples of mouflon from Cyprus *O. g. ophion,* grouped with Iranian *O. gmelini* samples in the C-E-X complex. These findings suggest that Tyrrhenian mouflons are closely related to recent domestic sheep, while the Cyprus mouflon belongs to the Asiatic mouflon.

Molecular dating indicated that the Corsican mouflon clade appeared 85,000 years ago, and the two Sardinian clades 84,000 years and 118,000 years ago, respectively (Mereu *et al.* 2025). These findings show that divergence of lineages predates both the domestication of these sheep and their subsequent translocation to the Mediterranean islands. Similar times of divergence were found between various domestic sheep samples. This suggests that early domestication and translocation were based on different wild ancestries, with derived lineages retaining haplotypes not represented in the wild samples used in the study. The HPG-B lineages of Tyrrhenian mouflons evolved separately from those found in domestic sheep breeds. This supports the hypothesis of two waves of ovine introduction: first, 'mouflon-like' animals and second, animals that led to 'modern' domestic sheep. However, none of these findings provides evidence that the initially translocated sheep had not been domesticated yet.

Even Mereu *et al.* (2025) refer to Tyrrhenian mouflons as 'remnants of those early domestic ancestors', i.e., of the first wave of translocations, despite arguing for their inclusion in *O. gmelini*. While the statement that 'these lineages were pre-existing and not attributable to domestication' is correct, it does not reject the hypothesis of the domestic ancestry of the introduced mouflon. The further claim that these lineages were 'easily distinguishable from each other, in the same way as the evolutionary lineage of the urial differs from those of the other Moufloniformes' is not supported by the results presented in this study. On the contrary, both Sardinian and Corsican mouflons cluster together with several domestic sheep in Haplogroup-B and are more closely related to Haplogroup-A, which includes samples of *O. g. anatolica* and several domestic sheep, and with the C-E-X complex, which includes most *O. gmelini* from Iran, all Cyprus mouflons and a few *O. g. anatolica*. All these *O. gmelini* with their domestic and feral descendants form a sister group to urial *O. vignei*, which diverged 1.8 million years ago -an order of magnitude earlier.

The conclusion reached by Mereu *et al.* (2025) that the descendants of *O. gmelini*, including the Tyrrhenian mouflon and domestic sheep, should be considered as subspecies of *O. gmelini* rather than being named as *O. aries* is, therefore, neither justified by their research results nor by the sources referenced in support of this judgement.

Turning to the second issue, we disagree with the approach of simply applying the taxonomic status of the Tyrrhenian mouflons to introduced European mouflons in Spain. The introduced European mouflons are descendants of those originally brought to the European mainland from Corsica and Sardinia. The first documented transfer occurred in 1566 to the game park near Belvedere Palace in Vienna (Tomiczek pers. comm. 1997 quoted by Franco & Damm, 2014). Further introductions to other game parks followed, and mouflons have been present in the wild since the 19th century. Mouflons were introduced to Spain in 1954 (Franco & Damm 2014). Due to this extensive documented and undocumented hybridisation with different breeds of domestic sheep, Damm & Franco (2014), referring to several authors, suggest viewing the introduced European mouflon as a hybrid and applying the scientific name *O. aries musimon* x *O. aries* ssp. They also quote Dauster (1963) that the introduced European mouflon is 'an artificially created animal, which has nothing to do with the original *muflone* of Sardinia or the *mufre* of Corsica'.

Furthermore, the suggestion by Mereu *et al.* (2025) to abolish the name *O. aries* also for domestic sheep contradicts the Opinion 2027 of the International Commission on Zoological Nomenclature (ICZN 2003), which explicitly rules to apply newer names for wild relatives of domestic species but to retain the older names of the domestic species, which are valid on the basis of their priority. Gentry *et al.* (2004) interpreted ICZN (2003) that 'the Commission ruling allows workers the freedom to decide whether or not to include domesticates in the wild species concept, in accordance with the stated aims of taxonomic freedom in the Code of Zoological Nomenclature. In practice, since wild species and their derivatives are recognisable entities, it is desirable to separate them nomenclaturally when distinct names exist'. Consequently, they recommended applying names based on domestic forms for the corresponding domestic derivatives.

Conclusions

The references provided by Román *et al.* (2025) do not provide compelling evidence to support their suggestion that the introduced European mouflon in Spain should be considered as a subspecies of *O. gmelini*. Firstly, we agree with the view that the mouflons of Sardinia and Corsica originated from introduction events occurring millennia before the introduction of modern sheep with non-shedding wool. However, such earlier introductions also seem to be the case for other primitive sheep breeds, which are commonly recognised as domestic sheep. Furthermore, the introduction to Corsica and Sardinia took place centuries or millennia after the initial domestication of sheep, and even if they were in an early stage of domestication, they should be recognized as domestic sheep *O. aries*.

Secondly, irrespective of our disagreement with the authors' view on the taxonomic status of the mouflons of Corsica and Sardinia, we concur with Damm & Franco (2014) that introduced European mouflons, including those in Spain, are not identical with those ancient feral mouflons and their descendants, the Tyrrhenian mouflon, due to their extensive hybridisation with domestic sheep as well as the captive breeding and selection they have undergone.

We also disagree with the suggestion by Mereu *et al.* (2025) that 'descendants (of *O. gmelini*) should be considered as subspecies, including domestic sheep'. Classifying domestic sheep and their feral descendants as *O. gmelini* would contradict long-standing taxonomic practice, the spirit of Opinion 2027 of the ICZN (2003) and the recommendations of Gentry *et al.* (2004) to use the names established by Linnaeus for domestic animals. These names have been in use for over 250 years and are internationally recognised.

For all the above reasons, we ask the Iberian Society for the Study and Conservation of Mammals (SECEM) to consider the European mouflon in Spain as *Ovis aries*, rather than *Ovis gmelini,* and to amend the name applied in the Checklist of the Mammals of Spain accordingly. We also recommend distinguishing these introduced European mouflons clearly from the Tyrrhenian mouflon. This would also prevent the problematic management and conservation implications that arise from applying the name of a wild species to introduced, feral, hybridised and, in some areas, invasive populations.

Taxonomy is a fairly subjective field of zoology but increasing nomenclatural confusion only puts conservation at risk (Zachos *et al.* 2013).

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