

Misconception and mismanagement of invasive species: The paradoxical case of an alien ungulate in Spain

Jorge Cassinello 

Estación Experimental de Zonas Áridas (EEZA-CSIC), Carretera de Sacramento s/n, La Cañada de San Urbano, 04120 Almería, Spain

Correspondence

Jorge Cassinello, Estación Experimental de Zonas Áridas (EEZA-CSIC), Carretera de Sacramento s/n, La Cañada de San Urbano, 04120 Almería, Spain.

Email: jorge.cassinello@csic.es

Abstract

Scientific evidence should dominate in any management decision dealing with alien species. It is also essential for all stakeholders to agree on the terminology used to avoid undesirable misinterpretations. A well-known example is the use of the term “invasive,” which has two basic meanings, one as a biogeographic criterion and the other as an impact criterion. The aoudad (*Ammotragus lervia*) is a North African ungulate introduced in Spain, which was labeled “invasive” by Spanish authorities due to misreading of the term used by early studies. Indeed, to date, there are no conclusive empirical data showing negative effects of the aoudad on native flora and fauna. Recent studies have shown that its closest native ungulate, the Iberian ibex (*Capra pyrenaica*), has expanded throughout territories already occupied by the aoudad, without any apparent conflict. Aoudad diet selection studies also show them to be markedly grazers, so its role in the Mediterranean trophic network might be similar to that of extinct wild ungulates that fed in natural meadows, maintaining landscapes heterogeneous. New opportunities for its study are opening, particularly in Iberian semiarid lands. Unfortunately though, its current simplistic definition as an invasive species keeps in suspense its eventual eradication throughout the country.

KEYWORDS

Alien species, *Ammotragus*, biodiversity conservation, biological invasions, conservation policy, ecological knowledge, empirical data, invasive species, native species, wildlife management

1 | INTRODUCTION

Public and private environmental institutions are making tremendous economic and legislative efforts to protect and conserve biodiversity and natural resources from so-called “invasive alien species,” generally considered a major worldwide threat to biodiversity (Bergmans & Blom, 2001). Not in vain, as in the United States alone they have been estimated to cause environmental damage and economic loss of about \$120 billion per year (Pimentel, Zuniga, & Morrison, 2005). The great majority of natural ecosystems are already suffer-

ing from some degree of alteration caused by human activity (habitats altered by roadways, rural areas, or agricultural fields and crop lands), so that some of the first aliens that appeared in these areas tended to be human commensals, species associated with human-altered habitats (Sax & Brown, 2000).

However, when the new discipline in invasion ecology emerged, no definition of the term “invasive species” was attempted (Elton, 1958). This has given rise to a multitude of disagreements, misconceptions, and misunderstanding of the growing amount of literature on the phenomenon being published and has led to numerous initiatives calling for a

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

Copyright and Photocopying: © 2018 The Authors. Conservation Letters published by Wiley Periodicals, Inc.



FIGURE 1 Aoudad males kept in captivity at the EEZA facilities. © EEZA-CSIC.

consensus (Colautti & MacIsaac, 2004; Valéry, Fritz, Lefeuvre, & Simberloff, 2008).

2 | DEFINING INVASIVENESS

In the scientific literature, two definitions predominate, one referring to a biogeographic invasion (equivalent to merely colonizing in time and space) and the other indicative of negative impacts on the environment, i.e., a biogeographic criterion versus an impact criterion (Valéry et al., 2008). Early studies on the subject tended to relate invasion to the geographic expansion of species, whether human-mediated or not (Vermeij, 1996; Williamson, 1996). However, at the beginning of the 21st Century, the International Union for Nature Conservation (IUCN) and the Convention on Biological Diversity (CBD) defined alien invasive species as alien species that threaten the biodiversity of the host ecosystem, disregarding their capacity for spreading (CBD, 2002; IUCN, 2000). Consequently, and under this premise, public and private institutions devoted to the protection of biodiversity have embraced this definition, which is currently the one used by most managers, politicians, and environmentalists, despite there still not being agreement on its use among ecologists and zoologists (see a recent review by Wijesundara, 2010).

As a consequence of this lack of consensus, when referring to particular studies and references dealing with “invasive species,” it is crucial to identify precisely what the authors meant by it, in order to cite them properly and understand their results or conclusions. Unfortunately, this is not always done, and therefore, misinterpretations may emerge.

3 | INVASIVE SPECIES

Alien species which are harmful to the environment require special attention by authorities and managers to decrease

their deleterious effects (Pallewatta, Reaser, & Gutierrez, 2003). Under some circumstances, eradication programs should be carried out (Myers, Simberloff, Kuris, & Carey, 2000), whereas in others, coexistence of native and non-native species might be the most reasonable management strategy (Schlaepfer, Sherman, Blossey, & Runge, 2005). Furthermore, although the precautionary principle should be followed when dealing with alien species (Rogers, Sindent, & De Lacy, 1997), in many instances there is no actual or updated knowledge on their ecological effects (Thomas & Palmer, 2015), and taking a decision on their management strategy may be untimely, controversial or just plain wrong (see below). Therefore, defining how to handle the impact of alien species is a must (Jeschke et al., 2014).

Habitat alteration, along with the decline in natural predator populations, associated with human activities (e.g., persecution, poaching, and unsustainable hunting), can exacerbate an increase in numbers of native species (Côté, Rooney, Tremblay, Dussault, & Waller, 2004; Garrott, White, & Vanderbilt White, 1993), which in turn may become invasive, i.e., harmful to their environment (Carey, Sanderson, Barnas, & Olden, 2012). A paradigmatic example is that of the wild boar (*Sus scrofa*) in its native range of distribution, where it tends to be associated with human sources of food (e.g., food containers and trashcans in the outskirts of towns), increasing in numbers in such high densities that it causes adverse effects (Apollonio, Andersen, & Putman, 2010). Consequently, identifying invasive native species is also crucial in any profound examination of ecological issues related to wildlife management and policy.

Therefore, the term “invasive” should be applicable to native species as well as non-native species.

4 | THE CASE OF THE AODAD

The aoudad or Barbary sheep (*Ammotragus lervia* Pallas, 1777; Figure 1) is a North African caprid widely introduced in several countries for hunting (Cassinello, 2015; Cassinello et al., 2008). The main wild-ranging alien populations are found in the United States (mainly Texas, New Mexico, and California) and Spain (southeastern mainland and La Palma Island, Canary Islands). Paradoxically, while these alien populations have settled and expanded their ranges, the species is threatened in its native area of distribution (Cassinello et al., 2008). So far, and apart from the population located in La Palma Island, where its Macaronesian flora is not evolutionarily adapted to the presence of large herbivores such as the aoudad, there is no empirical evidence related to any negative impact on native fauna or flora (Cassinello, 2015).

The first studies dealing with the presence of the species in Spain expressed serious concern for potential harm to native flora and competition for resources with the native Iberian

ibex (*Capra pyrenaica* Schinz, 1838), taxonomically the closest kin among native Iberian ungulates (Acevedo, Cassinello, Hortal, & Gortázar, 2007; Cassinello, Acevedo, & Hortal, 2006). In these studies, the species was depicted as invasive, but used the term in its biogeographic sense (“*The aoudad has shown a formidable capacity to establish, spread, and extend its distribution (...), characteristics typical of biological invasions (Williamson, 1996)*”). In the Region of Murcia alone, the aoudad population is as high as 2,000 free-ranging individuals.

Not critically reading the term “invasive” led to the inclusion of the aoudad in the first Spanish Catalogue of Invasive Alien Species (Ministerio de Medio Ambiente, y Medio Rural y Marino, 2011), although with some basically political peculiarities which prevented the populations present in the Region of Murcia from being included in the Catalogue. This bizarre procedure led environmental associations to appeal for a general classification of the aoudad as an invasive alien species throughout the country, an appeal which was finally approved by the Spanish High Court (Tribunal Supremo, 2016).

However, recent studies dealing with aoudad feeding habits have shown that the species is primarily a grazer, actively selecting forbs and grasses when available (Ben Mimoun & Nouira, 2015; Miranda et al., 2012); while their incidence on woody plants is similar to that of native herbivore ungulates, not showing particularly higher negative effects on threatened plants (Velamazán, San Miguel, Escribano, & Perea, 2017). The presence of wild grazers may be crucial to the preservation of mosaic landscapes in Mediterranean habitats (Malek & Verburg, 2017), as it is widely acknowledged that grazers, along with browsers, allow open pastures to be maintained by reducing shrubland colonization (Odum, 1969). These heterogeneous landscapes are fundamental to the preservation of biodiversity and species richness in ecosystems (Stein, Gerstner, & Kreft, 2014). The fact is that extant large wild herbivores in the Iberian Peninsula are basically browsers (Gebert & Verheyden-Tixier, 2001; Martínez, 2010), and apart from decreasing livestock activity, no specialist grazers are present any longer. Thus, it would not be venturous to expect beneficial outputs from the presence of new wild grazers, although from an exotic origin (Fernández-Olalla, Martínez-Jauregui, Perea, Velamazán, & San Miguel, 2016).

Furthermore, Iberian ibex populations have recently been showing impressive recolonization in southeastern Spain, reaching areas previously occupied by aoudads. However, the presence of the North African ungulate does not seem to affect ibex range expansion. In fact, it is rather the opposite, as in some mountainous areas the native ungulate seems to be displacing the exotic one (Eguía et al., 2015).

Despite current empirical evidence showing that the effects of the aoudad, both in the United States and the Spanish mainland, are not harmful, if not beneficial (Cassinello, 2015), the species is still classed as invasive by Spanish authorities

(Ministerio de Agricultura, Alimentación y Medio Ambiente, 2013), leading to the startup of eradication programs in some of its distribution areas (Consejería de Agua, Agricultura y Medio Ambiente, 2017). Another consequence of this policy is that a threatened species in its native range of distribution is being subject to eradication in exotic areas, which might well become species reservoirs if no harmful effects are detected (Garzon-Machado, del-Arco-Aguilar, & Perez-de-Paz, 2012; Marchetti, & Engstrom, 2016).

This is the first evidence of an unprecedented management policy based on an erroneous application of scientific evidence due to the misleading terminology applied to alien species, interpreting “invasive” as “harmful” instead of “colonizing.”

5 | CONCLUSIONS

Knowledge of whether an alien species poses a risk to the host environment, based on scientific data and proper identification of the results and conclusions in the available literature, is crucial to its management (Valéry et al., 2008). Invasive species, *sensu* impact criterion, may be either exotic or native (Carey et al., 2012), and their management and control should always be implemented according to scientific and empirical evidence. Apart from proper management policies, it is also important to implement further evaluation procedures enabling institutions to find out what benefits, if any, have been achieved (Ferraro & Pattanayak, 2006).

The alien aoudad, depicted as harmful in all the territories where it is present, is currently included in the Spanish Catalogue of Invasive Alien Species. This inclusion is based on a misinterpretation of the scientific literature available, and according to current findings, consideration of the populations located in the southeast of the Iberian Peninsula as invasive is ungrounded (Cassinello, 2015). A recent ruling by the Spanish High Court promotes its total eradication in the country, even though the ecological consequences of a massive eradication program are unforeseeable. Nevertheless, political commitments may still vary, as the Spanish Ministry of Environment is currently holding new meetings on this issue with concerned aoudad management stakeholders, including scientists devoted to their study. Hope for a better management policy based on actual ecological facts is still in the air.

6 | ADDENDUM

A few days after this manuscript was submitted, the Spanish Parliament approved a modification of the Spanish Law 42/2007 on the Natural Heritage and Biodiversity (Jefatura del Estado, 2007), so that invasive species that can be of eco-

conomic interest through fishing or hunting will be allowed to be sustainably managed in areas where they were present before Ley 42/2007 was approved, in December 2007; whereas in recently colonized areas, they should be controlled and eventually eradicated (Proposición de Ley, 2017). This legal modification, however, does not raise any change in invasiveness status of such species, as it is only based on socioeconomic profits in rural areas; it may also change over time if parliamentary majorities do so. Therefore, the issue on aoudad invasiveness status remains to be addressed and resolved.

ORCID

Jorge Cassinello  <http://orcid.org/0000-0001-8781-2009>

REFERENCES

- Acevedo, P., Cassinello, J., Hortal, J., & Gortázar, C. (2007). Invasive exotic aoudad (*Ammotragus lervia*) as a major threat to native Iberian ibex (*Capra pyrenaica*): A habitat suitability model approach. *Diversity and Distributions*, *13*, 587–597.
- Apollonio, M., Andersen, R., & Putman, R. (2010). Present status and future challenges for European ungulate management. In M. Apollonio, R. Andersen, & R. Putman (Eds.), *European ungulates and their management in the 21st Century* (pp. 578–604). Cambridge, UK: Cambridge University Press.
- Ben Mimoun, J., & Noura, S. (2015). Food habits of the aoudad *Ammotragus lervia* in the Bou Hedma mountains, Tunisia. *South African Journal of Science*, *111*, Art. #2014-0448. <https://doi.org/10.17159/sajs.2015/20140448>
- Bergmans, W., & Blom, E. (Eds.). (2001). *Invasive plants and animals. Is there a way out?* Amsterdam: The Netherlands Committee for IUCN.
- Carey, M. P., Sanderson, B. L., Barnas, K. A., & Olden, J. D. (2012). Native invaders – challenges for science, management, policy, and society. *Frontiers in Ecology and the Environment*, *10*, 373–381.
- Cassinello, J. (2015). *Ammotragus lervia* (aoudad). In CABI (Ed.), *Invasive species compendium*. Wallingford, UK: CAB International. Retrieved from <http://www.cabi.org/isc>
- Cassinello, J., Acevedo, P., & Hortal, J. (2006). Prospects for population expansion of the exotic aoudad (*Ammotragus lervia*; Bovidae) in the Iberian Peninsula: Clues from habitat suitability modelling. *Diversity and Distributions*, *12*, 666–678.
- Cassinello, J., Cuzin, F., Jdeidi, T., Masseti, M., Nader, I., & de Smet, K. (2008). *Ammotragus lervia*. The IUCN Red List of Threatened Species 2008: e.T1151A3288917. <https://doi.org/10.2305/IUCN.UK.2008.RLTS.T1151A3288917.en>. Downloaded on 10 February 2018.
- CBD. (2002). Decision VI/23: Alien species that threaten ecosystems, habitats or species. Retrieved from <https://www.cbd.int/kb/record/decision/7197?RecordType=decision&Subject=IAS>
- Colautti, R. I., & MacIsaac, H. J. (2004). A neutral terminology to define ‘invasive’ species. *Diversity and Distributions*, *10*, 135–141.
- Consejería de Agua, Agricultura y Medio Ambiente. (2017). Proyecto de Plan de Gestión para el Control y Erradicación del Arruí (*Ammotragus lervia*) en la Región de Murcia. Unpublished Report.
- Côté, S. D., Rooney, T. P., Tremblay, J. P., Dussault, C., & Waller, D. M. (2004). Ecological impacts of deer overabundance. *Annual Review of Ecology, Evolution, and Systematics*, *35*, 113–147.
- Eguía, S., Martínez-Noguera, E., Botella, F., Pascual, R., Giménez-Casaldueño, A., & Sánchez-Zapata, J. A. (2015). Evolución del área de distribución del arruí (*Ammotragus lervia* Pallas 1777) y la cabra montés (*Capra pyrenaica* Schinz, 1838) en la Región de Murcia. V Congreso de la Naturaleza de la Región de Murcia, 2015. Asociación de Naturalistas del Sureste, Murcia, Spain.
- Elton, C. S. (1958). *The ecology of invasions by animals and plants*. London, UK: Methuen.
- Fernández-Olalla, M., Martínez-Jauregui, M., Perea, R., Velamazán, M., & San Miguel, A. (2016). Threat or opportunity? Effects of an alien ungulate on the highly diverse vegetation of southeastern Spain. *Journal of Arid Environments*, *129*, 9–15.
- Ferraro, P. J., & Pattanayak, S. K. (2006). Money for nothing? A call for empirical evaluation of biodiversity conservation investments. *PLoS Biol*, *4*, e105.
- Garrott, R. A., White, P. J., & Vanderbilt White, C. A. (1993). Overabundance: An issue for conservation biologists? *Conservation Biology*, *7*, 946–949.
- Garzon-Machado, V., del-Arco-Aguilar, M. J., & Perez-de-Paz, P. L. (2012). Threat or threatened species? A paradox in conservation biology. *Journal for Nature Conservation*, *20*, 228–230.
- Gebert, C., & Verheyden-Tixier, H. (2001). Variations of diet composition of red deer (*Cervus elaphus* L.) in Europe. *Mammal Review*, *31*, 189–201.
- IUCN. (2000). IUCN guidelines for the prevention of biodiversity loss due to biological invasion. The World Conservation Union (approved by the IUCN Council, February, 2000). Retrieved from <https://portals.iucn.org/library/efiles/documents/Rep-2000-052.pdf>.
- Jefatura del Estado. (2007). Ley 42/2007, de 13 de diciembre, del Patrimonio Natural y de la Biodiversidad. *B.O.E.*, *299*, 51275–51327.
- Jeschke, J. M., Bacher, S., Blackburn, T. M., Dick, J. T. A., Essl, F., Evans, T., ... Kumschick, S. (2014). Defining the impact of non-native species. *Conservation Biology*, *28*, 1188–1194.
- Malek, Z., & Verburg, P. (2017). Mediterranean land systems: Representing diversity and intensity of complex land systems in a dynamic region. *Landscape Urban Plan*, *165*, 102–116.
- Marchetti, M. P., & Engstrom, T. (2016). The conservation paradox of endangered and invasive species. *Conservation Biology*, *30*, 434–437.
- Martínez, T. (2010). Selección y estrategia alimentaria de los machos, hembras y jóvenes de cabra montés (*Capra pyrenaica* Schinz, 1838) en el sureste de España. *Galemys*, *22*, 483–515.
- Ministerio de Agricultura, Alimentación y Medio Ambiente. (2013). Real Decreto 630/2013, de 2 de agosto, por el que se regula el Catálogo español de especies exóticas invasoras. *B.O.E.*, *185*, 56764–56786.
- Ministerio de Medio Ambiente, y Medio Rural y Marino. (2011). Real Decreto 1628/2011, de 14 de noviembre, por el que se regula el listado y catálogo español de especies exóticas invasoras. *B.O.E.*, *298*, 132711–132735.
- Miranda, M., Sicilia, M., Bartolomé, J., Molina-Alcaide, E., Gálvez-Bravo, L., & Cassinello, J. (2012). Contrasting feeding patterns of

- native red deer and two exotic ungulates in a Mediterranean ecosystem. *Wildlife Research*, *39*, 171–182.
- Myers, J. H., Simberloff, D., Kuris, A. M., & Carey, J. R. (2000). Eradication revisited: Dealing with exotic species. *Trends in Ecology & Evolution*, *15*, 316–320.
- Odum, E. P. (1969). The strategy of ecosystem development. *Science*, *164*, 262–270.
- Pallewatta, N., Reaser, J.K., & Gutierrez, A. (Eds.). (2003). *Prevention and management of invasive alien species: Proceedings of a workshop on forging cooperation throughout South and Southeast Asia*. Cape Town, South Africa: Global Invasive Species Programme.
- Pimentel, D., Zuniga, R., & Morrison, D. (2005). Update on the environmental economic costs associated with alien-invasive species in the United States. *Ecological Economics*, *52*, 273–288.
- Proposición de Ley. (2017). 122/000137 Proposición de Ley de modificación de la Ley 42/2007, de 13 de diciembre, del Patrimonio Natural y de la Biodiversidad. *B.O.C.G. Serie B*, *170–I*, 1–5.
- Rogers, M. F., Sinent, J. A., & De Lacy, T. (1997). The precautionary principle for environmental management: A defensive-expenditure application. *Journal of Environmental Management*, *51*, 343–360.
- Sax, D. F., & Brown, J. H. (2000). The paradox of invasion. *Global Ecology and Biogeography*, *9*, 363–371.
- Schlaepfer, M. A., Sherman, P. W., Blossey, B., & Runge, M. C. (2005). Introduced species as evolutionary traps. *Ecology Letters*, *8*, 241–246.
- Stein, A., Gerstner, K., & Kreft, H. (2014). Environmental heterogeneity as a universal driver of species richness across taxa, biomes and spatial scales. *Ecology Letters*, *17*, 866–880.
- Thomas, C. D., & Palmer, G. (2015). Non-native plants add to the British flora without negative consequences for native diversity. *Proceedings of the National Academy of Sciences of the United States of America*, *112*, 4387–4392.
- Tribunal Supremo. (2016). Sentencia de 16 de marzo de 2016, de la Sala Tercera del Tribunal Supremo. *B.O.E*, *146*, 41761–41762.
- Valéry, L., Fritz, H., Lefeuvre, J. -C., & Simberloff, D. (2008). In search of a real definition of the biological invasion phenomenon itself. *Biological Invasions*, *10*, 1345–1351.
- Velamazán, M., San Miguel, A., Escribano, R., & Perea, R. (2017). Threatened woody flora as an ecological indicator of large herbivore introductions. *Biodiversity and Conservation*, *26*, 917–930.
- Vermeij, G. J. (1996). An agenda for invasion biology. *Biological Conservation*, *78*, 3–9.
- Williamson, M. (1996). *Biological invasions*. London, UK: Chapman and Hall.
- Wijesundara, S. (2010). Defining invasive alien species. In B. Marambe, P. Silva, S. Wijesundara, & N. Atapattu (Eds.), *Invasive alien species in Sri Lanka – strengthening capacity to control their introduction and spread* (pp. 1–6). Sri Lanka: Biodiversity Secretariat of the Ministry of Environment.

How to cite this article: Cassinello J. Misconception and mismanagement of invasive species: The paradoxical case of an alien ungulate in Spain. *Conservation Letters*. 2018;e12440. <https://doi.org/10.1111/conl.12440>