CSIRO PUBLISHING

Wildlife Research, 2012, **39**, 711–720
http://dx.doi.org/10.1071/WR12121

On the use of the IUCN status for the management of trophy hunting

Lucille Palazy[A,B,C], *Christophe Bonenfant*[A], *Jean-Michel Gaillard*[A] *and Franck Courchamp*[B]

[A]Laboratoire Biométrie et Biologie Évolutive, UMR CNRS 5558, University Claude Bernard Lyon 1, 43 boulevard du 11 novembre 1918, 69622 Villeurbanne Cedex, France.
[B]Laboratoire Écologie, Systématique et Evolution, UMR CNRS 8079, University Paris Sud, 91405 Orsay Cedex, France.
[C]Corresponding author. Email: lucille.palazy@u-psud.fr

Abstract

Context. Whether trophy hunting is beneficial or a threat to the conservation of species is an open and hotly debated question. The International Union for Conservation of Nature (IUCN) is in charge of assessing the need for species protection at the global scale and providing a useful guide for sustainable exploitation and conservation. Consideration of the IUCN status in wildlife management and its consequences on the attractiveness of trophy-hunted species remains to be quantified.

Aims. The present study investigated the link between the IUCN status of the trophy species and its exploitation in 124 taxa. We expected that the number of trophies should be inversely correlated with the IUCN vulnerability status across species.

Methods. Using the database of the Safari Club International, one of the largest hunting associations worldwide, we investigated the effect (1) of the first status attribution and (2) of an upgrade of the IUCN status on the number of trophies recorded by the Safari Club International, by comparing the average number of trophies 5 years before and after a status change.

Key results. First, we found that the status attributed by the IUCN in a given year had no effect on the number of recorded trophies during the following 5 years. Second, upgrading the IUCN status led to an important decrease in the number of recorded trophies for most species (75%), except for the most vulnerable ones (African elephant, *Loxodonta africana*; banteng, *Bos javanicus*; lelwel hartebeest, *Alcelaphus buselaphus lelwel*; European bison, *Bison bonasus*).

Conclusions. Our results suggest that although a protective IUCN status lowers the exploitation of the moderately threatened species, hunting pressure on the most threatened one increases instead. The findings support the possibility of an anthropogenic Allee effect (AAE), i.e. a disproportionate exploitation of the rarest species.

Implications. The highly profitable exploitation of rare species could have harmful consequences, unless appropriate management actions and protection rules are enforced.

Additional keywords: hunting club, protection measures, threat, wildlife management.

Received 10 July 2012, accepted 9 October 2012, published online 19 November 2012

Introduction

Trophy hunting consists of shooting animals to collect trophies such as horns, antlers, skulls, tusks or teeth (or in many cases the whole head), usually for the purpose of display. This growing activity currently concerns hundreds of taxa, mostly large mammals (Milner *et al*. 2007), is omnipresent in the world, and generates huge incomes (Lindsey *et al*. 2007). Trophy hunting has been beneficial to the preservation of several species (Leader-Williams *et al*. 2005; Frisina and Tareen 2009; Lindsey *et al*. 2009). If well managed, trophy hunting has a great potential for conservation because of the large amount of money it generates (Leader-Williams *et al*. 2005; Leader-Williams 2009; Lewis and Alpert 1997). Trophy hunting is a vital activity for the well being of local people in several countries (Lindsey *et al*. 2007) and for the maintenance of wildlife-suitable habitat. For example, the novel establishment of private ranches in South Africa leads to the replacement of agricultural lands by more natural habitats. Such land-use shifts have been beneficial for several species, such as white rhinos (*Ceratotherium simum*; Cousins *et al*. 2008; Frisina and Tareen 2009).

However, other examples have shown that, when ill-managed, trophy hunting can cause the decline of lion (*Panthera leo*) and leopard (*Panthera pardus*) populations (Loveridge *et al*. 2007; Packer *et al*. 2009, 2011). Additionally, the recently demonstrated attractiveness of rarity for humans suggests that trophy hunting could be a threat to already fragile species (Courchamp *et al*. 2006; Johnson *et al*. 2010; Palazy *et al*. 2011, 2012; Prescott *et al*. 2011). Case studies demonstrating either population recovery

success or failure in relation to trophy hunting remain scarce (Frisina and Tareen 2009; Packer *et al*. 2011). Consequently, the question arises of whether trophy-hunted species are properly managed and, in particular, whether the most fragile species are sustainably harvested. One way of answering this question involves analysing the hunting bags of species harvested for their trophy with varying vulnerability level.

The widespread media coverage of species decline (Myers and Knoll 2001; Raven 2003) has led to the emergence of various organisations that aim to identify and protect threatened species. The IUCN is certainly the most famous for its reliability, comprehensiveness and usefulness in terms of conservation decisions (Collar 1996). This organisation is in charge of collecting and compiling information on population sizes, trends, distributions and threats (Baillie *et al*. 2004). This huge task involves classifying species in six classes of increasing extinction risk. The role of the IUCN is restricted to the attribution of the appropriate vulnerability status and does not include any remit to take appropriate conservation measures. The species vulnerability ranking, nevertheless, offers a reliable guide for conservation planning (Baillie *et al*. 2004; Rodrigues *et al*. 2006; Plumptre *et al*. 2007; DeMatteo and Loiselle 2008). Under the reasonable assumption that wildlife managers use the IUCN information as an index of species threat level, we could expect that species status should be taken into account for controlling wildlife harvest for trophy hunting, with fewer hunted individuals for more threatened species. Indeed, there are several criteria for a species to be classified as threatened by the IUCN, in particular, a low population count, which should, in theory, lead to restrictions on exploitation quotas. However, to our knowledge, the effect of IUCN statuses on trophy-hunting intensity has never been assessed.

In the present paper, we used the IUCN status as a proxy of species' rarity and the annual number of recorded trophies for a given species as a measure of the intensity of trophy hunting. We tested whether IUCN protection status has any effect on the number of recorded trophies. Under the hypothesis that wildlife managers and/or governments take IUCN protection status into account to ensure that threatened species are harvested in a sustainable way, we predicted that the number of trophies collected should be inversely correlated with the IUCN vulnerability status across species, with the most threatened species being the least hunted. We also predicted that upgrades in vulnerability status should be followed by a decrease in the number of trophies collected, so that increasingly vulnerable species should become less hunted.

Materials and methods

Data sources

The IUCN red list database provided the status under which each of the trophy-hunted species has been classified since its creation (the first red data book was edited in 1966; Thornback and Jenkins 1982). Among the species targeted by trophy hunting, we selected the 124 taxa (species and subspecies) whose trophies have been listed in the SCI record book between 1970 and 2011 (Table 1, Appendix 1). We distinguished between the attribution of an IUCN status (i.e. the transition from non-assigned to a definite status) and the transition between two vulnerability statuses (i.e. from one definite status to another definite status). Indeed, when the threat status changes from '*Data deficient*' to '*Vulnerable*' for example, it does not mean that the species status has deteriorated during the intervening period. It rather means that additional information has been collected which is now sufficient to assess the status of the species. This is qualitatively different from, for example, a change from '*Near threatened*' to '*Endangered*'.

Table 1. Composition of the dataset used, including family and International Union for Conservation of Nature (IUCN) status of the species in Year 2011

Family	Least concern	Near threatened	Vulnerable	Endangered
Bovidae	54	13	13	5
Cervidae	11	0	4	0
Felidae	2	1	2	0
Suidae/Tayassuidae	7	0	0	0
Ursidae	2	0	1	0
Other	6	1	2	0

Although the CITES is an independent institution that collects data on trophy hunting at the international level, we could not use data recorded by this organisation because only a small group of species of our dataset (less than 25% species) had regular entries in the CITES trade database. Hence, the trophy trade has only been followed in the long term for a few of them. The information on the total number of individuals legally harvested for their trophy per species and per year would have been ideal variable for our purposes, but this information was not available. To circumvent these difficulties, we used an original approach, taking advantage of the great wealth of data collected by the SCI (for the use of SCI data, see Lewis and Alpert 1997; Wilkie and Carpenter 1999; Johnson *et al*. 2010; Palazy *et al*. 2012). The SCI has compiled all the hunt data declared by its members since 1971 (www.scirecordbook.org, verified April 2012). For each hunt, a large quantity of information is registered, including the member's name, the date, the location and the trophy score (i.e. given in points, which is assessed with an official measurement manual and considers both trophy size and shape). This record book is intended to be an official and reliable information source as a professional trophy measurer validates each trophy score. In the record book, trophies are classified in several categories according to the animal's population origin. Indeed, the SCI makes a difference between trophies collected in the natural range of the species and where it has been introduced. For our purpose, the hunting pressure on exotic species is not of interest. Hence, we removed all the trophies that belong to individuals categorised as 'non-indigenous' or 'introduced' from the database used for the present analyses. We removed the species categorised as 'estate' for the same reason. The SCI record-book data cannot be used as an estimation of the annual number of trophy animals hunted *per se* because not all trophy hunters are SCI members. In addition, SCI members record only their most remarkable trophies, so do not provide data for all the trophies they collect. However, the method of trophy listing has been standardised and regular since 1971 and should thus be a reliable index of any trends over time in the intensity of

exploitation and, therefore, provides a useful source of data for investigating the correlation between these trends and changes in the IUCN status (Appendix 1). To use this variable, we made the reasonable assumption that the perception of trophy hunters towards what they would consider as remarkable trophy is a constant in time over the study period. We then studied the effect of IUCN status on the number of records over a 10-year period. We assumed that the temporal trend and relative variation in the number of trophies recorded by the SCI reliably reflects the temporal trend and relative variation in the total number of harvested trophies worldwide.

Data analyses

We first summed the number of lines in the record book (one line per trophy record) per year per species and obtained the annual number of records per species. Inter-specific analyses of the time series were made possible by a classical standardisation (centre and scale) of this variable. We first checked for the non-independence among species-specific data points by using the Abouheif test (Pavoine *et al*. 2008) on a taxonomy-based tree. We performed this test on the total number of trophies annually recorded per species over the study period.

We then investigated the general pattern of the temporal trend in the number of trophies recorded between 1970 and 2011 by using generalised linear models (GLMs) and generalised additive models (GAMs; Hastie and Tibshirani 1986) to obtain smoothed curves for graphical support. We next added the hunt location to the model by using the broad classification system of the SCI database in which hunts are pooled by continent (e.g. Africa, Europe, Asia, America, South-Pacific) to test for the occurrence of differing trends in the number of trophies over time among large-scale regions. Subsequent analyses were conducted on the 'detrended' number of recorded trophies because the number of recorded trophies increased over time (Grosbois *et al*. 2008). The 'detrended' variable was obtained by correcting the number of trophies for the time trend observed for each region. Therefore, we extracted the residuals of the model with the standardised number of recorded trophies as the response variable, and the time, the region and their interaction as the explanatory variables. The use of this procedure should allow us to determine whether an increase in the number of trophies is due to a global increase in the number of trophies over time or to the IUCN status changes.

In a second step, we used the non-parametric Kruskal–Wallis statistic to test for an effect of the initial status attributed to a given species on the temporal trend in the number of recorded trophies of that species. Our first prediction was that there should be a decrease in hunting pressure in the following years when the initial status attributed indicated species vulnerability. The IUCN status for a given species was the predictor variable. The response variable was the difference in the average number of trophies hunted over the 5 years before and over the 5 years following a change of the species IUCN status. In practice, we calculated the average number of trophies recorded after the change minus the average number of trophies recorded before the change. Our second prediction was that a change towards a more protective IUCN status should subsequently decrease the number of hunted animals. We used the same method to test both predictions. In a few cases, a new status was attributed to the species for a period of less than 5 years (21 of 140 observed changes). If the status was altered after 4 years instead of 5 years (corresponding to 13 cases), we analysed the 4 years before and after the change. If a status was given to the species for only 2 years and then changed again (the eight remaining cases), we considered only the subsequent status. For example, for the white rhinoceros whose first status, '*Conservation dependent*', was attributed in 2000 and was then changed to '*Near threatened*' in 2002, we ignored the '*Conservation dependent*' status. All analyses were run using the R 2.12 statistical package (R Development Core Team 2009).

Results

We did not detect any phylogenetic signal in the average number of trophies recorded per species (Cmean = 0.021 ± 0.485; $P = 0.29$). Hence, taxonomy has no impact on the number of recorded trophies among taxa. We, therefore, used standard statistical procedures to analyse our data.

The standardised number of recorded trophies markedly increased with time over the study period ($F_{1,5180} = 1618.7$, $P < 0.001$) and this temporal trend significantly varied among the five continents (interaction term between location and time: $F_{5,5180} = 12.05$, $P < 0.001$); however, the general patterns were similar (Fig. 1). The increase was sharp until 1985, then less marked until 2000. The number of trophies recorded appeared to have decreased slightly over the past decade.

We first expected a decrease in the number of records when the initial status attributed indicated that the species in question was threatened. We did not detect any statistically significant effect of the attribution of an IUCN status on the number of trophy records (multiple Kruskal–Wallis test comparison, $\chi^2 = 7.07$, d.f. = 4, $P = 0.13$; Fig. 2). Among species, the average difference between the number of recorded trophies, standardised and corrected for the effect of time, after and before status attribution was positive ($\Delta N_c = 0.14$, CI 95% = [0.05;0.21]).

According to our second hypothesis, we expected to find a decrease in the number of trophies recorded following an upgrade in the IUCN vulnerability status. We found that upgrading the status had a statistically significant effect on the number of trophies collected the following years (multiple Kruskal–Wallis test comparison, $\chi^2 = 8.71$, d.f. = 2, $P = 0.01$; Fig. 3). The average difference between the number of recorded trophies, standardised and corrected for the effect of time, after and before the status upgrade was negative ($\Delta N_c = -0.627$, CI 95% = [–0.93;–0.33]). In agreement with the IUCN protection-status hypothesis, the attribution of a higher IUCN vulnerability status was followed by a decrease in the number of recorded trophies for 75% of the studied species. However, for the other 25%, involving an upgrade to the status 'endangered' (i.e. species with the highest perceived rarity), the trend in the change of the number of recorded trophies was in the opposite direction ($\Delta N_c = 0.214$, CI 95% = [–0.12;0.55]). Using the raw data instead of the detrended number of trophies led to qualitatively similar results (Appendix 2).

Discussion

Assuming that the information provided by the IUCN on species-protection needs is used by biodiversity managers, including

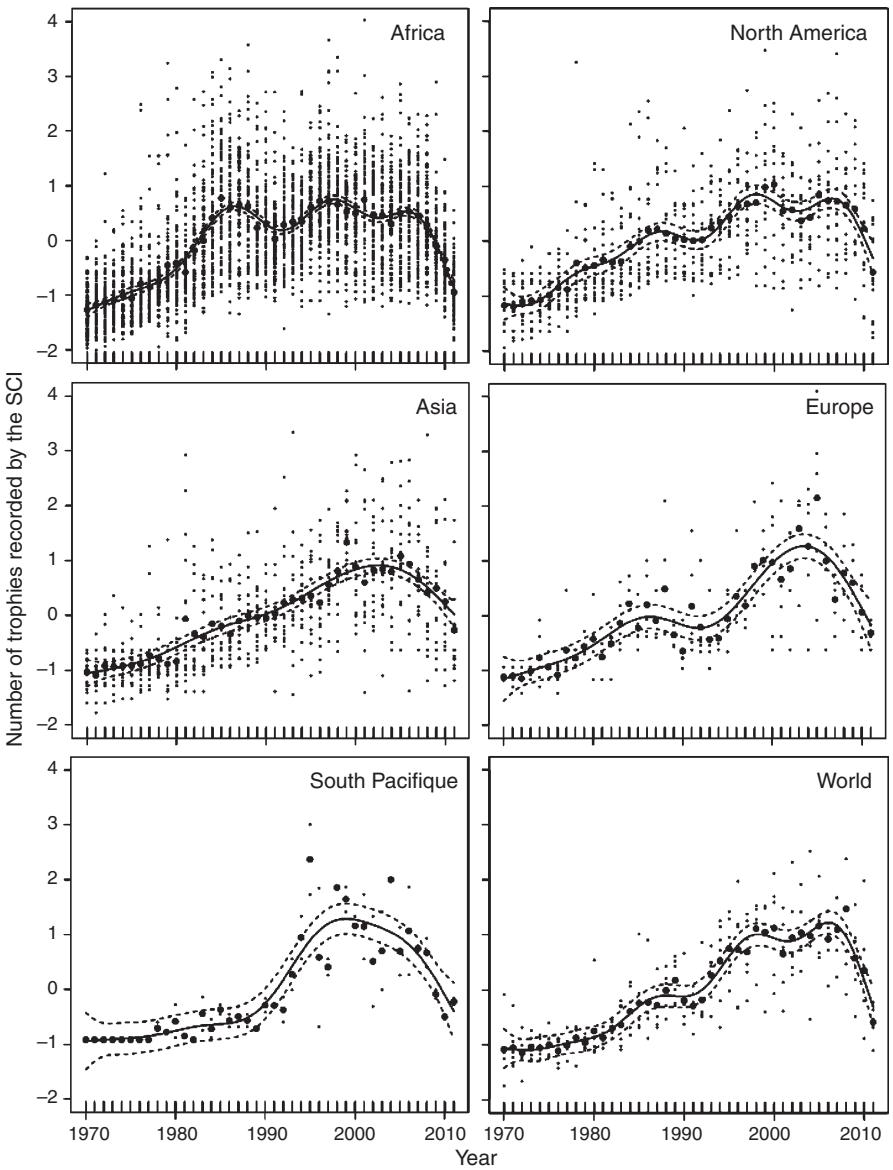

Fig. 1. Time trend of the number of recorded trophies in the Safari Club International database, standardised (centred and scaled) per species in each large hunting region. Small black points are the annual number of recorded trophies for a given species. Large black dots represent the average number of trophies recorded each year. The black line was obtained with a generalised additive model.

managers of trophy-hunted species, we expected to find (1) a lower number of animals hunted when they are initially described as threatened and (2) a decrease in the number of trophies after the vulnerability status has been upgraded. Contrary to our expectations, we found no statistical support for our first hypothesis of an effect of vulnerability-status attribution. In contrast, we found general support for our second hypothesis of an effect of vulnerability status upgrade for the majority of species, except for '*Endangered*' species. Our results, thus, suggest that the IUCN's recommendations are not systematically given full consideration when regulating trophy-hunting intensity for species protection. The AAE (i.e. the disproportionate valorisation and exploitation of rare species by humans; Courchamp *et al*. 2006) could provide an explanation for this counterintuitive effect of IUCN status for the most threatened species.

As a conservation policy, we expected a decreasing number of trophies to occur along the gradient of extinction risk. However, the attribution of an IUCN status had no significant effect on the number of trophies recorded in the SCI (Fig. 2). Generally, our results showed that upgrading the IUCN status for a given species leads to a corresponding decrease in the number of trophies recorded for most species (Fig. 3). Indeed, the number of recorded trophies decreased for all 12 species that were upgraded to '*Near threatened*' or '*Vulnerable*'. These results illustrated that a reduction in trophy-hunting activity occurs in

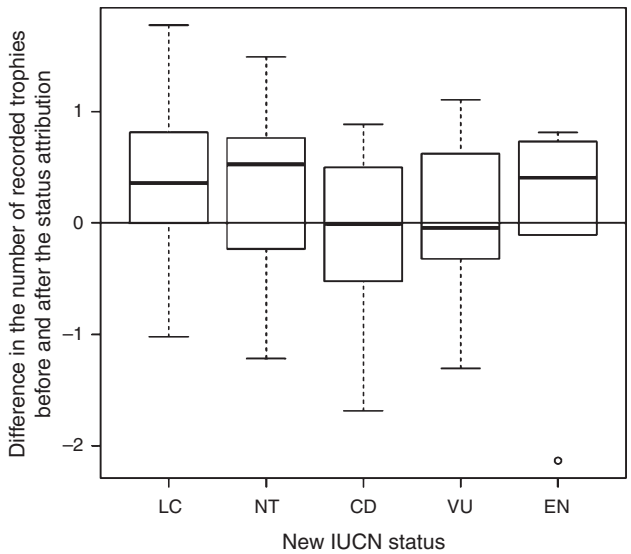

Fig. 2. Average difference between the mean number of recorded trophies in the Safari Club International database during the 5 years preceding and the 5 years following the attribution of the initial International Union for Conservation of Nature (IUCN) vulnerability status (after accounting for the increase in the total harvest over time per region). On the *x*-axis is represented the status attributed to the species, with an increasing extinction risk from left to right (LC for '*Least concern*', with 40 taxa; NT for '*Near threatened*', with 12 taxa; CD for '*Conservation dependent*', with 44 taxa; VU for '*Vulnerable*', with 23 taxa; EN for '*Endangered*', with five taxa). A negative difference means that the average number of trophies recorded after the change is lower than the average number of trophies recorded before the status attribution, which means that classifying the species to the *x* status (given on *x*-axis) leads to a decrease in the number of trophies recorded. The black thick lines in the boxes represent the median number of recorded trophies under this IUCN status. The lowest point in the '*Endangered*' category corresponds to the mountain nyala, *Tragelaphus buxtoni*.

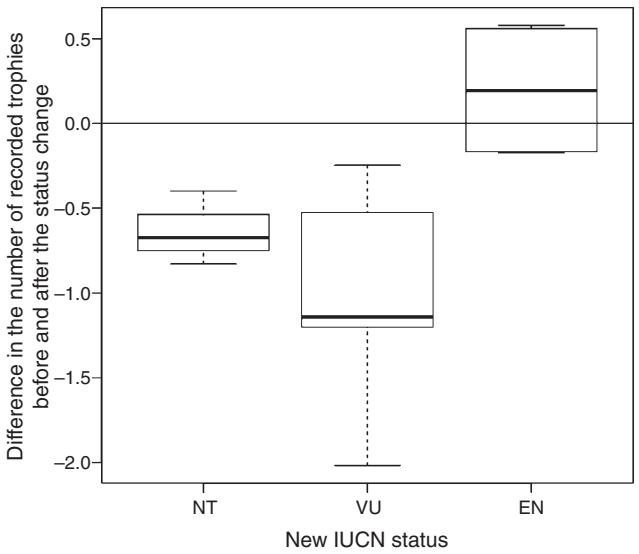

Fig. 3. Average difference between the mean number of recorded trophies in the Safari Club International database during the 5 years preceding and the 5 years following an upgrade of the International Union for Conservation of Nature (IUCN) vulnerability status for a given species (after accounting for the increase in the total harvest over time per region). On the *x*-axis is represented the status to which the species has been upgraded, with an increasing extinction risk from left to right (NT for '*Near threatened*', with three taxa; VU for '*Vulnerable*', with nine taxa; EN for '*Endangered*', with four taxa). A negative difference means that the average number of trophies recorded after the change is lower than the average number of recorded trophies before the change, meaning that classifying the species to the *x* status (given on *x*-axis) leads to a decrease in the number of recorded trophies. The black thick lines in the boxes represent the median number of recorded trophies under this IUCN status.

response to increasing concern over a given species. The IUCN's information is thus correctly used in trophy-hunting management for these species. However, it is noteworthy that for species identified as '*Endangered*', we obtained the opposite pattern; namely, the number of recorded trophies was stable or increased after the status change for the four species that were upgraded to '*Endangered*' (Fig. 3). The '*Endangered*' status indicates the most vulnerable species according to the IUCN's criteria of classification. Our results thus point out shortcomings in species-conservation system. As in most conservation-biology topics, the amount of data available for the most threatened species are rather limited. Despite the generality of our result being therefore questionable, the four species upgraded to '*Endangered*' showed the very same absence of reduction in hunting bags which is a rather unexpected response for their conservation (Fig. 3). These results do not mean that the most vulnerable species will be inevitably driven to extinction by trophy hunting; however, this possibility should be brought to the attention of managers. An AAE would occur only if the management measures are not appropriately chosen or enforced (e.g. respect of scientifically established quotas, cautious attribution of the land-use rights, and focus on prevention of illegal hunting).

One should keep in mind when interpreting these results that the large amount of information provided by the SCI is only suitable for a macroscopic study and is not representative of more local or regional conservation policies, where species may be locally abundant. Our conclusions could thus be different at a finer scale such as the country or population level. Moreover, we could not test for stability in the rate of return of the information over time (i.e. that the proportion of kills that are recorded in the database is temporally constant) because there are no available estimates for the global trophy harvest in the SCI over years. However, our study highlighted several points that improve our understanding of the link between vulnerability status and trophy hunting.

There are no examples of species extinction as a result of trophy hunting (Mysterud 2012). On the contrary, there are a few documented examples of declining populations that have recovered as a result of the appropriate use of the considerable income generated by well managed trophy hunting (Frisina and Tareen 2009). However, our results suggested that IUCN status is only partially taken into account in the global management of species that are hunted for their trophies. The outcomes of our study, as well as those of some other studies (Johnson *et al*. 2010; Palazy *et al*. 2011, 2012; Prescott *et al*. 2011), are sufficiently indicative to advise caution on behalf of decision-makers in the planning of management programs for the rarest species.

Acknowledgements

We are pleased to thank Mark S. Boyce and Mike Hoffman for their helpful comments on earlier drafts of this work and sharing their knowledge on the Safari Club International and the IUCN organisation, respectively. We acknowledge the Agence Nationale de la Recherche for their financial support, project « RARE » (ANR-09-PEXT).

References

Baillie, J. E. M., Hilton-Taylor, C., and Stuart, S. N. (2004). '2004 IUCN Red List of Threatened Species: a Global Species Assessment.' (IUCN Publications Services Unit: Cambridge, UK.)

Collar, N. J. (1996). The reasons for red data books. *Oryx* **30**, 121–130. doi:10.1017/S0030605300021505

Courchamp, F., Angulo, E., Rivalan, P., Hall, R. J., Signoret, L., Bull, L., and Meinard, Y. (2006). Rarity value and species extinction: the anthropogenic Allee effect. *PLoS Biology* **4**, 2405–2410. doi:10.1371/journal.pbio.0040415

Cousins, J. A., Sadler, J. P., and Evans, J. (2008). Exploring the role of private wildlife ranching as a conservation tool in south Africa: stakeholder perspectives. *Ecology and Society* **13**, 43.

DeMatteo, K. E., and Loiselle, B. A. (2008). New data on the status and distribution of the bush dog (*Speothos venaticus*): evalutating its quality of protection and directing research efforts. *Biological Conservation* **141**, 2494–2505. doi:10.1016/j.biocon.2008.07.010

Frisina, M. R., and Tareen, S. N. A. (2009). Exploitation prevents extinction: case study of endangered himalayan sheep and goats. In 'Recreational Hunting, Conservation, and Rural Livelihoods'. (Eds B. Dickson, J. Hutton and W. M. Adams.) pp. 141–156. (Wiley-Blackwell: Oxford, UK.)

Grosbois, V., Gimenez, O., Gaillard, J. M., Pradel, R., Barbraud, C., Clobert, J., Møller, A. P., and Weimerskirch, H. (2008). Assessing the impact of climate variation on survival in vertebrate populations. *Biological Reviews of the Cambridge Philosophical Society* **83**, 357–399. doi:10.1111/j.1469-185X.2008.00047.x

Hastie, T., and Tibshirani, R. (1986). Generalized additive models. *Statistical Science* **1**, 297–310. doi:10.1214/ss/1177013604

Johnson, P. J., Kansky, R., Loveridge, A. J., and MacDonald, D. W. (2010). Size, rarity and charisma: Valuing african wildlife trophies. *PLoS ONE* **5**, e12866. doi:10.1371/journal.pone.0012866

Leader-Williams, N. (2009). Conservation and hunting: friends or foes? In 'Recreational Hunting, Conservation, and Rural Livelihoods'. (Eds B. Dickson, J. Hutton and W. M. Adams.) pp. 9–24. (Wiley-Blackwell: Oxford, UK.)

Leader-Williams, N., Milledge, S., Adcock, K., Brooks, M., Conway, A., Knight, M., Mainka, S., Martin, E. B., and Teferi, T. (2005). Trophy hunting of black rhinos *Diceros bicornis*: proposals to ensure its future sustainability. *Journal of International Wildlife Law and Policy* **8**, 1–11. doi:10.1080/13880290590913705

Lewis, D. M., and Alpert, P. (1997). Trophy hunting and wildlife conservation in Zambia. *Conservation Biology* **11**, 59–68. doi:10.1046/j.1523-1739.1997.94389.x

Lindsey, P. A., Roulet, P. A., and Romanach, S. S. (2007). Economic and conservation significance of the trophy hunting industry in sub-Saharan Africa. *Biological Conservation* **134**, 455–469. doi:10.1016/j.biocon.2006.09.005

Lindsey, P. A., Romanach, S. S., and Davies-Mostert, H. T. (2009). The importance of conservancies for enhancing the value of game ranch land for large mammal conservation in southern Africa. *Journal of Zoology* **277**, 99–105. doi:10.1111/j.1469-7998.2008.00529.x

Loveridge, A. J., Searle, A. W., Murindagomo, F., and Macdonald, D. W. (2007). The impact of sport-hunting on the population dynamics of an African lion population in a protected area. *Biological Conservation* **134**, 548–558. doi:10.1016/j.biocon.2006.09.010

Milner, J. M., Nilsen, E. B., and Andreassen, H. P. (2007). Demographic side effects of selective hunting in ungulates and carnivores. *Conservation Biology* **21**, 36–47. doi:10.1111/j.1523-1739.2006.00591.x

Myers, N., and Knoll, A. H. (2001). The biotic crisis and the future of evolution. *Proceedings of the National Academy of Sciences, USA* **98**, 5389–5392. doi:10.1073/pnas.091092498

Mysterud, A. (2012). Trophy hunting with uncertain role for population dynamics and extinction of ungulates. *Animal Conservation* **15**, 14–15. doi:10.1111/j.1469-1795.2011.00519.x

Packer, C., Kosmala, M., Cooley, H. S., Brink, H., Pintea, L., Garshelis, D., Purchase, G., Strauss, M., Swanson, A., Balme, G., Hunter, L., and Nowell, K. (2009). Sport hunting, predator control and conservation of large carnivores. *PLoS ONE* **4**, e5941. doi:10.1371/journal.pone.0005941

Packer, C., Brink, H., Kissui, B. M., Maliti, H., Kushnir, H., and Caro, T. (2011). Effects of trophy hunting on lion and leopard populations in Tanzania. *Conservation Biology* **25**, 142–153. doi:10.1111/j.1523-1739.2010.01576.x

Palazy, L., Bonenfant, C., Gaillard, J. M., and Courchamp, F. (2011). Cat dilemma: too protected to escape trophy hunting? *PLoS ONE* **6**(7), e22424. doi:10.1371/journal.pone.0022424

Palazy, L., Bonenfant, C., Gaillard, J. M., and Courchamp, F. (2012). Rarity, trophy hunting and ungulates. *Animal Conservation* **15**, 4–11. doi:10.1111/j.1469-1795.2011.00476.x

Pavoine, S., Ollier, S., Pontier, D., and Chessel, D. (2008). Testing for phylogenetic signal in phenotypic traits: new matrices of phylogenetic proximities. *Theoretical Population Biology* **73**, 79–91. doi:10.1016/j.tpb.2007.10.001

Plumptre, A. J., Davenport, T. R. B., Behanyana, M., Kityo, R., Eilu, G., Ssegawa, P., Ewango, C., Meirte, D., Kahindo, C., Herremans, M., Peterhans, J. K., Pilgrim, J. D., Wilson, M., Languy, M., and Moyer, D. (2007). The biodiversity of the Albertine rift. *Biological Conservation* **134**, 178–194. doi:10.1016/j.biocon.2006.08.021

Prescott, G. W., Johnson, P. J., Loveridge, A. J., and Macdonald, D. W. (2011). Does change in IUCN status affect demand for African bovid trophies? *Animal Conservation* **15**, 248–252.

R Development Core Team (2009). 'R: A Language and Environment for Statistical Computing.' (R Foundation for Statistical Computing: Vienna.)

Raven, P. H. (2003). Biodiversity and the future. *American Scientist* **91**, 382.

Rodrigues, A. S. L., Pilgrim, J. D., Lamoreux, J. F., Hoffman, M., and Brooks, T. M. (2006). The value of IUCN red list for conservation. *Trends in Ecology & Evolution* **21**, 71–76. doi:10.1016/j.tree.2005.10.010

Thornback, J., and Jenkins, M. (1982). 'The IUCN Mammal Red Data Book: Threatened Mammalian Taxa of the Americas and the Australasian Zoogeographic Region (Excluding Cetacea).' (World Conservation Union: Gland, Switzerland.)

Wilkie, D. S., and Carpenter, J. F. (1999). The potential role of safari hunting as a source of revenue for protected areas in the Congo Basin. *Oryx* **33**, 339–345. doi:10.1017/S003060530003074X

Appendix 1. Number of trophies recorded and International Union for Conservation of Nature (IUCN) status changes over the study period for the 124 species included in the analysis

Ntrophies is the total number of recorded trophies in the Safari Club International between 1970 and 2011. Status changes give the first status attribute for each species and the status upgrades. NA = non-assigned. IUCN statuses classified from the lowest to the highest extinction risk are: LC= '*Least Concern*', NT = '*Near threatened*', CD = '*Conservation dependent*', VU = '*Vulnerable*', EN = '*Endangered*'

Species	Common name	Ntrophies	Status changes
Acinonyx jubatus	Cheetah	62	NA→VU
Aepyceros melampus	Impala	4435	NA→CD→LC
Alcelaphus buselaphus caama	Cape or red hartebeest	2410	NA→CD→LC
Alcelaphus buselaphus cokei	Coke hartebeest	340	NA→CD→LC
Alcelaphus buselaphus lelwel	Lelwel hartebeest	274	NA→CD→EN
Alcelaphus buselaphus major	Western hartebeest	209	NA→CD→NT
Alcelaphus lichtensteini	Lichtenstein hartebeest	970	NA→CD→LC
Alces alces	Moose	1691	NA→LC
Alligator mississippiensis	American alligator	309	NA→LC
Ammotragus lervia	Aoudad or barbary sheep	22	NA→VU
Antidorcas marsupialis	Springbok	2959	NA→CD→LC
Antilocapra americana	Pronghorn	3010	NA→LC
Antilope cervicapra	Blackbuck	287	NA→VU→NT
Axis axis	Axis deer	258	NA→LC
Bison bison	American bison	785	NA→CD→NT
Bison bonasus	European bison	90	NA→VU→EN→VU
Bos javanicus	Banteng	249	NA→VU→EN
Bubalus bubalis	Water buffalo	1002	NA→EN
Canis lupus	Gray wolf	444	NA→VU→LC
Capra aegagrus	Bezoar or Persian ibex	2211	NA→VU
Capra caucasica	Caucasian tur	171	NA→EN
Capra cylindricornis	East Caucasian tur	191	NA→VU→NT
Capra ibex	Alpine ibex	141	NA→LC
Capra nubiana	Nubian ibex	57	NA→EN→VU
Capra pyrenaica	Spanish ibex	1204	NA→NT→LC
Capra sibirica	Asian ibex	690	NA→LC
Capreolus capreolus	European roe deer	711	NA→LC
Cephalophus callipygus	Peters duiker	167	NA→NT→LC
Cephalophus dorsalis	Bay duiker	127	NA→NT→LC
Cephalophus harveyi	Harvey red duiker	62	NA→CD→LC
Cephalophus monticola	Blue duiker	504	NA→LC
Cephalophus natalensis	Natal red duiker	441	NA→CD→LC
Cephalophus nigrifrons	Black-fronted duiker	19	NA→NT→LC
Cephalophus rufilatus	Red-flanked duiker	272	NA→CD→LC
Cephalophus silvicultor	Yellow-backed duiker	107	NA→NT→LC
Ceratotherium simum simum	Southern white rhinoceros	450	NA→NT
Cervus elaphus	Wapiti or maral or red deer	2624	NA→LC
Cervus nippon	Sika deer	361	NA→LC
Cervus timorensis	Rusa deer	297	NA→LC→VU
Cervus unicolor	Sambar	104	NA→LC→VU
Civettictis civetta	African civet	120	NA→LC
Connochaetes gnou	Black wildebeest	1707	NA→CD→LC
Connochaetes taurinus	Wildebeest	3868	NA→CD→LC
Crocodylus niloticus	Nile crocodile	489	NA→VU→LC
Crocuta crocuta	Spotted hyena	662	NA→CD→LC
Dama dama	European fallow deer	976	NA→LC
Damaliscus dorcas dorcas	Bontebok	666	NA→VU→NT
Damaliscus dorcas phillipsi	Blesbok	3148	NA→CD→LC
Damaliscus lunatus jimela	Topi	437	NA→CD→LC
Damaliscus lunatus lunatus	Tsessebe	1045	NA→CD→LC
Gazella dorcas	Dorcas gazelle	108	NA→VU→NT→VU
Gazella granti	Grant gazelle	1165	NA→CD→LC
Gazella soemmerringi	Soemmerring gazelle	181	NA→VU
Gazella subgutturosa	Goitered gazelle	302	NA→NT→VU
Gazella thomsoni	Thomson gazelle	698	NA→CD→NT
Hemitragus jemlahicus	Himalayan tahr	988	NA→VU→NT

(*continued next page*)

Appendix 1. (*continued*)

Species	Common name	Ntrophies	Status changes
Hippopotamus amphibius	Common hippopotamus	701	NA→LC→VU
Hippotragus equinus	Roan antelope	808	NA→CD→LC
Hippotragus niger	Sable antelope	1352	NA→CD→LC
Hydropotes inermis	Chinese water deer	169	NA→VU→NT→VU
Hylochoerus meinertzhageni	Giant forest hog	91	NA→LC
Kobus ellipsiprymnus ellipsiprymnus	Common or ringed waterbuck	1935	NA→CD→LC
Kobus kob kob	African kob	321	NA→CD→VU
Kobus leche kafuensis	Kafue flats lechwe	466	NA→VU
Kobus leche leche	Red lechwe	519	NA→CD→LC
Kobus vardoni	Puku	631	NA→CD→NT
Leptailurus serval	Serval	145	NA→LC
Litocranius walleri	Gerenuk	668	NA→CD→NT
Loxodonta africana	African elephant	569	NA→VU→EN→VU
Madoqua kirki	Kirk dik-dik	656	NA→LC
Mazama gouazoubira	Gray-brown brocket deer	298	NA→LC→DD→LC
Mazama pandora	Yucatan gray-brown brocket deer	37	NA→LC→DD→VU
Muntiacus reevesi	Reeves muntjac	209	NA→LC
Nesotragus batesi	Bates pygmy antelope	48	NA→NT→LC
Nesotragus moschatus	Suni	360	NA→EN→CD→LC
Odocoileus hemionus	Mule deer or black-tailed deer	2701	NA→LC
Odocoileus virginianus	White-tailed deer	2959	NA→LC
Oreamnos americanus	American mountain goat	879	NA→LC
Oreotragus oreotragus	Klipspringer	961	NA→CD→LC
Oryx beisa callotis	Fringe-eared oryx	337	NA→CD→VU
Oryx gazella	Gemsbok	1910	NA→CD→LC
Ourebia ourebi	Oribi	836	NA→CD→LC
Ovibos moschatus	Greenland muskox	829	NA→LC
Ovis ammon	Argali	937	NA→VU→NT
Ovis canadensis	Bighorn sheep	1121	NA→CD→LC
Ovis dalli	Dall sheep	1348	NA→LC
Ovis gmelini	Mouflon or urial	850	NA→VU
Ovis nivicola	Snow sheep	269	NA→CD→LC
Ovis vignei	Urial	333	NA→VU
Panthera leo	African lion	1804	NA→VU
Panthera pardus	Leopard	1758	NA→VU→LC→NT
Pelea capreolus	Vaal rhebok	576	NA→CD→LC
Phacochoerus aethiopicus	Warthog	2408	NA→LC
Potamochoerus larvatus	Bushpig	639	NA→LC
Potamochoerus porcus	Red river hog	77	NA→LC
Procapra picticaudata	Tibetan gazelle or goa	97	NA→NT→LC→NT
Puma concolor	Cougar or mountain lion	1338	NA→LC→NT→LC
Rangifer tarandus	Reindeer or caribou	1689	NA→LC
Raphicerus campestris	Steenbok	1822	NA→LC
Raphicerus melanotis	Cape grysbok	447	NA→CD→LC
Raphicerus sharpei	Sharpe grysbok	481	NA→CD→LC
Redunca arundinum	Common reedbuck	1240	NA→CD→LC
Redunca fulvorufula chanleri	Chanler mountain reedbuck	76	NA→NT→VU
Redunca fulvorufula fulvorufula	Southern mountain reedbuck	952	NA→CD→LC
Redunca redunca	Bohor reedbuck	657	NA→CD→LC
Rupicapra pyrenaica	Alpine chamois	526	NA→CD→LC
Rupicapra rupicapra	Pyrenean chamois	751	NA→LC
Sus scrofa	Feral boar	755	NA→LC
Sylvicapra grimmia	Bush duiker	2772	NA→LC
Syncerus caffer	African buffalo	3521	NA→CD→LC
Taurotragus derbianus gigas	Central African giant eland	434	NA→VU→LC
Taurotragus oryx oryx	Cape eland	1670	NA→CD→LC
Tayassu pecari	White-lipped peccary	211	NA→LC
Tayassu tajacu	Collared peccary or javelina	1021	NA→LC
Tragelaphus angasi	Common nyala	1923	NA→CD→LC
Tragelaphus buxtoni	Mountain nyala	188	NA→EN

(*continued next page*)

Appendix 1. (*continued*)

Species	Common name	Ntrophies	Status changes
Tragelaphus euryceros euryceros	Western bongo	420	NA→NT
Tragelaphus imberbis	Lesser kudu	530	NA→CD→NT
Tragelaphus scriptus	Bushbuck	4433	NA→LC
Tragelaphus spekii	Sitatunga	670	NA→NT→LC
Tragelaphus strepsiceros	Greater kudu	5012	NA→CD→LC
Ursus americanus	Black bear	820	NA→LC
Ursus arctos	Brown bear	1991	NA→LC
Ursus maritimus	Polar bear	185	NA→VU→CD→VU

Appendix 2. Results of the analysis on the standardised number of recorded trophies (without detrending for the effect of time)

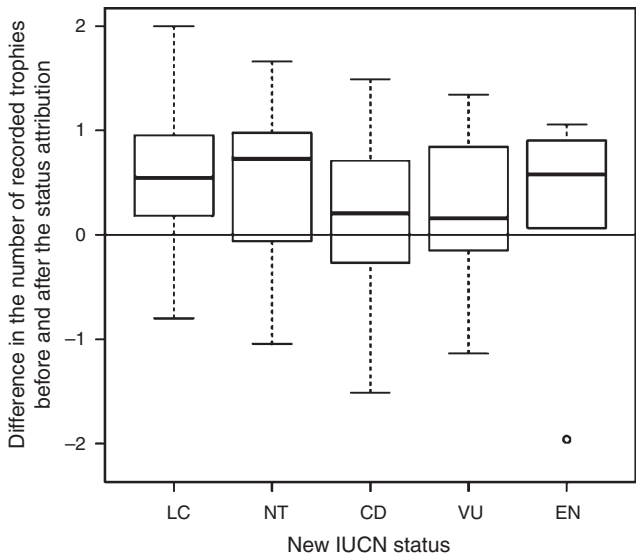

Fig. A1. Average difference between the mean number of recorded trophies in the Safari Club International 5 years after and 5 years before the attribution of the first International Union for Conservation of Nature (IUCN) vulnerability status (multiple Kruskal–Wallis test comparison, $P > 0.05$). On the *x*-axis is represented the status attributed to the species, with an increasing extinction risk from left to right (LC for '*Least concern*', with 40 taxa; NT for '*Near threatened*', with 12 taxa; CD for '*Conservation dependent*', with 44 taxa; VU for '*Vulnerable*', with 23 taxa; EN for '*Endangered*', with five taxa). A negative difference means that the average number of trophies recorded after the change is lower than the average number of trophies recorded before the status attribution, which means that classifying the species to the *x* status (given on *x*-axis) leads to a decrease in the number of trophies recorded. The black thick lines in the boxes represent the median number of recorded trophies under this IUCN status. The lowest point in the '*Endangered*' category corresponds to the mountain nyala, *Tragelaphus buxtoni*.

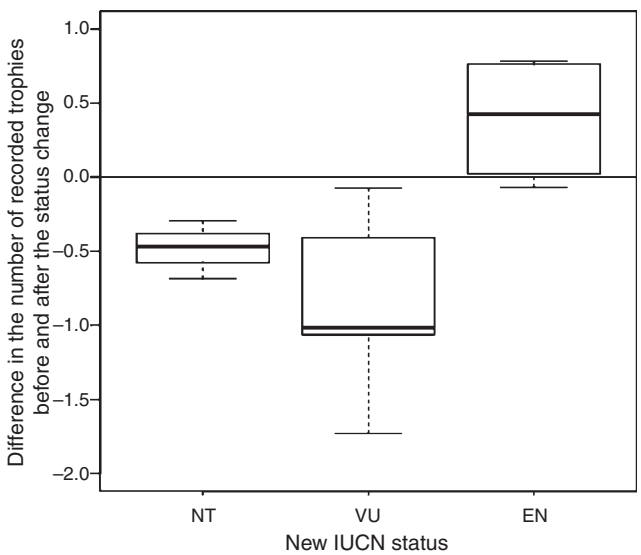

Fig. A2. Average difference between the mean number of recorded trophies in the Safari Club International 5 years after and 5 years before upgrading the species to a higher International Union for Conservation of Nature (IUCN) vulnerability status (multiple Kruskal–Wallis test comparison, $P = 0.01$). On the *x*-axis is represented the status to which the species has been upgraded with an increasing extinction risk from left to right (NT for '*Near threatened*', with three taxa; VU for '*Vulnerable*', with nine taxa; EN for '*Endangered*', with four taxa). A negative difference means that the average number of trophies recorded after the change is lower than the average number of trophies recorded before the change, meaning that classifying the species to the *x* status (given on *x*-axis) leads to a decrease in the number of trophies recorded. The black thick lines in the boxes represent the median number of recorded trophies under this IUCN status.