Institution: University of Oxford

Unit of Assessment: UOA5

Title of case study:

A novel vaccination strategy to safeguard the Ethiopian wolf from extinction

1. Summary of the impact

The Ethiopian wolf is the most endangered carnivore in Africa. It is chiefly threatened by rabies outbreaks that occur every 5-10 years with a mortality rate of up to 77% in affected populations. Dr Claudio Sillero-Zubiri and colleagues have developed a novel low-coverage vaccination strategy, now at the heart of a strategic plan to protect this species from extinction. Containment of rabies through a *cordon sanitaire* protects these rare wolves beyond the initial outbreak, offering a potential model for wildlife disease management elsewhere, and significant socio-economic and health benefits for the communities living in and around wolf areas.

2. Underpinning research

Fewer than 500 Ethiopian wolves survive in six small, isolated, mountain pockets across Ethiopia, over half in the Bale Mountains. Expanding agriculture and grazing in the Afroalpine region in which the wolves live brings them into closer contact with domestic dogs, the main reservoir of rabies. The risk posed by rabies is amplified by the wolves' social habits and high density; their small population size makes them vulnerable to extinction. Researchers at the Wildlife Conservation Research Unit (WildCRU) at Oxford University's Zoology Department, led by Dr Claudio Sillero-Zubiri and Professor David Macdonald, have carried out long-term studies to identify the major threats faced by the wolves, and to establish the most effective ways to ensure their continued survival.

As part of these long-term studies, Sillero-Zubiri observed that over a 4-month period in the early 1990s, 77% of the largest wolf population in the Bale Mountains died or disappeared. Rabies (a major threat to wild canids, and widespread amongst domestic dogs in Ethiopia) was the suspected cause, and a virus type consistent with dog-associated rabies was isolated from wolf carcasses. The results of all this research, published in 1996, provided clear evidence that rabies outbreaks linked to local domestic dogs were the main threat to the survival of wolves[1]. Further research suggested that canine distemper virus might also affect wolves, and reinforced the need to protect the wolves against diseases carried by local dogs, of which there are very large numbers[2]. Owing to their fragmented distribution, Ethiopian wolves effectively live on islands in a sea of dogs.

A breakthrough as to how this protection might be achieved was provided in a paper published in 2002. Sillero-Zubiri and colleagues used Population Viability Analysis (PVA) modelling to quantify the impact of rabies outbreaks on wolf populations. Modelling showed that, in the absence of disease, populations were remarkably stable, but that rabies epizootics caused extinction probabilities to rise substantially, particularly in smaller populations. Importantly, the model suggested that direct vaccination of as few as 20–40% of wolves against rabies might be sufficient protection from the largest epizootics[3]. By averting low population densities, and pack extinctions, this approach would ameliorate delayed population recovery exacerbated by social constraints on independent breeding[4]. This was a new approach to vaccination: rather than attempting to eliminate the disease altogether (often impractical in wild populations), targeted vaccination could curtail the largest and most damaging outbreaks, reducing extinction risk.

Another major rabies outbreak in 2003-04 gave the team an opportunity to test their vaccination strategy in practice. More than three-quarters (76%) of wolves in the Web Valley of the Bale Mountains died over a period of less than 6 months. Just under 40% of surviving wolves in neighbouring packs were strategically vaccinated in a *cordon sanitaire*, to prevent the spread of

rabies along the narrow valley 'corridors' used by the wolves; this intervention was successful in halting the spread of the disease[5, 6]. Further modelling demonstrated that, even if carcass detection rates fell as low as 20%, there would be sufficient time to implement a reactive corridor vaccination campaign triggered by the detection of two carcasses in a rabies outbreak[6].

3. References to the research

1. Sillero-Zubiri C, King AA, Macdonald DW. (1996) Rabies and mortality in Ethiopian wolves (*Canis simensis*). Journal of Wildlife Diseases 32: 80–86. doi: 10.7589/0090-3558-32.1.80 ***First published evidence of confirmed deaths from rabies amongst Ethiopian wolves*.**

2. Laurenson K, Sillero-Zubiri C, Thompson H, Shiferaw F, Thirgood S, Malcolm J. (1998) Disease as a threat to endangered species: Ethiopian wolves, domestic dogs and canine pathogens. Animal Conservation 1: 273-280. doi: 10.1111/j.1469-1795.1998.tb00038.x ***Paper confirming dog-borne diseases as a major threat to the Ethiopian wolf.***

3. Haydon DT, Laurenson MK, Sillero-Zubiri C. (2002) Integrating epidemiology into population viability analysis: Managing the risk posed by rabies and canine distemper to the Ethiopian wolf. Conservation Biology 16: 1372-1385. doi: 10.1046/j.1523-1739.2002.00559.x ***Paper reporting on the results of computer-based modelling, demonstrating that rabies vaccination levels of below 40% were likely to be effective in preventing extinction.***

4. Marino J, Sillero-Zubiri C, Johnson PJ, Macdonald DW. (2013) The fall and rise of Ethiopian wolves: a natural experiment on the regulation of populations of social carnivores. Animal Conservation doi: 10.1111/acv.12036 ***Paper reporting wolf population recovery and social effects on population growth.***

5. Randall DA, Williams SD, Kuzmin IV, Rupprecht CE, Tallents LA, Tefera Z, Argaw K, Shiferaw F, Knobel DL, Sillero-Zubiri C, Laurenson MK. (2004) Rabies in endangered Ethiopian wolves. Emerging Infectious Diseases 10: 2214-2217. doi: 10.3201/eid1012.040080 ***Initial report on the management of the 2003-04 rabies outbreak amongst Ethiopian wolves.***

6. Haydon DT, Randall DA, Matthews L, Knobel DL, Tallents LA, Gravenor MB, Williams SD, Pollinger JP, Cleaveland S, Woolhouse MEJ, Sillero-Zubiri C, Marino J, Macdonald DW, Laurenson MK. (2006) Low-coverage vaccination strategies for the conservation of endangered species. Nature 443: 692–695. doi: 10.1038/nature05177 ***Paper reporting on the successful implementation of the cordon sanitaire vaccination approach with <40% of wolves inoculated against rabies during an outbreak.***

Funding for research: Research since 1993 has been supported by ~£200,000 a year in grants, primarily from the Born Free Foundation and the Frankfurt Zoological Society.

4. Details of the impact

The key contribution of the research led by Sillero-Zubiri has been to provide robust, detailed evidence of the specific threats facing the Ethiopian wolf. This evidence has enabled proper strategic planning for the wolf's conservation and secured funds to implement effective protection programmes, within which vaccination against rabies has played the key role.

The first phase of the research documenting the importance of rabies as a source of mortality in Ethiopian wolves[1] catalysed several new and important conservation actions. It led immediately to the species being reclassified as Critically Endangered by the IUCN Red List of Threatened Species[7], and resulted in the first Ethiopian wolf action plan (drawn up by the IUCN/SSC Canid Specialist Group[8]). It also led to the establishment of the Ethiopian Wolf Conservation Programme (EWCP), a science-driven conservation initiative that has gone on to play a crucial role in the protection of the wolf and its habitat[9,10,11]. EWCP implemented a campaign of rabies vaccination in local dogs (later including canine distemper virus), aiming to inoculate 70% of the dog population

around wolf habitats; since 1996 more than 62,000 dogs have been vaccinated. Ethiopian wolves had been protected by law since 1974; due to their rarity the authorities were reluctant to authorize any management requiring handling or vaccination of the wolves themselves. Thanks to the compelling evidence provided by the underpinning research carried out by Sillero-Zubiri and colleagues, immediate funding and federal permission was forthcoming for the vaccination campaign that neutralized the 2003 rabies epizootic; vaccination began a mere two weeks after rabies was identified in the wolf population[12]. Confirming the success of this strategy the species was uplisted to Endangered from Critically Endangered by the IUCN in 2004[7].

The vaccination approach developed by creating a protective barrier or *cordon sanitaire* of vaccinated wolf packs was deployed again in August 2008 when a major rabies outbreak hit the wolves in the Bale Mountains. The Ethiopian authorities immediately approved an emergency vaccination campaign, and 98 wolves were vaccinated, using a more refined and systematic approach than previously, targeting the dominant pair to preserve breeding units. Vaccination was associated with successfully containing disease to the original outbreak (Fig 1)[10-13].

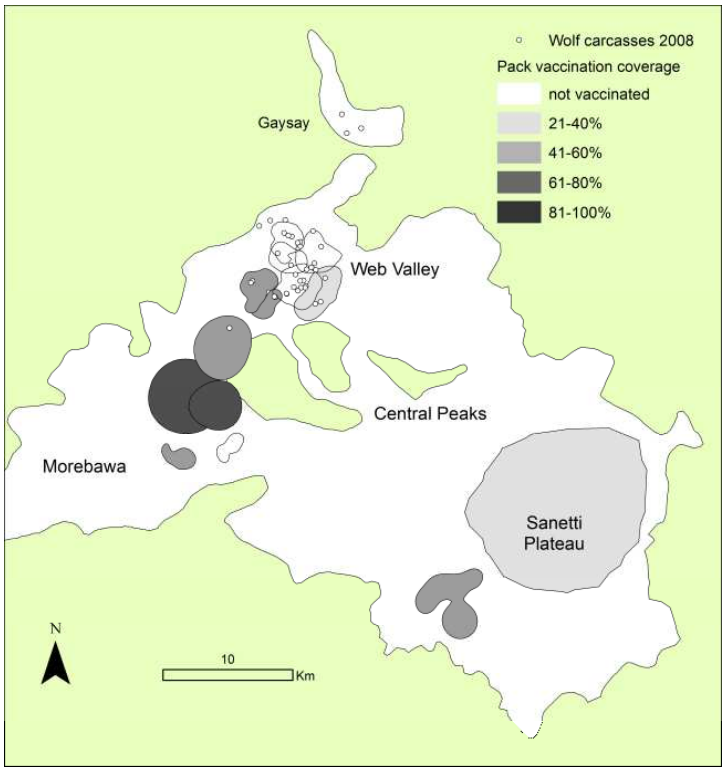

Figure 1: Distribution of wolf carcasses found in 2008 in relation to historical pack vaccination coverage. As predicted by modelling low coverage vaccination in surrounding packs was effective in restricting the spread of rabies outside the initial outbreak in Web Valley in 2008.

A consequential impact of the implementation of this research has been on the local people who co-exist with the wolves. Some 8,500 households with 12,500 dogs live in and around wolf habitats in the Bale Mountains, largely engaged in subsistence farming and grazing of livestock[9,14]. Dogs are essential to local people for herding and also for consuming human waste, but pose the greatest threat to wolves as vectors of canine diseases. EWCP's ongoing domestic dog rabies vaccination campaign results in significant economic and health benefits for local communities[12], which otherwise lose livestock to rabies and are also vulnerable to the disease themselves. The incidence of rabies in humans in villages where dogs were not vaccinated was up to five times higher than in villages where dogs were vaccinated[14].

The protection of the Afroalpine ecosystem, part of the Eastern Afromontane biodiversity hotspot, has increased due to the attention focussed on the Ethiopian wolf through this research. The efforts of EWCP and partner Frankfurt Zoological Society have helped to extend the areas designated as protected areas, with consequent impact for other rare endemic species. As a result, the amount of suitable wolf habitat that is protected has increased from 40% in 2000 to 87% in 2011[15]. The tourism value of the wolf is also important; wildlife tourism in Ethiopia is increasing, with associated benefits to the Ethiopian economy (most of the 2,000 people trekking in Bale each

year come to see wolves). EWCP provides other economic benefits through capacity-building and conservation jobs within the Ethiopian conservation community (for example, EWCP has funded 8 MSc and 2 PhDs by Ethiopian students). EWCP employs 36 field staff, of whom 5 work for the Vet team vaccinating dogs and wolves; 16 wolf monitors and Wolf *Ambassadors* monitor wolf populations, in order to ensure a swift response to rabies outbreaks[9,15].

As the apex predator in the Ethiopian highlands, the Ethiopian wolf has an important role as a flagship species for Afroalpine biodiversity: conservation of the species translates into the protection and maintenance of habitats and ecological processes. The vaccination strategy developed by Oxford University researchers has led both to the continued survival of the wolf as well as associated benefits for local people. There is now a robust National Action Plan in place for the wolf[15], and the current active level of research, together with the strong partnership of Ethiopian and international organisations involved, will ensure that conservation actions can be adapted to changing circumstances. The example provided by this initiative, of a science-led conservation programme which delivers timely targeted actions, offers a blue-print to similar conservation challenges elsewhere[16].

5. Sources to corroborate the impact

7. IUCN Red List entry for the Ethiopian wolf, including a history of its status. The species was reassessed in 2011, and on the basis of response to vaccination and resulting population recovery, Endangered status was upheld: http://www.iucnredlist.org/details/3748/0

8. Status and species conservation action plan for the Ethiopian wolf, prepared by the IUCN/SSC Canid Specialist Group in 1997: http://canids.org/PUBLICAT/EWACTPLN/ewaptoc.htm

9. EWCP Annual Report (2013). http://www.ethiopianwolf.org/publications/EWCP-Annual-Report-April-2013.pdf ***Evidence of community education programmes, wolf vaccination programmes and new areas under protection.***

10. Letter from Ethiopia Country Director, Frankfurt Zoological Society (held on file), ***confirming the importance of research and intervention in controlling recent rabies epizootics.***

11. Letter from Director Born Free Foundation Ethiopia (held on file), ***confirming importance of vaccination strategy in containing 2008 & 2009 rabies epizootics.***

12. Letter from Ethiopia's Chief Veterinary Officer (up to 2011); currently FAO Director Animal Production & Health Division, Rome (held on file).

13. Letter from Head of Wildlife Zoonoses and Vector-borne Disease Group, Animal Health and Veterinary Laboratories Agency (AHVLA), UK (held on file), ***stating support for vaccination strategies developed in underpinning research.***

14. Report on research carried out by Abera Yilma (MSc Diss.) into the impact of EWCP rabies vaccination of dogs on local people: http://www.ethiopianwolf.org/publications/JeedalaGazette_july09.pdf ***demonstrating no human casualties in wards where vaccination took place, and lower livestock losses to disease, when compared with wards without vaccination*.**

15. Strategic Plan for Ethiopian Wolf Conservation, prepared by the IUCN/SSC Canid Specialist Group in December 2011. http://www.ethiopianwolf.org/SPEWC.pdf **Includes evidence of the scope of dog vaccination campaign, and of range extension, resulting from research findings.**

16. Letter from Co-Chair IUCN/SSC Wildlife Health Specialist Group (held on file), **stating opinion that research has enabled a rare success in veterinary intervention in wildlife conservation.**