EcoHealth 14, S139–S143, 2017
DOI: 10.1007/s10393-016-1168-y

EcoHealth

Short Communication

Outcomes of a 'One Health' Monitoring Approach to a Five-Year Beaver (*Castor fiber*) Reintroduction Trial in Scotland

Gidona Goodman,[1] Anna Meredith,[1] Simon Girling,[2] Frank Rosell,[3] and Roisin Campbell-Palmer[2]

[1]*Exotic Animal and Wildlife Unit, Royal (Dick) School of Veterinary Studies, EBVC, Roslin, Midlothian EH25 9RG, UK*
[2]*Royal Zoological Society of Scotland, Edinburgh Zoo, 134 Corstorphine Road, Edinburgh EH12 6TS, UK*
[3]*Department of Environmental and Health Studies, Faculty of Arts and Sciences, University College of Southeast Norway, Bø i Telemark, Norway*

Abstract: The Scottish Beaver Trial, involving the translocation and release of 16 wild Norwegian beavers (*Castor fiber*) to Scotland, provides a good example of a 'One Health' scientific monitoring approach, with independent monitoring partners on ecology and public health feeding into veterinary health surveillance. Pathogen detection did not prohibit beaver release, although eight beavers were seropositive for *Leptospira* spp. Six deaths (37.5%) occurred during Rabies quarantine, followed by the death of two animals shortly after release and two wild-born kits due to suspected predation. Two host-specific parasites, the beaver fluke (*Stichorchis subtriquetrus*) and beaver beetle (*Platypsyllus castoris*) were also reintroduced.

Keywords: *Castor fiber*, *Leptospira* spp, *Stichorchis subtriquetrus*, one health, reintroduction

The Eurasian beaver (*Castor fiber*) was once widespread throughout Britain and is thought to have become extinct in Scotland by the 16th century due to hunting. In 2008, the Scottish Government licenced the Scottish Wildlife Trust (SWT) and the Royal Zoological Society of Scotland (RZSS) to conduct the Scottish Beaver Trial (SBT), a 5-year scientific trial reintroduction of the Eurasian beaver, in Knapdale forest (Latitude: 56.03631934, Longitude: −5.58656630) on the west coast of Scotland. The choice of site was made according to ecological suitability with a contained and short network of river systems minimising the risk of extensive dispersal of the beavers; broad local support; land owner permission and practical benefits such as local offices and visitor facilities (Webb et al. 1997; Gaywood 2014). Pre- and post-release public consultations were held involving all stake holders following International Union for Conservation of Nature (IUCN) reintroduction guideline recommendations (IUCN/SSC 2013) and reported majority public support for the process (SNH 1998; Parker et al. 2000; SBT 2007; Jones and Campbell-Palmer 2014). In May 2009, eleven beavers (three families) trapped in Norway were released, followed by another five individuals (non-family units) released in 2010. Norwegian beavers were used as a source population as they were perceived to be taxonomically most representative of what was formally present in Scotland, with comparable climate and vegetation (Kitchener and Lynch 2000). Mainland Norway is also free from pathogens of concern such as Rabies and *Echinococcus multilocularis* (Davidson et al. 2010; Wahlstöm et al. 2011). This is the first licensed reintroduction of a wild mammal sourced from outside the UK and provides a good example of the 'One Health'

Published online: September 21, 2016

Correspondence to: Gidona Goodman, e-mail: gidona.goodman@ed.ac.uk

principle, with the involvement and sharing of information between biologists, ecologists, veterinarians, local health departments and other stakeholders. The Research and Monitoring Co-ordination Group (RMCG) for the SBT was led by Scottish Natural Heritage (SNH) with a consortium of partners monitoring the socio-economic effects (Scottish Rural College), impact on habitat (University of Stirling and James Hutton institute), impact on mammals, fish and plant ecology (University of Oxford, Argyll Fisheries Trust and the University of Stirling), beaver health (University of Edinburgh) and public health (Argyll and Bute Council). The group met and reported annually to SNH, and during the monitoring period veterinary findings of zoonotic relevance, such as cryptosporidium, were reported directly at biannual stakeholder meetings and to public health authorities. The health monitoring and surveillance programme was set up to ensure that reintroduced beavers were healthy/fit for release, with no significant diseases of risk to livestock, wildlife or to human health, both at release and during the course of the five-year trial. The IUCN Guidelines for Reintroduction and other Conservation translocations (2013), and subsequently the Scottish Code for Conservation Translocations (2014), provided guidance for best practice.

The pre-release phase included a 6-month UK statutory rabies quarantine period, full clinical examination under general anaesthesia and robust disease screening (Goodman et al. 2012). Although the disease risk analysis did not follow the guidelines that have since been published (IUCN/OIE 2014a, b) as they should be in any future translocation, they did follow the IUCN guidelines at the time for rodents (Woodford 2000). The potential diseases of risk incorporated into the pre-release health screening were based on IUCN guidelines, UK government recommendations (Department of Environment, Food and Rural Affairs) and public health concerns relating to rabies, giardiasis and tularaemia. The risk of introducing certain pathogens, such as rabies and *E. multilocularis* (which at the time, no recognised ante mortem diagnostic tests existed, Gottsetin et al. 2014; Campbell-Palmer et al. 2015), were minimised by sourcing animals from areas free of such notifiable diseases. Animals were transported to the UK following one-month quarantine in Norway and then placed in specially designated quarantine facilities in the UK. The UK legislation at the time required imported beavers to be placed in approved rabies quarantine facilities for six months. The death of six animals (37.5%) during this quarantine period with no common cause of death identified led to a request to the Scottish Government veterinary advisors to allow for a reduced quarantine period [under the rabies (importation of dogs, cats and other mammals) (England) (amendment) order 2004], which permits the import of rodents to zoos and research institutes without rabies quarantine. Subsequently, four animals were imported to Scotland following veterinary certification by an official Norwegian Food and Safety (Mattilsynet) veterinarian declaring them rabies-free (trapped within a rabies-free area and not exhibiting any clinical signs of rabies following one-month quarantine in Norway). Post-release health surveillance by SBT field staff consisted of regular observations of body condition and behaviour, annual trapping of individual animals in order to weigh, assess body condition and collect biological samples (faecal and blood, if a veterinarian was present).

Faecal samples during pre-release screening were negative for zoonotic enteric bacterial pathogens. Eight animals prior to release were seropositive for *Leptospira* spp. antibodies (serovars *L. saxkoebing, L. canicola, L. copenhageni*, *L. icterohaemorrhagiae*, *L. autumnalis* and *L. javanica*). All the serovars tested are already present in the UK. Two of these individuals tested seropositive again post-release, one with seropositivity to two new serovars *L. ballum* and *L. javanica.* The two individuals belonged to two different families located in separate locations. A previous study in the Netherlands revealed that leptospirosis was a major contributor to the cause of death in beaver translocation (Nolet et al. 1997). None of the animals in this trial had clinical signs associated with leptospirosis. Neither *Giardia* spp. nor *Cryptosporidium* spp. were detected pre-release, although one kit born in Scotland tested positive for *Cryptosporidium* oocysts on a faecal sample obtained at post-mortem. No significant increase in the prevalence of *Cryptosporidium* oocysts or *Giardia* cysts were found in any of the watercourses within the trial site ($\sim$44 km^2 area of land in total) during the course of monitoring (Mackie 2014). Neither was there any related incidence of human cases of cryptosporidium in the area (Mackie 2014).

Two helminth species were identified in pre- and post-release faecal screening. Six animals were positive for *Travassosius rufus* and/or beaver fluke (*Stichorchis subtriquetrus*). Both these species have been recorded in beaver reintroductions throughout Europe, particularly the beaver fluke (Sweden—Ahlen 2001; Czech Republic—Koubková et al. 2002; Poland—Drózdz et al. 2004; Croatia—Sager et al. 2005; Slovenia—Vengušt et al. 2009). Two kits born during the trial were also positive for beaver fluke further

indicating that the beaver fluke has completed its life cycle in the wild, with an aquatic snail as its intermediate host (Khalil 1922). The animals were not treated for this parasite as no known effective treatment had been reported in beavers at the time and it is not deemed pathogenic under normal circumstances and the fluke is specific to beavers (Goodman et al. 2011). In addition, it is likely that the parasite has already been introduced by previous importation of beavers by landowners and zoological collections, and has been recorded in wild beavers (outside of the official trial reintroduction) within the River Tay catchment (Campbell-Palmer et al. 2013). The other parasite inadvertently reintroduced with the SBT beavers was the beaver beetle *Platypsyllus castoris Ritsema* (Duff et al. 2013).

Mortalities have been reported in other beaver reintroductions and translocations (Nolet et al., 1997; Bajomi, 2011). In the present study, six animals died during the UK Rabies quarantine period. One adult female had an infected anal gland and colitis. No pathogens were isolated from either organ. *Escherichia coli* was isolated from the intestine and liver of a male kit with an inflammatory reaction in the small intestines. One adult female had a meningitis/encephalitis but no significant bacteria were cultured. An adult male had osteomyelitis of the coccygeal vertebra (*Arcanobacterium pyogenes* isolated) and liver necrosis. In two individuals, no primary cause could be identified, this included an autolysed female kit from which no pathogens were isolated and a juvenile female in poor body condition with heavy loads of *S. subtriquetrus* parasitism. It is not possible to state conclusively whether the quarantine conditions specifically caused the death of these individuals; but very few animals seemed to thrive during the quarantine process. On average, most beavers lost bodyweight and condition between their capture in Norway and their subsequent release in Scotland (Jones and Campbell-Palmer, 2014). Rabies quarantine conditions are challenging for wild-caught animals. Balancing appropriate husbandry and environmental conditions favourable for captive beavers (diggable substrate, deep water, large amounts of browse for lodge construction) with quarantine requirements such as waste disposal and daily observations, along with the close proximity to humans, were most likely stressful and may compromise immune systems. In the wild, beavers consume a wide range of plants, and exhibit seasonal and spatial variations, which are hard to replicate in captivity. Two animals died shortly after release. One male died 24 h after release with lung, liver and kidney congestion suggestive of sub-acute circulatory failure, but with no evidence of infection or degenerative disease. The second, an adult male died several weeks post-release in poor body condition, most likely due to a failure to adapt to his new environment, no stomach contents were found. Autolysis of the carcass prohibited histological and microbiological examination to determine any other underlying contributing factors to his death.

A total of fourteen wild-born beavers were recorded. Two kits (in separate years) were predated, eight went missing before they were one year old and are almost certainly dead. In comparison with other reintroductions (across taxa), post-release mortality, based on known deaths, was low (Harrington et al., 2015).

The creation of a research and monitoring group including not only field staff, biologists and ecologists but also veterinarians and public health officials who assisted the beaver health monitoring component in several ways. Access to ecological data and field team observations supported the interpretation of the animal health data (Goodman, 2014). It facilitated direct communication between animal and public health stakeholders when animals tested positive for zoonotic pathogens such as cryptosporidium. It also eased the approach to governmental bodies to pragmatically amend policy (such as Rabies Order) and inform the government to allow it to make a policy decision on the future of beavers in Scotland (Scottish Natural Heritage, 2015).

Acknowledgments

Christian Robstad and Robert Needham—trapping and field work; Pia Paulsen and Jan Egil Aronsen—Norwegian vets; Donna Brown and Romain Pizzi—RZSS; Justine Armstrong, Alison Barr and Fiona Campbell—Dalriada Veterinary Surgery, local vets; Simon Jones—Scottish Wildlife Trust and Scottish Beaver Trial; Jorge Del-Pozo R(D)SVS—pathology.

References

Ahlen PA (2001) The parasitic and commensal fauna of European beaver (*Castor fiber*) in Sweden. Thesis in forestry, ecology and management. Uppsala: Swedish University of Agricultural Sciences, Department for Forestry, Ecology and Management.

Bajomi B (2011) *Reintroduction of the Eurasian beaver (Castor fiber) in Hungary*. Report to the Directorate of Duna-Dráva National Park, Budapest. Available: http://www.danubeparks.

org/files/792_BeaverReintroductionHungary.pdf. Accessed October 14, 2015.

Campbell-Palmer R, Girling S, Pizzi R, Hamnes I, Oines S, Del-Pozo J (2013) *Stichorchis subtriquetrus* in a free leaving beaver in Scotland. *Veterinary Record* 173:72

Campbell-Palmer R, Del-Pozo J, Gottstein B, Girling S, Cracknell J, Schwab G, Rosell F (2015) Pizzi R (2015) *Echinococcus multilocularis* detection in live Eurasian beavers (*Castor fiber*) using a combination of laparoscopy and abdominal ultrasound under field conditions. *Plos One* 10(7):e0130842 [online July 13]. doi:10.1371/journal.pone.0130842

Davidson R, Øines Ø, Norström M (2010) The surveillance and control programme for *Echinococcus multilocularis* in red foxes (*Vulpes vulpes*) in Norway. Annual report 2009. In: *Surveillance and Control Programmes for Terrestrial and Aquatic Animals in Norway*, Karlsson AC, Jordsmyr HM, Hell-berg H, Sviland S (editors), Oslo: National Veterinary Institute

Department for Environment Food and Rural Affairs (DEFRA). Notifiable diseases. Department for Environment Food and Rural Affairs, Animal health. Available: http://www.defra.gov.uk/ahvla-en/disease-control/notifiable/. Accessed October 14, 2015.

Department for Environment Food and Rural Affairs (DEFRA). Imports/Exports Animals and Animal products. Available: http://www.defra.gov.uk/animal-trade/imports-non-eu/iins/live-animals/iins-other-animals-balai/iin-bllv-5/. Accessed October 14, 2015.

Drózdz J, Demiaszkiewicz A, Lachowicz J (2004) Endoparasites of the beaver *Castor fiber* (L.) in northeast Poland. *Helminthologia* 41:99–101

Duff A, Campbell-Palmer R, Needham R (2013) The beaver beetle *Platypsyllus Castoris Ritsema* (Leiodidae: Platypsyllinae) apparently established on reintroduced beavers in Scotland, new to Britain. *The Coleopterist* 22:9–19

Gaywood M (2014) European beaver. Version 1.0. In: *The Species Action Framework Handbook*, Gaywood MJ, Boon PJ, Thompson DBA, Strachan I (editors), Battleby: Scottish Natural Heritage

Goodman G, Campbell-Palmer R, Meredith A (2011) To treat or not to treat parasites in conservation projects *Stichorchis subtriquetrus* in Eurasian beaver (*Castor fiber*) as an example of host- parasite reintroduction. Proceedings of the 7th International Symposium on Wildlife Fauna. Edinburgh, p 247.

Goodman G, Girling S, Pizzi R, Meredith A, Rosell F, Campbell-Palmer R (2012) Establishment of a health surveillance program for reintroduction of the Eurasian beaver (*Castor fiber*) into Scotland. *Journal of Wildlife Diseases* 48:971–978

Goodman G (2014) The Scottish beaver trial: veterinary monitoring of the Knapdale beaver population 2009-2014. Available: http://www.snh.gov.uk/docs/A1450714.pdf. Accessed October 14, 2015.

Gottstein B, Frey CF, Campbell-Palmer R, Pizzi R, Barlow A, Hentrich B (2014) Immunoblotting for the serodiagnosisi of alveolar echinococcus in live and dead Eurasian beavers (*Castor fiber*). *Veterinary Parasitology*. doi:10.1016/j.vetpar.2014.06.017

Harrington LA, Feber R, Raynor R, Macdonald DW (2015) *The Scottish Beaver Trial: Ecological monitoring of the European beaver Castor fiber* and other riparian mammals 2009–2014, final report, Report No: Scottish Natural Heritage Commissioned

IUCN/SSC (2013) Guidelines for reintroductions and other conservation translocations. Version 1.0. IUCN Species Survival Commission, Gland, Switzerland. https://portals.iucn.org/library/sites/library/files/documents/2013-009.pdf. Accessed October 14, 2015.

IUCN/OIE Manual of procedures for Wildlife Disease Risk Analysis (2014). Available: at:http://www.cbsg.org/sites/cbsg.org/files/documents/IUCN%20Wildlife%20DRA%20Manual%20PUBLISHED%202014_0.pdf. Accessed March, 2016.

IUCN/OIE Guidelines for Wildlife Disease Risk Analysis (2014). Available: http://www.iucn-whsg.org/sites/default/files/IUCN-OIE%20Guidelines%20to%20Wildlife%20Disease%20Risk%20Analysis.pdf. Accessed March, 2016.

Jones S, Campbell-Palmer R (2014) The Scottish Beaver Trial: The story of Britain's for licenced release into the wild. Final report 014. Scottish Wildlife Trust and Royal Zoological Society of Scotland. Available: http://www.scottishbeavers.org.uk/beaver-facts/publications/. Accessed October 14, 2015.

Khalil M (1922) *Travassosius rufus*: a nematode (Trichostrongylidae) parasitic in the stomach of the Norwegian beaver. *The Annals and Magazine of Natural History* 10:281–289

Kitchener Lynch J (2000) A morphometric comparison of the skulls of fossil British and extant European beavers, *Castor fiber*. *Scottish Natural Heritage Review* 127:1–31

Koubková B, Baruš V, Koubek P (2002) *Stichorchis subtriquetrus* (Digenea:Cladorchidae) - back to the fauna of the Czech Republic after 200 years. *Helminthologia* 39:155–158

Mackie P (2014) Scottish beaver trial independent public health monitoring 2009–2014 report and recommendations. Available: http://www.snh.gov.uk/docs/A1450214.pdf. Accessed October 14, 2015.

Nolet BA, Broekhuizen S, Dorrestein GM, Rienks KM (1997) Infectious disease as main cause of mortality to beavers *Castor fiber* after translocation to the Netherlands. *Journal of Zoology* 241:35–42

Parker H, Rosell F, Holthe V (2000) A gross assessment of the suitability of selected Scottish riparian habitats for beaver. *Scottish Forestry* 54:25–31

Sager H, Konjević D, Grubešić M, Janicki Z, Severin K, Beck R (2005) *Stichorchis subtriquetrus* in European beaver from Croatia: first report. *European Journal of Wildlife Research* 51:63–64

Scottish Beaver Trial (2007) Trial reintroduction of the European beaver, to Knapdale, Mid-Argyll. Local consultation report 1 October–30 November 2007. www.scottishbeavers.org.uk/…/SBT2007_ConsultationReport_Dec07.pdf. Accessed March 23, 2016.

Scottish Natural Heritage (1998) Scott Porter Research & Marketing 1998. Reintroduction of European beaver to Scotland: results of a public consultation. SNH Research, Survey and Monitoring 121, Battleby.

Scottish Natural Heritage (2014) National Species Reintroduction Forum. The Scottish Code for Conservation Translocations. Available: www.snh.gov.uk/protecting-scotlands-nature/reintroducing-native-species/scct/. Accessed October 14, 2015.

Scottish Natural Heritage (2015) Beavers in Scotland: a report to the Scottish Government. Available: http://www.snh.org.uk/pdfs/publications/research/Beavers%20in%20Scotland%20-%20Final%20-%2010%20June%202015.pdf. Accessed October 14, 2015.

Vengušt G, Bidovec A, Vergles Rataj A, Žele D (2009) *Stichorchis subtriquetrus* in two beavers (*Castor fiber*) from Slovenia. *Helminthologia* 46:59–61

Wahlstrom H, Isomursu M, Hallgren G, Christensson D, Cedersmyg M, Wallensten A (2011) Combining information from

surveys of several species to estimate the probability of freedom from *Echinococcus multilocularis* in Sweden, Finland and mainland Norway. *Acta Veterinaria Scandinavica* 53:9

Webb A, French D, Flitsch A (1997) Identification and assessment of possible beaver sites in Scotland. Scottish Natural Heritage Research, Survey & Monitoring 94, Battleby.

Woodford MH (2000) Quarantine and Health Screening Protocols for Wildlife prior to Translocation and Release into the Wild. Published jointly by the IUCN, Gland, Switzerland, OIE, Paris, France, Care for the Wild, UK, and EAWV.