Importance of lethal control of invasive predators for island conservation

James C Russell[1,2]; Holly P Jones[3]; Doug P Armstrong[4]; Franck Courchamp[5]; Peter J Kappes[6]; Philip J Seddon[7]; Steffen Oppel[8]; Mark J Rauzon[9]; Phil E Cowan[10]; Gerard Rocamora[2]; Piero Genovesi[11]; Elsa Bonnaud[5]; Bradford S Keitt[12]; Nick D Holmes[12]; Bernie R Tershy[13]

[1] School of Biological Sciences, University of Auckland, Private Bag 92019, Auckland, New Zealand

[2] Island Biodiversity & Conservation Center, University of Seychelles. Anse Royale.

[3] Department of Biological Sciences and Institute for the Study of the Environment, Northern Illinois University, DeKalb, Illinois, USA

[4] Wildlife Ecology Group, Institute of Natural Resources, Massey University, Palmerston North, Private Bag 11 222, New Zealand

[5] Ecologie Systématique Evolution, Université Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, 91400, Orsay, France

[6] Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97330, USA

[7] Department of Zoology, University of Otago, PO Box 56, Dunedin, New Zealand

[8] RSPB Centre for Conservation Science, Royal Society for the Protection of Birds, The Lodge, Sandy, Bedfordshire SG19 2DL, UK

[9] Laney College, Geography Department, Oakland, California 94607, USA

[10] Landcare Research, PO Box 69040, Lincoln 7640, New Zealand

[11] Institute for Environmental Protection and Research, and Chair IUCN SSC Invasive Species Specialist Group, Via V. Brancati 48, I-00144 Rome, Italy

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[12] Island Conservation, 2161 Delaware Ave Ste. A, Santa Cruz, CA 95060, USA

[13] University of California Santa Cruz, 100 Shaffer Road, Santa Cruz, California 95060, USA

We support the call of Wallach et al. (2015a) for a compassionate approach to conservation, and agree that any lethal control must be justified by a high probability of conservation gains and supported by relevant stakeholders. We believe that lethal control of invasive predators is justified when it will reverse the negative impacts of predators introduced by humans on native species and ecosystems, and when the extent of that predation endangers the survival of entire populations or species. Globally a few key introduced predator species are having disproportionately large effects on island ecosystems and their constituent species (e.g. Towns et al. 2006; Medina et al. 2011). Where invasive predators are killed to achieve conservation goals, we believe this can come from compassion for all of the ecosystem, its species, the individuals being protected, and the invasive animals themselves. This view is well supported by literature and policies relating to the role of animal welfare, animal rights, and environmental ethics in pest control programmes (e.g. Gunn 2007; Dunlevy et al. 2011).

When effective biodiversity conservation tools are available we believe the morally appropriate and compassionate choice is to take action, rather than inaction, despite those actions sometimes being perceived as unpalatable (e.g. Seddon et al. 2014). Such interventions are often critical to prevent endangered species from going extinct, which is the foundation of conservation biology (Soulé 1991). In some cases, lethal control is the most ethical and compassionate course of action. For example, on the islands of Uist, introduced hedgehogs (*Erinaceus europaeus*) were killing native bird species, and were the primary

agent of bird declines. An analysis of potential non-lethal and lethal control alternatives found lethal control to be the most humane option for the hedgehogs overall (Uist Wader Project 2002). Ultimately, however, preventing the arrival and spread of invasive species on islands through appropriate biosecurity measures would avoid the need to manage or remove those species, and would therefore represent the most compassionate approach, as Wallach et al. (2015a) demonstrate on Middle Island (Victoria, Australia). This prevention approach is advocated most strongly by groups such as the IUCN Invasive Species Specialist Group.

The principle of 'do no harm' should always underpin any comparison of possible conservation interventions. However, deciding to 'do nothing' is in itself an action, and like the decision to implement lethal control, it will determine which animals will die, how many will die, and how they will die. As a society, and as conservation practitioners, we can have a say in how humane any deaths may be. Although action and inaction may not be ethically equivalent, the consequences of inaction can be disastrous (Maguire 1991), and taking no action today is a tacit acceptance of historical human actions, including introduction of species that later became invasive (Russell 2012). Recognizing this context for decisions influences what sort of ecosystems are conserved in the long term, and the manner of the lives and deaths of the species, populations, and ecosystems under our stewardship. Being compassionate might mean 'not killing' but can also mean preventing invasive species from killing. If native species conservation cannot be achieved by non-lethal control of invasive predators, then taking no action against invasive predators is unethical.

In their essay and elsewhere (Wallach et al. 2015b) Wallach and colleagues focus largely on the continental context of predators and their control, where top-down regulation, typically by native predators, is common (Estes et al. 2011). This is in stark contrast to many

island ecosystems, where mammalian predators are generally absent (Blumstein 2002), and ecosystem regulation is naturally bottom-up (Polis and Strong 1996). Introduction of mammalian predators to such islands has resulted in most vertebrate extinctions over the past 500 years (Tershy et al. 2015). On islands, lethal control does not indicate a desire to disregard the ecological role of predators, nor to revert the ecosystem to a pre-human state, but rather to re-establish natural ecological processes and rates to the extent possible, such as native species colonisation, extinction, turnover and interactions. Restoration of such natural processes is at the core of the duty conservation biologists assume (Soulé 1985).

In response to the overwhelming impact of invasive mammalian predators on island ecosystems (Blackburn et al. 2004), conservation practitioners have implemented eradication programmes to conserve threatened species and populations and to restore island ecosystem functioning. Decades of evidence from island eradication and restoration programmes consistently demonstrate that well-implemented lethal control programmes achieve biodiversity benefits (Lavers et al. 2010; Veitch et al. 2011; Rocamora & Henriette 2015; Towns et al. 2016). Had practitioners and society decided not to eradicate invasive mammals from islands, many more endemic species would have become extinct (Butchart et al. 2006). Deciding not to remove or control invasive species on islands where they negatively affect native species would, in effect, be in conflict with the founding principle of compassionate conservation to ‘do no harm’. Furthermore, all costs, inclusive of financial, social and ethical, can be minimised by a single eradication program, rather than ongoing control (Pascal et al. 2008). Conservation scientists and managers are continually developing new effective and humane tools that improve island restoration (Cowan and Warburton 2011; Campbell et al. 2015).

Balancing individual welfare considerations and conservation goals is, in part, a classic multi-criterion decision problem. In such situations, the final decision often strongly depends on the values placed on different objectives. People's different values can create strong differences of opinion and associated predictions about the consequences of management actions. For example, people who strongly value the welfare of invasive predators may place less weight on evidence of biodiversity benefits gained by controlling those predators (Howald et al. 2010). Conversely, people who strongly value native biodiversity might underestimate the suffering experienced by individual invasive predators. Unbiased evidence is critical to decision making; however, it is not the role of scientists to tell people what their values should be. Formal decision analysis is useful because it helps distinguish the roles of values and science and allows both to be incorporated in the process (Gregory et al. 2012). In a predator-control decision, the optimal management option will depend on the predicted benefits, including for biodiversity and welfare , but will also depend on the relative value people put on those and other benefits and impacts. Carefully considering the values of stakeholders is therefore as important as evaluating the available scientific evidence (Moon et al. 2015).

Compassion is important in all aspects of conservation, but a robust environmental ethic must recognise and incorporate all levels of ecological organisation (Norton 1982). We agree with Wallach et al.'s call for compassion as a consideration in conservation decision making, and believe it can be readily incorporated into decision making frameworks for predator control. Such frameworks must necessarily balance multiple values such as ecosystem health, animal welfare and social justice (Redpath et al. 2013; Shoreman-Ouimet and Kopnina 2015). We must accept the ethical duty and responsibility humans have towards other species, whether invasive or native, and acknowledge that any conservation action,

including doing nothing, represents a decision affecting species and ecosystems reflecting multiple value judgements.

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