Investigating non-anthropocentric approaches to human-animal interactions in science: towards improved welfare of animals used in wildlife research

by

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B.Sc., University of Victoria, 2016

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Abstract

Drawing on anthropocentric, ecocentric and biocentric worldviews, I examine the use of research animals as a case to investigate human-animal interactions in science. Specifically, I investigate a case of potential tensions between eco- and biocentric worldviews by examining oversight mechanisms of animal care during research. Despite abundant focus on responsible care of laboratory animals, I argue that inattention to the treatment of wildlife constitutes an ethical shortcoming in contemporary animal research. I review significant shortcomings in legal and institutional oversight and argue for the relatively rapid and transformational potential of editorial oversight in preventing inhumane treatment to vertebrates studied in the field and outside the direct supervision of institutions. Straightforward changes to animal care policies in journals, which the analysis of 206 journals suggests are in many cases absent (34%), weak, incoherent, or neglected by researchers, could provide a practical, effective, and rapidly imposed safeguard against unnecessary suffering. The ARROW (Animal Research: Reporting on Wildlife) guidelines, an original contribution to the present work, coupled with strong enforcement, could result in significant changes to how animals involved in wildlife research are treated. The research process would also benefit. In many cases, reliability, validity, and replicability of data requires animal subjects to be physically, physiologically, and behaviorally unharmed. Accordingly, publication of methods that contravenes animal welfare principles risks perpetuating inhumane approaches and bad science. I conclude by assessing whether paradigms have shifted from anthropocentric to non-anthropocentric approaches to interacting with animals in research, and offer practical and conceptual suggestions for ensuring humane human-animal interactions.

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Contributions

Chapter two of this thesis was co-authored. The following outlines my contributions, and that of each of the authors. I also provide the publication status of the chapter.

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KF developed the concept of the work, collected the data, conducted the analyses, and prepared the manuscript for publication. CD and PP contributed to developing the concept of the work. KA contributed to the analysis. PP, KA, GP, RB and CD contributed to the concept and provided edits and advice on the manuscript.

Dedication

For the 733 wolves (*Canis lupus*), 91 ravens (*Corvus corax*), 36 coyotes (*C. latrans*), 31 red foxes (*Vulpe vulpes*), 4 American martens (*Martes americana*), 3 lynx (*Lynx canadensis*), 2 weasels (*Mustela spp*.), 2 fishers (*Pekania pennanti*), and wildlife whose mortalities went undetected in Hervieux et al. (2014).

1. Introduction and Research Context

"The question is not, can they *reason*? Nor, can they *talk*? but can they suffer?"

–Jeremy Bentham

1.1 Introducing and contextualizing anthropocentric, ecocentric and biocentric worldviews

The ways in which humans (*Homo sapiens*) interact with non-human animals (herein referred to as animals) depends largely on various forms of moral extensionism. Whereas an anthropocentric or human-centered worldview gives humans preeminence above all other entities, ecocentrism affords primary value to nature and ecosystems (Callicott, 1985). Biocentrism, like ecocentrism, is a non-anthropocentric worldview that attributes moral standing to nature, but differs from ecocentrism in the scale of its concern: biocentrism endorses a life-centered worldview that affords *prima facie* moral obligations to non-human individuals (Taylor, 1986), that is, the rights and welfare of animals rather than nature and ecosystems more broadly (Callicott, 1985). Intrinsic dichotomies between anthropocentric and non-anthropocentric worldviews present practical and political challenges to managing human-animal interactions. Additionally, tensions between the non-anthropocentric worldviews of biocentrism and ecocentrism persist.

In the following sections of this chapter, I draw on anthropocentric, ecocentric and biocentric worldviews to examine human-animal interactions, using research animals as a case study. I discuss biomedical research, conservation biology, and animal welfare science using anthropocentric, ecocentric, and biocentric lenses, respectively. Notwithstanding intrinsic linkages between eco- and biocentric worldviews, I articulate profound theoretical differences

between them. Finally, I provide an overview of the historical context for the use of research animals. Throughout, I identify conceptual and practical gaps in what should constitute humane human-animal interactions.

In chapter two, I examine a case of potential tension between eco- and biocentric worldviews by investigating oversight mechanisms of animal care during wildlife research. I offer a data-driven argument for policy reform to safeguard wild animals from researcher harm. One particular example of inhumane methods pursued in contemporary research "inspired" the data chapter as a response to moral urgency for reform.

In the concluding chapter, I assess whether and to what extent paradigms have shifted from anthropocentric to non-anthropocentric approaches to interacting with animals for scientific purposes. In denial of human superiority (Taylor, 1986), I argue that humane interactions between humans and animals requires an erosion of speciesism—a philosophical prejudice against animals (Ryder, 1970)—and anthropocentric worldviews informing human perceptions of, and behaviour towards, animals used in research. I emerge by articulating commonalities of non-anthropocentric worldviews—eco- and biocentrism—to converge their common elements in support of compassionate conservation (Bekoff, 2013; Ramp & Bekoff, 2015; Wallach et al., 2015; Wallach et al., 2018) outcomes.

In this thesis, I refer to both animal rights and animal welfare, where animal rights refers to philosophical claims about the status and moral worth of animals, and animal welfare refers to fitness, that is, the physical, behavioural and psychological health of animals.

1.2 Tensions between and within anthropocentric and non-anthropocentric approaches to human-animal interactions in research

Anthropocentrism, ecocentrism, and biocentrism in practice may be illuminated by biomedical research, conservation biology, and animal welfare science, respectively. The endorsement of anthropocentric or non-anthropocentric worldviews by each discipline is evidenced by the disciplines' focal beneficiaries of research outcomes. That is, humans, populations/ecosystems, and individual animals are the primary beneficiaries of biomedical research, conservation biology and animal welfare science, respectively. The most apparent divide between anthropocentric and non-anthropocentric research disciplines is the use of animals, who are not the beneficiaries of research outcomes, for the benefit of humans. The non-anthropocentric disciplines of conservation biology and animal welfare science, therefore, are conceptually and practically distinct from biomedical research, linked by their value-laden assumptions that afford moral worth to non-humans.

Discrepancies *within* non-anthropocentric approaches to science also exist. As a key example, the concerns of conservation biology practitioners and animal welfare scientists are conceptually distinct. This distinction lies in the scales at which their concern for animals is applied: conservationists prioritize the ecological integrity of populations and ecosystems, while animal welfare scientists are primarily concerned with individuals and the suffering they are capable of enduring (Paquet & Darimont, 2010). Therefore, a clash between individualism (welfare) and holism (conservation) exists. This represents a conceptual gap, which has been thoroughly discussed in the literature (e.g., Fraser, 2010; Paquet & Darimont, 2010), and spurred debate among conservationists (compassionate or otherwise) (e.g., Driscoll & Watson, 2019), whom in theory share common non-anthropocentric worldviews. Uniting non-anthropocentric

approaches to science may facilitate the ability of practitioners of each field to achieve common goals, thus attempting to fill this gap.

1.3 Paradigm shifts in animal use for science: a historical overview of practice and policy

Human-animal interactions in scientific research have historically been dominated by an anthropocentric worldview. The earliest records of animal experimentation were those conducted by Greek physician-scientists Alcmaeon of Croton (6th–5th century BC), Aristotle (384-322 BC), and Erasistratus (304-258 BC) (Franco, 2013; Hajar, 2011). The use of live animals for experimentation did not raise ethical or moral concerns during the era of their works, given the largely accepted higher ranking of humanity in *scala naturae* ("the chain of being") (Franco, 2013). This view of human superiority largely informed later dominant Judeo-Christian perspectives of dominion of nature. Dominionistic perspectives were distinct in texts of Augustine of Hippo, who proclaimed that animals were part of a natural world created to serve humans with no reciprocal component to this relationship (Franco, 2013). Early capitalism, modern science, and the emergence of Protestantism converged to diminish any lingering deification of nature (Armstrong & Botzler, 2016, p. 3), and thus animals.

Perhaps owing to these perspectives, the notion that animals feel pain has been widely dismissed or ignored by scientists. René Descartes (1596-1650) likened the cries of animals to "the ticking of a clock, no more" (Orlans, 1993, p. 4). Orlans (1993) describes vivisection—surgery preformed on live animals for the purpose of experimentation—that would be "impermissible by today's standards" (p. 13), including administering nux-vomica (a dried seed extract comprised mainly of strychnine) to examine whether the well-known convulsions it causes would still occur after severing dorsal and ventral roots of the spinal chord (p. 7). Claude

Bernard (1813-1878) had administered curare to frogs (*Rana* spp.), rabbits (*Oryctolagus* spp.), and dogs (*Canis lupus familiaris*), and subsequently dissected out their nerve and muscle systems. From this work emerged an understanding of how nerve impulses are transmitted and how they can be blocked. It was derived, however, at the cost of excruciating suffering of research animals. Bernard (1865) wrote, "…it is essentially moral to make experiments on an animal, even though painful and dangerous to him, if they may be useful to man." Such perspectives plainly exhibit anthropocentric worldviews and still persist in some form today.

Not everyone supported such behaviour, as the case of vivisection illustrates. The anti-vivisection movement, considered "an ancestor" of the animal liberation movement (Armstrong & Botzler, 2016, p. 6), was pivotal for improving animal rights and welfare. In contrast to the humane movement championed by the Royal Society for the Prevention of Cruelty to Animals, the anti-vivisection movement "challenged an entire institution" (Finsen & Finsen, 1994, p. 38, as cited in Armstrong & Botzler, 2016). Confronting institutionalized standards represented transformative action in support of oversight of the treatment of research animals.

Organized concern for the treatment of research animals was integral to the development of oversight mechanisms. Of the earliest examples, the first legislation to regulate the use of animals in research was enacted under the 1867 Cruelty to Animals Act in England. Shortly thereafter, the 1871 British Association for the Advancement of Science stated, "[n]o experiment which can be performed under the influence of an anesthetic ought to be done without it" (Orlans, 1993, p. 16). Several revolutionary milestones coincided with increased organized concern for, and oversight of, animal rights and welfare. The Industrial Revolution alleviated 'the beast' from many aspects of physical labour. Abolitionists were often the same players supporting momentum of the animal liberation movement (Armstrong & Boltzer, 2016).

Romanticism of nature harnessed a shift from the notion that wilderness and wild animals must be tamed, to one that endorsed human bonds with nature and wilderness areas (Mishori, 2017). More recently, in the 1970s the International Fund for Animal Welfare broadened to include wildlife, while the United States Animal Welfare Act strengthened in 1985 to require field research protocols be subject to Institutional Animal Care and Use Committee (IACUC) review.

Though the perceived moral precipice between humans and animals has indeed shrunk, they are not yet on equal footing. The continuity of biological function between humans and other animals gained acceptance with Charles Darwin's influence following his works: *The Descent of Man* and *The Expression of the Emotions of Man and Animals* (Fox, 1986). Nonetheless, an anthropocentric worldview persists to encompass human-animal interactions in research. For example, researchers remained unsure into the 1980s as to whether animals experience pain, and veterinarians trained in the United States prior to 1989 were trained to *ignore* animal pain (Rollin, 1989, as cited in Nurunnabi, 2013). Moreover, there is still debate in the literature around whether fish feel pain (Brown, 2016), despite increasing anatomical, pharmacological, and behavioural evidence that suggests pain, fear, and stress are experienced by fish in similar ways as in tetrapods (i.e., Class Amphibia, Reptilia, Aves, Mammalia) (Chandroo, Duncan, & Moccia, 2004). Similarly, cephalopod research was only recently acknowledged as warranting animal care review. With the knowledge that cephalopods exhibit motivational states and cognitive capabilities consistent with functional parallels to pain (Andrews et al., 2013; Crook & Walters, 2011), oversight of their use for research has been deemed necessary in a handful of countries, but not globally (Staaf, 2018).

Oversight of human-animal interactions in research has been largely informed by lines of inquiry regarding animal husbandry in laboratory settings to mitigate behavioural and

physiological harm. Indeed, the concept of animal welfare was traditionally centered on acts of cruelty and neglect directed toward domestic or captive animals (Fraser, 2010). Whereas extensive guidelines (e.g., National Research Council, 2011) are endorsed and recognized by the scientific community as a contemporary cultural norm, guidance for the care and use of wild research animals has received far less attention (Paul et al., 2016). This represents a notable and significant gap in what should constitute humane human-animal interactions in research.

Ethical frameworks for human-animal interactions in science can guide humane interactions in and out of the laboratory. As bioethics provides critical intellectual and problem-solving services to the biomedical community, ecological ethics can help inform ethical decision making in ecology and conservation communities (Minteer & Collins, 2008). Whereas discussion exists in the literature around ecological ethical frameworks, incorporation of such frameworks to inform decision-making tools is rare, and innovative mechanisms for incorporating compassion into wildlife research are in short supply. As discussed earlier in this chapter, challenging institutional standards can result in transformative action toward improved oversight of animal care. In the following chapter, I propose improvements for the humane treatment of animals studied in the wild. My objective is to identify shortcomings in policies governing the use of animals for scientific purposes. I then provide a resource that may contribute to refining practical decision-making tools when using animals during wildlife research.

References

Andrews, P. L., Darmaillacq, A. S., Dennison, N., Gleadall, I. G., Hawkins, P., Messenger, J. B., ... & Smith, J. A. (2013). The identification and management of pain, suffering and distress in cephalopods, including anaesthesia, analgesia and humane killing. *Journal of Experimental Marine Biology and Ecology*, *447*, 46-64.

Armstrong, S. J., & Botzler, R. G. (2016). Animal ethics: A sketch of how it developed and where it is now. In S. J. Armstrong & R. G. Botzler (Eds.) *The animal ethics reader* (pp. 1-12). Taylor & Francis.

Attfield, R. (1999). *The ethics of the global environment*. Edinburgh: Edinburgh University Press.

Bentham, J. (1781). *An introduction to the principles of morals and legislation.* McMaster University Archive for the History of Economic Thought.

Bekoff, M. (Ed.). (2013). *Ignoring nature no more: The case for compassionate conservation*. University of Chicago Press.

Brown, C. (2016). Fish pain: An inconvenient truth. *Animal Sentience: An Interdisciplinary Journal on Animal Feeling*, *1*(3), 32.

Callicott, J. B. (1980). Animal liberation: A triangular affair. *Environmental Ethics, 2*(4), 311-338.

Callicott, J. B. (1985). Intrinsic value, quantum theory, and environmental ethics. *Environmental Ethics 7*(3): 257-275.

Chan, K. M. A. (2011). Ethical extensionism under uncertainty of sentience: Duties to non-human organisms without drawing a line. *Environmental Values, 20*(3), 323-346. doi:10.3197/096327111X13077055165983

Chandroo, K. P., Duncan, I. J., & Moccia, R. D. (2004). Can fish suffer?: perspectives on sentience, pain, fear and stress. *Applied Animal Behaviour Science, 86*(3-4), 225-250.

Crook, R. J., & Walters, E. T. (2011). Nociceptive behavior and physiology of molluscs: animal welfare implications. *ILAR Journal*, *52*(2), 185-195.

Driscoll, D. A., & Watson, M. J. (2019). Science denialism and compassionate conservation: Response to Wallach et al. 2018: Compassionate conservation. *Conservation Biology, 0*(0), 1-4.

Fox, M. A. (1986). *The case for animal experimentation: An evolutionary and ethical perspective.* University of California Press.

Franco, N. (2013). Animal experiments in biomedical research: a historical perspective. *Animals, 3*(1), 238-273.

Fraser, D. (2010). Toward a synthesis of conservation and animal welfare science. *Animal Welfare, 19*(2), 121-124.

Hajar, R. (2011). Animal testing and medicine. *Heart Views: The Official Journal of the Gulf Heart Association, 12*(1), 42.

Key, B. (2016). Why fish do not feel pain. *Animal Sentience: An Interdisciplinary Journal on Animal Feeling, 1*(3), 1.

Minteer, B. A., & Collins, J. P. (2008). From environmental to ecological ethics: Toward a practical ethics for ecologists and conservationists. *Science and Engineering Ethics, 14*(4), 483-501. doi:10.1007/s11948-008-9087-0

Mishori, D. (2017). Environmental vegetarianism: Conflicting principles, constructive virtues. *The Law & Ethics of Human Rights, 11*(2), 253-284. doi:10.1515/lehr-2017-0008

National Research Council. (2011). Guide for the care and use of laboratory animals. Retrieved from https://grants.nih.gov/grants/olaw/guide-for-the-care-and-use-of-laboratory-animals.pdf

Nurunnabi, A. S. M., Afroz, R. D., & Alam, S. N. (2013). Ethical debate on animal research. *Bangladesh Journal of Bioethics, 4*(3), 11-18. doi:10.3329/bioethics.v4i3.17373

Orlans, F. B. (1993). *In the name of science: Issues in responsible animal experimentation. New* York: Oxford University Press.

Paul, E., Sikes, R. S., Beaupre, S. J., & Wingfield, J. C. (2016). Animal welfare policy: Implementation in the context of wildlife research—policy review and discussion of fundamental issues. *ILAR Journal, 56*(3), 312-334.

Paquet, P. C., & Darimont, C. T. (2010). Wildlife conservation and animal welfare: two sides of the same coin. *Animal Welfare, 19*(2), 177-190.

Ramp, D., & Bekoff, M. (2015). Compassion as a practical and evolved ethic for conservation. *BioScience, 65*(3), 323-327.

Rollin, B. E. (1989). *The unheeded cry: Animal consciousness, animal pain and science*. Oxford University Press.

Rolston, H. I. (1988). *Environmental ethics: Duties to and values in the natural world.* Philadelphia: Temple University Press.

Ryder, R. (1998). *The political animal: changing attitudes toward speciesism.* Oxford: Basil Blackwell.

Staaf, D. (2018). Humane studies of octopuses get a boost. *Science, 360*(6384), 14-15.

Taylor, P. W. (1986). *Respect for nature: A theory of environmental ethics.* Princeton, NJ: Princeton University Press.

Varner, G. E. (1998). *In nature's interests? Interests, animal rights, and environmental ethics.* Oxford, UK: Oxford University Press.

Wallach, A. D., Bekoff, M., Batavia, C., Nelson, M. P., & Ramp, D. (2018). Summoning compassion to address the challenges of conservation. *Conservation Biology*, *32*(6), 1255-1265.

Wallach, A. D., Bekoff, M., Nelson, M. P., & Ramp, D. (2015). Promoting predators and compassionate conservation. *Conservation Biology, 29*(5), 1481-1484.

2. Publication Reform to Safeguard Wildlife from Researcher Harm

2.1 Introduction

Scholarly journals can shape the behavior of researchers towards improved science and adherence to ethical standards. Editorial policies demanding open data and improved transparency, for example, encourage increased reproducibility in science (McNutt, 2014; Stodden, Seiler & Ma, 2018; Costello, Vanhoorne & Appeltans, 2015). Likewise, improving editorial standards for the just treatment of laboratory animals has come into sharp focus (Martins & Franco, 2015; Osborne, Payne & Newman, 2009). The welfare of vertebrates studied in the wild, however, has received less consideration despite the reality that wildlife research primarily occurs outside the direct supervision of research institutions. Moreover, whereas laboratory animals belong to only a handful of taxa, wildlife research can span physiological and behavioral variation across more than 60,000 vertebrate species (Paul, Sikes, Beaupre & Wingfield, 2016).

Herein, we describe how inattention to the just treatment of wildlife poses a significant problem in research ethics, but identify a potentially transformative route towards change. Analyzing data on animal care policies across 206 journals that commonly publish conservation and wildlife research, we reveal not only striking variation across journals and significant shortcomings of editorial oversight but also unrealized potential for change. Informed by patterns we reveal, we advocate for more robust animal care policy and strong enforcement by editors, reviewers, and scholarly societies with the aim of rapid change. Given that publishing is at the core of the academic reward system, we believe that this approach offers a practical and easily applied protection against mistreatment of wild research animals. To provide broader context and

to explain our focus on animal care policies, we also offer illustrative examples of how other layers of oversight, including legal and institutional, can fall short of safeguarding wildlife from researcher harm.

2.2 Why 'wildlife welfare' matters in wildlife science and conservation

Science provides information; it does not justify unethical behavior. Accordingly, values matter in the research process. In an agenda-setting article for the field of conservation biology, for example, a set of proposed postulates—a "normative set"— to systematize the field was centered on value-laden assumptions (e.g., "Biotic diversity has intrinsic value") (Soulé, 1985). Similarly, animal welfare science incorporates value-based assumptions about the moral significance of animals and their quality of life (Fraser, 2010). More broadly, the ethical appropriateness of animal suffering and killing in research has encouraged compelling scholarly dialogue and debate (Minteer & Collins, 2005; Paquet & Darimont, 2010; Wallach et al., 2018; Vucetich & Nelson, 2007). Some have argued that employing wildlife research methods without due consideration for the well-being of wildlife (herein referred to as 'wildlife welfare') is ethically untenable (e.g., Wallach et al., 2018). Although academic attention to wildlife welfare has been considerable, practical solutions towards rapid change (such as publication reform for which we advocate here) are rare.

Failure to consider wildlife welfare (Cattet et al., 2008) during research can harm not only individual animals but also the scientific process. In terms of harming animals, for example, Waugh and Manomy (2016) highlight how lethal sampling of free-swimming minke whales (*Balaenoptera bonaerensis*) via harpooning led to slow rates of death, suffering that could have been prevented with available non-lethal research approaches. Even non-lethal approaches, however, can cause harm. Capture and tagging of wildlife, common activities in wildlife

research, can impose physical handicaps that can last days to months, potentially compromising welfare, behaviour, fitness, and the reliability of data (Cattet et al., 2008; Saraux et al., 2011). Beyond animal welfare, sound science requires that animal subjects be unencumbered, physically, physiologically and behaviorally by harm; an individual's altered state can affect experimental and observational validity, reliability, and replicability (Garner, 2005). Accordingly, research methods that contravene animal welfare principles risk not only inhumane treatment of animals but also low quality science.

2.3 Existing oversight mechanisms and their shortcomings

Legal levels of oversight in theory provide enforceable direction to researchers but can fail. In some countries, the application of legislation to the care and use of wild research animals is not particularly clear (e.g., Mulcahy, 2003). For example, the United States Animal Welfare Act predominantly oversees the care and use of captive animals, and excludes studies from Institutional Animal Care and Use Committee (herein referred to as animal care committee) review if the study "…does not involve an invasive procedure, and which does not harm or materially alter the behavior of the animals under study." This exemption could compromise animal welfare; the terms "invasive," "harm" and "materially alter" are not defined and thus exposed to variable and subjective interpretation by researchers depending on their expertise, experience, and knowledge of physiological and behavioural indicators of pain and suffering (Paul et al., 2016; Mulcahy, 2003). Such uncertainty might be especially relevant to wildlife, which typically cannot be monitored as closely for harm as laboratory animals. Moreover, activities that cause mortality and morbidity, such as chemical immobilization (Nielsen, 1999), banding (Calvo & Furness, 1992) and capture (Catett et al., 2008), have been classified by some government agencies as not invasive, harmful, or materially altering of behaviour, thereby

granting them exemption (Mulcahy, 2003). Beyond ambiguity of what constitutes harmful methods in the US Animal Welfare Act, no legislation in the US governs who should perform surgeries on wild research animals, which have potential to be damaging if not executed meticulously (Mulcahy, 2003). By contrast, the European Union's Directive 86/609/EEC on the protection of animals used for scientific purposes regulates the use of animals, including (and explicitly) wildlife, through a systematic project evaluation requiring assessment of pain, suffering, distress, and lasting harm imposed on research animals (Buzek & Chastel, 2010).

Legal oversight can also vary within countries, which might limit clarity if fieldwork is conducted remotely from academic institutions. In Canada, the federal government does not have the jurisdiction to legislate research involving animals. Instead, animal care in research falls under provincial jurisdiction, which lacks regulatory consistency across the country. For example, whereas some provinces have legislation overseeing animal care in research (e.g., Nova Scotia), others merely endorse regulations (e.g., Alberta) (Canadian Council on Animal Care, n.d). Moreover, national standards for animal care in research, such as those suggested by the Canadian Council for Animal Care (CCAC), are inconsistently incorporated into provincial jurisdictions across the country (only five provinces refer directly to the CCAC) (Canadian Council on Animal Care, n.d). By contrast, the Australian code for the care and use of animals for scientific purposes 8th edition 2013, which applies to all live non-human vertebrates and cephalopods, has been incorporated under each state and territory's animal welfare legislation, making compliance mandatory in each jurisdiction.

Recognizing relevant legal frameworks and other sources of guidance, institutions serve a more direct role in oversight of their researchers. As do other scientists, wildlife researchers seek approval from an animal care committee for their research because it is required by their

university, and often the funding agencies supporting their research, and/or target journals in which they plan to publish their results. Owing to the profound differences between wildlife and laboratory animals (Paul et al., 2016), however, animal care committee members might lack wildlife-related expertise, rendering assessments inadequate to ensure wildlife welfare (Mulcahy, 2003). The *Guide for the Care and Use of Laboratory Animals* (the Guide) (National Research Council, 2011) is a standard mandated by the 1986 Public Health Service Policy in the United States to aid animal care committees in their reviews. Although recent revisions to the Guide incorporated consultation with wildlife biologists, a recent assessment considered the consultation to have occurred in a in a "cursory and broad manner" (Paul et al., 2016, p. 313). Taxon-specific organizations are engaging in outreach to animal care committees to address this potential inadequacy. For example, the American Society of Mammalogists developed a protocol form for Institutional Officials and animal care committee chairs, designed specifically for wildlife research conducted either in the field or in captivity (Paul et al., 2016). Despite these efforts, there is still uncertainty among some animal care committee members of how to apply such guidance in the context of wildlife research. Typically, members are less acquainted with evaluating field methods, especially under the constraints of an approval system primarily focussed on laboratory research animals.

Institutional animal care approvals can sometimes be sidestepped inappropriately. For example, Hervieux and colleagues (Hervieux et al., 2014; Hervieux et al., 2015) conducted what they referred to as 'experimental' killing of 733 wolves (*Canis lupus*) via aerial gunning and strychnine poisoning to measure the response of threatened caribou (*Rangifer tarandus*) prey populations in Alberta, Canada. Despite the involvement of several academic authors, there were no statements that an animal care approval was provided by their academic institutions, which

would have very likely rejected such inhumane methods (Brook et al., 2015). In another example, 1,966 lethal neck snares for coyotes (*Canis latrans*) were deployed to test effects of predator removal on caribou calf survival in Newfoundland, Canada (Lewis et al., 2017). Again, the authors (the lead of which is an academic) provided no reference to an animal care approval. Notably, killing neck snares have been deemed inadequate to render canids unconscious consistently and humanely (Proulx et al., 2015). Although the use of neck snares is legal in Canada, such legality should not trump animal welfare principles.

2.4 Towards editorial reform

Recognizing the shortcomings of other layers of oversight, we identify a pathway that could harness the influence of editors to prevent harm to wildlife and associated research processes. Because publishing comprises the central reward system of scientists, journals occupy a powerful position to standardize and improve conduct of researchers (Martins & Franco, 2015; Osborne, Payne & Newman, 2009). To assess the potential for change, we scored 206 journals that commonly publish wildlife research to survey and score the presence and comprehensiveness of animal care policies (which govern the care and use of research animals) in journals. We expose troubling patterns but identify clear opportunities for reform. Additionally, we offer a new and practical resource: a policy template for animal care that meets minimal expectations for journals to consider when updating their animal care guidelines.

2.4.1 Methods

To examine animal care policies, we searched ISI Web of Science™ Journal Citation Reports® year 2016 for all ‘Biodiversity Conservation’ and ‘Zoology’ journals to collate a broad sample of wild animal-related journals. Focusing on vertebrates (the subphylum most commonly

the focus of animal welfare), we excluded journals specializing in invertebrates. We added one journal not yet indexed (Canadian Wildlife Biology and Management), plus 14 interdisciplinary journals (e.g., Science, Nature, PNAS) that commonly publish wildlife studies (see full list of journals uploaded with data). We searched 'Instructions for Authors' or similarly titled documents or sections of websites across journals (n = 206). One person (KF) scored each on seven criteria guided by similar reviews of biomedical journals (Martins & Franco, 2015; Osborne, Payne & Newman, 2009). Two criteria were coded as present or absent, and five were graded on strength of compliance language using the National Institute of Health's interpretation of 'must', 'should' and 'may' (National Research Council, 2011; Table 1). Criteria were assigned 0 if absent from journal policies, 1 if their policies were suggestions, 2 if recommendations, and 3 if requirements. Data collection occurred during the period of October to December 2017.

Table 1. Scoring criteria for animal care policies in journals.

	Criteria	**Categorical Score**
1	statement regarding animal care policy	Yes, No
2	statement related to best practices for wildlife *in situ*	
3	statement regarding the adoption of the 3Rs (Replacement, Reduction and Refinement)	None, May, Should, Must[1]
4	requirement that authors state that an animal care permit or approval was granted	
5	requirement that authors identify the institutional authority that granted animal care permit or approval	
6	requirement that authors provide animal care permit or approval number	
7	statement informing authors that compliance with animal care journal policies is a condition of publication	

[1] "Must indicates actions that…[are] imperative and mandatory duties or requirements for providing humane animal care and use. Should indicates a strong recommendation for achieving a goal; however…individual circumstances might justify an alternative strategy. May indicates a suggestion to be considered." (National Research Council, 2011).

When journal instructions explicitly stated that authors must, should, or may follow external guidelines (n = 59 of 206) or publishing house guidelines (n = 29 of 206; S2 Data), we scored those external and publishing house guidelines for all criteria but one (criterion 7, which was journal-specific; Table 1). We then incorporated these external and publishing house guideline scores into the focal journal scores using a compliance-language hierarchical approach (S1 Fig., Appendix A). Books that were referenced in journal guidelines (n = 2 journals) were not scored.

We evaluated intra- and inter-observer precision in scoring. An external participant provided the lead scorer (KF) with a random 10% subset of journals to re-score, and another participant a non-overlapping 10% subset to score. The same external participant scored both these exercises for agreement. We excluded criteria with agreements lower than 85% (S1 Table, Appendix A). Across criteria with agreements higher than 85%, intra-observer rescores matched original assessments 94% of the time. Interobserver scores matched original assessments 86% of the time (S2 Table, Appendix A).

We conducted a logistic regression analysis to test for associations between the presence of any animal care policy and journal characteristics (impact factor, open-access status, animal welfare legislation in country of the journals' headquarters, and whether the journal was conservation-oriented). We centered all predictors (subtracted the mean from each observation) and scaled (divided by 2 SDs) (Gelman, 2008). We also used a Poisson regression analysis to test for associations with number of criteria detected among journals that had an animal care policy and the same journal characteristics. For the latter, criteria were considered fulfilled if a journal received any score other than "none". We considered journals conservation-oriented if the content and language of the 'aim and scope' reflected a conservation focus or if 'conservation'

appeared in the journals' title and/or 'aims and scope' (e.g., "Amphibia-Reptilia is a leading European multi-disciplinary journal devoted to most of the aspects of herpetology: ecology, behaviour, evolution, conservation, physiology, morphology, paleontology, genetics, and systematics"). We considered journals to be open access only if exclusively so (e.g., no 'hybrid' models). We categorized countries as "full" or "partial" application of legislation against causing animal suffering according to the Animal Protection Index by World Animal Protection (S3 Table, Appendix A) that is, whether animal protection laws that prohibit causing animal suffering either by a deliberate act of cruelty or by a failure to act are fully or partially endorsed; https://api.worldanimalprotection.org/). There were no countries in our dataset that Animal Protection Index classified as fully lacking animal protection legislation. We excluded journals from this analysis with headquarters located in countries not indexed by the Animal Protection Index (n = 8, S3 Table, Appendix A).

For the Poisson model, we excluded two criteria that were co-dependent (Does the journal ask that authors specify the institutional authority that granted animal care licenses or permits?; and Does the journal ask that authors provide animal care license or permit numbers?; were contingent upon Does the journal ask that authors state whether an animal care permit or approval was granted?).

We tested for correlation between variables using Pearson correlation coefficient. No two variables were correlated (S4 Table, Appendix A). We computed the variance inflation factors (VIF) for each model to test for multicollinearity. We did not detect multicollinearity (S5 Table. Appendix A). The mean and median impact factor of journals was 2.03 and 1.2, respectively, with journals removed that had not yet had an impact factor assigned. All analyses were conducted in R Version 3.4.2 (R Core Team, 2017).

2.4.2 Results and Discussion

Journals varied considerably in their inclusion of criteria, but collectively lacked fundamental safeguards against the mistreatment of wildlife. Of the 206 journals in our dataset, one third (n = 70) had no animal care policy. Of journals that had animal care policies, just 22% (n = 30, or 15% of total) had a statement related to best practices for animal care during fieldwork. The strength of policy also varied; for each compliance-language criterion, journals that used 'must' always constituted less than 34% of journals with animal care policies (n < 46, or < 23% of total). The strongest language was most consistently found for the criterion requiring authors to state that an animal care approval was granted, yet only 34% of journals with animal care policies stated it 'must' be followed (n = 46, or 22% of total). In addition, only 14% of journals with animal care policies (n = 19, or 9% of total) required authors to provide documentation of such an approval. Only 6% of journals with animal care policies (n = 8, or 4% of total) required that authors 'must' adopt the 3R tenet of replacement (avoiding or replacing the use of animals), reduction (in number of animals used per study) and refinement (of methods to reduce suffering and improve welfare; Fig 1.) – a central paradigm in the treatment of study animals (Russel & Burch, 1959).

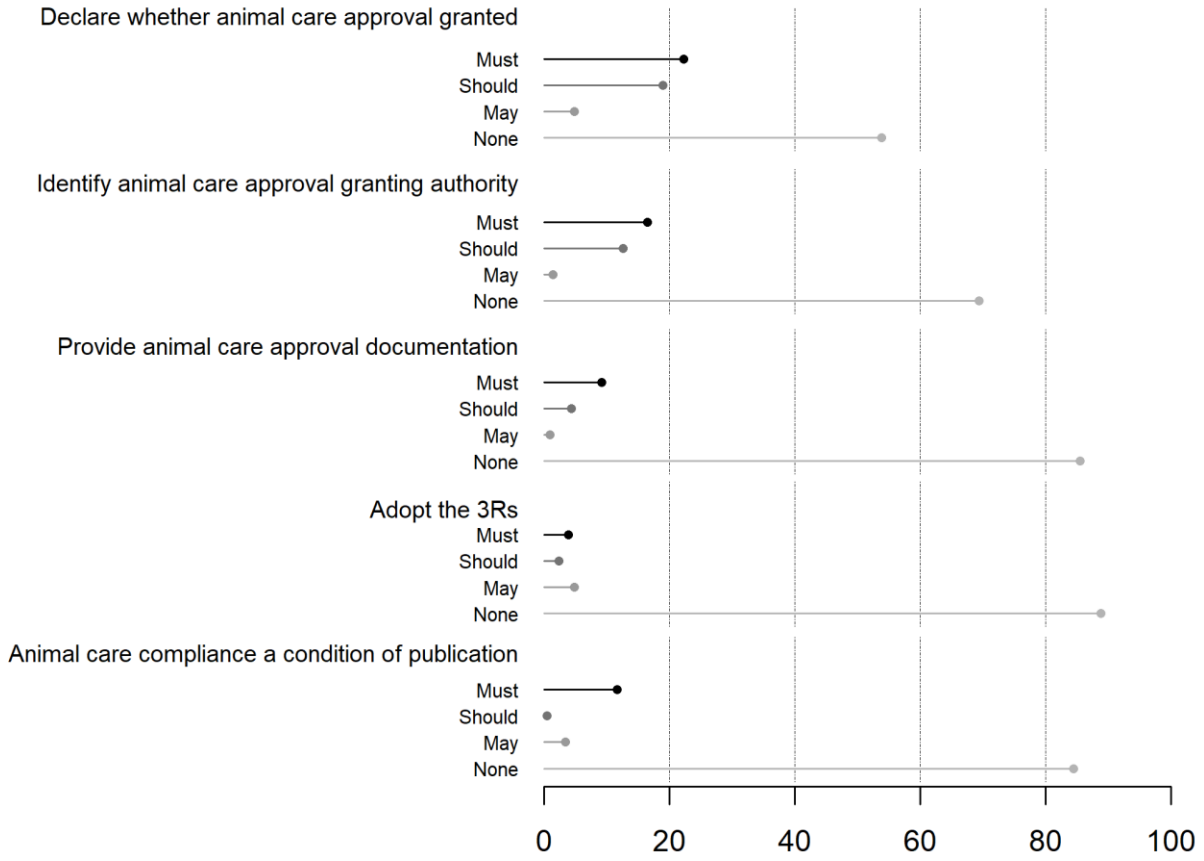


Fig 1. Presence and strength of compliance language in animal care policies across 206 journals that commonly publish wildlife research

We found associations between journal characteristics and the presence of animal care policies. Journals based in countries that endorse animal welfare law (Animal Protection Index; S3 Table, Appendix A) were more likely to have animal care policies (Fig 2). We encourage journals from countries without such legislation to adopt a best global practice to address this gap. We likewise found that journals with higher impact factors were more likely to have animal care policies (Fig 2). Although the association is not likely causative, lower ranking journals without animal care policies may nonetheless be motivated to emulate what is perceived as best practice. In a complementary way, higher impact journals with animal care policies can use their influence to advocate for change.

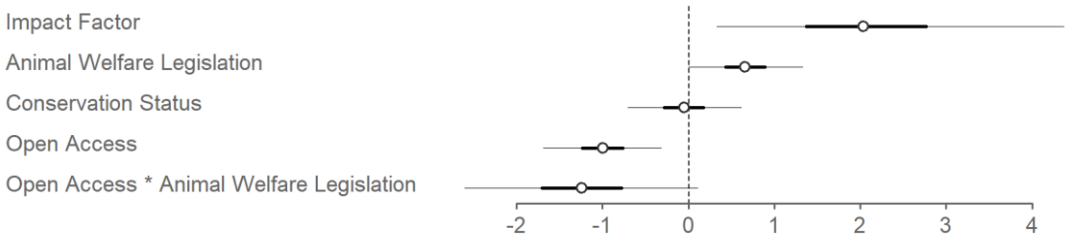


Fig 2. Association between journal characteristics and presence of animal care policies across 206 journals that commonly publish wildlife research. Coefficients shown are odds ratios from a logistic model, with thick and thin bars representing 50 and 95% confidence intervals, respectively. X scale unit is per 2 SDs of predictor.

Contrary to our predictions and previous findings related to biomedical journal policies (Martins & Franco, 2015; Rands, 2009), we found a negative association between open-access (OA) status and presence of animal care policy (Fig 2). We had reasoned that widely and readily accessible content would promote cautious editorial policy that avoided criticism from a potentially broad readership. Although we are uncertain why this differing pattern exists, we call for these OA journals without policies to adopt them rapidly.

The concerns of conservationists and animal welfarists sometimes fail to align. Across our data set, conservation-orientation among journals had no effect on animal care policies (Fig 2). A common contention is that animal welfare and conservation are incompatible because what is beneficial for conservation is not always so for individual animals and vice versa (Paquet & Darimont, 2010). Conservationists often prioritize the integrity of populations, whereas animal welfare scientists primarily express concern about the suffering individual animals can endure (Fraser, 2010; Paquet & Darimont, 2010). It has been suggested that “biologists recognize that conservation is engaged in the protection of the integrity and continuity of natural processes, not the welfare of individuals” (Soulé, 1985, p. 731). However, employing invasive and lethal

research methods in the name of conservation has raised important considerations about the welfare of individuals (Vucetich & Nelson, 2007; Brook et al., 2015). Furthermore, failing to address the welfare of animals may ultimately jeopardize the integrity of wildlife populations and the continuity of natural processes (Paquet & Darimont, 2010). Although the dichotomies between these two fields exemplify fundamental difficulties in harmonizing them, conceptual links exist (Beasoleil et al., 2018). Emerging from these linkages, 'Compassionate Conservation' is a movement that diminishes approaches that intentionally and unnecessarily harm wildlife individuals, while aligning with critical conservation goals (Wallach et al., 2018). Given the health of populations and their constituent individuals are linked, conservation journals could contribute to momentum toward uniting conservation and animal welfare with robust animal care policies.

We found that author instructions were inconsistently articulated to readers. Animal care policies were often (36%) a hybrid format of external, publishing house, and journal guidelines. Confusion as to which guidelines require compliance might be compounded by a patchwork of different compliance language designed to enforce them. Indeed, our assignment of compliance-language scores was not straightforward because synonyms were used across journals, subjecting instructions to variable interpretation. Notably, gaps in compliance and apparent author confusion have been reported for other dimensions of journal policies, not just animal care (Stodden, Seiler & Ma, 2018). Careful composition of journal policies explicitly posed as requirements could close loopholes that potentially accommodate sloppy reporting (Enserink, 2017). Simply put, policies posed as suggestions or recommendations lack force. Accounting for this reality and the criteria we surveyed, we propose a minimum template for mandatory animal care policy prescriptions that can be adapted to a wide variety of journals that contain wildlife

research (Box 1). These guidelines, which we label ARROW (Animal Research: Reporting on Wildlife, following ARRIVE guideline nomenclature; [Kilkenny et al., 2010]), are not only realistic for journals to adopt, editors to enforce, and authors to comply with, but also comprise a coherent baseline for journals currently lacking animal care policies (n = 70, or 34% of journals examined) upon which to build.

Box 1. Recommended minimum requirements for animal care policies in journals that publish research on wildlife ('ARROW – Animal Research: Reporting on Wildlife guidelines').

In the text of the manuscript, supplementary information, and/or cover letter, authors must:

- **state that they have obtained an institutional animal care approval, and cite documentation of such an approval (including relevant application number to support tracking)**
- **state that they have complied with the relevant national, international, and institutional guidelines regarding animal care, naming them**
- **state that they have complied with, and cite, animal care legislation in the countr(y/ies) where their research was conducted.**
- **state that they took all measures possible to follow the Three R's of *Replacement, Reduction,* and *Refinement,* and describe such measures**
- **for research involving wildlife (captive or in natural settings), state that they have followed taxon-specific guidelines for the ethical treatment of the taxa of study, and cite such guidelines**

Failure to comply with journal policies on the care and use of animals will result in manuscript rejection.

Editors maintain the discretion to reject work that imposes harm to research animals.

2.5 Other considerations towards reform

Although alleviating weaknesses and disparities within and among laws, regulations, codes, and guidelines at various layers of oversight might appear to be an onerous pursuit, we offer some considerations towards improvement. First, we recommend that animal care committees have both a wildlife veterinarian and wildlife biologist formally available for consultation (Mulcahy, 2003). The knowledge of these field-experienced professionals must be

relevant to the species and subject addressed by the research. Harnessing their knowledge of the physiology of pain and suffering, wildlife veterinarians can aid in assessing the humaneness of research methods in the field. Even where guidelines are endorsed by animal care committees (e.g., American Veterinarian Medical Association Guidelines on Euthanasia), veterinarians can aid in enforcing them. Wildlife biologists can likewise lend their expertise on techniques often used to study free-ranging species, addressing uncertainty among other animal care committee members to evaluate methods with which they might not be acquainted. Notably, the *Guide for the Care and Use of Laboratory Animals* encourages animal care committees engaged in the review of field studies to consult with a qualified wildlife biologist. This ought to be a requirement. Submission of wildlife-specific animal use applications could also be required of authors by institutions. As an example, the University of Montana requires that a Wildlife Animal Use Protocol be submitted for any study conducted on free-living wild animals in their natural habitat (https://www.umt.edu/research/compliance/IACUC/policies/PLCYfieldwildifestudies.php). Another contribution wildlife biologists can make involves external permits. Whereas animal care committees are primarily charged with assessing the welfare of individual research animals, a variety of international, national, state/provincial/territorial and local permits exist to inform animal care committees that population-level impacts are acceptable and relevant laws are followed (Paul & Sikes, 2013). Wildlife biologists can render their expertise to assess whether researchers have obtained all necessary wildlife research permits. This interaction aligns with the emerging understanding that healthy populations and the welfare of animals that comprise them are linked (Paquet & Darimont, 2010). With these additional contributions from veterinarians

and wildlife biologists, animal care committee approvals might provide a higher level of early (upstream) safeguard against unnecessary suffering of wildlife used in study.

When legal and institutional levels of oversight fail wildlife, editorial policy can provide an additional and potentially robust bulwark against harm. Our results and case studies, however, suggest animal care policies are not only inconsistent across journals but also insufficiently enacted to ensure welfare across taxa. Vast differences between biomedical and wildlife research animals (Paul et al., 2016) must be considered in journal animal care policies. Owing to an environment that can never be fully controlled (or even observed in the case of wildlife implanted with telemetry or other remote measuring devices), journal policies tailored to biomedical research animals will not guarantee the welfare of animals studied in the wild. Although taxon-specific organizations have created field-based animal care guidelines (e.g., Sikes, 2016), they are not widely endorsed in journal policies. While we agree taxon-specific guidelines ought to be endorsed, we suggest that they be approached critically. For example, some guidelines (e.g., Sikes, 2016) have proposed submersion trapping (death by drowning-induced hypoxia) to kill mammals, which does not align with criteria indicating relative humaneness of trap performance (Proulx, 2015).

Even the best animal care policies can fail wildlife if not enforced (Baker et al., 2014). Editorial implementation of the ARRIVE (Animals in Research: Reporting In Vivo Experiments) reporting guideline, for example, has not been effective because authors, reviewers, and journal editors have frequently ignored them (Bomzon, 2017). Accordingly, apparent violations of journal policy and subsequent failure of editorial oversight requires whistleblowing by concerned members of the public, scientists (e.g., Brook et al., 2015), and editors (e.g., Costello et al., 2016) to prevent abuse. Costello et al. (2016) set the agenda for impeccable editorial discretion when

they rejected wildlife studies they deemed inhumane, even though the studies had been institutionally approved. For manuscripts with potentially problematic treatment of animals, editors could solicit specialized reviewers to examine animal care statements of authors, perhaps also requesting from authors the associated animal care committee proposals and approvals for evidence of compliance. At minimum, editors could require authors to submit detailed documentation of approval from an animal care committee (Box 1)—such a statement was absent from 78% of journals with animal care policies (n = 106; or 85% of total, n = 176). Reviewers should also be involved in assessments of not only science but also animal care. In the most basic sense, whether or not authors adequately provided animal care information can constitute one of the standard questions reviewers must answer during reviews.

Researchers and members of scholarly societies, many of the latter publishing their own journals, can also lobby for change. If members are concerned and aware of the potential for journals to influence the behavior of wildlife researchers, and thus the animals they study, they can call on societies to ensure their policies, as well as the policies of their journals, are adopting best practices. Researchers can play a role via self-regulatory compliance. Individual behavior is shaped by values, laws, editorial policies, and membership in scholarly societies as well as the community norms that emerge from the interactions of these influences. Although editorial oversight occurs downstream from study design and interactions with animals, publication reform that standardizes animal care expectations will prompt researchers to conform to best welfare practices with knowledge that such is a condition of publication (notably, a criterion that we suggest journals adopt; Box 1). This aligns with an element of a ‘Nine R Theory’ (see Curzer, 2013), which offers ‘Refusal’ as a means to gauge whether the harm is worth the gain during planning stages of research. Animal Refusal “rejects the initial animal research plan completely

to prevent animals from suffering futile harm or harm not worth the gain," sending researchers back to the drawing board. Although transformation will take time, we envision a shift in researcher culture towards greater attention to animal care, similar to recent changes towards open data, reproducibility, and co-authorship expectations. Even if journals do not yet demand detailed evidence of best-practise animal care, scientists can practise and report on criteria we outline in ARROW guidelines.

The development and maintenance of non-legislated animal welfare standards relies heavily on voluntary compliance with codes of practice (e.g., Sneddon & Rollin, 2010). Codes often specify rules of protocol as well as the moral responsibilities of professionals. Unfortunately, codes are of limited value if not enforced, or can oversimplify moral requirements, causing professionals to suppose mistakenly that they have satisfied moral requirements simply by following the rules of the code (Beauchamp & Childress, 2001, pp. 6-7). Surveillance of, and reporting on, suspected animal care violations (e.g., Brook et al., 2015) would further ensure the maintenance of professional, self-regulatory compliance as well as wildlife welfare.

Ethical conduct in science occupies a significant place in the public's perception of the role of scientists (Atlas, 2003), affording social license to the research process. At the same time, public attitudes towards animals are often a driving force behind improvements in animal-related policy (Serpell, 2004). For example, societal objection to the use of hot-iron identification branding of pinnipeds encouraged the Australian government to ban the research method after video footage of branding was shown in the media. Despite all ethical and legislative permissions being granted, and all researchers working within the prescribed permissions' boundaries, the research was halted (Waugh & Monamy, 2016). Invasive research has indeed

marshalled compelling public opposition (e.g., Grimm, 2018; Marris, 2015) questioning the moral legitimacy of research that knowingly harms research animals. Use of wildlife to generate new knowledge hinges on implicit consent from the majority of society. Because the public generally cherishes wildlife, mistreating them jeopardizes the privilege of trust in the scientific endeavor.

2.6 Straightforward corrective action by journals

Scientific publishing is rapidly adapting to, and shaping, interests among research communities, governments, funders and the public. Emphasis on upholding ethical standards in science and its publication process receives high-profile attention and debate, exposing conduct ripe for reform. Responding to this opportunity, we have provided a practical resource (Box 1 – ARROW guidelines), and ideally ignited a discussion towards ethically-attuned animal care policies and practice to protect the welfare of wildlife.

2.7 Limitations and future research

There are several caveats to consider for this study. First, we note limitations in our ability to assign compliance-language scores: synonyms used by journals were subject to variable interpretation, evidenced by our moderate inter-observer variance. Second, our response variable being the presence of any animal care policy does not imply the policy was rigorous nor enforced. Finally, criteria for scoring journal policies should be refined. The most basic of animal care policies (e.g., follow legislation) were used for data collection. Future research should use finer-scale criteria that are wildlife-specific to score animal care policies. Future research might also consider applying a different set of criteria to score external guidelines,

rather than journal-specific criteria. Some external guidelines are tailored to guide authors specifically, whereas others were more general and therefore irrelevant to our scoring criteria, which were designed to score instructions for authors.

Data from: Publication reform to safeguard wildlife from researcher harm. Dryad Digital Repository. Openly available via https://doi.org/10.5061/dryad.c53k1d6

References

Atlas, M. C. (2003). Emerging ethical issues in instructions to authors of high-impact biomedical journals. *Journal of the Medical Library Association*, *91*(4), 442.

Baker, D., Lidster, K., Sottomayor, A., & Amor, S. (2014). Two years later: journals are not yet enforcing the ARRIVE guidelines on reporting standards for pre-clinical animal studies. *PLoS biology*, *12*(1), e1001756.

Beauchamp, T. L., & Childress, J. F. (2001). *Principles of biomedical ethics*. Oxford University Press, USA.

Beausoleil, N. J., Mellor, D. J., Baker, L., Baker, S. E., Bellio, M., Clarke, A. S., ... & Pitcher, B. J. (2018). 'Feelings and Fitness' not 'Feelings or Fitness'–the raison d'être of Conservation Welfare, which aligns conservation and animal welfare objectives. *Frontiers in veterinary science*, *5*, 296.

Bomzon, A. (2017). You and your research report: implementing the ARRIVE reporting guideline. Laboratory Animals, *51*, 121-123.

Brook, R. K., Cattet, M., Darimont, C. T., Paquet, P. C., & Proulx, G. (2015). Maintaining ethical standards during conservation crises. *Canadian Wildlife Biology and Management*, *4*(1), 72-79.

Buzek, J., & Chastel, O. (2010). Directive 2010/63/EU of the European parliament and of the council of 22 September 2010. *Official Journal of the European Union*, *276*, 33-74.

Calvo, B., & Furness, B. W. (1992). A review of the use and the effects of marks and devices on birds. *Ringing and Migration, 13*(3), 129-151.

Canadian Council on Animal Care [Internet]. (n.d.). Retrieved from https://www.ccac.ca/en/facts-and-legislation/canadian-legislation-and-policies/provincial-information.html

Cattet, M., Boulanger, J., Stenhouse, G., Powell, R. A., & Reynolds-Hogland, M. J. (2008). An evaluation of long-term capture effects in ursids: implications for wildlife welfare and research. *Journal of Mammalogy*, *89*(4), 973-990.

Costello, M., Beard, K. H., Corlett, R. T., Cumming, G. S., Devictor, V., Loyola, R., ... & Primack, R. B. (2016). Field work ethics in biological research. *Biological Conservation, 203*, 268-271.

Costello, M. J., Vanhoorne, B., & Appeltans, W. (2015). Conservation of biodiversity through taxonomy, data publication, and collaborative infrastructures. *Conservation Biology, 29*(4), 1094-1099.

Curzer, H. J., Wallace, M. C., Perry, G., Muhlberger, P. J., & Perry, D. (2013). The ethics of wildlife research: A nine R theory. *ILAR Journal, 54*(1), 52-57.

Enserink, M. (2017). Sloppy reporting on animal studies proves hard to change. *Science, 357*(6358): 1337-1338.

Fraser, D. (2010). Toward a synthesis of conservation and animal welfare science. *Animal Welfare*, *19*(2), 121-124.

Garner, J. P. (2005). Stereotypies and other abnormal repetitive behaviors: potential impact on validity, reliability, and replicability of scientific outcomes. *ILAR Journal*, *46*(2), 106-117.

Gelman, A. (2008). Scaling regression inputs by dividing by two standard deviations. *Statistics in medicine, 27*(15), 2865-2873.

Grimm, D. (2017). PETA targets early-career wildlife researcher. *Science, 357*, 1087.

Hervieux, D., Hebblewhite, M., Stepnisky, D., Bacon, M., & Boutin, S. (2014). Managing wolves (Canis lupus) to recover threatened woodland caribou (Rangifer tarandus caribou) in Alberta. *Canadian Journal of Zoology, 92*(12), 1029-1037.

Hervieux, D., Hebblewhite, M., Stepnisky, D., Bacon, M., & Boutin, S. (2015). Addendum to "Managing wolves (*Canis lupus*) to recover threatened woodland caribou (*Rangifer tarandus caribou*) in Alberta". *Canadian Journal of Zoology, 93*(3), 245-247.

Kilkenny, C., Browne, W. J., Cuthill, I. C., Emerson, M., & Altman, D. G. (2010). Improving bioscience research reporting: the ARRIVE guidelines for reporting animal research. *PLoS biology, 8*(6), e1000412.

Lewis, K. P., Gullage, S. E., Fifield, D. A., Jennings, D. H., & Mahoney, S. P. (2017). Manipulations of black bear and coyote affect caribou calf survival. *The Journal of Wildlife Management, 81*(1), 122-132.

Marris, R. (2015). Wolf cull will not save threatened Canadian caribou. *Nature,* doi:10.1038/nature.2015.16734

Martins, A., & Franco, N. (2015). A critical look at biomedical journals' policies on animal research by use of a novel tool: The EXEMPLAR scale. *Animals, 5*(2), 315-331.

McNutt, M. (2014). Journals unite for reproducibility. *Science, 346*(6210), 679-679. dio.10.1126/*science*.aaa1724

Minteer, B. A., & Collins, J. P. (2005). Why we need an "ecological ethics". *Frontiers in Ecology and the Environment, 3*(6), 332-337.

Mulcahy, D. M. (2003). Does the Animal Welfare Act apply to free-ranging animals?. *ILAR Journal, 44*(4), 252-258.

National Research Council. (2011). Guide for the care and use of laboratory animals. Retrieved from https://grants.nih.gov/grants/olaw/guide-for-the-care-and-use-of-laboratory-animals.pdf

Nielsen, L. (1999). Physical aspects of chemical immobilization. In: L. Nielsen (Ed.), *Chemical immobilization of wild and exotic animals.* Ames: Iowa State University Press; 1999. pp. 189-207

Osborne, N. J., Payne, D., & Newman, M. L. (2009). Journal editorial policies, animal welfare, and the 3Rs. *The American Journal of Bioethics, 9*(12), 55-59.

Paquet, P. C., & Darimont, C. T. (2010). Wildlife conservation and animal welfare: two sides of the same coin. *Animal Welfare, 19*(2), 177-190.

Paul, E., & Sikes, R. S. (2013). Wildlife researchers running the permit maze. *ILAR Journal, 54*(1), 14-23.

Paul, E., Sikes, R. S., Beaupre, S. J., & Wingfield, J. C. (2016). Animal welfare policy: Implementation in the context of wildlife research—policy review and discussion of fundamental issues. *ILAR Journal, 56*(3), 312-334.

Proulx, G., Rodtka, D., Barrett, M. W., Cattet, M., Dekker, D., Moffatt, E., & Powell, R. A. (2015). Humaneness and selectivity of killing neck snares used to capture canids in Canada: A review. *Canadian Wildlife Biology and Management, 4*(1), 55-65.

R Development Core Team (2011). R: A Language and Environment for Statistical Computing. Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org: R Foundation for Statistical Computing.

Rands, S. A. (2009). Ethical policies on animal experiments are not compromised by whether a journal is freely accessible or charges for publication. *Animal, 3*(11), 1591-1595.

Russell, W. M. S., Burch, R. L., & Hume, C. W. (1959). *The principles of humane experimental technique (Vol. 238)*. London: Methuen.

Saraux, C., Le Bohec, C., Durant, J. M., Viblanc, V. A., Gauthier-Clerc, M., Beaune, D., ... & Le Maho, Y. (2011). Reliability of flipper-banded penguins as indicators of climate change. *Nature, 469*(7329), 203.

Sikes, R. S. (2016). 2016 guidelines of the American society of mammalogists for the use of wild mammals in research and education. *Journal of Mammalogy, 97*(3), 663-388.

Serpell, J. A. (2004). Factors influencing human attitudes to animals and their welfare. *Animal Welfare, 13*, S145-S152.

Sneddon, J., & Rollin, B. (2010). Mulesing and animal ethics. *Journal of agricultural and environmental ethics, 23*(4), 371-386.

Soulé, M. E. (1985). What is conservation biology?. *BioScience, 35*(11), 727-734.

Stodden, V., Seiler, J., & Ma, Z. (2018). An empirical analysis of journal policy effectiveness for computational reproducibility. *Proceedings of the National Academy of Sciences, 115*(11), 2584-2589.

Vucetich, J. A., & Nelson, M. P. (2007). What are 60 warblers worth? Killing in the name of conservation. *Oikos, 116*(8), 1267-1278.

Wallach, A. D., Bekoff, M., Batavia, C., Nelson, M. P., & Ramp, D. (2018). Summoning compassion to address the challenges of conservation. *Conservation biology, 32*(6), 1255-1265.

Waugh, C. A., & Monamy, V. (2016). Opposing lethal wildlife research when nonlethal methods exist: Scientific whaling as a case study. *Journal of Fish and Wildlife Management, 7*(1), 231-236.

3. Conclusion: Towards improved animal welfare in scientific practice and policy

"…animal rights and environmental considerations may in some cases contradict one another, or at least co-exist in imperfect harmony"

–Daniel Mishori

3.1 Where are we today?

The use of animals in research has been supported predominantly by deeply entrenched anthropocentric perspective. Indeed, scientists are currently working within a paradigm where humans under study are referred to as *participants* and research animals as *subjects.* Biomedical research is dictated by anthropocentrism because the primary beneficiaries of biomedical research outcomes are humans. A theoretical shift to non-anthropocentric uses of research animals ostensibly occurred, evidenced in part with the emergence of conservation biology and animal welfare science. While discrepancies between non-anthropocentric worldviews still persist, identifying and converging commonalities between them can inform avenues towards achieving their common objectives.

Chapter two illustrates a case of policy lag behind the emergence of non-anthropocentric uses of animals in science. This lag is in part evidenced by the lack of welfare consideration for research animals studied in the wild. Such a lack of consideration is represented by pursuit of grossly inhumane methodologies in contemporary research, as well as inconsistent animal care policies in wildlife oriented journals. Nonetheless, the evolution of moral theories in the context of animal welfare during wildlife research seems to have occurred, evidenced by increasing literature around ecological ethics, compassionate conservation and conservation welfare (Minteer & Collins, 2005; Paquet & Darimont, 2010; Wallach et al., 2018; Wallach et al., 2015;

Vucetich & Nelson, 2007). On the other hand, antiquated methodologies (see Hervieux, 2014; and Lewis et al., 2017 for examples) run counter to this theoretical evolution.

As I highlight in chapter one, methods pursued at the dawn of institutionalized vivisection would have been impermissible by today's standards (Orlans, 1993). It is thus surprising that over 150 years later, comparable methods are still pursued with the knowledge they cause excruciating suffering. For example, the administration of nux-vomica to animals in 1844 (Orlans, 1993) and the deployment of strychnine-laced baits in 2014 (Hervieux et al., 2014) are inhumane methods used both historically and contemporarily, despite the reality we have empirically advanced our understanding of the suffering they impose (Brook et al., 2015). Ideally, refining modern decision-making tools to incorporate biocentric worldviews in ecocentric contexts can eliminate lingering unethical practices that ought to be abolished if non-anthropocentric approaches in science are to prevail.

3.2 Prospects for the future: commonalities of eco- and biocentrism regarding human-animal interactions in science

The moral urgency of animal suffering during wildlife research warrants immediate attention. Finding common ground between eco- and biocentric approaches is one way to address this urgency, but progress to date has been slow. While a perfect ethical system that eliminates eco-biocentric tensions has not been articulated, areas of overlap do exist. Providing practitioners of non-anthropocentric research disciplines with mutually agreeable concepts, metrics and objectives could provide a foundation for uniting the two perspectives. For example, research methods from each field can be used to address some scientific questions of the other. Stress-reduction and enrichment for wild animals being researched in captivity are well studied in animal welfare science and can be applied to conservation methods (Fraser, 2010). As another

example, a stress-distress paradigm proposes that ‘distress’ could unite animal welfare and conservation concerns because of its shared empirical language and currency of biological costs to fitness at both the population/ecosystem level and the individual level (Linklater and Gedir, 2010). Such a paradigm provides a shared objective between both parties, as well as defines what to measure and when to act.

Traditional views that animal welfare consideration is an impediment to research persists. Increased training in animal ethics might facilitate discussion around, and progression towards identifying conceptual links between eco- and biocentric approaches to science, potentially alleviating this concern. A lack of training in animal welfare and ethics in undergraduate biology programs (Zemanova, 2017) is an impediment to converging the two worldviews. Zemanova (2017) reported that a mere 9% of programs offered stand-alone courses in animal ethics. For a field that often entails invasive animal-use methodologies, this lack of training is striking.

Concerns for the welfare of research animals motivated the development of decision-making tools to inform ethical conduct. The 3 R’s of *Replacement, Reduction* and *Refinement* (Russel and Burch, 1959) are widely adopted as guiding principles for ethical use of animals during research. Briefly, the 3 R’s seek to avoid or replace the use of animals, reduce the number of animals used, and modify procedures to minimize pain and suffering. Several people have proposed additions to this standard. A 4th R of research implies addition of *Responsibility* (Nurunnabi, 2013), which seeks to “reflect integrity, honesty, and scientific correctness in appropriate and reasonable use of laboratory animals” (Arora et al., 2011). An extension of the 4 R model, the 7 R’s were proposed to include *Rehabilitation, Respect, Review,* and *Relate* (see Sass, 2008). Recognizing that the established R alternatives were tailored to biomedical research animals, Curzer et al. (2013) proposed a 9 R theory to govern the use of research on animals in

the wild. Curzer et al. (2013) discuss common-sense ethical constraints on ecosystem research parallel to the constraints that govern laboratory animal research. Curzer et al's (2013) 9 R theory is a living example of an innovative model designed to shift to a paradigm that affords warranted, rigorous consideration for the welfare of research animals studied in the wild.

Tipping the ethical scale to afford more weight to biocentric values in ecocentric contexts in research might allow us to craft a paradigm within which wildlife are granted greater moral consideration. It is possible for scientists to hold both biocentric and ecocentric worldviews, perceiving them as different facets of non-anthropocentric intuitions (Mishori, 2017). Virtue ethics, a moral approach that emphasizes the building of moral character and personal virtues, has been proposed as a basis for ameliorating the tensions between biocentric and ecocentric stand points as a means of articulating shared values (Mishori, 2017; Wallach et al., 2018). Where endorsement of such ethics is lacking, we need consistent and coherent policies to enforce best practice.

3.3 Concluding remarks and emergent properties

This thesis examines varying approaches to human-animal interactions in science to identify conceptual and practical barriers to improving the welfare of research animals. The ARROW guidelines proposed in chapter two (Box 1) might serve as one practical resource to facilitate such a progress via increasing biocentric considerations in ecocentric contexts, that is, consistently and coherently improving standards for the welfare of wild animals, while also achieving population- and ecosystem-level objectives towards broader conservation outcomes. Developing tools and practical resources that attempt to converge eco- and biocentric

worldviews should be realistic, opting for reforming, rather than abolishing, the use of animals for research while also upholding ethical standards.

To recognize an element of welfare not yet considered in animal care policies, I propose an additional R: *Re-cognition*—to recognise cognition. Chan eloquently highlights that "stories of solitary animals being so overcome with loneliness or grief that they appear to lose the will to live…suggest that emotions are a critical component of animal well-being. If animals anticipate and express preferences regarding the experience of future events—as rats seem to do—we have additional reasons to protect their lives" (Chan, 2011, p. 339). Given that we have empirically advanced our understanding of negative psychological states of animals (e.g., Meagher, Campbell, & Mason, 2017), scientists should apply this knowledge to uphold ethical interactions with research animals. Indeed, possession of experiences (e.g., complex sensations such as grief) warrants moral status and deep consideration of cognition and well-being (Chan, 2011). Moreover, psychological, and thus behavioural well-being of research animals is crucial for reliability, validity and replicability of experiments (Garner, 2005). As such, the proposed additional R, *Re-cognition*, offers a novel dimension to consider in decision-making tools to account for animal cognition, further informing whether proposed methods of research are ethical.

Shifting paradigms in what is perceived as ethical scientific conduct is not impossible. Outside of science, historical paradigm shifts in what is perceived as equitable may instill motivation for reform: the progression of moral rights pertaining to equitable consideration for women, racial minorities, and sexual orientations foreshadows a seemingly discernible development of equality for all animals, regardless of species, thus dissolving speciesism. Similarly, a historical track record of transformations towards increased ethical treatment of

research animals (e.g., anesthetized vivisection in the 1800s; affording invertebrates, specifically cephalopods, welfare consideration) lends the notion that transformation is possible. As such, increasing the welfare of research animals ostensibly lends itself as a logical candidate for the "next step in the sequence" (Callicott, 1980) via consistent, coherent and taxonomically appropriate practices and policies, as well as abandonment of anthropocentric worldviews.

References

Arora, T., Mehta, A. K., Joshi, V., Mehta, K. D., Rathor, N., Mediratta, P. K., & Sharma, K. K. (2011). Substitute of animals in drug research: an approach towards fulfillment of 4R's. *Indian Journal of Pharmaceutical Sciences, 73*(1), 1.

Broom, D. M. (2011). A history of animal welfare science. *Acta Biotheoretica, 59*(2), 121-137. doi:10.1007/s10441-011-9123-3

Callicott, J. B. (1980). Animal liberation: A triangular affair. *Environmental Ethics, 2*(4), 311-338.

Campbell, I. J. (2018). Animal welfare and environmental ethics: It's complicated. *Ethics and the Environment, 23*(1), 49-69.

Chan, K. M. A. (2011). Ethical extensionism under uncertainty of sentience: Duties to non-human organisms without drawing a line. *Environmental Values, 20*(3), 323-346. doi:10.3197/096327111X13077055165983

Fraser, D. (2010). Toward a synthesis of conservation and animal welfare science. *Animal Welfare, 19*(2), 121-124.

Garner, J. P. (2005). Stereotypies and other abnormal repetitive behaviors: potential impact on validity, reliability, and replicability of scientific outcomes. *ILAR Journal, 46*(2), 106-117.

Curzer, H. J., Wallace, M. C., Perry, G., Muhlberger, P. J., & Perry, D. (2013). The ethics of wildlife research: A nine R theory. *ILAR Journal, 54*(1), 52-57.

Lewis, K. P., Gullage, S. E., Fifield, D. A., Jennings, D. H., & Mahoney, S. P. (2017).

Manipulations of black bear and coyote affect caribou calf survival. *The Journal of Wildlife Management, 81*(1), 122-132.

Linklater, W. L., & Gedir, J. V. (2011). Distress unites animal conservation and welfare towards synthesis and collaboration. *Animal Conservation, 14*(1), 25-27. doi:10.1111/j.1469-1795.2010.00399.x

Meagher, R. K., Campbell, D. L., & Mason, G. J. (2017). Boredom-like states in mink and their behavioural correlates: A replicate study. *Applied Animal Behaviour Science, 197*, 112-119.

Minteer, B. A., & Collins, J. P. (2008). From environmental to ecological ethics: Toward a practical ethics for ecologists and conservationists. *Science and Engineering Ethics, 14*(4), 483-501. doi:10.1007/s11948-008-9087-0

Mishori, D. (2017). Environmental vegetarianism: Conflicting principles, constructive virtues. *The Law & Ethics of Human Rights, 11*(2), 253-284. doi:10.1515/lehr-2017-0008

Nurunnabi, A. S. M., Afroz, R. D., & Alam, S. N. (2013). Ethical debate on animal research. *Bangladesh Journal of Bioethics, 4*(3), 11-18. doi:10.3329/bioethics.v4i3.17373

Paquet, P. C., & Darimont, C. T. (2010). Wildlife conservation and animal welfare: two sides of the same coin. *Animal Welfare, 19*(2), 177-190.

Russell, W. M. S., Burch, R. L., & Hume, C. W. (1959). *The principles of humane experimental technique (Vol. 238)*. London: Methuen.

Sass, H. M. (2008). Animals in research: 7-R principles and corporate responsibility. *Eubios Journal of Asian and International Bioethics, 18*(3): 74-85.

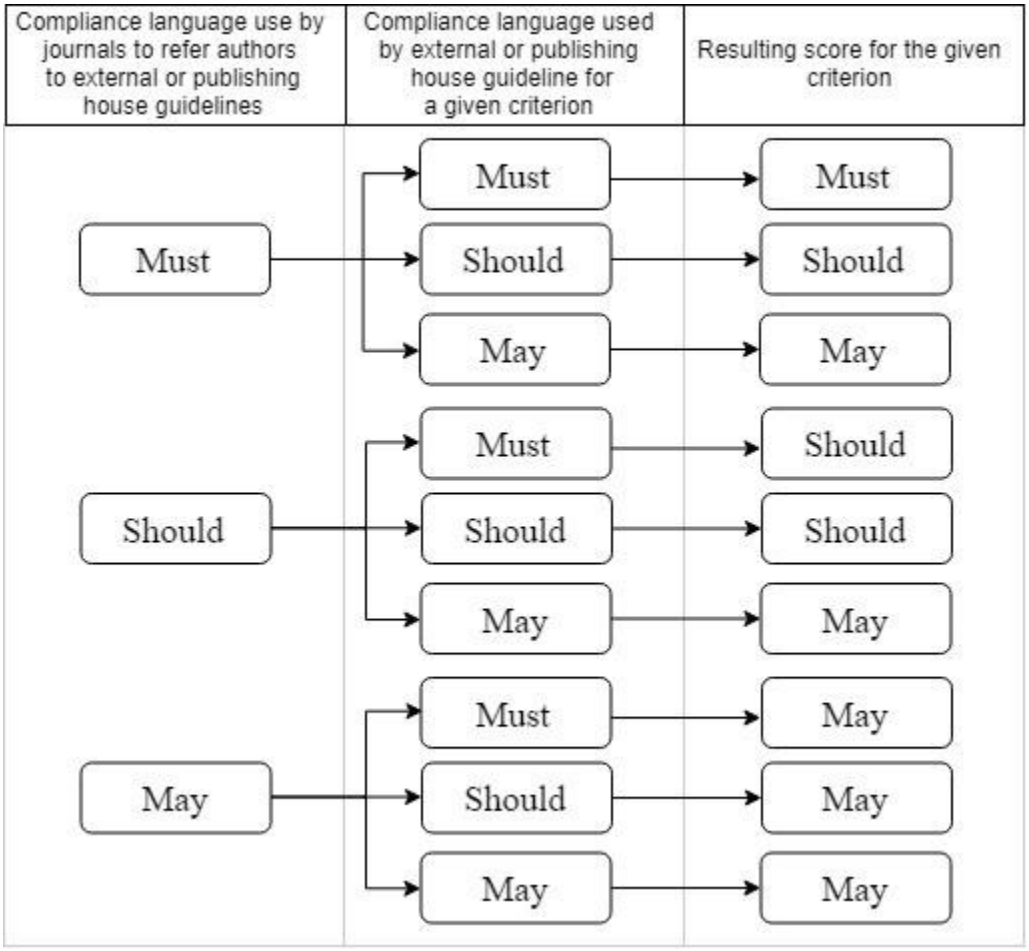
Vucetich, J. A., & Nelson, M. P. (2007). What are 60 warblers worth? Killing in the name of conservation. *Oikos, 116*(8), 1267-1278.

Wallach, A. D., Bekoff, M., Batavia, C., Nelson, M. P., & Ramp, D. (2018). Summoning compassion to address the challenges of conservation. *Conservation Biology*, *32*(6), 1255-1265.

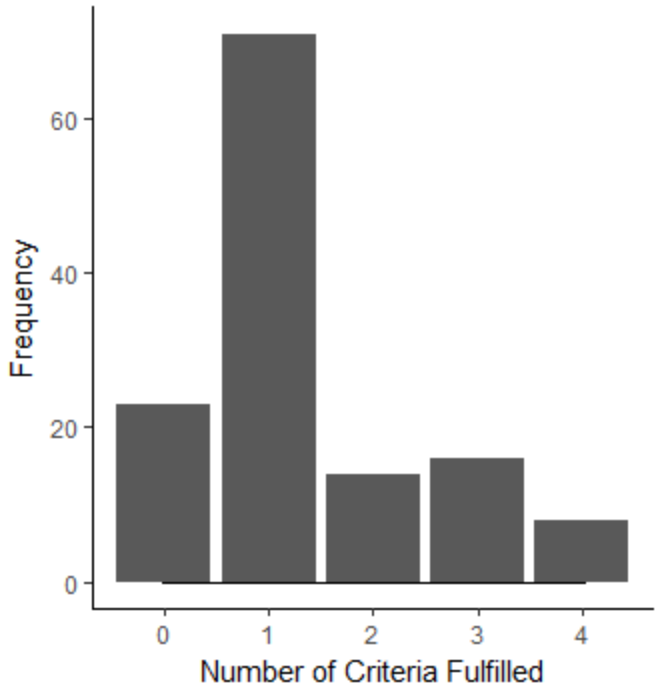
Wallach, A. D., Bekoff, M., Nelson, M. P., & Ramp, D. (2015). Promoting predators and compassionate conservation. *Conservation Biology*, *29*(5), 1481-1484.

Zemanova, M. A. (2017). More training in animal ethics needed for European biologists. *BioScience*, *67*(3), 301-305.

Appendix A



S1 Fig. Hierarchical approach to incorporating external and publishing house guideline scores into final journal scores based on compliance-language used 1) by a journal to direct authors to such guidelines, and 2) within such guidelines.



S2 Fig. Number of criteria fulfilled among journals. Regardless of compliance language and across criteria that were not co-dependent, most (72%; n = 98) journals that had animal care policies fulfilled less than two (of 4) criteria

S1 Table. Inter- and intra-observer agreement across criteria that were excluded due to low inter-observer agreement.

	Criteria	Intra-observer agreement (%)	Inter-observer agreement (%)
1	statement requiring that authors comply with relevant animal care legislation	95	60
2	statement requiring that authors comply with relevant national, international or institutional guidelines regarding animal care	95	55
3	statement requiring that authors state that they complied with relevant animal care legislation	100	60
4	statement requiring that authors state that they complied with national, international or institutional guidelines on animal care	95	50
	Average agreement	96	56

S2 Table. Inter- and intra-observer agreement across criteria.

	Criteria	Intra-observer agreement (%)	Inter-observer agreement (%)
1	statement regarding animal care policy	100	95
2	statement related to best practices for wildlife *in situ*	95	90
3	statement regarding the adoption of the 3Rs (Replacement, Reduction and Refinement)	95	85
4	requirement that authors state whether an animal care permit or approval was granted	85	75
5	requirement that authors identify the institutional authority that granted animal care licenses or permits	95	95
6	requirement that authors provide animal care license or permit numbers	90	90
7	statement informing authors that compliance with animal care journal policies is a condition of publication	95	75
	Average agreement	94	86

S3 Table. Animal Protection Index rankings of countries of journal headquarters. Data from https://api.worldanimalprotection.org

Country	Animal Protection Index Ranking for "Laws against causing animal suffering"
Australia	Legislation
Austria	Legislation
Belgium	Not ranked
Brazil	Legislation with partial application
Bulgaria	Not ranked
Canada	Legislation
Chile	Legislation
China	Legislation with partial application
Colombia	Legislation
Czech Republic	Not ranked
Denmark	Legislation
England	Legislation
Finland	Not ranked
France	Legislation with partial application
Germany	Legislation

Hungary	Not ranked
Italy	Legislation
Japan	Legislation
Kenya	Legislation
Mexico	Legislation with partial application
Netherlands	Legislation
New Zealand	Legislation
Pakistan	Legislation with partial application
Poland	Legislation
Romania	Legislation
Russia	Legislation with partial application
Singapore	Not ranked
Slovakia	Not ranked
South Africa	Legislation with partial application
Spain	Legislation with partial application
Switzerland	Legislation
Taiwan	Not ranked
Turkey	Legislation
USA	Legislation with partial application

S4 Table. Pearson's correlation coefficient for each pair of independent variables.

Variables	***r***	***P***
Open access * welfare legislation	-0.04	0.62
Open access * conservation oriented	0.01	0.90
Open access * impact factor	-0.06	0.37
Welfare legislation * conservation oriented	-0.11	0.11
Impact factor * welfare legislation	0.03	0.67
Impact factor * conservation oriented	-0.08	0.25

S5 Table. Variance inflation factor values for logistic and Poisson regression analyses.

Model	Variables	VIF
Logistic regression	Impact factor	1.014
	Open access	1.028
	Welfare legislation	1.054
	Conservation oriented	1.023
	Welfare legislation * open access	1.026
Poisson regression	Impact factor	1.013
	Open access	2.636
	Welfare legislation	1.384
	Conservation oriented	1.065
	Welfare legislation * open access	2.819