Editorial

Field work ethics in biological research

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Biological Conservation recently rejected a paper because we regarded the killing of thousands of vertebrates in a protected area as unnecessary and inappropriate. The authors had the required approvals from the conservation authorities for this work and argued that alternative non-harmful methods, such as camera-traps and baited video, or capture-release methods, would be too time-consuming and expensive because of the species' low population density. Since then, one of us declined to review another paper also on ethical grounds. This second study similarly used indiscriminate methods to kill hundreds of vertebrates in a protected area. In a third case, a paper was rejected because its capture-release data showed high mortality in vertebrates tagged for the study. These papers intended to demonstrate phenomena already known from other studies in different locations. In our opinion, these studies provided poor justification for harming species where the research simply confirmed a well-known phenomenon (e.g., species abundance increases when they are protected) for another location or species. Although the need to recognize the ethical issues of ecological field work has been highlighted more than once previously (e.g., Farnsworth & Rosovsky 1993, Marsh and Kenchington 2004), it seems they are not being universally addressed.

We urge scientists to conduct research in ways that are respectful to nature, and minimise harm to species and ecosystems. We discuss some of the ways that government regulations, journal policies, education practices, and individual researcher behaviour can contribute to more environmentally ethical practice. "Ethics" is widely defined as a theory of morality that guides individual and collective behaviour (e.g., Fuchs & Macrina 2005, Jax et al.,2013) but is subject to different interpretations and debate (e.g., Fazey et al., 2005, Wallace & Curzer 2013). We recognise that the damage to biodiversity caused by research is almost always minor in comparison to the widespread and extensive damage caused by other activities, such as logging, farming, fishing, mining, water pollution, ranching, and urbanization. However, scientific methods should minimise disturbance and stress to biodiversity, and any impacts should be explicitly justified.

Challenges

Too little regulation, education, and discussion

Many countries have implemented legislation and institutional review processes that require investigators to justify research procedures and use best practices to minimise pain and stress to animals in laboratories and other research (Gillespie 2014). These laws are implemented and enforced differently depending on country, target species, and the focus of the regulating agency or committee. Generally, requirements are focused on vertebrates and sometimes other 'popular species' (e.g. octopus, lobsters), and often do not require researchers to consider the impacts of fieldwork on ecosystems, invertebrates, or non-target species communities (e.g., Fazey et al., 2005). Ethics committees may consider animal manipulation in the laboratory and field, but not the killing of the same animals as part of 'sampling'.

Some universities also offer courses to conservation students in respectful (or ethical) research practices, and a field of study developing in this area (Minteer and Collins 2005a, b). Nevertheless, some researchers seem to choose more destructive methods without trying alternatives. Thus managers of protected areas sometimes need to press researchers to be more respectful of nature. For example, applications to conduct research in the Great Barrier Reef Marine Park (Marsh and Kenchington 2004) and other protected areas increasingly require researchers to justify the impact of fieldwork, including disturbance and collecting. However, discussion of unintended consequences and responsible research practices is still relatively rare in the literature and the field. In Acadia National Park in the United States, for example, park managers' return nearly all new applications for research permits for revision because investigators inadequately consider the impacts of their research on species and ecosystems. Based on our personal experiences, we believe this lack of consideration is widespread.

Uneven treatment of species

In the examples in our opening paragraph, the vertebrates were marine and freshwater fish. Two of the studies used gill-nets which are notorious for entangling all kinds of species. We wonder if the authorities would have been less likely to have given permission if they were mammals, birds or reptiles (McClanahan 1990). Fish feel stress and may be compared in cognitive and social behaviour to birds in aerial ecosystems (Sneddon 1990). Moreover, should respectful treatment of organisms depend on a species' sentience (Bateson 1991)? For example, what about invertebrates? Octopus and squid exhibit complex behaviours, and likely experience pain and stress. And what about other invertebrates, such as crustaceans, insects and spiders; should they be treated casually? In one past study published in *Biological Conservation*, researchers created fires of different intensities to test their impact on the mortality of soil-nesting bees (Cane and Neff 2011). Such fires are widespread, both deliberate and accidental, and this was the first and only practical way to assess their effects on these important pollinators. In contrast the studies mentioned in the first paragraph had limited novelty and could have been achieved without killing the animals.

Impacts on non-target species and ecosystems

Damage to ecosystems—for example, by trampling and removing vegetation, dredging and trawling, and noise and light pollution—is routine outside (and sometimes inside) protected areas. Any harm to species and ecosystems, especially inside protected areas, should be minimised, even if it is not included as a formal part of the process for reviewing research on animals. Impacts on one species may have indirect effects on others due to predator-prey interactions or habitat change (e.g., Leleu et al. 2010). This caution is particularly important in ecosystems that are not stable or are particularly stressed, in cases that may aid the transmission of wildlife diseases (e.g. chytridiomycosis or avian influenza), in areas that local people rely on for subsistence, or in cases where the research could alter local perceptions of the value of species or conservation measures. In particular, researchers should avoid inadvertent transport of species, especially invasive species and disease organisms, by using clean field equipment (Bunting and Coleman 2014). For example, cave explorers or bat ecologists may have inadvertently transported the deadly fungus that causes white-nose syndrome from Europe to the United States on contaminated clothing or equipment (Fenton 2012). Many disciplines have established best practices for field work and it is important that these are rigorously observed (e.g., Powell and Proulx 2003, Conour et al. 2006, Phillott et al. 2010, Winker et al. 2010, Buchholz et al. 2011, Donaldson et al. 2013).

Invasive species control

Conservation researchers and managers often kill species (vertebrates, plants and invertebrates) in studies and management actions related to the control of invasive species. This may be essential to prevent the extinction of native species in some circumstances. However, due diligence is required to ensure that non-target species are not affected and the methods follow ethical standards (Tuttle et al. 2008, Eason et al. 2011). Invasive species control should also consider public opinion, because this acceptance can contribute to the success of control programmes and public impressions of scientific ethics (Bremner and Park 2007).

Collecting

The collection of specimens, particularly of rare species, can also generate debate (Filardi 2015), because it may contribute to their decline (Minteer et al. 2014). Large-scale collecting methods, such as fogging tree canopies or netting in marine waters, may produce specimens of scientific value, but they often kill other organisms in the process (Costello et al. 2016). If researchers must collect specimens to address clear and compelling questions, such sampling should be justified. Generally, experienced researchers realise the cost of processing large samples of invertebrates is prohibitive and limit sampling such that impacts on species abundance is minimal. The spatial impact of research should also be considered. For example, lights and underwater acoustics may

disturb animals at a distance, and impact non-target species in ways as yet unknown (e.g., Verlaan 2007).

Relationships to hunters and hunting

In some cases, particularly those relating to game species (e.g., antelope, gamebirds), hunting laws are less restrictive than university ethics committees. Locally hunted animals represent a potential resource from which researchers can obtain additional data. For example, avian influenza research has often relied on local hunters to obtain samples from hard-to-catch waterbirds (e.g., Gaidet et al. 2007, Ip et al. 2008). In some countries, such as South Africa, it is relatively easy to obtain a hunting permit to shoot ducks and relatively complicated to obtain permission from state agencies to catch, sample, and release live birds. While we have no ethical objection *per se* to the collection of additional data from already-hunted animals, it is important that research should not stimulate additional hunting; that researchers favour non-fatal sampling approaches wherever possible; and that researchers do what they can to reduce or limit the transfer of capture technologies (e.g., novel trap designs or passing on damaged mist-nets) to local communities.

Public visibility and the potential to block good research

In many countries the public is increasingly concerned about the humane treatment of animals. Recent stories regarding the killing of Cecil the lion in Zimbabwe, and the killing of Harambe, a gorilla in a U.S. zoo, highlight this concern. If this concern expands to research practices, it could undermine support for scientific research and conservation. At the same time, we must be prepared to justify destructive research techniques when they are necessary and not let research that could greatly benefit conservation go undone when trade-offs between benefits and harm are reasonable.

Solutions

Use low-impact methods

Whenever possible, researchers should use well established methods that have negligible impact on species and ecosystems, such as observation, mark-release-recapture, collecting faeces and hair, and noting animal tracks and signs. New technologies that have minimal impacts, such as camera-traps (Meek et al. 2014), tags and sensors (Cooke et al. 2013), satellites (Andréfouët et al. 2008), drones (Vas et al. 2015), and environmental DNA (eDNA) (e.g. Russello et al. 2015, Thomsen and Willerslev 2015) are becoming easier to use and more cost-effective all the time (Costello et al. 2016). They can often be more effective at characterizing biodiversity and many aspects of ecology than destructive sampling techniques. There are also organisations that will fund researchers, particularly in the developing world, who want to use these newer low-impact techniques; e.g. the Conservation Leaders Programme. When research necessitates impacts on biodiversity, these impacts must be justified and kept to a minimum (Verlaan 2007, Parris et al. 2010). A useful rule is that any impacts on species and their habitats should persist for as short a time as possible (Cuthill 1991).

Improve regulations, policies, and behaviour

In cases where impacts may be uncertain, the precautionary principle should apply (Crozier and Schulte-Hostedde 2015). Marsh and Kenchington (2004) proposed that research institutions broaden their animal use committees to include environmental effects, and that scientific societies develop specialist codes of practice for their members. Accordingly, ethical guidelines and requirements should take into account impacts on hitherto underrepresented species groups and ecosystems in order to improve the public perception of their importance and biological sampling methods. In addition, the development and strengthening of collaborations between different disciplines and institutions may help to improve ethical guidelines in and enhance efforts to minimize harm to wildlife (e.g., Cattet 2013, Crozier and Schult-Hostedde 2015). It is possible that new methods developed in one field could be applied to another so as to reduce the impacts of research. It might also be relevant to employ veterinary professionals in specific cases (Deem et al.

2001). Thus, especially in protected areas, it could be justified to restrict research until less harmful methods are available, and recognise that for now, somethings may remain unknown.

It is essential that the results and data from research be made publicly available following best practice (Costello and Wieczorek 2014). If not, the research has limited capacity to benefit the science and conservation management because the knowledge gained will be restricted to the researchers. In considering papers for publication, journals should require authors to conform to particular codes of respectful or ethical research, and agencies with responsibilities for protected areas and species should have committees to review proposals before issuing field research permits (Marsh and Eros 1999). Researchers should document and be ready and willing to justify why they choose particular research methods, especially when those methods might harm species, ecosystems, or people. We support these recommendations while recognising the reality that their implementation will take time and may not cover every organisation, protected area, and situation.

Consider carefully your field sampling in conservation science

We recommend that conservation scientists consider at least the following questions when conducting fieldwork, in addition to meeting legal requirements for permits and avoiding public disclosure of sensitive threatened species locations (Table 1). We assume the investigators have carefully considered whether the research is necessary, and if the ends justify the means.

1. Will any animals or plants be harmed by the research?
2. If so, are there less invasive or harmful methods to carry out the research and collect the necessary data?
3. How long and over what area will the impacts of the research persist?

Researchers should set the highest standards, especially when working within protected areas and areas that contain threatened species. For our part, as editors of *Biological Conservation*, we will continue to question researchers and reject papers that do not meet reasonable standards of practice, as per our journal policies (Table 1). We expect the authors who publish in our journal to set examples of best practice for field research.

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Table 1. A checklist of ten considerations for respectful conduct during biological field sampling.

BEFORE

1. Justify any potential adverse impacts of the research in terms of advancing scientific understanding;
2. Comply with the spirit of institutional and national regulations regarding research and responsible care and use of animals, collecting samples and specimens, and working in protected areas;
3. Apply the precautionary principle in assessing potential impact of the research on species and their habitats. This includes inadvertent transport of pests, pathogens and introduced species;

DURING

4. Avoid killing animals and plants, especially species of conservation concern and species in protected areas;
5. Minimise disturbance to wildlife and habitats. Ensure that accidentally captured animals will be carefully and immediately released alive;
6. Minimise stress to animals that are sampled or handled;

AFTER

7. Remove research equipment and materials from study sites;
8. Maximise future benefits of research by archiving samples for future research and educational use;
9. Promptly report information that responsible authorities should know, such as, pollution, and rare and invasive species observations;
10. Publish findings and data in publicly accessible permanent archives for use in future research, education and management.