Chapter 19

Technological Ethics in Zoological Studies Opportunities and Challenges

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Abstract

This chapter examines the way technology is changing the ethical aspects of animal research, conservation and welfare. First, it explores the historical roots of ethics in zoology through the 3Rs which are key ethical principles and important philosophies, to show how ethical issues in animal science have evolved. The field looks into how advanced technologies such as AI, GPS tracking, remote sensing, CRISPR gene editing or bio-logging affect the environment, as well as the moral challenges they present. Animal welfare, ensuring data privacy, being mindful about the impact on nature and a focus on both utility and care are main issues here. This chapter considers issues such as depending heavily on technology and conflicts between humans and wildlife and it suggests using non-intrusive monitoring, citizen involvement and responsible research to advance ethics. Consequently, the chapter suggests updating codes of ethics and regulatory frameworks to support responsible and sustainable embracement of technology in zoological research. It seeks to strike a balance by using modern progress and protecting the natural value and dignity of animals.

Keywords

Zoological Ethics, Technological Integration, Animal Welfare, Artificial Intelligence in Zoology, GPS and Remote Sensing, CRISPR and Genetic Engineering

1. Introduction

Zoological studies involve observing and experimenting with animals to better understand their anatomy, habits, places they live, physical activities and the ways they evolved globally. Biodiversity and ecology studies made extensive use of both fieldwork and lab studies for quite a long time to understand the workings of ecosystems. The field of remote sensing has been transformed over the years by creating new tools like bio-logging, camera trapping and gene editing (Wilmers et al., 2015; Kays et al., 2015). Because of these tools, scientists can study animals worldwide, predict their interactions and assess how their populations are doing more closely.

Technological change creates new ethical issues which require the use of evaluation methods that can help control and monitor their use. Camera traps which are great for observing wildlife, have led to concerns about possibly overseeing Indigenous or rural communities living near such

conservation areas (Sandbrook et al., 2018). In the same way, using gene drive technology on wild populations to control invasive species or diseases leads to difficult ethical questions about species independence, the natural balance of ecosystems and possible irreversible effects on the environment (Esvelt & Gemmell, 2017). These new challenges are connected to ethics, the law and the values found within different cultures. Thus, joint efforts are needed from zoologists, ethicists and those who set policies to guarantee that the use of these technologies is in alignment with ecological and social concerns (Sandler, 2012).

Today, ethical considerations are a core focus in zoological science, mainly as we deal with the Anthropocene which describes humanity's growing influence on Earth's living things. Zylinska (2014) points out that since nonhuman life is essential for our existence, tolerance and concern for it have current and urgent meanings in this era. Research and monitoring involving animals in different fields now need to consider how such activities impact animals, the environment and society as a whole. Institute of Laboratory Animal Resources' Guide for the Care and Use of Laboratory Animals (1986) provides standards for proper animal care and use, but new technologies are creating new issues for these guidelines. For example, digital tools in zoos, such as interactive monitoring systems, not only affect animal cognition and welfare but also influence public attitudes toward conservation ethics (Coghlan et al., 2021).

Conservation practices and policies are being guided by new ethical and technical trends. The IUCN Red List, used in conservation decisions, is now using data-based assessments to give priority to helping species recover (Betts et al., 2020). At the same time, agreements like CITES (2019) and environmental laws placed a strong emphasis on controlling wildlife trade using technology and protecting animals' habitats (Dhakal & Dhar, 2024). Because of these changes, clear ethical rules are needed in all areas of governance so that biodiversity conservation is protected and no one's needs are neglected. It is important for ethical frameworks to address the indirect influence on the environment. For example, different host animals are very important in disease spread and activities involving wildlife may affect how pathogens are controlled or handled (Ostfeld & Keesing, 2012).

As a result of these obstacles, it is clear that structured methods for evaluating ethics are necessary. Fairness in these areas needs to evolve to include justice for entire ecosystems and how species are linked. For animal science to harmonize engineering and ethics, the perspective must shift from controlling animals to sharing space with them. Having ethical frameworks supports the review of decisions, prediction of future results and inclusion of affected groups when making choices. If zoological research does not rely on ethics, it could lead to harming animals and nature by reinforcing human-centered values (Sandler, 2012; Zylinska, 2014).

2. Literature review

This review explores the link between ethical matters, new scientific developments and the preservation of biodiversity in animal research, focusing on topics including AI, identifying species,

gene drive, animal welfare and how digital governance applies to this area.

Recent studies have shown that the principles behind animal research have transformed remarkably, particularly highlighting the importance of the 3Rs—replacing, reducing and refining animal tests. All research frameworks operating now keep these principles at their core (Gad, et al., 2020). It is usually more complicated for zoos in captive settings to balance ethical dilemmas and research compared to native settings, as explored by Fernandez & McWhorter (2023) and Coghlan et al. (2021).

Another aspect is seen in veterinary medicine, where Kiraga & Dzikowski (2023) discuss the ethical struggles, veterinarians deal with in animal research. Jaquet et al. (2022), Johannsen (2020) and Nesseler & Adelstein (2024) indicate that some people's attitudes about moral issues are guided by utilitarian and deontological ethics. Sandler (2012) brings a philosophical element into the discussion by focusing on specific ethical concerns for each species.

Artificial intelligence is quickly changing how we identify different species and watch ecosystems. Recent studies by Adebayo (n.d.) and Congdon et al. (2022) point out how AI can be used to classify organisms without human assistance and Neethirajan (2024) advocates for AI that supports and improves the well-being of both people and animals. Lahoz-Monfort & Magrath (2021) as well as Petso et al. (2022) discuss how drones and bio-logging are efficient for monitoring both species and their habitats.

Both Robstad (2020) and Robstad et al. (2021) stress the importance of careful use of bio-logging equipment, as they may have negative impacts on the organism being tracked. Sandbrook et al. (2018) and Serafinelli (2024) point out that using tools such as camera traps and drones for conservation raises concerns about privacy and consent.

Nanglu et al. (2023) emphasize that ecology and conservation depend greatly on natural history and taxonomy. However, Ceríaco et al. (2023) mention that renaming species to reflect ethics might change the system of species names, possibly hurting the link between various areas of science.

Instrumental to this field is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Secretariat, 2019). In Tonga, Etika (2023) studies how CITES authorities operate and Green et al. (2022) analyze the way the IUCN Red List and CITES Appendices are being applied by businesses. Betts et al. (2020) develop a mechanism for understanding the influence of the Red List on decisions and conservation action.

On the legal front, Dhakal & Dhar (2024) intersect zoology and environmental law in marine ecosystems, emphasizing the legal reinforcement of sustainable practices. Erwin (2024) and Venkataraman & Hefferon (2022) tackle the ethical implications of genetic interventions and gene drive technologies in response to climate change and biodiversity loss.

Moral reasoning plays a significant role in shaping attitudes toward animal ethics. Lin-Schilstra & Fischer (2020) analyze consumer dilemmas in choosing animal-friendly products. Psychological insights into utilitarian moral judgments and animal status are detailed by Jaquet et al. (2022), suggesting that public support for animal

welfare policies is closely tied to moral intuitions.

The evaluation of research proposals often involves the participation of Institutional Animal Care and Use Committees (IACUCs). Pippin et al. (2024) discuss the problems with IACUCs, especially when it comes to being open and responsible. Interacting with the public does not get easier with the arrival of new technologies. Thompson et al. (2021) and Stahl & Eke (2024) provide studies on how digital platforms and AI tools like ChatGPT need ethical governance in conservation science.

3. Historical Context and Ethical Foundations

There have been major changes in the ethics of zoological studies due to prior experiments on animals not being regulated. Back when there was little regulation of research, it was usual to prioritize discoveries over being sure animals were treated well (Arnason, 2020). In the middle of the 20th century, it was acknowledged that animals could experience pain, resulting in the formal creation of research ethics.

At the heart of this change is the 3Rs principle, known globally as Replacement, Reduction and Refinement which is now a basic ethical standard in animal research (Díaz et al., 2021; Kiani et al., 2022). Replacement seeks out animal-free options, Reduction works to use fewer animals and Refinement is about easing pain and enhancing animal care. Following these principles provides a humane framework and helps produce more accurate data (Harikrishnan, 2022). Even so, it is still difficult to apply the method practically, particularly in wildlife studies carried out in the field (Kiraga & Dzikowski, 2023).

Ethics from philosophy are also applied in zoos. Many times, utilitarianism is used to allow animal studies if the research leads to major positive impacts on people or the environment (Nesseler & Adelstein, 2024). But some critics argue that exaggerating the benefits may cause animals extra stress (Jaquet et al., 2022). Unlike the other approaches, deontological ethics stresses that we have a duty towards animals and should always consider them to be morally important. Ethical veganism and animal rights groups are now arguing against using animals for any type of experimentation along with these two approaches (Criscuolo & Sueur, 2020).

Nowadays, ethical issues are also being discussed in relation to wild species and the role natural history can play in conserving nature. As natural history becomes significant in zoological fields, like conservation and ecology, it points out the value of respectful and non-intrusive study methods (Nanglu et al., 2023). This wider perspective reveals that ethical obligations in zoology are found not only in labs, but also throughout the different types of study involving animals.

4. Emerging Technologies in Zoological Research

Technology is influencing zoological research by improving tools for observation, collecting data and analyzing how wildlife acts and evolves. Although artificial intelligence, gene editing and bio-logging can help in conservation and

animal science, they also bring up many ethical and practical issues.

Zoologists now rely heavily on Artificial Intelligence (AI) and Machine Learning (ML) for spotting species, studying their health and foreseeing their behaviors. Congdon et al. (2022) state that AI is now improving the efficiency of monitoring by handling most of the camera trap and drone imaging. Likewise, Adebayo discusses how AI is useful in arranging data, automating the work of assigning species to categories in ecological surveys.

There are still ethical issues that need attention, even though these benefits exist. If the training data used to develop algorithms has biases, using them can introduce new biases in the system. Additionally, AI should not replace human judgement in decision-making, since the outputs must be carefully evaluated and conservation decisions should not be based solely on uncertain models.

Real-time tracking of animals and their environment has been made possible through GPS and remote sensing technology. According to Rafiq et al. (2021), tagging animals allows researchers to know their behavior, migration patterns and where they live which helps plan better conservation efforts. In their paper, Lahoz-Monfort and Magrath (2021) emphasize that by using satellite imagery, LiDAR and acoustic sensors, it becomes simpler to inspect habitats and find animals in hard-to-reach areas.

On the other hand, these technologies might change the way animals behave and could lead to privacy issues. Invasion of wildlife by tagging or poorly placed tags may cause animals to behave differently or feel more stressed. We should use gentle methods and monitor well-being all the time while using captive animals.

Genetic engineering, with CRISPR/Cas9 being used the most, is gaining interest in conservation biology for activities such as bringing back endangered species and controlling pests. Gene drives are discussed by Venkataraman and Hefferon (2022) as a way to affect or stop the growth of invasive species.

While using these tools solves many ecological issues, it also brings up ethical problems related to unpredictable effects on the environment. Erwin (2024) states that making changes to the genes of wild populations can distort the environment and result in consequences that cannot be reversed. We must assess the risks and continue monitoring the environment carefully before applying these technologies more widely.

Bio-logging devices, such as GPS collars, heart rate monitors, and accelerometers, are used to study animal physiology and movement in natural settings. Williams et al. (2021) describe future trends in measuring physiology using minimally invasive tools, aiding in understanding animal responses to environmental stressors. However, concerns about welfare remain.

Robstad (2020) and Robstad et al. (2021) show that bio-logging can lead to short-term changes in body weight and stress in animals like the Eurasian beaver, suggesting that even temporary attachment of devices may have physiological consequences. Therefore, welfare considerations—such as minimizing device weight and ensuring ethical review—must be integral to research planning.

5. Ethical Challenges and Dilemmas

Ethical issues in zoological research are growing and are shaped by new inventions, emerging public views and updated guidelines for animal care.

It is challenging for scientists to find the right balance between making new discoveries and being responsible. According to Johannsen (2020), since there is a strong moral case to help animals by reducing their suffering, invasive studies are considered with more difficulty. According to Neethirajan (2024), artificial intelligence and sensors can be used to check on animals without harming them which complies with animal welfare and helps researchers. However, Fernandez and McWhorter (2023) point out that strict supervision should be used when working with captive exotic animals in zoos for research purposes.

Technological progress is leading to new guidelines for how data should be handled in research. Thompson et al. (2021) highlight that handling sensitive information related to ecology or species is a key concern in online conservation research. According to Ceríaco et al. (2023), some actions linked to ethical aims, for example, renaming species to remove offensive words, could impact science's foundation and expose the clash between ethics and long-used data methods.

With AI, researchers could perform their tasks more quickly and the connection between humans and animals might diminish. Stahl and Eke (2024) state that using automated technology can lead people to become less concerned about ethics or less mindful about their decisions. According to Lin-Schilstra and Fischer (2020), moral issues in today's world cause people to focus more on empathy and common sense, rather than just getting jobs done easily.

Drones and camera traps are now crucial for protecting wildlife and conserving nature. In addition, Von Essen et al. (2023) highlight that relying on such technology can increase both control and observation in animal-human interactions, breaking ethical standards. The use of technology to save wildlife could also lead to people's personal information being shared or animals displaying unusual behavior that creates ethical problems.

6. Opportunities for Ethical Technological Innovation

With recent technology, we can find new ways to protect animals and not break the ethical rules. Using tools like camera traps, sensors and wearable tags, researchers can observe animals' actions and well-being with minimal disturbance. The new equipment helps animals live safer and less stressful lives, reflecting the ethical principles in science.

These platforms help to involve all kinds of people in data gathering. Taking a community-based approach with other scientists means technology is now collecting more diverse kinds of data. Taking this approach encourages people to pay more attention to wildlife conservation.

AI can help to quickly find outbreaks of disease and signs of habitat destruction. Because AI systems process ecological information right away, they support researchers and conservationists in reacting promptly to new dangers which could lead

to saving both endangered and vulnerable ecosystems.

Also, digital technologies support openness and reapplication of research findings. Because of open-source software, blockchain and standardized data protocols, studies in zoology are trustworthy and transparent which increases belief in their working methods.

7. Regulatory and Ethical Frameworks

Governance of zoological research and wildlife conservation mainly depends on international rules and oversight bodies. CITES and the IUCN Red List are the main tools used at the global level to direct ethical wild animal commerce and conservation. CITES helps to control and monitor the trade of endangered species around the world. Tonga's fisheries case study, for example, highlights how CITES authorities ensure both compliance and sustainability through their management of trading (Etika, 2023). To add to this, the IUCN Red List offers research support for recognizing species at risk and advises corporate actions on trade so that activities follow important conservation principles (Green, et al. 2022).

They support conservation governance and their effects are seen in places other than the management of trade. Besides providing data, the IUCN Red List is used to assess how effectively conservation takes place, determine which species need help most and allocate money (Betts et al., 2020).

Institutional Animal Care and Use Committees (IACUCs) help uphold ethical conduct in animal testing at the institutional level. These committees need to go over and approve animal research proposals to check that they follow ethical rules and animal welfare standards. However, it can be quite difficult to evaluate research proposals, mainly because of concerns about transparency, consistency and scientific justification (Pippin et al., 2024). As well as this, frameworks including The Inner CRO detail the legal, ethical and regulatory duties involved in animal care and use (Gad et al., 2020).

As drones, artificial intelligence and digital surveillance are introduced in wildlife research, the field's ethics have to be rethought. Drone usage has become more common which leads to concerns related to visual ethics, the use of collected data and their impact on the environment and existing norms may not be enough to deal with these issues (Serafinelli, 2024). Also, exploring the ethics and politics of emerging digital technology requires us to think about surveillance, consent and power relations for both people and non-people (Surber & Stauffacher, 2022).

As a result of these changes, it is now necessary to update and widen ethical rules and regulations to include modern systems. Any alterations should be aligned with the modern equipment and procedures in research as well as ensure animal and environmental safety, transparency and respect for plants and animals.

8. Future Directions

Since technology advances so quickly, it is important to develop new ethical assessment methods for evaluating new research methods in zoology. They should be able to sense the context so that new technologies can be tested for what they are good for as well as potential ethical risks

they carry. Ethical courses should also be introduced to both zoologists and technology developers to encourage a caring and responsible attitude toward animals. It is also necessary for ethicists, zoologists and technologists to work with each other to make sure advancements in zoology support both the values of the community and the health of the environment.

9. Conclusion

Improvements in technology for zoological sciences can help care for animals, monitor the environment and save wildlife, yet at the same time, they can create ethical dilemmas. With support from AI and new technologies, the accuracy and scope of research in zoology have greatly improved. Still, they might negatively impact animals, reduce traditional field methods and bring up issues about who owns the data collected.

Therefore, we should ensure to proactively address the ethical impacts of technological advancements. Laws need to adjust to new technologies as they arise and everyone involved should focus on making the process transparent, inclusive and responsible.

We must move forward with responsible innovation, aiming to help both wildlife and the environment without sacrificing ethics. To progress, zoological sciences must follow this balanced approach that honours all living creatures.

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