



Original Research Paper

Integrated Human-Animal Ecosystem Framework for Evaluating Sustainable Coexistence Between Communities and Wildlife

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Key Words

Human-wildlife coexistence, Animal behaviour, Livestock husbandry, Wildlife ecology, Animal welfare, Community-based conservation.

Abstract

Sustainable coexistence of human settlements and wild animals continues to pose a critical challenge to contemporary animal science especially in environments that involve farming, grazing and wild habitats. Current measures of human-wildlife interactions are limited in scope as they are conducted individually based on behaviours, physiology and socio-economics. The current paper outlines an Integrated Human-Animal Ecosystem Framework through which the different aspects of animal behavioural ecology, physiological well-being, population dynamics and husbandry methods could be considered together as an evaluation framework. The framework is built from documented practices within applied animal behaviour science, wildlife ecology and husbandry sciences. Different aspects of coexistence include depredation rate, physiological stress, reproductive success rate and tolerance of domestic and wild animals. Examples of the strategies for enhancing coexistence include guarding animals use, herd management techniques and behaviour-based deterrence techniques. The paper argues that sustainable coexistence should not be viewed as lack of conflicts but rather an equilibrium achieved through consistent animal-based husbandry and management practices. Implications for animal science research, extension practice and community-based wildlife management are discussed along with suggestions for future research work.

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Introduction

Interactions between human societies and wildlife become more frequent as the result of habitat loss, fragmentation, and range changes that lead to more overlap of domesticated and wild species' habitats (Nyhus, 2016). Such interactions vary from being a source of conflicts, such as destruction of domestic animals by predators, and damage of crops to being peaceful coexistence when both people and wildlife coexist in such a way that neither suffers from unsustainable losses (König et al., 2020). Traditionally, animal science has approached this problem using two separate disciplines: wildlife biologists study predator ecology and population dynamics, whereas animal scientists deal with livestock behaviour and productivity.

This paper attempts to outline a new theoretical framework known as the Integrated Human-Animal Ecosystem Framework where the sustainability of coexistence can be measured using behavioural ecology, physiology, population biology, and practical husbandry indicators. This framework seeks to shift the focus of measuring sustainability of coexistence from a social/policy perspective and place it on the biological response of both domestic and wild animals since only the latter determines the viability of landscapes (Lamb et al., 2020).

Key Contributions

- Offers an integrated approach to assessing sustainable co-existence between human settlements and wildlife.

- Integrates behavioural, physiological, population, and community-based measures in an animal science framework.
- Promotes adaptive husbandry and wildlife management, and sustainability of coexistence in shared environments.

This paper is structured as follows. In Section 2, the coexistence concept in animal science is discussed. The Integrated Human-Animal Ecosystem Approach is provided in Section 3, while the applied animal science approaches to coexistence are presented in Section 4. The evaluation of sustainable coexistence is provided in Section 5, and the discussion follows in Section 6.

The Concept of Coexistence in Animal Science

The concept of coexistence is now being viewed as a dynamic process in which both people and wild animals live together on the same landscapes but at levels of tolerable risks to each other instead of an unconflicted situation (König et al., 2020). This change in the definition of coexistence places emphasis on biological indicators of tolerance, adaptation, and flexibility of behaviour of animals as opposed to counting the frequency of conflict alone. The role of large carnivore studies in achieving such a change is quite significant since it shows that coexistence between human beings and carnivores involves carnivore behaviour, prey density, and livestock density (Lamb et al., 2020).

In the field of applied animal science, the coexistence outcome is also influenced by the behaviour and husbandry of the domestic animals

involved. Composition of the herd, grazing habits, presence of a guarding animal, and time of husbandry practices affect the chance and the extent of encounters with wildlife (König et al., 2023). The assessment of coexistence must take into account not only the ecology of the wild species but also the state of the livestock.

An Integrated Human-Animal Ecosystem Framework

The proposed framework organizes coexistence evaluation across four interconnected dimensions, each grounded in established animal science methodology.

Behavioural Ecology Dimension

This component focuses on activity, spatial avoidance, and habituation responses of animals in their natural habitats in relation to the presence of humans and cattle. These include alterations in time of activity of the animals either towards night or dusk, altered use of habitat areas around settlements, and the occurrence of avoidance/approach behaviour when interacting with others. Similar behavioural metrics are measured in domesticated herds, such as vigilance response, flight distance, and clustering, which are linked to predation threat and impact foraging efficiencies (Lamb et al., 2020).

Physiological and Welfare Dimension

The chronic stress caused by repetitive encounters between humans and wildlife can be quantified by physiological parameters like cortisol levels, body condition scores, and reproduction in both wild and farm animals.

Long-term elevated stress hormone levels in farm animals due to continuous predation have been linked to low weight gain and reproductive success, and continuous human disturbance on wild carnivores is associated with changes in their movement and foraging efficiency (Lamb et al., 2020). The use of welfare-based physiological measures would enable assessment of the coexistence costs that cannot be determined only by depredations.

Population and Habitat Dimension

Indicators at the population level include survival rates adjusted for predation, recruitment levels, and carrying capacity of the wild species that live in agroecological mosaics as well as herd performance of domestic animals. Studies that incorporate landscape context have revealed that the arrangement of pastures, forest and the distance from settlements influences the probability of predation on livestock by wild predators with reasonable predictive power (König et al., 2023).

Socio-Community Dimension

Since management practices for animals are developed by herders and farming communities, the framework considers community practices such as tolerance levels, involvement in compensation programs, and adoption of new forms of husbandry that are non-lethal. Community-based interventions developed with herders, utilizing indigenous ecological knowledge of how their animals and predators behave, have shown greater success than imposed interventions (Bijoor et al., 2021).

Applied Animal Science Approaches to Coexistence

Several applied husbandry practices operationalize the framework's dimensions and provide practical pathways toward measurable coexistence outcomes.

Guarding Animal Deployment and Non-Lethal Deterrence

Animal guarders, especially dogs, continue to be one of the best-studied non-lethal techniques in the field of animal behaviour science. Animal guarders affect both the predator, by virtue of territorial and deterrent signals, and the livestock, which become less dispersed and less vigilant while grazing (König et al., 2023). However, according to systematic studies of intervention effectiveness, the results may differ depending on the degree of proper training, herd size, and topography of the area, which requires specific behavioural assessment of each individual case (Eklund et al., 2017).

Herd Behaviour Monitoring and Husbandry Timing

Modifications to grazing time, corralling activities, as well as calving and lambing time can decrease the period of interaction between the livestock and predators in order to minimize their vulnerability without resorting to lethal means of predator management. The monitoring of livestock vigilance and grouping can be used as the early sign of increased predation danger (Lamb et al., 2020).

Community-Based Adaptation

Approaches involving participation, which integrate the ecological knowledge of herders and behaviour analysis of animals, have resulted in locally relevant mitigating practices, including enclosure designs and grazing rotations, which are more reliably implemented by the communities compared to the ones devised from outside the community (Bijoor et al., 2021). Such approaches exemplify the socio-community aspect of the framework and highlight the importance of bringing applied animal science recommendations in line with the realities of pastoral lifestyles.

Evaluating Sustainable Coexistence

The application of the Integrated Human-Animal Ecosystem approach entails monitoring of the indicators in all four dimensions over time, instead of focusing on one conflict indicator. It could be assumed that a given landscape is approaching sustainability in terms of coexistence if livestock productivity remains stable, considering depredation effects; if wild animal populations can achieve sufficient reproductive and survival success; if there are no excessive levels of stress indicators in domestic and wild species; and if community tolerance and acceptance of non-lethal husbandry techniques continue throughout seasons. A bibliometric analysis of coexistence research demonstrates that scientists have paid increasing attention to multi-dimensional assessments of coexistence landscapes, acknowledging the fact that conflict-frequency counting is an inadequate

measure of sustainability of coexistence (Guzman et al., 2025).

Discussion

The present framework differs from the conflict-centred approach in the sense that both wild animals and domesticated ones are considered active players in the coexistence processes through their behaviour and physiology. The animal-centred perspective adopted here is consistent with trends in animal science research that recognize the importance of welfare and behavioural competency for sustainability in animal production systems, but expand them into human-wildlife interface areas. One important consequence is that animal science extension programs together with wildlife management organizations have a part to play in coexistence processes.

The limitations in this approach are associated with the cost and complexity involved in acquiring physiological and behavioural data in both wild and domesticated settings and the differences in the applicability of the indicators from one animal to another and from one agro-ecological setting to another. Future research needs to validate the framework's indicators in different animal systems such as predator/prey, ungulates, and primate interactions.

Conclusion

The sustainable coexistence of human and wildlife populations can be assessed better by considering this dynamic balance of animal interests instead of using an abstract policy objective. The framework of the Integrated

Human-Animal Ecosystem that is proposed in the present paper integrates the behaviour, physiology, population and community aspects identified through previous studies in animal science to provide an improved evaluation model. Considering the behaviour and welfare of both domestic and wild animals, the framework provides a tangible foundation for achieving coexistence in the shared ecosystem of agricultural and wildlife habitats.

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