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Forum: Ideas

Integrating animal behavior and conservation biology: a conceptual framework

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Conservation behavior is a relatively new interdisciplinary field aimed at investigating how proximate and ultimate aspects of animal behavior can be of value in preventing the loss of biodiversity. This new discipline's usefulness in promoting practical conservation-matters is subject to debate, with some scientists arguing that the importance of behavior in conservation practice is overemphasized. Here, we propose a conceptual model that identifies the key linkages between animal behavior and conservation biology. The model is a simply structured, hierarchical, and parsimonious framework that will help bridge the gap between the 2 disciplines and establish a common ground on which the field of conservation behavior can evolve and from which paradigms can be developed. *Key words:* adaptive behavior, behavior-based management, behavioral indicators, conceptual model, conservation behavior. *[Behav Ecol 22:236–239 (2011)]*

Although the disciplines of animal behavior and conservation biology are already conceptually intertwined, no unifying framework exists for this interdisciplinary field. The idea of incorporating behavioral understandings in conservation management has been around for at least 35 years (Geist and Walther 1974; Harcourt 1999). However, in the last decade, a surge of publications exploring and highlighting the connections between the fields of behavioral sciences and conservation have emphasized the key role animal behavior plays in conservation practice (e.g., Clemmons and Buchholz 1997; Sutherland 1998; Linklater 2004; Blumstein and Fernandez-Juricic 2010). This discipline, termed "conservation behavior," aims to investigate how proximate and ultimate aspects of the behavior of animals can be of value in preventing the loss of biodiversity (Buchholz 2007).

Numerous studies demonstrated that behavior is relevant to conservation biology and that conservation behavior can be applied successfully to assist conservation efforts (e.g., Wallace and Buchholz 2001; Shier 2006; Moore et al. 2008). Furthermore, ignoring behavioral data may lead to failure of management programs (Knight 2001). Nevertheless, the linkage between the 2 disciplines is still weak (Angeloni et al. 2008), and the integration of animal behavior into mainstream conservation efforts and its ability to promote practical conservation-matters is subject to debate (Buchholz 2007; Caro 2007), with some scientists arguing that the importance of behavior in conservation practice is overemphasized (Caro T, personal communications).

To enhance the linkage between the 2 disciplines and overcome the inherent differences between them (Clemmons and Buchholz 1997; Caro 1998, 1999; Buchholz 2007; Angeloni et al. 2008), a unifying framework is necessary (Moore et al. 2008). Newly developing, interdisciplinary scientific fields are often characterized by having no paradigm (Kuhn 1970). To evolve, paradigms require a well-structured underlying framework. With no underlying framework, every researcher has to invent the foundation for his or hers own work, and the body of research becomes a random collection of observations with little structure. A good framework should be logical, parsimonious, and hierarchical; and although tending to oversimplify, it enables better focused studies, identification of key research areas, and future research directions and development. A framework unifying the behavior and conservation sciences can, therefore, facilitate bridging the gap between the 2 disciplines and establish a common ground in which the field of conservation behavior can develop and paradigms can be formed.

We propose a conceptual model in which we aim to create a framework that will lend structure to this new evolving field and will help define the goals of conservation behavior studies, sharpen our vision for what can be done and how, and set the stage for generating hypotheses and developing subfields within the discipline.

THE CONSERVATION BEHAVIOR FRAMEWORK

Our framework is composed of 3 basic themes by which conservation and behavior are linked (Figure 1): 1) Direct and indirect anthropogenic impacts on animal behavior that, in turn, impact biodiversity; 2) behavior-based management, representing the use and consideration of behavior in conservation practice; and 3) behavioral indicators to other processes that are of conservation concern. All 3 require knowledge of animal behavior. The key element of behavioral ecology is the adaptive nature of behavior. Behavioral strategies in a population are the outcome of evolutionary processes that depend on the fitness of particular strategies under prevailing environmental conditions (Krebs and Davies 1997; Norris 2004). Behaviors should evolve to maximize the fitness of the individuals showing those behaviors (Krebs and Davies 1981; Owens 2006). Within the field of behavioral ecology, we recognize 3 key behavior domains that are central to the attainment of high fitness in individuals of all species and are therefore of key

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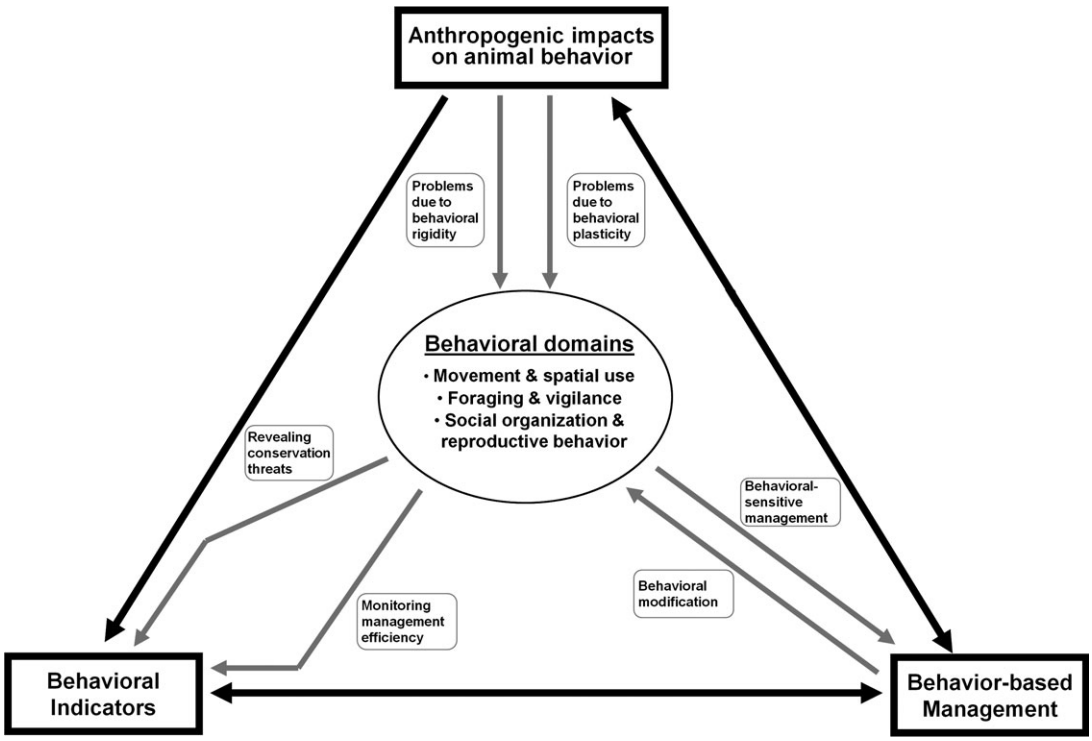

Figure 1
The conservation behavior framework is composed of 3 basic interrelated conservation themes: 1) Anthropogenic impacts on animal behavior; 2) behavior-based management; and 3) behavioral indicators. The black arrows represent interactions between the conservation themes. Gray arrows represent the pathways that connect each theme to the behavioral domains.

concern in conservation: 1) movement and space-use patterns. 2) Foraging and predator–prey related behaviors. 3) Social behavior and reproduction. All the different behaviors in the 3 domains affect survival and reproduction (hence recruitment), thus providing invaluable information on population and community dynamics.

Within each of the 3 basic themes, we identified 2 focal pathways on which behavior oriented conservation studies should focus:

• Theme 1: anthropogenic impacts on animal behavior

Anthropogenic impacts on animal behavior come about by direct human disturbances, such as overharvesting, fragmentation, and nuisance disturbances, and by indirect disturbances, such as the introduction of alien species or the creation of ecological traps (Robertson and Hutto 2006). These disturbances can affect behavior-dependent animal fitness through 2 distinct pathways (Figure 1):

First, when humans alter the environment, the fitness value of existing behavioral strategies changes. If fitness is drastically reduced and the strategies are either not sufficiently "plastic" to respond to the environmental change or an evolutionary response to the altered environment is slow relative to the rate of environmental change, the population will decline (Norris 2004).

Second, and in contrast to the first, if behavior is plastic it may be altered by anthropogenic changes. Although this may be adaptive in the short term, the behavioral response may change other fitness related behaviors, such as social structure or mating success, thus altering the evolutionary trajectory of the species or the ecosystems in question, which may facilitate the closure of evolutionary options (Ehrlich 2001), creating conservation concerns on a longer evolutionary timescale (Manor and Saltz 2003). Furthermore, a change in behavior of one species may alter the dynamics of an entire community or ecosystem (Wright et al. 2010).

In the cases where anthropogenic impacts on animal behavior lead to conservation concerns, the best solutions are in most cases behavioral-based management schemes that leads us to the next conservation behavior theme.

• Theme 2: behavior-based management

Here too, we recognize 2 pathways incorporating animal behavior into active management for conservation (Figure 1). In the first, the species' behavior is considered in conservation decision-making and protocols. We term this pathway "behavior-sensitive management." Behavioral considerations may play a crucial role in reserve design and corridor planning (e.g., Schultz 1998; Pe'er et al. 2004; Afonso et al. 2008), wildlife epidemiology (Craft et al. 2009), and planning of reintroductions and translocations (Saltz et al. 2000; Bar-David et al. 2005; Shier 2006; Zidon et al. 2009).

The proximate goals of behavior-based management will usually have a strong demographic nature—whether they aim to stabilize or increase the numbers of small or declining populations or to control populations of invasive or pest species. However, in cases where the change of the animal's behavior is the cause for conservation concern, the proximate goal of the management efforts may be changing the behavior of the target population. Thus, in contrast to the first pathway in this theme—where management decisions are made based on the species' behavior, in the second pathway, the manager seeks to change or preserve the behavior itself. This approach is commonly applied in training captive-bred individuals designated for reintroduction to become predator-savvy, etc. (e.g., McLean et al. 1996; Griffin et al. 2000; Alberts 2007). We term this pathway "behavioral modification."

• Theme 3: behavioral indicators

The various adaptive behaviors of organisms give us a great deal of information about the evolutionary forces shaping these behaviors, the environments which the organisms

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inhabit, and any recent changes to either the selection forces or the environment. Thus, we can use the behavior itself as an indicator to the organism's state as well as to the state of its environment (Kotler et al. 2007). Such indicators include foraging and patch use behaviors (e.g., Whelan and Jedlicka 2007), diving behaviors (e.g., Mori et al. 2007), habitat selection (e.g., Heithaus et al. 2007), and home range use (Owen-Smith and Cain 2007). The 2 pathways in which behavioral indicators have been used in conservation are 1) behavioral indicators that provide an early warning to population decline or habitat degradation before numerical responses are evident (e.g., Searle et al. 2007; van Gils et al. 2009). 2) Behavioral indicators used to monitor the effectiveness of management programs, or evaluate the success of a management program at its early stages, before population or ecosystem-level responses are evident (e.g., Ikuta and Blumstein 2003; Lindell 2008).

LINKING BETWEEN THE THEMES

The 3 behavioral conservation themes are strongly linked (Figure 1). For example, anthropogenic impact on animal behavior may be detected using behavioral indicators and can suggest the need for behavior-sensitive management (Ikuta and Blumstein 2003; Zidon et al. 2009). Alternatively, behavior-sensitive active management can be evaluated using behavioral indicators, and this knowledge may change the management plan accordingly. However, in many situations, the behavioral aspect of one theme may dictate a nonbehavioral component of another theme (e.g., behavioral indicators may often be indicative of disturbances impacting nonbehavioral elements, such as dynamics).

One can view the 3 themes as entry points for behavioral ecologists aiming to use their knowledge and expertise of animal behavior in conservation. In each of the themes, new research should be based on previous knowledge of animal behavior as well as on pressing conservation concerns. In this way, conservation behavior can serve as a much needed link between the ever-expanding knowledge in behavioral ecology and the more practical needs of conservation biologists. Although behavioral ecologists may, in many cases, address only one of the proposed 3 themes in any given research, the role of the conservation biologist facing a conservation issue is to consider and integrate all 3 themes into one adaptive management scheme.

CONCLUSIONS

Although the role of behavior in conservation is still moot to some extent, with critiques claiming that behavioral studies make little practical contribution to conservation (Caro 2007), our framework provides a sound response to such claims by pinpointing the contexts and aspects where animal behavior is important to conservation. The framework is simple, hierarchical, and parsimonious, providing a sound basis that is easily integrated into research in both disciplines. This, in turn, should help focus future studies, highlight the importance of such cooperation between the fields, and should make it conceptually easier for researchers to combine their efforts toward one goal and serve as a basis for the development of a new paradigm.

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