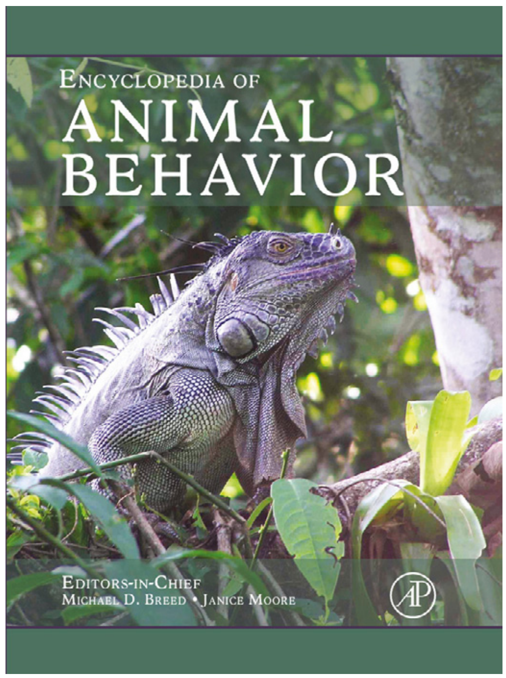

Angeloni L., Crooks K.R., and Blumstein D.T. (2010) Conservation and Behavior: Introduction. In: Breed M.D. and Moore J., (eds.) Encyclopedia of Animal Behavior, volume 1, pp. 377-381 Oxford: Academic Press.

Conservation and Behavior: Introduction

L. Angeloni and K. R. Crooks, Colorado State University, Fort Collins, CO, USA
D. T. Blumstein, University of California, Los Angeles, CA, USA

Introduction

Separately, the disciplines of animal behavior and conservation biology are well-established, thriving fields of scientific inquiry, each with its own history and approach. Animal behavior is a chiefly theoretical discipline, while conservation biology is more of an applied science, established in response to the ongoing biodiversity crisis. Recent attempts have been made to apply principles of animal behavior to conservation problems to create a formally integrated discipline, commonly called *conservation behavior*.

There are several reasons why the union of these fields seems intuitive and profitable. First, behavioral ecologists focus on understanding how the state of an individual influences behavior. State-dependent behaviors include those that are plastic or flexible rather than fixed, whose expression can depend on environmental influences, such as temperature, resources, social cues, or maternal condition. Because the environment can influence the experience or condition of an individual, which can consequently influence its behavior, these state-dependent behaviors are of particular conservation relevance; in effect, they have the potential to be impacted by anthropogenic factors that alter the environment, such as disturbance and global climate change. There is growing evidence that anthropogenic disturbances are disruptive to behavioral processes. Disturbance may increase stress levels, thereby affecting behavior and physiology, and may also disrupt normal foraging, movement, communication, and mating patterns, among other behaviors.

Second, behavior is expected to have conservation relevance because it can affect demographic processes, such as survival and reproduction, and hence fitness. Quantification of fitness consequences is a major research area in behavioral ecology and is essential to conservation behavior because it is these fitness links that allow the development of individual-based models to better understand anthropogenic impacts. In fact, a shortcoming of most studies that investigate the effects of disturbance on behavior is that they fail to formalize the link to demography and fitness.

Third, many forms of behavioral information have been identified as useful conservation tools. For example, captive breeding and reintroduction programs have clearly demonstrated the importance of managing natural behavior (e.g., mating behavior, social behavior, and experience with predators and prey) to increase captive breeding and reintroduction success.

Fourth, behavioral diversity is a potential currency to consider, along with species and genetic diversity, when setting future conservation priorities. Behavior plays a key role in animal survival and evolution and its variation may allow species to respond to mounting changes to the environment. Conservation plans that incorporate the diversity of interesting behavioral traits also have the added benefit of harnessing public interest and support.

Several barriers have impeded the full integration of these disciplines, and these hurdles are being crossed only gradually. In this article, the history and current status of the field of conservation behavior are reviewed, barriers to the integration of behavior and conservation as well as tools to overcome them are described, and some of the conservation behavior topics that are covered in the other articles of this section are highlighted.

History

Although the formal integration of behavior and conservation is a recent effort, wildlife biologists have been using basic behavioral data to inform management decisions since the inception of the discipline of wildlife management. For the last century, wildlife biologists have been documenting the basic natural history of animals, including descriptions of fundamental behavior such as movement patterns, habitat selection, sociality, mating systems, and foraging. Indeed, the early history of wildlife biology was often dominated by naturalistic observations of the behavior of animals in the wild, employing traditional tools such as visual observations, binoculars, spotting scopes, and trapping. Ironically, the advent of new technologies, such as radio-telemetry, trip cameras, and remote-sensed satellite and GIS data, has allowed wildlife researchers to spend less time in the field directly observing wildlife, including their behavior. These new approaches, combined with an increasing focus on population-level processes such as estimating sizes and dynamics of populations, may have contributed to the decline of the importance of animal behavior in the field of wildlife biology in recent decades. For example, to become a certified wildlife biologist through The Wildlife Society, a course in animal behavior is not required but rather an elective; such is also the case for most undergraduate wildlife biology programs.

Encyclopedia of Animal Behavior (2010), vol. 1, pp. 377-381

Conservation biology was formalized in the 1980s with the founding of the Society for Conservation Biology. The mission of this new 'crisis discipline' was to conserve the earth's biological diversity in the face of mounting anthropogenic impacts on the natural world. By necessity, conservation biology developed as a multidisciplinary science, merging fields of biological and social sciences to confront the growing biodiversity crisis. To accomplish their mission, conservation biologists have drawn heavily from the expertise in social sciences such as economics, political science, and sociology, in applied natural resource fields such as wildlife biology and forestry, and in theoretical natural sciences such as ecology and genetics. However, theoretical animal behavior was absent from almost all the early conceptual models of the interdisciplinary nature of the field. This disconnect remains today, with animal behavior typically receiving relatively little attention even in the most recent conservation biology texts.

In response to the perceived lack of integration between the behavior and conservation fields, the discipline of conservation behavior emerged in the mid-1990s when a number of symposia and subsequent publications highlighted the potential linkages between behavior and conservation and advocated greater overlap between the disciplines (see Further Reading). There was a great deal of promise for this new approach as scientists looked to a future where behaviorists and conservationists would work closely together, sharing knowledge and finding new ways for behavior to inform conservation practices. Since that time, a large literature has developed on the potential for the field of conservation behavior, on the recent work that has helped to initiate this field, and on the barriers that have slowed its development.

Several analyses have tried to address whether the new discourse on conservation behavior that began in the mid-1990s actually led to greater integration of the fields. Investigations of the scientific literature, which analyzed keywords, cross-citation rates, and the focus of articles in primary behavior and conservation journals, have found relatively little integration of research between the two disciplines over the subsequent decade. Where there is research overlap, it was found to be largely descriptive literature published outside of primary behavior journals.

The progress of this initially promising field of conservation behavior has been interpreted with different perspectives by two prominent contributors to the current discourse. Tim Caro has criticized behavioral biologists for not making greater advances in integrating with and contributing to conservation biology. He conceded that descriptive behavioral data have helped solve conservation problems, but argued that the primary theoretical advances in behavior 'have proved rather irrelevant in helping to solve the biodiversity crisis.' By contrast, Richard Buchholz has focused on the continuing development of this young field, arguing that 'the growing pains of conservation behavior are not symptoms of dysfunction, but rather positive signs of a thriving adolescence.' Only the future will tell whether conservation behavior matures beyond this adolescence and becomes more relevant to the biodiversity crisis.

Integration: Barriers and Tools

Given the potential for behavior to inform conservation, why has there been limited integration to date? An underlying cause is the historical and institutional separation of the fields of conservation biology and animal behavior. Typically, animal behaviorists and conservation biologists are housed in different departments, belong to different scientific societies, attend separate meetings, and apply for funds from different sources. They have been trained to ask very different research questions, with behaviorists focused on theory and conservationists focused on applied questions. As such, scientists studying animal behavior may feel that they have little to contribute to conservation biology or that the applied nature of the subject makes it less intellectually challenging and objective. In turn, those studying conservation biology may feel that animal behavior, particularly questions grounded in theory, has little relevance to their work. Ultimately, conservation biologists and animal behaviorists publish in journals that often have little overlap in topics, authors, readership, or scientific literature. Indeed, many behavior journals discourage articles with an applied focus, and conservation journals reject theoretical behavior papers without a conservation focus.

In addition, the two disciplines are focused on different biological scales that can be challenging to link. Behavioral ecologists address evolutionary questions at the level of the individual, whereas conservation biologists typically focus on processes occurring at the population, community, or landscape scales. When linking behavior and conservation, a primary challenge is, therefore, to relate behavior to fitness, and then relate fitness to the persistence, and hence conservation, of populations. The rapid development of computationally intensive individual-based modeling has the potential to help forge this link. Individual-based models rely on a fundamental understanding of factors that influence individual decisions. Such individual decisions can be thought of as mechanisms by which animals acquire fitness. Viewed this way, individual-based modeling may have an important role to play in developing population viability models.

Because conservation biology is a crisis discipline, critics argue that there may not be sufficient time to develop the necessary behavioral knowledge that can inform management. While acknowledging this, it is important to note that many conservation solutions will involve a long-term process, not a short-term intervention. Thus, by designing such programs to collect behavioral information along the way, behavioral knowledge and behaviorally inspired management strategies may be developed. Such adaptive management is an important part of current conservation biology.

The strategies for integrating behavior with conservation that were initially suggested in the 1990s apply even today. Behavioral biologists should collaborate with wildlife and conservation biologists and serve on management teams, providing expertise and advice on conservation issues. They should consult with conservation practitioners to determine how to modify their research programs to ask questions that are relevant to conservation. This may involve conducting research on rare species of conservation concern or species in disturbed environments, with reduced sample sizes as a potential consequence. The results of their research should then be publicized widely in conservation and behavior journals, as well as other formats – workshops, reports, popular writing, public speaking engagements – to make them accessible to conservation practitioners and the general public. There are a number of examples of successful integration of behavior and conservation that may serve as a model for those who are looking to do it in the future. In the following section, we highlight some of the behavioral topics that are beginning to be integrated with conservation issues by briefly reviewing the other articles within this section.

Topics at the Interface

The entries in this section emphasize that behavior and conservation will intersect in important ways when behavior is state-dependent and therefore potentially influenced by environmental disturbance, when behavioral change results in fitness or demographic change, and when behavioral knowledge can be used to provide useful tools in conservation programs. For example, the article by Henrik Brumm outlines how anthropogenic disturbance, specifically noise, can disrupt normal animal behavior. Noise can induce stress in animals, which can affect any number of behaviors (e.g., reproductive or antipredator behavior) that depend on being in good physiological state, but it can also interfere with animal communication by masking intentional acoustic signals as well as cues used to find prey and avoid predators. Anthropogenic noise has been shown to affect animal behavior in both terrestrial and aquatic systems for diverse groups including insects, fish, frogs, birds, bats, and whales. When it induces stress, when it masks sounds that are used to find prey and avoid predators, and when it interferes with courtship calls that are used to find mates or begging calls that are used to provision young, noise can impact individual fitness, which may translate to demographic consequences at the population level. Some of these negative effects of noise can be mitigated behaviorally, for example by adjusting the communication signal so that it can be heard, by increasing visual attentiveness to compensate for lost auditory awareness, or by displacing to a quieter habitat. However, these forms of behavioral compensation may also have negative fitness consequences themselves. In the end, further research is needed to formally assess the effects of anthropogenic noise on reproductive success and population viability.

Ulrika Candolin further develops the idea that human disturbance can negatively impact signaling between animals, in particular sexual signaling by males and the ability of females to assess male ornaments. Noise is not the only form of disturbance that can interfere with signaling between potential mates. Visual displays can also be muddled, particularly for aquatic animals like fishes, as nutrient pollution can lead to an increase in primary productivity resulting in eutrophication and turbidity. Chemical pollution and acidification of aquatic habitats also interfere with chemical cues that fish use to find appropriate mates. If these male ornaments advertise their quality to potential mates, then disruption of these signals may result in the choice of a lower-quality mate, potentially causing reduced fitness of the female or her offspring. Worse yet, anthropogenic disturbance may interfere with species recognition cues, causing individuals to hybridize across species boundaries, not only reducing fitness but also potentially influencing biodiversity. In some species, such as the threespine stickleback, males mitigate these effects of disturbance by displaying more vigorously, but this too may come at a cost of time, energy, and fitness. The conservation relevance of disrupted sexual signaling will depend on discovering its relative importance in determining fitness and population demography.

There are additional ways that anthropogenic effects can cause mating interference, as outlined by Alejandra Valero. Humans have introduced exotic species worldwide both intentionally and accidentally, which can negatively impact populations of native species. In addition to ecological interactions between native and exotic species (e.g., competition or predation), there can also be behavioral interactions that interfere with the reproduction of the native species. The signals of exotic species may mask the acoustic mating signals of the native species or may even jam their chemical pheromone receptors. Males may expend energy on courtship with females, and on rivalry with males, of the other species. Mating interference can reduce the ability of native females to choose the highest quality mate, can reduce the rate of successful copulation for the native species, and can result in hybridization across species boundaries. These behavioral effects, seen in a number of taxa, including insects, fishes, and lizards, provide another reason to prevent the introduction of exotic species and to control or eradicate those that are already introduced.

Humans impact not only the behavior of animals in the wild, but also those in captivity. Jennifer L. Kelley and

Constantino Macías Garcia explore how behavior can be inadvertently altered in species of conservation concern when they develop as part of a captive breeding and reintroduction program. Only a small number of reintroduction programs have successfully established self-sustaining populations in the wild, in part because captive animals have not had the opportunity to develop normal foraging, antipredator, and social behavior. High densities and limited space in captivity can cause stress and aggression and can impede the development of territoriality, seasonal migratory behavior, exploratory behavior, and social behavior. The regular provisioning of food reduces the ability to develop foraging behavior and the lack of predators reduces the ability to develop antipredator behavior. Reduced exposure to parents and the opposite sex and a lack of mate choice may hinder development of appropriate reproductive behavior. Abnormal repetitive behavior sometimes develops as a result of frustration, fear, or discomfort, and it may be a sign of stress during early development. Fortunately, the negative behavioral effects of captive breeding can often be reversed once they are discovered, through greater exposure to conspecifics and predators, through environmental enrichment (including rearing in seminatural environments), and by acclimatizing individuals to natural conditions prior to release. These methods have enhanced the captive breeding and reintroduction programs for a number of birds and mammals.

Andrea S. Griffin further explores the way that experience and learning can impact captive populations that are later reintroduced to the wild, as well as wild populations that experience human-modified environments. Although additional postrelease monitoring is needed to establish the link between learning in captivity and fitness in the wild, there is much evidence that learning is important for the development of natural behavior needed to survive and reproduce in the wild. Postrelease survival of animals, such as houbara bustards and black-tailed prairie dogs, improves when captive individuals are trained to avoid predators, for example by experiencing dangerous stimuli and watching the alarm responses of others. A number of birds and rodents have been shown to learn about food aversions and food preferences, as well as the timing and location of food sources. Some species (e.g., some birds, mammals and fishes) also learn to identify appropriate mates and develop mating preferences from their social experiences. Thus, detailed knowledge about the behavior of the particular species in nature, although sometimes difficult to obtain for an endangered species, can provide useful tools for captive management. Outside of captivity, learning can also have conservation implications for wild populations that live in human-modified environments. Species that are thought to have greater capacity for learning, including larger brained birds and mammals, seem to have greater flexibility in their behavior. Behavioral flexibility also seems to increase survival in harsh, modified, or novel environments, and large-brained birds and mammals are more likely to become established when introduced to new environments than species with smaller brains. Thus, knowledge about behavioral flexibility may help conservation biologists predict which species are most likely to be successful invaders, which are most likely to adjust to habitat modification and urbanization, and which to target for protection because of their vulnerability. However, while large-brained species may be more flexible in novel environments, they may also have life history characteristics such as delayed maturation and slow reproduction that make them more vulnerable to extinction and more difficult to rear in captivity. These counteracting forces must be evaluated before determining whether the ability to learn is a help or hindrance in our increasingly modified world.

Finally, Elisabet V. Wehncke makes the important point that the behavior of a particular animal species affects not only its own conservation status, but also the conservation status of other species that it interacts with, including that of plants. Animal behavior can affect seed dispersal by determining which seeds are dispersed, where seeds are deposited, and whether they survive after dispersal. In particular, the way that mammals, birds, reptiles, and insects are attracted to, prefer, handle, and process fruit determines which seeds will be dispersed. The social organization, including group size and degree of territoriality, and the movement patterns of the animal determine the pattern of seed deposition. How dispersers handle and deposit seeds will also affect the likelihood of subsequent seed mortality from desiccation, predation, damage, or competition. Understanding the link between animal behavior and its complicated effects on seed dispersal and plant demography will be important in predicting how habitat fragmentation, climate change, invasive species, and the loss of seed dispersers will affect plant populations. In turn, alterations in vegetative communities have the capacity to ripple throughout ecosystems, impacting animal populations and important processes such as nutrient cycling, hydrology, and succession.

Together, the entries within this section highlight several possible steps in the future development of the discipline of conservation behavior. Links could be identified between anthropogenic impacts and their effects on behavior. Further connections could be made between these modified behaviors and their effects on fitness and population demography, not only for the animal species in question, but also for other interacting species. In the end, this would allow us to develop individual-based models to predict how anthropogenic impacts might affect population persistence, to develop appropriate behavioral tools for conservation programs, to determine whether behavioral diversity is itself an important currency for conservation, and ultimately, to evaluate how animal behavior might be used to inform conservation biology.

See also: Anthropogenic Noise: Implications for Conservation; Learning and Conservation; Male Ornaments and Habitat Deterioration; Mating Interference Due to Introduction of Exotic Species; Ontogenetic Effects of Captive Breeding; Seed Dispersal and Conservation.

Further Reading

Angeloni L, Schlaepfer MA, Lawler JJ, and Crooks KR (2008) A reassessment of the interface between conservation and behaviour. *Animal Behaviour* 75: 731–737.

Blumstein DT and Fernández-Juricic E (2004) The emergence of conservation behavior. *Conservation Biology* 18: 1175–1177.

Blumstein DT and Fernández-Juricic E. (2010) A Primer on Conservation Behavior. Sunderland, MA: Sinauer Associates.

Buchholz R (2007) Behavioural biology: An effective and relevant conservation tool. *Trends in Ecology & Evolution* 22: 401–407.

Caro T (1998) *Behavioral Ecology and Conservation Biology.* Oxford: Oxford University Press.

Caro T (2007) Behavior and conservation: A bridge too far? *Trends in Ecology & Evolution* 22: 394–400.

Clemmons JR and Buchholz R (1997) *Behavioral Approaches to Conservation in the Wild.* Cambridge: Cambridge University Press.

Curio E (1996) Conservation needs ethology. *Trends in Ecology & Evolution* 11: 260–263.

Festa-Bianchet M and Apollonio M (2003) *Animal Behavior and Wildlife Conservation.* Washington, DC: Island Press.

Gosling LM and Sutherland WJ (2000) *Behaviour and Conservation.* Cambridge: Cambridge University Press.

Linklater WL (2004) Wanted for conservation research: Behavioural ecologists with a broader perspective. *Bioscience* 54: 352–360.

Soule ME (1985) What is conservation biology? *Bioscience* 35: 727–734.

Sutherland WJ (1998) The importance of behavioural studies in conservation biology. *Animal Behaviour* 56: 801–809.