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Editorial

Animal behavior can inform conservation policy, we just need to get on with the job – or can it?

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1 Conservation Behavior as an Emerging Discipline on the Brink of Success, or Unrealistic Ideal?

It seems intuitively sensible that an understanding of the behavioral characteristics of animals, such as their home ranges, diets, mating systems, and dispersal mechanisms, may be useful to inform conservation efforts in determining, for example, suitable reintroduction areas, or the design of dispersal corridors. Behavioral work can also determine the importance of a species within its habitat, for example as a seed disperser, and can highlight which extant species may play fundamental ecological roles, especially in areas where recent extinctions have led to drastic changes in biological composition (e.g., Young et al., 2012). So why is it that these two disciplines rarely merge, despite now being the discipline of Conservation Behavior in its own right? This disconnect and where it occurs has been identified by Palestis(2014), and multiple times by Caro (e.g., 1999, 2007), whom contribute to this special column. Both Palestis (2014) and Caro (2007) suggest that behavioral ecologists have been "slow to link with conservation biologists" (Palestis, 2014).

As a behavioral ecologist, I wanted to be editor of this special column because I like to believe that behavior and conservation should go hand-in-hand. Consequently, out of curiosity and a touch of skepticism that these disciplines rarely merge, I ran a simple analysis, finding that Caro (1999, 2007) and Palestis (2014) seem to be correct. For this analysis, I did a search on Web of Science™ (Table 1), looking up the search terms "ethology", "animal behavior", "behavioral ecology" ('behavioral terms'), and "conservation biology", both in conjunction and independently, for the past 30 years, from 1983–2013. I further restricted all searches to "articles" and "reviews". The earliest record that had 'conservation biology' and any of the behavioral search terms was in 1992 ('animal behavior': 1992, 'behavioral ecology': 1994, 'ethology': 1996), so I restricted further searches and analyses to the period from 1992 to 2013, as the last year for which I could get full records.

Since 1992 there has been an almost ten-fold increase in the number of papers in the discipline of conservation biology, and over four-fold increase in behavioral papers (Table 2). These increases have been almost linear (Fig. 1A). However, there has been a 36-fold increase in the number of papers that use both terms (Table 2). Clearly, this is a rapidly expanding area,

Table 1 Web of Science™ search of disciplines, filtered by 'articles' and 'reviews', from 1983–2013

Search terms	*n*	Mean citations/item
Conservation Biology AND Animal Behavior[1]	175	24.68
Conservation Biology AND Behavioral Ecology[1]	965	28.15
Conservation Biology AND Ethology[1]	7	64.14
Conservation Biology[2]	7,091	26.88
Animal Behavior[2]	65,056	Data not available*
Behavioral Ecology[2]	4,665	21.90
Ethology[2]	857	13.45
Ethology, OR Behavioral Ecology, ORAnimal Behavior AND Conservation Biology[2]	253	26.71

*Web of Science cannot calculate statistics for searches with over 10,000 records; [1]searches from 1983, [2]searches from 1992.

albeit a minority in both disciplines, with less than 1% of behavior papers referring to conservation, in contrast to over 5% of papers pertaining to conservation now referring to animal behavior (Table 2). Interestingly, on a yearly basis, papers referring to both conservation and behavior are typically an order of magnitude more common as a function of the total number of conservation papers than behavior papers.

I normalized the data in Table 2 by the maximal value across all years for conservation papers (680 in 2012) and for the maximal value for behavioral papers (5,701 in 2013). The number of papers containing any behavioral search terms, as well as ‘conservation biology’, was then normalized by the maximal value for conservation papers, and independently for behavioral papers. This was to give a proportion of papers spanning disciplines as a factor of the normalized number of papers in each discipline. Doing this clearly shows that, as a proportion of conservation papers, there is a large increase of publications spanning disciplines. However, the proportion of papers spanning disciplines remains stable, and low, as a proportion of behavioral papers (Fig. 1B). Indeed, behavioral ecologists do not appear to be engaging with the conservation community.

I sincerely hope that this special column will serve as a new call to behavioral ecologists to become involved with conservation scientists and practitioners (e.g., Caro, 1999, 2007; Caro and Sherman, 2011). Importantly, revealing conservation implications of behavior in a practical manner adds relevance to research in animal behavior beyond discipline-specific confines, making-behavioral work relevant both to scientists in other disciplines and to wildlife managers as we confront the shared problem of retaining our biota.

Somewhat cynically, in the current funding framework, an interdisciplinary approachmight provide the best opportunity to secure resources to meet the looming crisis of loss of biodiversity. A contrasting perspective is given in this special column by Caro and Riggio (2014). They maintain that in practice behavior is not obviously beneficial to many species under threat, and challenge behavioral biologists to demonstrate how be-

Table 2 Increase in discipline-specific (behavior and conservation) publications from 1992–2013. In behavior, this increase is four-fold, in conservation 10-fold and in conservation behavior this is 36-fold, although still a minority of papers in each discipline refer to both disciplines, especially among behavioral publications

Year	Number of conservation papers	Number of behavior papers	Number of conservation and behavior papers	% papers referring to behavior within N conservation papers	% papers referring to conservation within N behavior papers
1992	70	1,336	1	1.4	0.1
1993	63	1,334	3	4.8	0.2
1994	78	1,495	2	2.6	0.1
1995	93	1,787	2	2.2	0.1
1996	158	2,039	6	3.8	0.3
1997	135	2,266	3	2.2	0.1
1998	166	2,320	4	2.4	0.2
1999	181	2,369	9	5.0	0.4
2000	211	2,458	7	3.3	0.3
2001	224	2,518	6	2.7	0.2
2002	288	2,627	7	2.4	0.3
2003	292	2,855	10	3.4	0.4
2004	309	3,186	11	3.6	0.3
2005	344	3,234	12	3.5	0.4
2006	393	3,538	14	3.6	0.4
2007	428	3,894	17	4.0	0.4
2008	523	4,288	17	3.3	0.4
2009	558	4,442	14	2.5	0.3
2010	607	4,635	21	3.5	0.5
2011	634	5,238	27	4.3	0.5
2012	680	5,594	24	3.5	0.4
2013	661	5,701	36	5.4	0.6

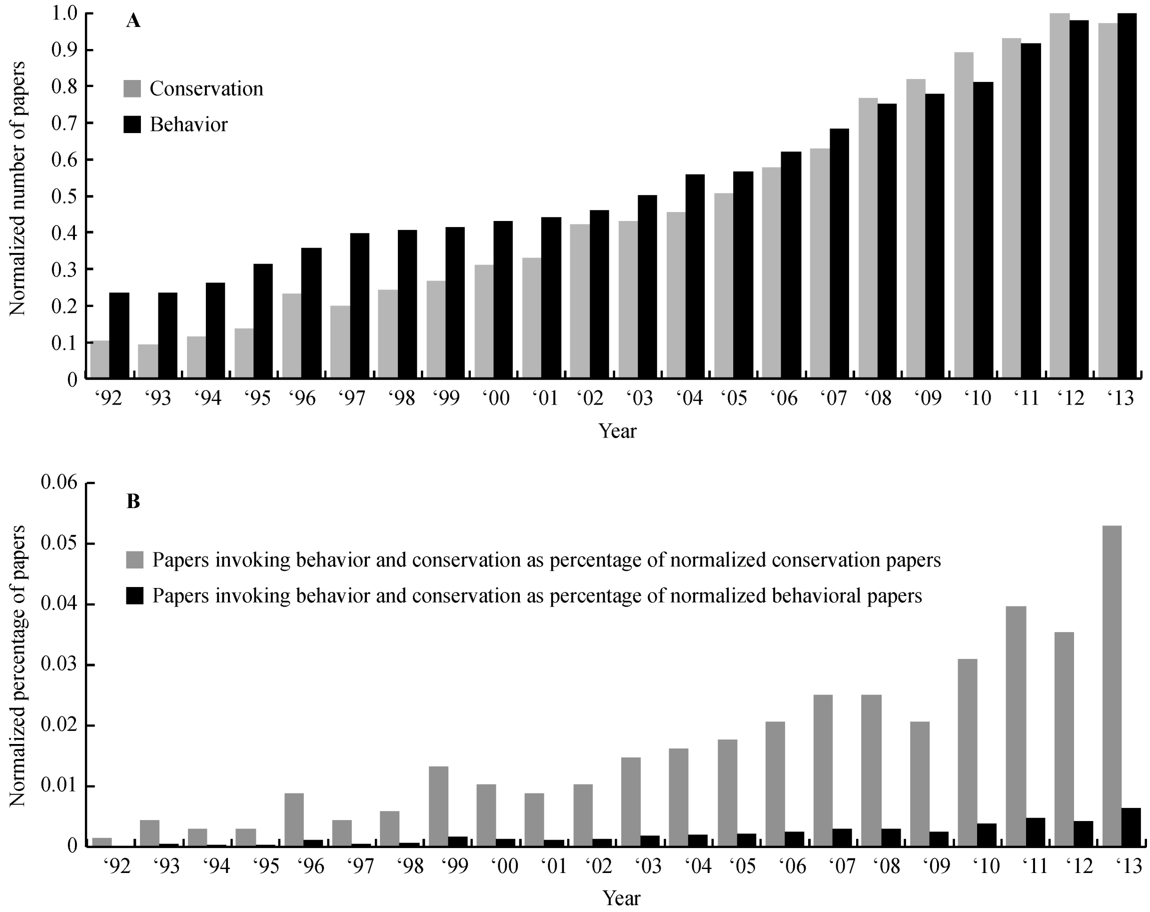

Fig. 1 Papers published in the disciplines of Animal Behavior and Conservation from 1992 to 2013 normalized by the maximal number of publications (see Table 2) in all years for conservation (680, in 2012) and for behavioral papers (5,701, in 2013)

A. Linear increase of the relative proportions of publications for the discipline of conservation and of behavioral papers. **B**. Normalized number of papers using behavioral search terms (see Table 1) in conjunction with 'conservation biology'.

havioral knowledge can make a difference to conservation management problems in light of the far more dominating effects of anthropogenic threats. With this challenge as a starting point, I hope that this special column will stimulate not only concerted discussion, but also practical action and solutions on behalf of behavioral biologists to rise to the challenge, as demonstrated here by Berger-Tal and Saltz(2014).

2 Contributions to the Special Column

Animal (and plant) conservation is, as we are often told, a global issue. Appropriately, in this special column, we have review and original research papers describing work from North and South America, Asia, and Europe. Together, these papers offer a sense of the breadth of approaches that make a merging of these disciplines an exciting interdisciplinary area, albeit one which has had a rocky start (Caro, 2007; Berger-Tal et al., 2011; Caro and Sherman, 2011).

Within the seven contributions to this special column, the broader implications and difficulties pertaining to research exploring the relationship between behavioral and conservation-based research are readily evident in two review contributions, which also provide helpful guidelines for researchers in the area, as well as constructive areas for further research (Caro and Riggio, 2014; Palestis, 2014). Berger-Tal and Saltz (2014) discuss how GPS technology serves as an aid to managers post reintroduction of animals, and provide data from fallow deer and from oryx to support their argument. An additional four papers are original research papers that explore the relationship between animal behavior and its implications for conservation in fish (Paciorek et al., 2014), birds (Blesdoe and Blumstein, 2014; Kleindorfer et al., 2014) and, on a larger scale, elephants (English et al., 2014).

Caro and Riggio (2014) review six species (and associated subspecies) of African 'trophy' mammals: elephants, black and white rhinoceros, lions, leopards, and buffalo. Looking at the overall evidence they conclude that, on balance, behavior has had rather little to offer conservationists in their management activities to date, but conclude that this is likely because behavioral knowledge is more critical in situations of captive breeding and reintroduction programs (as illustrated nicely by Berger-Tal and Saltz's work in this special column), rather than conservation in the wild, which is the norm for these species. They do, however, make a number of recommendations regarding how behavioral knowledge can aid conservation in wild populations through management of hunting practices and the provision of dispersal corridors.

Similarly, Berger-Tal and Saltz (2014) make numerous practical suggestions useful for management of reintroduced wildlife. In their paper, Berger-Tal and Saltz (2014) discuss spatial behavior, or the movement patterns of animals when reintroduced into new habitats. They specifically concentrate on spatial data provided by GPS-tagged fallow deer and oryx reintroduced in different habitats in Israel. They eloquently use these data to describe how familiarization with the novel environment affects its use by animals, but in a species-specific manner determined by the animal's life history. These data also clearly show how anthropogenic effects such as roads affect movement patterns. Using these examples, Berger-Tal and Saltz (2014) provide simple guidelines on how to use GPS-based data without the need for complex analyses to improve the success of future reintroduction programs and subsequent management.

Also using GPS-based data, English et al. (2014) consider the spatial behavior of Asian elephants over the course of a year. Here, the authors looked at possible causes underlying the spatiotemporal patterns of 'recursion behavior', or the repeated use of specific foraging areas. Based on GPS data, behavioral sampling and measuring abiotic and biotic site characteristics, they found that recursive site-use was a function of the intensity of the last use, as expected by optimal foraging theory (Charnov et al., 1976). Additionally, English et al. (2014) found two peaks in recursion behavior, one recursion occurring within two days of the initial visit, with another occurring between five and eight months since the previous visit. Immediate recursions were typically brief, while recursions occurring after a long absence were longer. Coupled with their finding that habitat characteristics affected the intensity of use of different sites, the authors attribute the longer visits after long absences to the regeneration of previously depleted resources at the site. These results highlight the importance of how habitat characteristics affect behavior, and the need for these interactions to be accounted for in conservation management plans.

In an interesting take on the theme of interactions between habitat and behavior, Paciorek et al. (2014) consider the effect of habitat loss on the behavior of two endangered species of fish, in which one may pose a significant predation threat to the other, especially as competition for drastically reduced suitable habitat increases. They based their work on fish living in desert springs, in which crucial spawning habitat for one species had been artificially increased to reduce encounters between the two species. The focus of this study was also to compare the behavior of natural and introduced fish. Their results suggest that individuals raised in captivity over multiple generations are similarly successful at defending their territories to wild individuals. This promising result leads the authors to suggest that, while this work is still in its infancy, captive-raised fish may be used as a source of animals for reintroduction purposes in restored habitat.

Kleindorfer et al. (2014) take advantage of the 'natural laboratory' provided by isolated islands to explore the effect of recently introduced parasites on naïve birds in the Galapagos. Their data depict a rather bleak picture of three species of Darwin's finches rapidly succumbing to a novel parasite fly larvae. While theoretical models (e.g., Lively, 2006; Duffy and Sivars–Becker, 2007) predict that parasite virulence should decrease if the host is so susceptible that it kills the host too soon (and thus cause considerable fitness detriment to the parasite species), the reality here appears to be that selection on the parasite may not be fast enough to prevent near-extinction or extinction of the host, despite evidence of fitness consequences on the parasite becoming apparent. What happens to these Darwin's finches and the behavior of their parasites remains to be seen. Given the finches' namesake, this is a grim reminder that species are going extinct at an extremely high rate, only 150 years after Darwin's original insights on speciation and extinction (Darwin, 1859).

Bledsoe and Blumstein (2014)adopt a novel approach when considering the effects of avian sensory systems on anti-predator behavior. They hypothesize that the function of non-linear acoustic vocalizations, characterized by unpredictable changes in frequency, is to minimize the chance of habituation to a repeated stimulus, and consequently should be used in an antipredator context, especially when there is clear danger, as has been tested in mammals (Blumstein and Récapet, 2009; Townsend and Manser, 2011). Bledsoe and Blumstein (2014) used audio playback experiments to investigate whether white-crowned sparrows were more attentive to their environment when hearing a variety of digitized non-linear sounds compared with the same sound as a pure tone and white noise. While they had very high baseline levels of vigilance, the results of this novel hypothesis are suggestive and intriguing, with birds being significantly more vigilant with white noise and when there were abrupt downward frequency changes, but not the reverse. Tantalizingly, the sounds used in playbacks were not scrambled calls of the same species, suggesting that response to non-linear phenomena may not be a species-specific attribute. A review of the literature on avian vocalizations analyzing the broad structural characteristics of alarm calls, and whether they often contain downward frequency modulations, would be a particularly enlightening follow-up study. If so, this suggests that anthropogenically-derived non-linear noises may adversely affect animals within hearing range, and adds a new dimension to the rapidly expanding literature on the effects of anthropogenic noise on wildlife, especially regardingtheir signaling systems and use of habitat (Slabbekoorn et al., 2010; Wale et al., 2013).

Most species of terns are on the national, state or province conservation lists, and Brian Palestis (2014) discusses the role of behavior in tern conservation across the globe. He identifies current and future threats to these birds, and what can be done to mitigate these threats, in particular highlighting that, as colonial breeders, appropriate management can benefit a large number of individuals. In this review, he focuses on key behavioral attributes, namely an understanding of habitat selection, spatial behavior, and sex-based behaviors (e.g., sexual differences in migration patterns), in order to in form conservation managers about habitat restoration. Palestis (2014) notes that individual differences in reproductive success associated with sex roles and mating systems may have important ramifications on the effective population size (Anthony and Blumstein, 2000), rather than the net population size. Palestis (2014) provides in-depth analysis of the issues facing a specific group of birds and the trade-offs faced by related species living in different habitats. These issues include anthropomorphic threats, such as how wind farms affect foraging efforts during chick rearing and concomitant sex-biased mortality. This review is informative by highlighting a number of areas of behavior that have been successfully addressed in conservation management plans, which may provide a springboard for researchers to consider in other animal groups.

3 Where to from now?

It is rather sad that almost more has been published regarding how to successfully merge the disciplines of conservation biology and animal behavior than there are research articles adopting both approaches. Original research articles in this special column illustrate that these two disciplines can ‘work together’. Nevertheless, it is readily apparent that there is still disagreement regarding whether behavioral research suitably informs conservation management policies. Caro (2007) points out that much of behavioral research occurs at the level of the individual, while conservation policies are acted on at the level of populations. Yet much of behavior does deal with population-level dynamics, and conservation policies are effective when they take into account not only population-level systems, but also individual level characteristics (e.g., Berger-Tal and Saltz, 2014). On a similar note, relating to terns, Palestis (2014) makes the relevant point that sampling biases can occur if research is focused on birds living in large stable colonies. This conclusion can be carried over to other systems, and highlights that if we are to use behavioral work in conservation plans, we need to ensure that the populations from which we derive preliminary data are relatively similar to the situation faced by animals whose populations are being managed.

Caro (2007) suggested that the descriptive work provided by behavioral ecologists was of use to conservation scientists, but Linklater’s (2004) work implies that this is a minority of the work done by behavioral ecologists and suggests that behavioral ecologists have tended to address only questions of adaptive value, at the expense of developmental mechanisms, and proposes that behavioral ecologists return to the basis of ethology, suggested by Mayr (1961) and Tinbergen (1963), of addressing both proximate and ultimate causation. A promising start is that the past decade has seen a large increase in work addressing proximate issues in behavior, particularly regarding sensory ecology and animal personality, or temperament. Nevertheless, more recently, it has been suggested that behavioral ecologists will run out of study species if they do not engage with conservation scientists (Caro and Sherman, 2011). Caro and Sherman (2011) suggest that behavioral ecologists might find it too depressing to face the reality of extinction of the organisms they work on. They also suggest that the ‘ostrich head in the sand’ approach (my words; and a saying which has no basis in reality) may be due to promotion outcomes in a university environment increasingly demanding of ‘achievement’. As a rule, behavioral ecologists care deeply about the environment, but there appears to be a sad basis in truth in the notion that we will run out of ‘charismatic’ (read: ‘endangered’) study species if we do not more readily engage with conservation scientists and conservation initiatives. I count myself entirely among those that need to do considerably more in this regard because, as suggested, I am fearful of facing the reality that this will entail. I suspect instances of promotion and achievement indices preventing people from engaging with conservation initiatives are very few indeed, as it seems unlikely that behavioral ecologists are ‘in it for the money’. Additionally, the simple citation analysis I ran here shows that measures looked at (such as citations, and for funding purposes, interdisciplinarity) suggest that ‘ambitious’ behavioral ecologists would do well to engage with conservation efforts.

In addition to behavioral knowledge, it is clear that for long-term conservation practices to be successful, knowledge regarding the physiological responses of animals (Cook et al., 2013), and also how global environmental changes affect meta-populational and interaction-based ecological systems (Tylianakis et al., 2008) is key. Conservation Biology truly needs to be interdisciplinary to maximally achieve its aims. However, at a more local level, in Conservation Behavior, Caro (2007) and Berger-Tal et al. (2011), both contributors to this special column, have made a number of useful suggestions about ‘how to bridge the gap’ between these disciplines, and I shall not reiterate them here. I would add to those suggestions that, in addition to Caro’s (2007) suggestion of popularizing the work through dissemination in non-scientific fora, key aspects of behavior that may currently be published in a behavioral journal might fruitfully be published in conservation-based journals to reach a target audience that could fruitfully use this work.

Enabled by GPS trackers/loggers, spatial ecology and movement behavior is now a large and ‘sexy’ area of study, and this research is of clear value to conservationists for any reintroduction plan and for management of wild populations. More subtle attributes of behavior exemplified in this special column, such as perception and ability to respond to predators and parasites, ability to convey information to social groups and social group composition required to facilitate specific behaviors, as well as individual temperaments being accounted for in reintroduction and captive breeding projects (McDougall et al., 2006; Berger-Tal and Saltz, 2014), are also aspects which might successfully be conveyed to those involved in conservation management plan. These aspects aid in the continuation of many of the species with which behavioral ecologists spend so much time obtaining heard-earned data.

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