The animal mind and conservation of species: Knowing what animals know

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The question of why studies of the animal mind and behavior have yet to become synthesized with findings by conservation biology is examined by an analysis of the historical interests of the two fields, then by the presentation of two ongoing case studies within conservation biology with the golden lion tamarin, *Leontopithecus rosalia*, and black-footed ferret, *Mustela nigripes*, and concludes with an evaluation of whether the desired synthesis is possible or desirable.

Keywords: Animal mind, behaviour, *Leontopithecus rosalia*, *Mustela nigripes*, species conservation.

HUMANKIND'S interest in the mental life of other animals is obviously prehistoric, although for almost all of recorded human history the interest has been practical, concerned chiefly with domestication for human needs or avoidance or elimination of species considered dangerous. Stories of interactions, including transmutations with nonhuman animals, abound in religious texts, as do the use of animals as symbols of human traits. Human beings routinely project on animals their own characteristics and values, both in literature and everyday speech, a fact that makes difficult meaningful analysis and human understanding of the animal mind.

Although it is intuitive that conservation of species requires knowledge of the behavior, and therefore the perceptions and thought-processing of the species, there is a perceived scientific gap between the two – between conservation and the study of animal behavior. In this introductory essay, I suggest that the reason is a difference in goals, therefore in methodologies, but more generally, in a longstanding and tacit difference in viewpoint as to how we human beings conceive of animal life.

Analysis is made difficult by the inexact and often shifting definitions and understanding of terms. For example, some consider 'mind' to be a metaphysical construct, one that is a trap for the scientist: the measurable behavior is what must be measured if scientific reliability and validity are sought. For others, the idea of a mind contains estimates of its functions, its cognitive capacities, in, for example, decision-making, sense of quantity, and use of something akin to language. For the purposes of this essay, I accept the possibility that through observable and verifiable behavior, the concept of mind is a heuristic, although it would not be wise to posit its structure without eventual neurological correlation. We do not yet know how or in what ways the human and nonhuman mind differ; however, we may experimentally determine the capacities of either. The differences between ethology and comparative psychology are explained in the text that follows, but both are subsumed under the more general term 'animal behavior' or 'behavioral biology'. In like fashion, it is recognized that species conservation is the interest of many, ranging from academic specialists in zoology to hikers. In this essay, however, I have in 'mind' when speaking of 'conservation biology' the notions of those who specialize in wildlife management, ecology, and population dynamics.

Until the recent past, 'understanding' animal behavior was a matter of cataloging and describing, what Aristotle[1] among others thought to be the primary but lowest form of scientific analysis. Linnaeus's system[2] of nomenclature offered, a millennium and a half later, an opportunity to classify animal forms in ways that revealed relationships among them, a method that made it possible for Darwin[3] and others to articulate an understanding of how animal life evolved.

In recent times, the ground of experimental attention has shifted in unexpected and therefore dramatic ways. The first shift of attention was toward a regained respectability of positing and investigating the animal mind, 'mind' being a term that somewhat mystifyingly, sometimes does and sometimes does not include behavior. The second was the understanding that human beings through domestication long able to modify species genetically also can determine extinction and speciation through their use of the environment for human needs.

The first shift has occupied the now twin methods of investigation known as 'ethology' and 'comparative psychology'. Both, as Singh and Kaumanns point out in this issue, are at times subsumed under the term 'behavioral biology'. The second has given rise to a specialty within zoology and biology (and human politics, perhaps) called 'conservation biology'. The question posed for the set of articles that follow is how the two might find commonground leading to advantage for both our understanding of animal behavior and the survival of species endangered by human action. As I argue that tacit differences in philosophy determine the questions posed, therefore the methodology, and eventually the direction of research, I

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begin with a history of the study of animal behavior, especially in the West, then consider how human perceptions of animals determine our ways of understanding, provide two examples of how conservation and biology have attempted to join, and provide a conclusion which argues that a recognition of underlying assumptions held differently by current animal behavior studies and studies in conservation biology is required to form a coherent science.

An instructive history: Ethology and comparative psychology

It is to the half-cousins Charles Darwin and Frances Galton that Europe and West owes its divergent methods in the scientific, as opposed to the anecdotal, investigation of the animal mind along with the epistemologies for studying animal behavior that today guide our thinking, often tacitly. For reasons political, financial, and scientific their ideas overshadowed, at least in the English-speaking world, the well-developed ideas regarding animal behavior that had evolved through practical experience in other cultures, notable those of China and India[4–7].

In several writings, Darwin mentions that the evolution of the mind follows the same principles as the evolution of body structure, and although he performed some experiments on the mental life of animals in his care, he seemingly saved his theories of the evolution of the human mind for a book never written[8]. Galton developed statistical methods, notably, the coefficient of correlation, that made possible the establishing of statistical relationships among human mental differences. Galton's experimental work, especially with genetics, made it technically possible for the development of two variant ways of investigating the animal mind, ethology and comparative psychology[9]. Today, these methods of studying the animal mind appear less starkly different than was once evident, yet the difference in philosophy remains a powerful influence, all the more so when the differences are unrecognized by researchers.

In French and, conspicuously, in German-speaking countries, both approaches are to be found by the turn of the 19th into the 20th century, along with a technique for studying the animal mind that is now all but abandoned; the use of phenomenology to describe and understand the animal mind. This third 'way' considers determination of the perceptual ability of animals to be logically prior to understanding the mind. Its influence was pronounced from around 1920 to 1935 and now, if anywhere, appears to have been melded into ethology.

Meanwhile, in North America, comparative psychology held authority, at least among academics. Based on the goals of comparative anatomy or morphology, the methods were rigidly experimental and concerned with how animals modify their behavior in response to aspects of the environment by learning, forgetting, and forming memories. Work on animal learning and memory from 1890 to 1980 exemplifies the development of this plan[10–14].

In Germany, Austria, and, later, the United Kingdom, ethology became dominant. The reasons for the separation of philosophic method relate to national culture almost certainly, but this issue need not detain us, however promising to intellectual history it may be, for after the World War II a sort of intellectual truce was reached. Some called this a 'synthesis' – and the term is appropriate. For example, examination of last year's editions of the journals *Animal Behaviour* and the *Journal of Comparative Psychology* shows a like spread of species studied and problems investigated. Nonetheless, the older divisions of philosophic underpinnings remain embedded in methodologies: the importance of the evolution of instinct to ethology, of developing a science of comparisons among species to comparative psychology, and the emphasis on perceptual organization by the phenomenologists[15–17]. Especially in the years that featured the Nobel prize-receiving work of Karl von Frisch, Niko Tinbergen, and Konrad Lorenz, the phenomenological contribution to ethology was evident, for studies of animal behavior tried to identify the perceptual organizations that produced specific, invariant, kinds of behaviour. Von Frish's works on bee communication, Tinbergen's on insects' and birds' territorial recognition, and Lorenz's on imprinting illustrate the importance of the animals' perceptual world as the primary, propaedeutic form of explanation[18–21].

What is the animal mind and how can we human beings know it? Through trial-and-error learning on his own part, the hunter knows some behavior to be expected from the prey, but he also knows through the human culture than collects and teaches about such animal behavior. The hunter's predictions regarding behavior, however, are not usually accompanied by postulations regarding the mind, even though the hunter may say 'He thinks I am turning right' or 'He understands the danger of my arrow'. There are, then, three historical ways we have identified structure of the animal mind: (i) such anecdotal evidence which can be informative, say between hunter and hunted, but which rarely if ever leads to useful generalities or deeper understandings, (ii) the task of arranging aspects of mental life of genera along some line similar to what is done with structure in comparative morphology or (iii) investigation of the underlying, presumably genetic and therefore evolutional, aspects that unite behaviour with genetic structure.

Human perception of animal life

That human beings reflect their perceptions, personalities, prejudices, and idea of intelligence on other animals is undeniable. The fields of comparative psychology and ethology sought to ameliorate this confusion, the first by comparing species on mental tasks (Galton's legacy) and the

other by finding genetic patterns of behavior by which animals display Fixed Action Patterns (FAPs) (perceptions) to Innate Response Mechanisms (IRMs) (Darwin's legacy). While comparative psychology strove for laboratory-provided control over the stimuli applied and the responses measured, ethology examined a specialized behavior, FAPs, preferable those occurring in the animals' choice of environment. This statement is an intentional simplification made to illustrate that the question a student of animal behavior asks reflects philosophic preferences – whether she or he knows it or, dangerously, not.

A discovery that well illustrates the task of comparative psychology is that the shapes of the 'learning curve' and the 'forgetting curve' are characteristic of all vertebrates studied and of some fish and fowl. Such comparisons under the control of a laboratory environment are vital to find the reliability and generality of this law of behavior. To the ethologist, such a discovery is one from animal training, a method that largely bypasses what is unique about natural animal behavior, such as homing and migration, the ideas of inter-species imprinting, intraspecific bee communication, and how animal instincts are organized to produce complex behaviors – how the beaver builds and rebuilds its dam, how fish and birds find 'home', of how migration is possible.

All approaches were rattled in the mid 1970s by development of the ideas of William Hamilton and Robert Trivers which, much augmented, became the name and topic of E. O. Wilson's 1976 book, *Sociobiology*[22–24]. In addition to showing how complex behaviors could be explained by phenotypic preferences, Wilson predicted by the year 2000 the end of psychology and its replacement by 'social-biology'. In general, the prediction of the end is occurring, whether for his reasons or others.

The prediction could not have anticipated a second series of studies that also disturbed established thought. These focused popular and scientific attention for a decade or more while also solidifying comparative psychologists and ethologists against a common intellectual enemy, the anecdotal school, and which, when the dust had settled, told us more about the mind of one order than could have been imagined. I refer to the two decades and more of concentrated study on primates (and members of a few other orders) in regard to their ability to communicate with human beings by sign-language, invented languages, symbols, and human speech itself. It may have taken 400 years to attend to Samuel Pepys' suggestion[25] that a 'she-monkey' he saw at the London docks might be taught language by hand signs, but when it was, the study of the animal mind was forever altered.

Seen from the advantage of the first years of the 21st century, the courageous and inventive work on chimpanzees by the pairs of human Kelloggs, Hayeses, Gardners, Premacks, Rumbaugh and Savage-Rumbaugh, and Terrace along with Patterson with gorilla[26–31] is a study in the development of how behavioral science evolves its methods. Each set of authors had the advantage of being able to see the oversights of those who worked before. Each found the goal necessitated both the laboratory-controlled study favored by comparative psychologists and the natural conditions favored by ethologists: each in its place; each with its benefits and limitations.

What we have learned, beside much about methodology, is that our fellow primates, at least the Great Apes, form hypotheses about their worlds, use their inquisitiveness to guide their investigations, and, comment on these through one of the variety of means investigators employed. Whether what they 'say' is syntactically correct (English is required seemingly), learned from their human caretakers, or represents 'nothing more' than operant conditioning, most independent readers of this vast, uneven, and conflicting literature, would agree that even if we have no map of the primate mind, we believe that there is 'something there', some mental processes that we would recognize as our own. Such studies are hugely expensive, rarely done on a sample of the species, but with the animal most adept, and require human beings capable and willing to devote their own professional lifetimes often to a single animal. On the one hand, one result of primate–human communication endeavors was and is a revolution; on the other, like so many human revolutions, the process destroyed bystanders and the revolutionaries alike.

While ethology (melded with phenomenology) and comparative psychology have continued on their paths, their aims and methodology have become background to the ideas of sociobiology and human/animal communication. 'Communication' studies are based on the precept that animals can be taught to speak of their worlds and to interact with human beings by communicating their thoughts. Language, expressed in a variety of forms, has been the mode of communication. Arithmetic, which one would think avoids the likely human projections of articulated language, has only now begun to be explored with, let it be said, encouraging results[32,33]. Studies of primate–human communication may have encouraged the melding of ethology and comparative psychology, but their peak has passed. For the most part, the key animals and investigators have ceased their chats, not because there is nothing more to know or say, but because of cost, and, alas, because human interest has waned. The effect of the findings on the study of animal behavior has waned as well, not from methodological fault so much as from the mysterious forces that decide what is currency in scientific investigations, whether regarding animal communication or discoveries in space.

Sociobiology appears to favor examining instinct and therefore genetics as the primary way to understanding behavior. Sociobiology, as practised, uses the ideas of Trivers to find cases of altruism, selfishness, spite, and cooperation, (these here used as operational terms referring to how behavior alters the genetic mix) arguing that these profit one genetic mix over another, thereby becom-

ing the prime movers of the evolution of behavior. At least, this is how investigators (and popularizers) have understood sociobiology in the decades since it is most clear and forceful statement by E. O. Wilson in 1976. There is, however, a deeper motif: that we have it backwards when we think of genes as determining social organization. Sociobiology, in its pure form, argues that as social organization alters the probabilities in mate selection, the genetic pool is a product of the society and culture, not the reverse.

Exemplars from behavioral biology and conservation biology

Whether the fact of the promotion of sociobiology and the onset of behavioral biology occurring at the same time, in the last quarter of the last century, is a matter of zeitgeist or cause and effect is impossible to say, but the originating of texts and journals shows the correlation. Concern for threatened and endangered species has concentrated on population genetics, demography, and the factors that guide endangerment: habitat degradation, predation, human intervention, and the like. For the most part, academic investigations have had little access to endangered species while conservation biology has been concerned with how animals' respond behaviorally to aspects of endangerment rather than the mental abilities of the species.

What might seem a question with an obvious answer to why ethology and comparative psychology contribute so little to conservation biology is a matter of pragmatic consideration as well as of differing histories and methodologies. A more instructive answer may come from a review of two examples of species conservation – that of the black-footed ferret (*Mustela nigripes*) and the golden lion tamarin (*Leontopithecus rosalia*).

A carnivore of the family Mustelidae, these ferrets were once numerous (although being nocturnal and living underground, rarely seen) in the plains from southern Canada to the southern United States and northern Mexico. Agriculture dispenses with prairie dogs, a primary food for the ferrets. Indeed, in the 1930s, the state of Nebraska, US, required annual extermination procedures of prairie dogs, a law repealed[34,35] in 1985. The extinction of the ferrets is presumably caused by the loss of their chief food source, prairie dogs, and their susceptibility to distemper, a fact that argues for the benefits of dispersal. But dispersal also lowers the prospective gene pool.

Black-footed ferrets were rediscovered in 1981 in a prairie dog compound, thus offering conservation biology not only a chance to recover a species but an opportunity to study population genetics. The prairie dogs, however, in 1985 were found to have a plague, one that was lethal to the ferrets. Additionally, canine distemper was recorded among the few ferrets. The twin enemies of low populations, lack of genetic diversity and inbreeding, lead to a population of 18 by 1987. Captive breeding has succeeded in producing a larger number of animals of this species, one exterminated first by humankind for agriculture and, second, by the paradox that while keeping the few remaining members of a species together reproduction and genetic variability may be enhanced but the probability of a single disease passing to all remaining members enhanced[34].

What has, or can, ethology and comparative psychology teach us about the black-footed ferret? The reasons for its decline in number are evident; the problems associated with its recovery are clear. Emphasis must be on successful reproduction and on establishing genetic variability. The causes of the extinction are largely human needs, aided by the ferrets' food needs. Unless an understanding of the ferrets' mental structure can ameliorate these forces, primary focus must be on genetic variability and reproductive success. What we can say about the utility of studying these ferrets' behavior is that members reintroduced into nature after a pre-release period in a 'halfway' home survive more numerously. Here the animals have the opportunity to practice, if not fully develop, skills in food-getting and predator-avoidance. We do not know what aspect of their learning is responsible for the rate of success, and we cannot know without controlled studies of individual aspects of their interpretation of the environment. Given the small numbers of species-mates available, such studies are inopportune and unlikely.

The now long-standing and complex attempts to reinvigorate and re-establish in Brazil the Golden Lion Tamarin (*L. rosalia*) is equally instructive as it demonstrates how studies of behavior can be used to enhance genetic variability. Like the ferrets, the monkeys' number and therefore genetic variability was limited by human use of resources, in this case use of the forest and wood supply along the Brazilian Coast. It is estimated that 1000 such tamarins remain in the 'wild' and 500 in zoos. Unlike the plan for ferret survival, the tamarins were redistributed in pairs or family groups to zoos, thereby decreasing the probability of a single transmissible disease destroying the remaining stock, but requiring redistribution of captive animals to enhance genetic variability. Not unimportantly, the assignment of pairs to many zoos allowed the facility to advertise its cooperation in captive breeding and, thereby, served to educate the public as to the merits of the approach and give public credence to the financial expense.

Enhancement of the population has not been simple, but the difficulties are instructive for future such attempts. For example, when introduced into the habitat, animals born in captivity did not develop appropriate reactions to predators and, in some cases, to use the food supply. Presumably, these activities require 'learning' and 'memory', mental abilities of interest to comparative psychology and ethology alike. Eating and avoiding predation may seem instinctive, but the form the behavior takes is clearly a matter of survival or not. The possible importance of knowl-

edge of how animals learn and modify behavior might seem crucial and its application to conservation established.

Not so: a long-term comparison of the success of tamarins raised in zoos and trained for the wild compared to those merely released directly suggests no advantage[36,37]. We might thereby assume that learned or modifiable behaviors are irrelevant to the aims of conservation biology, but we may be wrong. Studies of 'animal learning' have historically preferred a laboratory environment in which control can be maintained over variables other than those of direct interest to the investigator. That animals learn in this environment but not in nature suggests that nature – whether environment, resources, or family membership – may supply opportunities and rewards not imagined in the laboratory setting. For example, a tamarin may be taught to avoid the shape of potential predators by a human being working, say, in a zoo, but not view a predator as such with the background of the noise and sights of the rainforest. Similarly, training by a human might not transfer to training by the tamarin's group mates.

The study of animals' behavior in their 'natural' groups and environment is sometimes, somewhat meaninglessly, called the 'ecological' approach. It suffers from a lack of control over the potential variables affecting the behavior under consideration, but presumably shows what an animal can do under natural conditions. The sharpness needed in associating variables with outcomes demanded for behavioral science to build its understandings is offset by the practical gain of the survival of species, these unique combinations of genes and mental activities. If the study of animal behavior/behavioral biology and of conservation biology are to assist one another, insularity in academic research and in professional management must be avoided. Moreover, as Festa-Bianchet[38] has pointed out in a recent book heralding a melding of interests, the media, government, and those who use the environment – and that is all of us – need to see that our overall concern is far more important than our individual professional approach.

It remains to be emphasized that the seeming lack of convergence between conservation biology and animal behavior is the result of differing goals, different methodologies, and, most important, the priority of questions posed. The differences can be seen, for example, in the meaning of 'success' to these differing ventures. It is one thing to ask if an animal has a concept of number; another to measure the increase in population of a species. We are considering not a situation in which two scientific methods disagree as to how to go about their work, but the point at which each methodology thinks its work to be done. If our goal is to learn all we can about what animals know, knowledge of the many elements that determine diversity and the qualities of the animals' perceptions, minds and behavior require inclusion. The two paths to this goal – animal behavior/behavioral biology and conservation biology – will separate now and then, misleading the investigator to think that there is but a single way.

Conclusion

We know that conservation biology both learns and remembers from its practice of identifying the causes of extinction and adds to our understanding of natural selection. We know that ethology and comparative psychology are able to investigate how and why animals modify their behavior. We yet wonder deeply about animal behavior: how animals migrate, orient themselves, and 'home'. With extinction of species, we lose not only a physical structure, but the possibility of learning about the mind of the animal as well.

The articles commissioned for this section well represent the successes and problems of the human study of animal behavior, ranging as they do among orders and species, on the one hand, and being concerned with longstanding issues, such as ultimate and proximate causation, on the other. Just as the study of the animal mind is enriched by the techniques of comparative psychology and of ethology, so conservation biology and our understanding of the causes (and cures) of extinction may continue to meld with investigations of the animal mind. We human beings lose both in knowledge and in our humanity when a species disappears through our ignorance and mismanagement: the responsibility is in the human brain and hands.

1. Aristotle, *De Partibus Animalium (1-4)*, Lennox, J. G., Oxford Press, Oxford, 2001.
2. Linnaeus, C. von, see Fränzmyr, T., *Linnaeus: the Man and his Work*, Univ. of California at Berkeley, Berkeley, 1983.
3. Farber, P. L., *Finding Order in Nature: The Naturalist Tradition from Linnaeus to E. O. Wilson*, Johns Hopkins, Baltimore, 2000; Hinde, R., *Ethology: its Nature and Relations with other Sciences*, Oxford, UK, 1982; Thorpe, W. H., *The Origins and Rise of Ethology: the Science of the Natural Behaviour of Animals*, Heinemann, London, 1979.
4. Rahman, A. and Chattopadhyaya, D. R. (eds), *History of Indian Sciences AD 1100–1800*, Oxford Press, Oxford, 1999.
5. Huff, T. E., *The Rise of Modern Science: Islam, China, and the West*, Cambridge, UK, Cambridge, 2003, 2nd edn.
6. Sterckx, R., *The Animal and the Daemon in early China*, New York State Univ Press, Albany, 2002.
7. French, R. and Greenway, F., *Science in the early Roman Empire: Pliny the Elder, his sources and influence*, Barnes and Noble, Totowa, New Jersey, 1986.
8. Darwin, C., *The Expression of Emotions in Man and Animals*, John Murray, London, 1872.
9. Gillham, N. W., *A Life of Sir Francis Galton*, Oxford Press, Oxford, 2001.
10. Thorndike, E. L., Animal intelligence. *Psychol. Rev.*, 1898, **1**, 1–109.
11. Mills, T. W., *The Nature and Development of Animal Intelligence*, Macmillan, New York, 1898.
12. Watson, J. B., *Psychology, From the Standpoint of a Behaviorist*, Lippincott, Philadelphia, 1919.
13. Skinner, B. F., *The Behavior of Organisms*, Appleton-Century, New York, 1938.
14. Greenberg, G. and Haraway, M. (eds), *Handbook of Comparative Psychology*, Garland, New York, 1998.
15. Buytendijk, F. J. J., *The Mind of the Dog*, Houghton Mifflin, New York, 1936.

16. von Uexküll, J., *Im Kampf um die Tierseele*, Leitfader, Weisbaden, 1934.
17. Schiller, C. H. (Trans. and Ed.), *Instinctive Behaviour: the Development of a Modern Concept*, International Universities Press, New York, 1957.
18. von Frish, K., *Tanzsprache und Orientierung der Bienen*, Springer-Verlag, Berlin, 1967 Also (In English) Cambridge, US: Harvard, 1993.
19. Tinbergen, N., *The Study of Instinct*, Oxford Press, Oxford, 1951.
20. Lorenz, K., Der Kumpan in der Umwelt des Vogels. *J. Ornithol.*, 1935, **83**, 137–213.
21. Lorenz, K., Kant's doctrine of the a priori in the light of contemporary biology. In *Learning, Development, and Culture: Essays in Evolutionary Epistemology* (ed. Plotkin, H. C.), Wiley, New York, 1982.
22. Hamilton, W. D., The genetical theory of social behaviour I and II. *J. Theor. Biol.*, 1964, **7**, 1–52.
23. Trivers, R. L., The evolution of reciprocal altruism. *Quart. Rev. Biol.*, 1973, **46**, 35–57.
24. Wilson, E. O., *Sociobiology, the New Synthesis*, Harvard, Cambridge, US, 1975.
25. Pepys, S., *The Diary of Samuel Pepys* (eds Latham, R. and Matthews, W.), Univ. of California Press, Berkeley, 1970.
26. Kellogg, W. N. and Kellogg, L. A., *The Ape and the Child: A Study of Environmental Influence upon early behavior*, McGraw-Hill, New York, 1933.
27. Hayes, C., *The Ape in our House*, Harper, New York, 1951.
28. Gardner, R. A., Gardner, B. T. and van Cantfort, T. E. *Teaching Sign Language to Chimpanzees*, State University Press, New York, 1989.
29. Premack, D. and Premack, A. J., *The Mind of an Ape*, Norton, New York, 1983.
30. Rumbaugh, D. E. and Washburn, D. A., *Intelligence of Apes and other Rational Beings*, Univ. Press, New Haven, Yale, 2003.
31. Patterson, F. R. and Linden, E., *The Education of Koko.*: Holt, Rinehart and Winston, New York, 1981.
32. Brannon, E. M. and Terrace, H. S., Ordering of the numerosities 1–9 by monkeys. *Science*, 1998, **282**, 746–749.
33. Smith, B. R., Piel, A. K. and Candland, D. K., Numerity of a socially housed hamadryas baboon (*Papio hamadryas*) and a socially housed squirrel monkey (*Saimiri scureus*). *J. Comp. Psychol.*, 2003, **117**, 217–225.
34. Biggins, D. E., Vargas, A., Godbey, J. L. and Anderson, S. H. G., Influence of prerelease experience on reintroduced black-footed ferrets (*Mustela nigripes*). *Biol. Conserv.*, 1999, **89**, 121–129.
35. Biggins, D. E. and Godbey, J., Black-footed ferrets. hthtp: //biology.usgs.gov. December 9, 2003.
36. Kleiman, D. and Rylands, A. (eds), *Lion Tamarins: Research and Conservation*, Washington DC, Smithsonian, 2002. See especially Chapter 13 by Beck, B. B. *et al.*, The effects of prelease environments and postrelease management on survivorship in reintroduced golden lion tamarins.
37. http://nationalzoo.si.edu/conservation and science/ endangered species/glt program.
38. Festa-Bianchet, M., Where do we go from here?. In *Animal Behavior and Wildlife Conservation* (eds Festa-Bianchet, M. and Apollonio, M.), Island Press, Washington DC, 2003.

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