Researching wildlife in New Zealand: conservation applications are both constraints and opportunities

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Abstract

Within the guidelines and principles of animal ethics for research, experimental studies on endangered wildlife for basic biology and conservation management represent a critical conundrum. Specifically, to what extent is manipulative field or captive research justified to provide recommendations for the conservation of rare taxa? In the face of ongoing population declines as a result of natural and anthropogenic factors, even observational studies might lead to negative impacts on the breeding success or longevity of individuals of protected species. In this essay I discuss extensive recently published work on native Australasian gannets (*Morus serrator*), endangered endemic kaki (*Himantopus novaezealandiae*), and introduced thrushes (*Turdus spp.*) within the uniquely New Zealand setting. These three alternatives illustrate how the diverse conservation techniques to protect native fauna have come to represent potential opportunities for both basic biological research and applied management. By adhering to the framework of *refine, reduce, and replace,* these examples also call for more innovative and informative research avenues in the face of practical research constraints and important ethical guidelines.

A personal introduction

As a new faculty member settling into my first job, at the University of Auckland, I was faced with many questions regarding the potential for basic scientific research on vertebrate animals in the uniquely New Zealand setting (Fraser & Hauber 2008). Before my arrival, I had been intensively studying a handful of bird species in North America, in particular the Brown-headed Cowbird (*Molothrus ater*) (Hauber et al. 2001), which as a species represented minor obstacles to obtain ethical and governmental approval for vertebrate-based studies of wild animals. Cowbirds, as native migratory birds, are themselves protected under USA and Canadian regulations. Yet, any research to capture, sample, manipulate, and take into captivity this species was quickly approved because cowbirds, as brood parasites laying their eggs into other birds' nests, repress the reproductive success of their hosts (Hauber 2003), and so special exemptions are quickly granted so as to protect the many host species of this generalist social parasite.

In contrast, studying native and endemic vertebrates in New Zealand requires not only a university animal ethic committee's approval but also the combined formal support of local landowners, conservation agencies, and involved Iwi representatives. Specifically, the application to the New Zealand Department of Conservation requires a special justification for why and how the proposed research benefits the species and its ecosystem with respect to conservation management. While certain aspects of basic biology, including animal behaviour and behavioural ecology, might have critical implications for conservation biology (Sutherland 1998), studies on more common species driven by theoretical rather than applied reasons are not always easy to reconcile either with animal ethics principles, conservation programmes, and cultural practices, or with the long-term benefit for the study species itself.

In fact, much of basic behavioural biology involves moderate to severe interference with the day-to-day activities of the study subjects because, critically, to understand the phenotypic and behavioural diversity requires detailed knowledge of the sex, identity, and past history of the individual and its social partners. In other words the capture, measurements, DNA sampling, banding, and release, followed by extensive observations of subjects are the bread-and-butter of any behavioural ecologist even when conducting correlational studies. Experimental work, critical for testing cause-and-effect scenarios and for higher impact scientific contributions, additionally imposes the requirements of more severe interference with the study subjects that might negatively influence not only the behaviours but the longer term prospects of their survival and reproductive success. How can we justify and reconcile such work on native species that are either rare and endangered or are not yet of a critical status but may become so in the face of ongoing global change and anthropogenic effects?

This essay presents three examples of how work in my laboratory solved this conundrum to conform to the guidelines of the ethical treatment of animals for research and the practical constraints of the study of native fauna in New Zealand, all the while considering the framework of *refine, reduce,* and *replace*. All three of these examples are drawn from my research group's collaborative scientific outputs in the peer-reviewed, published literature on New Zealand-breeding taxa and had been discussed, presented, and approved by institutional and governmental animal ethics committees and permitting agencies.

Case study I (Galbraith et al. 2007)

Kaki or black stilts (*Himantopus novaezelandiae*) are one of the world's rarest wading birds. Once occupying much of both islands of New Zealand, today this species is limited to an adult population size of less than 90 individuals, with all known eggs and chicks captive raised in a facility near the focal area of the species' current distribution in the Central South Island. There is a critically high mortality rate of the eggs, chicks, juveniles, and adults of this species owing to predation of introduced species and ecologically released native species, and to impact from anthropogenic change, and so all known eggs are transported for captive incubation and raising until the independent free-flying juvenile stage.

In contrast to over 90% mortality up to the fledging stage in the wild, captive chicks of this precocial species are successfully raised to independence in groups of conspecifics without the presence of adults, because hatchlings are capable of independent movement and self-feeding soon after hatching. However, the absence of adult companions may impact on the behavioural repertoire of developing kaki, in particular with respect to conspecific vocalisations, including alarm calls. So it has become standard operating practice in the captive reared facility to broadcast alarm calls of adult conspecifics while the doors of the brooders housing the chicks (in which they are held during the first weeks following hatching) are open for cleaning, food exchange, and handling.

Theoretically, repeated exposure to the same stimulus type may have at least two contrasting effects on the behavioural responses of subjects: (i) individuals may become habituated to the stimulus, which in the case of alarm responses may increase the response latency and even eliminate species-specific reaction to predators as alerted by conspecifics; or (ii) individuals may become sensitised, which would enhance species-appropriate responses to alarm calls and potentially aid in avoiding some predators by naïve, captive-raised juveniles. Both the infrastructure (built-in CD playback and speakers in each brooding chamber) and the manipulative practice (i.e. acoustic playbacks on a repeated basis) were already integral components of the captive-raising protocol of kaki chicks (Fig. 1a,b). This represented a unique opportunity to set out to design a playback experiment to determine the relative impact of repeated alarm call playbacks of conspecific calls upon captive kaki chicks. The study and its background are described in detail in Galbraith et al. (2007).

In brief, we conducted a repeated measures playback experiment using conspecific familiar and unfamiliar alarm calls and heterospecific control vocalisations to videotape the behavioural responses of captive kaki chicks during their first days of life. This design

Fig. 1 Examples of concepts and study systems for behavioural studies in the context of conservation biology. (a) Links and opportunities between basic biology and conservation management; (b) captive-raised chick of the endangered kaki endemic to New Zealand (photo credit: J. Galbraith); (c) a free-flying Australasian gannet over the Cape Kidnappers colony, New Zealand (photo credit: C. Daniel); and (d) an experimentally dyed egg within the clutch of introduced song thrush in New Zealand (photo credit: M. Hauber).

allowed us to use controls in the experiments as well as monitor the developmental course of species-specific alarm responses. We conducted the experiments during the afternoons, when husbandry to support the captive raising facility had no regularly planned activity, thereby not impacting on the operating protocols of this intensive conservation programme. Although the presence of one additional personnel in the facility may have increased the possibility of outside infections, by going through the standard hygiene steps and not having the experimenter physically handle or even open the brooders, these effects were minimised.

The findings revealed that kaki chicks showed species-specific drop-to-ground-and-freeze responses following alarm playbacks of both familiar and non-familiar conspecific calls more so than following control vocalisations, and increased the duration of these behavioural displays throughout early ontogeny in accordance with predictions of the sensitisation scenario. In other words, repeated playbacks of conspecific alarm calls did not have a habituation-like effect on the naïve chicks in this critical antipredatory context, thus justifying the future continuation of this protocol in the captive management of the endangered kaki.

Case study 2 (Matthews et al. 2008)

Australasian gannets (*Morus serrator*) are large seabirds breeding in New Zealand and Australia with colonies spread over offshore islands and some "mainland" sites in both countries (Fig. 1c). Unlike most of the South Pacific's seabirds, Australasian gannets (hereafter: gannets) are increasing in population sizes at the global and many local levels, with gannetries spreading visibly during recent times in the vicinity of some highly touristic near-urban sites, including Muriwai Beach at Auckland, New Zealand (Nelson 1978). Gannets are large and frequent bycatches in fisheries operations, yet show population increases instead of declines while also breeding sympatrically with introduced mammals throughout New Zealand. Thus, they can be considered a model system in which to study the ecological and anthropogenic factors promoting population changes in the face of anthropogenic global changes. In addition, despite much interest in the foraging and breeding ecology of gannets and boobies (family Sulidae), there has been relatively little work on the basic behavioural ecology of gannets, including social and genetic mating system, parental investment, sexual dimorphism, and population genetic structure (Daniel 2007). Therefore, we have been following up on previous work conducted at the Cape Kidnappers gannetry, Hawkes Bay, New Zealand (Stephenson 2005) to band, tag, identify, measure, DNA sample, and monitor the seasonal changes in sex-specific behaviours of individuals.

Because gannets are sexually size monomorphic (Daniel 2007), in addition to attaching site bands to individuals to allow identification from a distance, we obtained permission to take DNA samples (blood and feather) from each individual for genetic methods of sexing. In birds, females are the heterogametic sex, and we used several methods to reconcile the specificity of our sex assignment methods using different genetic markers on the same individuals sampled at our study site, as well as using veterinarian-conducted necropsy followed by gonadal examination from salvaged specimens (Daniel et al. 2007). The genetic sexing results were then cross-referenced with behavioural observations to conclude that opposite sex membership in pairbond and copulation positions (top or bottom) were a statistically reliable, although not fully error-proof, method of predicting genetic sex in the Australasian gannet.

Gannets are well known to carry heavy loads of seaweed on their return flight to the colony, with other colony members frequently pilfering seaweed directly from the beaks of the arrivals or stealing it from within the nest structure. The function and sex-specificity of seaweed delivery were unconfirmed but hypothesised to be a male specific trait in this species (Nelson 1978). We therefore used our repertoire of behavioural predictors of sex and modern thermo-imaging technology to conduct an observational study on seaweed delivery behaviour in gannets without the need of handling, interfering, or experimenting with these large and feisty birds (which have the ability to damage themselves and researchers alike during handling). First we followed the behaviours of individuals arriving with and without seaweed to determine whether individuals (i) copulated in the top (males) or bottom (females) position; (ii) were more likely to engange in copulations; and (iii) what the thermal environment (temperature) of nests were with and without seaweed. We needed to rely on our behavioural proxies of sex because despite over 300 individuals banded at the gannetry during recent years, these ringed individuals typically represent less than 10% of the colony members present at any given point. We also used a digital thermo-imager camera to determine the temperature of nests, feet, and eggs of incubating gannets which was able to give us accuracy within 0.1°C from a distance of ~5 m (i.e. without the need to handle individuals). The specific methods and equipment are described in detail in Matthews et al. (2008).

Our results showed that all individuals copulating after seaweed delivery assumed the top position, compared to ~50% of individuals copulating on top or bottom following no seaweed-delivery, in support of the male-specificity of this display. However, copulations were no more likely to occur following seaweed delivery than non-delivery, and so the sex of over half of the seaweed-delivers could also not be confirmed. Critically, the temperature of nests with seaweed in the mornings was consistently higher than nests without seaweed, implying a potential benefit of this behaviour for thermally and energetically costly incubation (Monaghan & Nager 1997) of gannets, which use their feet and not a brood-patch to warm eggs. Overall, our observations were informative in that they allowed us to discriminate between alternative behavioural hypotheses for a prominent sexual display in Australasian gannets, while neither the observed subjects nor their neighbors throughout the specific project were subject to capture, handling, or manipulation beyond what had been previously carried out at this colony.

Case study 3 (Cassey et al. 2008a)

New Zealand is a land of dual conservation concerns. Its native and endemic species are devastated by the introduction of exotic pests following human settlement of the islands. In turn, the land is also overrun by some of the less predatory introduced species which have shifted into occupying both vacant native habitats and the anthropogenic landscapes created by the disappearance of endemic flora and fauna. Such species include European-sourced large bodied thrushes (*Turdus spp.*), including the blackbird (*T. merula*) and the song thrush (*T. philomelos*). Research on such introduced species, which reach high densities in urban and rural landscapes, is not regulated by permits of conservation agencies, but is under the guidance of local landscape owners, regional and city councils, as well as university animal ethics committees. As such, basic biological research, including sampling or manipulative experiments, are more feasibly justified on introduced species in New Zealand than on native species. Importantly, from a basic biological perspective, introduced species represent a series of historical manipulations (Briskie & Mackintosh 2004), because most bird species were brought to New Zealand under planned aims, with population sizes at release serving as a proximate measures of genetic bottleneck severities for each of these species (Briskie & Mackintosh 2004).

Introduced species of birds in New Zealand also show a duality in traits that resemble and vary from their native ranges. For example, clutch sizes of thrushes in New Zealand are smaller than in Europe (Cassey et al. 2005) while the rejection of foreign egg phenotypes within the clutch (through egg ejection and nest desertion, in response to intra- or interspecific brood parasitism, Grim & Honza 2001) resembles behavioural responses shown in the native ranges (Hale & Briskie 2007). As such, New Zealand represents the opportunity to sample and measure behavioural traits and unincubated egg phenotypes of thrushes without the need for enhanced conservation or ethical concerns.

We conducted such a study by measuring the physical reflectance spectra of song thrush eggs (Fig. 1d) in New Zealand, as part of an ongoing effort to understand the chemical and sensory functions of diverse eggshell colours amongst birds (Cassey et al. 2008b). First, we obtained full-spectrum avian-visible reflectance spectroscopy data on eggshell colours of song thrush from rural North Island sites, and then used perceptual sensory modelling of the thrush visual system to determine whether eggs from different nests can be discriminated and, thus, rejected by song thrush in New Zealand compared to their native ranges in Europe. In support of behavioural responses to colour differences between eggs laid by different females, our perceptual models confirmed the sensory basis of higher rates of behavioural rejection responses of conspecific eggs in New Zealand compared to Europe (Hale & Briskie 2007 vs. Honza et al. 2007) to be related to the extent of colour differences of eggs from different clutches. Note, however, that measurements on shape, size, or olfactory cues remain to be taken yet in New Zealand because these sensory cues and modalities might too contribute to egg rejection decisions (Hauber & Sherman 2001). Nevertheless, our study (Cassey et al. 2008a) demonstrated the utility of tapping into a New Zealand-based ecological opportunity to provide alternative means of testing basic biological principles that call for minimal conservation concerns.

Concluding remarks

In this essay I set out to describe some innovative approaches for the general principles guiding conservation-informed and -oriented research in New Zealand. The first example was an experimental study on the endangered kaki where the captive raising facility to produce juveniles for release on an annual basis already incorporated both the behavioural manipulation and the instrumentational infrastructure required for a playback study on the acoustic recognition system of developing stilts (Galbraith et al. 2007). The second example was the application of a predictive series of statistical links between behavioural and genetic data already amassed for one of the handful of New Zealand bird species, the Australasian gannet, which is a species whose conservation value lies in the trend that it has experienced population inclines rather than declines, to use non-invasive methods to estimate sex-specific benefits of reproductive behaviours in a colonial seabird (Matthews et al. 2008). Finally, I illustrated how the ecological catastrophe generated by the introduction of dozens of exotic species to New Zealand following human settlement also formed a research opportunity to study the evolutionary and ecological correlates of sensory perception and behavioural responses of diverse avian eggshell colours (Cassey et al. 2008a). In this last study we specifically analysed the colour of unincubated eggs of introduced species which are not subject to either animal ethics protocols or conservation regulations in New Zealand. Overall, these approaches illustrate potential alternative paths and contribute strongly towards the aims of the ethical guidelines to *refine, reduce,* and *replace* the need for handling species of critical conservation concern in particular, and manipulative research on vertebrate animals in general.

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