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A JOURNEY OF RAPTOR RESEARCH: COMMEMORATING THE SCIENTIFIC CONTRIBUTIONS OF GARY R. BORTOLOTTI

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This special issue of the *Journal of Raptor Research* is dedicated to the memory of Gary R. Bortolotti. Gary's passion and excitement for avian research, and in particular for raptors, was extremely infectious, and he instilled this excitement in all of us who were fortunate enough to have had the privilege of working with him over the course of his career. Sadly, Gary's career was cut short with his untimely passing on 3 July 2011 at the age of 56 years. Those left behind felt a deep sense of loss, not only because he was a valued colleague, but also because we had lost a great friend. Soon after his passing, a proposal was made that an appropriate way to honor Gary's memory would be to publish a selection of papers in a special issue of the *Journal of Raptor Research*, and I am privileged to write the introduction to this issue. A number of tributes and memorials to Gary have already been published both in this issue (Arroyo et al. 2013, Houston 2013) and elsewhere (Dawson 2011, Blas et al. 2011, Gerrard 2011, Houston and Gerrard 2011); readers wishing more details on Gary's life are referred to these. In the text that follows, I therefore provide an overview of the diversity of research interests that Gary pursued over his career, and integrate these with a brief synopsis of the topics that are included in this issue.

EAGLES AND BESNARD LAKE

The research interests that occupied the career of Gary Bortolotti were many and diverse. Although he received his B.Sc. in Forestry from the University of Toronto, during the course of his undergraduate degree it became apparent that forestry was not his true calling. Gary contacted Jon M. Gerrard, a professor of hematology at the University of Manitoba with a keen interest in raptors who, along with Douglas W.A. Whitfield, had been studying the Bald Eagles (*Haliaeetus leucocephalus*) that nested around Besnard Lake, in Saskatchewan's boreal forest. Jon was able to get Gary out to Saskatchewan and out onto the lake for a summer to conduct surveys of the eagles. This first trip to Besnard Lake was formative, and Gary continued to study the eagles at Besnard for his Ph.D., completed in 1984 under the supervision of Jon C. Barlow of the Royal Ontario Museum. Unquestionably, Besnard Lake would play a central role not only in Gary's professional career, but in his personal life as well.

The initial motivation for Gerrard and Whitfield to first go to Besnard in the late 1960s was to conduct a population census of Bald Eagles, and over the course of many decades of surveys, the population dynamics of eagles at Besnard Lake have been extremely well documented (e.g., Gerrard et al. 1990), as have their general patterns in reproductive biology over a similar time frame (Gerrard et al. 1992). Indeed, the extensive time spent on the water working on eagles also has allowed for population surveys of other birds using the aquatic environments of Besnard Lake (Gerrard et al. 1993, Bortolotti et al. 1996b, Gerrard et al. 2006). Gary and Jon's general interest in the birds of this area of Saskatchewan, as well as Gary's later work on American Kestrels (*Falco sparverius*) in the area surrounding the lake, culminated in a 27-yr-long inventory of the birds of Besnard Lake and the surrounding boreal forest (Gerrard et al. 1996). In the present issue of *Journal of Raptor Research*, Mougeot et al. (2013) continue to examine trends in both

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Gary Bortolotti at Besnard Lake, Saskatchewan, Canada, in 2004. Photo courtesy of Heather Trueman.

population size and productivity of the Bald Eagles of Besnard Lake. Their study is particularly noteworthy for its duration, which encompasses over 40 yr. Such investigations are rare, but extremely important for the insights that they reveal; Mougeot et al. (2013) are able to demonstrate that many of the reproductive variables of eagles show density dependence, and that there also is density dependence in population growth rate, suggesting that this population of Bald Eagles is being regulated.

During the course of Gary's Ph.D. research, he was able to develop some simple and accurate methodologies for determining the sex of both mature and adult Bald Eagles based on their morphology (Bortolotti 1984b, 1984c). Gary also developed similar methods for determining sex of Golden Eagles (*Aquila chrysaetos*; Bortolotti 1984a), and in this issue Harmata and Montopoli (2013) present results of their study of morphological variation in Golden Eagles, where they are able to correctly classify the sex of birds with 100% accuracy. The determination of the sex of nestling Bald Eagles was an important step in Gary's innovative research on facultative sex ratio manipulation. Like most raptors, Bald Eagles show reverse sexual size dimorphism, with females larger than males. Gary showed that male-first, female-second broods were rare in Bald Eagles because they lead to greater sibling conflict (Bortolotti 1986). Sex ratios, sibling competition and aggression, and sex biases in the order of hatching of eagles continued to be a fruitful area of research for the next decade and beyond (e.g., Bortolotti 1989, Dzus et al. 1996, Wiebe and Bortolotti 2000). In this issue, Woolaver et al. (2013) examine sex ratios in Ridgway's Hawks (*Buteo ridgwayi*) and show that the remaining females in this endangered species show a consistent bias for producing female-biased broods, which may be a consequence of abundant food resources for these birds, or alternatively a consequence of inbreeding.

THE KESTREL YEARS

Although the focal species of Gary's research changed from Bald Eagles to American Kestrels when he became a faculty member in the Department of Biology at the University of Saskatchewan in 1987, the physical location of his studies remained the area around Besnard Lake. An extensive network of nest boxes was established along roads and logging trails within an approximately 80-km radius of Besnard, and the convenience of using a nest-box population of kestrels for research was immediately apparent. In fact, research on kestrels at the Besnard study site has continued more or less continuously up until the present (e.g., Smallwood et al. 2009, Greenwood and Dawson 2011), primarily because of the logistics associated with using nest boxes. In this issue, Liébana et al. (2013) report on occupancy of nest boxes by raptors in central Argentina, while Rodríguez et al. (2013) describe the establishment of a breeding colony of Lesser Kestrels (*Falco naumanni*) within an urban environment.

With American Kestrels, Gary's work focused on an array of issues, including more studies on facultative sex ratio manipulation, as well as the causes and consequences of hatching asynchrony, parasitism, and parental investment decisions (e.g., Wiebe and Bortolotti 1992, 1994a, 1994b, Dawson and Bortolotti 2001, 2002). One key question that Gary was interested in examining was how American Kestrels selected mates, and while he was not able to perform experimental studies, he was able to show that they paired assortatively with respect to both body condition and feather quality (Bortolotti and Iko 1992, Bortolotti et al. 2002). In this issue, Arroyo et al. (2013) examine the sexual functions of sky-dancing displays in Montagu's Harrier (*Circus pygargus*), and show that males have more intensive displays and that such displays are costly for the individuals performing them, suggesting that they are traits that are honest advertisements of individual quality.

Indeed, during many of his studies, one of the key characters that Gary attempted to quantify in kestrels was some component of ''individual quality.'' And while defining exactly what individual quality actually might be is difficult, he nonetheless tested the utility of various aspects of blood chemistry (e.g., Dawson and Bortolotti 1997) and feather quality (fault bars; Bortolotti et al. 2002) as surrogates for quality. Kestrels also have bare skin at the base of the bill and anterior to the eyes, the cere and lores, respectively, which ranges from dull yellow to bright orange, and he began to quantify variation in coloration among individual birds. Such coloration in animals often is the result of the deposition of carotenoid pigments, which animals cannot synthesize and therefore must be obtained from the diet. Brightly colored birds may therefore be advertising their quality because it shows superior foraging ability. Carotenoids also have many biological functions, including roles in the immune system and as antioxidants for detoxifying free radicals, so the ability to deposit these pigments in ornaments as opposed to utilizing them for physiological processes may also indicate an individual's quality.

In 1995, Gary made a trip to David Bird's Avian Science and Conservation Centre (ASCC) at MacDonald College of McGill University, where David kept a captive colony of American Kestrels. The goal of this trip was to gain further insight into the physiological underpinnings of the expression of color by kestrels, and together with Spanish colleagues, Gary provided evidence that these traits in kestrels were condition dependent and sexually selected, and furthermore, by examining seasonal patterns of coloration and circulating carotenoids, that kestrels were physiologically regulating their expression of color (Bortolotti et al. 1996a, Negro et al. 1998). Although much work has focused on carotenoid-dependent color within the context of sexual selection, in this issue Blas et al. (2013) examine skin color in the highly social Black Kite (*Milvus migrans*), and test its role as a signal of status in social situations beyond mate choice and sexual selection. Their results also suggest that kites are physiologically regulating the expression of carotenoid traits, and furthermore that this regulation differs not only between the sexes, but also between breeders and floaters within the population.

AN EVOLVING RESEARCH AGENDA

The original work that Gary conducted at the ASCC on carotenoids and coloration of kestrels with Spanish colleagues resulted in collaborations that were enduring, and Gary would eventually develop many friendships and close working relationships with other Spanish researchers. At the same time, the work on carotenoids and coloration would ultimately lead to a major shift in the direction of his research program. Ecologists were becoming increasingly interested in using various methods in an attempt to quantify an individual's ability to respond to challenges to their immune system, and Gary was involved in studies that were among the

first to relate immune responses of nestlings to attributes of their parents (Tella et al. 2000a), as well as to examine the heritability of immunocompetence (Tella et al. 2000b). As some of his research became more physiologically oriented, Gary and colleagues developed a number of projects examining issues related to toxicology, such as the exposure of Bald Eagles to lead poisoning in prairie Canada (e.g., Miller et al. 2001), as well as a multifaceted study looking at an array of effects resulting from exposure of American Kestrels to polychlorinated biphenyls (e.g., Fernie et al. 2001, Bortolotti et al. 2003). Not only was this new avenue of research driven by an interest in using physiological tools to answer behavioral and ecological questions, but also I believe from Gary's desire that his research make a contribution toward the conservation of species. In this issue, Speziale and Lamertucci (2013) examine the published literature on how introduced nonnative species influence raptors, and while there is clearly a paucity of information available, the majority of evidence suggests the effects are detrimental, owing both to reductions in the prey base of birds, or through poisoning associated with the introduced species.

Perhaps related to his long-term interest in individual quality, Gary developed a keen interest in measuring stress levels in birds (e.g., Blas et al. 2005), which eventually led to the development of a novel noninvasive technique to quantify avian endocrine status through feather composition. This involved the extraction of the primary stress hormone of birds, corticosterone, from feathers (Bortolotti et al. 2008, 2009a). While the groundbreaking technique of using corticosterone levels in feathers as a means to monitor stress in wild bird populations opened up new avenues of research not only for Gary but for all avian ecologists, it also has allowed the reexamination of many previous questions. For example, it was now possible to examine the role that stress played in the expression of secondary sex traits and more clearly understand that the ability to express ornaments was ultimately a result of the cumulative physiological response to challenges individuals faced from their environment (Bortolotti et al. 2009b). Similarly, while some of his previous work on kestrels examined the role that parasites might play in mediating color expression (Dawson and Bortolotti 2006), it was now feasible to examine such relationships in much greater breadth than was previously possible (Mougeot et al. 2010). Coloration of nestling birds, and in particular raptors, has been largely ignored in previous studies, but in this issue, Martínez-Padilla et al. (2013) examine relationships between feather corticosterone and carotenoid-dependent skin coloration in nestling Common Buzzards (*Buteo buteo*). They show that the degree of coloration is negatively related to corticosterone levels, but only among female nestlings, again suggesting that regulation of coloration and carotenoids is carried out differently by each sex (see also Blas et al. 2013).

Corticosterone level in feathers of nestlings has added a new dimension to assessing the impacts of pollution on birds (Harms et al. 2010) and has also revealed sex-specific investment strategies by parents (Fairhurst et al. 2012). In this issue, Yosef et al. (2013) examine how resource availability and sibling competition influence stress responses of Upland Buzzards (*Buteo hemilasius*), and show that although nutritional condition appears to have little influence on responses, junior siblings have higher levels of feather corticosterone than their senior siblings. Because these differences became more pronounced as the age difference between siblings increased, this study provides compelling evidence for the importance of sibling conflict in mediating levels of stress within nestling raptors.

Coming Full Circle

In recognition of his research accomplishments, the Department of Biology at the University of Saskatchewan named Gary the first Stuart and Mary Houston Professor of Ornithology in 2002 (Houston 2013). In addition to the honor of holding this professorship, it allowed the pursuit of research opportunities that otherwise might not have been possible. For example, Gary was able to assess whether the white plumage of Snowy Owls (*Bubo scandiacus*) could act as a social signal, and further, how the signaling potential of this trait could be modified with behavioral adjustments such as body posture and orientation (Bortolotti et al. 2011). In this issue, Bettega et al. (2013) similarly explore the signaling role of white plumage patches in Eurasian Eagle-Owls (*Bubo bubo*) and, in addition to showing age and sexual dimorphism, are able to demonstrate condition dependence of reflectance patterns. The Houston Professorship also facilitated work on Turkey Vultures (*Cathartes aura*), a species that has increased in number and expanded their breeding range within Saskatchewan over the past 30 yr (Houston et al. 2007). Herein, Rollack et al. (2013) report on a number of aspects of breeding Turkey Vultures in Saskatchewan and, through the use of cameras mounted within the

abandoned buildings that are used for nesting sites, are able to provide new information on natal dispersal distances as well as age at first breeding. Using satellite transmitters, the Saskatchewan vultures also were tracked to their wintering ranges in Venezuela, which were considerably larger than has been previously reported (Hedlin et al. 2013).

The relationships and linkages between Stuart Houston and Gary Bortolotti have roots that extend much longer and deeper than the Houston Professorship. Houston's influence on the ornithological community is substantial and well known, and Stuart has a long history of providing mentorship to aspiring amateur biologists, especially raptor enthusiasts. Among the many mentees of Stuart's was Jon Gerrard, who in turn provided mentorship to Gary and so influenced the direction that Gary's professional life was to take. It is therefore appropriate that this special issue of the *Journal of Raptor Research* close with some of Stuart's personal reflections on Gary (Houston 2013). In a sense, we have come full circle.

CLOSING REMARKS

This issue of the *Journal of Raptor Research* is dedicated to the memory of Gary Roy Anthony Bortolotti—professor, biologist, photographer, mentor, husband, father, and friend. His passion, enthusiasm, colorful language, warmth, humor, and friendship will be profoundly missed, but never forgotten.

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