



Editorial: How Prides of Lion Researchers Are Evolving to Be Interdisciplinary

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Editorial on the Research Topic

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INTRODUCTION

Lions (*Panthera leo*) are one of the most charismatic, enigmatic, and polarizing species on the planet (Macdonald et al., 2015; Albert et al., 2018; Courchamp et al., 2018). Human connections to lions, as functional members of ecological communities and as icons of strength and courage, are truly cross-cultural (Schaller, 1972). Lion symbology, for instance, appears around the world, even in geographic locations outside of the species range (McCall, 1973). The images of lions adorn currency, jewelry, art, clothing, corporate logos and masonry, among others, where they are used and traded on a daily basis (Evans, 1896; Olupona, 1993; Mwangi, 2002). People experience strong emotions when in the company of lions whether that be at zoos, from the relative safety of a safari vehicle, or while grazing livestock on open rangelands in Africa or India (Hemson et al., 2009; Goldman et al., 2010; Meena et al., 2014). Lions clearly command reverence and yet, as humans, we have grown acutely accustomed to conflict with this species. Fears relating to insecurity and loss of livestock motivate swift and aggressive retaliatory responses to lions (Patterson et al., 2004; Dickman, 2010; Millspaugh et al., 2015). Thus, lions seem capable of captivating and scaring humans in equal measure. Perhaps not surprisingly then, here in the twenty-first century, lions are a species of immense conservation concern and one that has defied numerous efforts toward population restoration outside of inviolate protected areas. Lions have experienced precipitous and unabated population declines over the last 100 years causing the conservation community to periodically downgrade the species conservation status (Bauer et al., 2015; Riggio et al., 2015).

The conservation of lions therefore presents a thorny challenge. In their contributing paper to this special issue, Montgomery et al. identify that human-lion conflict is a highly complex issue involving not only the two implied domains (i.e., humans and lions), but also characteristics of livestock and human culture, factors associated with wild prey populations, and abiotic conditions in the environment. This paper articulates that the issue of human-lion conflict is one that is clearly multifaceted and multidimensional. Several calls among the scientific community have demonstrated the utility of evaluating complex problems with research teams that are multidisciplinary, interdisciplinary, and, hopefully at some point, transdisciplinary (White and Ward, 2010; Rylance, 2015). Thus, the objective of this special issue is to highlight the ways in which research teams assessing human-lion conflict and those assessing lion ecology, more broadly,

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have been, and are evolving to be, interdisciplinary. This special issue features 11 papers exploring these topics across the range of lions from West Africa to East Africa and from South Africa to the Greater Gir Landscape of India.

In this editorial piece, we frame three of the major questions pursued among these papers. The first question examines the degree to which lion research has been interdisciplinary. Several papers in this special issue quantified various indicators of interdisciplinarity among teams of lion researchers historically. The second question assesses the role of interdisciplinarity in lion conservation. These papers examine spatial variation in conservation decision-making involving topics such as trophy hunting, human-lion conflict mitigation, and cultural tolerance of lions. The final question evaluates how lion research can become more interdisciplinary. Technological advancements are presented as a means to improve our understanding of lion ecology and develop solutions for human-lion conflict. We ground the discussion of these three major questions within the context of renewed efforts to implement innovative conservation strategies to improve the population trajectories of lions throughout their range.

HAS LION RESEARCH HISTORICALLY BEEN INTERDISCIPLINARY?

Exploring the extent to which lion research has been interdisciplinary historically, several papers in this special issue evaluated various aspects of team science. Scientific assessments of team science represent a comparatively recent area of inquiry examining the impacts of team composition and demographics on the outcomes and impact of collaborative research (Stokols et al., 2008; Ledford, 2015). To quantify the levels of interdisciplinarity inherent to historic research on human-lion conflict, Montgomery et al. used team science tools to review peer-reviewed research on this topic. They found that human-lion conflict research increased exponentially from 1990 to 2015. Despite this growth however, the number of co-authors on the resultant publications was highly consistent over time. There were just 3.28 (SD = 0.19) co-authors per publication. When evaluating the disciplinary identities of these co-authors, Montgomery et al. determined that almost all derived from three highly-related disciplines (i.e., biology/ecology/zoology, wildlife management/conservation, and environmental science). Co-authors from the humanities or social sciences, were particularly underrepresented among this literature as they occurred among <4% of the co-authors. These observations suggest that researchers of human-lion conflict have not mirrored the complexity inherent to the subject matter. Importantly however, these low levels of interdisciplinarity do not speak solely to a failure of lion biologists to engage with humanities or social science colleagues. Rather, they speak to broader problems associated with interdisciplinary team science writ large (Bromham et al., 2016). Namely, low ability to attain sustainable funding, variation among currencies of evaluation, and inconsistencies in expectations for research output are widely detrimental to interdisciplinary science (Lélé and Norgaard, 2005; Eigenbrode et al., 2007).

The species range of lions is divided across some 18 countries and two continents (Bauer et al., 2016). The amount of research and the allocation of conservation effort varies considerably across that extent. Sobratee and Slotow conducted a review of South African-led lion research between the years 1990 and 2018. They found that interdisciplinarity among this research grew 3- and 6-fold growth with each advancing decade. Interdisciplinarity was particularly manifest when evaluating the application of research methodologies and technologies. Sobratee and Slotow did note considerable power dynamics inherent to the research that they evaluated. These power dynamics were illustrated by low levels of first authors that were female or derived from portions of Africa outside of South Africa. The authors discuss the underlying power differentials associated with these observations. Trends such as these however, are not exclusive to South African led research on lions.

Bauer et al., for instance, detected similar patterns when evaluating lion research across Africa. The authors reviewed 615 lion papers and looked in detail at co-author demographics. They detected 199 authors that contributed to ≥ 3 papers. Approximately 70% ($n = 138$ of 199) of these co-authors were male. However, despite the fact that this research occurred in Africa, only 30% ($n = 61$ of 199) of these co-authors were African nationals and just a fraction of those authors were non-white. Bauer et al. discuss the evident barriers to diversity that exist among lion research. A problematic consequence of these patterns that Bauer et al. discuss is the dearth of lion expertise within African countries. They issue an urgent call to action to change the demographics of lion research under what they term a “shared responsibility.”

While Montgomery et al. demonstrated the five dimensions inherent to human-lion conflict, and human-carnivore conflict more broadly, Beck et al. demonstrate the inherent interconnectedness of the variables that define these five dimensions. They present a conceptual model with a number of overlapping and interacting factors that move between and across these dimensions of conflict. Beck et al. discuss how this conceptual model can be used to prioritize the preparation of research teams poised to respond to challenges inherent to human-lion conflict. They provide an example of how to put this process into action so as to illustrate the application of this conceptual model. Beck et al. also provide a series of recommendations about how barriers to interdisciplinarity can be overcome in human-lion conflict research with benefits to lion conservation and the improvement of human well-being. While this suite of papers demonstrates that interdisciplinarity has been rather low historically, current research on lions reflects the critical need for interdisciplinary team science promoting improved understandings of lion ecology with subsequent benefits to lion conservation.

WHAT IS THE ROLE OF INTERDISCIPLINARITY IN LION CONSERVATION?

The next set of papers examined the role of interdisciplinarity in conservation work across the range of lions. While the

vast majority of remaining lions occur in Africa, a remnant population of Asiatic lions (*Panthera leo persica*) continue to inhabit the Greater Gir landscape of India. Jhala et al. discuss the history of Asiatic lions in India. This paper compares lion ecology and sociology between India and Africa. This is an apt comparison given that it has been suggested that cultural tolerance of lions is higher in the Greater Gir than it is across the species African range (Banerjee et al., 2013; Meena et al., 2014). Jhala et al. explore this variation and discuss the important conservation actions (such as national park establishment and community-based tourism benefits) that may be necessary to secure Indian lion populations for future generations.

In a novel assessment of several dimensions that could reduce human-lion conflict, Ng'weno et al. examine the impact of livestock and wild prey interactions on lion ecology. They looked specifically at apparent competition associated with Jackson's hartebeest (*Alcelaphus buselaphus lelwel*) and plains zebra (*Equus quagga*) that are preyed upon by lions in Laikipia County, Kenya. The analysis found that lions selectively killed hartebeest while they took zebra at rates to be expected given their relative abundance. Ng'weno et al. detected zebra use of abandoned livestock corrals, which were comparatively higher in nutrients, and a positive correlation between hartebeest survival and distance from these corrals. The authors discuss the ways in which livestock corrals could be logically distributed to conserve hartebeest, a species of conservation concern, within this coupled natural and human system. Ng'weno et al. articulate a series of conservation implications from this research including the impact of managed livestock grazing on wild prey populations.

In an applied analysis, Kushnir and Packer explore patterns of risk perception among Tanzanian communities vulnerable to lion attack. This is a region of the world that experiences intense human-lion conflict. The authors quantified ~1,000 lion attacks on people in Tanzania between 1990 and 2007. Via the implementation of questionnaire surveys, Kushnir and Packer found that perceptions of risk from lions among local people were far higher than the actual risk of attack. Furthermore, many of the respondents viewed risk from lions to be comparable to those deriving from disease (i.e., malaria and AIDS) or environmental conditions (i.e., drought and famine). Kushnir and Packer place these observations within the context of lions being able to exert considerable fear in people. For example, while the probability of lion attack is very low, the rate at which people die following an attack (66%) is high.

Another important assessment of the social dimensions inherent to lion research involved the point source response of large swaths of global society to the trophy killing of Cecil the lion in Zimbabwe in 2015 (Macdonald et al., 2016). As an example of interdisciplinarity, Buhrmester et al. convened a team of researchers from anthropology, political science, and conservation biology to assess the demographics and actions of private donors that supported the Wildlife Conservation Research Unit (WildCRU) at Oxford University, responsible for studying Cecil in Hwange National Park, in the wake of Cecil's killing. Buhrmester et al. implemented a longitudinal survey to examine the social psychology associated with motivations to give monetary support to lion conservation. They found

signatures of social cohesion in the private donor behavior that were representative of identity fusion. Despite the fact that Cecil was a lion living in Zimbabwe before being killed by a trophy hunter, Buhrmester et al. found that private donors from around the world were able to relate to the animal across spatio-temporal dimensions and that the sense of relatability that was formed, translated to a powerful call to action. These observations, and others like it among this suite of papers, were only made possible by the formation of interdisciplinary research teams bringing together scholars from the biological sciences, social sciences, and humanities in the pursuit of coordinated inquiries around lion conservation.

HOW CAN LION RESEARCH BECOME MORE INTERDISCIPLINARY?

The study of lion ecology, much like the study of large mammals more broadly, has been defined by advancements in technology. Such advancements for wildlife research are inherently dependent upon interdisciplinary research involving wildlife ecologists, engineers, physicists, technicians, and many others. The growth of technology in lion research, particularly within the context of the Serengeti Lion Project, is the subject of Craig Packer's sole-authored paper in this special issue. In that paper, Packer provides a chronology of the expansion of research focus from the time that the project was initiated by George Schaller in 1966 to the end of Packer's 40-year involvement in the study. The paper demonstrated how teams of interdisciplinary colleagues were prepared to study the evolution of lion social behavior, assess lion mating strategies, develop applied solutions for canine distemper virus (which spread from domestic dogs to the Serengeti and Ngorongoro Crater lion populations), and manage the big data deriving from a broad scale camera trapping system termed Snapshot Serengeti. Packer ends the paper by discussing the role of interdisciplinarity in developing progressive solutions capable of conserving lions in a dynamic twenty-first century.

Wijers et al. provide a case study of the technological growth of lion research. An emerging area of inquiry in the field of ecology examines the soundscape, or acoustic landscapes (Pijanowski et al., 2011). In their paper, Wijers et al. demonstrate how bio-loggers could be developed to record audio of lions. When combined with GPS and accelerometer information, these lion-borne acoustic sensors not only revealed interesting information on the acoustic range of lions but also provided an accurate means to create a behavioral ethogram. Behaviors revealed via these bio-loggers included drinking, eating, and three different movement states (stationary, slow moving, and fast moving). Wijers et al. discuss the far-ranging applicability of this technology across the field of animal behavior.

In Botswana's Okavango Delta, Weise et al. present a technological system that alerts local communities to the advancing presence of tagged lions. This version of a "geofence" was piloted across a 24-month period where alerts, in the form of text messages to livestock-owners' phones, were issued in response to the movement of nine study lions. Weise et al.

describe the human actions that corresponded to the information of lion presence detected on this system. These included herder modification of livestock space use on the rangelands, increasing vigilance in herding practice, protecting livestock in kraals overnight, and tending fires to act as a deterrent to lions. Weise et al. simultaneously evaluated the efficacy of these actions as well as the satisfaction of livestock-owners. They found that the changes in human behavior associated with the information deriving from this system significantly decreased lion depredation of livestock. Furthermore, livestock-owners were far more satisfied with this alert system than they were with *post-hoc* financial compensation schemes. Weise et al. provide a balanced discussion of the opportunities and challenges that are inherent to the application of this technology and expound upon the implications of this research for lion conservation. These three papers clearly demonstrate the fundamental role of interdisciplinarity in developing novel and original technologies to facilitate the research-informed conservation of lions.

CONCLUSION

Lions are a species of immense conservation concern across the globe. Despite that concern however, it remains firmly in doubt whether lions will continue to be functional components of the ecosystems that they inhabit 25–50 years from now. Conflict with humans is a powerful driver of lion population declines. Once weakened by conflict, lions become even more vulnerable to swift declines via the concurrent mechanisms of habitat loss, population isolation, prey depletion, and disease. Human-lion conflict is a highly complex issue involving five dimensions (Montgomery et al.), with scores of interacting

components within each dimension (Beck et al.). What is clear is that the livelihood of lion populations is dependent upon teams of interdisciplinary scientists, stakeholders, policy-makers, and local communities productively collaborating to confront the challenges inherent to conserving this species. Though the markers of interdisciplinary team science within this context have been rather low historically, present and future trends demonstrate a shift in the structure of lion research. Self-reflective questions are being assessed (Montgomery et al., Beck et al.), weaknesses highlighted and solutions derived (Bauer et al., Sobratee and Slotow), technological advancements are being embraced (Packer, Wijers et al., Weise et al.), and new and productive partnerships are being forged (Jhala et al., Ng'weno et al.). Thus, the papers in this special issue provide clear indications that research on human-lion conflict is rapidly evolving and that this evolution will be part of securing lion populations for future generations.

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All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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