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Long-term field studies of mammals: what the short-term study cannot tell us

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Long-term studies provide us with crucial information for understanding mammalian biology, which is often lacking from short-term studies. In this Special Feature we focus on 7 mammalian taxa and review ways long-term studies have contributed to our knowledge of ecophysiology, social systems, population and community processes, and conservation. Our aims are to highlight the ways long-term studies on mammals have informed theory, to identify missing information needed to advance theory, and to suggest directions for future long-term studies on mammals.

Key words: community, ecophysiology, long-term, mammals, population, social system

One of the main objectives in biology is to understand how species become well adapted to their changing environment. To achieve this objective, it is crucial to study species in their natural environment. Short-term field studies of 1–3 field seasons are typical of many projects, including Ph.D. studies, but offer only a glimpse of the natural variation that can occur, both in environmental variation and the variability and plasticity of the response of animals to this variation. In contrast, long-term field studies offer several advantages and insights (Clutton-Brock and Sheldon 2010; Kappeler and Watts 2012; Lindenmayer et al. 2012; Mills et al. 2015). These benefits include detailed knowledge of individual life history and social strategies and population and community processes, as well as insight into the evolutionary importance of extreme environmental events. Consequently, long-term studies can provide data that serve as a foundation for effective conservation strategies. Furthermore, long-term studies often provide essential basic information and a broader context for short-term studies by Ph.D. students and postdoctoral fellows.

Long-term studies on mammals have significantly increased our knowledge of ecophysiology, social systems, and population and community processes over recent decades, and these have allowed for important conservation efforts. Ecophysiology, the study of how environmental factors change the physiology of an organism, is essential to understanding how individuals adapt their behavior, reproduction, osmoregulation, and metabolism to prevailing circumstances. Such physiological adaptations, representing phenotypically plastic responses, can only be fully understood in long-term studies (Wikelski and Ricklefs 2001; Wikelski and Cooke 2006). Long-term studies are also needed to understand the diversity of mammalian social systems—i.e., social organization, social structure (who interacts with whom), and mating systems (Kappeler and van Schaik 2002). In particular, long-term studies can determine the underlying environmental factors and social mechanisms, as well as the resulting fitness consequences, of different social systems. For example, the question why group-living species are singular or plural breeders (Hayes 2000) could only be resolved by studying populations over several generations in their natural habitat.

The field of population ecology depends on long-term studies to understand the dynamics of populations. From an evolutionary point of view, extreme years might be the most important in shaping the gene pool of a population. In other words, fitness measures during average years might be less important than in years characterized by strong deviations in environmental conditions, for example, those induced by climate abnormalities. Studies on the mechanisms and ultimate consequences of phenotypic and demographic responses to

environmental change (Ozgul et al. 2010; Schradin and Hayes this issue) and how different species in a community interact with each other and coexist (Gutierrez et al. 2010) must be conducted over many years and generations. Such studies were among the 1st long-term studies emerging, in part, because they did not require the marking of single individuals. For example, monitoring the population sizes of large herbivores in the Serengeti in Tanzania was achieved without individual marking (Grzimek and Grzimek 1959). As such, long-term studies are also essential for conservation of mammals, as the status of populations can only be known if these are monitored over long time intervals, including multiple generations. In the 2nd half of the 20th century, naturalists expressed concern that by the 21st century, many large mammals such as elephants (*Loxodonta africana*) and lions (*Panthera leo*) might be extinct (Grzimek and Grzimek 1959). At the same time, monitoring projects developed and were continued as long-term studies, contributing to the conservation of natural populations. These early—and often still existing—long-term studies are certainly 1 of the reasons our children and our grandchildren are still able to observe these magnificent animals in their natural habitat.

Despite the benefits, there has been a dearth of long-term field studies of mammals. Long-term studies require extensive investments in time, effort, and finances that few researchers can afford or are willing to allocate to a single study. Thus, long-term studies are often not suitable for early-career researchers such as doctoral students with limited time to conduct experiments. Although long-term studies have been linked to increased scientific productivity (Clutton-Brock and Sheldon 2010), some researchers may perceive long-term studies as being "high risk" relative to short-term studies. This perception may be particularly strong for early-career researchers under pressure to publish frequently and in high-ranking journals in order to maintain academic positions and to be competitive for research funding. Those researchers with long-term studies face considerable risks, most notably the high probability of breaks in funding that can disrupt long-term project goals (Clutton-Brock and Sheldon 2010; Lindenmayer et al. 2012; Mills et al. 2015). Scientifically, long-term studies are not replicable and have rarely been adequately compared to identify common patterns as well as missing information among closely related taxa.

Aims and organization.—It is important that we conduct more long-term studies on mammals and that existing long-term studies receive support from funding agencies. Mammals vary considerably in body size and life history, social systems and social complexity, habitats, cognitive ability, and behavioral flexibility (Kappeler et al. 2013; Lukas and Clutton-Brock 2013; Schradin 2013). Mammals share some key physiological constraints: with only a few exceptions, all give birth to live young, nurse them, and maintain their body temperature during periods of parental care. Birds, fishes, and insects (taxa that also vary considerably in social systems) have different and unique fundamental constraints. The fact that mammals share similar constraints permits us to focus on a reduced set of potential causes and consequences.

The 3 aims of this Special Feature are to highlight how long-term studies on mammals have informed theory, to identify missing information needed to advance theory, and to suggest directions for future long-term studies on mammals. We identify long-term studies as those with ≥ 10 consecutive years of data collection in the same population (Clutton-Brock and Sheldon 2010). There are 7 taxon-based papers in this Special Feature, 1 each for the following taxa in which long-term studies have been conducted: Proboscidea (Fritz this issue), Artiodactyla and Perissodactyla (Festa-Bianchet et al. this issue), Cetacea (Mann and Karniski this issue), Carnivora (Smith et al. this issue), Rodentia (Hayes et al. this issue), simian primates (Chapman et al. this issue), and prosimian primates (lemurs, lorises, and tarsiers—Kappeler et al. this issue). To facilitate comparisons across taxa, all of the papers are organized similarly, highlighting the extent to which long-term studies have contributed to our knowledge of ecophysiology, social systems, population and community processes, and conservation. Our intent is to reveal patterns and gaps in knowledge across these taxonomic groups, information that is critical to inform theory and new directions in research. Additionally, some papers conclude with suggestions for future study. Some also include an open-ended section in which authors provide information on other research areas to which long-term studies contributed significantly. The final paper is a synopsis of the papers, aimed at identifying patterns and differences among the long-term studies in the different taxa. Additionally, the final paper includes recommendations for starting and managing long-term studies.

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