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A synopsis of long-term field studies of mammals: achievements, future directions, and some advice

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Long-term individual-based field studies are essential for understanding how animals are adapted to their natural environment and how they will adapt in the future. Long-term studies conducted on more than 200 mammalian species have accumulated 11,000 study years and covered more than 17,000 generations. They have been dominated by studies on social systems and population biology, with little research on ecophysiology—typically, ecophysiological studies are short-term projects embedded in long-term studies. However, physiological data are necessary for understanding how mammals respond to rapid global changes. This is especially important in conservation, for which long-term monitoring of natural populations is essential. Maintaining a successful long-term study requires an understanding of the unique "life history" of long-term studies. Like short-term studies, long-term studies progress from onset to end, but long-term studies differ in the way they are maintained. The greatest challenge to long-term research is the need for consistent and regular funding. Long-term research also requires principal investigators with strong organizational skills, productive collaborations, and creative ways of maintaining financial support. We address challenges and discuss strategies, some based on our own experiences, for the successful management and life history of long-term studies.

Estudios de largo plazo basados en individuos son esenciales para entender como los animales se adaptaron a su medio ambiente, y como se adaptarán en el futuro. Estudios de largo plazo conducidos en más de 200 especies de mamíferos han acumulado 11,000 años de estudio e incluido más de 17,000 generaciones. De este total, estudios de sistemas sociales y biología de poblaciones han dominado respecto a aquellos enfocados en ecofisiología; estos últimos son principalmente proyectos de corto plazo incluidos en estudios de largo plazo. Sin embargo, datos fisiológicos son necesarios para entender la capacidad de los mamíferos para responder a cambios globales rápidos. Esto es particularmente importante para su conservación, para lo cual el monitoreo de largo plazo de poblaciones naturales es esencial. Un exitoso mantenimiento a largo plazo requiere entender los ciclos de vida únicos que posee un estudio de largo plazo. Similar a estudios de corto plazo, los estudios de largo plazo progresan desde un comienzo hasta el final, pero se diferencian en la manera en que estos últimos son mantenidos. El reto más grande de estudios de largo plazo es la necesidad de fondos consistentes y regulares. En adición, éstos también requieren un investigador principal con grandes habilidades organizativas, colaboraciones productivas, y maneras creativas de mantener el apoyo financiero. Evaluamos los retos y discutimos estrategias, algunas basadas en experiencias propias, para el éxito del manejo y del ciclo de vida de los estudios de largo plazo.

Key words: cognition, community ecology, conservation, ecophysiology, funding, population ecology, research management, social organization, social system

Long-term studies of populations of marked individuals yield significant scientific insight that cannot be achieved by short-term studies, providing important data to develop and test theory (Clutton-Brock and Sheldon 2010; Lindenmayer et al. 2012; Mills et al. 2015). Research topics of long-term studies have included the analysis of age structure, quantification of social structure, measurements of lifetime reproductive success, determining estimates of selection, linkage between generations, quantifying ecological responses to environmental change, and understanding complex ecosystem processes (Clutton-Brock and Sheldon 2010; Lindenmayer et al. 2012). The aims of this Special Feature are to highlight long-term studies in 4 areas: ecophysiology, social systems, population and community ecology, and conservation. We asked the authors to note how long-term studies have informed theory in the 4 areas, to identify missing information needed to advance theory, and to suggest directions for future long-term studies on mammals (Hayes and Schradin this issue).

To address these aims, contributing authors reviewed long-term field studies of 7 taxa: 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). Contributors were asked to highlight important results that were possible only because data of ≥ 10 years were available or because shorter studies embedded in these long-term studies created significant insight that would have been unlikely in an isolated short-term study. In addition to long-term studies where single individuals were marked or could be recognized (see Clutton-Brock and Sheldon 2010 for a review of individual-based long-term studies in mammals), we also considered long-term studies in which populations, not individuals, were monitored. Population-based long-term studies (i.e., individuals not marked) have been important to the fields of population and community ecology as well as conservation. Further, in some taxa such as cetaceans, marking and identifying individuals is extremely difficult.

The 1st aim of this synopsis is to give an overview of how studies on the 7 taxonomic groups contributed to the 4 research fields. Our 2nd aim is to promote future avenues of research. Long-term studies, while critical in advancing theory, have unique challenges and are prone to failure, possibly explaining why so few researchers conduct them. Other comprehensive reviews exist about the scientific significance and the major insights of long-term studies (Clutton-Brock and Sheldon 2010; Lindenmayer et al. 2012; Mills et al. 2015). To our knowledge, none have discussed how to establish and manage a long-term study. Therefore, a 3rd and major aim of our synopsis is to address these challenges and discuss strategies, some based on our own experiences in South Africa and Chile, for the successful management and life history of long-term studies. With this emphasis, our objective is that our synopsis will be a source of ideas and motivation and will stimulate discussion among new and experienced field ecologists who aim to start a new long-term study or develop an ongoing study into a long-term study.

Long-Term Studies of Mammals: An Overview

To get information on entire life histories and lifetime reproductive success requires studies that cover the lifetime of individuals. For rodents, multiple generations can often be studied within a single year, making them good study species for addressing evolutionary questions. In contrast, long-term studies of elephants, cetaceans, and simians cover both the lifetime of the study individuals and that of the researchers. For example, while a similar number of rodent species have been studied for a similar number of study years as primates (84 species in ~3,200 study years for rodents compared to 81 species in ~3,100 study years for primates), 42 times more generations have been studied for rodents than for primates (16,640 generations in 68 rodent species compared to 395 generations in 81 primate species; Table 1). In cetaceans, 40 species have been studied in 2,593 study years, but this only covered 127 generations, as most long-term studies were too short and did not cover 1 entire generation. Other taxa, such as carnivores, lie between these extremes (Table 1). Most of the long-term studies reported in these taxonomic groups covered multiple generations, tracked marked individuals, and were theory-based. Consequently, information from these studies can inform a wide range of theory and provide valuable data for conservation.

The impact of long-term studies is not automatically determined by the number of generations studied. For example, a long-term study by the Forest Agency of Japan, a governmental

Table 1.—Overview of long-term studies on mammals, as reviewed in the taxon-specific papers published in this Special Feature (detailed information can be found in the Supplementary Data files of each taxon-specific paper). Numbers are minimum estimates, as for community studies (rodents and simians), total number of species and generations are often unknown. Taxa are listed in order of increasing number of species.

Taxon	Number of long-term studies	Number of continuing long-term studies (% of total)	Number of species studied/total extant species in group	Number of years of long-term studies (through 2016)	Estimated minimum number of generations studied
Proboscidea (Fritz this issue)	20	18 (90%)	3/3	470	21[a]
Cetacea (Mann and Karniski this issue)	129	38 (29%)	40/90	2593	127[a]
Strepsirrhini and tarsiers (Kappeler et al. this issue)	21	20 (95%)	16/134	511	224
Artiodactyla and Perissodactyla (Festa-Bianchet et al. this issue)	24	22 (92%)	14/248	720	115
Carnivora (Smith et al. this issue)	35	25 (71%)	18/286	921	550
Simians (Chapman et al. this issue)	89	82 (92%)	65/311	2,656	171[a]
Rodentia (Hayes et al. this issue)	93	15 (16%)	84/2,300	3,244	16,640
Total, all taxa	411	220 (54%)	240/3,372	11,115	17,848

[a]Elephants, simians, and cetaceans are long-lived, and for many studies entire generations from birth to death have not been covered. These studies were still counted as 1 generation.

organization, reported data on population dynamics from more than 5,900 generations in 50 populations of the gray red-backed vole, *Myodes rufocanus* (Saitoh et al. 1998). The study generated data on more generations than all other studies on all other (nonrodent) taxa combined (5,215 generations; Table 1), revealing that *M. rufocanus* exhibits density-dependent growth (Saitoh et al. 1998). Data from this study have been used to model population processes and host–parasite relationships (Saitoh and Takahashi 1998) and may have implications for conservation biology. While these contributions are important, the impact of this study is limited because it lacked a strong conceptual focus and did not follow individually marked voles. Other long-term studies covering fewer years and generations, but with a focus on hypothesis testing and longitudinal analyses afforded by studying individually marked animals (Clutton-Brock and Sheldon 2010), are likely to provide greater insight across a wide range of disciplines through publication of high-impact papers.

What are the major insights from this Special Feature? Long-term studies on mammals have improved our understanding of what regulates natural populations and social systems of free-ranging mammals. Population-based studies of rodents (Hayes et al. this issue) and ungulates (Festa-Bianchet et al. this issue) have revealed how multiple ecological factors influence population dynamics. For example, pioneering work on rodent communities in Chile led by P. L. Meserve and colleagues showed that environmental factors can switch the main process affecting population dynamics from bottom-up (e.g., water and food availability determine recruitment into the population) to top-down (e.g., predation reduces population size) within the same population (Hayes et al. this issue). These observations are important because they provide insight into the complex role of ecological regulation of animal communities, information that is critical to modeling how predictable events (e.g., El Niño-Southern Oscillation events) or unpredictable environmental perturbations affect mammals.

Long-term studies of mammals, particularly of primates and carnivores, have made important contributions to modern socioecological theory (Chapman et al. this issue; Kappeler et al. this issue). Research on primates has shown that there are 3 interrelated components of social systems (social organization, social structure, mating systems) and that these components are influenced by ecological and demographic variation. To understand social systems, therefore, we must think holistically about the ecological drivers and functional significance of social living. Several long-term studies of carnivores, for example, the study of spotted hyenas by K. E. Holekamp and study of meerkats by T. H. Clutton-Brock and M. B. Manser, have provided extraordinary insights into the social and environmental determinants of cooperation, mechanisms underlying social behavior, and reproductive consequences of group-living and cooperation (Smith et al. this issue). Moreover, the female-dominated social structure of hyenas has provided an excellent system for testing predictions of sexual selection theory.

Studies of ecophysiology are rare, are typically embedded in long-term studies, and rarely encompass > 10 years. Most ecophysiological studies rely on the ability of researchers to obtain samples for physiological measurements, a task that is relatively easy for rodents, difficult for large and mobile mammals such as ungulates and primates, and nearly impossible for cetaceans. New methods such as noninvasive sampling of urine and feces can help to overcome these problems (Chapman et al. this issue; Festa-Bianchet et al. this issue), even for cetaceans (Mann and Karniski this issue). As such, ecophysiological research has become an important component of long-term studies, providing important insights into how mechanisms such as the stress response of the hypothalamic–pituitary–adrenal axis is associated with social status (Hayes et al. this issue; Smith et al. this issue). So far, physiological adaptation to change is understudied but is sure to become more important in the future, particularly as more species are forced to respond to rapid environmental change (Hofmann and Toddgham 2010).

Mammals have significant effects on ecosystems. They are important seed dispersers as well as plant predators that engineer their ecosystems; this occurs with very small rodents (Keller and Schradin 2008), medium-sized primates (Chapman et al. this issue), and large herbivores such as elephants (Fritz this issue). Although many long-term studies have been done on endangered or threatened species such as elephants, lions, and apes, conservation has seldom been the original focus of these studies. Conservation only became an important focus at a later stage as researchers conducting these studies came to realize how vulnerable their study species or their study areas were to human impact. Long-term field studies contribute to conservation efforts by providing information about how population sizes are changing. This can help to differentiate between normal cycling of populations, as observed in some rodent species (Hayes et al. this issue), and a steady decline that needs specific conservation actions.

There are, however, shortcomings to long-term studies of mammals. Because long-term studies are very challenging (see below), researchers of social systems in primates and carnivorans have largely focused on species that can be easily observed. For example, long-term studies of carnivoran social systems have focused primarily on social and often diurnal species; solitary and nocturnal species of Mustelidae receive very little attention (Smith et al. this issue). This is problematic, as we might learn much about the evolution and ecological causes of group-living by studying species that are believed to be solitary, but which might in the end be more social than expected (Roux et al. 2009; Valomy et al. 2015). Very few studies concentrate on the question of why animals live solitarily (Schradin 2005; Schradin et al. 2010). In rodents, the focus has been on species that can easily be captured alive although not easily observed in the wild. However, studies of rodents that can be directly observed in their natural habitat, such as marmots (Sciuridae), degus (*Octodon degus*), and African striped mice (*Rhabdomys pumilio*), have made important contributions to a comprehensive understanding of mammalian social systems (Hayes et al. this issue). An advantage of these rodent systems is that populations do not move, making it possible to monitor groups for many generations. However, subterranean rodents such as the naked mole rat (*Heterocephalus glaber*) are not easily observed; like cetaceans and some primates, they are hard to capture and sample, characteristics that challenge the ability of researchers to maintain long-term studies. Not surprisingly, there is only 1 long-term data set on a subterranean, social rodent (the colonial tuco-tuco, *Ctenomys sociabilis*—Woodruff et al. 2013). Pigs and hogs (Suidae) have rarely been the subject of long-term studies (Festa-Bianchet et al. this issue) despite being relatively large and easy to see, and they often having interesting social systems (Nowak and Wilson 1999).

Future Directions

One theme that received significant attention in the papers in this Special Feature was that of changes accelerated by anthropogenic activities, resulting in climate change, pollution, and destruction and fragmentation of habitats. To understand how animals can cope with change, it is important to know how individuals can adapt behaviorally, morphologically, and physiologically (Rymer et al. 2016). Ecophysiological studies, critical to understanding these mechanisms, have been incorporated into long-term studies but rarely are the basis for them. Future studies should focus more on how individuals maintain homeostasis and physiologically adjust osmoregulation, metabolism, and reproduction in response to environmental change as well as how these mechanisms change over generations (Wikelski and Ricklefs 2001; Wikelski and Cooke 2006). Furthermore, long-term studies will be crucial to our understanding of the adverse effects of aging (e.g., oxidative stress, changes in telomere lengths) because a full understanding of these phenomena requires information on entire life histories of individuals (Monaghan et al. 2009). To achieve these goals, we need to continuously collect samples for physiological measures, such as blood samples (endocrinology, immunology, oxidative stress) and tissue samples (oxidative stress, telomere length as an indicator of aging). Of great advantage would be the establishment of field laboratories that can collect the same physiological data over many years and generations. For example, a respirometry laboratory would offer important data on how animals cope with allostatic load (McEwen and Wingfield 2003) and whether they can adjust their metabolism to environmental change. Another important aspect would be to include studies on the ecophysiology of cognition—the link between environmentally induced changes in physiology and how this affects cognitive performance (Maille and Schradin in press).

There is a growing recognition that greater integration of genetic and physiological mechanisms is critical for future insights, especially in the study of social systems (Hofmann et al. 2014; Nunn et al. 2015). While some methods are too disruptive to be used in long-term studies (e.g., killing animals for neuroanatomical assessment), there remain numerous opportunities for integration of novel ideas into long-term field studies. Notably, simple, noninvasive procedures can be used to determine how interannual variation in the early social environment influences the development and life history of individuals (Fouqueray et al. 2014). Laboratory studies indicating that subtle changes to the early social environment have transgenerational effects on behavior (Cushing et al. 2003) could be adapted for and tested in long-term field studies. Insight generated from these types of studies would inform life-history theory and have important application to conservation biology and social and educational sciences (Reynolds et al. 2001).

To understand how global change affects natural populations, we need long-term data sets on population dynamics, which in turn can be used to model how population size will develop when conditions continue to change, such that early warning signals can be detected before a population collapses (Clements et al. 2015). A promising method that can be applied to long-term data sets is to model the effects of interannual variation in ecology on the relationship between social organization and reproductive success. Additionally, experimental studies would be important to test for the observed causal and interacting effects of intrinsic and extrinsic mechanisms driving population dynamics (Hayes et al. this issue). In sum, while we still do not fully understand how populations are regulated, multiple long-term studies should allow for improved understanding across both spatial and temporal scales.

One major advantage of long-term studies is that they collect data during extreme events such as droughts, which are predicted to become more common and more intense in the future (Dai 2011). Similarly, long-term studies are necessary to understand how periodic environmental events such as the El Niño-Southern Oscillation or resource pulses (such as emergences of periodical cicadas) affect mammal populations and communities. It is the years with an extreme decline in population density that determine the gene pool of the following generations and whether a population survives. Thus, evolutionary consequences of individual traits studied might only become evident under such "extreme" conditions, with studies conducted during "average" years contributing little to our understanding (Ebensperger et al. 2014). Still, we know relatively little about which factors lead to increased frequency of deaths and how much individuals can react with phenotypic adaptation to extreme events (Rymer et al. 2016).

Managing Long-Term Studies and Challenges Threatening Them

Long-term individual-based field studies are essential if we want to understand how animals are adapted to their natural environment and how they will respond to a changing environment. Long-term studies are expensive, time consuming, and logistically difficult, which are reasons that very few researchers start long-term studies (Clutton-Brock 2005; Lindenmayer et al. 2012; Mills et al. 2015; Hayes and Schradin this issue). Moreover, the overwhelming pressure to publish frequently in high-impact journals may dissuade early-career investigators from investing time in starting long-term studies. Nevertheless, the more than 400 long-term studies reviewed in this Special Feature (Table 1) are evidence that successful long-term studies are possible. But how do researchers accomplish high productivity in a long-term study? Authors rarely publish accounts of how long-term studies come into existence and develop, and how they respond to intrinsic challenges (e.g., population declines, disagreements among collaborators) and extrinsic challenges (e.g., natural disasters, changes in funding priorities). Herein, we describe the "life history" of a long-term study.

Life history of long-term studies.—We identify 4 stages of long-term studies: onset, establishment, maintenance, and ending of the project. The onset of some long-term studies was intentional; but many have developed out of successful short-term studies that were started with different goals. For example, the degu social systems project co-led by L. A. Ebensperger and one of us (LDH), as well as the Kalahari meerkat project and the Inkawu Vervet Project, were started as long-term studies focusing on social behavior. In contrast, the striped mouse project led by one of us (CS) started as a short-term study to determine whether the results of laboratory studies on paternal care could be replicated in the field (Schradin and Pillay 2003).

Many long-term studies became established because consecutive short-term studies built on one another. This is a critical period, because at this point it will be decided whether or not a long-term study will be established. In this phase, it is important that the participating students, postdoctoral fellows, and researchers publish high-quality papers in high-impact journals to ensure continuous financial support from granting organizations. Methods that can be replicated from year to year must be established, allowing for consistency within long-term data sets. Moreover, it is during this time that the principal investigator (PI) must be successful in building the research support and infrastructure, and attract collaborators who can design diverse projects that will attract their own funding (see below).

The maintenance of long-term studies is characterized by production of high-quality scientific results arising from long-term data sets. Long-term studies are typically maintained because they are scientifically productive and have acquired high prestige within the scientific community. Sustained funding, usually from multiple sources, and continuity of leadership are critical during this stage. If the PI retires from the project, it is important that a new, highly competent PI be ready to continue the project. The new project leader must be familiar with the field site, be able to support students and postdoctoral fellows, and have the necessary time and skills to organize and continue the long-term study. Recent examples of smooth transitions include the marmot project at Rocky Mountain Biological Laboratory in Colorado (D. T. Blumstein took over from K. B. Armitage) and the Kalahari meerkat study (M. Manser is currently taking over from T. H. Clutton-Brock).

Nearly half of the long-term studies covered in this Special Issue have been terminated (191 out of 411 studies; Table 1). The vast majority of terminated studies were on unmarked populations. In contrast, most studies with marked individuals are continuing, including long-term studies on primates, carnivores, and rodents (Sciuridae, degus, and African striped mice). Inevitably, all long-term studies come to an end, though for different reasons. Long-term studies could reach a natural end when all relevant questions have been answered (Lindenmayer et al. 2012). Many might end because the challenges outlined in Table 2 become overwhelming or key personnel such as the PI retire or die and cannot be replaced.

The major risk for the scientific community is not the end of a long-term study, but if no new long-term studies are established. Here, we provide some advice based on our own experiences and from what we learned from this Special Feature. Our advice should be one source of information to researchers interested in starting long-term studies; we hope that PIs of other long-term studies will also share their experiences and opinions on how to manage long-term studies. Following are what we see as 5 key steps in setting up and maintaining a long-term study.

Establish strong collaborations.—Long-term studies often require strong collaborations or teams of researchers to accomplish goals. Collaborative efforts increase creativity and are often crucial to maintaining the high levels of productivity needed to sustain long-term studies. Strong collaborations are essential in nearly all other aspects of running a long-term study.

Build relationships with members of local communities.—Good relationships with local communities, landowners, and station managers are essential to successful long-term studies. Participants need to be understanding and accepting of local cultures and traditions. PIs and their workers benefit from the ability to speak a local language. Meetings with all stakeholders (e.g., local landowners, local authorities, local researchers) are critical to dispelling potential concerns or biases. Researchers should consider the inclusion of people from local communities in research efforts. In addition to being a source of humanpower, well-trained "citizen-scientists" can enhance a research group with their knowledge of local natural history and through cultural exchanges. Job creation can be important—and appreciated in many countries. The PI will need to learn about the local bureaucracy, which goes along with understanding the local culture. Working with local collaborators is often critical to successfully interacting with local authorities, for example, to obtain permits.

Incorporate short-term objectives into a long-term study.—The only way to maintain a long-term study is to produce high-quality science from the onset. This can be accomplished by integrating short-term studies within the framework of a long-term study, which is especially important in the establishment phase. PIs will need a vision for questions that can be addressed based on long-term studies. The papers in this Special Feature serve as good models for developing questions. Long-term studies require consistent methodology so that long-term data sets are comparable throughout the study. However, researchers will need to be flexible and willing to implement new technologies that may emerge over the course of a long-term study.

Develop a creative, flexible funding strategy.—Researchers seeking to start and maintain long-term studies need to seek creative funding solutions. National and private funding agencies rarely support project objectives exceeding 3–5 years. Critically, researchers need to integrate short-term projects within the framework of a long-term study. Seed funding from

Table 2.—Challenges faced by long-term field studies and how to cope with them. Not all challenges have the same importance for every project. Projects based in a foreign country can have challenges that do not occur in the home country—and the other way around. NGO = non-government organization; NPO = not-for-profit organization.

Challenge	Strategies to cope with challenge
Political and economic stability of country	Choose country in which to start a long-term study wisely. Seek support from local communities.
Working in a foreign country with a different culture	Involve local community in scientific endeavors, cultural exchange, and planning meetings. Learn to speak a local language.
Collaboration with local authorities	Learn the local bureaucracy and the local culture. Local collaborators help with obtaining permits.
Logistical problems	Anticipate potential problems including issues with shipping materials or vehicular and housing problems. Establish clear alternative plans in the event of problems. Communicate plans with local scientists, regulators, and managers.
Obtaining time	Have principal investigator delegate responsibilities to reliable students, research manager, or postdoctoral fellows. Schedule other responsibilities, such as teaching, in a way that allows travel to the field site.
Maintaining the field site and field station	Hire an on-site field manager or technicians to care for equipment and field site.
Data quality, data management, and data analysis	Follow strict protocols to ensure consistency and reliability of data.
Changes in animal care protocols	Communicate with animal care committees to ensure all protocols are approved. Validate new methods and compare them with the old method.
Conflict of interest between personnel	Frequent discussions about project directions, personnel, etc., using face-to-face meetings. Establish and communicate clear personal and collaborative objectives. Write contracts or agreements about leadership on projects and products. Save e-mail communications.
Obtaining funding	Apply to federal agencies and interact with them (serve on funding panels, meet with panel members). Seek funding from foundations that support science and conservation. Use crowdfunding programs for additional funds. Seek collaborative funding from international agencies.
Surviving years without funding	Try to extend grants if sufficient funds are available. Establish a legal structure for the study (e.g., NGO) that allows the project to function as a foundation. Use funds saved from your legal structure (NPO, NGO) that were obtained during years with good funding. Reduce expenses but maintain minimal level of data collection.

private sources such as the National Geographic Society or federal funding programs that place greater emphasis on training junior scientists rather than on pure science can be sources of short-term funding. Crowdfunding programs, such as Kickstarter, Experiment, and Sciencestarter, may provide initial funding or help researchers bridge the gap between major grants, but they typically provide relatively small amounts of money (Wheat et al. 2013). In many cases, financial support from multiple national agencies is critical to sustaining international projects. Under these circumstances, collaborations are essential in order to achieve a situation where grants to several different PIs cover the costs and reduce the risk of funding interruptions.

An important aspect to consider is the legal structure of the long-term study. Depending on the national legislation, long-term studies could be registered as foundations, not-for-profit organizations (NPOs), non-government organizations (NGOs), or something similar. This can offer several advantages. First, an NPO or NGO can function as a foundation and manage funds for the long-term studies. The funding can be obtained from donations, generated income, and research fees charged by the NPO to large governmental foundations in years with funding. A long-term study registered as an NPO or NGO can thus build up a financial stock for periods with low or no third-party funding. Second, the NPO or NGO is associated with the PIs of the project, not with a specific university. Thus, if a PI changes his or her university, there are no (or limited) administrative problems for the PI to continue the long-term study. Third, the NPO or NGO can buy large equipment such as field vehicles without restrictions. Fourth, the NPO or NGO can take over all liability from the PIs and his or her institution. As a legal structure, it can take out insurance policies, especially for liability, and also for buildings and vehicles. Agreements such as indemnity forms can be signed between students and the NPO or NGO, taking liability away from the PIs in case of accidents.

Be prepared to weather a storm.—Inevitably, researchers working in the same location for 10 or more years will be negatively impacted by challenging events such as natural disasters or gaps in research funding. Strong collaborators, mature students, and effective field managers and technicians, as well as strong relations with local stakeholders, are essential to mitigating some of these problems. Clear strategies for dealing with logistical problems such as transport of research material and samples should be developed. For example, the frequency of transport of samples should be reduced, such as transporting samples once a year for all students together. Maintaining high productivity and a minimal effort to collect data will decrease the likelihood that funding gaps will lead to the end of a long-term study.

Conclusions

Asking new and interesting questions as well as innovation and new ways of thinking are keys to scientific progress. However, a heavy emphasis on rapid publication of novel results often comes at the expense of long-term studies. Long-term field studies are essential to understanding biodiversity as well as social systems, demographic processes within populations, and interactions between the species in a community. Long-term studies provide us with detailed life-history data on individuals as well as with insight into rare and extreme environmental events—which are likely to become more common in the future. An important message from this Special Feature is that long-term studies are essential to understanding how animals are adapted and will adapt to rapid environmental change. Thus, we call on researchers to start more long-term studies and we encourage funding agencies and foundations to establish more mechanisms to support long-term studies.

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Special Feature Editor was Barbara H. Blake.