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Relating Long-Term Studies to Conservation Practice: the Case of the Serengeti Cheetah Project

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Abstract: *Although detailed, long-term scientific studies provide potentially crucial information for conservation, they are rare. Moreover, there is often a disjunction between scientists and managers that can affect whether scientific results are applied to help solve conservation problems. Long-term studies can promote increased communication between scientists and managers and hence offer an opportunity for constructive engagement between the two groups. We examined direct and indirect impacts of a 30-year study, the Serengeti Cheetah Project (SCP). Much of what is currently known about wild cheetahs comes from the SCP. In particular, the SCP has demonstrated that cheetahs have a combination of semisociality and ranging patterns that is unique among mammals. This system arises because cheetahs need to be mobile to avoid predators and competitors, yet maintain access to prey; this results in densities much lower than for other large carnivores and a requirement for large areas of heterogenous and connected habitat. The SCP started as a research project, but expanded into a national program, developing capacity for carnivore conservation within Tanzania. Long-term studies such as the SCP are uniquely placed to establish effective working relationships between scientists and managers, engage local and national institutions, and strengthen national capacity for biodiversity conservation. This process is best realized through the establishment of frameworks for conservation that seek to align scientific research with management needs. Long-term studies also play an important role in identifying international priorities for conservation. Nonetheless, the integration of science and management in conservation is a two-way process that requires concerted efforts by both sides to improve and maintain dialogue. Ultimately, conservation depends on people, and maintaining a commitment to a particular area over many years—such as through implementation of a long-term research project—helps establish mutual trust and respect, particularly when combined with development of local and national capacity for scientific research and conservation management.*

Keywords: *Acinonyx jubatus*, capacity development, conservation management, long-term conservation studies, Serengeti Cheetah Project, Tanzania

Relacionando Estudios de Largo Plazo con la Conservación en la Práctica: El Caso del Proyecto Guepardo del Serengeti Durant et al.

Resumen: *Aunque los estudios científicos detallados, de largo plazo, proporcionan información para la conservación, son raros. Más aun, a menudo hay una desvinculación entre científicos y gestores que puede influir en la aplicación de resultados científicos en la solución de problemas de conservación. Los estudios de*

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largo plazo pueden promover una mayor comunicación entre científicos y gestores y por lo tanto ofrecer una oportunidad para una relación constructiva entre los dos grupos. Examinamos impactos directos e indirectos de un estudio de 30 años, el Proyecto Guepardo del Serengeti (PGS). Mucho de lo que se conoce actualmente de los guepardos silvestres proviene del PGS. En particular, el PGS ha demostrado que los guepardos tienen una combinación de semisociabilidad y patrones de distribución que es única entre los mamíferos. Este sistema surge porque los guepardos necesitan movilidad para evitar a depredadores y competidores, y mantener acceso a presas; esto resulta en densidades mucho más bajas que otros carnívoros y en un requerimiento de áreas extensas de hábitat heterogéneo y conectado. El PGS comenzó como un proyecto de investigación, pero se expandió a un programa nacional, desarrollando la capacidad para la conservación de carnívoros en Tanzania. Los estudios de largo plazo como el PGS tienen la posibilidad de establecer relaciones de trabajo efectivas entre científicos y gestores, involucrar a instituciones locales y nacionales y reforzar la capacidad nacional para la conservación de la biodiversidad. Este proceso se realiza mejor por medio del establecimiento de marcos de para la conservación que busquen alinear la investigación científica con las necesidades de gestión. Los estudios de largo plazo también juegan un papel importante en la identificación de prioridades internacionales de conservación. Sin embargo, la integración de la ciencia y la gestión a la conservación es un proceso de dos vías que requiere esfuerzos concertados por ambas partes para mejorar y mantener el diálogo. En última instancia, la conservación depende de personas, y el mantenimiento de un compromiso en un área determinada por muchos añosomo la implementación de un proyecto de investigación a largo plazoyuda al establecimiento de una confianza y respeto mutuos, particularmente cuando se combina con el desarrollo de una capacidad local y nacional para la investigación científica y la gestión de la conservación.

Palabras Clave: *acinonyx jubatus*, desarrollo de capacidad, estudios de conservación de largo plazo, gestión de la conservación, Proyecto Guepardo del Serengeti

Introduction

Detailed, long-term scientific studies of long-lived vertebrates are relatively unusual (Clutton-Brock 1988), not least because funding agencies usually operate on short-term funding cycles, making it difficult to maintain the continual levels of support required for long-term research. Nevertheless, such studies are essential to understanding the factors that drive population size and dynamics and to provide crucial information for conservation that cannot be obtained by other means. Unfortunately, applying such information to conservation management and practice has not always been straightforward. Because scientists are rarely managers and managers rarely scientists, effective communication between the two groups can be problematic. Scientists and managers generally work at different time scales (Linklater 2003) because managers often need to respond quickly to immediate problems, whereas scientists can sometimes take years to generate appropriate information. In developing countries, this problem is particularly acute because wildlife science is funded predominantly by science agencies of developed countries, whose priorities may differ from local or national priorities.

Fortunately, scientists are increasingly concerned that their research has "meaning" through influence on conservation efforts. Long-term studies are ideally placed to improve mutual trust, respect, and understanding between scientists and managers, which often leads to new collaborative conservation ventures. Yet, such studies often only survive because of the drive and determination of the lead scientists and thus are never likely to be numerous. Nevertheless, one can build on lessons learned from existing long-term studies to improve communication between scientists and managers and develop general mechanisms for making science more responsive to conservation management needs, which is increasingly important given accelerating rates of global biodiversity loss.

We assessed the conservation impact of the Serengeti Cheetah Project (SCP; conducted in Serengeti National Park [SNP], Tanzania), which is the world's longest-running field study of wild cheetahs. Cheetahs (*Acinonyx jubatus*) are listed as vulnerable by the World Conservation Union (IUCN) and are thought to be declining throughout their range (Marker 1998). Serengeti National Park, covering approximately 14,000 km^2, contains one of the world's largest cheetah populations within a strictly protected conservation area (IUCN category II; IUCN 1994). We examined the SCP's key conservation-relevant scientific findings, contributions to national capacity development, and impacts on conservation policy and practice at three levels: locally (SNP); nationally (Tanzania); and internationally. We used the SCP's experiences to explore ways in which conservation impacts of field research projects can be improved.

History and Description of the Serengeti Cheetah Project

George and Lory Frame initiated the SCP in 1974–1977, when virtually nothing was known about cheetahs in the wild, and information on their conservation status was limited (Myers 1975). Tim Caro ran the project during 1980–1990, and S.M.D. took over its management from 1991. The SCP's historical study area covers some 2200 km^2 of short- and long-grass plains in the southeastern SNP. The project locates cheetahs within this area and uses a card index system to identify individuals by unique spot patterns on their face and body.

Demographic information including data on reproduction, survival, and ranging patterns has been collected on individual cheetahs throughout the study. In addition, short-term projects have focused on different aspects of cheetah behavior and ecology, making use of information on the life histories of individual cheetahs. Initial research focused on establishing the basic natural history of cheetahs, whereas later work in the early 1980s was largely theoretical in nature. From the late 1980s the project started to address issues that were directly relevant to conservation. Today, the SCP continues to collect demographic data but focuses almost entirely on issues of conservation significance.

Key Findings from the Long-Term Study

A basic understanding of the natural history of a species, including ranging patterns and ecological requirements, is key to its conservation in the wild (Caro & Durant 1995). This information and regular monitoring informs decisions for policy and management (Caughley & Gunn 1996). Population monitoring can alert managers to sudden changes in numbers, allowing action to be taken to prevent catastrophic declines. Understanding the ecological processes that affect numbers and distribution enables managers and policy makers to determine appropriate management interventions and prioritize suitable areas for conservation. Information about impacts of humans is also key to overall species management. A combination of these data can be used in predictive models as tools for management and planning and to determine the extent to which management intervention is necessary (Kelly & Durant 2000).

Significance of Monitoring for Conservation

Cheetahs show a combination of semisociality and ranging patterns that present challenges for monitoring. Female cheetahs live alone or with dependent cubs, whereas males can live in permanent coalitions of two or three individuals (Caro & Collins 1987). In SNP females occupy large, overlapping, annual home ranges (average 833 km^2), whereas males either defend small territories (average 37 km^2) where females collect, or wander over large ranges (average 777 km^2) (Caro 1994). The formation of long-term male coalitions in mammals is unusual (Caro 1994), and the cheetah system—where coalitions of males hold small territories that are <10% of a solitary female's home range—is unique among mammals. In addition, cheetahs, with the exception of territorial males, are tolerant of other cheetahs nearby; thus, many different cheetahs often occur within a few kilometers of each other where hunting conditions are good and predator densities are low (Durant 1998). This aggregation in transient hotspots makes population size estimation difficult. Questionnaire data are particularly unreliable because densities can be radically overestimated if cheetahs are counted only in a hotspot without consideration of kilometers of cheetah-free habitat outside these areas. The converse is also true because it could be concluded that there are no cheetahs in an area because a crucial temporary hotspot has been excluded. Selecting an area for survey that is too small or is not sufficiently representative is likely to lead to misleading conclusions about population size and distribution of cheetahs, which can have unfortunate consequences for conservation priority setting and management.

Cheetahs are affected adversely by human activities, but there are few quantitative data on how human activities have affected their abundance or distribution. An objective and reliable measure of cheetah distribution and density is essential to assess their overall status, identify and address threats to long-term survival, influence national policy in favor of cheetah conservation, identify conservation priorities, and assess the effectiveness of management action and policy changes (Berry et al. 2001; Crosier et al. 2002). Nevertheless, it is difficult to replicate long-term studies, such as the SCP, which are costly in human, financial, and technical resources. Consequently, in recent years the SCP has been testing alternative techniques for estimating population size that are potentially more rapid and cost-effective, and applicable in other habitat types, including spoor counting, use of tourist photographs, and distance-based transect counts (Bashir et al. 2004). Because the size of the SNP cheetah population is known, the SCP is ideally placed to test the accuracy and suitability of new techniques and develop survey protocols. No single technique is ideal for all habitat types; however, tourist photos are particularly appropriate for well-visited sites with relatively habituated cheetahs, whereas spoor counts are useful in bushy habitats with sandy soils (Bashir et al. 2004). Transect counts are limited to open habitats (Bashir et al. 2004).

Prey Requirements and Interspecific Competition

Cheetahs on the Serengeti plains rely on Thomson's gazelles (*Gazella thomsonii*) for 67.3% of their kills (Hunter et al. 2007). Thomson's gazelles move from the woodland edges within the park in the dry season onto the short-grass plains, often outside the park, in the wet season (Durant et al. 1988). Most cheetahs move with the gazelle and exploit this prey throughout their migration. Hence, cheetahs move outside the park over the year, mainly to the south and east, making them vulnerable to human impacts outside the park. Cheetahs occur at much lower densities than most other large carnivores in the ecosystem, with total abundances <10% that of lions, 5% of spotted hyenas (*Crocuta crocuta*), and 25% of leopards (*Panthera pardus*) (Caro 1994). They lose around 11% of their kills to scavengers, principally to spotted hyenas (78%) and lions (15%) (Hunter et al. 2007).

Cheetahs survive alongside the much larger and more aggressive lions and hyenas through predator avoidance (Durant 2000*a*, 2000*b*). Nevertheless, their reproduction is severely affected by these predators. Most of the available information on wild cheetah reproduction was generated by the SCP, through a detailed study in the late 1980s (Laurenson et al. 1992). Although nearly all adult females are able to conceive and give birth, cubs have a very high mortality due to predation, particularly in the first 2 months when they are largely immobile and lodged in a lair (Laurenson 1993). During this time mothers generally leave after dawn to hunt, returning at dusk (Laurenson 1993). Overall, only 5% of cubs survive to reach independence at 14 months (Laurenson 1995*a*), and predation by lions accounts for most (nearly 75%) of known cub deaths (Laurenson 1994). There is no evidence that genetic defects or disease play a major role in cub mortality (Caro & Laurenson 1994; Laurenson 1994).

The causes of adolescent and adult mortality are less clear because it is seldom observed, occurs at lower rates, and carcasses are rarely found owing to high abundances of scavengers. Furthermore, SCP data do not allow confident differentiation of mortality from dispersal, except when individuals have been radiocollared. Nevertheless, minimum annual mortality estimates are much higher for males than for females: adolescent mortality averages 35% for females and 74% for males, and adult mortality averages 15% for females and 31% for males (Durant et al. 2004). This is almost certainly due to male–male competition over territories (Caro 1994). Both male and female adolescent and adult cheetahs have also been documented as being killed by lion (Caro 1994; Durant et al. 2004)

Cheetahs have developed ways of coexisting alongside lions and hyenas, despite high interspecific competition. Playback experiments conducted in the 1990s, along with detailed spatial analysis, show that cheetahs actively avoid both species by moving away or reducing hunting activity when lions and hyenas are nearby (Durant 1998, 2000*a*, 2000*b*). Furthermore, cheetahs avoid large herds of gazelles, which tend to attract lions and hyenas (Durant 1998). Avoidance translates into real benefits for cheetahs in terms of improved cub survival and hence individual reproductive success (Kelly et al. 1998; Durant 2000*b*) and explains the low density and extensive ranging patterns of cheetahs. Nevertheless, this strategy also results in a dependency on large areas with spatial heterogeneity in prey and predator distributions.

Impacts of People

Humans are likely to have relatively few direct effects on the cheetah population inside SNP. There are few records of adult cheetahs being killed in snares inside the park (Campbell & Hofer 1995), unlike other large carnivores in the ecosystem, probably because they rarely scavenge and therefore are not attracted to snared prey. They are also less likely to be hit by cars than other large carnivores because they use roads less frequently. Nevertheless, cheetahs may be particularly sensitive to the impacts of tourism. Because cheetahs are diurnal hunters, there is greater likelihood that their hunts will be disrupted by insensitive or unaware tourists. Such disruption can have particularly adverse impacts on denning females, whose movements are restricted at this time (Laurenson 1995*a*). Movement restriction and lactation costs place extra demands on mothers, and they abandon their cubs if they are unable to forage effectively (Laurenson 1994).

Outside SNP people are likely to have a greater impact on cheetahs. Their dependence on migratory prey means that individuals can move from the center of SNP to surrounding game reserves and the Ngorongoro Conservation Area within days, and many cheetahs range outside the park for long periods (Maddox 2002). Although the western SNP boundary is densely settled farmland, and thus unsuitable cheetah habitat, the eastern boundaries are inhabited by traditional Maasai pastoralists, whose lifestyle and land-use patterns appear to be largely compatible with that of cheetahs. Nevertheless, there are anecdotal reports of cheetahs being speared, and cheetahs suffer from persecution outside protected areas elsewhere in Africa, particularly in South Africa and Namibia because of perceived losses of game or livestock to cheetahs (Marker et al. 2003).

In the late 1990s the SCP examined the cheetah conservation potential of Maasai areas adjoining SNP in Ngorongoro Conservation Area and Loliondo Game Controlled Area, which harbor substantial populations of large carnivores (Maddox 2002). A problem-weighting analysis (Oppenheim 1992) in a survey of 179 interviewees showed that cheetahs ranked below the other common large carnivores in the ecosystem: lion, leopard, and hyena (Fig. 1a). In addition, of all the large carnivores, respondents said cheetahs posed the least threat to livestock (Fig 1b). Nevertheless, many interviewees confused cheetahs and leopards and the majority of interviewees used the same word in the local language, Maa, for both species. Descriptions of predators breaking into bomas at night, attacking people, and killing cattle suggest that some of the incidents attributed to cheetahs were probably perpetrated by leopards (Maddox 2002). During such an attack, Maasai may only glimpse a fleeing spotted cat, and

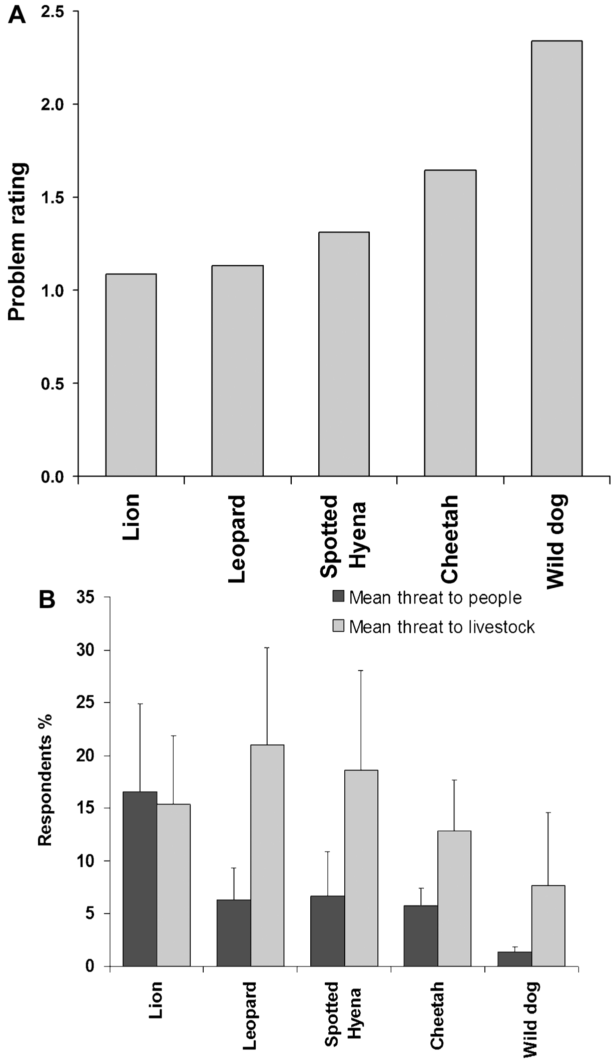

Figure 1. (a) Average Maasai pastoralists' problem rating (perceived problem; Oppenheim 1992) of five carnivore species. A low score indicates a respondent considered the animal a big problem (adapted from Maddox 2002). (b) Perceived threat of large carnivores to people and livestock (adapted from Maddox 2002).

without binoculars and in low visibility, it is not always easy to distinguish the two species. If a diurnal cheetah is seen near the boma the morning following an attack, it is likely to be blamed for it.

Management and Policy

Detailed information on long-term population dynamics is perhaps the most important data for determining appropriate management and policies because it can be used to make predictions. This information can be obtained only through long-term study and includes estimates of mean and variances of demographic parameters. Additional data on key environmental and ecological parameters leads to an understanding of their role in population dynamics, enabling predictions to be made in the face of environmental and ecological change. Detailed analysis of the SCP data demonstrates that cheetah demography is affected by a complex set of interrelated factors (Durant et al. 2004). Rainfall, prey numbers, cheetah and lion numbers, and their interactions all affect recruitment and survival in cheetahs to varying degrees (Durant et al. 2004). For example, recruitment is related to an interaction between lion and cheetah numbers, such that, overall, it is high when lion numbers are low but very low when lion numbers are high (Durant et al. 2004). Male survival, by contrast, is not affected by environmental parameters, but is influenced by coalition size.

The detailed demographic data gathered through the SCP allowed a population viability analysis of the study population, which shows that extinction risk for cheetahs is relatively high due to high levels of environmental stochasticity observed in adult and juvenile survival (Kelly & Durant 2000). High lion numbers increase extinction risk through their effect on cubs, to the extent that if lion numbers remain at the highest level observed during the study, then the cheetah population would go extinct should it become isolated (Fig. 2). This demonstrates the potential impact lion densities can have on the long-term survival of cheetahs, showing that fragmented populations may not be viable in areas that maintain high lion densities (Kelly & Durant 2000). Thus, conservation of cheetahs ultimately relies on their survival across extensive areas of connected habitat with heterogeneous populations of prey and predators. Here the mobility of cheetahs is an advantage because cheetahs from areas with low densities of predators, such as might exist

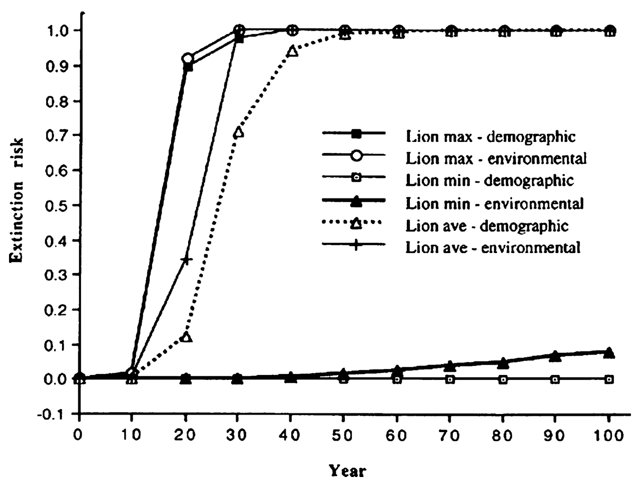

Figure 2. Projected extinction risk under demographic and environmental stochasticity for the studied cheetah population when subjected to varying lion density (low density, 72 adult female lions [the minimum recorded over 20 years]; high density, 120 adult female lions, [maximum recorded]; average lion density, 98) (reproduced from Kelly & Durant 2000).

outside protected areas, can easily recolonize areas with high densities, forming a source/sink network of populations. Where cheetah populations are isolated, as in some smaller protected areas, the potential impact of larger predators may be catastrophic. The SCP data demonstrate that cheetah population size needs to be large (over 300 individuals, including cubs) to ensure long-term demographic viability (Durant 2000*a*). Few protected areas contain populations this large because even in optimum habitat this requires a minimum area of 4000–8000 km^2.

Even where cheetah populations are demographically viable, they are unlikely to be genetically viable in the long term without management intervention because a minimum effective population size of 5000 or more may be needed (Lande 1995). Fragmented populations could be managed as a metapopulation by moving cheetahs artificially between reserves, taking advantage of the fact that cheetahs adopt cubs by unrelated mothers (Caro 1994). Cubs could be translocated to families with cubs of a similar age, enabling them to learn from their new mother how to survive in an ecosystem that may differ from that of their origin. This is particularly useful when cubs face different predator threats—a major cause of failure for reintroductions and translocations of carnivores (Carbyn et al. 1994; Woodroffe et al. 1997).

Capacity Development

Scientific research can only be used to inform conservation practice and policy if there are sufficient trained personnel with the ability to interpret and apply its findings. Tanzania has limited national capacity in wildlife ecology and monitoring. Such capacity urgently needs to be developed further and strengthened if research is to guide conservation management and policy in Tanzania. Consequently, in 2002 S.M.D. established the Tanzania Carnivore Program (TCP) within the Tanzania Wildlife Research Institute (TAWIRI) with funding from the Darwin Initiative. The TCP aimed primarily to develop national capacity for carnivore research across the country and to ensure long-term sustainability of monitoring by establishing an institutional framework for carnivore conservation in the country. The program has a number of data-gathering activities, including a national carnivore atlas project to map the distribution of Tanzania's 35 carnivore species and a camera-trap survey program to address gaps in data coverage and to establish more detailed information in priority areas. Training in all activities for program staff and stakeholders is a fundamental part of the program.

In 2005–2006 the TCP and the Tanzanian wildlife authorities developed a Carnivore Conservation Action Plan for Tanzania, setting out national priorities for research and conservation management. Data from the SCP provided crucial inputs to the cheetah component of the plan. Coincident with these activities, the SCP has expanded into a national program for cheetah conservation, the Tanzania Cheetah Conservation Program, which seeks to address the lack of information on the distribution and status of cheetahs in Tanzania outside the Serengeti ecosystem and to develop a program for their conservation. Both programs support further academic training for nationals, including a master's and doctoral student from senior staff. This form of external training will increase over the coming years now that the Tanzanian Carnivore Program is firmly established.

Impacts on Conservation Policy and Practice

Long-term scientific studies on threatened species should also yield conservation benefits. The SCP is now primarily concerned with activities, including research, which address management needs and/or have broader conservation application. But this work can only have real impact if the management and conservation implications of scientific results are communicated effectively to local and national conservation managers and policy makers and to the broader scientific and conservation community. Existing mechanisms for such dialogue and exchange between different stakeholders operate at different scales, locally, within the park, nationally, and internationally. All levels are important, but each needs to be addressed in different ways.

Local Impacts

Tanzania National Parks (TANAPA) has a policy of nonintervention in natural processes, except under extreme circumstances, such as when a population is in imminent danger of extinction. Moreover, cheetahs are only one component of a very large and diverse ecosystem. This means there are limits to the extent to which the project can or has influenced conservation policy and practice within SNP itself. Informal dialogue between the SCP and park managers is arguably the most effective means of influence at the local level, enabling park managers to make use of adaptive management strategies (Salafsky et al. 2002), and the SCP has maintained good relations with Serengeti National Park staff, TANAPA, and TAWIRI to facilitate this process.

The SCP's main local influence on conservation practice is in tourism management in SNP. Cheetahs are important species in the ecosystem and for tourism, as is recognized by park managers (TANAPA 2006), but insensitive tourism can adversely affect cheetahs. The SCP has produced leaflets and posters on cheetah-friendly viewing practices for tourists and guides, which are distributed at park gates and lodges. The SCP also advises park management on cheetah-friendly guidelines for tourists, including restricting access to areas where cheetahs are particularly vulnerable. Such restrictions have included limiting off-road driving in important denning areas and closing access to artificial sandpit areas formed to meet construction needs, where a dense network of roads enable cheetahs to be surrounded by tourists. The SCP, and increasingly the TCP, also frequently give talks to tour groups and presentations and annual reports to wildlife authorities.

The importance of population monitoring is also recognized by park managers and is key to assessing impacts of management, but a monitoring plan that is sustainable needs techniques that are easier to use and that can be done more quickly than those used by the SCP. A protocol developed by the SCP for a carnivore survey provides a means of meeting this objective. This survey was initiated in 2002, was modeled on two earlier surveys in 1977 and 1986 (Hofer & East 1995), and made use of subsequent developments in distance-based transect methods (Buckland et al. 1993). Each survey is conducted over 3 days and relies on the support and participation of volunteers from the scientific, conservation, and park-management communities. The surveys provide reasonable density estimates for lions, spotted hyenas, golden jackals (*Canis aureus*), cheetahs, silver-backed jackals (*C. mesomelas*), and bat-eared foxes (*Otocyon megalotis*) (S.M.D. et al., unpublished data). The method is relatively inexpensive and provides a feasible means of regular monitoring for the most commonly seen carnivores in the ecosystem and hence has potential for acceptance into TANAPA's long-term monitoring plan.

National Impacts

A key implication of the research by the SCP is that the protected-area system is unlikely to be sufficient for the long-term conservation of cheetahs throughout their range. Cheetahs live at low density, and thus populations in smaller protected areas may not be viable. Ensuring the survival of cheetahs outside protected areas is therefore crucial for their conservation. Even in the SNP the long-term survival of cheetahs may rely on viable populations persisting in the areas bordering the park, particularly in pastoralist areas with good populations of prey but low populations of other large carnivores (Kelly & Durant 2000). Investigating options for maintaining corridors between smaller protected areas and habitat patches and supporting cheetah populations in buffer zones are matters of increasing urgency. Fortunately, the SCP has found that conflict between humans and cheetahs is currently relatively low (Maddox 2002). The confusion between cheetahs and leopards suggests that an awareness program to differentiate the two species might help reduce inappropriate retaliatory killing of cheetah when livestock have been predated.

Translating local research into national conservation action has been hampered historically by the lack of a national framework or action plan for cheetah conservation in Tanzania and a lack of information about cheetahs outside the Serengeti. A high priority is to refine techniques with which to survey cheetahs and initiate new surveys in key representative habitats in Tanzania. Without good information on where cheetahs are and which areas are important for conservation, it is impossible to plan cheetah conservation at a national level. These information gaps are now being targeted by the Tanzania Cheetah Conservation Program (Dickman 2005).

The TCP has an important role to play in increasing national conservation impact. The TCP provides a national institutional framework within a government wildlife authority, TAWIRI, through which cheetah conservation activities can be maintained sustainably in the long term. The program has developed capacity for monitoring and surveying carnivores across the country and established a substantial database on sighting and distribution information for cheetah. It has also produced a draft Cheetah Conservation Action Plan, which, after endorsement by the wildlife authorities, will provide a national framework for cheetah research and conservation.

International Impacts

The SCP has been the single largest contributor to an expanding body of published scientific knowledge about cheetahs and thus has contributed to an improved understanding of their conservation requirements in the wild. It has provided baseline data and methodologies that underpin much of the work done on cheetahs elsewhere. Internationally, the SCP works with the Global Cheetah Forum (GCF) to apply SCP findings to broader cheetah conservation issues and to initiate new research to address key conservation issues. The GCF produced a Global Cheetah Action Plan in 2000 and a review of this plan in 2001 (Berry et al. 2001; Crosier et al. 2002), and the SCP actively addresses the priorities of this plan. These priorities included testing new methods of surveying, monitoring cheetahs in the SNP, organization of a cheetah-monitoring workshop in the Serengeti in 2004 to review and standardize existing monitoring techniques for cheetahs, prioritizing areas for surveys, and production of a monitoring manual.

The SCP data suggest that possible relatively low levels of genetic diversity in cheetahs has had no measurable impact on wild populations (Caro & Laurenson 1994), despite a series of articles in the 1980s that suggested that low diversity posed serious problems for the species (O'Brien et al. 1983, 1985, 1986). In these articles the authors cite evidence, mainly from captives, that cheetahs have difficulties breeding and are susceptible to disease. These articles have been the subjects of much controversy, and some of the results have been disputed (Caughley 1994; Merola 1994). Nevertheless, results from the Serengeti study show that cheetahs in the wild do not have breeding problems and show no signs of deleterious impacts of low genetic diversity (Caro & Laurenson 1994). Furthermore, disease has not had a serious impact on the population, despite a canine distemper epidemic that swept through the ecosystem in 1994 (Roelke-Parker et al. 1996). These findings illustrate the risk of drawing general conclusions based on observations of captive animals and demonstrate the value of long-term studies of animals in the wild.

The SCP data originate from a single area that could be considered atypical. Nevertheless, accumulating information suggests that the behavior of cheetahs in other areas is not that much different from that in the Serengeti. Male coalitions have been observed in farmland in Namibia and in Kruger National Park (Broomhall et al. 2003; Marker et al. 2003). There also appears to be a pattern of smaller male and larger female home ranges in Namibia, although the differences are less pronounced than in the Serengeti (Marker 2002). In the Namibian study a lack of direct observation of males on the ground makes it impossible to confirm whether any males in the study were territorial. In Kruger, which is largely woodland habitat, male territories appear to be larger than that observed by the SCP (Broomhall et al.), which agrees with a pattern observed in the woodlands in northern Serengeti (S.M.D., unpublished data). A single female and a coalition of three males were observed directly in the Kruger study, which demonstrated that the males were territorial, whereas the female was not.

Finally, there are less-tangible conservation benefits arising from a long-term project, which are difficult to quantify yet undeniably have major impacts, possibly even more than the benefits discussed earlier. In particular, the scientific publications, popular articles, and wildlife films generated through the study have undoubtedly increased public awareness about the plight of cheetahs and the Serengeti ecosystem. This has led to greater public understanding and interest in cheetahs and the ecosystems they inhabit and in conservation issues in general—factors that are also directly linked to availability of funding for conservation.

Improving Long-Term Projects' Impacts on Conservation

Long-term studies generate a wealth of information relevant to conservation. Nevertheless, without frameworks for conservation management and policy at a local, national, and international level, this information will not often translate into changes in conservation management and policy. Such frameworks can formalize the links between research and management and serve the dual purpose of ensuring that managers and policy makers are aware of key scientific findings and that researchers are aware of the information needs of managers and policy makers. There are a number of mechanisms by which this can be achieved. In the case of cheetahs an international framework exists in the form of the Global Cheetah Conservation Action Plan formulated by the GCF (Berry et al. 2001; Crosier et al. 2002). National frameworks include the Tanzania Carnivore Conservation Action Plan for 2006, and TANAPA has an overall strategic plan and is in the process of finalizing a plan for each park's ecology department that lays out monitoring priorities. Locally, within the Serengeti, the general management plan for the park (TANAPA 2006) may also provide a suitable framework. It is important that any such frameworks engage managers, policy makers, researchers, and other key stakeholders.

Nevertheless, although strategies and action plans are important, their effectiveness depends on active engagement of all stakeholders. This can be achieved in several ways. For example, at a local level within a protected area, regular meetings and fora can be organized to ensure that researchers and managers meet and exchange views and information. At a national level workshops and meetings can be initiated to encourage transfer of information. In Tanzania the annual TAWIRI scientific conferences provide a useful mechanism for conveying recent research results to international and national scientists. At present, however, within Tanzania there is no national meeting that brings together researchers and managers. With the spread of satellite links in remote areas, email and Internet offer potential for improving communication, and list servers provide a useful means of disseminating information, provided this can be done in a concise and accessible format.

Conservation in developing countries is hampered by a lack of capacity among both researchers and managers. Institutions need to be able to interpret and apply scientific information appropriately and have the capacity to prepare and implement long-term monitoring plans. Conservation operates most effectively when conservation professionals in developing countries are trained to the highest standards available, enabling them to better engage with international scientific and conservation organizations from a position of strength, thereby allowing greater control over national conservation agendas. Nevertheless, institutions that offer training in relevant disciplines such as conservation biology and wildlife management to international standards within developing countries are limited. In Tanzania both TANAPA and TAWIRI are actively trying to increase national capacity by making degree qualifications a prerequisite for senior promotions. Nevertheless, funding for such capacity development remains an issue, particularly for overseas training opportunities, which can provide a wide range of skills, including invaluable exposure to the international scientific and management community. Funding for longer-term training is particularly problematic because many of the internationally renowned universities charge prohibitive fees for overseas students from developing countries. Long-term field studies in developing countries that have established links to internationally recognized research institutions potentially provide an alternative beneficial environment in which nationals can conduct research toward higher degrees because they offer a framework for study and mentorship from an academic supervisor linked to the project, providing high-quality training to international standards.

Ultimately, however, the integration of science and management in conservation is a two-way process that requires concerted efforts by both sides to improve mechanisms of information exchange, consultation, and dialogue. Scientists publish their findings in scientific journals, but these are often inaccessible to park managers or difficult for nonscientists to understand. Furthermore, there is often a substantial lag time between when results are known to their appearance in print. Managers are busy people and require information in a distilled and accessible form. If scientists wish to provide inputs into conservation management, policy, and practice, they need to understand and take into account management needs, priorities, and constraints. In developing countries scientific research is often driven by expatriate scientists because these countries have little resources for funding science themselves. Maintaining a commitment to a particular area over many years, such as by managing a long-term research project, is an important means of developing mutual trust and respect between such scientists and protected-area managers, particularly when accompanied by an equally strong commitment toward national capacity development.

Long-term studies are uniquely placed to establish effective working relationships between scientists and managers, engage with local and national institutions, and increase national capacity for biodiversity conservation. Scientists leading long-term projects in developing countries, if they are not already doing so, should consider what they can do to increase the impact of their projects. Funding organizations, universities, and research institutions should seek to facilitate this by maximizing opportunities for generating conservation benefits as well as scientific advancement because without greater concerted efforts to stem biodiversity loss and improve its management, we risk losing much of the basis for future ecological research. Scientists working together with managers to address these issues can help develop lasting national capacity for better biodiversity conservation management.

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