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Conserving and studying tortoises: A local community visual-tracking or radio-tracking approach?

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Abstract

A management concern for any endangered species is how to allocate limited resources for the most conservation benefit. Ideally, management decisions should be based upon scientific experiments that compare different methods. We therefore compared activity range and center estimates of the endangered Egyptian tortoise, *Testudo kleinmanni*, from data gathered by local people visually tracking tortoises and through the use of radio-tracking. Our results showed that although radio-tracking requires less effort, visually tracking tortoises can provide similar activity range (minimum convex polygon (MCP) and 95% kernel density (KD)) and activity center estimates (50% KD). Our study shows that conservation programs, with limited budgets, should hire local people to achieve both direct conservation action and carry out scientific studies to protect an endangered species. In addition, hiring local people increases conservation awareness in the greater community, is a source of pride because indigenous knowledge and skills are recognized, and provides financial opportunities to protect wildlife in an area in which the few economic opportunities often involve harvesting wildlife.

Keywords: Activity center; Activity range; Indigenous people; *Testudo kleinmanni*

1. Introduction

A concern for the management of any endangered species is how to allocate limited resources to achieve the most conservation benefit (Franco et al., 2007). There are often a wide range of techniques available for conservation biologists to address a particular threat or answer a needed question. Ideally, management decisions should be based upon scientific experiments that demonstrate the effectiveness of techniques from a conservation and financial perspective (Almeida and Mendes, 2007; Franco et al., 2007; Pullin and Knight, 2001; Pullin et al., 2004). The ramifications of this challenge are enormous as many conservation projects

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operate on just a few thousand dollars with little provision for erroneous financial or management decisions. Resources can be used for an academic/science-based approach that involves studying aspects of the species ecology or population dynamics. This approach is useful because management decisions are more likely to be successful if based on scientific information (Pullin et al., 2004). In addition, formal studies allow the effectiveness of management strategies to be tested (Franco et al., 2007). Another method would be a more local community approach. The hiring of local people provides economic support, increases conservation awareness, recognizes the value of indigenous knowledge and skills, and serves as a deterrent to wildlife collectors (Berkes, 2004; Berkes et al., 2000; Grainger, 2003; Townsend et al., 2005). The benefit of this approach is that it addresses a direct threat to the species.

Radio-tracking is often used to locate and study hard to observe wildlife because the individuals are almost always located and relocations are less biased than surveys, which is dependent upon habitat, time, season, the animal's behavior, and observer skill (Franco et al., 2007; Kernohan et al., 2001). Radio-tracking is especially useful in estimating activity ranges and centers. Estimates of activity ranges can have important conservation implications as these values represent the minimum area used by an individual or group of individuals. In addition, activity center estimates identify areas of high use that could be protected or undergo habitat restoration efforts. However, the use of radio-tracking is often too expensive for most conservation projects (Franco et al., 2007). For example, an initial cost of approximately US $2000 would be needed to estimate the activity range and center for five animals as the receivers can cost US $1000, with each transmitter costing roughly $200. Although such equipment costs can decrease over time as transmitters can often be refurbished for 1/4–1/3 of their initial price. In contrast, more conservation value may be achieved and similar scientific information obtained using resources to hire local people to patrol and collect data on wildlife. Unlike radio-tracking, having local people visually track wildlife is not dependent upon expensive equipment, but instead relies upon the participation and employment of people from the local community.

We are continually faced with the question of how to allocate limited resources in our efforts to protect the Egyptian tortoise *Testudo kleinmanni*. The Egyptian tortoise is one of the smallest, most endangered, among the least studied, and has the most restricted range of all tortoises in the Mediterranean basin (Attum et al., 2007b; Baha El Din et al., 2003). In Egypt, much of the Mediterranean coast has been altered through urban development and large-scale agriculture with suitable habitat now existing only in a few protected areas which are also inhabited by local communities (Baha El Din et al., 2003). We have taken a local community approach to Egyptian tortoise conservation by employing members from the local community to patrol for wildlife collectors and record data on behavior, habitat use, and location of tortoises encountered (Attum et al., 2007a). We therefore wanted to compare the activity center and range estimates of the Egyptian tortoise from data collected by a local community tracker visually tracking tortoises and through the use of radio-tracking.

2. Material and methods

This study took place in Zaranik Protected Area (ZPA) in North Sinai, Egypt. ZPA is located 30 km west of the town El Arish (N31°05′, E33°25′), occupies 250 km^2, has an altitude range (0–30 m), is characterized by stable and unstable sand dunes, and receives 50–100 mm rainfall per year. The vegetation community of our study site is dominated by *Artemisia monosperma*. Approximately 1400 people, mostly of the Sweirki Bedouin tribe, live within ZPA. There are limited employment opportunities for the Bedouins residing in ZPA, with most of their income derived from livestock and small-scale seasonal agriculture of fruits, such as dates and watermelon. The ability to track animals is a widespread skill in the local community, as even children can regularly locate tortoises from their tracks.

We compared the two monitoring techniques by locating five tortoises, four ♀ and one ♂, equipped with R1-2C transmitters (6.6 g, Holohil Systems Ltd.) between February 2005 and May 2006. The first treatment and monitoring technique, radio-tracking, was considered the control and consisted of locating each tortoise, 4 days a month, approximately once a week. The second treatment and monitoring technique, 10 days visual-tracking, consisted of a local community member locating each tortoise by tracking 10 days a month, approximately every 3 days. The tracker was already familiar with the tortoises' movements as he has been monitoring the tortoises the past several years as part of a conservation project to protect the tortoises from wildlife collectors and collect natural history data (Attum et al., 2007a). In order to overcome any problems with illiteracy, a special data sheet was created using symbols and numbers (Attum et al., 2007a). The third treatment, 4 days tracking, consisted of randomly selecting the equal number of sampling days as the radio-tracking treatment from the 10 days visual-tracking data. Tortoise relocations by radio-tracking and visual-tracking did not occur on the same day. For each tortoise location, longitude and latitude coordinates were recorded using a GPS unit. Search effort duration using radio-tracking was 2–3 h and approximately 3–4 h for visual-tracking. The transmitters weighed less than the recommended 4–6% of body weight (Cochran, 1980). Carapace lengths and mass of the four females ranged from 92 to 105 mm and 190 to 237 g, and the one male (89 mm, 160 g).

Despite disagreement on the most appropriate activity estimators to use, we chose to calculate activity ranges and center using minimum convex polygon (MCP), 95% kernel density (KD), and 50% KD, because these measurements are widely reported in the literature and allow species comparisons (Powell, 2000). The MCP approximates the minimum area containing all relocation points and was calculated using the convex hulls extension (Jenness, 2004). KD calculates the probabilities of an animal occurring in a given area (Powell, 2000). The 95% KD represents an activity range, while 50% KD is considered an estimate of activity center (Powell, 2000). KDs were calculated using the animal movement extension and the least-squares cross-validation to smooth the kernel contours (Hooge and Eichenlaub, 1997). We used Arc View 3.2 GIS software to calculate all activity measurements. We tested if treatment effected activity range size by separate ANOVAs and used post-hoc multiple analysis to test differences between treatments. All data were log transformed prior to analysis. We corrected *P*-values for the multiple tests by using the sequential Dunn–Sidak method and considered tests to be significant if the *P*-value was less than the new adjusted *P*-value (α_{adj}) (Quinn and Keough, 2002).

3. Results

The tortoises were least active or not active as they aestivated from July to the first week in October. We therefore removed relocations in which the animal did not move from the previous relocations. Also, the transmitter from one tortoise was stolen approximately in the middle of October. Therefore, the activity ranges and centers of this tortoise were estimated based on relocations until the transmitter was removed.

The overall mean activity ranges and centers were largest for the radio-tracking treatment, followed closely by 10 days visual-tracking, and then the 4 days visual-tracking treatment (Table 1). Although the mean activity ranges and center estimates were the largest using radio-tracking, a couple of tortoises had larger activity ranges and centers estimated from the 10 days visual-tracking treatment. Although the MCP activity ranges were significantly different between methods ($F_{2,12} = 8.66$, $P = 0.005 < \alpha_{adj}$ 0.0167), there was no significant difference between the MCP activity ranges of radio-tracking and the 10 days visual-tracking treatment ($P = 0.99$). However, both radio-tracking ($P = 0.009$) and 10 days visual-tracking ($P = 0.014$) produced significantly larger MCPs than the 4 days visual-tracking treatment. Similar to the MCP analysis, there was a significant difference of 95% KD estimates between methods ($F_{2,12} = 5.68$, $P = 0.018 < \alpha_{adj}$ 0.025). There was no significant difference between the radio-tracking and the 10 days visual-tracking treatment in their estimate of 95% KD ($P = 0.99$), with both radio-tracking ($P = 0.035$) and 10 days visual-tracking

Table 1
Egyptian tortoise mean ± S.E. activity ranges and center estimates through the use of radio-tracking and visual-tracking

Measurement	Radio-tracking	10d visual-tracking	4d visual-tracking
MCP	18.42 ± 4.54	17.18 ± 4.36	3.80 ± 1.03
KD95	18.07 ± 3.41	17.63 ± 3.31	7.80 ± 1.37
KD50	3.09 ± 0.91	2.52 ± 0.65	1.41 ± 0.31
Relocations	41.8 ± 4.2	28.2 ± 1.9	13.6 ± 0.8

All estimates are in hectares (ha). MCP, minimum convex polygon; KD95, 95% kernel density; KD50, 50% kernel density; radio-tracking, radio-tracking treatment; 4d visual-tracking, visually-tracking tortoises 4 days a month; 10d visual-tracking, visually tracking tortoises 10 days a month; relocations, the number of tortoise relocations. Sample size $N = 5$.

($P = 0.042$) being significantly larger than 4 days visual-tracking treatment. Despite the 50% KD of the radio-tracking and the 10 days visual-tracking treatment being larger than the 4 days visual-tracking treatment, there was no significant difference between any of the methods ($F_{2,12} = 1.74$, $P = 0.22$). The number of relocations were also significantly different between treatments ($F_{2,12} = 41.45$, $P < 0.0001 < \alpha_{adj}$ 0.0125), with all methods being significantly different from one another ($P < 0.03$; Table 1).

4. Discussion

Our study suggests that the two monitoring techniques of radio-tracking and having local people visually track tortoises provide similar activity range and center estimates, despite radio-tracking providing more tortoise relocations and requiring less sampling effort (4 days/month for radio-tracking and 10 days/month for visual-tracking). These two monitoring techniques provide similar results because activity range estimates often plateau after a certain number of relocation points (Kernohan et al., 2001). This is supported by a past study that found MCP estimates of the Egyptian tortoise start to plateau after approximately 20–25 relocation points (Geffen and Mendelssohn, 1988).

From a conservation perspective, it is therefore more beneficial for conservation programs to employ local people to visually track tortoises rather than purchase more efficient and expensive research equipment. These different research methods have inherently different qualities that have conservation implications. Radio-tracking is more equipment dependent and the data can be collected from someone outside the community, whereas visual-tracking is entirely dependent upon the participation of the local community. Hiring local people provides financial opportunities to protect wildlife, in an area in which the few economic opportunities often involve harvesting wildlife. In addition, hiring local people increases conservation awareness in the greater community and is a source of pride because indigenous knowledge and skills are recognized and valued (Attum et al., 2007a).

Having local people track tortoises also provides numerous research and conservation benefits. For example, when using radio-tracking, the investigator locates the animal by a signal that indicates the approximate distance to the animal and then traverses the most direct path to the animal. However, when visually tracking, the investigator follows the tortoise's movement path and is able to potentially collect important natural history data that are more likely to be missed by only directly approaching the animal. For example, courtship, breeding and predation locations and attempts can be determined by following tracks. Insight into the tortoise's diet can also be gained by following the tracks, as it is possible to determine which plants the animal visited to eat.

Visually tracking tortoises 10 days a month also provide direct conservation action by serving as patrols for wildlife collectors and the development of relationships with people inhabiting the area. This proved to be especially valuable when two tortoises were collected with their transmitters in November 2005. The tracker was able to follow the tracks of the collectors, children, for several kilometers until he reached the collector's residence. The tracker knew the collector's father and was able to retrieve the tortoises and transmitters. The children collected the tortoises because they were curious about the transmitters. This experience demonstrates how equipment used to study or mark animals can also attract unwanted attention that places the animal at risk.

Our data suggest that visually tracking tortoises 4 days a month would not provide reliable estimates of activity ranges and centers. Trackers were able to locate tortoises approximately 35% $\pm$ S.E. 6 of the time and when following an infrequent tracking schedule of 4 days a month, the sample size of relocations was too small compared to the other treatments. However, this low relocation rate underestimates the ability of the tracker as he was often able to determine the presence of the tortoise in a general area, but not the exact location due to a variety of factors that affected the tortoise track visibility. For example, wind or rain can remove tracks from the surface. Searching for tortoises during mid-day or on cloudy days can reduce track conspicuousness due to lack of shadows. Livestock also trample the tracks, making it difficult to follow tortoise movement. Furthermore, infrequent visual-tracking is more likely to miss outlier locations, such as exploratory movements outside the general core area. This may explain why the 4-day visual-tracking estimates of MCP, which are derived from outermost location points and 95% KD, were significantly smaller than estimates from radio-tracking or visual-tracking tortoises 10 days a month. In addition, the tracker also had other responsibilities such as finding other tortoises, which could have reduced the amount of time devoted to finding the selected tortoises. Perhaps if the tracker was only responsible for only the five tortoises in this study, relocation rate could have been higher.

Radio-tracking can also suffer from potential bias, especially from small sample sizes such as in this study. For example, it is often recommended that at a minimum of 25 animals be used in radio-tracking studies because data obtained using a smaller sample size may not be representative of the larger population (Otis and White, 1999). The large sample size recommended for activity range studies is often not obtainable when working with rare species. In addition, purchasing 25 transmitters to use for radio-tracking is often financially out of reach for many conservation agencies or projects with small budgets.

We are able to use a local community approach to the conservation and study of the Egyptian tortoise for several reasons. First the animals have relatively small activity ranges and centers, which make it easier to locate animals on foot. Unlike other *Testudo* species, the Egyptian tortoise has conspicuous tracks and occurs on a sandy substrate which is conducive to visual-tracking (Lagarde et al., 2003). The area is also inhabited by local people with detailed knowledge of the area and a long visual-tracking tradition. The strong intercommunity bonds between people were also helpful as livestock herders often notified the tracker when they observed a tortoise or strangers in the study site.

Our study shows that conservation programs should hire local people to achieve both direct conservation action and carry out scientific studies to protect an endangered species (Almeida and Mendes, 2007; Townsend et al., 2005). We advocate increasing the hiring of local people as research technicians in conservation projects as opposed to manual laborers, porters, or security guards. This approach can both address direct threats to the species and allow scientific data to be collected and analyzed for the creation of sound management decisions.

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