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Validating methods to determine walking rates of elephants within a zoological institution

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Abstract

*Much controversy surrounds the welfare of elephants within zoological institutions. Among the many concerns are lack of exercise and the prevention of sedentary health and welfare issues due to smaller exhibits in comparison to the home-range sizes for elephants in Africa and Asia. While many scientists have used GPS to examine distances travelled by wild elephants, there is currently little information on distance travelled by elephants within zoological institutions. In the wild, it is necessary to chemically immobilise elephants using a dart gun in order to put on or take off collars which are used to acquire GPS data. Within a zoological institution, elephants can be trained to wear a collar with a GPS device but this training can be time consuming and also dangerous depending on the level of expertise of animal care staff. However, training an elephant within a zoological institution to wear an anklet outfitted with a GPS device can be much safer and less time consuming. The purpose of the current research was to validate methods for examining the walking rates of elephants in a zoological facility. This included testing GPS units, examining walking rates of eight elephants at the San Diego Zoo Safari Park using collars and conducting trials on a subset of elephants wearing both a collar and anklet outfitted with GPS devices to determine reliability. The average distance travelled by eight African elephants (*Loxodonta africana*) within a 24-h period was 8.65 (± 0.64) km which corresponds to a rate of 0.360 (± 0.033) kph. Trials comparing anklets to collars were found to be highly reliable except on days when weather conditions were overcast or there was rainfall at the park. The methods used for the current study can be utilised in future studies to examine walking rates as a component of animal welfare for elephants or other large mammals within zoological institutions.*

Keywords: *activity levels, African elephant, animal management, animal welfare,* Loxodonta africana*, zoological institution*

Introduction

Controversy surrounding the welfare of elephants within zoological institutions has increased in recent years. One concern for zoo biologists is whether or not elephants are active enough to prevent sedentary-related health and welfare issues within zoological institutions. It has been suggested that compromised survivorship in zoo elephants is related to either stress or obesity (Clubb *et al* 2009). Both factors have been found to decrease the lifespan of humans through a variety of diseases such as coronary heart disease (eg Eckel & Krauss 1998; Kubzansky & Kawachi 2000) and could be a concern for elephants within zoological institutions. Increased activity may be beneficial to zoo elephants, but is yet to be fully explored.

In the wild, research has shown that daily movements by elephants vary considerably based on many factors, such as distribution of resources and season (Sukumar 2003). In addition, many different methodologies have been utilised to examine distances travelled by wild elephants which make it important to take into account the situations under which distances are measured and the methods used to calculate those distances. Methods which utilise the recording of only one GPS location per day would under-represent the actual distance travelled while utilising focal follows of elephants might be inaccurate leading to over- or under-representation of actual distances travelled. Within zoological institutions, resources are plentiful, so the main factors to consider are seasonal/daily patterns, exhibit size, and the methods and technology to record accurate distances.

Within zoological institutions there has only been one study that examined walking distances of African elephants (*Loxodonta africana*). Leighty *et al* (2009) found that seven female African elephants moved at an average rate of 0.409 kph during daytime hours. This rate translated to an average of 3.68 km travelled between 0800 and 1700h. Night-time walking rates were not addressed during this study as elephants were only exhibited outdoors during daytime hours. Clearly, more information is needed on elephants within zoological institutions to determine if distances travelled within these institutions are meeting the activity requirements for elephants in these facilities. The purpose of the current research was to validate methods that allow for the examination of walking rates of elephants in a zoological facility. This included validating the use of anklets with GPS devices as a potentially safer and less time-consuming method for examining walking rates of elephants.

Table 1 Study subjects for examining walking rates in African elephants.

Subject	Sex	Date of birth	Focal animal	Sire	Dam	Height (cm)	Weight (kg)
E01	M	1/1/1990*	Y	Unk	Unk	274	4,548
E02	F	1/1/1990*	Y	Unk	Unk	259	3,090
E03	F	1/1/1990*	Y	Unk	Unk	249	2,978
E04	F	1/1/1990*	Y	Unk	Unk	237	2,870
E05	F	1/1/1990*	Y	Unk	Unk	245	2,676
E06	F	1/1/1990*	Y	Unk	Unk	249	2,978
E07	F	1/1/1991*	Y	Unk	Unk	220	2,250
E08	M	2/23/2004	Y	E01	E03	217	1,922
E09	F	9/11/2006		E01	E05	N/A	964
E10	F	3/11/2007		E01	E04	N/A	978
E11	M	9/19/2007		E01	E06	N/A	776
E12	M	3/13/2009		E01	E05	N/A	334

N/A: Not available; * Date of birth is an estimate for wild-caught animals rescued from a scheduled cull in Swaziland in 2003.

Figure 1

Female African elephant wearing GPS collar.

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Figure 2

Female African elephant wearing GPS anklet.

Materials and methods

Subjects and exhibits

At the time of the study, the herd of African elephants at the San Diego Zoo Safari Park (Escondido, CA, USA) was comprised of one adult male, six adult females, and their offspring (Table 1). The elephants were exhibited in an approximately 13,000 m^2 main exhibit with two additional indoor barn facilities. During the course of the study, animals were exhibited in the main yard except during husbandry training or cleaning of the main exhibit. The elephants were also given access to indoor holding areas during the winter months. Andrews *et al* (2004) provides a complete description of husbandry procedures and exhibit details.

Design and procedure

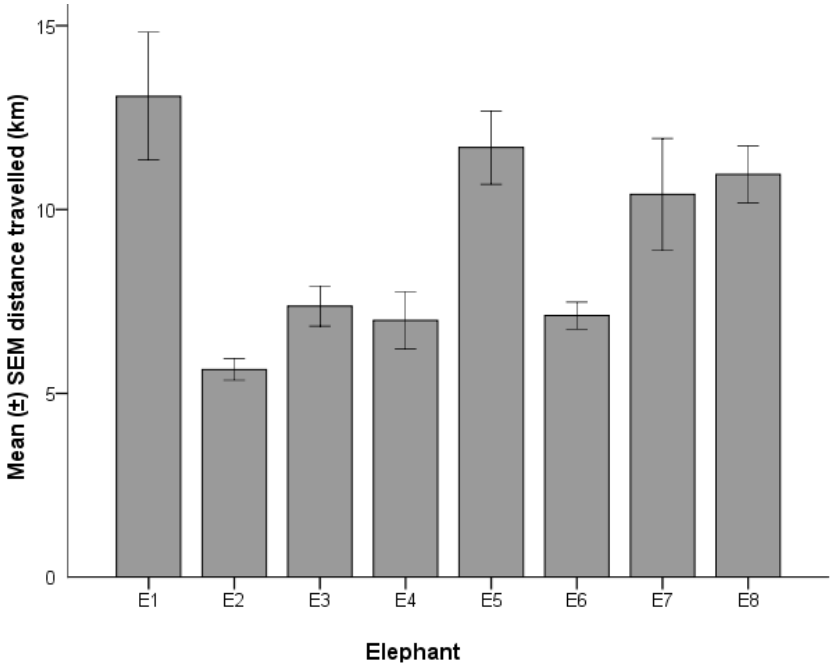
Prior to data collection, the elephants were conditioned for several months to allow leather collars to be placed and removed for GPS data collection. The animals were trained to position their bodies parallel to a protective barrier where keepers could safely reach through the barrier to place collars over the animals' necks and then secure the collars underneath. This training relied upon the use of positive reinforcement, as a function of operant conditioning, to slowly approximate the animals over many months to accept and wear the collars. The animals were then systematically desensitised to wearing the collars for longer periods of time and in various social situations until they were apparently accustomed to wearing them for multiple days at a time (Figure 1). Similar methods were utilised for anklets (Figure 2), however the training procedures took much less time, typically under a month.

Data were collected using only collars between November 2009 and February 2010. This included one 24-h (1200–1159h) trial per week for a total of ten trials. Data collection using a subset of elephants to validate the use of anklets was conducted between February 2011 and June 2011. During the second set of trials both anklets and collars with GPS devices were used simultaneously during five separate 24-h (1200–1159h) trials. GPS locations were collected every 5 s using Qstarz BT-Q1000X (Taipei, Taiwan) data recorders. Units were reported by the company to be accurate within 2.5 m. However, due to concerns surrounding precision, trials were conducted before the study to determine the accuracy of the GPS units similar to previous research (Rothwell *et al* 2011). Testing included measuring short distances (1-m intervals) with the units and determining horizontal shifting between points for a stationary unit which could lead to an increase in distances recorded for animals that were in fact stationary. For example, a large spread in data points for a stationary object could increase the reported distances travelled even for animals that were standing still or sleeping.

Data analysis

All data were examined for horizontal position accuracy (HDOP) and the number of satellites in view. Any data points where the HDOP value was greater than 2.00 or there were less than six satellites in view were excluded from the dataset due to potential inaccuracy. The resulting dataset were used to examine walking rates and total distances travelled by day and hour. The resulting dataset were used to create descriptive statistics representative of the subjects walking rates throughout the study. Reliability of anklets compared to collars were examined using Pearson's product moment correlation coefficient. Alpha levels were set at $P < 0.05$ for all statistical tests.

Figure 3



Average daily distance walked for eight African elephants within a zoological facility.

Table 2 Comparison of walking rate data collected from African elephants wearing both collars and anklets.

Trial	Date	Weather condition	Focal	Correlation
1	2/17/2011	Rain	E1	0.479*
2	2/22/2011	Clear	E5	0.969**
3	3/1/2011	Clear	E1	0.946**
4	5/25/2011	Clear	E5	0.975**
5	6/13/2011	Fog/overcast	E2	0.402

* $P < 0.05$; ** $P < 0.01$.

Results

GPS accuracy

Overall, the GPS units were more accurate than anticipated based on reported accuracy by the manufacturers. Measurements of 1-m intervals with the units resulted in accuracies of 0.8405 (± 0.0635) m (n = 20). In addition, leaving a GPS unit collecting data every 5 s in the same location over 24 h resulted in horizontal shifting of 0.0087 (± 0.0002) m (n = 17,210; range 0.000–0.4657 m). From this trial, 91.20% (n = 15,696) of the data points registered a 0.0000-m change from the previous location indicating high levels of precision.

Elephant walking rates

Throughout the study, a total of 240 h of GPS data locations were collected for each of the eight subjects using collars. After removing locations that were considered inaccurate based on HDOP and number of satellites visible, the final dataset included 1,324,633 GPS locations which represented 97.01% of the total data points collected. The average daily distance travelled by each of the elephants ranged from 5.51 (± 0.28) to 11.44 (± 1.04) km (Figure 3). The average daily distance for all elephants was 8.65 (± 0.64) km which corresponds to a rate of 0.360 (± 0.033) kph. During the daytime hours (0800 to 1600h) the average rate increases to 0.537 (± 0.0513) kph.

During the trials which utilised both collars and anklets containing GPS devices, a high level of correlation was found for hourly distance travelled (Table 2). Differences between collar and anklet GPS units were minimal except during days when weather conditions consisted of overcast days or rain. An example of the relationship between collar and anklet data from Trial 2 can be seen in Figure 4.

Discussion

Results from the current study suggest that both collars and anklets outfitted with GPS devices similar to those used in the current study can be used to accurately assess walking rates for elephants in a zoological institution. It is recommended that institutions with limited training experience or those exhibiting aggressive animals should utilise anklets

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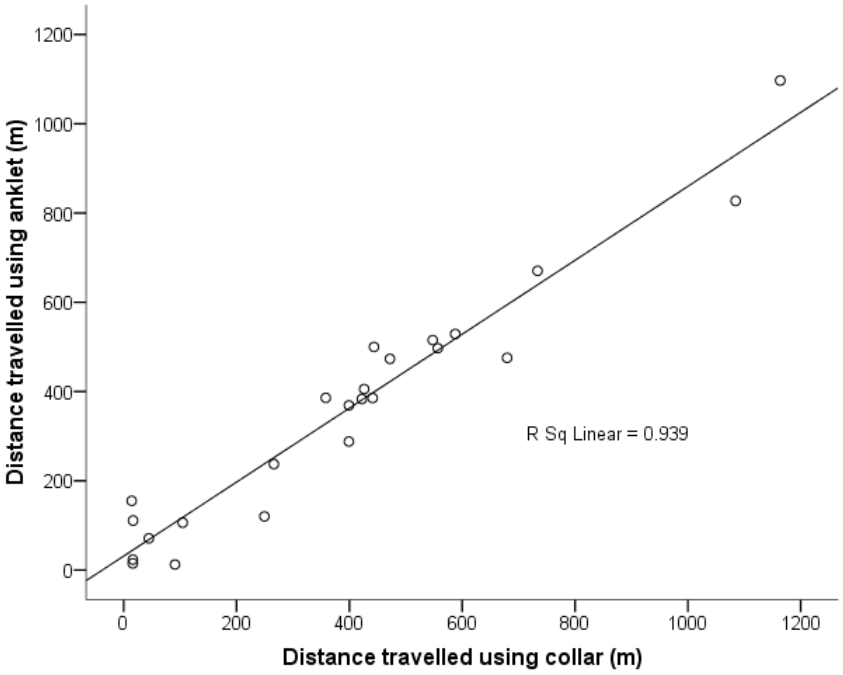
Figure 4



Relationship between measurements from collar and anklet for anklet trial number two.

with GPS instead of collars to ensure the safety of animal care staff. The data gathered using these devices can help answer questions surrounding the amount of exercise elephants within zoological institutions receive to ensure the highest levels of care for animals at these facilities. However, based on the current results, it is recommended that similar research only be conducted on days with limited cloud cover to ensure the accuracy of the instruments utilised to gather the data.

Leighty *et al* (2009) found that elephants exhibited at a different zoological institution walked at a rate of 0.409 kph between 0800 and 1600h. This was slightly lower than the current observed rate of 0.537 kph over this same time period. Over a 24-h period, the average rate for the elephants in the current study was lower than that observed by Leighty *et al* (2009) due to lower activity levels during the evening. The elephants at the San Diego Zoo Safari Park walked an average of 8.65 km over a 24-h period. Differences between the two studies could be attributed to methodological differences, differences in the animals, and/or differences in the management styles or facilities. With the methods utilised in the current study, future research should continue to explore these different variables and their effects on activity levels of elephants within a zoological institution to ensure the highest quality of care.

It is important to note that using collars on elephants may result in an overall increase in distance travelled for elephants that engage in abnormal swaying behaviour. In such elephants, the use of anklets would decrease any inconsistency due to swaying. Elephants that engage in pacing behaviour would also increase the reported walking rates for elephants using either of these methods. It is recommended that any facility where elephants potentially engage in swaying or pacing behaviour also collect behavioural data to ensure accuracy in recording actual distances travelled. While animals are still receiving exercise by engaging in pacing behaviour it has been associated with negative welfare (Mason *et al* 20007) and should be examined as a separate animal welfare issue outside of sedentary-related issues.

While the current methods only provide information on walking rates for elephants, it is important to consider all factors related to the welfare of elephants within zoological institutions. Future research should examine the relationships between walking rates and other indicators of welfare (eg stress hormones, veterinary health records, and behaviour) to better understand the welfare of elephants in zoological institutions. Given the number of elephants exhibited in zoological institutions throughout the world, continued research is essential to ensure the highest levels of care for this intelligent and complex species.

Animal welfare implications

Determining if the animals within zoological institutions are active enough to prevent sedentary health or welfare issues is important in ensuring these facilities are meeting their animal management goals. Many zoological institutions around the world have elephants as part of their collection and determining appropriate methodologies can help in gathering required information to make informed management

decisions. The elephants throughout these facilities serve as ambassadors for their wild counterparts and ensuring proper animal care and management will allow visitors the chance to view animals engaging in species-appropriate behaviour free of health-related issues. These methods can also be used to determine differences in management routines, exhibit sizes and exhibit complexity on walking rates and activity levels of many species within zoological institutions where there are concerns around such issues.

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References

Andrews J, Mecklenborg A and Bercovitch FB 2004 Milk intake and development in a newborn captive African elephant (*Loxodonta africana*). *Zoo Biology 24*: 275-281. http://dx.doi.org/10.1002/zoo.20048

Clubb R, Rowcliffe M, Lee P, Mar KU, Moss C and Mason GJ 2009 Fecundity and population viability in female zoo elephants: problems and possible solutions. *Animal Welfare 18*: 237-247

Eckel RH and Krauss RM 1998 American heart association call to action: obesity as a major risk factor for coronary heart disease. *Circulation 97*: 2099-2100. http://dx.doi.org/10.1161/01.CIR.97.21.2099

Kubzansky LD and Kawachi I 2000 Going to the heart of the matter: do negative emotions cause coronary heart disease? *Journal of Psychosomatic Research 48*: 323–337

Leighty KA, Soltis J, Wesolek CM, Savage A, Mellen J and Lehnhardt J 2009 GPS determination of walking rates in captive African elephants (*Loxodonta africana*). *Zoo Biology 28*: 16-28. http://dx.doi.org/10.1002/zoo.20199

Mason G, Clubb R, Latham N and Vickery S 2007 Why and how should we use environmental enrichment to tackle stereotypic behaviour? *Applied Animal Behaviour Science 102*: 163-188. http://dx.doi.org/10.1016/j.applanim.2006.05.041

Rothwell ES, Bercovitch FB, Andrews J and Anderson M 2011 Estimating daily walking distance of captive African elephants using an accelerometer. *Zoo Biology 30*: 579-591. http://dx.doi.org/10.1002/zoo.20364

Sukumar R 2003 *The Living Elephants — Evolutionary, Ecology, Behaviour and Conservation.* Oxford University Press: Oxford, UK

https://doi.org/10.7120/09627286.21.4.577 Published online by Cambridge University Press