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Commentary

Assessing the reliability of biologger techniques to measure activity in a free-ranging primate

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Assessment of animal activity patterns can shed light on a range of behavioural and ecological processes. The timing of activity can help improve understanding of a species' spatial ecology, chronobiology, energetic demands, reproductive strategy and nutritional requirements (Halle & Stenseth 2000; Erkert 2003). Activity data are also useful for the assessment of animal welfare and conservation planning (Kitchen & Martin 1996; Broom & Fraser 2007; Cooke 2008); Activity patterns allow us to measure the impact of human disturbance on habitat viability and behaviour (Williams et al. 2006; Yang et al. 2007), and to predict the influence of local or global climate change on the survival and distribution of a species or population (Walther et al. 2002; Hetem et al. 2012). Reliable measures of activity are thus fundamental to furthering our understanding of animal behaviour and ecology.

Two main methodological approaches have been used to record the activity patterns of free-ranging animals: behavioural observation and biologging (reviewed in Cooke et al. 2004; Nathan et al. 2012; Ropert-Coudert et al. 2012). Instantaneous scan sampling (Altmann 1974) is the most commonly used method to record activity and behaviour data in traditional studies of animal behavioural ecology. Scan sampling involves human observers recording the activity state (i.e. resting, foraging, travelling or social) of study animals at predetermined time intervals, to provide a descriptive measure of an individual's or group's activity. Scan sampling allows a range of behavioural information (e.g. diet, posture and proximity to conspecifics), in addition to states of activity, to be recorded simultaneously. However, scan sampling often requires study subjects to be individually identifiable and habituated to the presence of human observers, and data can, by definition, only be collected during those periods when human observers are present. These prerequisites for successful scan sampling may constrain the collection of activity data. In some species or populations it may not be feasible to follow animals regularly, for example, if they are nocturnal or live in an inaccessible habitat, or if the researcher's presence disrupts normal activity patterns.

Biologgers, either attached externally or implanted in the animal's body, have become increasingly popular for recording activity remotely (Cooke et al. 2004; Ropert-Coudert et al. 2012). These devices

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generally consist of accelerometers or mercury tilt switches, which allow activity to be recorded continuously. Biologgers have been used to collect activity data from a wide range of species, such as Adélie penguins, *Pygoscelis adeliae* (Yoda et al. 1999), blue-fin tuna, *Thunnus thynnus* (Block et al. 2001), owl monkeys, *Aotus azarai azarai* (Fernandez-Duque & Erkert 2006), Arabian oryx, *Oryx leucoryx* (Hetem et al. 2012) and griffon vultures, *Gyps fulvus* (Nathan et al. 2012).

Despite the extensive use of scan data and the more recent emergence and development of increasingly sophisticated activity biologgers (Ropert-Coudert et al. 2012), no study has tested empirically whether long-term (e.g. seasonal) patterns of animal activity collected using biologging techniques are quantitatively comparable to those ascertained using traditional scan sampling methods. Moreover, to date, very few studies have investigated the activity patterns of free-ranging nonhuman primates using biologgers (but see studies on owl monkeys: Fernandez-Duque & Erkert 2006; Fernandez-Duque et al. 2010). With the increasing use of biologgers to assess animal activity, it is important to establish that such data are both meaningful and comparable to traditional observational methods.

Following the assumption that scan sampling provides a reliable and objective measure of animal activity (Altmann 1974), we examined the extent to which biologger data could be used to replicate these methods. We aimed to test whether activity data collected using both scan sampling techniques and implanted activity biologgers (which record whole-body movements in a three-dimensional space) provide a directly comparable account of the diurnal and seasonal activity of wild vervet monkeys, *Chlorocebus pygerythrus*. We investigated the activity patterns of our study animals over monthly and hourly timeframes.

METHODS

Study Animals

Data were collected between May 2011 and March 2012 from two groups of wild vervet monkeys in the Samara Private Game Reserve in the Eastern Cape, South Africa (32°22′S, 24°52′E). At the beginning of the study, both groups consisted of 28 adult/subadult individuals (17 males and 11 females). Study animals lived on a completely natural diet, inhabiting the semiarid riparian woodland of the Nama Karoo (Pasternak et al. 2013). Study animals were fully habituated to the presence of human observers and were individually recognizable using unique body and face characteristics. The data presented here were collected as part of a longitudinal study of the behavioural ecology and physiology of wild vervet monkeys.

Behavioural Observations

Scan sampling methods (Altmann 1974) were used to collect data on the activity of our study groups. Scan data were collected from all adult and subadult individuals from each of the two groups, including those implanted with biologgers (see below). Across all daylight hours, instantaneous scan samples were collected on the activity state (i.e. resting, moving, foraging, allogrooming, playing and aggression) of all study animals that could be located during a 10 min period every 30 min. An animal was sampled once in a single scan. In total, 10 780 animal scans were collected across the 144 days for which data are presented here (mean = 121, median = 99 scans/subject).

Activity Biologgers

In April 2011, we implanted 13 adult/subadult animals from the two study groups (males = 7, females = 6) with activity biologgers (model: ADXL345, Sigma Delta Technologies, Perth, Australia). ADXL345 biologgers had a triaxial accelerometer with equal sensitivity across three planes (resolution = 4 mg/least significant bit). Motion changes were recorded as activity counts on each of the three axes at inclination changes of less than 1.0°. Activity counts were taken across a 10 s interval at the start of every minute. The battery and memory capacity of the biologgers lasted up to about 12 months. Before implantation, the biologgers were sealed in antistatic cellophane and coated in three layers of inert wax (Sasol wax 1276; Sasol, South Africa.) for waterproofing (total mass of waxed biologger = 20–25 g, < 1% body mass; subject body mass: mean = 4.40 kg, range 2.85–6.53 kg).

Monkeys were blow-darted and anaesthetized with a combination of midazolam (2.5 mg: Roche Products, Isando, South Africa) and ketamine (50 mg: Bayer, Isando, South Africa). Once recumbent (after about 5 min), animals were transported to a temporary operating theatre within 5 km of their home range. Animals were intubated and anaesthesia was maintained (0–2% isoflurane in oxygen: Isofor, Astra Zeneca Pharmaceuticals, Johannesburg, South Africa) throughout surgery. The mean duration of anaesthesia ±SD was 50 ± 15 min. Arterial haemoglobin oxygen saturation, blood pressure, rectal temperature, heart rate and respiratory rate were monitored throughout the surgery. Once intubated, a 100 × 100 mm region of the abdominal surface was shaved and sterilized using chlorhexidine (Hibicol, Kyron Laboratories, Benrose, South Africa). Prior to surgery, animals were injected intramuscularly with an antibiotic (Peni LA: 0.1 ml/kg) and an anti-inflammatory (Carprofen: 3 mg/kg, Pfizer Laboratories, Sandton, South Africa). Electric blankets were used to prevent hypothermia and eye ointment kept their eyes moist (Terra-Cortril: Pfizer Laboratories). After a local anaesthetic (Lignocaine: 40 mg/animal, Bayer) was given subcutaneously, waxed biologgers (dry-sterilized in formaldehyde vapour) were implanted via an incision made through the dermal layer and linea alba. During surgery, Ringers solution (B. Braun Medical, Northriding, South Africa) was administered at 1 drop/s. Biologgers were tethered to the abdominal muscle wall before the incision was sutured closed. Following surgery an analgesic (Buprenorphine: 0.02 mg/kg, Kyron Laboratories) was administered intramuscularly and the wound sprayed with F10 germicidal wound spray (Health and Hygiene, Sunninghill, South Africa). Animals were allowed to recover fully in transport cages before they were released back into their group. In March 2012, the implanted monkeys were recaptured and the biologgers removed using a similar method to that described above. The mean duration from capture to release ±SD was 165 ± 35 min. Following capture and recapture the monkeys were followed daily to monitor the progress of their recovery; normal behaviour resumed on the day after surgery. No monkeys were physically impaired as a consequence of surgery.

Ethical approval was granted by the Animal Ethics Screening Committee, University of the Witwatersrand (AESC: 2010/41/04). Research permits were obtained from the Department of Economic Development and Environmental Affairs, South Africa (Permit number: CRO 97/10CR) and permission to work at the field site was provided by Samara Private Game Reserve (E:32/2011/GR). This study complies with South African regulations regarding the ethical treatment of research subjects.

Data Analysis

To explore the activity patterns of the study animals, we quantified the proportion of time the group spent active each month of the year (May 2011 to March 2012) and across each hour of daylight within each of the four seasons. We defined the four seasons in South Africa as follows: autumn = April to May, winter = June to