

Making Sense of Animal Locomotion

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Abstract

Studies that have directly observed feeding have found strong relationships between track-based feeding metrics and true feeding (Hill *et al.*, 2000; Nolet & Mooij, 2002). It is recognized that feeding can be inferred, at least in part, from the observation of localized areas of movement, assuming that an animal will preferentially spend more time in regions of successful feeding (McConnell *et al.*, 1999; Wood *et al.*, 2000). Studies of grazing animals also indicate that the animals respond to their environment and make grazing choices at a variety of spatial scales (Ginane *et al.*, 2002; Ginane *et al.*, 2003; Swain *et al.*, 2007). These hypotheses are supported by numerous studies in which many species exhibit a distinct change in movement behaviour upon arrival at a feeding area (Fauchald & Tveraa, 2003; Haskell, 1997; Nolet & Mooij, 2002).

The location of feeding areas, as identified by localized areas of high use, has been investigated using a number of analytical tools based entirely on animal movement (Robinson *et al.*, 2007). Most of these methods assign behaviour to points along an animal's route using variables based on locomotion rate, turning rate, or the period of time that an animal spends in a defined area. The means by which these variables are determined for terrestrial species is generally via the use of GPS or VHF collars. These technologies allow systematic patterns of animal movement to be identified, and through subsequent statistical analysis, foraging behaviour of animals are derived. However, many of these approaches, fractal analysis (Fritz *et al.*, 2003), sinuosity indices (Benhamou, 2004), and first passage times (Frair *et al.*, 2005) were also designed to deal with poor-quality positional data (Wilson *et al.*, 2007), and to circumvent the issue of not knowing what the animal is actually doing at a location.

Animal movement is typified by variable acceleration, and measurement of acceleration is becoming established as a reliable method of quantifying activity patterns of animals in the field (Yoda *et al.*, 2001). The use of acceleration to measure movement is logical because muscular contraction resulting in movement produces acceleration in a corresponding moving part — usually a limb. Theoretically, if accelerometers were put onto all moving parts of the body, it should be possible to quantify all movement. However, because the moving parts of the body are all connected with the trunk, any movement should produce a corresponding, albeit dampened, movement in this area. In general, the more substantial the movement in the extremities, the greater will be the movement of the trunk. Thus, a single set of accelerometers to monitor all elements of animal movement should ideally be placed on the trunk where movement in any of the extremities can be perceived. With the ability of accelerometry to identify behaviours (Watanabe *et al.*, 2005), this technique should ultimately allow researchers to determine how free-living animals partition their time into particular behavioural strategies.

Given recent developments in the miniaturization of accelerometer sensors we have used accelerometry and step detection techniques to combine GPS with dead-reckoning methods to address the limitations of both GPS and VHF positioning techniques. The benefit of dead-reckoning is that it produces finely grained, regular, sequential positional data without gaps, something that is in general, difficult to acquire in studies of many wildlife species. As such, dead-reckoning is a unique tool for describing animal movements.

The work presented in this paper will compare the results of data obtained from a dead-reckoning based system with those acquired from common wildlife tracking techniques. To highlight the benefits of this technology, we will examine to what extent movements in space can be characterized by linearity and velocity when different temporal sampling regimes are employed. The objective of this work is to provide the wildlife research community with tools and methods that will enable the identification of behaviors so that links between an animal's location, their local environmental conditions, and the activities that the animal is performing can be established so that better informed wildlife management plans can be developed.

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