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Short Communication

A cost-effective and informative method of GPS tracking wildlife

Blake M. Allan[A,C], *John P. Y. Arnould*[A], *Jennifer K. Martin*[B] *and Euan G. Ritchie*[A]

[A]School of Life and Environmental Sciences, Deakin University, 221 Burwood Highway, Burwood, Vic. 3125, Australia.
[B]Department of Zoology, The University of Melbourne, Vic. 3010, Australia.
[C]Corresponding author. Email: bmallan@deakin.edu.au

Abstract. In wildlife research, our ability to GPS track sufficient numbers of individuals is always limited by cost, which restricts inference of species–habitat relationships. Here, we describe the modification and use of a relatively new and inexpensive off-the-shelf GPS device, to provide detailed and accurate information on the movement patterns of individuals (mountain brushtail possums, *Trichosurus cunninghami*), including how movement varies through time, and how individuals interact with each other. Our results demonstrated that this technology has enormous potential to contribute to an improved understanding of the movement patterns and habitat preferences of wildlife at a fraction of the cost of traditional GPS technology.

Additional keywords: animal movement, ecological niche, habitat use, home range, locomotion, radio telemetry.

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Introduction

There are several commercial suppliers specialising in various types of wildlife GPS-tracking devices. However, GPS tracking remains a relatively expensive method of collecting location data, compared with traditional methods such as spool-and-line tracking or VHF tracking, with wildlife GPS devices costing thousands to tens of thousands of dollars (Matthews *et al*. 2013). This high expense typically reduces the number of units that can be purchased by researchers and, as a result, the number of individuals that can be tracked simultaneously. This can create statistical problems (e.g. low power) and limits the inferences that can be made about populations, such as habitat use and interactions among individuals. Furthermore, the purchase of commercially available wildlife GPS-tracking devices does not always guarantee successful deployment, because many fail as a result of construction error or damage sustained from the animal (Gau *et al*. 2004; Soutullo *et al*. 2007; Strauss *et al*. 2008; Zucco and Mourao 2009; Uno *et al*. 2010; Cumming and Ndlovu 2011; Ruykys *et al*. 2011).

A cheaper alternative is to purchase a GPS data logger or data transmitter built for purposes such as travel, sport, domestic pet tracking or personal tracking (see Table 1). These pre-assembled GPS devices usually comprise a GPS antenna, processor, storage device, power supply and often timer chips. Stripping these units of excess packaging, and attaching them to an animal, is the easiest means of creating a cheap and effective tracking device. However, challenges arise in the repackaging of devices in ways that reduce size, while creating sufficient protection against both the environmental conditions and the species that they are attached to.

We describe a novel technique for customising and modifying cheap GPS devices to increase aspects such as durability, orientation and battery life. These cost-effective GPS wildlife-tracking devices can be constructed either as data loggers or as data transmitters, and can be constructed for as little as US$50.

GPS modification

We designed our GPS devices to study the ecology and movement patterns of an arboreal mammal, the mountain brushtail possum (*Trichosurus cunninghami*; Martin and Martin 2007). From our data, we aimed to examine individual possum movements within the habitat, and examine interactions among possums in the same habitat. Collaring all of the possums resident in a habitat patch simultaneously could potentially require a large number of collars, so we required a cost-effective method.

We modified and collar-mounted the Mobile Action i-gotU GT-120 (Table 1) because it was the cheapest available GPS including postage, and is small (44.5 × 28.5 × 13 mm) and lightweight (20 g, 15 g without casing, 7 g chipboard only). A GPS antenna is most accurate and most efficient when it is pointed towards the sky with nothing obscuring its view (Belant 2009; Williams *et al*. 2012), so we moved the position of the battery on the collar to counterweight the GPS antenna. We also increased the size of the battery, because larger batteries will allow the device to record for longer periods of time (data storage permitting), and larger batteries are also heavier, creating a better

Table 1. Examples of commercially available GPS devices
Prices accurate as of February 2013

Device name	Type	Supplier	Intended purpose	Retail price
GPS CatTrack 1	Data logger	Catnip Technologies Ltd	Domestic-pet logger	US$49
i-gotU GT-120	Data logger	Mobile Action Technology Inc.	Travel and sports logger	US$49.95
DG-200	Data logger	USGlobalStat Inc.	Personal GPS logger	US$49.99
GPS CatTrack Live 3	Data transmitter (GSM network)	Catnip Technologies Ltd	Domestic pet tracker	US$110
Spark Nano 3.0	Data transmitter (GSM network)	BrickHouse Security	Personal GPS tracker	US$169.95
i-gotU GT-1800	Data transmitter (GSM network)	Mobile Action Technology Inc.	Personal GPS tracker	US$199.95
Dog Tracking Collar	Data transmitter (GSM network)	My Pet Tracker	Domestic pet tracker	US$249.00
Trackstick Mini	Data logger	Telespial Systems	Personal GPS tracker	US$289.95

counterbalance. We re-encased the device by using epoxy resin, becaus this is relatively lightweight, very strong and does not cause skin irritation to animals.

The total cost was $US300 per collar, including a VHF transmitter ($US220). The GPS in the collars is also rechargeable, making subsequent deployments effectively free. The VHF is not re-chargeable, but the battery lasts for 15 months. Therefore, the finished collar can be deployed and re-deployed for 15 months, at which time it can be refurbished for approximately $US230 by removing and remounting a new VHF transmitter. A full demonstration video of how collars were constructed is available at http://youtu.be/UaSvS0grVjw (verified 30 July 2013).

Field trials

All trappable male mountain brushtail possums were collared simultaneously along a roadside. We decided to focus solely on males for the field trial because their home ranges are more than twice the size of those of females (Martin *et al*. 2007). Using only males also limited the number of possums required for testing the collars. The collars were set to record from 1900 hours to 0600 hours (local time) every day, to coincide with sunset and sunrise, and were set to record in 5-min intervals until the battery died. For accuracy purposes, only data points with an expected horizontal position error (EHPE) of <10 m were deemed accurate enough for our fine-scale analysis (Frair *et al*. 2010).

Three individual male mountain brushtail possums were captured (Identification codes M1, M2 and M3). An individual M1 collar recorded for 110 h (10 nights), with 1375 attempted fixes. Of these, 1003 fixes were successful, 76% of which had an EHPE of <10 m. An individual M2 collar recorded for 44 h (4 nights), with 465 attempted fixes. Of these, 378 fixes were successful, 70% of which had an EHPE of <10 m. An individual M3 collar recorded for 94 h (9 nights), with 912 attempted fixes. Of these, 610 fixes were successful, 65% of which had an EHPE of <10 m. The accuracy and frequency of the GPS fixes is adequate to clearly divide the roadside into three home ranges with very little overlap (Fig. 1). From this, we could surmise that male mountain brushtail possums occupied exclusive home ranges along roadsides.

The battery life varied greatly among the three collars because of inferior batteries not meeting their listed milliamp-hour (mAh) capacity specifications. We have subsequently rectified this variation by using a different brand of batteries.

Because of the variation in recording time, we chose the individual with the most fixes (M1) to analyse activity per night (Fig. 2). The GPS recorded an average of 100.3 successful fixes per night (s.d. = 23.63), of which an average of 76.4 (s.d. = 24.83) had an EHPE of <10 m. Fixes with an EHPE of >10 m tended to be in groups of 3 or 4 consecutive fixes at a time. The average time between fixes was 6 min 35 s; however, each night tended to have blocks of unsuccessful fixes at the beginning and the end of the recording time. Possums do not forage for the entire night (J. Martin, pers. obs.), and subsequent spotlighting has led us to believe that the blocks of unsuccessful fixes represent the time the possum is in the tree hollow. The average length of time that fixes were recorded was 8.5 h per night (s.d. = 1.63 h). When we removed the blocks of unsuccessful fixes from the beginning and end of each night, only 18 fixes over the entire 10 nights were unsuccessful. The average time between fixes also dropped from 6 min 35 s to 4 min 49 s, being slightly faster than the 5-min interval the collars were set for.

GPS performance

The GPS tracking collars used for the present study cost $US300, including the VHF transmitter. Even though this is only a fraction of the price of a commercial wildlife GPS-tracking collar, the GPS devices used were still able to record the majority of the fixes with an EHPE of <10 m, which we deemed accurate enough for fine-scaled analysis of the animal movement (Frair *et al*. 2010). Furthermore, the collars were all retrieved with no damage sustained, and could be redeployed after recharging the batteries.

Building your own GPS devices has a considerably higher investment of time to obtain successfully recording reuseable devices, and the modification of the components used obviously voids all warranties. However, there is also greater flexibility to customise the design to specifically suit a particular species. The scope of cost-effective GPS tracking of wildlife is vast. Furthermore, once built, these devices can be recharged and redeployed as often as required, until the battery in the VHF transmitter runs out. The construction of a rechargeable VHF transmitter could greatly increase the life span of these collars.

The increased commercial availability of relatively inexpensive GPS devices for purposes such as sport or domestic pet tracking has made it possible to cheaply obtain high-quality GPS data. Such advancements allow for many more individuals to be tracked at once, providing a better picture of population dynamics and individual interactions.

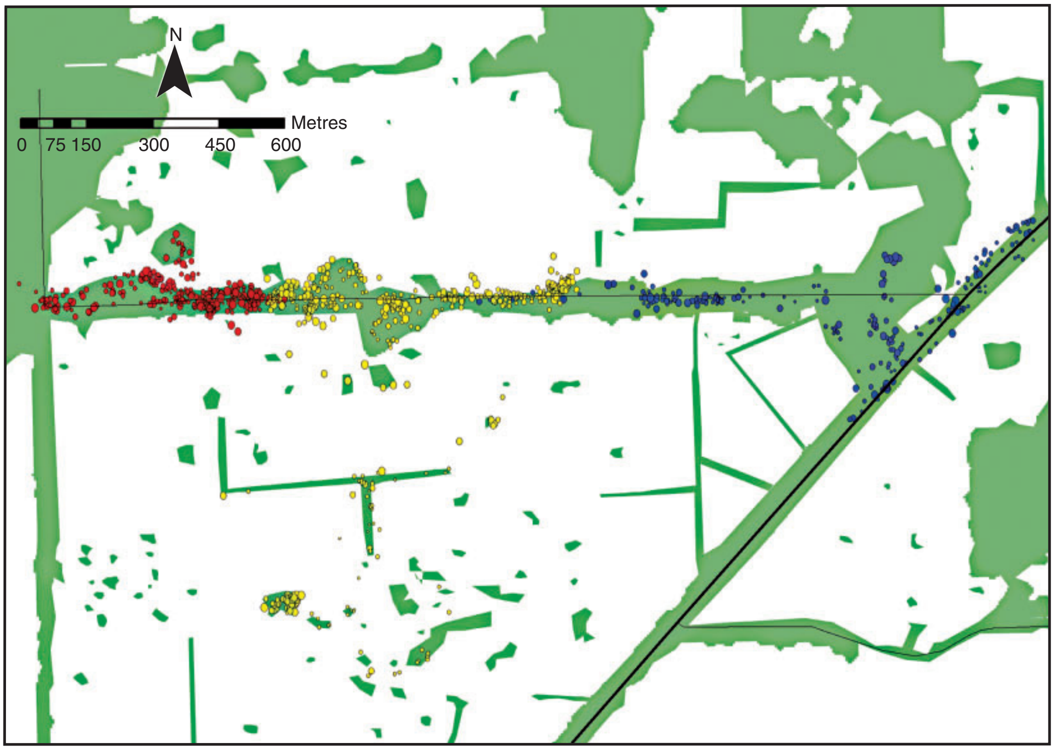

Fig. 1. GPS locations of three male mountain brushtail possums (M1 = yellow, M2 = blue, M3 = red) in vegetation (green) along a roadside in the Strathbogie Ranges, north-eastern Victoria, Australia. Each point encompasses the estimated location of the animal for each fix. The larger the point, the less accurate the location fix.

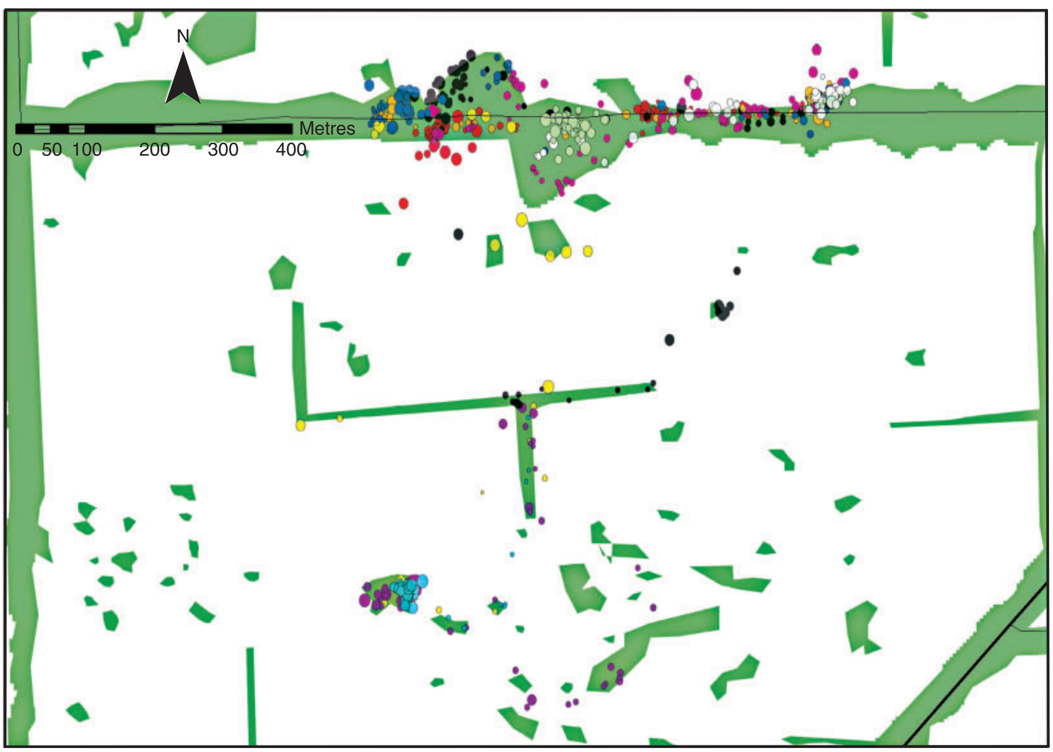

Fig. 2. GPS location of one male mountain brushtail possum (M1) in vegetation (green) along a roadside in the Strathbogie Ranges, north-eastern Victoria, Australia, for 11 consecutive nights. Different colours represent different nights. Each point encompasses the estimated location of the animal for each fix. The larger the point, the less accurate the location fix.

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