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Australian Magpies *Gymnorhina tibicen* cooperate to remove tracking devices

Joel Crampton[1], Celine H. Frère[2] and Dominique A. Potvin[1*]

[1]School of Science, Technology and Engineering, University of the Sunshine Coast, Petrie QLD 4502, Australia
[2]School of Biological Sciences, University of Queensland, St Lucia QLD 4067, Australia
*Corresponding author. Email: dpotvin@usc.edu.au

Abstract. Recent advances in tracking technology have enabled devices such as Global Positioning Systems (GPS) loggers to be used on a wide variety of birds. Although there are established ethical considerations to these processes, different species may react differently to particular devices and attachments. Thus, pilot studies are still of utmost importance in this field. Here, we describe one such study trialling a novel harness design for GPS tracking devices on Australian Magpies *Gymnorhina tibicen*. Despite previous testing demonstrating the strength and durability of the harness, devices were removed within minutes to hours of initial fitting. Notably, removal was observed to involve one bird snapping another bird's harness at the only weak point, such that the tracker was released. This behaviour demonstrates both cooperation and a moderate level of problem solving, providing potential further evidence of the cognitive abilities of this species. To our knowledge, this is the first study to report the conspecific removal of GPS trackers, and should be considered when planning future tracking studies especially on highly social species.

Introduction

Understanding patterns of animal movement is an essential step towards comprehending both large- and fine-scale ecological and behavioural patterns (Kremen *et al*. 2007; Williams *et al*. 2020). Research in this field is of value not only to behavioural and evolutionary ecologists, but it also increases the effectiveness of conservation action (Rubenstein & Hobson 2004; LaPoint *et al*. 2015). Yet, it is only relatively recently that we have developed the technology required to track individuals or populations at fine scales remotely and accurately as well as the ability to store data in a device itself, especially for smaller animals (Webster *et al*. 2002). In recent years, the use of Global Positioning Systems (GPS) devices has enabled more and more sophisticated and precise studies of animal movement (Scharf *et al.* 2019). One major constraint of GPS tracking studies, however, is the size of the tracking device itself. Approximately 70% of avian species and 65% of mammalian species are too small to be GPS tracked given that the required GPS tracker size is too large to ethically be attached, mostly because of the size and weight of the attached battery (Bridge *et al.* 2011; Taylor *et al.* 2017). Charged batteries are required not only for data collection in many systems, but also for storage, and data can be lost if devices are not retrieved while the battery still contains charge. Small batteries, in particular, are unable to keep a charge for long periods of time, and remote recharging (i.e. on the animal) is thus far limited to solar panels, which add weight and require exposure to sunlight across a minimum surface area to function properly. It is therefore important that we continue to improve tracking technologies to allow for the tracking of smaller animals, as well as the means of recharging smaller batteries. In particular, allowing for a controlled, remote system that enables battery charging and/or removal of a tracker would be highly advantageous for many animal-tracking studies.

The ability of new GPS tracking technology to give greater insight into the ecology of species is well-established (Webster *et al*. 2002; Thomas *et al*. 2012; Kays *et al*. 2015; Pimm *et al*. 2015). However, there has been little tracking done on passerines because of their generally small size. This study proposed to investigate the possibility of using GPS technology on an iconic Australian passerine, the Australian Magpie *Gymnorhina tibicen*, given its rather large size making it a model candidate for initial trials. One novel aspect of our pilot project was the development of a passive release mechanism that relied on the birds approaching a magnet at a station designed to release the harness supporting the GPS unit (Figure 1). This system was intended to help make the fine-scale GPS tracking of birds more plausible and efficient, enabling safe data collection, convenient GPS tag retrieval, and potential battery recharging via a wireless system. This last factor, in particular, was expected to help overcome the limitations of constraints on battery weight associated with current GPS technology.

Methods

The Australian Magpie is a large (~300g), native Australian passerine that is an omnipresent species across the Australian continent (Kaplan 2004). It is a woodland and open habitat generalist that has adapted well to land clearing and urbanisation (Jones 2008; Dobson *et al*. 2019). In general, Australian Magpies live in social groups of 2–12 individuals, occupying and strongly defending a permanent single territory ranging between 4 and 10 ha (Brown *et al*. 1993; Kaplan 2017). The Magpie is a cooperatively breeding species with both males and females contributing help to raise young (Pike *et al*. 2019). Although an abundant species, there is little known about Magpie movement, social interactions within and between family groups, and range at a high temporal and spatial resolution.

We conducted our study in August 2019, at Pacific Paradise, Queensland (–26.8541667, 153.9297222). Here, we targeted a suitable territorial Magpie group for the study. A focal group of approximately ten individuals was habituated to researcher presence over a period of

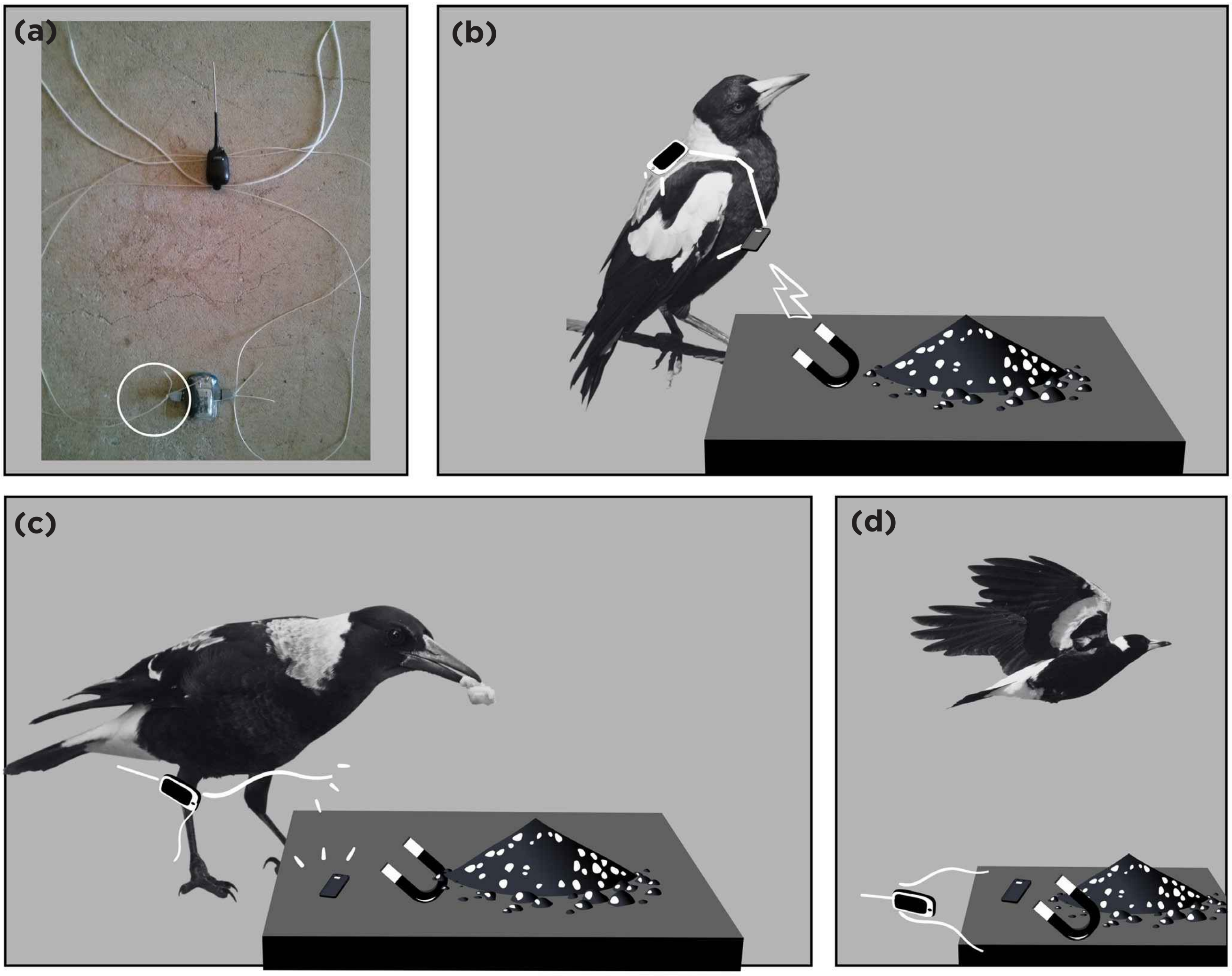

Figure 1. (a) Photograph of the harness and tracker (body of tracker is 15 mm long) used. Photo: Rob Appleby. (b)–(d) Diagrams of how the harness detaches once in contact with a magnet. White circle denotes the 'weak' point of the harness released once magnetised.

4 weeks. Once habituated to the researcher's presence, an open (but not set) soft-netted spring trap was introduced to the area, upon which a small amount of Magpie feed (Wombaroo Insectivore Mix) was placed. This was done for a further 6 weeks. We then trapped five Magpies using the soft-spring-loaded net traps over the course of one morning and attached the GPS trackers (Lotek pinpoint GPS archival loggers PP50, Lotek Inc.) with harness (weight combined ~2.7 g) (Figure 1), along with an individually numbered aluminium Australian Bird and Bat Banding Scheme (ABBBS) band. We also fitted each bird with an individually coloured leg-band for easy visual identification. The birds trapped were one adult male, two adult females and two juveniles (first to second year) of unknown sex. The GPS harness had a weak point engineered into the thread that would release when magnetised, thereby creating a passive release system for the retrieval of the GPS tracker and negating the need to recapture the birds. Habituated birds returning to the feeding station would encounter a magnet, magnetising and thus releasing the harness and tracker, and allowing for easy retrieval of the GPS device afterwards. In order for the birds to remove the harness themselves, they would have to locate this sole weak point and apply moderate, targeted sharp force. Initial aims were also to test the plausibility of a wireless charging station at the feeding station for longer-term studies.

Observations

Of the five Australian Magpies that had trackers attached, we directly observed four actively removing the trackers. Individuals were observed pecking at the tracker harness by themselves—this behaviour was noted by the researchers over the course of 2 days. On the day of trapping, one individual was observed attempting to remove its own tracker but was then approached and aided by another juvenile (without a tracker or coloured leg-band) once again pecking the harness part of the tracker. The tracker remained but, within the next 10 minutes, an adult female (also without a tracker or leg-band) proceeded to approach and successfully pecked the harness at various points such that the tracker came off the fitted juvenile within *c.* 10 minutes. This first Magpie that had been tagged had its GPS device removed within 1 h. Concurrently, the removal of a second tracker from another Magpie by a different adult (without a tracker) was also occurring atop a powerline. After two Magpies fell from the line during the process of trying to remove the tag, they were seen to relocate and continue the removal in a nearby tree. This behaviour was captured on video (https://youtu.be/mM0j_GybEKw) until the birds left the area. On returning to the site the following day, we noted two Magpies present with the GPS trackers still attached. The juvenile that was previously being aided in the removal of the trackers was not observed on this day. On the third day post-trapping, no Magpies that had been previously caught and tagged were observed. On the fourth day post-trapping, only one Magpie was observed, and it was seen to have a leg-band attached by researchers but it no longer had its GPS tracker. Eight days post-trapping, a large male that could be visibly identified by the previously fitted aluminium leg-band (but without a coloured tag) was observed feeding. This bird had also had its GPS tracker removed. On subsequent days, we were able to observe up to ten Magpies (none had coloured leg-bands) in the immediate area but none had had trackers attached. The study site was revisited for a further month, yet no Magpies with GPS trackers were observed, even though individuals with our previously fitted ABBBS aluminium bands were present.

Discussion

We observed that Magpies used cooperative behaviour, and likely some level of problem solving, to release GPS tracker harnesses on conspecifics. Here we discuss the implications of these observations—both immediate and in the broader context of tracking studies in general.

Tracking studies

Tracking studies using devices attached to animals are now commonplace (Williams *et al.* 2020). However, despite the insights that we have gained as a scientific community from the use of tracking devices, the ethics of attaching trackers are still being investigated and debated (López-López 2016; Bodey *et al*. 2018). If any attachment results in a change of behaviour, this may indicate that the animal is in discomfort or pain. This is of concern for animal welfare, but it also is of limited use to science if an animal being tracked is demonstrating abnormal movements. The accepted size of a tracker of 3–5% of an animal's body weight is commonly cited and used (our trackers were ~1% of an adult Magpie's body weight). However, the empirical research supporting whether this size results in normal behaviour is lacking (Barron *et al.* 2010). Additionally, weight should not be the only consideration when planning tracking studies. To be considered ethical, the overall size and shape of the tracker, and how it is attached, should also result in no behavioural or physiological change in the animal to be considered ethical.

We therefore argue that pilot studies, such as ours, are important before engaging in larger-scale experiments using logging devices carried by animals. Previous meta-analyses on the effects of these devices on avian survival, reproduction and behaviour found varying effects of loggers depending on style and location of attachment (Barron *et al*. 2010; Bodey *et al*. 2018; Brlík *et al*. 2020). Only one of these gave attention to behaviours directly associated with the devices themselves, showing that a significant number of studies had reported increased levels of preening, fluffing, stretching and unrest (Barron *et al*. 2010). None, to our knowledge, described the behaviour that we observed: that of conspecifics removing trackers from other individuals, even when the 'helper' did not have a tracker. Explanations for why this novel behaviour could not be located in the literature would be speculative. Although, to date, many studies on bird tracking have focused on species such as seabirds and waterfowl, which have not been shown to display the potential high levels of cooperation, social structure or problem solving that might be required to remove a tracker from a conspecific (Geen *et al.* 2019). It may be that an animal's social context and problem-solving abilities affect its susceptibility to behavioural change when a device is attached and should be considered alongside previously identified factors such as body size and flight style (Bodey *et al*. 2018; Brlík *et al*. 2020).

Cooperative behaviours

Many birds live in social groups in which cooperative interactions are essential for population survival and function. To better understand the motivations behind cooperative behaviours, behavioural ecologists have delineated two potential forms that they may take. Collaboration is defined as two or more individuals working together to achieve mutual benefits, whereas prosocial behaviour is defined as any altruistic behaviour which benefits another individual, regardless of potential or actual personal benefit (Cheney 2011; Crockford *et al.* 2012; Cronin 2017).

There are several non-exclusive hypotheses describing the evolution of cooperation and the selective pressures that shape collaborative and prosocial abilities of animals. The adaptive cognition hypothesis posits that social animals that are naturally faced with cooperative challenges (e.g. care of young, hunting, or alliance formation) are more likely to utilise social problem solving in novel scenarios (Cronin 2017). According to the social intelligence hypothesis, social environments create unique challenges to form social bonds, track third-party relationships, and anticipate the actions of others (Ashton *et al*. 2019). These challenges in turn assist in cognitive development. Thus, the larger the social group, the greater the cognitive abilities to solve problems (Ashton *et al*. 2019). Both of these hypotheses may help explain why individuals from socially cohesive groups tend towards cooperative behaviours when presented with novel tasks. The Australian Magpie, being a highly social species, is known to form cooperative groups. It is therefore possible that individuals have previously encountered scenarios whereby cooperation is known to be advantageous, and that this may contribute towards adopting a cooperative strategy in a novel, yet similar, challenge.

One of the most common situations where prosocial cooperative behaviour is observed is social grooming. Social grooming serves several functions, including increasing the hygiene of group members, facilitating partnerships, and maintaining social hierarchies (Morales Picard *et al*. 2020). Social grooming has also been linked to reductions in circulating stress hormones (corticosteroids), and de-escalating aggressive interactions (Morales Picard *et al*. 2020). Several species of birds specifically engage in allopreening, a social grooming behaviour that aids the maintenance of layered contour feathers through spreading secretions of the uropygial (preen) gland throughout, as well as removing small parasites from feathers (Robinson 2009; Morales Picard *et al*. 2020). Allopreening has been observed in >100 species (Morales Picard *et al*. 2020), but how and why allopreening evolved as a social behaviour is still under some debate. Interestingly, although the behaviour should theoretically assist in removing difficult-to-reach ectoparasites, no correlation has been found thus far between allopreening behaviour and parasite load (Villa *et al*. 2016).

Prosocial behaviour in Australian Magpies

Research into prosocial behaviour in Australian Magpies is limited, so therefore it is not known how common it might be or how it may manifest in this species. The GPS trackers might have presented a challenge similar to ectoparasitism, initiating an allopreening response by either nesting adults or helper individuals within the group. Although stimulus-driven allopreening because of the presence of parasites is not well understood in birds, Rock Doves *Columba livia* appear not to increase allopreening rates with increases in ectoparasite levels (Goodman *et al*. 2020). The prosocial behaviour response that we observed in Magpies could also have been initiated by the conspecific because of increased stress levels (Hammers & Brouwer 2017). Regardless of the stimulus that prompted the helping behaviour, both hypotheses on collaboration and prosocial behaviour (e.g. the adaptive cognition hypothesis and the social intelligence hypothesis) could be supported here (Pike *et al*. 2019).

Rescue behaviour is a specific form of cooperative behaviour that involves a helper working to free another individual in distress, with no obvious direct benefit to the rescuing individual (Nowbahari & Hollis 2010). Although rescue behaviour has most commonly been described in ants (Formicidae), there are rare cases in the literature of rescuing in birds (Nowbahari & Hollis 2010). For example, Seychelles Warblers *Acrocephalus sechellensis* have been observed removing sticky 'bird-catcher tree' *Pisonia grandis* seeds from the feathers of other individuals (Hammers & Brouwer 2017), a very similar behaviour to what we have described here. It is possible that what we have observed is the first documented case of rescue behaviour in Australian Magpies.

The observed behaviour is also indicative of complex cognitive problem solving. The individual being initially assisted unsuccessfully by a conspecific juvenile was then later assisted by an adult female. For example, it is not clear if the Magpies tested different parts of the harness before being able to snap it off at the weakest point, or if they simply persevered until the harness broke. If the former, this may demonstrate cognitive flexibility and learning with collaborative problem solving. Without further specific testing, however, it is difficult to establish if the Magpies worked on a weak point of the harness or if attempts at removal were somewhat random or systematic. Nevertheless, further research into cognitive problem solving within Magpies, especially in the context of helping other group members, is warranted to further understand collaborative behaviour. In addition, we suggest that attempts to track animals with high cognitive and/or cooperative abilities, should take into consideration potential collaborative efforts to remove devices. For further studies using GPS devices on Magpies, other attachment methods besides a harness (e.g. using adhesive tape on moulting feathers: Geen *et al*. 2019) would be advantageous. However, our harness system was designed for easy retrieval of both tracker and data, which is not possible using adhesive methods. Thus, it would likely be more effective to investigate different safe, ethical and robust styles (e.g. a leg-loop harness: Geen *et al*. 2019) to adjust to be magnetically or trigger-released for this purpose. In short, we highlight the importance of similar pilot studies whenever testing a new tracking system or attachment method: this is important for ensuring the effectiveness of the system, monitoring the behavioural responses of animals to new devices or attachments, and considering the implications of these responses to ethical ecological study.

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