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INVASION NOTE

Reliability and effective use of electronic trap monitoring systems based on cellular networks

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Abstract The deployment of cage traps rather than kill traps can greatly reduce non-target mortality in an invasive species control/eradication operation, but their use is normally constrained by the need for them to be checked frequently on animal welfare grounds. This paper examines the reliability of electronic monitoring devices that use cellular (mobile phone) networks to alert the operator when a trap door closes, and also discusses the management network that is needed to convert an alarm into a timely trap visit without fail. The two monitoring systems tested were 100% reliable in notifying the operator when a trap door closed, and their use reduced the burden of trap visits by 98% compared to the standard protocol of daily checks. As such, these systems can be of great value to campaigns operating large numbers of traps, especially when capture rates are low.

Keywords Cage trap · Humane trapping · Trap alarm · Pest eradication · Invasive animal

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Introduction

Trap monitoring based on cellular (mobile phone) networks is a relatively recent innovation, but its use is expanding rapidly, especially in large-scale operations when kill traps cannot be used because of the risk of non-target catches and live traps offer the only acceptable solution. A small box attached to the trap senses when the door closes and promptly sends a signal to a control system. This system then automatically generates an alarm message, by email and/or phone text, to one or more people registered to that particular trap. Traps equipped with this facility are becoming known as 'smart' traps. This paper investigates the reliability of such systems, and how best to manage a network of traps using this technology.

An experimental system based on the local cellular network was trialled between 1999 and 2001 in the U.S.A. (Larkin et al. 2003), but in this system the traps communicated via a large intermediate station. A homemade system allowing direct communication from trap to mobile phone was used in Ireland in 2005 and 2006 (Neill et al. 2007), but commercially made monitoring units were not available until some years later. Such units are now small enough to be retrofitted to existing traps, and offer many advantages over the use of traps without a unit. They monitor the trap door continuously, and notify the trap operator within minutes of the door closing. In situations where captures are infrequent, this facility can greatly reduce both the number of site visits required to properly manage the trap, and the length of time an animal is held captive before the trap operator arrives. These potentially important advantages are, however, dependent on the reliability of the units and the communication systems that support them. The Animal Welfare Act 2006 (Gov.uk 2006) allocates responsibility for the welfare of trapped animals, and practitioner organisations recommend inspection of live traps at intervals of no more than 24 h (PTES 2019). Any replacement for physical checks therefore needs to be extremely dependable. Although users of electronic monitoring systems anecdotally report them to be reliable, no published study is available to allow users and managers of trap-based research and conservation work to assess whether they can justifiably replace physical checks with an automated equivalent.

This paper examines the reliability of 112 monitoring devices (hereafter called Remote Monitoring Devices, RMDs) in use for varying lengths of time over a four-year period, amounting to a cumulative total of 47,116 trap nights (129 trap years). Given that the systems cannot, in themselves, manage traps—they only initiate the process of notifying a human trap operator of the need for a trap visit—this study also involved the development of a management system that should render a reliable, robust human response to trap alarms in all circumstances.

Study area and methods

RMDs were attached to metal cage traps (c. 590 × 180x150mm) with a door at one end, the device being attached directly to the cage. The target species was American mink (*Neovison vison*), an invasive predator in the UK, and each trap was placed within a square-sectioned tunnel on a tethered, floating raft (Reynolds et al. 2004). Rafts were placed on rivers, drains and flooded pits in eastern England, in the counties of Lincolnshire, Norfolk, Suffolk and Cambridgeshire. Traps were consequently always below local ground level, sometimes by as much as 5 m, and often on narrow waterways with steep banks. This, and the fact that most of the traps were situated in locations with sparse cellular mast coverage, presented a substantial challenge for a system based on mobile phone networks. Traps were unbaited, relying on the natural curiosity of mink to enter, and were spaced at intervals of between 1 and 10 km.

Two systems were used—trade names *Remoti* [www.remotisystems.com] (109 units) and *Mink Police* [www.minkpolice.com] (three units). The devices of each system were similar in function, and also in construction and size—waterproof plastic boxes of c. 120 × 90 × 40 mm. To arm them, a magnet was placed in a marked location on the casing. This activated a reed switch, thereby initiating an electronic 'handshake' with the respective control system which then informed the trap operator of its status. The magnet was securely attached to the trap door, usually by means of a flexible cable, such that the closing door pulled the magnet off the RMD, tripping the reed switch and initiating the software process that resulted in an email and mobile phone text being sent to nominated recipients.

Results

Between November 2017 and October 2021, 112 different RMDs were deployed for between 13 and 1195 (mean 421) trap nights each, yielding a collective total of 47,116 trap nights (129 trap years) across 133 different sites. In all, 378 alarms were received from 95 of these devices, with a maximum of 20 for any one device. The traps were promptly visited in each case. On 345 occasions the trap door had closed; on the other 33 occasions, the door remained open but the RMD magnet had been displaced, thereby triggering the alarm.

The probability of an alarm being promptly sent and received when a trap door closed was ascertained during bench testing and field experience. Every RMD was tested before each deployment; the period of time between alarm activation and receipt of the notification was never more than three minutes, and usually less than two minutes. On the 292 occasions when an animal was in the trap after an alarm notification had been received, it's health and behaviour was always consistent with a recent capture. Every non-target animal captured was released alive and well. On none of the 419 occasions when traps were visited other than in response to an alarm was a trap door found to be closed when it was expected to be open. Most such visits were routine quarterly inspections to service the traps.

An important feature of both the Remoti and Mink Police devices is that they routinely transmit a 'heartbeat' signal at 12 h intervals, to demonstrate that the RMD is alert and functioning. In the case of the Remoti system, if a heartbeat signal is not received within two hours of its expected time, the trap operator should automatically be notified of this failure. This situation arose158 times during this study, for various reasons including poor signal strength from a deep drain, trap damage and temporary failure of the cellular network; a system message was received by the operator every time, prompting a trap visit.

Discussion

This study has demonstrated that the two monitoring systems most commonly available in the UK are, if used correctly, extremely reliable. Every trap door closure resulted in the trap operator being promptly notified. Similarly, every time the management system failed to receive a routine heartbeat signal from an alarm unit within two hours of the expected time, the trap operator was quickly advised. In this sample of a cumulative 129 trap-years of use, the two systems used were faultless.

That said, the management of smart traps is as dependent on human reliability as is that of traps not equipped with monitoring equipment. Even if the device is perfect, it will not send an alarm if the magnet has not been securely linked to the trap door, or if the RMD has not been correctly registered and activated via the respective system website. Further, even if the alarm signal is sent, the trap will only be visited within an acceptable period if a failsafe protocol is in place to ensure that this happens, every time.

The operation of an extensive trap network for research or, as here, conservation work normally demands the participation of many people. Even with thorough training, it is inevitable that some in the team will be less careful and less reliable than others, and not even the most dedicated can be expected to attend a trap in all circumstances. Illness, prior commitments or transportation problems may intervene, sometimes at short notice.

An important feature of both monitoring systems used in this study is that multiple persons can be alerted when a trap door closes, and an attendance protocol can be set up for each trap individually. Experience gained during this study demonstrated that a safe and effective way to manage a substantial network of smart traps was to have oversight provided by one person (the Administrator), and each individual trap allocated to a 'First Responder'—someone preferably living near the trap location. Alarm messages from each trap should be received by the Administrator and First Responder, at minimum, and also by an Alternate Responder if the First Responder is often unavailable.

By default, the First Responder would react to an alarm from that trap by confirming their availability to the Administrator and subsequently reporting the result of the trap visit. If the Administrator does not receive such confirmation, and cannot contact the First Responder, they will either arrange for an alternate to visit the trap or go themselves. To provide an element of safety management, the Administrator should arrange for the trap visitor to acknowledge when they leave the field site. The alarm system website allows the Administrator to see if and when the trap was reset, and thus to know if the visit was made or not. When the Administrator is unavailable, a deputy must step in and assume the same role and responsibility.

The ability to know when a trap door has closed, within minutes of the event, has two substantial advantages over the standard once-a-day checks of cage traps. Firstly, because the event is relatively unusual in most operations, it normally prompts a rapid response, and this leads to improved animal welfare. Secondly, the frequency of visits to traps is often greatly reduced, especially when a trapping regime has been underway for a prolonged period. For example, in this study, visits to active traps, including visits for routine maintenance or to move traps, were made on average 7.4 times per year per trap, compared to the minimum of 365 visits required for standard cage traps (once per day). This reduced the burden of trap visits by 98%. Such a saving may have profound impacts on the viability of medium- and long-term projects, especially when they are reliant on volunteer trap operators. Daily checks become repetitive and boring, particularly when the traps rarely catch anything, leading to loss of enthusiasm and eventually a high degree of personnel turnover (Beirne and Lambin 2013). In contrast, when trap visits are infrequent, and usually involve the capture of an animal, volunteer motivation and retention are high.

The reduced burden of trap checks may also mean that traps will be left active when otherwise they would be closed due to lack of available manpower. The traps become silent sentinels, operating for long periods with little or no investment of human resources, yet always alert to catch a passing animal and to communicate the news of that event rapidly and reliably. In this way, the average number of animals caught in an electronically monitored trap can be expected to exceed that of an unequipped trap. A closed trap cannot catch anything. Reducing the number of trap visits may also increase trapping efficacy when the quarry species is sensitive to human disturbance or odour.

Approximately 9% of the alarms sent and received in this study were false positives, i.e., the trap door was found not to have closed. In a few cases, this was due to the door being held up mechanically after the trap had tripped (e.g., by a twig that had been washed inside the trap), so the animal activating the trap treadle was able to escape. This had nothing to do with the monitoring device. In the majority of cases, it was clear that the trap had not been tripped; the alarm had been triggered because the magnet had moved from its allotted place on the RMD housing. Evidence, including video clips from trail cameras pointed at the traps, indicated that this was due to interference from mammals or birds in most cases. By placing the RMD on top of the trap, such that the magnet and cable were protected from interference by the tunnel roof, this problem was greatly reduced. By the end of the study, fewer than 5% of alarms were false. Using a magnet to initiate the sending of an alarm, as both types of device did in this study, is not without its problems. It is, however, simple, inexpensive and extremely reliable in avoiding a false negative (i.e., failing to report a door closure). With careful trap placement and good design of the trap housing, false positives can be reduced to almost inconsequential levels.

In summary, cage traps fitted with an electronic monitoring device can, and should, yield better animal welfare and more captures than a trap without such a device, at a greatly reduced cost in terms of trap visits. These advantages, which become ever greater as the abundance of the quarry diminishes, could plausibly bring success to a pest eradication campaign that would otherwise fail due to the huge and costly effort required to deal with the last vestiges of the target population.

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Data Availability On request from author.

Declarations

Conflict of interest None.

Ethical approval The trapping reported on here was carried out in the UK and conformed with UK law.

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