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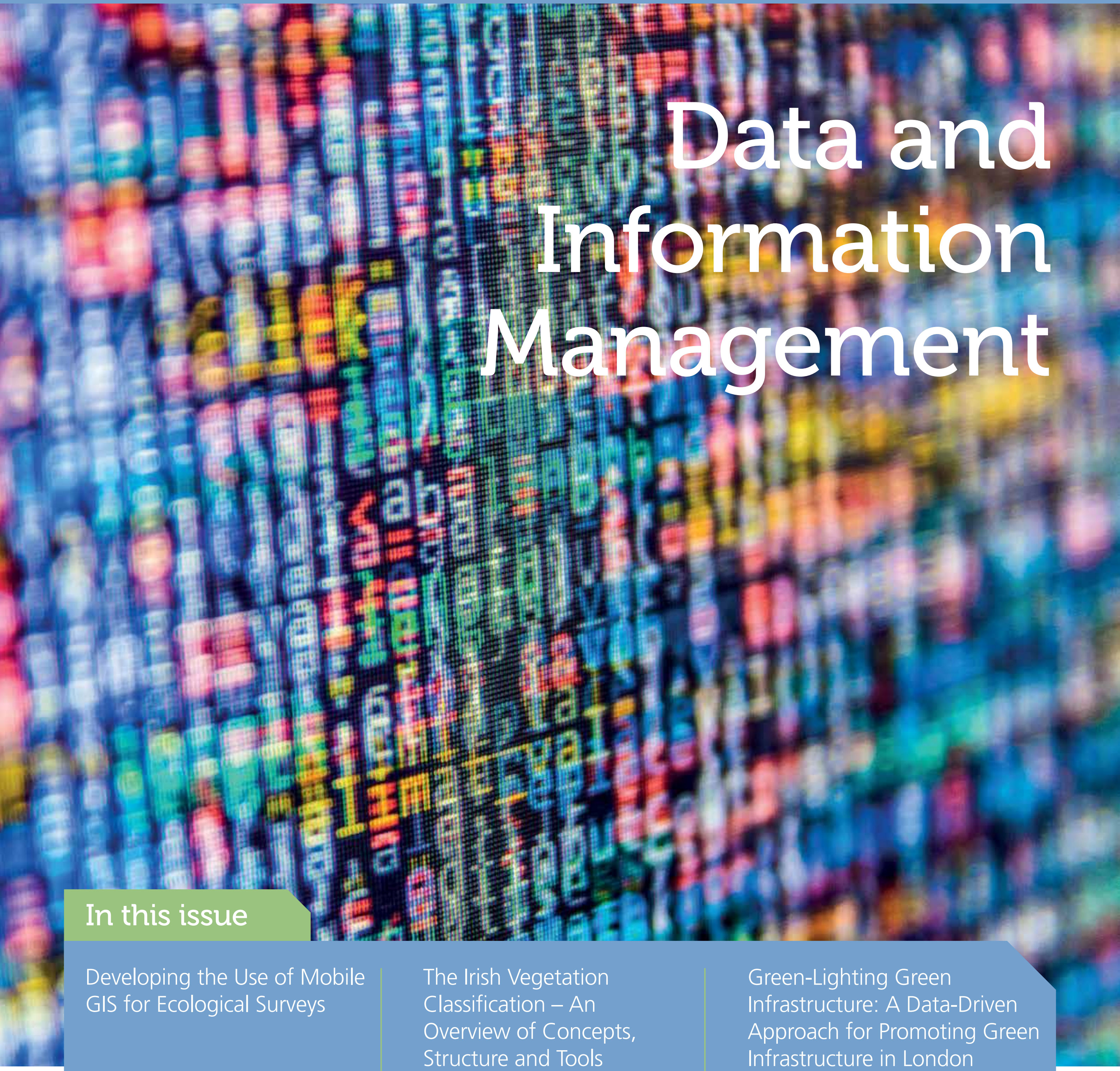

Data and Information Management

In this issue

Optimising Camera Trap Data Quality at Mammal Resting Places

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Image from video of otter visiting a resting site. Copyright CC-BY-4.0.

A thorough understanding of how camera traps function is essential for ensuring correct set-up and quality of data. We illustrate the challenges through a case study of camera trapping an otter *Lutra lutra* resting and breeding place. Appropriate survey design, such as using multiple cameras, decreasing the distance between camera and otter holt entrance, and camera trapping for sufficient duration, is likely to reduce the propensity for false negatives and increase our ability to correctly identify and protect mammal resting places.

Introduction

Data quality is important for best practice. It should be optimised pre-survey, via a careful sampling design and well-designed data entry protocols, and via post-survey quality control. This relies upon knowledge of how the tools we use function in order to identify any bias or limitations to the data collected. It is crucial to ensuring that the data we collect actually represents the real world. This includes camera traps, a popular remote-sensing technology used within our industry.

Based on recent research, we discuss the broader issue of data quality when using camera traps for ecological survey, and the specific use of camera trapping to identify mammal 'resting/breeding places', protected by the Habitat Regulations. These regulations protect such sites from damage and prohibit disturbance to animals when they are occupying such sites.

We focus particularly on false negatives and how these relate to camera trap function and survey design. Finally, we provide recommendations for ecologists to improve camera trap data quality.

False positives and false negatives in the context of mammal resting places

An immediate hurdle to data quality when identifying resting or breeding places is that these terms are not strictly defined and apply to species with widely different behaviour. Guidance from the EU (European Commission 2017) describes breeding places as *'areas needed to mate and… give birth'*. Resting places are described as *'areas essential to sustain an animal or group… when they are not active…'* and *'required for: resting, sleeping or recuperation… hiding, protection or refuge'*. The guidance also states that *'resting places that are used regularly, either within or between years, must be protected even when not occupied'*. However, these descriptions still leave room for ambiguity. How can we know if our data reflect the real world if the real world is not well defined?

For protected species that use a structure in which to rest or breed (holts, dens, setts), it's ostensibly simple: we locate a potential site (perhaps based on field signs), deploy a camera trap facing its entrance(s), and confirm/refute use based on recordings. In certain circumstances this can give a clear result: a lactating female regularly rests and collects bedding or an animal enters then exits some time later. In this scenario we can clearly confirm a structure as a breeding or resting place, a true positive (Table 1a).

	The structure is a resting place	The structure is not a resting place
Identified as a resting place	(a) **TRUE POSITIVE** BENEFIT: Legislative compliance and biodiversity protection	(b) **FALSE POSITIVE** COST: Erosion of duty to provide accurate information
Not identified as a resting place	(c) **FALSE NEGATIVE** COST: Erosion of duty of legislative compliance and biodiversity protection	(d) **TRUE NEGATIVE** BENEFIT: Legislative compliance

Table 1. Possible outcomes when identifying structures as 'resting places' for mammals. There are costs to both false negatives and false positives.

Inevitably, grey areas exist. What if the target species is only seen outside the structure, or just entering – is this a 'resting place' that deserves protection or could it be a false positive (Table 1b)? Does it matter if we misidentify breeding/resting places? We will be more likely to protect real sites overall, but false positives may present a more insidious harm to our profession. The data that ecologists use for advice and decision-making must be of the best quality and have the highest integrity. We must be seen to be balanced and to avoid restricting economic activity based on scant evidence and loose application of legislation (see CIEEM Code of Professional Conduct point 4). By contrast, false negatives (Table 1c) are clearly harmful. Failure to identify a site that should be protected risks un-mitigated disturbance to the target species, and failure of compliance.

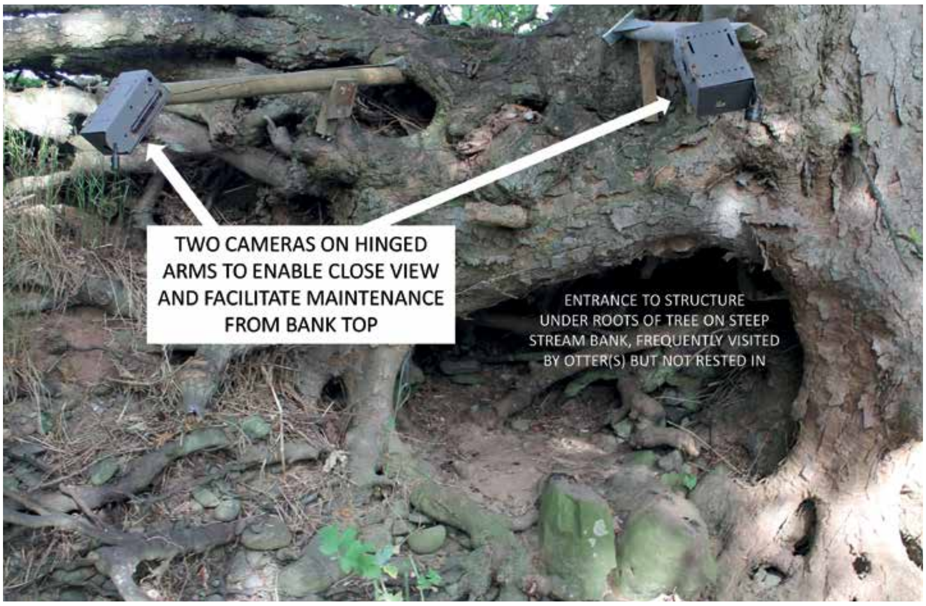
Evidence-based guidelines can help to minimise false positives and false negatives in ecological surveys but such guidance is lacking for camera trapping surveys. Specifically, there is currently an acute danger of poor data when ecologists use camera traps for identifying mammal resting and breeding places. Data quality could be improved by a more thorough understanding of camera trap function, a clear integration of such knowledge (alongside species ecology) into survey design, an adaptive approach to set-up, and robust processes of data capture from the camera trap footage.

Camera trap function and sources of false negatives

False negatives are possible at the scale of the whole survey, i.e. whether a structure is correctly identified as a breeding or resting site (Table 1), but they will be made more likely if there is a high proportion of false negatives within the data itself, i.e. an animal passes through the 'detection zone' of a camera trap, but the camera trap fails to capture it. The majority of camera traps use 'passive infrared' (PIR) sensors. An accessible guide to understanding how these function can be found in Welbourne *et al*. (2016).

The surface of every object emits infrared (IR) 'heat' radiation, including animals and their environment. A camera trap's Fresnel

Concealed camera-traps monitoring an otter holt. Copyright CC-BY-4.0.



Set up to elevate cameras from water levels during spates. Copyright CC-BY-4.0.

lens focuses infrared onto two elements in the PIR sensor. When an animal passes through the detection zone, this usually leads to a change in infrared received by the elements in the PIR sensor, warming one element more than the other and creating a signal which can trigger the camera. However, in some circumstances, an animal may emit a similar amount of infrared to the background (e.g. cold-blooded reptiles, mammals in a warm environment, mammals whose surface is particularly cold) and can generate false negatives by not triggering the sensor. This has been observed in semi-aquatic mammals such as otters, whose body surface temperature may be similar to the background when exiting water (Kuhn and Meyer 2009) and therefore may not trigger a PIR camera (Lerone *et al*. 2015).

The 'detection zone' of the PIR sensor should not be considered to be a fixed zone with a discrete boundary. At a given distance, detection may be higher if the animal is closer to the centre-line (Rowcliffe *et al*. 2011), while an animal is less likely to trigger the PIR sensor the further it is away (Howe *et al*. 2017). This distance effect can vary widely between species, and may depend on context (wet/dry, background temperature, vegetation density) and within species. Distance and angle are therefore variables which affect the probability of a false negative.

Camera traps are so called because they 'capture' images of animals. Capture relies on more than just the camera being triggered. The signal from the PIR sensor has to activate recording via control circuits, which takes time. This delay (often called 'trigger speed' or 'latency') can also generate false negatives. The locations of a passing animal at triggering and subsequently at the initiation of recording may differ; the latter may be outside of the camera's field-of-view! Camera trap users will know that footage frequently records no animals ('false triggers'). These could be true negatives (e.g. waving vegetation or sunlight), but may also be false negatives. Ongoing research using CCTV will help to determine which factors influence false-negatives.

There are trade-offs when selecting between still images or videos. Stills have faster trigger speeds reducing false negatives for fast-moving animals. The advertised trigger speed for a camera will usually represent stills, not video. However, videos can yield more data on behaviour/activity, and give multiple angles, aiding individual identification or sexing. However, videos use more memory and power (if either are exhausted, the camera trap will stop functioning), and require longer processing time. These considerations become important when monitoring a busy site, or if non-target species or false triggers are frequent.

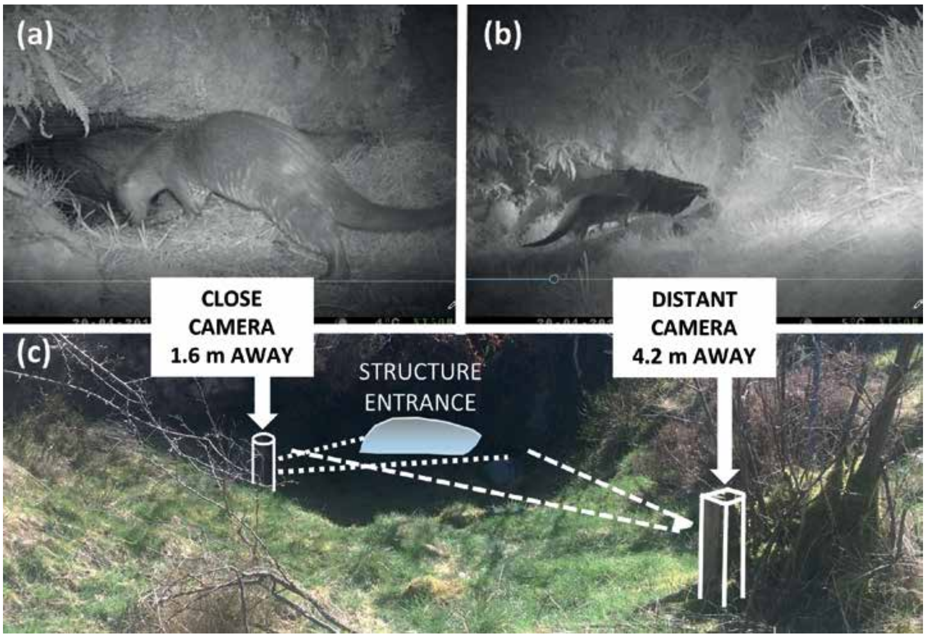
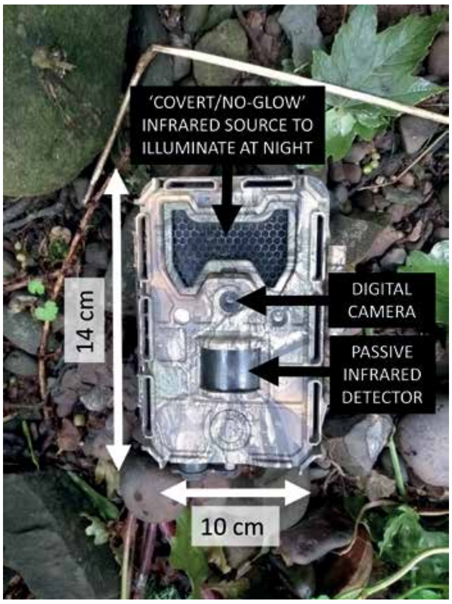


Figure 1. Camera trapping set-up of a structure in southern Scotland used by otters as a breeding and resting place, showing (a) image from the close and (b) from the distant camera traps, and (c) their locations relative to the structure entrance. Copyright CC-BY-4.0.



Bushnell Trophy Aggressor camera trap. Copyright CC-BY-4.0.

A case study from an otter breeding and resting site

Knowledge of how camera traps function is important because every potential resting site is different necessitating an adaptive approach. With the aim of generating some general principles and minimum standards, we are carrying out camera trap studies on Eurasian otters which have unpredictable denning habits making it challenging to identify resting/breeding places.

We discuss a six-year study of a structure in southern Scotland used for resting and also breeding (Findlay *et al*. 2017). The site was monitored continuously using two camera traps at different distances ('close' and 'distant') from the structure entrance (Figure 1). The initial client brief was to determine if the structure was a natal or breeding holt, but it also presented an opportunity to assess our camera trapping set-up. One of our objectives was to optimise camera set-up for data quality while recognising constraints on time and resources. Given a known breeding and resting place, could we have monitored the site less intensely (e.g. fewer cameras, shorter study duration, shorter video clips, setting a 'duty time' to reduce non-target and false triggers; see Box 1), whilst still reaching the same true positive identification as a breeding and resting site? The key findings are summarised in Box 1.

Reconciling data from multiple cameras and images

If multi-camera set-ups are more effective (Box 1), how do we reconcile these into one coherent dataset for interpretation? We developed the 'events-list' approach, an 'event' being a unit of continuous otter activity which combines the maximum data from both cameras. For example, an event could be a male otter arriving at the holt and sprainting before leaving. The close camera may record a male arriving and sprainting, but not leaving, while the distant camera may not provide data on sex or record arrival and sprainting, but may record the animal leaving. Using one or other of the recordings would provide incomplete data, but the combined data informs a complete event and reduces false negatives. A chronological list of events could then be compiled. Although two camera traps improved the number of events recorded, false negatives were still possible if both camera traps failed to record.

The 'events-list' was essential to establishing how the structure was used (Findlay *et al.* 2017). There is no published advice on how long a 'rest' has to be and we had no prior knowledge of how long otters might remain in the structure. By examining paired entry-exit 'events', we found a striking bimodal distribution for this site (Figure 2).

Box 1. Summary of key practical findings from a long-term camera trap study of a confirmed Eurasian otter breeding and resting place (Findlay *et al.* 2017). Camera trap positions are shown in Figure 1.

One or two cameras?

While the close camera detected a third more presences of otters, the distant camera still recorded 11% of presences that the close camera missed. We recommend using ≥ 2 cameras at different angles and distances to an entrance. If only a single camera is feasible, a closer distance is likely to reduce false negatives. We found no evidence that the camera traps (min. 1.6 m from entrance) or maintenance visits disrupted activity patterns, although there may have been habituation to these visits over time.

Duration of study?

There was a winter bias in breeding. Monitoring during May to October only would not have identified a breeding place (false negative), therefore multi-seasonal monitoring is recommended. When the structure was not being used for breeding, 5% of rests would have needed ≥ 29 days monitoring to detect. This does not account for possible habituation time at the start of monitoring. Camera trapping over 1-2 months would have been necessary to significantly reduce the probability of a false negative for resting when the female did not have young cubs.

'Duty time' of cameras?

Cameras were set to run 24 h/day, but this required viewing of much extraneous footage. 89% of all otter footage occurred between 1 h pre-sunset and 1 h post-sunrise (100% during natal periods). Setting a 'duty time' on the camera (i.e. a daily cycle of active and inactive periods), or ignoring some diurnal footage could have saved significant resources whilst minimally impacting on breeding/resting site identification.

Clip duration

Cameras were set to record 30 s videos, resulting in significant post-processing time. The most useful data (presence, sex, count, behaviour) was skewed towards the beginning of clips. In a presence-only study, very short videos, or still images, would have sufficed. Where sexing otters (e.g. to determine breeding), we could have reduced clip duration to c. 20 s (33% reduction) while only reducing the number of successful sex determinations by 5%. This could be a worthwhile trade-off given the commensurate reduction in battery-drain, memory-use and data analysis time.

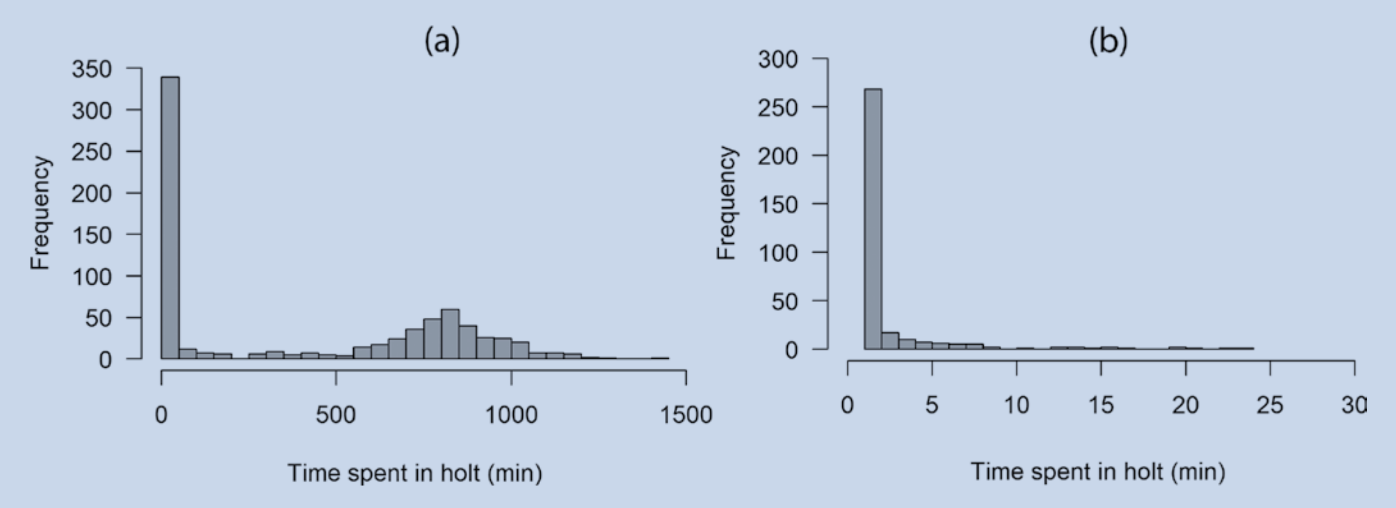


Figure 2. Frequency distributions of time spent by an otter in a holt in southern Scotland: (a) bimodal distribution of time spent in holt (n = 797), and (b) detail of the distribution in the first 30 min only (n = 425). Copyright CC-BY-4.0.

Most paired entry-exits were either < 1 min (Figure 2b) or clustered around 800 min (c. 13 hours; Figure 2a), the latter primarily representing rests through daylight. Some shorter rests did occur, and are known to be more frequent at other structures. This second peak at c.13 hours provides strong evidence that the site is used for resting. Sites not used for resting exhibit only the first peak of < 1 min as otters frequently visit structures used for resting and also those not used for resting.

Conclusions and advice for practitioners

There is considerable variation between camera trap models, and the technology is improving all the time. There are other aspects of camera trap function that impact data quality but are not discussed here (e.g. illumination type), and we would encourage attendance at CIEEM camera trap training courses. Detailed and species-specific, evidence-based guidelines are needed for ecologists using camera traps for breeding/resting place identification but some best-practice principles are emerging from recent research. Each survey site will differ and there is no one-size-fits-all sampling design, but initial recommendations include:

1. Ecologists should become familiar with their camera trap model(s). Test the trigger speed (which can differ from that advertised) for stills and videos, and trial the equipment in a dark, quiet room to ensure no red-glow or noise from the camera.
2. Cameras closer to a structure's entrance are more likely to detect animals, and multi-camera set-ups are likely to improve data quality. Where feasible, cameras should present different angles and distances to the entrance, with overlapping fields-of-view.
3. Camera trapping duration should be as long as feasible, ideally a couple of months to incorporate habituation time; trapping for just four months carries a significant risk of missing breeding activity. When resources are limited, an adaptive approach can increase efficiency (shorter clips, setting duty time, see Box 1). If breeding or resting is not confirmed, surveys should be repeated in each season.

Data quality in camera trapping resting places can only be fully optimised through a combination of evidence-based survey protocols and improved knowledge of how different species use structures to 'rest'. However, these two elements are not mutually exclusive, as improved camera trapping techniques will shed greater light on the way in which these structures are used.

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