Field protocol for camera trap surveys with camera calibration for measuring animal positions for unmarked density estimation

Background

The random encounter model (REM), camera trap distance sampling and related methods for estimating the density of unmarked animals require data on animal positions relative to camera in order to estimate camera detection zone size and (for REM) animal speed of movement. These positions can be efficiently estimated using a computer vision process based on mapping image pixel positions to real world ground positions relative to camera. This "map" can then be used to estimate the positions of animals in images with minimal effort. To create the map, images of calibration poles are required at each camera deployment in the field. This protocol sets out field methods for generating the necessary calibration images.

Survey design and set up

Unmarked camera trap density estimation methods require representative sampling, placing cameras randomly with respect to animal movement. This is best achieved by preselecting camera deployment locations using computer-generated random points. Usually these points should be in a systematic grid with fixed spacing between them across a defined study area (if you don't have the necessary GIS skills in your team, this web app provides an accessible tool for doing this: https://marcusrowcliffe.shinyapps.io/mapping).

In cases where the study area covers more than one clearly distinct habitat, and especially when animals of interest are strongly attracted to a relatively rare habitat, it may be useful to stratify your grid, selecting a similar number of points in each habitat, rather than planning a single consistently spaced grid across the whole area.

Survey designs that CANNOT be used to estimate the density of unmarked populations include preferentially placing cameras on animal or human trails, targeting spots preferred by the animals such as water sources, mineral licks or high value foods, and using bait to attract animals. Using unmarked density estimation analysis on data gathered in these ways will give results that are biased to an unpredictable extent, and therefore of no value.

In the field, find or make a suitable attachment point for the camera as close as possible to the computer-generated point. If using pre-existing attachment points (rather than placing your own), this will almost inevitably require moving away from the computer-generated point to some extent. When choosing a location away from the computer-generated point, keep in mind the microhabitat in which it fell and aim to place the camera in the same habitat. Do choose a camera viewpoint with sufficient open ground to give some prospect of clear animal images, but resist the temptation to choose spots that seem good for animals when doing this. To the extent possible, point cameras at ground that is reasonably even, not extremely rough.

Making calibration poles

Take a straight, strong pole (e.g., PVC electrical tube) at least 1 m in length, and mark it in a durable way with bands in a contrasting colour, e.g. white duct tape on a black pole (Fig. 1). Place five bands at 20 cm intervals from one end, from 0.2 to 1 m. Indicate height by adding additional bands below the height marker, with the number of bands indicating height increment, so that 1 band = 0.2 m, 2 bands = 0.4 m etc.

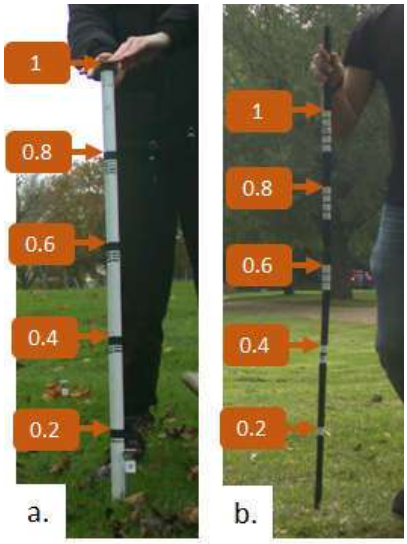

Fig. 1. *Two examples of calibration poles. The top of each group of bands is at a known height above ground at 20 cm intervals. Heights above ground are indicated in metres, with the number of bands in each group indicating the height increment.*

Taking deployment calibration images

Carry out the following procedure at each deployment:

1. Set up the camera firmly to minimize risk of subsequent movement, and in position ready to capture wildlife images. Switch it on ready to trigger photos.

2. Starting about 1m directly in front of the camera, hold the pole with its base on the ground so that it is clearly visible to the camera. Take care to ensure that the pole is held perpendicular to the camera's line of sight. On level ground with camera line of sight roughly parallel to the ground surface, the pole should be roughly vertical, but if the camera is angled to observe a slope the pole may need to be tilted accordingly (see Fig. 2).

3. Hold the pole still long enough to ensure a clear image (generally 5-10 seconds). In order to indicate when the pole is resting on the ground, give a distinctive hand gesture when this is the case. For example, in Fig. 1a, the pole is held by pressing on the top with outstretched fingertips. Closer to the camera, the pole top may not be visible, so it may be

necessary to signal lower down, for example with a clenched fist held next to the middle of the pole.

4. Repeat this for further pole placements across the field of view and away from the camera, with placements spaced about 0.5 m apart. Continue away from the camera to the maximum extent that any animals are likely to be captured, or if possible a bit beyond. As you reach greater distances, it may help to have a second person next to the camera to keep it triggering.

Note that if the camera position is moved, even slightly (for example when checking batteries), the calibration process should be repeated for that deployment. If possible it should also be repeated when removing the camera, as well as when setting and checking it.

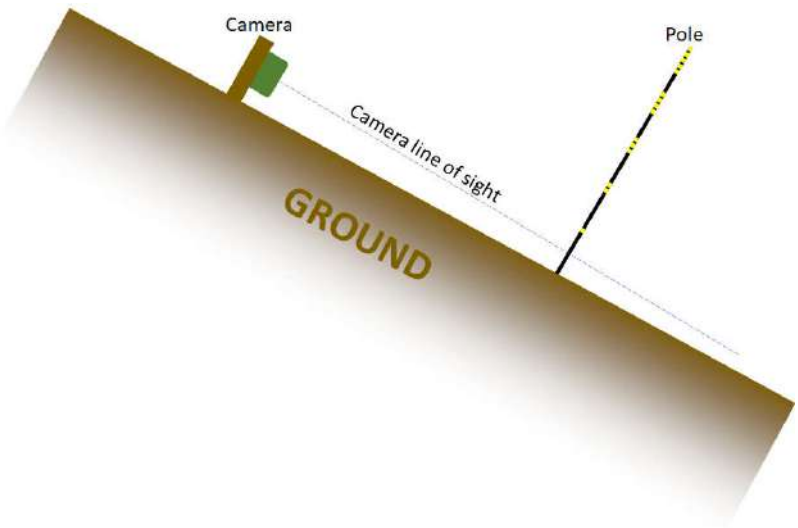

Fig. 2. *Diagram illustrating a camera set up to observe sloping ground, and the orientation of the calibration pole required to keep it perpendicular to the camera line of sight. Orientation can be judged by eye, and need not be measured precisely in the field.*

Training and trialing

Before going to the field, it is important run trials of the deployment calibration process. Complete the deployment calibration process described above (Taking deployment calibration images) in a convenient location and inspect the images. Check that you have taken at least 10, and ideally 20 or more useable images of the pole resting on the ground, distributed reasonably evenly across the surface visible to the camera, ranging from very close (1 m or less) to at least as far as the furthest distance you expect to record animals. Fig. 3 shows an example of a good set of calibration pole images for a deployment. If at first you don't obtain enough useable images, or your coverage of the detection zone is poor, modify your process to obtain a better set of images, for example by waiting a little longer at each pole placement, or taking more pole images at greater density. Do this with your deployment team to ensure that all team members understand the process fully.

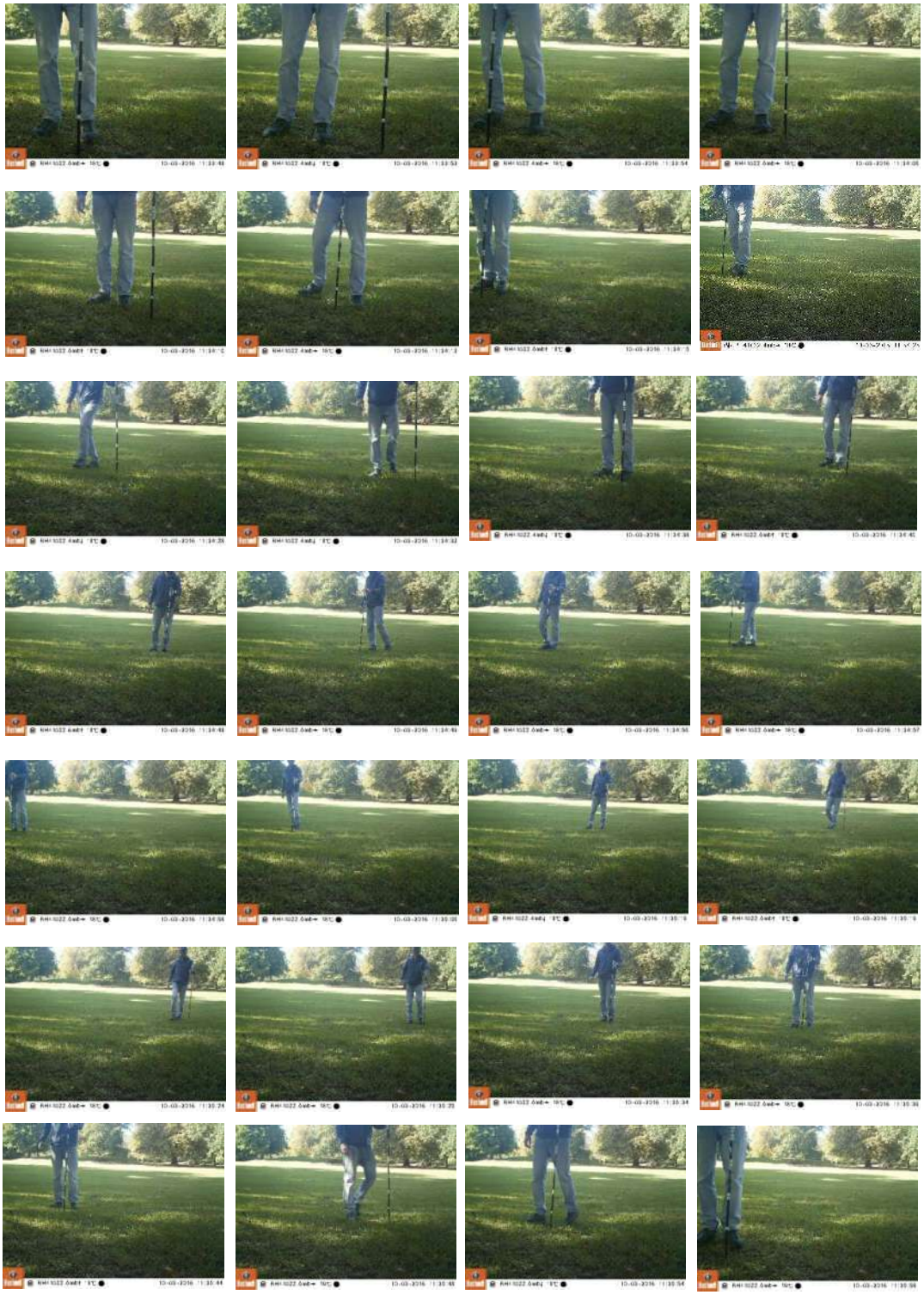

Fig. 3. *A set of deployment calibration images showing 28 pole positions with good coverage of the detection zone.*

Taking camera calibration images

The goal is to take pictures of objects of known size at a range of known distances from the camera to calculate the camera model's intrinsic properties, which then allow us to calculate the distance of calibration poles in deployment calibration. This needs to be done for each combination of camera model and image resolution setting used in the field. It's best to keep image resolution consistent throughout deployments; if you do this, and use a consistent camera model, you only need to calibrate one camera, once. The steps are as follows:

1. Set up the camera in a convenient location in front of a level surface, either indoors or outside.

2. Mark out nine positions at a range of radial and angular distances from the camera, measuring the distances from camera accurately. Fig. 4 gives an example of placement positions, with poles at three distances (1, 2 and 4 m), and a range of angles. It's not necessary to measure angle, but it should be variable, and within the camera's field of view (usually about 20 degrees either side of the midline), but you may need to check the field of view for your camera.

3. With a camera positioned in front of the arena and switched on, take images of a calibration pole (making instructions above: Making calibration poles) at each position on the array, holding up some visible marker of the distance. For example, in Fig. 5, the pole is placed at 2 m from the camera, with distance indicated in metres by the number of fingers displayed. As in the deployment calibration process, care should be taken to hold the pole perpendicular to the camera's line of sight.

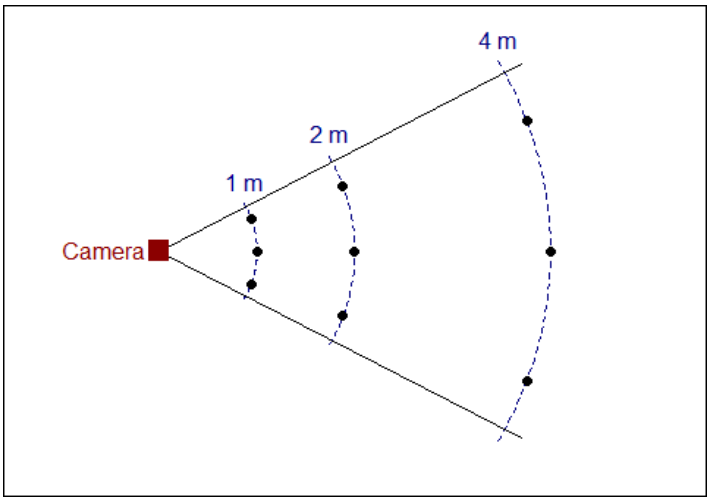

Fig. 4. *Plan view of an example layout for a camera calibration pole grid.*

Fig. 5. *A camera calibration image with pole in position 2 m from the camera.*

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April 2022