



# Camera trap surveys can reveal the dynamics of deer “hotspots” in Ireland



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## ABSTRACT

Systematic camera trap surveys are important for gathering information on terrestrial wildlife. Such surveys reveal distributions, abundances, and behaviours that can inform conservation and wildlife management by providing evidence of animal presence at known locations and times. However, in Ireland, international-standard camera trap surveys have not been undertaken to inform the management of large terrestrial wildlife. Through participation in a continent-wide initiative (Snapshot Europe) with a shared methodology, we undertook Ireland’s first systematic camera trap survey for large mammals over a two-month period in 2021 in a known deer “hotspot” - central Wicklow, Ireland. We captured eight wild mammal species from 19 forest camera trap sites. Sika (*Cervus nippon*) or sika-red deer hybrids (*Cervus nippon* × *Cervus elaphus*) were detected at all sites and comprised 92% of all independent camera trap events of wild mammals. Sika (and hybrid) events occurred at an average rate of 1.1 events per site per day. Females were more often detected than males (male:female = 1:1.42). We also noted that most females were not accompanied by juveniles (female:juvenile = 1:0.31). Overall, we demonstrate the efficacy of even this exploratory survey for revealing wildlife dynamics and generating data for science-informed management and conservation. We recommend that further surveys should be carried out across Ireland to achieve minimum international standards for monitoring terrestrial wildlife.

## INTRODUCTION

Camera traps (i.e. game/trail cameras) are remote-operated tools primarily purposed with recording wildlife (mammals, birds, reptiles, amphibians) while minimising disturbance. They have numerous advantages over manual observation methods, such as continuous recording throughout the day (Wearn and Glover-Kapfer 2019). When following systematic approaches applied across many systems and species, they provide powerful spatial and temporal data for inference about populations (Palencia et al. 2021; Rowcliffe et al. 2008) and behaviours (van Beeck Calkoen et al. 2021). An interesting paradox to the extensive use of camera trap surveys globally is the absence of systematic camera trap surveys for large mammals in Ireland in the scientific literature. This encourages a glaring divergence between Ireland and the rest of Europe regarding wildlife management and conservation - especially true for larger mammal species that are often prone to coexistence

issues while simultaneously being of conservation priority (Linnell et al. 2020). Deer are important species ecologically, economically, and culturally in Europe. Either red deer (*Cervus elaphus*), sika deer (*Cervus nippon*), or fallow deer (*Dama dama*) can be found across most of Ireland (Carden et al. 2011). They now comprise Ireland’s largest extant terrestrial wildlife, yet there is no coordinated national management plan for deer in Ireland. Red deer are typically considered native to Ireland and stemming from their ancient Neolithic introduction is a single population of conservation importance, yet the total population has seen numerous modern introductions from continental European and British stock (Carden et al. 2012; McDevitt et al. 2009). Subsequently, fallow deer became established after their introduction during the post-medieval period (Beglane et al. 2018).

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Sika were first introduced to Ireland for hunting and ornamental purposes in 1860 to Powerscourt Estate, Wicklow (close to our study area), but then escaped captivity and established a wide distribution (Carden et al. 2011; Morera-Pujol et al. 2022). They have hybridised with red deer (Senn and Pemberton 2009) since their Irish introduction, with genetics revealing a substantial proportion of deer in Wicklow are hybrids (McDevitt et al. 2009; Pérez-Espona et al. 2009; Smith et al. 2014). Sika are classified as a “high impact alien” species of “multi-state concern” in the Europe Union (European Commission 2020; EASIN ID: R03227) and listed as an established, highly invasive species according to the National Biodiversity Data Centre (National Biodiversity Data Centre 2022). All deer at high densities can exert pressure on agriculture, forestry, and conservation areas

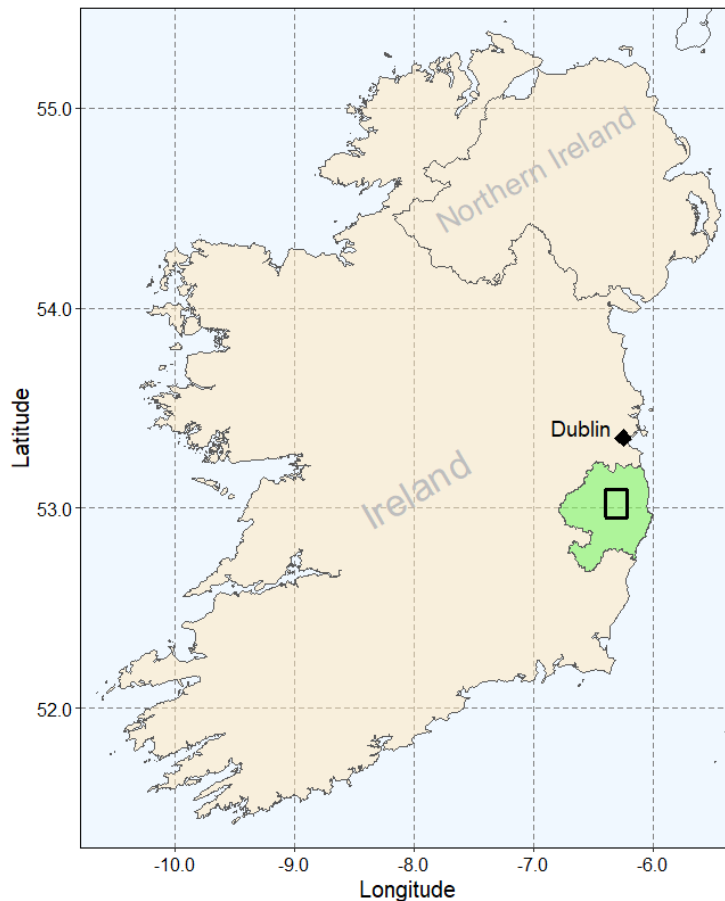
(Reimoser and Putman 2009), exacerbated in Ireland’s highly modified landscapes where all native predators of adult deer have been eradicated (Hickey 2000). Research on deer in Ireland is scarce despite their importance as Ireland’s largest native/alien mammals, and the need for monitoring of harvested species for both population control and food. Compounding this are the unquantified patterns of abundance, distribution, and behaviours of other terrestrial mammals in Ireland. In this study, we aimed to apply an international-standard camera trapping methodology in Ireland to demonstrate its data collection efficacy for science-informed conservation and management. Our results examine deer dynamics and can be built upon for future monitoring of Irish mammals.

## METHODS

We deployed camera traps as part of the Snapshot Europe project, with the goal of simultaneously (during September and October 2021) surveying wildlife across Europe with camera traps using a shared methodology (see supplemental for the full Snapshot Europe Methodology). Our survey area was a known deer

“hotspot” - central Wicklow, Ireland (Figure 1), and encompassed private and public forested land. The survey area borders the Wicklow Mountains National Park. Before deployment, we contacted landowners for permission to place equipment.

**Figure 1. The location of our study area (black rectangle) in central County Wicklow (green polygon), Ireland – a known deer “hotspot.”**



At the start of each month, we deployed Browning Strike Force HD MAXPLUS camera traps at 20 sites from 3<sup>rd</sup> September until 10<sup>th</sup> November 2021. One camera trap failed completely and was not considered in analysis. We first identified forest habitats using maps and then navigated to a suitable trail (where animals may easily pass) to place a camera trap. We spaced monitoring sites such that the distance between them was larger than our

estimate of the radius of a sika female home range (less than 1 km<sup>2</sup>). The minimum distance between sites was 607 m and the maximum was 1807 m (median = 923 m). We monitored each site for a minimum of 28 days up to a maximum of 39 days (median = 37). We oriented camera traps north ( $\pm 10^\circ$ ) at a height of 50 cm parallel to the ground and without bait. They recorded at all times and took rapid-fire bursts of three photographs with the fastest

possible recovery time.

We classified camera trap data using the Wildlife Insights platform ([www.wildlifeinsights.org](http://www.wildlifeinsights.org)). Before uploading data, we used featureless shapes as placeholders over human images. On Wildlife Insights, photographs within one minute of one another from the same site were concatenated into sequences. Within each sequence, we identified the species to the highest taxonomic resolution possible, as well as relative sex and age class. We classified deer based on their phenotypic appearance (i.e. sika phenotype, hereinafter “sika”; or red deer phenotype, hereinafter “red deer”), since external visual appearance alone cannot reveal the degree of hybridisation of the individual (McDevitt et al. 2009).

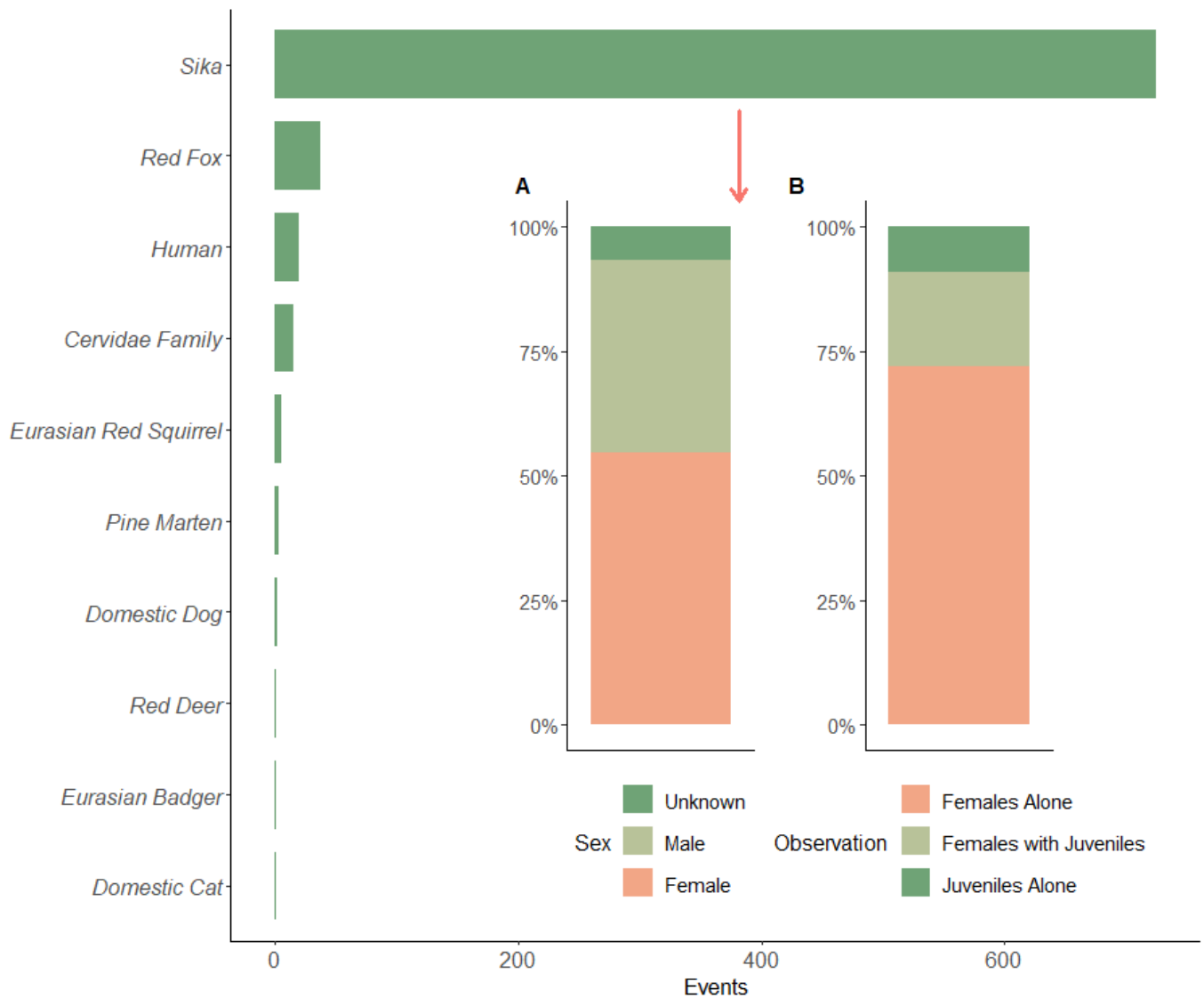
We conducted data analysis on classified sequences in R version 4.0.2 (R Core Team 2021). To ensure temporal

independence, we removed subsequent one-minute sequences of the same species at the same site with a time difference of less than 30 minutes using the *assessTemporalIndependence* function from the package *camtrapR* (Niedballa et al. 2016). We tallied these independent sequences as “events” per site and per species detected. To analyse female:juvenile deer ratios, we used the original one-minute sequences from Wildlife Insights to keep sequential events of female-juvenile pairs.

As sika were the most observed, we examined key demographic parameters: a) the male:female ratio and b) the female:juvenile ratio. We also quantified the rate of detection per sex and averaged across the whole study for each camera trap site.

## RESULTS

**Figure 2. Counts of mammal species events across all camera trap sites. From the sika detections (n = 725), we broke down the proportion of (A) male:female and (B) female:juvenile events to examine demographics.**



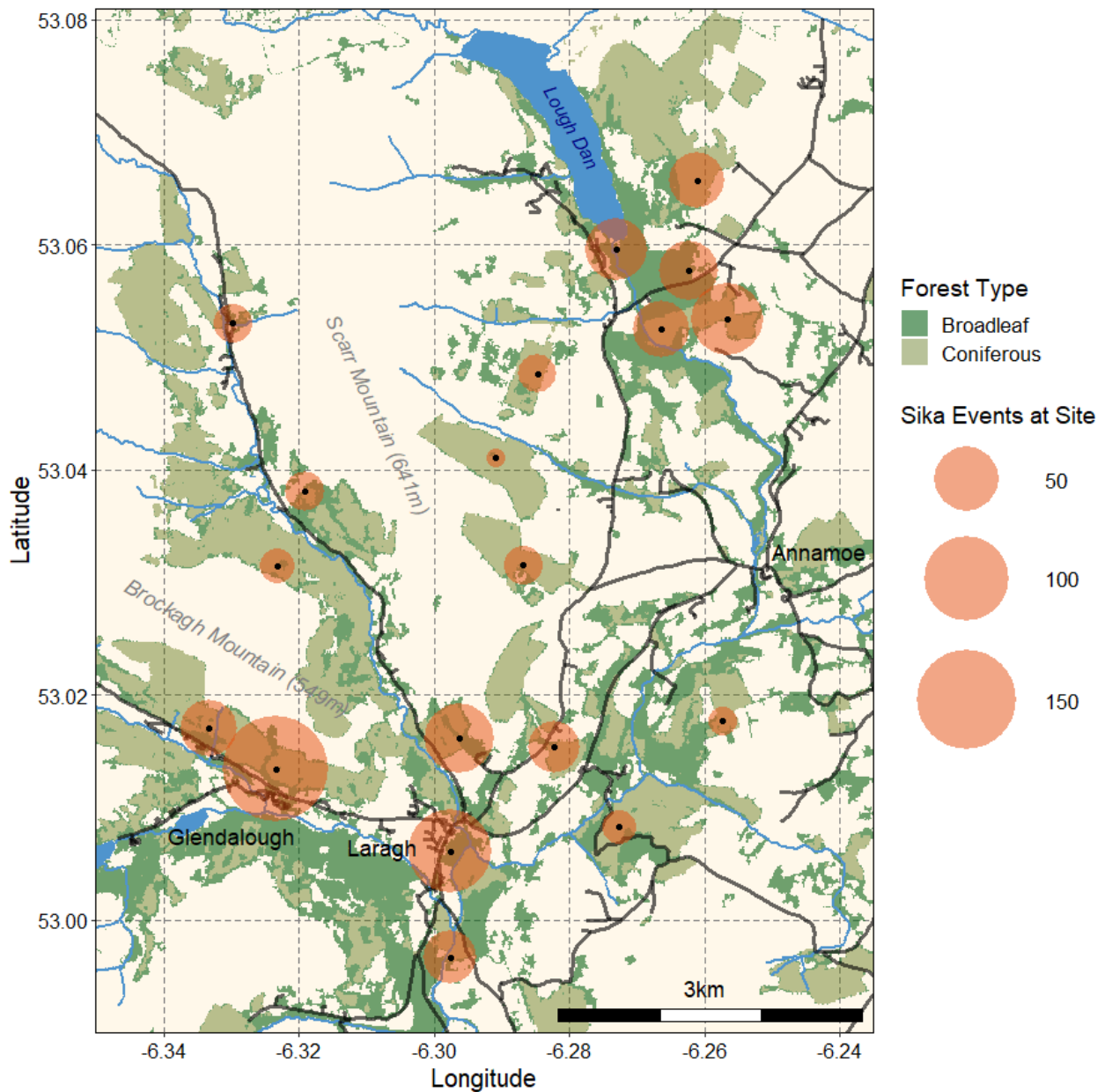
From 19 camera trap sites, we collected 9729 photos over 643 camera trap days. We detected 8 wild mammal species (Figure 2) and recorded 725 independent sika events during the study, 92% of all events. We detected sika at all camera trap sites (Figure 3). The number of

sika events was nearly 20 (19.6) times higher than the next most common species, red fox (*Vulpes vulpes*), with 37 independent events. There were 15 events of unknown cervids. There were also five red squirrel (*Sciurus vulgaris*) events, and three pine marten (*Martes*

*martes*) events. Domestic animals were rarely detected, with just two dogs (*Canis lupus familiaris*) and one cat (*Felis catus*) event. Eurasian badger (*Meles meles*) was

only detected once, and there was only a single phenotypic red deer event (Figure 2; Figure S1).

**Figure 3. The study area and camera trap sites (n = 19) in central County Wicklow. Each site was monitored for 28-39 days and counts of sika events per site are depicted by the bubble size.**



The majority of adult sika events we recorded (Figure 2A) were female (326, 54.7%), compared to a lower number of male events (229, 38.4%). Sex for some sika was indiscernible (41, 6.9%). The male:female ratio was 1:1.42. We also noted most sequences of sika females were without juveniles (342; Figure 2B). Females with

juveniles accounted for a smaller proportion of sequences (89), while juveniles alone accounted for the minority (44). We estimated that the female:juvenile ratio based on these data is 1:0.31. Across all camera trap sites, the rate of all sika events was 1.1 events per day, with 0.37 events per day for males and 0.52 for females.

## DISCUSSION

By utilising an international methodology, we demonstrate the efficacy of camera traps for monitoring mammals in Ireland for the first time, particularly in areas of abundant deer. As the first systematic camera trap survey of its type, our study collected data on multiple species and established a rate of detection, male:female ratio, and female:juvenile ratio of sika in central Wicklow. Our most striking result is the severe skew of events between sika and other species. Despite the locality

being considered a deer “hotspot,” the proportion of events relative to all other species is distinctly high compared to similar studies, where species like red fox are proportionally more common (e.g. in Poland, Belarus, Ukraine, A. F. Smith unpublished data 2022; Germany, Czech Republic - Henrich et al. 2021; Norway - Hofmeester et al. 2021; Italy - Oberosler et al. 2017). In Wicklow, sheep farming and management for ground nesting birds may reduce fox numbers through lethal

control. However, we believe the skew probably reflects local sika over-abundance rather than low fox abundance, because the number of other mammal events were also considerably fewer. While we did not attempt to calculate the density of sika here, indices of abundance from camera traps are often positively and linearly correlated with density (Kinnaird and O'Brien 2012; Rowcliffe et al. 2008). Further camera trap work may move towards density estimation (Palencia et al. 2021).

We demonstrated camera traps can reveal deer demographics in Ireland. Our female:juvenile ratio is lower but not dissimilar to ratios in sika studied by Kaji (2005) and Ikeda et al. (2013) in Japan, nor for red deer calculated by Henrich et al. (2021) in the Bavarian-Bohemian Forest. Female sika can breed as yearlings, yet the high reproductive rate in sika is thought to be offset by juvenile mortality of about 30-40% in the first year (Putman 2009), which may also be linked to local deer densities (Ciuti et al. 2015) and requires further monitoring. Similar to other studies, our sika sex ratios are female skewed (Ikeda et al. 2013; Kaji et al. 2005), but it is unknown whether nature or hunting determine this. Since the sika rutting period cut through our survey, the increased movement of male cervids (Heurich et al. 2016; Ikeda et al. 2013) may over-inflate the detection rate, meaning more male events than other seasons. We detected only one "red deer" during the study, matching genetic sampling from Smith et al. (2014) who found no "pure" red deer in Wicklow, stressing conservation concerns (e.g. competition, hybridisation) faced by Ireland's largest terrestrial mammal. Though

controversial, local extermination or drastic reductions of non-native sika or hybrids may be possible with considerable effort and ambition, allowing the possibility of locally restoring native, red deer for their conservation and sustainable use into the future while maintaining the importance of Ireland's island biogeography.

As sika are an invasive but valuable game species, cultural and ecological management goals are best guided by systematic monitoring (e.g. camera trap surveys), which simultaneously allows adaptive management (Nagy-Reis et al. 2021) and aligns with the objectives of European hunters for managing invasives (Monaco et al. 2013). Since even a single male sika can sire multiple offspring, targeted hunting towards females has been suggested as the fastest way to reduce density over time (Brown et al. 2000) but is not without caveats (see Simard et al. 2013). Such management approaches are haphazard without similar data to that we collected. Camera trap surveys should be expanded in Ireland seasonally and with additional locations in order to inform mammal conservation and management in Ireland. While hypothesis-driven surveys will approach specific questions, "Snapshot-style" surveys also have demonstrable value (Cove et al. 2021). Likewise, citizen-science platforms like MammalWeb (Green et al. 2020) provide opportunities for anyone in Ireland to upload camera trap data, allowing for low-cost, extensive monitoring. These tools and minimum standards of best practice are important to embrace now for monitoring terrestrial Irish mammals and science-informed conservation and management into the future.

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## SUPPLEMENTAL

### Snapshot Europe Protocol

1. Each collaborator selects one combination of setting (Urban, Suburban, Rural, Wild, Other) and habitat (agricultural areas, artificial non-agricultural vegetated areas i.e. gardens and parks, shrubby vegetation, pastures and natural grassland, forest, open areas i.e. beaches, burnt areas and glaciers, wetland) to focus on when deploying camera traps.
2. Between 7 and 40 camera traps will be deployed across 10 to 50 locations matching the selected setting-habitat combination. The location, start date, end date, and camera make and model for each deployment must be recorded.
3. Collaborators can use any model of camera that has:
  - a. has IR (infrared) flash.
  - b. has a trigger speed less or equal to 0.5 seconds.
  - c. can fire a burst of pictures without delay between a trigger and the next. Cameras must be set in rapid-fire mode and take, at a minimum, 3 images per burst.
4. Cameras should be placed so that they are 50 cm off the ground and with regular orientation.
5. The deployed cameras must be at least 200 metres away from other cameras (but no farther than 5 kilometres).
6. No food bait or scent lure must be used.
7. While cameras can be placed on trails or logging roads, this must be indicated by the collaborator.
8. Once field work is complete, the collaborator will upload images and metadata to Wildlife Insights.

**Figure S1. The single “red deer” phenotype detected from the camera trap survey effort in central County Wicklow. Image saturation is 125% for clarity.**

