Articles

Using camera traps to assess mammal and bird assemblages in a midwestern forest

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Abstract

Ecologists are increasing the use of remote technologies in their research, as these methods are less labor intensive than traditional methods and oftentimes minimize the number of human errors. Camera traps can be used to remotely measure abundance and community composition and offer the potential to measure some phenotypic traits, such as body size. We designed a camera-trap setup that enabled us to capture images of both large and small animals and used our camera-trap design to investigate the community

composition of mammals and birds and to estimate the biomass of mammals along two transects in a conservation reserve in Missouri. One transect ran from the edge of an agricultural field to an upland forest and another from the edge of a wetland to an upland forest. Over the 4.5-week study, our cameras recorded 2,245 images, which comprised 483 individuals of 16 species of mammals and birds. Coyotes and armadillos were unique to the riparian transect, as were several bird species. Fewer species use the forest immediately adjacent to the agricultural field, but more species use the forest immediately adjacent to the wetland. Biomass estimates from our camera trap images were similar to published accounts. This is the first study we are aware of to use camera traps to successfully estimate biomass. We show that the value and utility of camera traps in wildlife studies and monitoring can be expanded by a) using multiple cameras at different heights from the ground so as to capture different sized animals and b) obtaining phenotypic information of the captured animals.
Keywords: diversity, edge effects, species composition, biomass, riparian, agriculture

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Running Heading: Mammal and bird assemblages in the midwest

Introduction

As anthropogenic activities modify and degrade habitats, landscapes are transforming into a mosaic of natural and human-modified habitats (Lambin et al. 2001). For example, more than 75% of naturally occurring deciduous forests in eastern and midwestern North America were cleared by 1850, primarily for agriculture (Stein et al. 2000). This conversion of native forests has increased habitat fragmentation (Demers et al. 1995; Stephens et al. 2013), isolated populations that were historically connected genetically and, thus, increased

inbreeding depression (Mills 1995; Keller and Waller 2002). Increased fragmentation has also produced more field-forest edges, increasing the negative impacts of edge effects on forest interior species (Hargis et al. 1999; Gehring and Swihart 2003; Elliott and Root 2006). Changes to native landscapes affect species differently with habitat specialists often being negatively impacted by fragmentation and habitat generalists often benefiting from such changes (Humber and Hermanutz 2011).

Forests across eastern and midwestern North American contain mammal and bird species that are both adversely and beneficially affected by landscape modifications. For example, white-tailed deer (*Odocoileus virginianus*) and nine-banded armadillos (*Dasypus novemcinctus*) are both forest interior specialists (Humphrey 1974; Taulman and Robbins 1996; Lingle and Wilson 2001; Lingle 2002), and as such should be less common near agricultural fields compared to riparian areas and upland forests. In contrast, raccoons (*Procyon lotor*), coyotes (*Canis latrans*), and grey squirrels (*Sciurus carolinensis*) are habitat generalists and should be common in both forested and agricultural habitats (Spritzer 2002; Moorcroft et al. 2006; Lesmeister et al. 2015). Understanding exactly how these and other species respond to landscape changes is important for wildlife management to effectively manage these populations (Andrén et al. 1997).

Technological advancements over the past few decades have revolutionized how biologists monitor wildlife in the field. The use of motion-activated camera traps (Karanth and Nichols 1998; Silveira et al. 2003; Rovero and Marshall 2009), automated identification and tracking systems (Dell et al. 2104), and unmanned aerial vehicles (Jones et al. 2006; Vas et al. 2015) can provide high-throughput methods that vastly decrease manual labor. Camera traps enable researchers to non-invasively determine the occurrence (and even abundance) of a wide range of animals (Bondi et al. 2010; Srbek-Araujo and Chiarello 2005), including rare and endangered species (Karanth and Nichols 1998; Roberts et al. 2006; Smith and Coulson 2012). However, different camera-trap designs optimize what types of species the cameras detect (Gompper et al. 2006; Rowcliffe et al. 2011; Smith and Coulson 2012). Some designs are better for large or small animals (Gompper et al. 2006; Rowcliffe et al. 2011) and others are designed for specific species (Smith and Coulson 2012).

In addition to being able to identify species and individuals, images from camera traps can be used to estimate properties of an animal's phenotype, including traits such as

body size and condition (Kühl and Burghardt 2013). Obtaining information on body size and condition can be vital to many wildlife studies and for monitoring wildlife populations and health (Hilderbrand et al. 2000; Cattet et al. 2002; Crooks 2002). For example, the effects of habitat fragmentation can be body size dependent, as larger animals move longer distances than smaller animals and thus are more affected by fragmentation than smaller animals, which may never leave a fragment during their lifetime (Crooks 2002). However, despite this relatively easy and non-invasive way to estimate body size, we are unaware of any studies that use camera traps to do so.

In this study, we designed a camera trap array that enabled us to obtain images from large and small mammals as well as birds. We used this camera trap design to assess mammal and bird community composition along two survey transects we positioned in a local field site that had modified and natural habitat types. From the images captured by the camera traps, we estimated the number of individuals captured per day of mammals and birds as well as the body size of mammals and compared our estimates of biomass to published accounts.

Study Site

Our study was conducted at Lindenwood University's Daniel Boone Field Station, located in St. Charles County, MO (Lat: 38.652777; Long: –90.854376). This 400-ha field station maintains an annually harvested, 6.5-ha hayfield embedded within a 280-ha mixed deciduous forest dominated by black oak (*Quercus velutina*), post oak (*Quercus stellata*), and white ash (*Fraxinus americana*). Ten small forested, ephemeral wetlands with emergent vegetation are interspersed throughout the forested area, providing an important local water resource for birds and mammals during the drier summer months when we undertook our study (see below). Climate at the field station is highly seasonal, with average temperatures in the winter ~3 °C, spring ~17 °C, summer ~26 °C, and autumn ~15 °C. Meteorological data from a weather station at the field station's headquarters showed that the average temperature during the sampling period (June/July 2015) was 24.2 °C and the average daily precipitation was 1.68 cm.

Materials and Methods

Data collection

Remote camera traps were used to monitor mammal and bird assemblages along two 300-m transects, both positioned to span distinct environmental gradients across the field station. The first transect ("Agricultural") ran from the edge of the 6.5 ha hayfield north into the surrounding upland forest, while the second transect ("Riparian") ran from a small wetland (~125 m^2) east into the surrounding forest. The wetland at the beginning of the riparian transect was bordered by forest on three sides, and by a small, mesic meadow to the north.

Monitoring of each transect was conducted over a 32-day period (8 June through 10 July 2015). A total of 42 randomly-determined locations (plots) along each transect were monitored each for 48 or 72 h (depending on access to field site), with a total of three plots monitored simultaneously on each transect (the order in which plots were sampled was also randomly determined). At each plot, three infrared (IR) motion-sensor game cameras (Browning Model BTC-5; http://btc-omrc.com/wp-content/uploads/2014/02/2014_Strike_Force_Instruction_Manual.pdf) were positioned so that their fields of view overlapped, optimizing detection of small to large birds and mammals (Figure 1). Two of the cameras were attached to the same tree – one 20 cm and the other 50 cm above the substrate; both pointing in the same direction – while the third camera was placed 1–5 meters away on a tree at 50 cm above the ground so that its field of view was perpendicular to the other two cameras (Figure 1). All cameras were aimed parallel to the ground, and we assumed that the total area covered by the three cameras in each plot was approximately the same for all 84 plots. A total of 18 cameras were deployed simultaneously, with nine each on the agricultural and riparian transects. Vegetation in front of the cameras was removed to prevent it from obscuring the field of view. Cameras were programmed to capture images immediately after motion was detected, with subsequent photos delayed five seconds to reduce multiple images of the same individual being recorded. The field of view for each camera was 55°. The limits of the IR trigger and the IR flash illumination were 13 m and 30.5 m, respectively. Image resolution was set at 1920 x 1080 pixels, with each image also recording time and date. This project conformed to the legal requirements for the use of vertebrates in research and was approved by the University of Illinois' Institutional Animal Care and Use Committee (Protocol Approval # 15074). At each camera-trap site, we collected additional environmental data, including: i) canopy cover (%) calculated with a

spherical densiometer; ii) leaf-litter depth (mm) estimated as the average litter depth of four random locations near the center of each plot measured with a hand ruler; and iii) environmental temperature (°C), which we measured with iButtons (Maxium Integrated, San Jose, CA) every hour. The iButtons were deployed for the duration that the camera traps were set at each plot and were used to determine the maximum and average temperatures of the plot while the camera-trap plots were deployed.

Image analysis

The taxonomic identity of all birds and mammals in each image was determined using published literature and expert opinion. While most individuals could be identified to species, squirrels (*Sciurus* spp.) and mice (*Peromyscus* spp.) were only identified to genus (for simplicity, throughout the rest of the paper we refer to these taxonomic groups as species). Images of the same species (or genus for *Sciurus* and *Peromyscus*) taken within 10 min of each other at the same plot were considered the same individual, unless this was obviously untrue (e.g., different size, antlered versus non-antlered deer). We identified individuals to species for all images that we were clearly able to identify the individual. Images that were too blurry to clearly see the animal and images in which the animal was partially blocked, such as by vegetation or low light levels, were not used in the analysis. The body length of all mammals was estimated from each camera trap image by comparison to standardized images from each plot that included a human observed at specific distances from the cameras. We did this by taking pictures of a person of known height at meter-long increments from the cameras. We estimated the distance that each individual was from the camera using these images of a person at known distances from the camera. We then used these pictures to establish pixel lengths at different distances from the camera and used these pixels lengths to estimate the lengths of each individual in the picture. Published length-weight regressions were used to estimate body mass; for deer we used $W = 0.0287L^{3.03}$, while for all other mammals we used $W = 0.0374L^{2.92}$, where W = weight and L = length (Prothero 1992). We did not calculate the body weight of birds because it was often difficult to determine their lengths. At the species level, we estimated the biomass for all the individuals in which we were able to calculate body length from the image. We combined biomass for both transects

to obtain an average for each species. At the site level, mammal biomass was summed across all individuals of all species at each plot and was standardized per day.

Analyses

Each plot was binned according to distance from the hay field (agricultural transect) or wetland (riparian transect), with each bin spanning 50 m (i.e., bin 1 contained all plots between 0–50 m, bin 2 contained all plots between 51–100 m, etc., to 300 m). We binned each transect in this way as to standardize the number and length of bins in both transects. We then used one-way analysis of variance tests (ANOVA) to determine differences in environmental variables along each transect, where environmental variables (average temperature, maximum temperature, leaf litter depth, and percent canopy cover) were response variables, and bin number was the explanatory variable.

To account for different sampling effort across plots, we calculated abundance as the number of individuals captured per day for each species. To test whether our sampling effort included most-to-all species present, we used rarefaction curves, where cumulative species richness is measured over time. When these curves reach an asymptote, it indicates that most species present in that area have been detected.

Results

Environmental variables

Average temperature varied along the agricultural transect (Figure 2A; ANOVA: F = 3.124, df = 5, 32, p = 0.021), with significant differences occurring between bin 2 (51–100 m) and bin 6 (251–300 m; p = 0.027) and between bin 2 and bin 3 (101–150 m; p = 0.030). Average temperatures did not differ along the riparian transect (Figure 2A; F = 0.282, df = 1, 37, p = 0.598). Maximum temperature did not vary with distance along the agricultural (Figure 2B; F = 1.233, df = 5, 32, p = 0.317) or the riparian transect (Figure 3B; ANOVA: F = 1.218, df = 1, 37, p = 0.277). Litter depth did increase with distance from the hay field (Figure 2C; ANOVA: F = 4.533, df = 5, 32, p = 0.003). Along the agricultural transect, a Tukey's Honest Significant Differences test found that litter depths were significantly different between bin 1 (1–50 m) and bin 4 (151–200 m; p = 0.053), bin 1 and bin 5 (201–250 m; p = 0.007), and bin 1 and bin 6 (251–300 m; p = 0.003). There was no change in litter

depth along the riparian transect (Figure 2C; ANOVA: F = 2.554, df = 1, 37, p = 0.119). Along the agricultural transect, canopy cover was lowest nearest the hay field (Figure 2D; ANOVA: F = 4.443, df = 5, 32, p = 0.003). The canopy cover was significantly different between bin one and every other bin number along the agricultural transect (bin two: p = 0.021; bin three: p = 0.002; bin four: p = 0.013; bin five: p = 0.038; bin six: p = 0.007). The canopy cover did not change along the riparian transect (Figure 2D; ANOVA: F = 0.446, df = 1, 37, p = 0.508). The data for these analyses can be found in Data S1 (*Supplemental Material).*

Species composition and biomass

Using rarefaction curves, we found that cumulative species richness plateaued very early for the agricultural transects and well before the end of the sampling period for the riparian transects (Figure S1). We recorded at least one mammal or bird from 92% of the plots we sampled; 38 of 42 plots along the agricultural transect and 39 of 42 plots along the riparian transect. In total, we captured 2,245 images that included at least one mammal or bird, which we estimated to represent 483 individuals. For mammals, this consisted of 231 squirrels (*Sciurus* spp.), 81 white-tailed deer (*Odocoileus virginianus*), 64 Virginia opossums (*Didelphis virginiana*), 38 raccoons (*Procyon lotor*), 36 mice (*Peromyscus* spp.), 6 armadillos (*Dasypus novemcinctus),* and 3 coyotes (*Canis latrans*) (Table 1). We recorded a total of 24 birds, with tufted titmouse (*Baeolophus bicolor*), wild turkeys (*Meleagris gallopavo)*, and the northern cardinal (*Cardinalis cardinalis)* occurring on both transects and Cooper's hawks (*Accipiter cooperii),* blue jays (*Cyanocitta cristata),* wood thrushes (*Hylocichla mustelina),* and barred owls *(Strix varia*) found only on the riparian transect. Due to their low numbers, all birds were included as a single taxonomic group in subsequent analyses. Squirrels (the most common species on both transects), white-tailed deer, and raccoons were captured at similar rates per day between our two transects (Table 1; Figure 3A, B). Virginia opossums and mice were captured more often on the agricultural transect, whereas birds were captured more frequently on the riparian transect (Table 1; Figure 3A, B). Armadillos and coyotes were recorded only on the riparian transect (Table 1; Figure 3A, B), and no species were found exclusively on the agricultural transect.

Along the agricultural transect, squirrels, white-tailed deer, raccoons, and birds were captured most frequently at intermediate distances from the hay field (Figure 3A). Virginia opossums were uncommon nearest the hay field edge, becoming more abundant moving away from the hay field (Figure 3A). Mice were most common farther from the hay field, although they also had relatively high abundances near the hay field (Figure 3A). Along the riparian transect, white-tailed deer, Virginia opossums, raccoons, and armadillos were captured most frequently at intermediate distances from the wetland (Figure 3B). Squirrels and mice had two distinct modes of abundance, near the wetland and at intermediate distances from the wetland (Figure 3B). Birds were most abundant near the wetland and at plots farthest from the wetland (Figure 3B). The data for all these analyses can be found in Data S1 (*Supplemental Material).*

At the individual level, estimated biomass ranged from 0.02 kg for mice to 38.73 kg for deer and was similar to published accounts for most species (Table 2). Biomass at each plot was also similar between the two transects (agricultural: 13476 g ± 27616; riparian: 12378 g ± 13842). Biomass increased with distance from the hayfield but was higher adjacent to the wetland and at intermediate distances from the wetland.

Discussion

Using remote camera traps, we estimated community composition and abundance of mammals and birds and the biomass of mammals along two transects that traversed two distinct environmental gradients. Our use of multiple cameras per plot – positioned at different heights above the forest floor – increased our ability to record both small and large species. Cameras placed at standard heights above the ground (~50 cm) often do not capture small mammals and birds (Gompper et al. 2006; Rowcliffe et al. 2011), while cameras placed lower can miss large mammals (Rowcliffe et al. 2011). Thus, our multi-camera setup, with three cameras, two of which were at different heights (Figure 1), was ideal for capturing large and small mammals as well as a wide range of bird species. Having multiple cameras with overlapping fields of view also reduced the probability of missing animals due to failure of a single camera to trigger, which can occur for a number of reasons (Smith and Coulson 2012). Thus, this camera setup was more robust at determining species abundances and

community composition of wider range of mammal and bird species. Additionally, this is the first study that we are aware of that uses camera traps to estimate biomass and demonstrates a new type of measurement that can be obtained from camera trapping studies.

The riparian and agricultural transects were environmentally different from one another. The environmental conditions along the agricultural transect were similar to other studies that show forests adjacent to agricultural fields are warmer and have less litter depth and canopy cover compared to interior forests (Murcia 1995). Average temperature was higher on the agricultural transect compared to the riparian transects and varied more along the agricultural transect than along the riparian transect. Likewise, maximum temperature was higher along the agricultural transect. Litter depth was similar between the transects but increased significantly with distance from the hayfield. Canopy cover was higher on the riparian transect. Canopy cover was quite low in the forest immediately adjacent to the hay field but increased with distance from the hay field. Thus, these results are consistent that human activities, clearing forests for agricultural fields, have led to changes in the environmental conditions of the forests along each of these transects, which can potentially lead to differences in species abundance and community composition along these transects (Murcia 1995).

Virginia opossums were captured more often along the agricultural transect (Figure 3A, B). Armadillos were only present on the riparian transect, corroborating studies that found armadillos avoid open habitats and grasslands (Humphrey 1974; Taulman and Robbins 1996). The two species of squirrels at our site are considered habitat generalists and are quite adaptable to novel environments (Wiggers and Beasom 1986; Spritzer 2002; Gonzales 2005; McCleery et al. 2007; Lee et al. 2009), so it was unsurprising they were captured frequently on both transects (Table 1). Similarly, raccoons are a common habitat generalist in the midwestern United States (Lesmeister et al. 2015) and were captured nearly equally between the transects. White-tailed deer, a species often associated with forests (Lingle and Wilson 2001; Lingle 2002), were captured in approximately equal numbers on the two transects. While white-tailed deer prefer forested habitats, they will still use a wide range of habitats, including open fields (Wiggers and Beasom 1986). Coyotes were captured only on the riparian transect in our study. Coyotes are habitat generalists that will use habitats associated with their prey (Moorcroft et al. 2006; Lesmeister et al. 2015). Coyotes have been shown to

be one of the few species that did not avoid agricultural fields (Gehring and Swihart 2003), and it was therefore surprising that they were not captured on the agricultural transect, where their prey were equally abundant as on the riparian transect. Furthermore, these results may change had the study been performed over a longer time period that included different seasons. This study was performed during the early summer and several species may have been dispersing, searching for mates, or gestating, any of which could change behaviors and locations where organisms may be found.

The number of individuals captured per day varied along each transect. Along the riparian transect, many species, including squirrels, deer, mice, raccoons, and birds, were captured more frequently adjacent to the wetlands and at intermediate distances from the wetland. Along the agricultural transect, most species were infrequently captured adjacent to the hayfield and were more common at intermediate distances and farther from the hayfield. This suggests that mammals and birds frequently use the forest adjacent to the wetland but may avoid the forest adjacent to the hay field. The forest adjacent to the wetland was cooler and potentially provided more refuge for mice and squirrels and other small animals in the form of increased litter depth and for birds in the form of increased canopy cover. The forest adjacent to the hayfield was warmer and provided less refuge compared to the wetland. Finally, the wetland provides an often-essential water resource for many animals. Thus, the forest associated with the wetland transect may provide a slightly higher quality habitat than the forest associated with the agricultural transect.

Estimating biomass with camera traps expands the utility of camera trapping. The average biomass estimation for squirrels, deer, opossums, mice, armadillos, and coyotes were quite similar to published accounts from Midwestern areas (Table 1). Estimations of biomass for raccoons were less than reported elsewhere, which may have occurred because it may not have been possible to accurately estimate the length of raccoons due to their body shapes or because we had no good profile images of these species. At the site level, biomass was similar along the two transects. Camera trap studies have previously been limited to estimating presence/absence, abundance/density, and diversity/species richness. Using camera traps to non-invasively measure phenotypic traits can greatly increase their capabilities as an ecological tool (Kühl and Burghardt 2013). In our study, we were able to use camera traps to accurately estimate biomass of most species, and, hence, the amount of

biomass moving through each of the plots. As far as we know, this is the first study to utilize camera traps to obtain body sizes, and we conclude that future wildlife studies and monitoring can use camera traps to obtain body size and incorporate that information into their analyses.

An important caveat in the use of camera traps for wildlife studies is that it can be difficult to accurately determine density and abundances of animals that cannot be individually identified. Species with unique individual markings (e.g., tigers and jaguars) can be used in mark-recapture methods (Karanth and Nichols 1998; Soisalo and Cavalcanti 2006). When researchers are unable to identify individuals from markings, it becomes impossible to determine if each photograph represents separate individuals. However, researchers can take actions to reduce counting an individual more than once. We set our camera traps to have a five second delay after a photo was taken and when more than one image of the same species (or genus for *Sciurus* and *Peromyscus*) were taken within 10 min of each other at the same plot, they were considered the same individual, unless they were obviously different individuals (e.g., different body size, antlered versus non-antlered deer). Many researchers have compared camera-trapping methods with traditional methods and have found that camera trapping provides comparable and reliable results (Silveira et al. 2003; Rovero and Marshall 2009; Tobler et al. 2008). Others have found that camera traps under-estimated abundances and richness compared to traditional methods, but these under-estimations were not significantly different from traditional methods (Roberts et al. 2006; Barea-Azcón et al. 2007). As such, the risk of resampling the same individuals more than once does not appear to affect the results any more than it does with traditional methods.

In conclusion, we found that our camera trap design worked well to estimate abundances and community composition of both large and small mammals and birds. As such, this camera trap design improves the ability for researchers and wildlife managers monitoring wildlife communities and to provide more accurate measures of diversity and species richness. Additionally, we demonstrated that camera traps can be used to estimate body mass of mammals. We were able to use this camera trap setup to show that abundances and biomass was similar between two transects that traversed different ecotones in eastern Missouri. Fewer species were found near the hay field while more species were found near the wetland. Armadillos and coyotes were unique to the riparian transect, and birds were

more common and diverse on the riparian transect. Virginia opossums were more common along the agricultural transects, but no species were unique to the agricultural transect. Wildlife researchers and managers who use camera traps to monitor wildlife populations can benefit from using this type of camera trap setup and by incorporating estimates of biomass in their studies and monitoring.

Supplemental Material

Data S1: This provides the data that we obtained from the 4.5 week camera-trapping study that we performed from early June to early July 2015. This data provides information for each site (i.e., location along transect and dates the site was sampled), as well as the environmental information (average and maximum temperature, litter depth, and percent canopy cover) for each site along each transect. This data also provides the number of the individuals of each species captured at each site along each transect as well as the per day abundance. Finally, this data provides the diversity, species richness, and biomass for each site along each transect.

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Figure S1: Rarefaction curves showing sampling saturation for the **(A)** agricultural and **(B)** riparian transect. In these figures, the cumulative number of species captured is plotted against the duration of the experiment. When curves reach an asymptote it indicates that the number of species that have been detected represents the species found in that community. Our results indicate that we had reached sampling saturation in ~10 days for the agricultural transect and about ~20 days for the riparian transect.

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Table 1: Total number of individuals captured on each transect located in the Lindenwood University's Daniel Boone Field Station, Missouri during the sampling period June 8 through July 10, 2015. Numbers in parenthesis are the relative abundances for each transect. We captured images of squirrels (Sciurus spp.), white-tailed deer (Odocoileus virginianus), Virginia opossums (Didelphis virginiana), mice (Peromyscus spp.), raccoons (Procyon lotor), armadillos (Dasypus novemcinctus), coyotes (Canis latrans), as well as many bird species. Squirrels, white-tailed deer, and opossums were the most common animal species captured.

	Agricultural	**Riparian**
Squirrels	110 (0.44)	121 (0.52)
Deer	43 (0.17)	38 (0.16)
Opossums	45 (0.18)	19 (0.08)
Mice	23 (0.09)	13 (0.06)
Raccoons	24 (0.10)	14 (0.06)
Armadillos	0 (0.00)	6 (0.02)
Coyotes	0 (0.00)	3 (0.01)
Birds	6 (0.02)	18 (0.08)

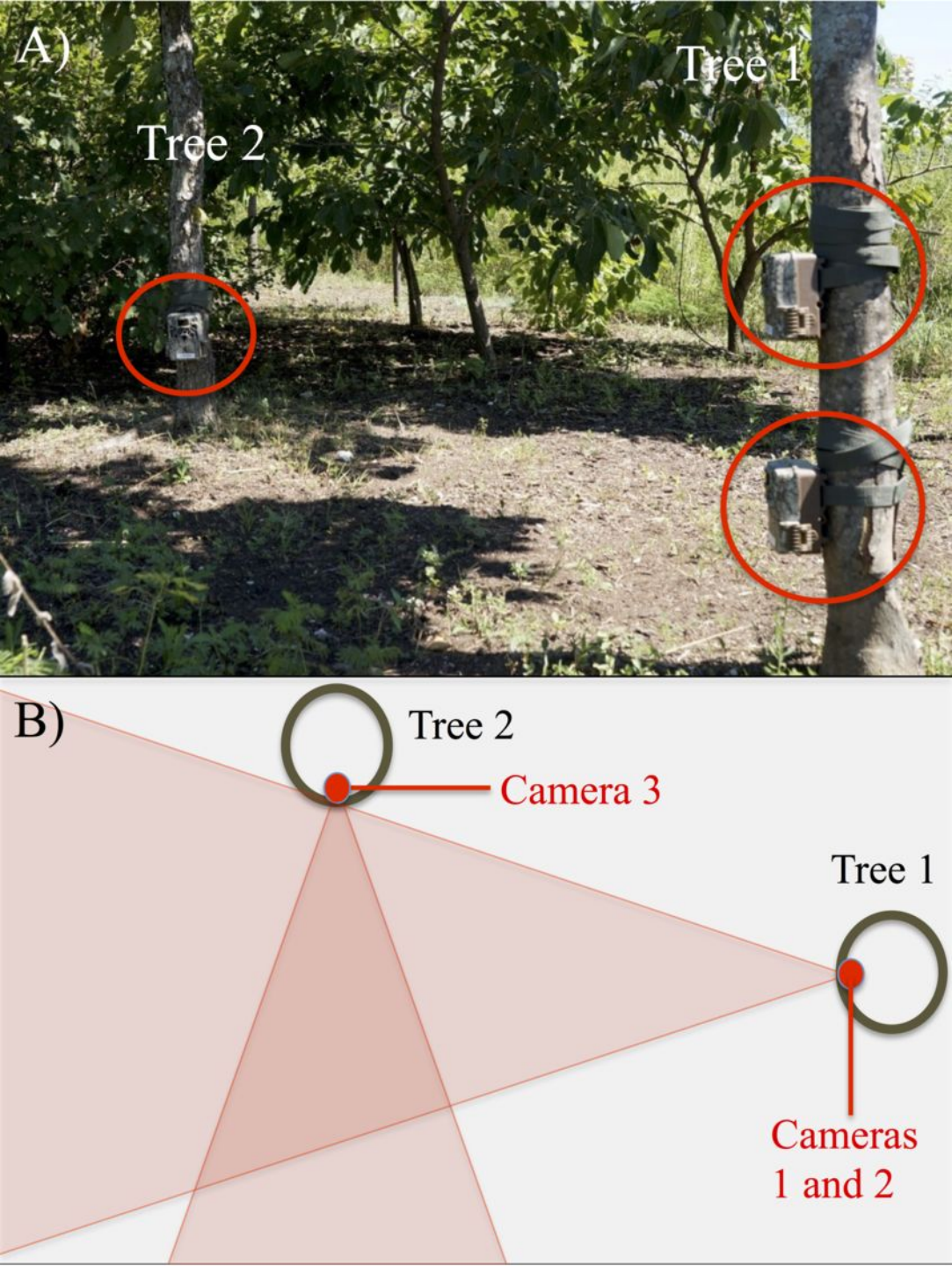
Table 2: Average estimated weight (± SD) of each species captured by camera trap crossing a transect located in the Lindenwood University's Daniel Boone Field Station, Missouri during the sampling period June 8 through July 10, 2015. We compared estimated weights with values reported in the literature. We found that our estimated weight values were similar to published accounts from the Midwestern region for all species expect raccoons, which were smaller in our study.

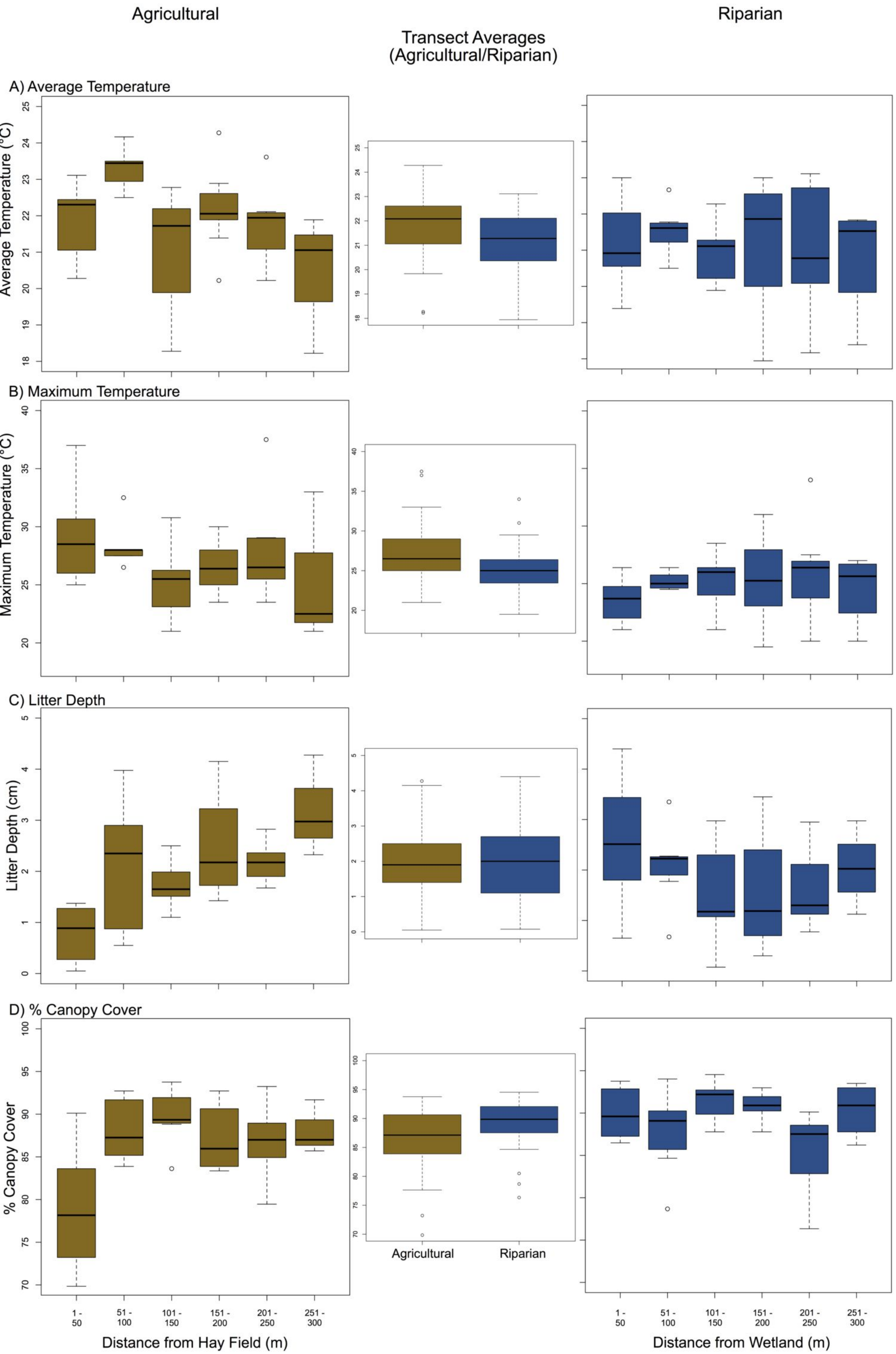
Species	**Estimated Weight (kg)**	**Literature Weight (kg)**	**Citation**
Squirrels	0.90 ± 1.36	0.82 ± 0.017	Reighard et al. 2004
Deer	38.73 ± 7.60	39.64 – 58.06	Pierce II et al. 2011
Opossums	3.8 ± 1.80	3.02 ± 0.11	Nixon et al. 1994
Mice	0.02 ± 0.05	0.02 ± 0.04	Stephens et al. 2014
Raccoons	2.91 ± 1.52	4.91 ± 0.18	Clark et al. 1989
Armadillos	3.34 ± 0.84	4.69 ± 0.55	McDonough 2000
Coyotes	12.56 ± 0	13.6 ± 0	Way and Proietto 2004

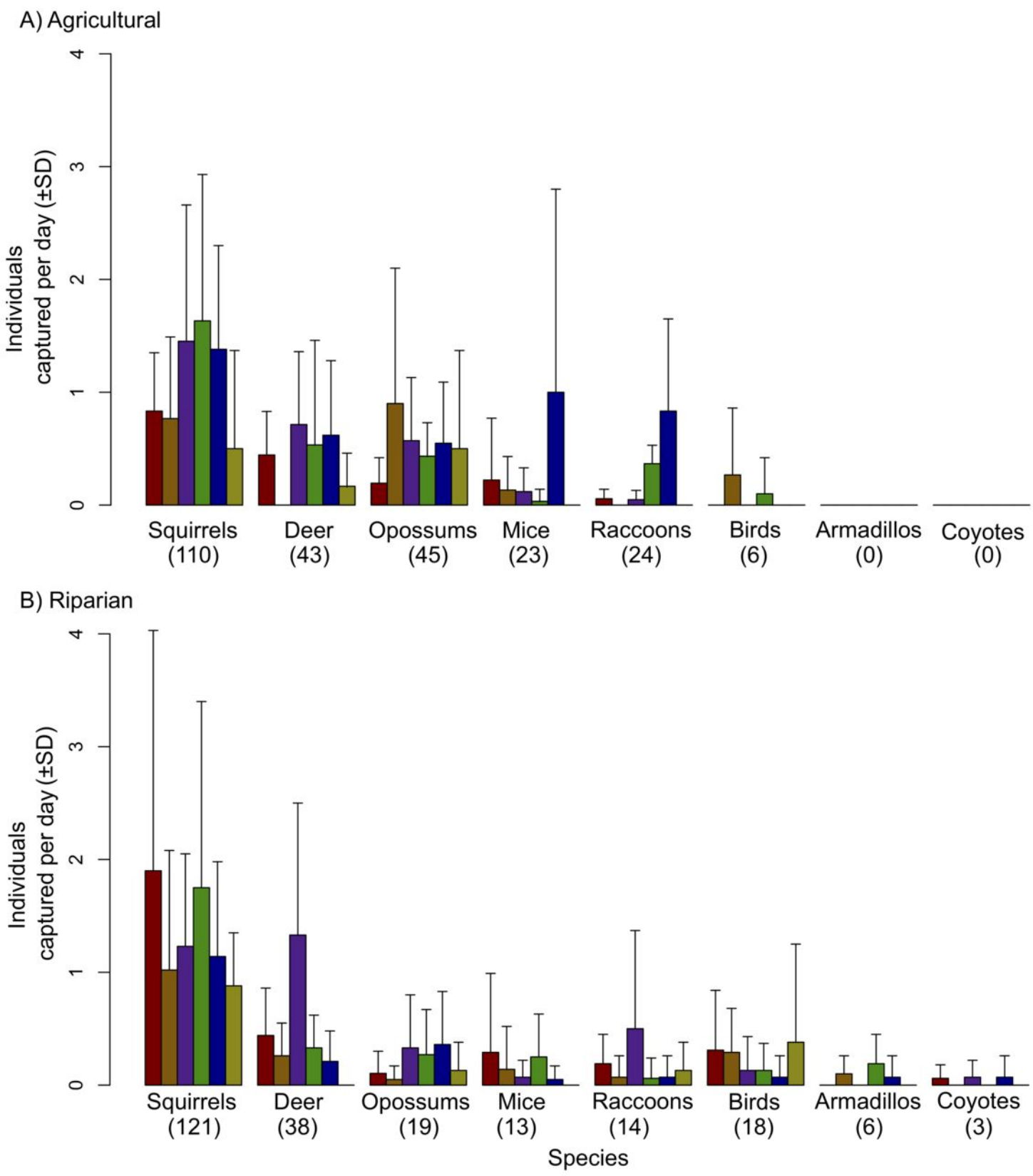
Figure 1: Details of our 3-camera setup at each plot crossing a transect located in the Lindenwood University's Daniel Boone Field Station, Missouri during the sampling period June 8 through July 10, 2015. This setup enabled us to capture images from both large and small animals. **(A)** Shows a photo of our field setup, with cameras circled in red. **(B)** Schematic of the camera trap setup from above, showing the overlap in the field of views of the three cameras at each plot. See main text for more details.

Figure 2: Box plots showing how environmental variables differed along each transect in the Lindenwood University's Daniel Boone Field Station, Missouri, agricultural (left column), riparian (right column) and comparisons between the two transects in the middle column, for the 4.5 week study period that ran from early June to early July 2015. Environmental variables we measured include **(A)** average temperature, **(B)** maximum temperature, **(C)** litter depth, and **(D)** percent canopy cover. In general, environmental variables were more consistent along the riparian transect than the agriculture transect. Average and maximum temperature decrease with distance from the agricultural field, while litter depth and percent canopy cover increased with distance from the agricultural field.

Figure 3: Abundance per day (±SD) of each species/genus at different distances along the **(A)** agricultural and **(B)** riparian transects located in the Lindenwood University's Daniel Boone Field Station, Missouri. Each color represents a different distance along the transects. Red =0-50m, orange = 51-100m, purple = 101-150m, green = 151-200m, blue = 201-250m, and yellow = 251-300m. Values in parenthesis below each taxa name represent total number of individuals recorded on that transect throughout the 4.5 week study that ran from early June to early July 2015. We captured images of squirrels (*Sciurus* spp.), white-tailed deer (*Odocoileus virginianus*), Virginia opossums (*Didelphis virginiana*), mice (*Peromyscus* spp.), raccoons (*Procyon lotor*), armadillos (*Dasypus novemcinctus)*, coyotes (*Canis latrans*), as well as many bird species. Squirrels, white-tailed deer, and opossums were the most common animal species captured.


A)
Tree 1
Tree 2
B)
Tree 2
Camera 3
Tree 1
Cameras
1 and 2


Agricultural
Riparian
Transect Averages
(Agricultural/Riparian)
A) Average Temperature
Average Temperature (°C)
B) Maximum Temperature
Maximum Temperature (°C)
C) Litter Depth
Litter Depth (cm)
D) % Canopy Cover
% Canopy Cover
Agricultural
Riparian
1 - 50
51 - 100
101 - 150
151 - 200
201 - 250
251 - 300
Distance from Hay Field (m)
Distance from Wetland (m)


A) Agricultural
Individuals captured per day (±SD)
0
1
2
3
4
Squirrels (110)
Deer (43)
Opossums (45)
Mice (23)
Raccoons (24)
Birds (6)
Armadillos (0)
Coyotes (0)
B) Riparian
Individuals captured per day (±SD)
0
1
2
3
4
Squirrels (121)
Deer (38)
Opossums (19)
Mice (13)
Raccoons (14)
Birds (18)
Armadillos (6)
Coyotes (3)
Species