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A novel method using camera traps to record effectiveness of artificial perches for raptors

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Agricultural areas can benefit from the reduction of rodents by raptors, yet many croplands and pastures do not provide adequate perching structures needed by raptors to hunt effectively. Many artificial raptor perches have been constructed as a solution to this deficiency, however, monitoring the benefits of these perches has proved challenging. We developed a method using artificial perches and camera traps mounted on poles that allows for 24-hour monitoring of perch utilization. We tested the new method in an agricultural area in northern California and demonstrated its ability to facilitate accurate species identification and to quantify raptor use and activity. Three of the six raptor species observed at the site utilized the artificial perches: American kestrels (*Falco sparverius*), red-tailed hawks (*Buteo jamaicensis*), and red-shouldered hawks (*B. lineatus*). We did not document any rodent predation events from the perches; but we did observe American kestrels using perches to hunt for invertebrates. Overall, we found that using camera traps mounted on poles can successfully monitor artificial perches and can be easily used to study the effectiveness of hunting perches for raptors in agricultural areas.

Key words: agriculture, artificial perches, *Buteo jamaicensis, Buteo lineatus,* camera traps, *Falco sparverius*, foraging, pests, raptors, rodents

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Raptors have the potential to provide an important ecosystem service in agricultural areas by removing rodent pests (Kay et al. 1994; Whelan et al. 2008). Certain raptor species are skilled rodent specialists and will hunt in human-modified landscapes including cropland and pastures (e.g., barn owls (*Tyto alba*) and red-tailed hawks (*Buteo jamaicensis*); Pearlstine et al. 2006; Kross et al. 2016). However, some agricultural areas lack appropriate structures for raptors to perch on. A possible solution to increase the attractiveness of agricultural areas is to augment these areas with artificial perches, which many raptor species are known to use (Hall et al. 1981; Reinert 1984).

Studies of artificial perches for raptors have examined perch use (Askham 1990), effect of perch installation on rodent population numbers (Kay et al. 1994; Wolff et al. 1999; Sheffield et al. 2001) and how perch setup features such as perch height (Kim et al. 2003) and surrounding habitat (Kross et al. 2018; Wong and Kross 2018) affect use. Monitoring raptor use of perches has proved challenging in part because observer presence may impact perch use. Forren et al. (1984) attempted to remotely monitor raptor perch use with a mechanical spring device that recorded use, but this method required the perch to be checked every day, and raptors could not be identified to species. Wong and Kross (2018) used camera traps to monitor perch use by placing cameras on ground level tripods angled up to view perches, but this method sometimes failed (e.g., cameras were knocked over). Additionally, this method could make species identification difficult and lead to theft or vandalism of equipment because of unsecured ground placement. Kross et al. (2018) attached cameras to pre-existing fence t-posts and angled them upwards to face artificial perches. This method improved equipment security but periodically experienced cattle interference.

We developed a new method for monitoring artificial perch use by raptors utilizing camera traps attached to poles adjacent to perches. By placing cameras on poles at the same height of the perch, we obtained clear photos and decreased the likelihood of camera theft, vandalism, or interference. We tested the new method in an agricultural area in northern California, which consisted of two habitat types: an open grassland field with cattle and a semi-open grassland surrounded by forest. Our objectives were 1) to determine how effective the perches were in attracting raptors to use them in the two habitat types and 2) to demonstrate that camera traps mounted on poles could successfully monitor raptor use of artificial perches, and 3) to capture photos of sufficient quality to identify raptors to species.

METHODS

Study area

We conducted our study at the Leavey Ranch property located between the cities of Arcata and Blue Lake, California (40.874, -124.008; elevation: 40 m). The climate in this area is characterized by wet winters and dry summers. The average annual rainfall is approximately 120 cm and temperatures range from 4–22 °C across the year. The property contains 52.6 ha of rangeland that is fenced, bordered by forests and the Mad River, and is bisected by a two-lane road (Figure 1). During our study, approximately 100 domestic cows were fenced in the northern section of the rangeland, and two bulls and two horses were fenced in the southern section of the rangeland. The northern section of the rangeland is open and relatively flat while the southern section is semi-open with sporadic trees and closely surrounded by secondary forestland composed primarily of coastal redwood (*Sequoia sempervirens*), tan oak (*Notholithocarpus densiflorus*) and Douglas fir (*Pseudotsuga menziesii*). At the time of the study, both sections had ground vegetation consisting of vari-

Figure 1. Study area map of Leavey Ranch in Humboldt County, California with artificial perch locations in the northern open grassland section (n = 3) and southern semi-open grassland sections (n = 3). Imagery was collected by The National Agriculture Imagery Program (NAIP; 2012).

ous grass species; however, the northern section had more bare ground (likely due to cattle grazing; Figure 1). Raptor species in this area include American kestrels (*Falco sparverius*), red-tailed hawks (*Buteo jamaicensis*), red-shouldered hawks (*B. lineatus)*, great horned owls (*Bubo virginianus*) and barn owls (*Tyto alba*). Small mammal prey include Botta's pocket gophers (*Thomomys bottae*) and California voles (*Microtus californicus*).

Artificial perch setup

We constructed the artificial perches using 3 m long hollow metal poles for the stands and 60 cm long wooden dowels of 3 cm diameter for the perches (Figure 2a; Appendix I). Perches were attached to the poles using a PVC tee piece bolted to the top end of the pole. We constructed the camera trap poles by using 3 m long hollow metal poles for the stands and then attaching the cameras to a L-bracket bolted to a modified cylindrical sliding mechanism (made from a metal electrical conduit connector) that could be slid up and down the poles (Figure 2d). Once the camera almost reached the top of the pole, it was held in place by a bolt approximately 7.5 cm from the top and an additional bolt at the top prevented the cameras from being pushed too far up and off the pole (Figure 2c). The bolt at the top of the pole also served to prevent any wildlife inadvertently entering the pole, which is a concern with open-topped pipes (Harris et al. 2019). In addition, epoxy (J-B Weld) was adhered to the metal cylinder to provide a structure that the hoisting pole could push on when moving the camera up the pole, and we attached a carabiner clip with plastic zip ties to the L-bracket to aid in retrieving the camera. This setup allowed for cameras to be activated on the ground, attached to the L-bracket, hoisted up the pole, and then later slid down the pole when checking the camera and collecting the data. We used a 1.5 m long wooden stick with a hook on the end to slide the camera up the pole, to release the camera trap from the bolt, and to slide it down the pole (Figure 2b).

To set up the perches and camera poles, we secured a metal t-post into the ground using a post-pounder and then attached the poles to the t-post using two U-bolts (the first near the top of the post and the second closer to the ground). We first installed the perch pole and then set up the camera pole 3m away (Figure 3). We placed the camera pole so that the camera trap would face one end of the wooden perch. We faced cameras north, or not directly east or west when possible, to prevent interference from sunlight (Wearn and Glover-Kapfer 2017). We secured the camera pole with the U-bolts after we slid the camera up the pole and adjusted it to point at the perch. See Appendix I for more details about artificial perch and camera poles and estimated cost of parts and equipment.

Data collection and analysis

Visual raptor surveys.– We conducted raptor surveys twice before we set up the perch stations (on 24 and 25 September and 1 and 2 October 2018) and twice after the perches had been set up for three weeks (on 22, 23, 29 and 30 October 2018); the first day of surveys were in the southern section of the rangeland and then the northern section on the day after. Survey objectives were to determine which species of diurnal raptor species were using the study areas (since owls are unlikely to be seen during the day). On each survey day, six survey crews of four members were spread across the southern or northern section of the rangeland (approximately 100–200 m apart). Surveys started between 1340–1410 hours.

Each crew had one person recording the data and three observers scanning and listening for raptors for 30 minutes (all observers were trained to identify raptors by sight and sound). We recorded raptors when they were seen or heard within the section including those perched on the ground or structures/trees or flying. Weather conditions were consistently mild across all survey days with temperatures ranging 18–25 °C, and no precipitation or strong wind.

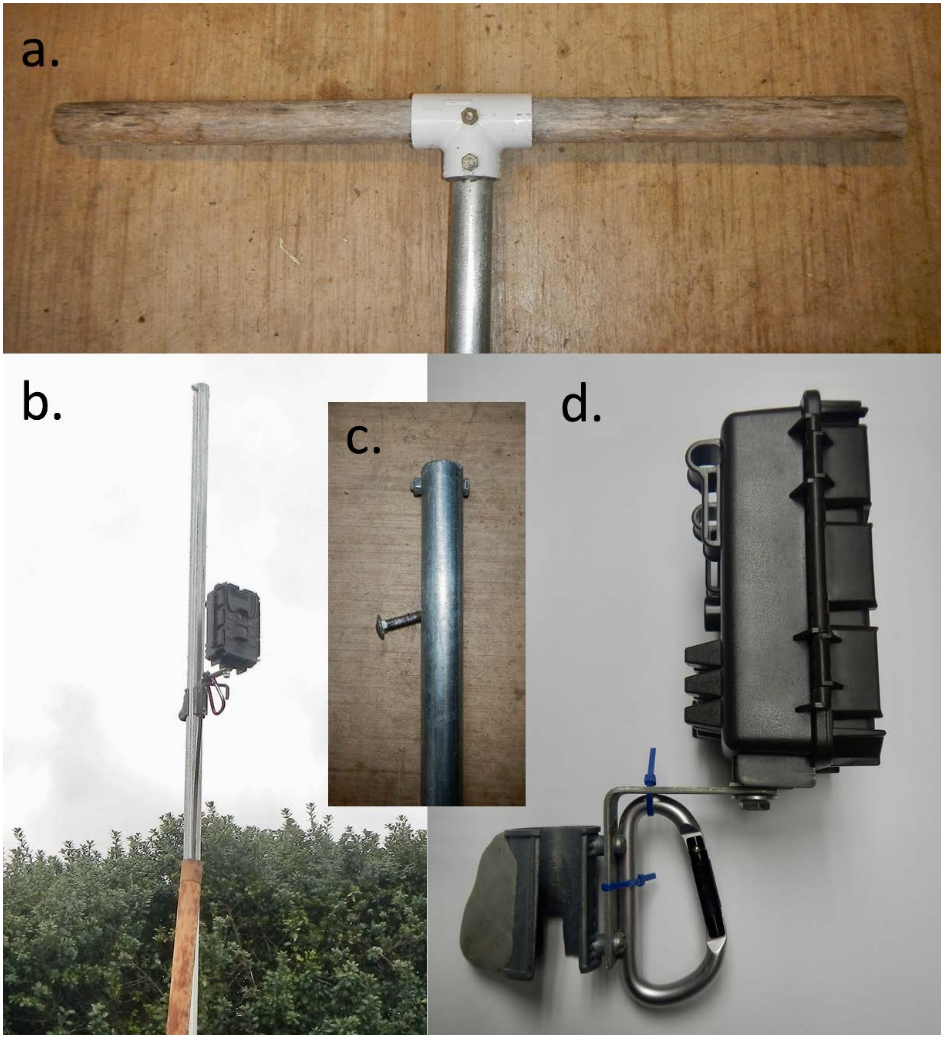

Figure 2. Artificial perch and camera trap pole and attachment setup used at the Leavey Ranch, Humboldt County, California, from September–October 2018: a. Artificial perch consisting of wooden dowel connected to pole with PVC tee and bolts, b. Camera trap attachment on pole with demonstration of using wooden pole with hook to hoist up or retrieve, c. Top of camera trap pole with bolts to hold camera in place, and d. Camera trap attachment including the L-bracket and bolt to hold the camera, a cylindrical metal electric conduit connector attached to L-bracket with one side of the connector cut open to allow it to pass the holder bolt on the pole (see c.) and the other side cut only partially to allow it to rest on the holder bolt, and epoxy on the connector and a carabiner zip-tied to the L-bracket to aid in hoisting and retrieving the camera.

We tallied the presence of raptors seen during the surveys by combining all records from across the six survey teams for a given section (northern or southern). That is, on a given survey day if one or more groups observed one individual or multiple individuals of a species, it was counted once as the species being present during the survey.

Artificial perch camera surveys.–We established six artificial perch and camera pole stations along fence lines or by tree stumps: three in the southern section of Leavey Ranch on 1 October 2018 and three in the northern section on 2 October 2018 (Figure 1). Stations were approximately 100–200 m apart within the southern and northern sections.

The camera traps were activated and hoisted into position on the pole to record triggered still image data for 28 days. We used Bushnell camera traps (Trophy Cam HD E2, Model #119836) programmed to take three photos per trigger with a 10-second interval between successive triggers. We checked cameras weekly to replace memory cards and batteries when necessary.

Figure 3. Artificial perch and camera trap pole stations on Leavey Ranch in Humboldt County, California from September–October 2018 set up: a. Along fence (semi-open grassland), b. Adjacent to nest box (open grassland), and c. Adjacent to tree stump (semi-open grassland).

We reviewed perch camera trap photos and recorded the perch station, date, time, and species corresponding to each instance a raptor was detected. We summarized the data into five types: 1) species seen at each station, 2) the latency to raptor perch use (in days), 3) the total number of raptor photos (as a measure of perch use activity), 4) the number of raptor perching events (defined as a series of photo detections of a raptor separated by no longer than 5 minutes between consecutive photos), and 5) hunting behavior of the raptors (defined as direct evidence of attacking, handling and/or consuming prey).

We also established camera traps (Bushnell Trophy Cam HD E2 Model #119836) on the ground to capture ground predation events. We placed the cameras within 1 m of the base of the artificial perch pole, facing outwards from the fence or tree stump (Figure 3). The cameras were attached to rebar pounded into the ground (0.5 m off the ground) and secured to fencing with a cable lock when possible.

Given the small sample size, our analyses were descriptive. We compared the species of raptors that used the perches to those that were seen during raptor surveys to determine perch use by species active in the area. We also compared the species of raptors that used perches between the open grassland with cattle versus semi-open grassland. We used t-tests to determine if there were more perching events in the northern versus southern sections, first comparing all species pooled together and then each species separately.

RESULTS

We recorded six species of diurnal raptors during our visual raptor surveys with red-tailed hawks and American kestrels (*Falco sparverius*) being the most active in the area (Table 1). Of these diurnal species, three used the artificial perches, with American kestrels recorded most often (Table 1).

Table 1. Number of surveys when raptor species were observed during visual surveys (n = 4 surveys per section) and number of perching events on artificial perches captured by camera traps (n = 3 perches per section for 28 days) in open grassland (northern section) and semi-open grassland surrounded by forest (southern section) on Leavey Ranch in Humboldt County, California from September–October 2018.

	Number of surveys when species observed		Number of perching events	
Species	North	South	North	South
American kestrel	4	2	6 (2[a])	30
Red-tailed hawk	3	4	2 (3[a])	0
Red-shouldered hawk	0	2	2	0
Northern harrier	2	1	0	0
Cooper's hawk	0	1	0	0
Rough-legged hawk	1	1	0	0
Great horned owl	NA	NA	0 (3[a])	0
Total Number	*4*	*6*	*10 (8[a])*	*30*

[a]On nest box next to perch

Five of the six artificial perches were used by at least one species of raptor (Table 1; Figure 4). Latency to perch use ranged from within 2 to 23 days from installation, with American kestrels using perches the fastest (Table 2). In total, across the 28-day survey period, we captured 185 photos on perch camera traps of perched raptors and recorded 48 raptor perching events. Eight of these perching events in the northern section were of raptors perching on an adjacent nest box rather than the perch (Figure 3b). We did not record any raptor predation events (or attempts) on rodents on the perch camera traps or ground camera traps. The American kestrel was the only species seen handling and consuming prey, which were all invertebrates (Table 2). We also captured several instances of birds perching on the camera pole itself (n = 6; American kestrels, black phoebes, *Sayornis nigricans,* and

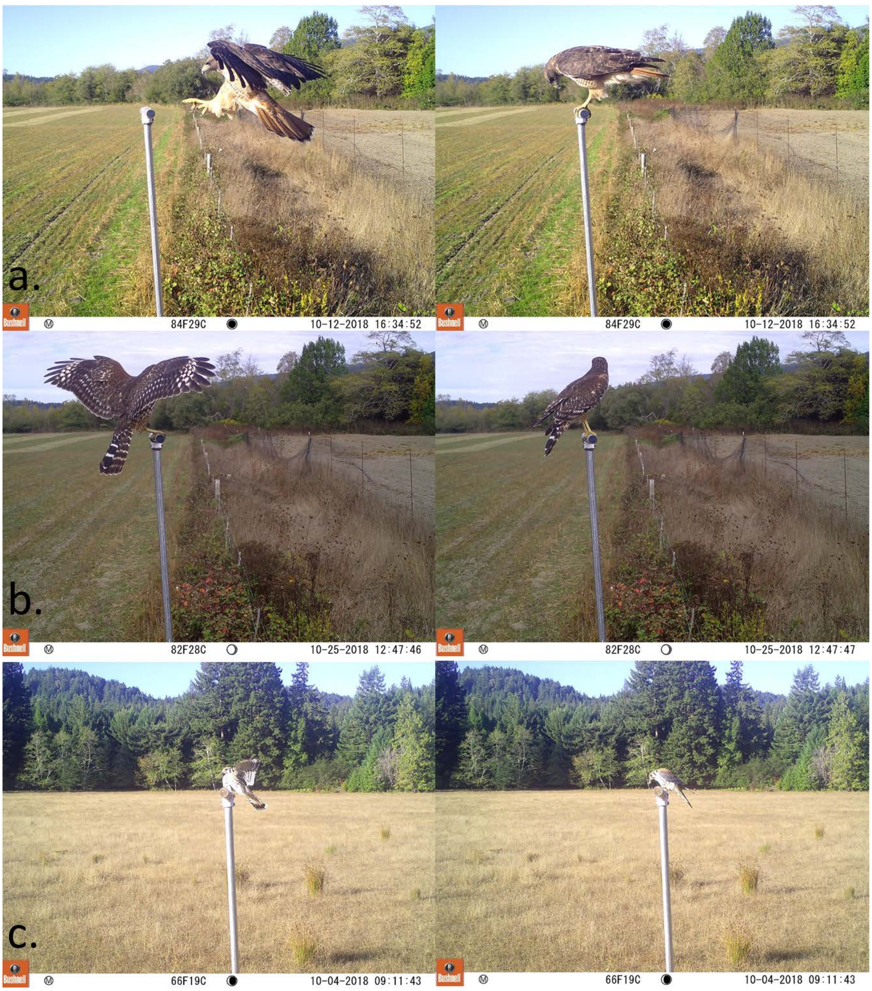

Figure 4. Example camera trap photos of raptors using artificial perches on Leavey Ranch in Humboldt County, California from September–October 2018: a. red-tailed hawk (open grassland), b. red-shouldered hawk (open grassland), and c. American kestrel (semi-open grassland) with insect prey.

Steller's jays, *Cyanocitta stelleri*); however, in most of these instances the bird used the artificial perch immediately before or after. We did not detect any interference by livestock on the perches or camera poles.

Although we recorded more perching events in the semi-open grassland perches than the open grassland perches, there was not a significant difference ($t_6 = 0.541$, $P = 0.607$). Species that used perches varied between the habitat types. American kestrels used perches in both the semi-open and open areas, while red-tailed hawks and red-shouldered hawks only used perches in the open areas. There was not a significant difference in perching events for American kestrels between the two habitat types ($t_6 = 0.987$, $P = 0.361$).

DISCUSSION

Raptors used the majority of the artificial perches in both open and semi-open grassland. Camera trap photos taken of raptors using the artificial perches were clear and could be used to identify individuals to species. While our sample size was small, we found that our novel method of using camera traps provided an efficient way to monitor artificial perch use and identify bird species using the perches.

We only observed American kestrels foraging on invertebrates from perches and did not document any evidence of predation on rodents either from the perch cameras or ground cameras. However, given the quality of the photos obtained with this method, we are certain that a raptor with a rodent in its talons or beak would be clearly visible and perhaps identifiable to genus (e.g., a gopher versus a mouse). Several studies have attempted to determine the effects of perch installation on rodent population numbers (e.g., Kay et al. 1994; Wolff et al. 1999). Our camera pole method could allow researchers to directly quantify the number of rodents removed due to the presence of artificial perches.

Table 2. Number of total raptor perch photos and raptor handling/consuming prey on perch photos from camera trap (n = 3 perches per section for 28 days) in open grassland (northern section) and semi-open grassland surrounded by forest (southern section) and average latency to perch (in days) for each species (excludes perching on nest box) on Leavey Ranch in Humboldt County, California from September–October 2018. All prey in prey consumption photos were invertebrates.

	Total perch photos		Consuming prey photos		Average latency to perch in days (+/-SD)
Species	North	South	North	South	All perches
American kestrel	24 (5[a])	122	11	69	7.2 (6.3)
Red-tailed hawk	6 (13[a])	0	0	0	11[b]
Red-shouldered hawk	6	0	0	0	23[b]
Great horned owl	0 (9[a])	0	0	0	NA
Total for all species	*36 (27[a])*	*121*	*11*	*61*	*10 (9.2)*

[a]On nest box next to perch
[b]Only landed on one perch

The lack of rodent predation events during our study does not indicate that perches are unable to provide a mechanism to increase raptor predation on agricultural pests. Rather, it may be that the length of our study (28 days) was too short to allow raptors to get accustomed to hunting from them. Our study was also limited to only one season (autumn), so for American kestrels it may coincide with a time period when they focus more on invertebrates (e.g., Collopy and Koplin 1983). For larger raptors, it may be that the perch height (3 m) was not sufficient given that height preference has been recorded from 6.3 m to 12.3 m on natural and human-made structures (Leyhe and Ritchison 2004; Worm et al. 2013). Our camera pole method was shown to work with 6 m perches in a previous study (B. Clucas, Humboldt State University, unpublished data). However, if 6 m poles are used in particularly windy areas, the sturdiness of the camera pole should be considered so wind does not cause the camera to take photos due to the pole swaying.

Despite this study's limitations, we demonstrated that the elevated camera trap mechanism is an effective tool for monitoring wildlife utilization of artificial perches. This mechanism allowed for the collection of clear photos of wildlife, well above ground level. Although deployed in tandem with artificial raptor perches for our study, this camera setup may be beneficial to other wildlife professionals who require monitoring of features above what typical ground camera deployments can capture (e.g., tree cavities, bat boxes).

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Author Contributions

Conceived and designed the study: BC and TS
Collected the data: BC, TS, JC, AD, SD, LD, MMG, SHKL, SL, KJK, KMK, KAL, JAM, EASM, AMP, MS, AS, and ST
Performed the analysis of the data: BC, TS, JC, SD, AD, LD, MMG, SHKL, SL, KJK, KMK, KAL, JAM, EASM, AMP, MS, AS, and ST
Authored the manuscript: BC
Provided critical revision of the manuscript: BC, TS, JC, SD, LD, MMG, SHKL, SL, KJK, KMK, KAL, JAM, EASM, AMP, MS, AS and ST

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APPENDIX I.

Estimated cost to construct and deploy an artificial perch and adjacent camera pole with camera trap. Prices will vary depending on location, brand and quality.

Equipment	Item	Quantity	Price per unit	Cost
Artificial Perch	Wooden dowel (60cm x 3cm diameter)	1	$5	$5
	PVC tee	1	$2	$2
	Bolts and nuts	2	$0.50	$1
	Pole (3m x 2.6 diameter EMT*)	1	$10	$10
	Metal t post (2.4m)	1	$7	$7
	U bolt with plate and nuts (inside diameter 3.5cm, inside height 10cm, thread length 6.3)	1	$2	$2
Subtotal				***$27***
Camera Trap Pole	Pole (3m x 2.6 diameter EMT*)	1	$10	$10
	Pole bolts and nuts	2	$1	$1
	Metal t post (2.4m)	1	$7	$7
	Electric conduit (EMT* set screw coupling)	1	$2	$2
	L bracket (6.5 cm)	1	$1	$1
	Carabiner clip	1	$4	$4
	Zip ties	2	$0.50	$1
Subtotal				***$26***
Camera trap	Camera trap (Bushnell Trophy Cam)	1	$110	$110
	SD card (16gb)	1	$8	$8
	AA batteries	8	$1.25	$10
Subtotal				***$128***
Total Cost				**$181**

*EMT = Electrical metallic tubing