Western North American Naturalist 73(2), © 2013, pp. 248–253

CATCHING LARGE GROUPS OF RAVENS: A NOTE ON PROCEDURES USING ROCKET NETS

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ABSTRACT.—Capturing Common Ravens (*Corvus corax*) is very difficult. Several methods are currently used, but none effectively catch large numbers (>25 birds) of ravens at one time. Efficient capture of large numbers of ravens is needed for some autecology studies. We describe and evaluate the effectiveness of using a prebaited rocket net trapping method for simultaneously capturing large numbers of ravens. The study sites were within 2 landfills in California's Mojave Desert, one at Edwards Air Force Base and the other at Fort Irwin National Training Center. We captured 283 ravens on 5 trapping occasions between 1995 and 1997, with an average of 57 birds per trapping occasion. We observed greater numbers of ravens at the bait sites with increasing bait duration, and these numbers appeared to level off after 25 to 30 days of baiting. Longer bait durations may habituate ravens to the resource and compensate for their wariness, which could increase capture success. More than half of the ravens captured (55%) were adults, and subadults composed the remaining age class (42%). Only 3% of the ravens captured were hatch-year birds, a result of trapping early in the breeding season. Using rocket nets is a safe and effective method to capture large numbers of ravens.

RESUMEN.—Es muy difícil capturar cuervos comunes (*Corvus corax*). Si bien en la actualidad se utilizan varios métodos, ninguno de ellos logra capturar de manera efectiva grandes cantidades (>25 aves) de cuervos; la captura masiva resultaría útil para realizar estudios de autoecología. Describimos y evaluamos la efectividad de un método de captura que consiste en una red con cebo para capturar una gran cantidad de cuervos de manera simultánea. El estudio se realizó dentro de dos vertederos en el Desierto Mojave de California: uno ubicado en la Base de la Fuerza Aérea Edwards y el otro ubicado en el Fort Irwin National Training Center. Capturamos 283 cuervos en cinco ocasiones de captura por año, entre 1995 y 1997, con un promedio de 57 aves por cada trampa. Observamos una mayor cantidad de cuervos en los sitios donde había cebos, en los cuales el cebo estuvo una mayor cantidad de tiempo, y se estabilizaban después de 25 a 30 días de colocarlos. Es posible que con una mayor duración de los cebos los cuervos se acostumbraran al recurso y dejaron de desconfiar, lo cual posiblemente haya incrementado las posibilidades de éxito en la captura. Más de la mitad de los cuervos que se capturaron eran adultos (55%), mientras que el resto eran subadultos (42%). Debido a la captura temprana durante la temporada de reproducción, sólo el 3% de los cuervos que se capturaron eran recién nacidos. El método de la red para capturar grandes cantidades de cuervos es seguro y efectivo.

Capturing Common Ravens has proven difficult, and most capture techniques have low capture rates and yield only a few individuals (Engel and Young 1989). However, understanding raven autecology (Boarman 2003, Webb et al. 2004), population structure (Kristan and Boarman 2003), and movement (Boarman et al. 2006) requires large numbers of individually marked birds.

Techniques for trapping ravens include box traps (Restani et al. 1996), drop-in traps (Stiehl 1978), Havahart® traps (Woodstream Corp., Canada; Schwan and Williams 1978), leghold traps (Engel and Young 1989), net guns (Coda Enterprise Inc., USA; Caffrey 2001), and cannon or rocket nets (Engel and Young 1989). Engel and Young (1989) assessed several techniques for capturing individual ravens; capture rates for all methods were low (i.e., <2 birds $\cdot$ day^{-1}), except for drop-in traps (Coldwell 1972). In contrast, Restani et al. (1996) captured approximately 6 ravens $\cdot$ day^{-1} using box traps, but their trapping effort was labor intensive. Cannon or rocket nets have been used to effectively and safely capture a variety of wildlife, including ravens and other corvids (Engel and Young 1989, Schemnitz 1994, Caccamise et al. 1997, Caffrey 2001).

We provide herein a detailed description of using rocket nets to trap Common Ravens, and we briefly describe and evaluate the effectiveness of a prebaited rocket net system to

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simultaneously capture large numbers of ravens. A rocket net uses explosively driven rockets that are attached to a net, whereas a cannon net uses a projectile attached to the net and launched from a smooth-bore cannon. In addition, we describe the age class ratio of ravens captured by using rocket nets at landfills.

We trapped ravens from 1995 to 1997 in the desert southwest on 2 military bases in California, USA: Edwards Air Force Base (EAFB; UTM zone 11, 413000 E, 3868000 N) and Fort Irwin National Training Center (FINTC; UTM zone 11, 528000 E, 3902000 N; see Kristan and Boarman 2003 and Boarman et al. 2006 for military base location details). Ravens appeared habituated to human and heavy equipment activity at landfills and were attracted to the refuse. Each of the landfills operated similarly, serving as the sole facility for solid waste disposal at their respective base. The landfills received waste on weekdays, and the refuse was either baled and put into a pit (EAFB) or dumped directly into a pit (EAFB and FINTC). At the end of each day, the refuse was covered either with a minimum of 15 cm of soil or with a heavy tarp weighed down with tires. One trap site was established within each landfill in an area that received little disturbance from military activities or landfill operations. A 100-m^2 area was cleared of all trash and debris, and a military camouflage net, held in place with sandbags, was set up to simulate the rocket net. In addition, to simulate the rocket stands, 4 T-stakes attached to 8 cm diameter plastic pipes were set 0.5 m behind the net, with 1.5 m of pipe protruding aboveground. A 4-m semicircle in front of the net was marked with gypsum to delineate the target area. We placed approximately 25 metal stakes—1.3 cm diameter by approximately 30 cm long rebar rods with a 5-cm diagonal downward cross member—throughout and along the leading edge of the net footprint. These stakes were used to stop the net from rebounding after launching and to hold the leading edge of the net securely to the ground. On the morning that trapping was performed, the decoy equipment was replaced with a 12 × 20-m cord net (Wildlife Materials Inc., USA). At EAFB, the rocket net was tested on a separate day and at a different location each year, whereas at FINTC in 1996, the rocket net was tested at the trap site before the baiting period commenced.

Bait was presented between 07:00 and 09:00 at EAFB from 5 to 23 January 1995 (19 days), 26 April to 7 May 1996 (12 days), and 14 April to 14 May 1997 (31 days). At FINTC, bait was presented from 8 to 30 May 1996 (23 days) and 15 March to 20 May 1997 (67 days). Bait was placed within the semicircle in the shape of a T. The top of the T was 1 m from the net and 1 m from the edges of the semicircle, while the stem of the T stretched 2 m perpendicular to the net. Bait consisted of meat scraps, fast-food refuse (i.e., hamburgers, french fries, and pizza), and dry cat food at EAFB; however, the amounts of bait were not recorded. Only meat scraps were provided at FINTC. Approximately 5–80 L of bait was placed at the FINTC trap site on weekday and most weekend mornings between 07:00 and 09:00. An average of 8.7 L (2.7 SD; range 5–15 L) of bait was dispersed in 1996, whereas in 1997 there was 25.4 L (18.3 SD; range 5–80 L) dispersed.

A 1.2 × 1.2 × 2.4-m plywood blind draped with camouflaged netting was used for making observations and for launching the net at EAFB. The blind was set up on the first day of baiting, approximately 200 m from the trapping area, and was removed within 5 days of the completion of trapping. Temporary structures were not allowed on the FINTC landfill; therefore, observations and launching of the net were conducted from vehicles parked >150 m from the trapping area on a 10 m high despoil mound. From these vantage points, the number of ravens within the trapping area was recorded, as well as the maximum number seen in the 30 min following bait deployment.

After each deployment of the rocket net, captured birds were removed from the net and processed. Ages of captured ravens were assigned to one of the following categories: hatch-year, subadult, adult, or undetermined. Age determination was based on a combination of plumage, iris color, wing and tail conditions, and mouth color, following guidelines in Kerttu (1973), Heinrich and Marzluff (1992), and Heinrich (1994). All capture and experimental techniques followed guidelines described by the American Ornithologists' Union (1986) and were approved by the Colorado State University Animal Care and Use Committee. We used chi-square goodness-of-fit analyses to detect differences in numbers of ravens captured between age categories, pooled across site and

TABLE 1. Capture success of Common Ravens by site and year.

Location	Year	Bait duration[a]	Bait days[b]	Captured	Success ratio[c]
EAFB	1995	19	19	48	2.5
	1996	12	12	60	5.0
	1997	31	25	57	2.3
Subtotal		62	56	165	3.27 (1.50)
FINTC	1996	23	23	81[d]	3.5
	1997	67	50	37	0.7
Subtotal		90	73	118	2.13 (1.97)
Total		152	129	283	2.81 (1.58)

[a]Bait duration is the number of days between initiation of baiting and netting.
[b]Bait days is the number of days bait was delivered.
[c]Success ratio—the number of ravens captured divided by bait duration—is presented for each location and across locations (total; mean [SD]).
[d]Two birds escaped before being processed and banded.

year. Data were pooled to avoid issues associated with small sample size. Only the subadult and adult age categories were included in analyses because we expected very few captures of hatch-year birds; at the time of most trapping occasions, hatch-year birds had not fledged except for those from the earliest nesting attempts.

We captured 283 ravens on 5 trapping occasions between 1995 and 1997, averaging 57 birds per trapping occasion. No birds were injured or killed during our study. Capture success ratio (= number of ravens captured/bait duration) ranged from 0.7 to 5.0 ravens · d^{-1}, with a mean of 2.81 (SD = 1.58; Table 1). The maximum number of ravens observed in the trapping area typically increased with baiting duration and leveled off between 25 and 30 days (Fig. 1). Short baiting duration, <25 days, appeared to yield numbers of captured ravens comparable to numbers captured after longer baiting duration (30–60 days), but with one-half to one-third the time commitment and effort (Table 1).

We expected an equal age ratio between subadult and adult ravens; however, this expected result was not observed (Table 2; $\chi^2 = 4.66$, df = 1, $P = 0.03$). We were able to place 270 captured ravens into age classes; 55% were adult birds (149/270) and 42% were subadult birds (114/270). Because we trapped early in the breeding season, usually before nestlings had fledged, we did not expect to catch hatch-year birds, and <3% (7/270) of captures discernible to age class were hatch-year birds.

Common Raven capture success is typically low (<2 ravens · d^{-1}, in 11 previous studies; Engel and Young 1989, Bub 1991). However, Coldwell (1972) and Restani et al. (1996) had much higher success rates, >4 ravens · d^{-1}, using drop-in traps and baited box trap methods, respectively. We consistently had high capture success using rocket nets (an average of 57 birds per occasion; 3.5 ravens · d^{-1}, excluding the FINTC 1997 site where we purposefully continued baiting to determine if the number of ravens attracted to the bait site plateaued or continued to increase). The total time required for a 30-d baiting period amounts to <40 h: daily baiting typically required <60 min, including transportation, baiting, and clean-ups; total netting 2 h; and total post-capture processing ~6 h.

We attribute our capture success rate to several factors: (1) The availability of natural prey/forage was still low from winter, so ravens were still congregating at sites such as landfills, where prey/forage was readily available (Boarman et al. 2006). (2) We used high-calorie baits (e.g., meat scraps), which attracted and retained more ravens than lower-calorie foods (e.g., household refuse). (3) The baiting period provided sufficient duration to attract ravens through local enhancement (see Restani et al. 1996). (4) Ravens were habituated to landfill operations, including human activities, unnatural objects, and site manipulation; consequently, ravens were not particularly bothered by our presence or by our replacing the decoy equipment on netting days. As a result of these factors, our trapping method was effective for capturing large numbers of ravens at our study sites.

To capture large numbers of ravens, the birds must be attracted to a small area. Counts immediately prior to net launching included about 20 birds more than were caught, and ravens were observed escaping from under the net during launching. These escapes were

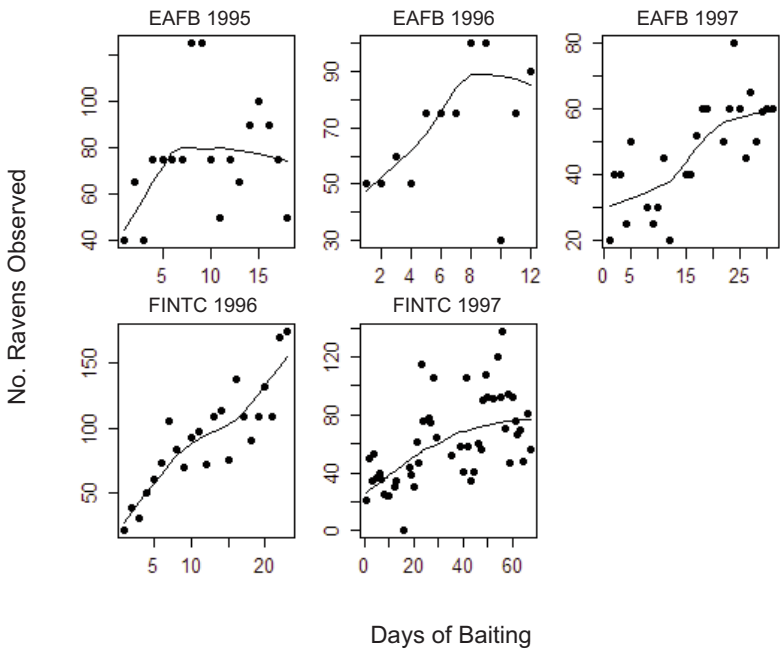

Fig. 1. Numbers of ravens observed within the trapping area by site and year. The LOWESS smoother line on each panel indicates the pattern in ravens attracted to the bait site.

TABLE 2. Number of Common Ravens captured by age category[a], location, and year.

Location	Year	Month	Hatch year	Subadult	Adult	Undetermined
EAFB	1995	Jan	0	15	33	0
	1996	May	0	27	32	1
	1997	May	2	19	26	10
Subtotal			2	61	91	11
FINTC	1996	May	5	40	34	2
	1997	May	0	13	24	0
Subtotal			5	53	58	2
Total			7	114	149	13

[a]Age defined as hatch year, subadult, adult and undetermined categories.

due to ravens' wariness, extremely quick response time, and flushing/avoidance behavior. Therefore, it is imperative that large numbers of ravens are within the net footprint and that most of the ravens are concentrated within the target area.

To optimize capture probability, bait must be carefully distributed so as to concentrate ravens within the target area. We achieved this optimization by placing the bait in a T shape instead of piling the bait in the center or dispersing the bait throughout the net footprint. Piling the bait in the center of the net footprint did not allow large numbers of ravens to access the bait. We observed birds vying for the bait and flushing once they acquired a piece. Dispersing the bait more evenly throughout the net footprint allowed access by a large number of birds; however, we observed too many birds remaining on the footprint periphery, and therefore outside the target capture area. Distributing the bait in a T shape allowed access by large numbers of ravens, while concentrating the birds within the target area in the middle and leading edge of the net. The T shape maximized the available edge of the bait to birds while keeping them well within the target area. In addition, we observed that most of the bait was consumed or removed when only 5 L of bait was delivered.

Thus, we recommend that at least 10 L of bait should be dispersed to ensure that sufficient numbers of birds congregate within the target area to improve capture success.

We suggest that the target area be marked to ensure that large numbers of ravens are congregated at the bait just before net launching. We also suggest counting the number of ravens to maximize the numbers caught. We observed that the number of ravens present increased until about 15 min after bait delivery. We usually launched the net between 15 and 20 min after delivering bait. This period allowed for most of the ravens at the landfill to assemble about the trap area and for the birds to settle down and forage. It is possible this time was sufficient for coyotes (*Canis latrans*) and gulls (*Larus* spp.) to satiate themselves and move out of the trap area.

In this study, more adult birds were captured than subadult birds; therefore, we surmise that more adult ravens were utilizing the landfills than subadult birds. Hatch-year birds started showing up at the landfill in May, and few were caught in our study. This observation corresponds to fledging timing, which does not begin until mid-May and occurs in earnest throughout June and early July (Webb et al. 2004).

Under conditions similar to those in this study, we recommend the use of rocket nets to capture large numbers of ravens simultaneously because the technique is efficient and reliable. No birds were injured or killed during our study, although injury and mortality have been reported for other avian species captured with this technique (e.g., King et al. 1998). The method would not be useful for capturing target individuals (e.g., a specific breeding pair). In addition, repetitive netting may increase capture success. Ravens in the vicinity of the trap area were always disturbed by the rocket launching and capture activities; however, some ravens returned to the bait, after disturbances ceased. At EAFB in 1996, approximately 30 birds returned to the bait within 10 min after we vacated the area. While we processed the captured birds, additional ravens continued to return to the bait and more than 50 ravens were observed feeding in the target area within 90 min after we vacated the area. Thus, if adequate numbers of handlers are present to process additional ravens, the rocket net could be redeployed for a second launching on the same day. A second launch would increase the numbers of ravens captured and maximize baiting efforts without significant additional costs.

This project was supported with funds from the U.S. Air Force, Edwards Air Force Base, and the U.S. Army, National Training Center, Fort Irwin. Institutional support and logistical assistance were provided by Edwards Air Force Base and Fort Irwin National Training Center. Edwards Air Force Base and Fort Irwin National Training Center Explosive Ordinance Device personnel handled all rocket ordinances. Tracy Bailey, Glen Goodlett, Paul Hamilton, Mark Pavelka, Clark Winchell, and many other volunteers helped handle and process captured ravens. This manuscript was improved by the comments of Doug Chamblin, Bill Kristan, Karen Phillips, Sara Schweitzer, Bill Webb, Julie Yee, and 2 anonymous reviewers. Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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Received 31 May 2012
Accepted 25 March 2013