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Research Report

Seasonal and study site variation in box-trapping eastern coyotes

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Abstract

A detailed analysis of eastern coyote (also referred to as coywolf *Canis latrans* x *lycaon*;) box trapping data at two study sites in eastern Massachusetts was conducted, including an examination of monthly, seasonal, and study site variation. Forty-eight individuals were captured 66 times. Eastern coyotes were most commonly captured during spring (winter = 14 captures, spring = 28, summer = 14, fall = 9; $\chi^2 = 12.4$, df = 3, P = 0.006), especially during the month of May with lactating females being the majority of those captures. Capture efficiency (captures per 1,000 armed trap nights) ranged from 3.9 in October to 33.9 in May with an overall average of 17.5 eastern coyotes captured per 1,000 armed trap days. Similarly, effort efficiency (captures per 1,000 trap visits) was lowest during October (0.9) and highest in May (11.3) with an average of 4.6 eastern coyotes captured per 1,000 trap visits. There was a significant difference between study sites and capture efficiencies, with the Cape Cod study site capturing more individuals per unit effort compared to north Boston. Results from this paper inform canid researchers: (1) that box traps are useful in capturing eastern coyotes; (2) that spring/early summer is the most effective time to capture study subjects, especially lactating females; and (3) that box traps can be useful in capturing a representation of all canid age and sex classes in a population.

Introduction

Recent genetic research on eastern coyotes indicates that they are actually a hybrid between western coyotes *Canis latrans* and eastern/red wolves *Canis lycaon* (Way et al. 2010) and should perhaps more appropriately be called coywolves *Canis latrans* x *lycaon* since they are larger (Way 2007b) and genetically distinct from western coyotes and eastern/red wolves (Way et al. 2010). However, I will hereafter refer to them as eastern coyotes in this paper for consistency with currently accepted terminology.

Capturing carnivores is critical in order to study them for radiotelemetry purposes, marking individuals and collecting blood samples (Mills 1996). The common way to capture canids is by foot (or leg) hold trap but the use of the devices is unpopular with the general public and it is now banned/prohibited in many areas (especially urban) and states (e.g. Way et al. 2002). Eastern coyotes are notoriously difficult to capture. This is especially the case in locations where foothold traps are not permitted because these traps are generally deemed to be more efficient than other capture methods such as box traps (Shivik et al. 2005, Way et al. 2002). Previous research has indicated that it is possible to capture eastern coyotes via box traps (Way et al. 2002) but the relatively small sample size obtained in that study prevented detailed analysis and led to the conclusion that box traps were undesirable for use as a capture technique. Shivik et al. (2005) advised against the use of box traps to capture eastern coyotes after conducting an extensive literature review and performing brief (one month at each site) field testing in Arizona and Texas where they failed to capture any coyotes.

While research indicates that eastern coyotes are difficult to capture in box traps, it is a more common technique for capturing other predators including smaller canids such as foxes (Baker et al. 1998, Kamler et al. 2002, Kozlowski et al. 2003). In addition, Mills (1996) noted that large African carnivores, including spotted hyaenas *Crocuta crocuta*, lions *Panthera leo* and leopards *P. pardus* could be captured using a cage trap device (the "drop-door"). Interestingly though, large canids such as African wild dogs *Lycaon pictus* and Ethiopian wolves *Canis simensis* could not be captured in cage traps (Mills 1996, Sillero-Zubiri 1996).

While predators, including smaller canids can be captured in high numbers in box/cage traps, the published literature is inconclusive as to the efficacy of capturing medium (e.g. eastern coyotes, jackals e.g. *Canis aurues*) and large canids (e.g. wolves, African wild dogs) in box

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traps. Therefore, in this paper I report on study site variation and in the seasonality of capture success using a larger, statistically significant sample size of captured animals than previous studies (i.e. Shivik et al. 2005, Way et al. 2002) to address the question: "Is box trapping a useful capture device for conducting behavioural studies of a medium-sized wild canid?" I will consider it an acceptable capture technique if eastern coyotes can be captured in numbers comparable to other trapping methods (e.g. foothold traps), and representing all age/sex classes of the populations under study.

Methods

This research was part of a larger study documenting eastern coyote ecology in two urbanised areas of eastern Massachusetts (Way et al. 2001, 2004; Way and Eatough 2006). The first site was within Barnstable County, Cape Cod, southeastern Massachusetts (approximately 250km^2), with the town of Barnstable (155.5km^2) as the core study site (Way et al. 2001, 2002, 2004). Research took place between March 1998 and December 2008 with Animal Care protocols approved from both the University of Connecticut Storrs (1998-2000) and Boston College (2001-2008), and with subsequent permits from Mass Wildlife.

Estimated human density in the town of Barnstable was 290/km^2, whereas the entire Barnstable County had an average density of 203/km^2 (U.S. Census Bureau, 2000 estimates). The second study area occurred in the bordering towns/cities on the north edge of Boston, Massachusetts (hereafter "north Boston"; Way and Eatough 2006), centring around Everett (4,345 people/km^2), Malden (4,291 people/km^2), and Revere (3,089 people/km^2; U. S. Census Bureau, 2000 estimates), as well as the towns/cities immediately bordering those cities (including Saugus, Melrose, and East Boston).

Box traps (Tomahawk Live Trap Co., Tomahawk, WI; Tomahawk models 610B [152.4cm x 50.8cm x 66.0cm] and 610C [182.9cm x 50.8cm x 66.0cm]) were used to capture eastern coyotes with the methodology described in detail by Way et al. (2002). Traps were bedded (i.e. the metal bottom covered with dirt, leaves, and/or pine cones) in a wooded area ca. 5km from other traps in attempts to capture members of different packs. Typically 5-6 traps were deployed at any one time and they were usually wired open for 2–3 months to condition eastern coyotes (as well as other animals) to the traps. Bait consisted of supermarket meat scraps (mainly cow parts, as well as chicken scraps) and occasionally road-killed animals (mainly grey squirrels *Sciurus carolinensis*). When bait was regularly taken from the back of the trap (i.e. behind the pan) we then armed traps for capture. Traps were checked twice daily (at or close to dawn and dusk) when armed for capture and typically 2–3 times per week when wired open (i.e. conditioning period) and could not capture an animal. Only eastern coyotes were individually identified because they were given a radiotag (i.e. implant or collar); thus, all non-coyote captures reported herein are number of captures of a particular species.

Because of the use of bait (meat scraps), many animals were attracted to the traps especially during critical periods of the year (e.g. pup-raising or winter) when food resources are typically in limited supplies (winter) or when animals need extra food (pup-raising). However, I believe that the food reward associated with being trapped compensated for the animal's welfare because it supplemented its natural diet. Conversely, many studies of canids employ foothold traps and when animals (including non-targets) are captured in these devices they are not rewarded with food while held captive and often suffer higher injury rates than when captured in box traps (see Way et al. 2002).

We immediately released non-coyote captures except for raccoons *Procyon lotor* which were occasionally (excluding very cold or hot days and usually only for repeat captures at a particular site) left in traps during dawn checks and released at dusk (<24h in traps) in an attempt to negatively condition them to the traps. All eastern coyotes were immobilised and classified as juveniles (born in April [Way et al. 2001] – their first fall), yearlings (full-sized pups in their first winter up through the summer of their second year), and adults (>1.5 years). Yearlings were young eastern coyotes (i.e. little tooth wear, still located on their natal range) and were classified separately to provide a third category between young pups and older adults (Way et al. 2001, 2004).

As defined in Way et al. (2002), a "capture" was an instance in which an animal was trapped and held until the next trap check. A "trap day" was defined as one trap being in the field for one 24hr period. "Trapping effort" was the number of times trap sites were visited by researchers (e.g. pre-baiting before trap was deployed in an area, baiting wired open traps, checking traps twice/day when set). "Capture efficiency" was defined as captures/1,000 set (armed) trap nights and "effort efficiency" as captures/1,000 trapping efforts.

To examine possible variation in coyote captures between months, seasons (Winter = December–February; Spring = March–May; Summer = June–August; Fall/Autumn = September–November), and study sites, a chi-square goodness of fit test (Microsoft Excel, Microsoft Corporation, www.microsoft.com) was used to detect differences in capture rates (Way 2009). Similar to Way (2009), to avoid the effect of differences in trapping effort and number of days traps were set for capture in a given month (i.e. highest effort during May and lowest in September; Figure 1), the average of each month's and season's efficiency values (capture and effort) was used and not the overall efficiency value (i.e. all captures divided by all trap nights/efforts then divided by 12), which is biased to high and low months. The data from the two study sites were pooled to calculate capture and effort efficiency values and separated when comparing between sites. Significance was set at $P<0.05$.

When comparing captures across seasons, it is acknowledged that movements, vulnerability, and/or numbers of individuals in the different age-sex groups are not constant throughout the calendar year – i.e. pups are born in early spring, unavailable in early summer (because they are not travelling and likely will not enter a box trap unless placed near a den site), more vulnerable (i.e. less wary than adults) to capture but have small home ranges in late summer and early fall, and use much larger ranges and traverse the entire family territory in the late-fall and winter. Therefore total captures are pooled across months and seasons with the acknowledgement that populations fluctuate throughout the year. However, the goal of this paper is to analyse a statistically robust data set to determine the seasonality of capture to better determine when box traps are most effective at capturing eastern coyotes. Therefore, the recognised biases of differential vulnerability and population fluctuations are less important for the purpose of this paper than the overall output – i.e. how many were captured and when?

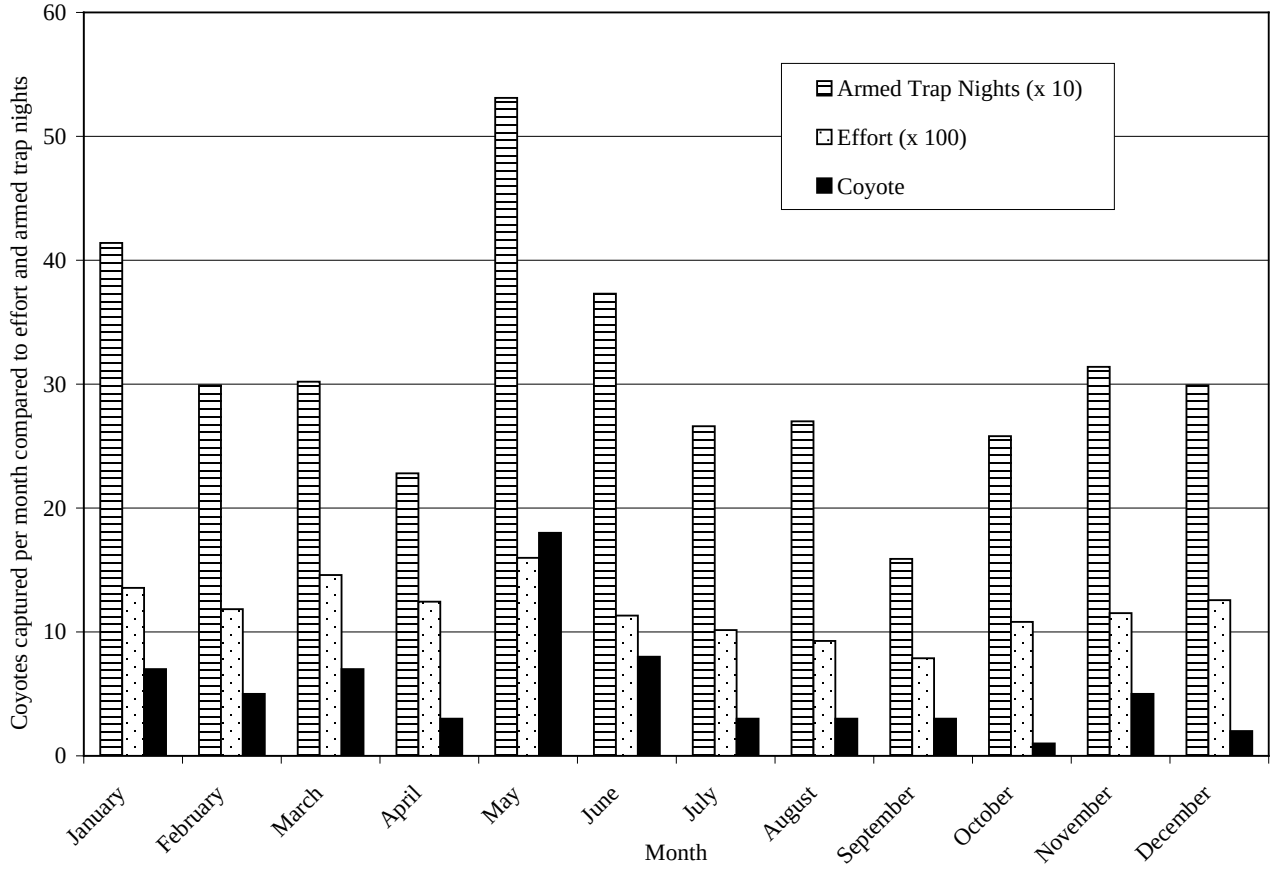

Figure 1. Combined eastern coyote captures per month in box traps on Cape Cod (1998-2008) and north Boston (2002-2005), Massachusetts, compared to effort and armed trap nights.

Results

Traps were in the field for 19,014 trap days (TD; Cape Cod = 11,066; north Boston = 7,948); of those, 13,922 (Cape Cod = 7,966; north Boston = 5,956) involved days when traps were physically wired open and 3,713 (Cape Cod = 2,324; north Boston = 1389) TD occurred when traps were armed for capture. Trapping effort was 14,193 trap visits (Cape Cod = 8,916; north Boston = 5,277). Nine hundred and thirty one animals of 21 different species (Table 1) were captured in 1,077 sprung traps (Cape Cod = 719; north Boston = 351), including 66 eastern coyotes. Traps were also sprung 194 times without a capture (i.e. nothing on Table 1). There were 12 multiple capture events (i.e. more than one animal captured in the same trap at once) in north Boston involving four pairs of red-tailed hawks *Buteo jamaicensis*, one pair of common starlings *Sturnus vulgaris*, one pair of raccoons, three trios of American crows *Corvus brachyrhynchos*, and one group of six crows captured at once. Additionally, two traps had multiple species in the same trap: two starlings and two house finches *Carpodacus mexicanus* in one capture and one starling, three finches, and one black-capped chickadee *Parus atricapillus* in another. There were 24 multiple capture events on Cape Cod involving 19 pairs of crows, one triple crow capture, three pairs of raccoons, and a triple raccoon capture (mother and two juveniles).

Forty-eight individual eastern coyotes (26M, 22F), consisting of 11 juveniles (7M, 4F), 12 yearlings (8M, 4F), and 27 adults (12M, 15F), were captured 66 times in box traps; eight individuals were captured twice (seven adults [2M, 5F], and one male was captured once as a yearling and once as an adult), two adults (1M, 1F) were captured three times, and two females were captured four times (one female first captured as a yearling then three times as an adult, the other as an adult for all four captures). There was no difference between the number of male and female captures during the study ($\chi^2 = 0.33$, df = 1, P = 0.564). However, more females (n = 18; three yearlings, 15 adults) were captured than males (n = 8; three pups, two yearlings, two adults) during May/June when eastern coyotes were raising pups ($\chi^2 = 3.846$, df = 1, P = 0.0499). Fifteen of those 18 females (83.3%, all adults) were lactating during May/June captures.

Eastern coyotes were most commonly captured during spring (winter = 14 captures, spring = 28, summer = 14, fall = 9; χ^2=12.4, df = 3, P = 0.006), especially during the month of May with lactating females being the majority of those captures (of 18 total captures [4M, 14F], 12 of 14 females were lactating) (Figure 1). Capture efficiency ranged from 3.88 in October to 33.90 in May with an overall average of 17.51 captured per 1,000 armed TD (Table 2). Capture efficiency values were significantly different between months ($\chi^2 = 43.45$, df = 11, P < 0.0001) and approached significance between seasons ($\chi^2 = 7.23$, df = 3, P = 0.065) with a peak in springtime captures and lows during summer and fall (Figure 1). Similarly, effort efficiency was lowest during October (0.93) and highest in May (11.26) with an average of 4.58 eastern coyotes captured per 1,000 trap visits (Table 2). The difference for effort efficiency values between months ($\chi^2 = 19.15$, df = 11, P = 0.058) approached significance but not for season ($\chi^2 = 1.58$, df = 3, P = 0.66).

Fifty-seven coyote captures occurred on Cape Cod, while nine were caught in north Boston. There was a significant difference between study sites and capture efficiencies (Cape Cod = 24.5 captures/1,000 armed TD; north Boston = 5.76; $\chi^2 = 11.61$, df = 1, P = 0.00066) while the difference between effort efficiency values and study sites (Cape Cod = 6.39 captures/1,000 efforts; north Boston = 1.52; $\chi^2 = 3.00$, df = 1, P = 0.08) approached significance.

Table 1. Species captured by box traps on Cape Cod (1998-2008) and the north edge of Boston (2002-2005), Massachusetts, in descending order from most to least frequently captured animal.

Common Name	Species Name	Cape Cod	N. Boston	Total
Raccoon	*Procyon lotor*	187	125	312
Nothing	(trap fired/shut, nothing inside)	130	64	194
American crow	*Corvus brachyrhynchos*	136	15	151
Virginia opossum	*Didelphis virginiana*	83	41	124
Striped skunk	*Mephitis mephitis*	46	40	86
Eastern coyote	*Canis latrans* x l*ycaon*	58	8	66
Red-tailed hawk	*Buteo jamaicensis*	27	26	53
Domestic cat		26	16	42
Domestic dog		30	2	32
Fisher	*Martes pennanti*	1	16	17
Red fox	*Vulpes vulpes*	11	2	13
Turkey vulture	*Cathartes aura*	4	4	8
Muskrat	*Ondatra zibethicus*	1	1	2
Common starling	*Sturnus vulgaris*		6	6
House finch	*Carpodacus mexicanus*		5	5
Northern harrier	*Circus cyaneus*	4		4
Gull	*Larus* spp.	4		4
Grey squirrel	*Sciurus carolinensis*		3	3
Grey fox	*Urocyon cinereoargenteus*		1	1
Norway rat	*Rattus norvegicus*		1	1
Black-capped chickadee	*Parus atricapillus*		1	1
Blue jay	*Cyanocitta cristata*	1		1

Table 2. Eastern coyotes captured per month in box traps in eastern Massachusetts along with monthly capture efficiency (captures/1,000 set trap nights) and effort efficiency values (captures/1,000 trapping efforts).

	Days armed	Effort	Captures	Capture efficiency	Effort efficiency
January	414	1356	7	16.9	5.2
February	299	1184	6	20.0	5.1
March	302	1459	7	23.2	4.8
April	228	1244	3	13.2	2.4
May	531	1598	18	33.9	11.3
June	373	1132	8	21.4	7.1
July	266	1015	3	11.3	3.0
August	270	927	3	11.1	3.2
September	159	788	3	18.9	3.8
October	258	1081	1	3.9	0.9
November	314	1152	5	15.9	4.3
December	299	1257	2	6.7	1.6
Totals	3,713	14,193	66	17.5	4.6

Discussion

Larger sample sizes in this study allowed for a more detailed analysis than Way et al.'s (2002) paper on box-trapping eastern coyotes. However, values from this study (capture efficiency = 17.51; effort efficiency = 4.58) were similar compared to Way et al. (2002; capture efficiency = 20.0; effort efficiency = 6.5) which were similar to capture rates using foothold traps in other studies (see Way et al. 2002 for discussion). Most eastern coyotes in this study were captured in the spring (Table 2; Fig. 1). Lactating females (15 of 18 females captured during May/June vs. eight males [including three male pups]) were provisioning their offspring during that time of year and showed a marked increase in capture rate (Way et al. 2001; Table 2). In fact, even though effort and capture efficiency values were standardised (i.e. per 1,000 attempts) to give an unbiased estimate of capture success (i.e. increased effort in May due to increased capture success – Figure 1) per month and season, the highest value was still in the spring (specifically in May when females were weaning pups – Way et al. 2001). Although eastern coyotes can be captured year-round (Figure 1), future researchers might consider concentrating their efforts of using box traps to capture canids during the pup-rearing period (April – June in our study area) especially with the noted success of capturing breeding adults during this time (Way et al. 2001).

Despite using the same techniques and the author tending to (Cape Cod) and/or directing (north Boston) trapping operations at both sites, there was a marked increase in capture success on Cape Cod. While effort was similar at both sites (i.e. 5–6 traps in the field at one time), capture and effort efficiency values were higher on Cape Cod. There are ≥3 possibilities for this difference: (1) north Boston animals were unusually wary compared to Cape Cod individuals and avoided the traps; (2) survival of radio-collared eastern coyotes in Boston (e.g. Way and Eatough 2006) was lower than on Cape Cod, some of whom were studied for years (Way and Strauss 2004, Way and Timm 2008). Possibly a more numerous and longer-lived population on Cape Cod increased trapping success; and (3) the individual humans involved affected trapping success as J. Way did the majority of the trapping on Cape Cod, but directed the north Boston research while two colleagues carried out the bulk of the actual field work. Shivik et al. (2005) predicted that eastern coyotes would be more likely to be captured in suburban areas in response to nuisance complaints and that it would

be unfeasible to capture them in more rural environs where they used human structures less. However, our results demonstrate that we captured more canids on suburban Cape Cod despite urban north Boston having human population densities >10 times that of Cape Cod.

Results from this paper are intended to help guide researchers to safe and effective capture of canids in box traps. Although time and labour intensive, this technique will be more important as other trapping methods (e.g. foothold traps) become illegal in other areas (see Way et al. 2002 and sources within). Previous research (see Way et al. 2002) indicates that box traps are a safe capture method with only minor injuries occurring on a small proportion of captured animals. Perhaps most pertinent to this study, and despite the lack of success in other studies (e.g. Shivik et al. 2005), it is now sufficiently demonstrated that eastern coyotes can effectively be captured in box traps throughout the year including all age and sex classes.

Way et al. (2002) concluded by noting that box traps were undesirable for capturing eastern coyotes because they were expensive, frequently caught other species (because of the use of bait/food), and required lengthy periods to capture individuals. While all of these reasons are still valid, upon gathering a significant sample size from the same study area, I tend to disagree with the tune of those results. Rather than being undesirable for capturing eastern coyotes because of the stated factors, I believe that those factors simply complicate (and frustrate as in the case of non-target captures) capturing canids in box traps. Indeed the capture efficiency values are relatively high compared to other capture techniques, notably foothold traps (see preceding discussion). However, because foothold traps are becoming prohibited in more and more locations (e.g., Massachusetts, California, Colorado; European Union countries), box traps are an important and viable alternative capture technique since results from this paper inform canid researchers that: (1) it is possible to capture a sufficient sample size of eastern coyotes (despite this success, typically only 5-6 traps were functional at any one time); (2) spring/early summer is the most effective time to capture them, especially adult/breeding females; and (3) a representative sample of all age and sex classes in a canid population under study can be captured using box traps. Researchers should prepare to allot significant resources (money for traps, personnel to check and bait traps, and fuel/funding for travel) and time when box trapping eastern coyotes or any other canid under study. Future researchers using box traps should attempt to determine if: (1) coyotes can be captured in other areas (e.g., more rural/wilderness areas, western United States); (2) other medium sized canids (e.g., jackals, Ethiopian wolves) can be captured; and (3) large canids (e.g., eastern/red wolves, grey wolves, African wild dogs) can be captured in these devices.

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Biographical sketch

Jonathan (Jon) Way is the leader of the coywolf ("eastern coyote") ecology project in eastern Massachusetts. His book Suburban Howls describes his research in layman's language and his website, www.easterncoyoteresearch.com, is a resource for researchers and layman alike looking for information (including publications) on these canids.