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Research Report

Factors affecting captive eastern coyote activity levels

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Abstract

To gain a better knowledge of eastern coyote (*Canis latrans* var.) behaviour, we directly observed a socialized, hand-reared captive pack of five eastern coyotes to examine how activity during morning and late afternoon was related to the following variables: (i) age, (ii) temperature, (iii) social/hierarchal rank, (iv) body mass, (v) weather, and (vi) gender. An estimate of each coyote's overall activity level index (ALI) was obtained through 609 30-minute observation sessions with 120 (19.7% for each) bouts conducted on coyotes named "Caon", "Late", and "Trans", 124 (20.4%) on "Cane", and 125 (20.5%) on "Lupe". ALI per session varied for each animal with averages of 1.78 for Cane (range 1.01 – 2.53), 1.74 for Caon (range 1.02 – 2.42), 1.79 for Late (range 1.00 – 2.50), 1.69 for Lupe (range 1.01 – 2.40), and 1.79 for Trans (range 1.03 – 2.38). The model explained 11.5% of the variance in ALI (adjusted R-squared = 0.115). Age in days (β = -0.270, $p < 0.0001$), temperature (β = -0.178, $p < 0.0001$), and rank (β = 0.135, p = 0.001) were the three variables that best predicted ALI. Our study showed that coyotes display plastic behavioural patterns, and that they are capable of altering activity based on environmental circumstances. Because most wild coyote populations are inherently difficult to observe, data from coyotes in captivity complement data from studies of coyotes in the wild.

Introduction

Coyotes (*Canis latrans*) are notoriously difficult to observe in the wild with only the Yellowstone/Grand Teton Parks area of northwest Wyoming producing consistent, reliable direct observations of free-ranging (usually radio-collared), undisturbed coyotes (Bekoff and Wells 1980; Gese et al., 1996a, b, c; Switalski, 2003). These benchmark studies have contributed to our knowledge of important facets of coyote ecology and behaviour including activity related to social class (Bekoff and Wells 1980), response to grey wolf (*Canis lupus*) reintroduction (Switalski 2003), foraging ecology (Gese et al. 1996a), predation success (Gese et al. 1996b), social factors influencing dispersal (Gese et al. 1996c), and behavioural ecology (Camenzind 1978).

However, in most areas of the coyote's ubiquitous range (see Parker, 1995) they are difficult to observe because they are mostly nocturnal (Woodruff and Keller 1982, Chamberlain et al. 2000, Grinder and Krausman 2001, Tigas et al., 2002, Riley et al. 2003, Way et al. 2004) and/or live in heavily forested regions making them difficult to see (Harrison and Harrison 1984, Harrison 1992, Patterson et al. 1999, Patterson and Messier 2001).

In some of these locations seasonal observations of coyotes are possible (Way 2003, Way 2007b), but in most landscapes (e.g. forested, suburban, hunted areas) observers must rely on radio-telemetry data to remotely (i.e. not visually) detect coyote activity (Patterson et al. 1999, Kitchen et al. 2000, Grinder and Krausman 2001, Way et al. 2004).

The eastern coyote living in northeastern North America is a larger version of the species (Way and Proietto 2005, Way 2007a) and its ecology has only recently been investigated (Harrison et al. 1991, Harrison 1992, Patterson et al. 1999, Patterson and Messier 2001, Way et al. 2002). There has only been a limited amount of behavioural observations of wild eastern coyotes in this region (Way 2003, Way et al. 2006, Way 2007b). However, numerous researchers have demonstrated the importance of studying canids in captivity as much behavioural research is difficult, or even impossible, to obtain in the wild (Bekoff 1972a, Bekoff 1974, Bekoff 1978, Frank 1987, Mech and Boitani 2003, Packard 2003, Macdonald and Sillero-Zubiri 2004, Way et al. 2006). For example, no study has documented in detail the development and hierarchal relationship of a litter of wild coyotes from birth until independence (i.e. to their first autumn, at approximately six months of age) although many captive studies have examined this aspect of coyote behaviour (Bekoff 1972b, Bekoff 1974, Bekoff 1978, Parks 1979, Way et al. 2006, Way 2007b). Also, coyotes are heavily harvested in many areas of their range (Parker 1995), which often causes them to become even more secretive (Kitchen et al. 2000).

It would be useful to have a benchmark of eastern coyote behaviour/activity in a setting where coyotes are not persecuted by humans. Therefore, we directly observed a socialized captive pack of eastern coyotes to examine how activity was related to variables such as (i) age, (ii) temperature, (iii) social/hierarchal rank, (iv) body mass, (v) weather, and (vi) gender.

Methods

On 12 April 2002, five wild-born sibling coyote pups (two males = "Lupe" and "Trans"; three females = "Cane", "Caon", and "Late") of an original litter of nine (three males, six females) estimated 25 days old (Parks 1979), were removed from under a small outbuilding in a residential area in Falmouth (Cape Cod), Massachusetts and were reared at JGW's house (note: the other four pups [one male, three females] were placed back under the outbuilding. The wild parents were observed with the four pups until the end of summer 2002 when wildlife officials lost track of them). This large litter was deemed a problem situation by wildlife authorities because of the large number of pups and three or more wild adults raising these pups in an urbanized area. In addition, we were granted a permit to study coyotes for both scientific (Way et al. 2006) and educational purposes (Way 2005). We hoped that these two factors justified the study for both moral and ethical reasons (also see Way 2007b).

The five coyotes taken into captivity were contained within a 53m^2 area both inside and outside JGW's house until 13 May 2002, when the coyotes were transferred to a 16m^2 quarantine facility for one month at the Franklin Park Zoo, Boston, Massachusetts. On 13 June 2002 the five coyotes were moved to their permanent 403m^2 public viewable exhibit at the

Stone Zoo located in Stoneham, Massachusetts and remained there for the duration of this study (late-October 2003 – pup age 585 days). We chose the endpoint of our study as the last day of data collection prior to the coyotes being permanently separated due to intra-pack aggression (Late and Trans were removed – Way 2007b). The area of their exhibit was a suitable size for a long-term study of canid behaviour (Frank 1987). Although the coyotes were hand-reared and socialized to people (Way 2007b), we made no attempt to interfere with nor discipline their activities and therefore gave the coyotes free access, at all times, to their exhibit/living facilities. The coyotes were provided with puppy milk (Esbilac, PetAg, Inc., Hampshire, Illinois) via bottle or bowl until 15 May 2002 and were given access to water and dry dog food (commercially available dog foods until March 2003 then Mazuri exotic canine diet [PMI Nutrition International, LLC., Brentwood, Missouri] thereafter) at all times. They were group fed (i.e. all five at once) 0.75 – 1.6kg (varying with their age) of Nebraska Brand chopped frozen canine meat (Central Nebraska Packing Co., North Platte, Nebraska) mixed with dog food on a daily basis and were given frozen or thawed laboratory rats, guinea pigs and mice (donated from a rodent breeding facility), and/or bones two to four times per week. Within their exhibit, the coyotes commonly hunted (at least one prey item two to three times daily) and captured (about one to two prey items per week) starlings *Sturnus vulgaris*, house sparrows *Passer domesticus*, chipmunks *Tamias striatus*, Norway rats *Rattus norvegicus*, meadow voles *Microtus pennsylvanicus*, and grey squirrels *Sciurus carolinensis*, but did not appear to eat much or any of these wild prey items. Care and use of animal subjects was approved by Zoo New England's Institutional Animal Use and Care Committee (letter dated 23 January 2002 to JGW), by Boston College's Institutional Animal Care and Use Committee Protocol Number 01-03, and by the Massachusetts Division of Fisheries and Wildlife Permit # 052.02LP.

We developed an ethogram that noted basic behavioural patterns (Way et al. 2006) with observations beginning 15 April with the pups ≤ four weeks of age. To avoid influencing coyote behaviour with different observers, only JGW interacted with and conducted activity budgets on them. Using this technique, we acknowledge that we did not have inter-observer reliability as described by Bekoff (1974) but the large amount of data collected attempted to mitigate fluctuations in intra-observer reliability. We used focal individual animal sampling (i.e. one coyote per 30 minute bout of data collection), took instantaneous point or scan samples (Martin and Bateson 1986, Macdonald et al. 2000) every 15 seconds for 30 minutes on the target coyote, recorded the date, time, and weather before each observation bout took place, and noted important contextual information in between each 15 second sampling period. By using frequent (i.e. every 15 seconds) instantaneous samples, we tried to obtain an accurate approximation from continuous recording (Martin and Bateson 1986). Thus, 120 samples per 30 minute behavioural bout on a coyote were ideally recovered. However, there were two reasons why we occasionally did not obtain 120 samples per bout: 1) a coyote was momentarily out of sight during a particular 15 second sampling period (usually, at most, this happened one to two times per 30 minute bout); and 2) we had to stop a sampling bout earlier (e.g. rain, darkness, or some kind of disturbance that forced JGW to abandon an activity budget). The number of fixes in these instances (which was infrequent) was pro-rated to 120 fixes for ease of statistical comparison.

We randomly chose which coyote to conduct observations on before entering the exhibit but attempted to evenly sample all coyotes (i.e. each coyote was scored every fifth time) during the study. We typically recorded behavioural data five to six days per week and took between one and four (usually one to two) 30 minute behavioural bouts per day during daylight hours. Behaviours were also recorded on digital still and video-cameras and 35-mm film cameras weekly for the duration of the juvenile period of the pups (Parks 1979) then *ad lib* after pups reached full-size (one year of age - Bekoff and Jamieson 1975). We conducted most of the behavioural bouts during early to mid-morning (between 0700-1100h) or between late-afternoon to early-evening hours (between 1600-1930h); these were the times with the least amount of people around the zoo (the zoo opened at 1000h and closed at 1630-1800h depending on the time of year).

Because the coyotes were habituated to and did not react negatively to JGW's presence, JGW followed them around the exhibit similar to the description of Goodall's (1986) "follows" of wild chimpanzees *Pan troglodytes* in Gombe, Tanzania and to Henry's (1986: 23-24) description of red foxes *Vulpes vulpes* in Saskatchewan, Canada. JGW made an effort not to influence the movements and/or behaviour of coyotes by minimizing movement in the exhibit. This was especially important because the coyotes would follow him around the exhibit when he interacted with them but would generally ignore him when he was standing erect and writing on a clipboard (J. Way, unpublished data). Following was a necessary technique to use on the coyotes because there was not a single observation spot outside the exhibit where the coyotes could reliably be seen all of the time (i.e. many times trees and shrubs concealed the coyote under observation). Besides JGW's presence, other human contact was kept to a minimum before and after each sampling period to avoid humans from affecting coyote behaviour. Context was a critical variable with respect to the coyotes' response to human behaviour. For example, they generally ignored people (unless very loud) on the public path but would intently watch and/or bark at staff that were behind (i.e. the opposite side of the public path that was off-limits to non-employees) or approaching their exhibit. Accordingly, zookeepers did not enter the exhibit to feed the coyotes when JGW interacted with them. Despite these precautions there were undoubtedly many instances where coyotes changed their activity in response to a person's (public or staff) presence – sometimes even when a person simply walked by their exhibit area. Similar instances of coyotes shifting their behaviour because of the presence of people have been documented in areas where wild coyotes inhabit urbanized areas (Way 2001). We attempted to mitigate these factors by increasing the total size of the pool of sample bouts.

We entered all of the ethogram/behavioural data into an Excel (Microsoft Excel, Microsoft Corporation, www.microsoft.com) spreadsheet. First, we entered the raw data into the spreadsheet. Then we alphabetized that data and grouped similar behaviours for each budget. Next we summed the frequency of each distinct behaviour observed. Finally we entered those summed values into a separate file (for each coyote) that had our developing ethogram. Due to the large amount of data and behaviour sequences in our ethogram (Way et al. 2006), properly entering and compiling data was a critical part of this ethogram's creation.

From the ethogram, we calculated the relative activity of each behaviour catalogued. Activity levels were classified as Low, Medium, or High. All behaviours from the ethogram were pooled into one of the three categories. Low activity consisted of minimal body movements such as resting and sitting where the basal metabolic rate appeared low. Medium activity consisted of activities such as standing, barking, growling, walking, and trotting. These were movements that required minimal amounts of energy expenditure but were subjectively scored above basal levels of activity. High activity consisted of animals expending copious amounts of energy such as running, chasing, wrestling, and fighting. Animals often panted or breathed hard during and/or after these activities.

As a caveat, we acknowledge that animals might use more energy during certain activities. For example, while a coyote was sitting alert we recorded low activity, but we had no way of quantifying the mental energy being spent by that coyote if it was very focused or nervous while sitting (this might be analogous to a person being at a conference; they sit for long periods of time but are exhausted by the end of the day because of the mental drain of focusing on people talking all day). Thus, our data was a representative snapshot of what an animal was doing at a given moment.

For each observation session a coyote had a certain number of low, medium, and high activity fixes which added up to 120 observations (or was pro-rated to 120 if $\geq$1 fix was not obtained per bout) during a 30 minute bout. An estimate of each observation's overall activity level index (ALI) was created by using the following formula:

$ALI = (L + 2M + 3H)/120$, where

L = low activity level fix

M = medium activity level fix

H = high activity level fix

The resultant ALI theoretically ranged from 1.00 – 3.00, with the coefficients in front of L (1), M (2), and H (3) in the ALI formula representing relative activity levels. Lower numbers (ALI < 2) represented sessions of lower coyote activity levels and higher numbers (ALI > 2) reflected days of medium to high activity levels. For example, during a theoretical observation session we recorded 20L, 40M, and 60H fixes; the resultant ALI would be 2.33 indicating high activity for that coyote during that particular observation session.

Using SPSS (v. 11.5, Chicago, Illinois), a multiple regression model was run to test for variables that most affected ALI. The factors affecting coyote activity (which were the independent variables) that we examined were gender, temperature, age of coyote in days, and group rank (one to five, with one the highest). Group rank was determined by examining dyadic interactions between pairs of coyotes (Bekoff 1972a). Coyotes that were tied in a given rank (i.e. there did not appear to be a hierarchical difference between the two) were both ranked the same number, with other coyotes remaining in their correct order (e.g. if two coyotes were ranked second in the group the rankings would be 1, 2, 2, 4, 5).

Due to multicollinearity there were some variables (e.g. body mass was correlated with age and hierarchy, season was correlated with temperature, and age in days because of the relatively short duration of the study [18 months]) that we did not use in the final model. The independent variables were entered stepwise into the regression model in SPSS; we did not make assumptions about factors affecting ALI because the purpose of the study was to explore which factors affected ALI. We set significance at $P < 0.05$..

Results

We conducted 609 30-minute observations with 120 (19.7% for each) of the sampling bouts conducted on Caon, Late, and Trans, 124 (20.4%) on Cane, and 125 (20.5%) on Lupe. For 2.6% (n = 16 of 609) of observation sessions and 1.1% (n = 833 of 73,080) of possible point fixes, extenuating circumstances (e.g. lack of light, heavy rain, or coyotes being temporarily out of sight) limited the number of fixes in that 30-minute observation to less than 120.

Our ethogram revealed 523 distinct behavioural acts (see Way et al. 2006). We categorized 166 behavioural acts (32%) as low, 261 (50%) as medium, and 96 (18%) as high energy activities within the ethogram. ALI per session varied for each animal with averages of 1.78 for Cane (range 1.01 – 2.53), 1.74 for Caon (range 1.02 – 2.42), 1.79 for Late (range 1.00 – 2.50), 1.69 for Lupe (range 1.01 – 2.40), and 1.79 for Trans (range 1.03 – 2.38). Although activity varied per animal, all study subjects showed the highest percentage of moderate activity.

Inspection of a scatterplot in SPSS with standardized residuals on the X axis and predicted values on the Y axis revealed no violations of multiple regression assumptions, with clustering of residuals along the centreline and residuals trailing off from the centreline. The distribution of the 609 observation sessions was normal, with a mean of 1.75 (range = 1.00 – 2.53) and a standard deviation of 0.3 (Figure 1).

The model explained 11.5% of the variance in ALI (adjusted R-squared = 0.115). Age in days ($\beta = -0.270$, $p < 0.0001$), temperature ($\beta = -.178$, $p < 0.0001$), and rank ($\beta = 0.135$, $p = 0.001$) were the three variables that best predicted ALI.

Age in days most affected activity levels with younger coyotes being more active than older coyotes (Figure 2).

Higher temperatures resulted in lower activity levels among all of the coyotes (Figure 3). Finally, hierarchical rank was inversely correlated with activity levels, with established higher ranking coyotes (e.g. Lupe) showing the lowest activity levels (Figure 4).

Discussion

The relatively small area of the zoo exhibit was somewhat equivalent to a rendezvous site for developing pups in the wild (Way et al. 2001, Way 2003, Way 2007b). At these sites, pups often stay in localized areas while adults hunt and return to these areas to tend the pups. Despite the obvious importance of adult coyotes to the survival of coyote pups, pups in the wild spend the most time with each other, similar to our study, as adults periodically return to feed, watch/protect, or

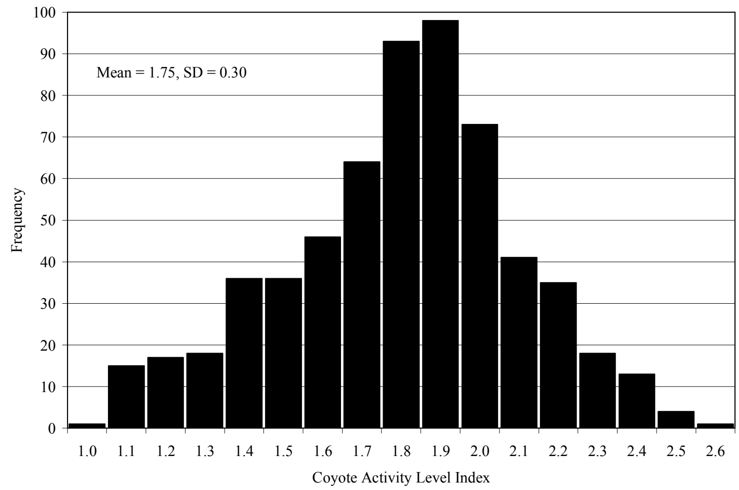

Figure 1. Inspection of a scatterplot in SPSS with standardized residuals (Coyote Activity Level Index of 1 [low levels], 2, or 3 [high levels]) on the X axis and predicted values on the Y axis (frequency) revealed no violations of multiple regression assumptions, with clustering of residuals along the centreline and residuals trailing off from the centreline. The distribution of the 609 observation sessions was normal, with a mean of 1.75 (range = 1.00 – 2.53) and a standard deviation of 0.3.

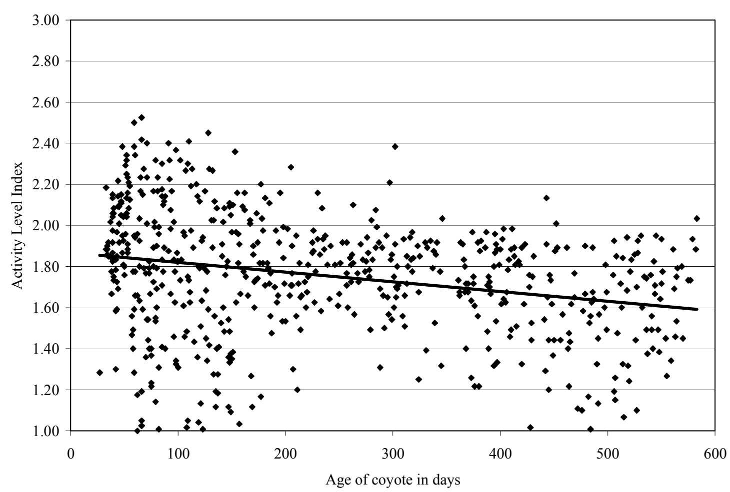

Figure 2. Age of coyote (in days) most affected the activity level indices (ALI, n = 609) with younger coyotes being more active than older coyotes.

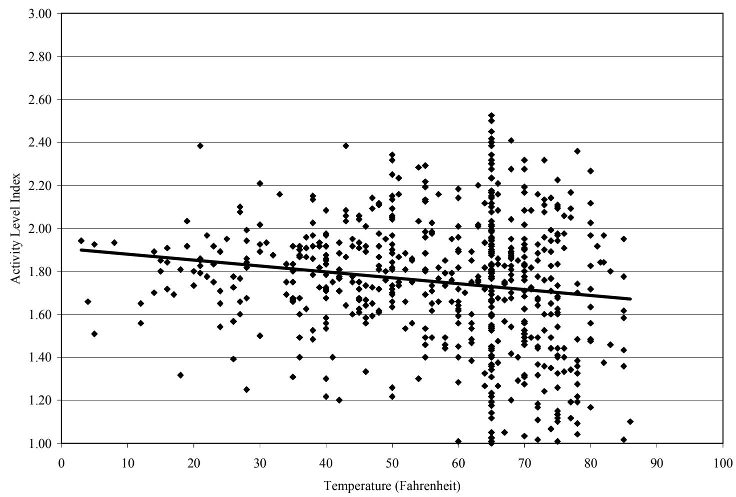

Figure 3. Higher temperatures resulted in lower activity level indices (ALI, n = 609) among all of the coyotes.

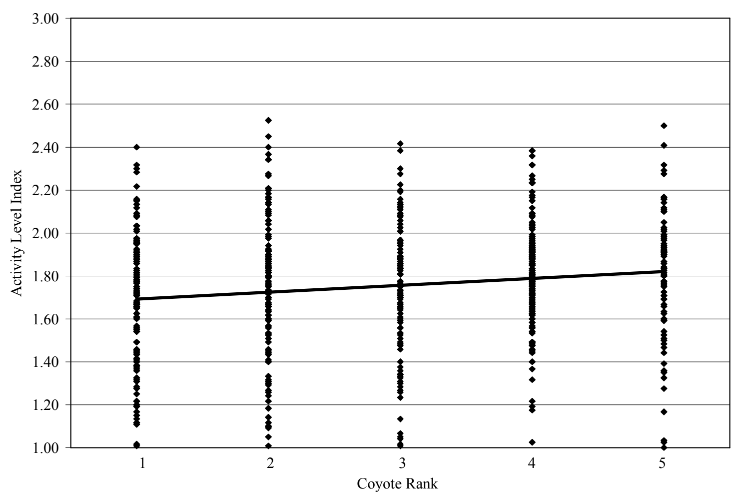

Figure 4. Hierarchical rank was inversely correlated with activity levels, with established higher ranking coyotes showing the lowest activity levels.

play with the pups. In the wild, coyotes increase the area that they use with increasing age (Harrison et al. 1991). However, little is known about what coyotes do at these sites due to the difficulties of capturing and monitoring coyotes at young ages, individually identifying coyote pups, and/or simply seeing them during this period. In other words, our observations of activity in this appropriately-sized captive exhibit (Frank 1987) likely approximates coyote activity in the wild during different stages of a coyote's life. Kreeger et al. (1996) noted that captive grey wolves showed similar levels of activity even when housed in widely different-sized enclosures/kennels. Additionally, we did not document any stereotypical behaviours (e.g. pacing) resulting from this relatively restricted area for a coyote pack (Clubb and Mason 2003). Therefore, data from coyotes in captivity, especially given the described circumstances, complement data from studies of coyotes in the wild.

Having coyotes habituated to the researcher was important for this study. However, one potential bias existed because of the direct (or lack thereof) interactions that occurred between the researcher and the study subjects. On some of the observations (especially on hot days), the coyotes showed very little activity during a given activity budget. However, immediately upon cessation of the observation bout the coyotes would immediately become active, clearly responding to JGW's activity within the exhibit (Way 2007b, J. Way unpublished data). While this could be construed as a bias it also indicated the degree of habituation of the researcher as the coyotes ignored JGW's presence within the exhibit when not interacting with them (i.e. during an observation session). This enabled us to examine other factors more consistent to what undisturbed wild coyotes would experience, such as effects of rank, pup age, and temperature on activity (rather than effects of human activity).

In the wild, coyotes are often more active at night around people presumably to avoid them (Grinder and Krausman 2001, Way et al. 2004), yet in many undisturbed areas (i.e. where people do not target and kill them) they do not display daily time preferences for activity (Gese et al. 1996a, Gese et al. 1996c, Patterson et al. 1999). This study, however, using coyotes socialized to people, attempted to look at non-human influencing variables. We did not test for differences in daily time of activity because direct observation of individuals was practical only during the day, which limited our observations to diurnal hours. Furthermore, anecdotal observations (e.g. JGW going to the exhibit at night) showed that coyotes were only limitedly active during non-observation (nocturnal) hours. Activity patterns of canids can shift to adjust to changes in predictable patterns of an animal's environment (Kreeger et al. 1996, Packard 2003), and because these captive coyotes were socialized to a researcher (Way 2007b) they were mostly active when that researcher was there, similar to descriptions of captive wolf activity (Kreeger et al. 1996). This set of circumstances enabled us to test activity for many ambient factors, excluding time of day.

We found significant relationships with younger coyotes, lower temperatures, and lower ranked coyotes showing increased activity. Firstly, the coyotes were often observed playing when they were younger, which likely produced higher levels of activity (Figure 2) at that age (Bekoff 1974, Way 2003, Way et al. 2006). As adults, they rested more often during observation sessions.

Secondly, canids show great variability in their activity patterns and are often more active when it is cooler; hence why most wild canids are nocturnal during the summer (Packard 2003). We found that there was a clear relationship between increased activity and cooler conditions (Figure 3). It should be noted, though, that activity differences could also have happened both on a daily basis and a seasonal basis. For example, on a normal day temperature increases steadily until peaking in the afternoon. Thus, we focused our observations (especially in the summer) during early mornings and late-afternoons to avoid the influences of extreme temperatures. However, coyotes generally could be less active in the summer and more active in the winter due to seasonal temperature differences. Future research should examine this more fully. Along the same lines, age of coyotes was possibly related to monthly temperatures, because the pups grew older as the summer temperatures steadily increased. Thus, less activity for older pups could have been due to increasing monthly temperatures and not necessarily age.

Thirdly, we found higher ranking coyotes to be less active (Figure 4). Higher ranking, more dominant (often parent) coyotes in the wild often have better access to resources and spend less time travelling and hunting, especially when food (e.g. ungulate carcasses) is abundant (Bekoff and Wells 1980, Gese et al. 1996a, Gese et al. 1996c). In this study, higher-ranking coyotes spent less time vying for dominance and more time resting, often close to the author (a resource for them - Way 2007b). Meanwhile, lower-ranking coyotes (e.g. Late and Caon) regularly (daily) tested each other, and this tension likely kept lower-ranked coyotes more active as they continually established and/or reinforced dominance hierarchies. In the wild these lower ranking coyotes may be the first to disperse from a pack. For example, Gese et al. (1996c) found that individuals that remained in their packs in Yellowstone National Park were dominant and higher-ranking, typically had greater access to carcasses/resources in their respective packs, and captured small mammals at a higher rate than dispersing individuals.

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References

Bekoff, M. 1972a. The development of social interaction, play, and metacommunication in mammals: an ethological perspective. *Quarterly Review of Biology* 47:412-434.

Bekoff, M. 1972b. *An ethological study of the development of social interactions in canids: a dyadic analysis* [Ph.D. Dissertation]. St. Louis, Missouri, USA: Washington University.

Bekoff, M. 1974. Social play and play-soliciting by infant canids. *American Zoologist* 14:323-340.

Bekoff, M. 1978. Behavioural development in coyotes and eastern coyotes. Pp. 97-126 in M. Bekoff (ed.), *Coyotes: biology, behaviour and management*. Blackburn Press, Caldwell, New Jersey, USA.

Bekoff, M. and Jamieson, R. 1975. Physical development in coyotes *Canis latrans* with a comparison to other canids. *Journal of Mammalogy* 56:685-692.

Bekoff, M. and Wells. M.C. 1980. The social ecology of coyotes. *Scientific American* 242:130-148.

Camenzind, F.J. 1978. Behavioural ecology of coyotes on the national elk refuge, Jackson, Wyoming. Pp. 267-294 in M. Bekoff (ed.), *Coyotes: biology, behaviour and management*. Blackburn Press, Caldwell, New Jersey, USA.

Chamberlain, M.J., Lovell, C.D., and Leopold, B.D. 2000. Spatial-use patterns, movements, and interactions among adult coyotes in central Mississippi. *Canadian Journal of Zoology* 78:2087-2095.

Clubb, R. and Mason, G. 2003. Captive effects on wide-ranging carnivores. *Nature* 425:473-474.

Frank, H. 1987. *Man and wolf: advances, issues and problems in captive wolf research*. Dr. W. Junk, Boston, Massachusetts, USA.

Gese, E.M., Ruff, R.L. and Crabtree, R.L. 1996a. Foraging ecology of coyotes *Canis latrans*: the influence of extrinsic factors and a dominance hierarchy. *Canadian Journal of Zoology* 74:769-783.

Gese, E.M., Ruff, R.L. and Crabtree, R.L. 1996b. Intrinsic and extrinsic factors influencing coyote predation of small mammals in Yellowstone National Park. *Canadian Journal of Zoology* 74:784-797.

Gese, E.M., Ruff, R.L. and Crabtree, R.L. 1996c. Social and nutritional factors influencing the dispersal of resident coyotes. *Animal Behaviour* 52:1025-1043.

Goodall, J. 1986. *The chimpanzees of Gombe: patterns of behaviour*. The Belknap Press of Harvard University Press, Cambridge, Massachusetts, USA.

Grinder, M.I. and Krausman, P.R. 2001. Home range, habitat use, and nocturnal activity of coyotes in an urban environment. *Journal of Wildlife Management* 65:887-898.

Harrison, D.J. 1992. Dispersal characteristics of juvenile coyotes in Maine. *Journal of Wildlife Management* 56:128-138.

Harrison, D.J. and Harrison, J.A. 1984. Foods of adult Maine coyotes and their known-age pups. *Journal of Wildlife Management* 48:922-926.

Harrison, D.J., Harrison, J.A. and O'Donoghue, M. 1991. Predispersal movements of coyote pups in eastern Maine. *Journal of Mammalogy* 72:756-763.

Henry, J.D. 1986. *Red fox: the catlike canine*. Smithsonian Institution Press, Washington, D.C., USA. 174 p.

Kitchen, A.M., Gese, E.M. and Schauster, E.R. 2000. Changes in coyote activity patterns due to reduced exposure to human persecution. *Canadian Journal of Zoology* 78:853-857.

Kreeger, T.J., Pereira, D.L., Callahan, M. and Beckel, M. 1996. Activity patterns of grey wolves housed in small vs. large enclosures. Zoo Biology 15:395-401.

Macdonald, D.W. and Sillero-Zubiri, C. (eds.). 2004. *Biology and conservation of wild canids*. Oxford University Press, New York, New York, USA. 450 p.

Macdonald, D.W., Stewart, P.D., Stopka, P. and Yamaguchi, N. 2000. Measuring the dynamics of mammalian societies: an ecologist's guide to ethological methods. Pp. 332-388 in L. Boitani, and T.K. Fuller (eds.), *Research techniques in animal ecology: controversies and consequences*. Columbia University Press, New York, New York, USA.

Martin, P. and Bateson, P. 1986. *Measuring behaviour*. Cambridge University Press, New York, New York, USA. 200 p.

Mech, L.D. Boitani, L. (eds.). 2003. *Wolves: behaviour, ecology, and conservation*. University of Chicago Press, Chicago, Illinois, USA. 448 p.

Packard, J.M. 2003. Wolf behaviour: Reproductive, social, and intelligent. Pp. 35-65 in L.D. Mech, and Boitani, L., (eds.), *Wolves: Behaviour, ecology, and conservation*. University of Chicago Press, Chicago, Illinois, USA.

Parker, G.R. 1995. *Eastern coyote: the story of its success*. Nimbus Publishing, Halifax, Nova Scotia, Canada.

Parks, M.B. 1979. *Physical and behavioural development of captive eastern coyote pups*. M. S. Thesis, University of Maine, Orono. 60 p.

Patterson, B.R., Bondrup-Nielsen, S. and Messier, F. 1999. Activity patterns and daily movements of the eastern coyote, *Canis latrans*, in Nova Scotia. *Canadian Field-Naturalist* 113:251-257.

Patterson, B.R., and Messier, F. 2001. Social organization and space use of coyotes in eastern Canada relative to prey distribution and abundance. *Journal of Mammalogy* 82:463-477.

Riley, S.P.D., Sauvajot, R.M., Fuller, T.K., York, E.C., Kamradt, D.A., Bromley, C. and Wayne, R.K. 2003. Effects of urbanization and habitat fragmentation on bobcats and coyotes in southern California. *Conservation Biology* 17:566-576.

Switalski, T.A. 2003. Coyote foraging ecology and vigilance in response to grey wolf reintroduction in Yellowstone National Park. *Canadian Journal of Zoology* 81:985-993.

Tigas, L.A., Van Vuren, D.H. and Sauvajot, R.M. 2002. Behavioural responses of bobcats and coyotes to habitat fragmentation and corridors in an urban environment. *Biological Conservation* 108:299-306.

Way, J.G. 2001. The eastern coyote: documenting the habits of one of Cape Cod's newest residents. *Conservation Perspectives, the online journal of the New England Chapter of the Society for Conservation Biology*. http://www.nescb.org/epublications/spring2001/coyotes.html.

Way, J.G. 2003. Descriptions and possible reasons for an abnormally large group size of adult eastern coyotes observed during summer. *Northeastern Naturalist* 10(3):335-342.

Way, J.G. 2005. *Assessing student learning and interest in eastern coyotes*. Ph.D. Dissertation, Boston College.

Way, J.G. 2007a. A comparison of body mass of *Canis latrans* (Coyotes) between eastern and western North America. *Northeastern Naturalist* 114(1):111-124.

Way, J.G. 2007b. *Suburban howls: Tracking the eastern coyote in urban Massachusetts*. Dog Ear Publishing, Indianapolis, Indiana. http://www.easterncoyoteresearch.com.

Way, J.G., Auger, P.J., Ortega, I.M. and Strauss, E.G. 2001. Eastern coyote denning behaviour in an anthropogenic environment. *Northeast Wildlife* 56:18-30.

Way, J.G., Ortega, I.M. and Auger, P.J. 2002. Eastern coyote home range, territoriality and sociality on urbanized Cape Cod, Massachusetts. *Northeast Wildlife* 57:1-18.

Way, J.G., Ortega, I.M. and Strauss, E.G. 2004. Movement and activity patterns of eastern coyotes in a coastal, suburban environment. *Northeastern Naturalist* 11(3):237-254.

Way, J.G. and Proietto, R.L. 2005. Record size female Coyote, *Canis latrans*. *Canadian Field-Naturalist* 119(1):139-140.

Way, J.G., Szumylo D.-L.M and Strauss E.G. 2006. An ethogram developed on captive Eastern Coyotes *Canis latrans*. *Canadian Field-Naturalist* 120(3):263-288.

Woodruff, R.A. and Keller, B.L. 1982. Dispersal, daily activity, and home range of coyotes in southeastern Idaho. *Northwest Science* 56:199-207.

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