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Abstract: Coyotes (*Canis latrans*) live in social groups with relatively small territories or as single, non-territorial transients with large home ranges in southern Texas. Coyotes communicate and establish territories through auditory, olfactory, and visual means They consume mammals, fruits, and insects with their diets reflecting differences in abundance and vulnerability of prey, effects of plant phenology and weather conditions. Coyotes have adapted to human exploitation by avoiding humans and their control techniques. Because coyotes habituate to nonlethal control techniques (e.g., frightening devices), I suggest apply frightening devices only when coyotes are a problem. Lethal techniques likely will be most effective at resolving coyote depredations if they are applied at depredation sites and immediately before or when losses occur

Coyotes have been studied well enough in Texas to provide a fairly comprehensive picture of their behavior. In this paper, I review social organization, home range, activity patterns, reproduction, communication, predatory behavior and learning by coyotes in Texas and provide implications for their management

Social organization

Seventy percent of the coyotes on the Rob and Bessie Welder Wildlife Refuge (WWR) in southern Texas existed in groups (3-7 coyotes), 17% as mated pairs, and 13% were transients (i.e., coyotes that ranged over large areas, usually alone) (Andelt 1985). Coyote groups also were reported in Jim Wells (Bradley and Fagre 1988*a*) and Webb counties in Texas (Knowlton et al. 1985), but transients composed a greater proportion (34%) of the female population (Windberg and Knowlton 1988) than at the WWR.

Although coyotes existed in groups and interacted occasionally on the WWR, an average of only 1.4 coyotes were observed together per sighting. Each group consisted of a mated pair and associates The mated pairs interacted frequently, maintained pair bonds for at least 3-22 months and were found together most frequently during the breeding season. Male and female associates interacted with other group members less frequently than did individuals of mated pairs The social organization of coyotes in southern Texas was similar to that reported for other unexploited coyote populations (Bowen 1978, Camenzind 1978).

Mated pairs and associates were active around pups, spending about 30% of the time near them on the WWR (Andelt 1995). Males and females of mated pairs spent similar amounts of time near pups; associates spent similar or only slightly less time near pups than did the mated pair Bekoff and Wells (1982) speculated that adult coyotes spend time near pups to protect them, but adults did not alternate in attending pups on the WWR The percentage of time pups were unattended by adults was not related to the size of coyote groups. Pups spent less time together as they matured.

The majority (21 of 25) of coyotes classified as transients on the WWR appeared to be healthy adults; only 2 were <1 year old (Andelt 1985). Knowlton et al. (1985) and Windberg and Knowlton (1988) reported that the majority of transient female coyotes were $\leq$2 years old, whereas the majority of territorial females were >2 years old Two transients on the WWR entered resident groups, paired, and remained in the groups (Andelt 1985).

Larger coyote groups have been reported from more northern regions (Camenzind 1978, Bekoff and Wells 1980, Bowen 1981) presumably as an adaptation in capturing or defending large prey. However, prey size in coyote diets was not related to the number of coyotes interacting within groups or to the average number of coyotes observed together on the WWR (Andelt 1985). The relatively large size of coyote groups on the WWR likely resulted from a lack of human exploitation and saturation of habitat by territorial coyotes

Home range

Adult resident male coyote home ranges averaged 2 to 3 mi^2 (95% polygon method) and adult resident female home ranges averaged 1.8 to 2.9 mi^2 in southern Texas (Andelt 1985, Bradley and Fagre 1988*b*, Windberg and Knowlton 1988) Home range size did not differ among seasons on the WWR (Andelt 1985). Minimum home ranges of adult male and female transients averaged 28 mi^2 and 21mi^2, respectively on the WWR. The home ranges of pups increased in size as the pups grew older.

Adult pairs and groups primarily occupied non-overlapping but contiguous home ranges (Andelt 1985, Knowlton et al. 1985, Windberg and Knowlton 1988) The home ranges of transients overlapped those of residents; transients were found more frequently on the perimeter than on the interior of resident adult coyote home ranges (Andelt 1985, Knowlton et al 1985, Windberg and Knowlton 1988). The minimal overlap among adjacent resident coyote home ranges, observations of resident coyotes chasing intruders, and the higher proportion of transient locations on the perimeter than interior of resident home ranges indicates resident home ranges were territories

Coyote and bobcat (*Felis rufus*) home ranges overlapped and there was no indication of avoidance among the 2 species in southern Texas (Bradley and Fagre 1988*a*, W. F. Andelt, unpublished data).

Some adult coyotes on the WWR were found within the same home range for at least 48 months and 1 pup was found within its natal range for at least 29 months (Andelt 1985). Coyotes also maintained stable home ranges in Jim Wells County for 153 to 499 days (Bradley and Fagre 1988*a*) Adult coyote home range size was not related to the number of adult coyotes living in groups on the WWR (Andelt 1985). Twelve to 29% of the adult males and 4-9% of the adult females on the WWR emigrated annually. The extended period that coyotes were found within home ranges and fairly low emigration rate suggests that coyotes within groups were related Coyotes in Jim Wells County, Texas appeared to have a high tolerance of human activity and did not shift home ranges in response to herbicide treatments of brush (Bradley and Fagre 1988*b*).

Territorial female coyotes were more likely to be captured (i e , trapped) on the edge or periphery of their home range than within their territories in southern Texas (Knowlton et al. 1985, Windberg and Knowlton 1990). However, the distribution of all coyote capture sites did not differ from that of trap locations (Windberg and Knowlton 1990), indicating non-resident coyotes were captured within resident home ranges.

Activity patterns

Coyotes were active during day and night but were most active at, and just after, sunset on the WWR (Andelt 1995) and during crepuscular periods in Jim Wells County, Texas (Bradley and Fagre 1988*b*). Timing of activity periods of adults and pups were similar. Coyotes were more active during the daytime on the WWR where they were not exploited than in Nebraska where they were exploited by humans (Andelt and Gipson 1979*b*).

Distances moved by adult male ($\bar{x}$= 5.0 mi) and female ($\bar{x}$= 5 2 mi) coyotes during 24-hour periods were similar, and were greatest during the breeding season. Movement distances were not related to the size of coyote groups nor to the size of prey in their diets

Reproduction

Pups were born in all 5 coyote groups studied during 1978 and 1979 on the WWR (Andelt 1985). Only 1 female was known to whelp pups in each of 2 groups containing multiple females. Knowlton et al (1985) reported that 12 of 14 territorial females ovulated and 6 whelped. Although 9 of 19 transient females ovulated, none whelped (Knowlton et al. 1985) Ovulation by non-territorial females and their establishment within some territories suggests transients range over large areas seeking breeding opportunities in resident groups as suggested by Messier and Barrette (1982).

The fairly large number of transients found in coyote populations suggests that an ample pool of reproductive coyotes are available to fill any vacancies created by animal damage control and reflects the resilience of coyote populations to exploitation (Knowlton et al. 1985).

Communication

Coyotes communicate through auditory (vocalizations), olfactory (scent marking), and visual (e.g. aggression, dominance, and greeting displays) means (Lehner 1978). Coyotes vocalized most frequently during the breeding season (16 Jan-15 Feb) on the WWR (W. F. Andelt, unpublished data) and in Jim Wells County (Walsh and Inglis 1989). They also vocalized more frequently during moderate than extreme temperatures, on clear nights, and during low wind speeds (Walsh and Inglis 1989). Walsh and Inglis (1989) cautioned that the increase in vocalizations heard during low wind possibly might have been related to a greater human ability to hear coyotes during low wind.

Coyote vocalizations were not related to the intensity of moonlight in Jim Wells County (Walsh and Inglis 1989), but coyotes vocalized more often during nights without moonlight than on nights with a full moon on the WWR (W. F. Andelt, unpublished data). The increased vocalizations on nights without a moon may have compensated for a presumed lower ability to see other coyotes during lower light.

Coyotes deposit urine scent marks more frequently on the edge than within the interior of their territories (Barrette and Messier 1980) Coyotes deposited numerous scats on roads of the WWR (Andelt and Andelt 1984); more scats were found on the edge than on the interior of their home ranges (W. F. Andelt, unpublished data). Scats likely function to mark territories.

Foraging behavior

Coyotes consumed a variety of prey items including mammals (primarily deer [*Odocoileus virginianus*]) and lagomorphs (primarily cottontails [*Sylvilagus* spp.]), fruits (primarily Texas persimmon [*Diospyros texana*]), and insects in southern Texas (Andelt et al. 1987, Windberg and Mitchell 1990) Coyote diets varied among years due to successional changes in vegetation and changes in prey abundance (Andelt et al. 1987, Windberg and Mitchell 1990). Coyote diets also varied seasonally, reflecting differences in abundance of a variety of food items, differential vulnerability of prey, effects of plant phenology and weather conditions (Andelt et al. 1987). Coyotes appear to feed selectively on cotton rats (*Sigmodon hispidus*) (Windberg and Mitchell 1990), fruits, and insects (Andelt et al. 1987) when they are available.

Learning

Coyotes are adaptable animals that are able to learn quickly how to avoid humans and their control techniques. Coyotes have maintained their numbers during considerable man-induced mortality by learning to detect and avoid strychnine drop baits, traps, lethal bait stations (Robinson 1948) and scent stations after being captured and released from traps (Andelt et al 1985). Coyotes apparently have learned to avoid humans in areas where they are exploited by becoming less active during the daytime (Gipson and Sealander 1972, Andelt and Gipson 1979*b*, Andelt 1985*a*) and by avoiding open areas near roads (Roy and Dorrance 1985). Coyotes also have adapted to exploitation by increased immigration into areas where they were removed (Knowlton 1972, Connolly and Longhurst 1975).

Coyote behavior: implications for management

Coyotes cause large economic losses for ranchers by killing significant numbers of livestock, especially sheep (National Agricultural Statistics Service 1991). We can apply our knowledge of coyote behavior to more effectively manage depredations with non-lethal and lethal control techniques. Because coyotes learn to avoid control techniques, nonlethal techniques (e.g., frightening devices) should not be used for extended periods. They should be employed shortly before predation begins (if it is predictable) to avoid the establishment of a problem or pattern that may be difficult to disrupt. Frightening devices should be removed as soon as they are no longer needed to minimize habituation by coyotes

Because most coyotes are territorial and have small home ranges, depredating coyotes can be selectivity removed by applying aerial and ground controls near sites of predation (Andelt and Gipson 1979*a*, Connolly and O'Gara 1987). If coyotes are not causing depredations, it seems unwise to attempt to kill these animals because they may learn to avoid the control technique, or they may be replaced by other coyotes that cause depredations or avoid control techniques.

Coyotes moved between ranches in southern Texas (Bradley and Fagre 1988*a*). Based upon

simulation models, Windberg and Knowlton (1988) indicated that 35 coyotes would occasionally occupy an area of 1 mi2;, 97 an area of 10 mi^2; and 480 an area of 100 mi^2, although densities were only about 3.2 coyotes/mi^2 The large number of coyotes using an area and the presence of transients which readily occupy vacant territories indicates resolving coyote depredation problems through population reduction will be difficult, especially on small areas.

Lethal controls for removing specific offending animals should be employed as soon as predation begins to minimize livestock losses. If local populations of coyotes are removed before predation begins, control efforts should be implemented immediately before coyotes become a problem because other coyotes quickly move into vacated areas. Control applied long before damage starts likely will be relatively ineffective. Dorrance (1980) suggested that dispersal by coyotes, primarily from mid-February through April, probably negates the effect of preventive control on local coyote populations prior to mid-February in central Alberta.

Fruits and insects may buffer coyote predation on livestock and deer (Andelt et al. 1987) Thus, in some instances it may be possible to predict the intensity of coyote predation by monitoring fruit and insect abundance.

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