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# Social and Spatial Relationships of Coyote Families and Neighboring Coyotes

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SOCIAL AND SPATIAL RELATIONSHIPS OF COYOTE  
FAMILIES AND NEIGHBORING COYOTES

by

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A THESIS

Presented to the Faculty of  
The Graduate College in the University of Nebraska  
In Partial Fulfillment of Requirements  
For the Degree of Master of Science

Department of Forestry, Fisheries and Wildlife

Under the Supervision of  
Dr. Philip S. Gipson and Dr. Ronald M. Case

Lincoln, Nebraska

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## INTRODUCTION

A study of coyote social and spatial relationships was conducted in southeastern Nebraska from August 1976 through March 1978 to fulfill research requirements for an M.S. degree in Wildlife Ecology. The results of this investigation have been organized into two sections, each written in a style suitable for publication in a scientific journal.

In the first section, findings related to spatial relationships of 21 radio-tagged coyotes are presented. Data on the 1) influence of wind direction on spatial separation, 2) home range characteristics and relationships, and 3) temporal and seasonal movement characteristics of coyotes are included in this section.

Home range and movement relationships of seven breeding adults and six pups during the August to December period are presented in the second section. These findings are related to domestic poultry losses.

## ACKNOWLEDGEMENTS

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I am indebted to many individuals for volunteering to assist me in field work. The help of Brian R. Mahan and the members of the Alvo-Eagle Coyote Hunting Club 16 January 1977 and James G. Bruner, J. Patrick Costigan, Edward S. Jochum, Steve A. Kilpatrick, Wayne Richter, and Martin Wandrey 16-17 February 1978 in the successful recapture of members of the "Piper Family" was indicative of the support I received. David A. Baker, Steve A. Kilpatrick, Dale G. Luce, and Brian R. Mahan assisted in trapping efforts and searches for coyote dens.

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Home range sizes and relationships of radio-tagged coyotes have been investigated by several researchers, however social and spatial relationships, both diurnal and seasonal, are yet to be fully understood. Little is known about the interactions among coyotes and spacing mechanisms involved in their distribution over time and space.

Gier (1975:251) states that ". . . territoriality of coyotes is poorly understood." He suggested that defense of territory is apparently evident only during the denning season. Chesness and Bremicker (1974) observed non-overlapping home ranges for adult females and suggested that they were highly territorial. They also found some overlap in adult male ranges. Andelt (1976:34) noted that ". . . temporal overlap of adult male or adult female home ranges was not evident." He recorded considerable movement around the edge of their ranges and suggested that these coyotes may have been defending their ranges. Danner's (1976) findings indicated considerable amount of range overlap as did Gipson and Sealander (1972), but the former attributed a great deal of the overlap to the constant availability of carrion at a feedlot. Perhaps the most complete treatment of coyote home ranges, at least during late fall, winter and early spring is Hibler's (1977) work in Utah. He observed considerable variability in home range size and use among different age groups.

A 20-month investigation was conducted in southeastern Nebraska to study social and spatial interactions among coyotes, with emphasis on these relationships to domestic poultry losses. This report deals with findings related to spatial relationships of coyotes, especially

with respect to the influence of wind direction on spacing of coyotes. Interactions of breeding adults and pups during the August to November period is treated at length in another paper (Althoff and Gipson, in preparation).

Hibler's (1977:46) concept of home range was adopted for this paper: ". . . the area or volume that is habitually occupied or traversed by an animal in pursuit of routine activities, within a specific time period. . .(in this study months). . .specific movement patterns such as, sallies, dispersal, homing and migration not generally considered routine and therefore excluded from the concept."

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#### STUDY AREA

Field work was conducted in eastern Lancaster and western Cass Counties near Waverly, Nebraska. Topography consists of low rolling hills with sloping upland and bottom land areas. Row crops of grain sorghum (Sorghum vulgare), corn (Zea mays), wheat (Triticum aestivum) and oats (Avena sativa) and forage crops of brome grass (Bromus ineris),

alfalfa (Medicago sativa) and native grasses comprised most of the vegetation in the area. Waterways were planted to brome and native grasses with most woody vegetation occurring along creek bottoms and fence rows.

The Bevans turkey farm, consisting of range production sites A and B, was located in the northern portion of the study area. Site A was 48 ha (hectares), site B 61 ha. Both were almost completely enclosed by a 2 m (meters) high woven wire fence. About 120,000 domestic turkeys were raised in semi-confinement or range pens from April to November of each year.

#### METHODS AND MATERIALS

Coyotes were captured with snares and number 3 steel traps. Traps were set intermittently from 20 August 1976 through 13 February 1978. Most captured coyotes were toe-clipped (Andelt 1976), ear-tagged with monel metal tags, and outfitted with 151 MHz radio-telemetry collars. Radio signals were received on a portable receiver (Model LA-12, AVM Instrument Company, Champaign, Ill.) using a car-top mounted null-peak antenna system.

Radio locations were determined by triangulation using one vehicle as described by Andelt (1976). Accuracy of fixes was  $\pm 2^{\circ}$  with most fixes taken within 1.5 km (kilometers) of the coyote.

Additional locations were obtained from positively identified snow and/or mud tracks of toe-clipped coyotes. Each animal was usually located once weekly, and was monitored during an all-night tracking shift (approximately sunset to sunrise) at least once a month

(locations were taken at hourly intervals). The sunset to sunrise tracking period coincided with peak activity periods observed by Andelt (1976) for coyotes in Nebraska.

Weather data were obtained in the field and from the U.S. Department of Commerce Weather Bureau at Lincoln Municipal Airport 18 km west of the study site. Hourly wind direction was determined to the nearest 10 degrees. A non-parametric sign test (Steel and Torrie 1960) indicated no significant difference in wind direction between the study area and the airport ( $P < .0001$ ,  $\pm 60^\circ$ ).

Response to wind direction was analyzed relative to the coyote's position and its home range based on 1) hourly locations and 2) overall movement patterns observed each tracking shift. To test for hourly response to wind direction we assumed the animal made a random decision every hour. Examples of upwind ( $\pm 90^\circ$  of wind direction) and downwind movements ( $> \pm 90^\circ$  of wind direction) are illustrated in Fig. 1. Movements during each tracking shift were compared to the home range of the animal to see if only certain portions of its range were occupied relative to wind direction. Terms used in describing home range and movements with respect to the home range and wind direction are illustrated in Fig. 2. Range periphery was the area 0.5 km either side of the home range boundary (Hibler 1977). Core refers to the center of the range and generally contained 70-90% of all locations and nearly all bedsite locations for type I ranges (see below). Frontside of the range includes the core and the portion of the periphery upwind, as determined by drawing an imaginary line

perpendicular to wind direction through the geometric center of the range. Backside of the range refers to the downwind portion of the periphery.

Minimum area method (Mohr 1947) was used to determine home range size and boundaries. Ranges were grouped into two basic types based on a modification of Hibler's (1977) home range classifications for coyotes: type I--home ranges with relocations primarily contained within one contiguous area and, type II--ranges with relocations in two or more disjunct areas within a common time interval. Examples of both range types are illustrated in Fig. 3. For type II ranges two measurements were made, one of the total area and one of the intensely utilized areas (when they could be detected). Exploratory movements or sallies (Burt 1943) were not included in determining type I home range boundaries. We considered movements of greater than 1 km from the normal home range as a sally if the coyote moved back to the range and was not observed in that general area again during the month(s) monitored. Similar movements of coyotes with type II ranges could not be readily distinguished from other movements and thus, they were included in determining the total area of home ranges.

Distances traveled were calculated by measuring distances between hourly locations obtained during all-night tracking shifts. At best, they represent the minimum amount of movement by any coyote.

Biological seasons for the coyote as proposed by Andelt (1976) were used in the analysis. Movement data were grouped according to six physiologically defined seasons: gestation (March-April), nursing

(May-June), pup training (July-15 September), adolescence (16 September-15 November), prebreeding (16 November-January), and breeding (February). Home range data were divided into two groups: pup rearing period (nursing-pup training-adolescence) and non-pup rearing period (prebreeding-breeding-gestation). Coyotes were aged as adults (2 years or older), yearlings (1-2 years old) or juveniles (less than 1 year old).

Data were processed with an IBM 360 computer using programs developed at the University of Arkansas and the University of Nebraska.

## RESULTS

Information was obtained from 30 coyotes from August 1976 through 31 March 1978. Data for each coyote with respect to sex, age, period monitored, number of locations, and number of all-night tracking shifts are summarized in Table 1. Movement and home range were collected for 21 coyotes (12 adults, 3 yearlings and 6 juveniles) permitting detailed analysis of spatial relationships.

### Response to Wind Direction

Hourly Movements.--Of 1792 observations, 890 were upwind and 902 downwind. A non-parametric sign test (Steel and Torrie 1960) indicated no significant departure from a 50:50 ratio ( $P>0.05$ ). No significant differences were observed between PM or AM movements. Of movements greater than 0.8 km, 53.0% were upwind, 47.0% downwind based on 549 observations. A sign test indicated no significant departure from a 50:50 ratio ( $P>0.05$ ).

Home Range Use.--Neighboring radio-tagged coyotes were located within 1 km of each other during only one tracking shift. Movements of adults with type I ranges were confined to the core or upwind periphery of their home ranges on 64 of 79 tracking shifts. Only on 6 shifts did an adult with a type I range visit the backside of its range before 2400, and only 9 tracking shifts after 2400. Eight of the 15 nights coyotes visited the backside of the range were during late fall. Adults were never observed to visit all portions of their home range in any one night.

Two examples of typical movement patterns of adults with type I ranges are illustrated in Fig. 4. In Fig. 4a, coyote F15 (F=female) moved to the frontside of its range, then moved along the periphery of the range during the early portion of the night. Fig. 4b shows the same overall pattern of the coyote only occupying the frontside or core area of the home range, with the exception that F14 moved from the core area to range periphery and back again more often.

Adherence to occupation of parts of the range relative to wind direction can be further supported by the occurrence of damage at the turkey production sites. We observed F14 moving to the southeast part of her range, where production sites A and B were located, only when a southeast, east, or northeast wind prevailed. A review of Andelt's (1976) tracking shifts of coyotes M11 (M=male) and F14 earlier in the summer of 1976 indicated that of the 13 nights they were radio-tracked into the pens the wind was from the southeast, east or northeast.



Three of five exploratory movements were into the wind and most were recorded during the non-pup rearing period. One exception was a sally made by F29 during the night of 2 June 1977 (she was not suspected of whelping pups in 1977), and it, too, was into the wind. On the night of 2 February 1977, adult F25 was located 6.4 km northeast of her range. During a tracking shift that night she moved crosswind until the following morning. Her bedsite that morning was 15.5 km northeast of her range. From 1710 to 1810 she was located close (0.7 km) to adult M27. After 1910 she continued moving to the northeast but was not accompanied by M27.

Adults, yearlings and juveniles (post-natal range movements only) with type II ranges moved upwind during early hours of the night, during 45 of 46 tracking shifts, even more so than apparent for adults with type I ranges. Usually coyotes with type II ranges moved downwind into areas they had previously visited that night. An example of this type movement is illustrated in Fig. 5. When moving from one area of intensive use to another, nearly straightline movements were indicated. These movements between or on the edges of home ranges of neighboring breeding adults were the longest of any movements observed. Fig. 6 shows F12's travels on 5-6 January 1977, illustrating such a movement pattern.

During January 1977, F12's movements were confined to the core of what had been F13's range the previous year. Her movements during this period were similar to adults with type I ranges, except she was located fewer times on the periphery of the range. This same basic

movement pattern was observed for adult F26 until transmitter failure in late January 1978, and for yearling F32 for the 7 months monitored.

Movements of juveniles in relation to adult ranges while confined to the natal range are treated at length in another paper (Althoff and Gipson, in preparation). On 3 November 1976 when littermates M20 and F21 were known to leave the natal range for the first time, they moved directly into the wind, passing through the core area of another breeding pair's (M11 and F14) home range. However, after this time only post-natal movements of M20 were observed (radio contact was lost with F21). His movements were similar to those described for adults and yearlings with type II ranges in that he moved into the wind when traveling at least 0.5 km from his bedsite. His bedsites near the range of M11 and F14 were always on the periphery of their range.

Occasionally, major wind shifts (greater than  $90^{\circ}$  and speeds exceeding 8 km/h) occurred during a tracking shift. Coyotes on the periphery of their ranges responded to this change in wind direction. Fig. 7 is an example of how the wind direction apparently influenced the periphery movements of adult M33 and yearling F32 in such a way that they visited the same area during the same night but not the same time. During periods of relative calm early in night adults were generally not observed to visit the periphery until the wind speed increased to approximately 2 km/h or greater.

Capture Locations.--Nine adults with type I ranges were trapped or snared, and recaptured 11 times. Five were trapped outside their

home range, mostly on scent post or bait sets, or snared under turkey pen fences. Five were caught on the periphery of their ranges and one (F34 in a blind set) in the core. Wind direction indicated that 10 of the 11 times adults apparently were moving upwind on the night of capture.

Capture sites of five yearlings and adults with type II ranges were on the range periphery of radio-tagged adult ranges. Of seven juveniles captured, only one, F23, was caught on the periphery of an adult range. She, too, was apparently moving upwind the night of capture.

#### Home Range Characteristics and Relationships

Home range sizes of all coyotes are summarized in Table 2. Of those animals having type I ranges, adult females had the largest overall home ranges (19.2 km<sup>2</sup>), followed by adult males (10.5 km<sup>2</sup>), yearling females (9.6 km<sup>2</sup>), juvenile males (4.3 km<sup>2</sup>) and juvenile females (2.3 km<sup>2</sup>). The latter two groups are for natal ranges only. Coyotes with type II ranges generally roamed over larger areas, range 23.0-78.6 km<sup>2</sup>, than observed for coyotes with type I ranges. But these areas represent wandering movements and not intense areas of utilization. Detectable areas of intense use for coyotes with type II ranges were smaller for adults with type I ranges (8.9 km<sup>2</sup> average for F12, M20, F21, F26, and M27). Most adults with type I ranges, monitored during both non-pup rearing and pup rearing periods, had larger home ranges during the non-pup rearing period.

Non-overlapping contiguous ranges were noted for adults and yearlings with type I ranges during the pup rearing period in 1976 (Fig. 8) and 1977 (Fig. 9). However, range expansion was evident during prebreeding and breeding (Table 2) resulting in some overlap of ranges between neighboring adults, as Figs. 8 and 9 indicate. Yearling F32's range overlapped little with the mated pair M25 and F33.

Adult F26, M27, and M40 exhibited type II ranges. All were trapped during late January or early February, lost one foot from the trapping process and showed limited movement for the month following release. Whether these coyotes maintained type I ranges before capture is not known, but possibly due to poor health status during breeding, they apparently did not mate that season. F29 also was lame during the breeding season and there was no indication she whelped pups in 1977. Her home range was similar in size and utilization to those noted for breeding adults, but the movement patterns observed were not comparable.

No total shift in ranges were noted for any of the adults, although adult F26 restricted her movements to a very small area ( $3.7 \text{ km}^2$ ) for the last 6 months she was monitored. Yearling F12 restricted her movement to a smaller area in January 1977. Fig. 10 shows these changes in home ranges.

The ranges of yearling F12 (1976) and F32 (1977) partially overlapped with ranges of breeding F13 and an untagged breeding female, respectively during the pup rearing period. Andelt (1976) located F12

in the core of breeding F13's range during breeding, gestation, and nursing but not during pup training. While F13 was alive, F12 was not located in the core of her range during our study, but was occasionally located on the periphery. F13 was shot on site B on 6 November 1976. During January 1977, yearling F12 was located for the first time in the core area of F13's former range. For 11 days she was located in this vicinity, at least twice as long as she was known to occupy any area of similar size. She was shot in that area on 23 January 1977. Regular checks for activity in the area F13 previously occupied during the remainder of 1977 indicated very little use by coyotes and no active den. F26 and M27 were located in this area for various periods from February through May but never at the same time. Thus, in terms of breeding adults it was apparent this range was not occupied during the 1977 pup rearing period.

An active den was located in the south central portion of yearling F32's range during 1977, but she did not whelp pups. She was often located in the general area of the den throughout July 1977 to January 1978 while she was monitored.

During 1976, coyotes M11, F12, and F14 were suspected of causing damage at turkey production site B (see Andelt 1976 and Appendix A, Table 1). At least one other unmarked coyote visited this site and killed turkeys. Only mates M11 and F14 were known to visit either site. Whereabouts of M11 was unknown, but snow and mud tracking indicated F14 had a different mate in 1977. There was no indication that her new mate accompanied her on forays to sites A or B.

### Distances Traveled

Average minimum hourly distances traveled by coyotes during all-night tracking shifts are summarized in Fig. 11, according to biological seasons. Considerable variation among and within age groups was noted. Average minimum hourly distances traveled were greatest for adult males (0.89 km/h), followed by adult females (0.75 km/h), yearling females (0.61 km/h), juvenile males (0.56 km/h) and juvenile females (0.42 km/h).

Trends observed from season to season may be a reflection of the number of movements to the range periphery and not a true indicator of overall activity. For example, adult breeding females would be expected to be more active during nursing and pup training because of increased food demands. Our tracking schedule of taking hourly locations may not have detected short forays from the den when in fact one or more forays may have occurred during an hour. Thus, considerable caution is taken in interpreting the observed trends.

Greatest hourly distances traveled by adults were during adolescence, prebreeding, and breeding (Fig. 11). Yearling movements were greatest during adolescence, but data were obtained for only 3 of the 6 seasons. Yearlings and adults with type II ranges showed considerable variation in hourly distances traveled from tracking shift to tracking shift. Greatest hourly distances traveled were noted when these animals were moving from one intensely used area to another.

## DISCUSSION

## Relationships of Movement and Home Range Use to Wind Direction

A plausible explanation as to why coyotes did not always move upwind would be that coyotes generally concentrated their activities in familiar territory. One advantage of a home range is the familiarity which it affords the resident animal. If breeding adult coyotes are territorial, as the data indicate, they would be confined to some extent by range boundaries or increasingly less familiar areas. This means they can only move into the wind so far before they have reached their own or their neighbor's boundary.

Even though no hourly differences for upwind versus downwind movements were noted, the wind influence was profound; only 5 of 79 tracking shifts of adults with type I ranges showed occupation of the backside of the home ranges and only 1 of 46 tracking shifts of coyotes with type II ranges indicated substantial movement to the area downwind from their bedsites during the sunset to midnight period. Knowledge of wind direction made prediction relatively easy as to which portion of the range a coyote would visit each night.

Observations of coyotes captured on the periphery of their ranges was first substantiated by Hibler (1977). Our data indicate that most movements outside the home range are restricted to areas upwind, thus permitting the coyote to take advantage of its keen sense of smell in unfamiliar areas. Two explanations discussed by Hibler (1977:59-60) as to why coyotes were captured in areas beyond the core of the home range were that 1) animals in more novel environments

apparently are not only more attentive to stimuli but more thoroughly investigate the area and/or 2) coyotes avoid novel stimuli, such as trap scent, in familiar areas.

Coyote ranges clearly exhibited a spatial separation both diurnally and seasonally (Figs. 7, 8, and 9). Some type of interaction between breeding adult coyotes resulted in a spatial separation of territories. Tracking data suggested an absence of territorial defense by residents confronting one another. It was apparent, rather, that adults were avoiding close contact with one another. Where range boundaries met or overlapped, two neighboring adults were almost never located in the same area at the same time. Hornocker (1969:462) observed similar avoidance behavior in mountain lions (Felis concolor) and termed it a ". . . mutual avoidance reaction." Sargeant (1972:227) reported red foxes (Vulpes vulpes) territorial boundaries ". . . were not patrolled, yet there appeared to be an acute awareness of the presence and a mutual avoidance between family members holding adjacent territories."

Some yearlings and juveniles (post-natal range data) did not frequent use of a contiguous area in the manner observed for most adults. Ranges were larger and discontinuous. They probably reflected the lack of sufficient space in any one area that was unoccupied by conspecifics.

The observed response of all coyotes cuing to the wind direction in direct or indirect ways explains why so few encounters between neighboring coyotes were observed (Fig. 7). With adults only visiting



the frontside of their range boundaries the chances of coming in contact with a neighboring or roaming coyote is reduced considerably.

Perhaps dispersal of young animals is influenced by wind direction. Only juveniles M20 and F21 were observed to be in the dispersal process. All their movements resembled patterns observed by Storm et al. (1976) for dispersing red foxes in that onset of movement beyond 100 m of the bedsite were oriented in one direction. Such movements over 1 km by M20 and F21 were directly into the wind.

Scent marking is a well known phenomenon among canids and there is considerable speculation about its function. Dominant animals have been observed marking more frequently than subordinate (Ralls 1971, Mech 1966, Zimen 1975). Peters and Mech (1975) presented a basic description and hypothesis of how scent-marking functioned in territorial maintenance by timber wolves (Canis lupus). Van Lawick-Goodall (1971) observed a pair of golden jackals (Canis aureus) marking portions of their territorial boundaries each hunting trip and Golani and Keller (1975) observed conspecifics investigating urination spots of a pair of mated jackals but not urinating on the spots themselves. Other than cursory observations, similar data detailing scent marking by coyotes is limited. Ozoga and Harger (1966) and Gipson and Sealander (1972) recorded varying rates of urination while snow tracking coyotes. The latter suspected coyotes were marking to maintain home ranges. Gier (1975:259) has speculated that it may serve in territorial demarcation. For canids in general, Kleiman (1966:176) suggested that scent marking may not be used in agonistic

display for territorial defense ". . . even though the behavior is effective in maintaining a territory. . . its efficiency simply lies in the avoidance responses which are shown by intruding individuals." Eisenberg and Kleiman (1972:24) stated that scent marking ". . . permits the exchange of chemical information among animals that live with overlapping home ranges but tend to move and forage alone. . . (and) gives information with respect to age, sex, and reproductive condition. . ." As Anisko (1976:283) surmised ". . . most canid forms, even those that are not pack living, have complex social systems which rely on intricate signals for communication."

With the above discussion in mind, we hypothesize that wind dictated movements of coyotes permitting an efficient means of spacing coyotes, in that lack of temporal overlap results in 1) few energies are expended in aggressive defense of territory and 2) considerable information is transmitted between coyotes via scent marking on a regular basis.

Certainly moving into the wind has its advantages in hunting. Ables (1975:258) noted red foxes hunting commonly approached ". . . brush piles, fence rows, etc. from the downwind side (and) such behavior would favor hearing but more likely olfactory means." Mech (1970:197) observed wolves scenting moose, as opposed to tracking them, on 42 of 51 hunts. Moving upwind would enable the wolves to detect large prey at distances of up to 2.4 km. In 300 observed hunts of lions (Panthera leo), Schaller (1972:240) recorded 28% stalked upwind, and 43.7% with the wind from either side. He concluded that

they did not consider wind direction. In our study area, white-tailed deer (Odocoileus virginianus) were the only large prey available to coyotes, but their numbers were low and were not considered a major prey item. Scent from smaller prey such as lagomorphs and rodents would not be expected to be carried as far as that of large prey. For these reasons we do not believe the observed movement patterns were solely for efficiency in hunting. However, spatial separation of coyotes may have increased hunting success by decreasing hunting pressure temporally.

Interestingly, coyote movements to the periphery of the range tended to be delayed during periods of relative calm. Ables (1969) noted a positive correlation of distance traveled and wind velocity during the summer and suspected it was partially related to the amount of dew. This might partially explain why coyotes apparently moved less during calm periods. However, considerable movement was apparent within the core of the ranges for some coyotes on such nights. Joslin (1967:284) observed that wolves responded almost ten times greater to his howling imitations during calm periods than during windy conditions. No other weather factor showed correlation with howling response. He believed (p. 288) ". . . that wolves advertise their presence over an area ranging from at least three square miles to nearly 50 square miles. . . (and) that howling may serve to keep packs out of each others home range." Wolfe (1974) and Wenger (1975) in their investigations of siren-elicited howling of coyotes reported responses to the siren or failure to hear the responses were most evident when

wind speeds exceeded 8 km/h. Frequency of unsolicited howling was not determined. Camenzind and Lehner (1975) and Lehner (1976) suggested that the "group-yip-howl" vocalization is used to announce occupancy of an area by coyote groups. If the relationships Joslin (1967) speculated for wolves exist for coyotes, perhaps vocalizations (especially howling) serve to convey information to neighboring coyotes of the caller (Gier 1975:259). Thus, howling may substitute for scent marking as a form of advertisement on nights of relative calm. During calm periods, howling would likely carry further in all directions whereas on windy nights long-distance vocalizations would carry mostly downwind.

Overlap of neighboring adult coyote territories was most evident during the non-pup rearing period and appeared to be a result of expansion of ranges into areas between adjacent ranges and not necessarily one coyote moving into areas occupied by another breeding adult. Juveniles and yearlings were usually located in the areas between ranges and we hypothesize that such areas serve as movement corridors or common ground for all coyotes. Yearlings and juveniles would use the corridors throughout the year while adults with type I ranges apparently limited their movement into corridors during the non-pup rearing period. There were areas observed where one roaming animal was located one week or month and another would be located in the same vicinity days or weeks or months later. Overlap of adult ranges at site B and movement of several coyotes in this area suggested some areas were common ground. Danner (1976) found similar overlap

in area occupancy apparently due to a dump site where large quantities of carrion were available.

Adult F25's sally during breeding was the only observation of a breeding adult moving outside its home range a considerable distance. Perhaps by moving crosswind, an estrous female increased the probability of attracting a prospective mate.

#### Home Range Characteristics and Relationships

We observed home range relationships consistent with those reported by Chesness and Bremicker (1974) in Minnesota, and Hibler (1977) in Utah in that minimal or no overlap between neighboring adult ranges was evident. We found no indication that several adults were occupying the same range, as Camenzind (1975) observed in Wyoming. Although Gipson and Sealander (1972) observed considerable overlap they suggested that family groups may have been maintaining exclusive use of portions of their ranges.

Home range size for all coyotes averaged  $21.7 \text{ km}^2$  which is considerably smaller than the overall average observed by Ozoga and Harger (1966) ( $52-130 \text{ km}^2$ ) snow tracking and Hibler (1977) ( $83 \text{ km}^2$ ) radio-tracking. A  $34.0 \text{ km}^2$  average was observed by Andelt (1976), but elimination of a yearling female's range from the calculation resulted in a  $27 \text{ km}^2$  average. Gipson and Sealander (1972) reported an overall average of  $22.5 \text{ km}^2$ , using the ellipse method which generally gives larger estimates of range size than the minimum area method. Differences in observed ranges between studies may reflect differences in age and sex of coyotes, breeding status, habitat types,

tracking schemes, number of days monitored, or method of delineating range boundaries.

Our adult females had considerably larger home ranges than adult males (Table 2). Hibler (1977) observed a similar trend. Chesness and Bremicker (1974) and Gipson and Sealander (1972) detected larger ranges for adult males. Differences may, in part, be due to our monitoring fewer males for shorter periods than females.

Adults.--Freedom from pup rearing responsibilities appeared to have a profound effect on home range sizes of breeding adults. Changes in adult home range size with changes in biological seasons were first reported by Andelt (1976). Increased range size during the non-pup rearing period may reflect adults investigating areas to check on their availability for utilization. Thus, we located them more often on the periphery. Difficulty in obtaining food during the winter months or high mortality of coyotes (19 of 30 marked coyotes were killed during our study, 14 by hunters) resulting in large portions of unoccupied space may have prompted coyotes to investigate outlying areas.

Large discontinuous ranges observed for coyotes F26, M27 and M40 probably indicated a continual search for a sufficient portion of unoccupied space to establish a range and/or search for a mate. Apparently F26 found such an area during summer 1977 as she concentrated her movements in 3.74 km<sup>2</sup> for the remainder of the year. Such activities indicate that reproductive status is important in home range selection and maintenance.

Yearlings and Juveniles.--Large ranges observed for most yearling and juveniles probably represented dispersal activities. Hibler (1977:13) noted home ranges continued to enlarge for most juveniles even when monitored for several months. Range overlap of yearlings F12 and F32 with breeding females suggest some interaction with them, probably related to the rearing of pups. Van Lawick-Goodall (1971:142) noted that occasionally a non-breeding yearling golden jackal, believed to be an offspring of one or both of the mated adults, served as a nursemaid during pup rearing. Such a relationship is possible also for coyotes.

#### Movements (Diurnal)

As noted, some caution must be taken in interpreting distances traveled by coyotes based on hourly locations. We found all age groups moving the greatest distances during adolescence (Fig. 11). This is in slight contrast to Andelt's (1976) observations, as he noted coyotes in Nebraska traveled greatest distances during prebreeding and breeding. Increased movement of adult females during adolescence may reflect they are breaking close ties with offspring. Our adult-pup interaction data support this belief (Althoff and Gipson, in preparation). Similar to Andelt's (1976) study, we observed gestation to be the period that adult coyotes traveled the least distances.

Yearling and juvenile (post-natal range movements only) coyotes intensely use smaller areas in comparison to breeding adults for several days to a week and then move directly to another similar sized

area 3 km or more away. As Hibler (1977:24) noted for coyotes in Utah, these animals ". . . may actually have been avoiding prolonged visits to the intervening area." Movements of these non-breeding coyotes on the edges of breeding coyote home ranges further indicate that the latter are territorial.

#### CONCLUSIONS

We hypothesize that distinct territories are maintained by breeding adults with movement corridors existing between territories. Wind serves as a temporal spacing mechanism minimizing direct contact with neighboring or roaming coyotes. In conjunction with response to wind direction, it is suggested that scent-marking serves as an important form of communication among coyotes. This results in a reduction of competition for natural resources, stress and agonistic behavior. How such a system would operate under different population densities is unknown. However, the spacing mechanisms discussed warrant strong consideration as a plausible explanation of how spatial relationships of coyotes in other regions, other canids and felids are maintained on a temporal basis.



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Table 1. Summary of data on study coyotes.

No.	Sex	Age <sup>1</sup>	Period Radio Tracked	No. Locations	No. Tracking Shifts
11	M	A	8-20-76/10-22-76 <sup>2</sup>	31	2
12	F	Y	8-20-76/1-23-77 <sup>3</sup>	95	5
13	F	A	8-20-76/11-6-76 <sup>4</sup>	119	6
14	F	A	8-20-76/11-21-76 <sup>5</sup> 6-29-77/3-16-78	370	21
15	F	A	8-21-76/6-10-77	309	17
16	M	A	12-5-76 <sup>6</sup>	1	-
18	F	A	9-29-76	1	-
19	M	J	9-29-76	1	-
20	M	J	10-1-76/1-24-77	216	11
21	F	J	10-10-76/11-6-77	108	6
22	M	A	10-22-76/1-6-77	91	5
23	F	J	11-13-76/12-9-76	45	2
24	F	Y	11-30-76/1-23-77	34	1
25	F	A	1-16-77/8-12-77 2-16-78/3-16-78	259	14
26	F	A	1-19-77/1-16-78	276	15
27	M	A	1-28-77/4-5-77	82	4
28	F	Y	2-11-77	1	-
29	F	A	2-13-77/8-20-77	178	9
30	F	Y	3-13-77/3-16-77	3	-
31	M	A	3-31-77	1	-
32	F	Y	7-19-77/1-30-78	188	9
33	M	A	7-20-77/9-28-77 2-16-78/3-31-78	125	7
34	F	A	8-1-77/9-29-77	39	2
35	M	J	8-1-77/9-19-77	71	4
36	M	J	8-2-77	1	-
37	F	J	8-25-77/10-20-77	75	4
38	F	J	8-26-77/10-30-77	75	4
39	M	A	1-18-78/1-29-78	5	-
40	M	A	2-9-78/3-31-78	28	2
41	M	J	2-16-78/2-20-78	2	1

<sup>1</sup>A=adult, Y=yearling, J=juvenile

<sup>2</sup> Andelt (1976) monitored from 12-3-75 to 8-19-76

<sup>3</sup> Andelt (1976) monitored from 1-20-76 to 8-19-76

<sup>4</sup> Andelt (1976) monitored from 1-23-76 to 8-19-76

<sup>5</sup> Andelt (1976) monitored from 4-3-76 to 8-19-76

<sup>6</sup> Andelt (1976) monitored from 4-18-76 to 7-10-76

Table 2. Home range sizes (km<sup>2</sup>) of coyotes during non-pup rearing, pup rearing and overall period monitored. Numbers in parentheses are areas of intense use.

Coyote	Non-Pup Rearing		Pup Rearing		Overall Period Monitored	
	Type I	Type II	Type I	Type II	Type I	Type II
Adult Males						
M11			7.8		7.8	
M22	5.8		7.7		9.2	
M27		16.6 (1.9)				16.6
M33	14.6		9.5		14.6	
M40		27.5				27.5
Adult Females						
F13			17.3		17.3	
F14	18.0		15.7		19.2	
F15	24.7		24.3		30.6	
F25	19.6		13.6		19.6	
F26		46.8 (3.7)		32.4 (7.8)		58.9
F29	19.0		11.4		21.5	
F34			6.8		6.8	
Yearling Females						
F12		37.2 (12.8)		59.9		73.8
F24	9.5				9.5	
F32	6.9		7.5		9.7	
Juvenile Males						
M20		78.7 (9.4)		25.9 (12.6)		78.7
M35			4.3		4.3	
Juvenile Females						
F21				23.0 (9.4)		23.0
F23	1.5				1.5	
F37			3.2		3.2	
F38			2.2		2.2	
Mean	13.4	41.4 (7.0)	10.1	35.3 (9.9)	12.0	41.1
Grand Mean						21.7

Fig. 1. Illustration of coyote's hourly response to wind direction (wd). Direction of movement between 1800-1900 ( $30^{\circ}$ ) was compared to wind direction at 1800 ( $0^{\circ}$ ). Direction of movement between 1900-2000 ( $110^{\circ}$ ) was compared to wind direction at 1900 ( $0^{\circ}$ ). The former was considered an upwind movement, the latter a downwind movement.

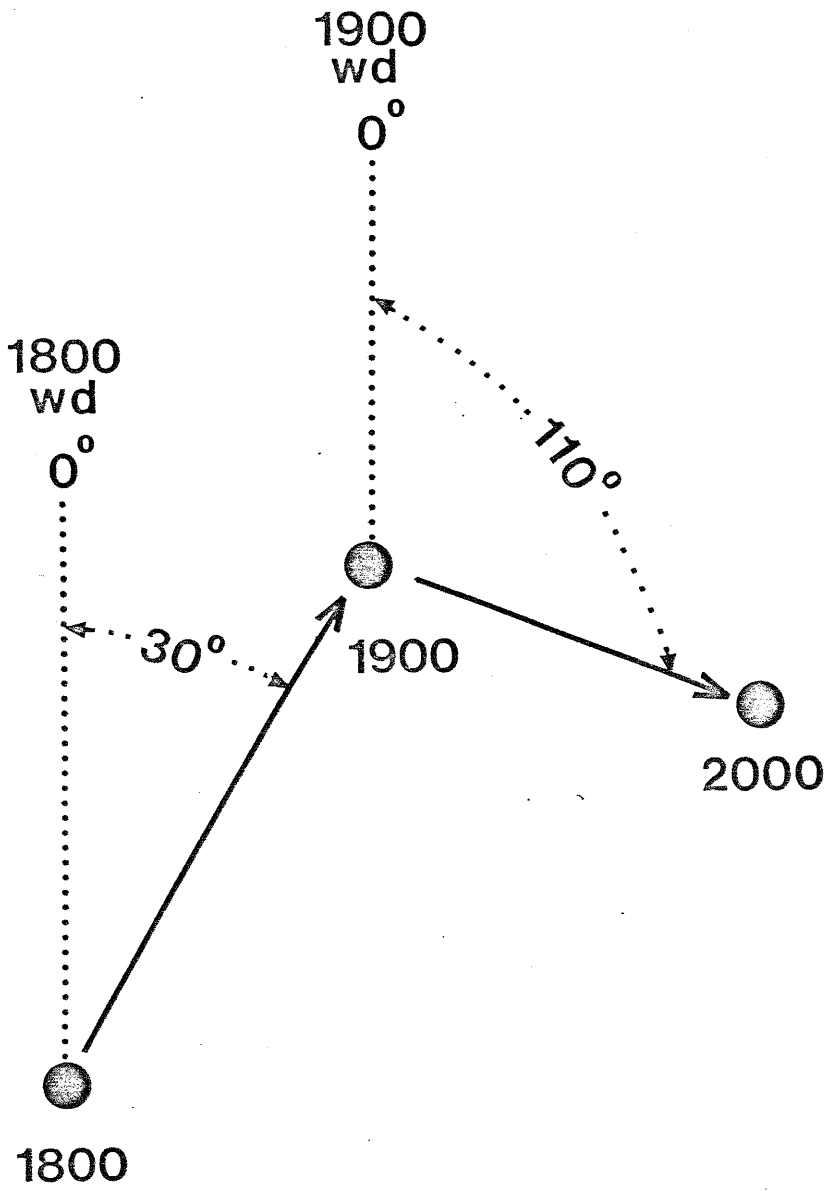
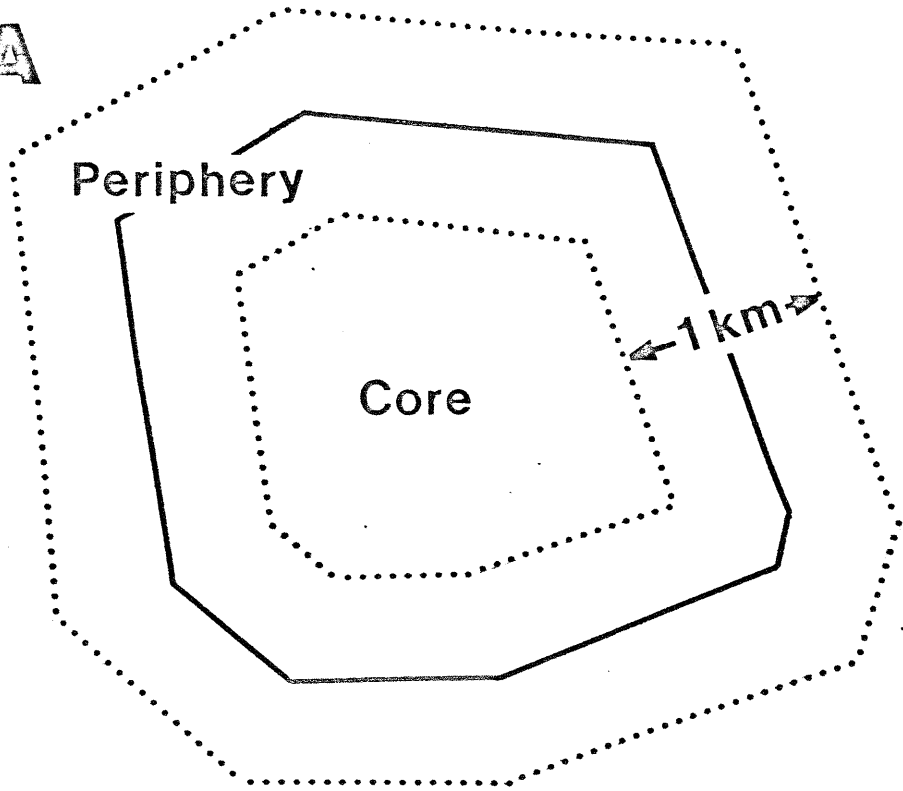


Fig. 2. Diagrammatic representation of terms used to describe home range relative to wind direction (wd). A--core refers to the center of the range. Range boundary is delineated by solid black line, and periphery, a 1 km wide zone, is bounded by the dotted lines. B--frontside refers to shaded area (upwind periphery and all of core) and backside refers to unshaded area (downwind periphery).



**A**



**B**

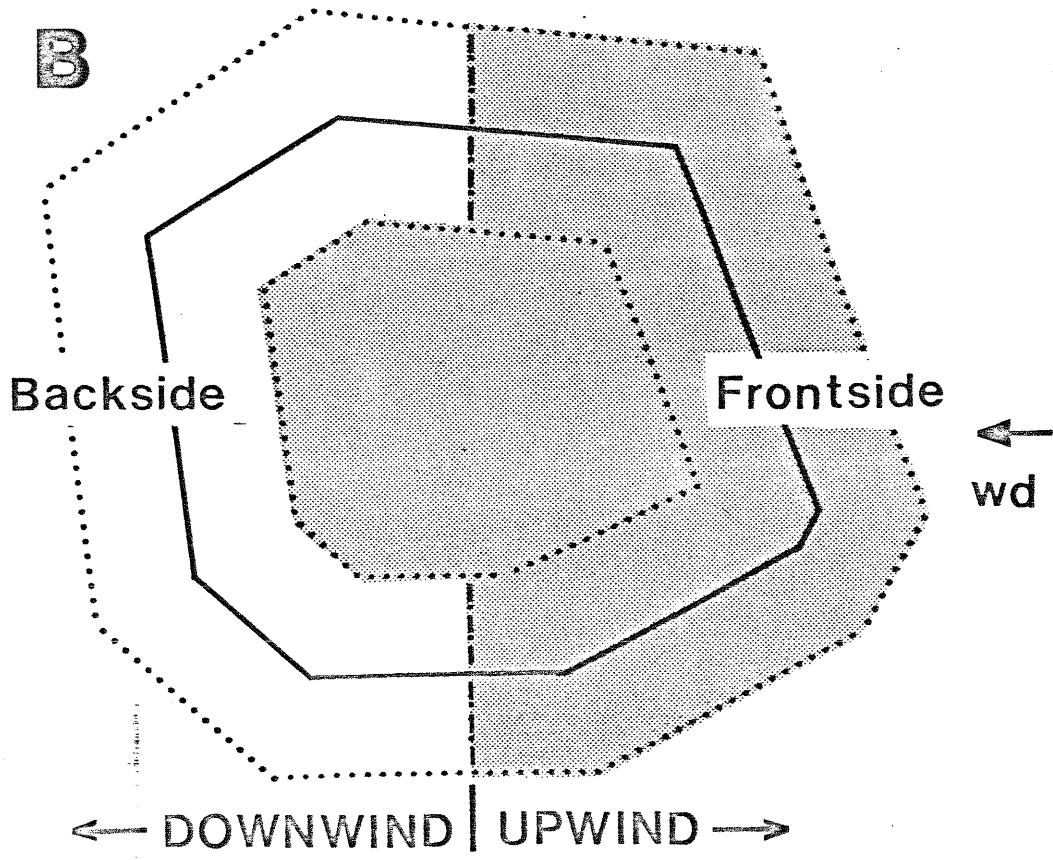
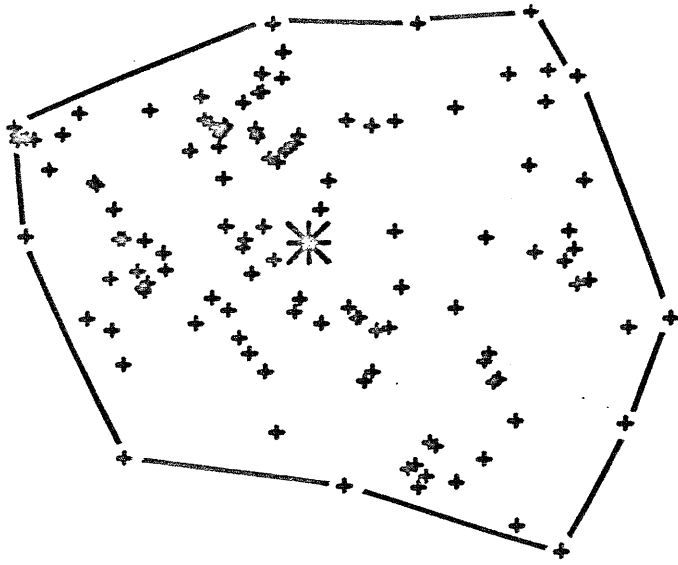


Fig. 3. Illustration of type I (A) and type II (B) home ranges. Each home range is outlined by solid black lines. Radio locations are denoted by (+). Shaded portion in B denotes area of intense use.

**A**



↑ N

1 km

**B**

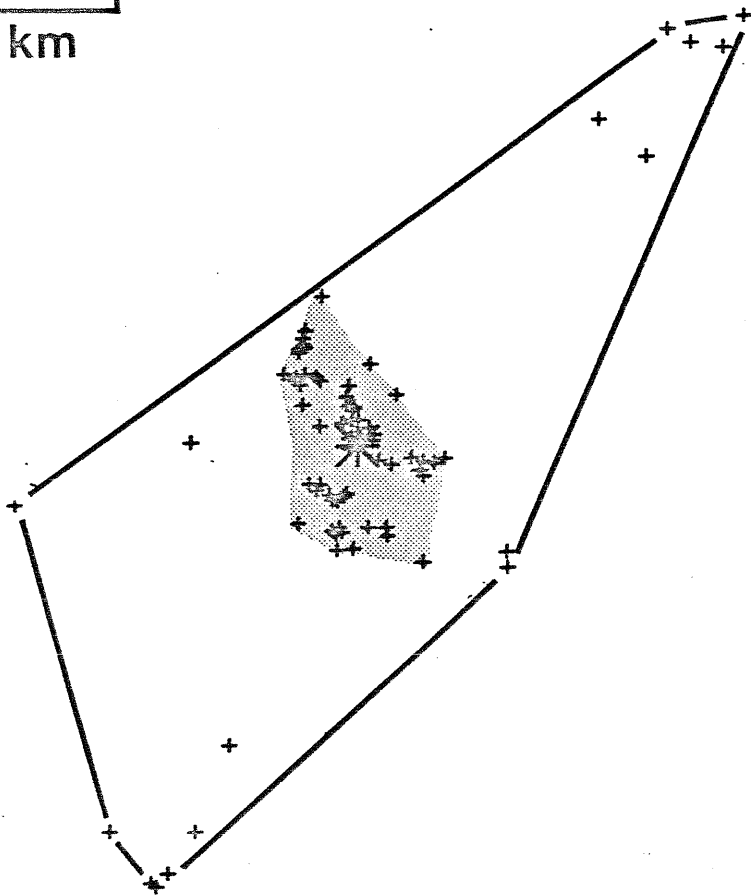
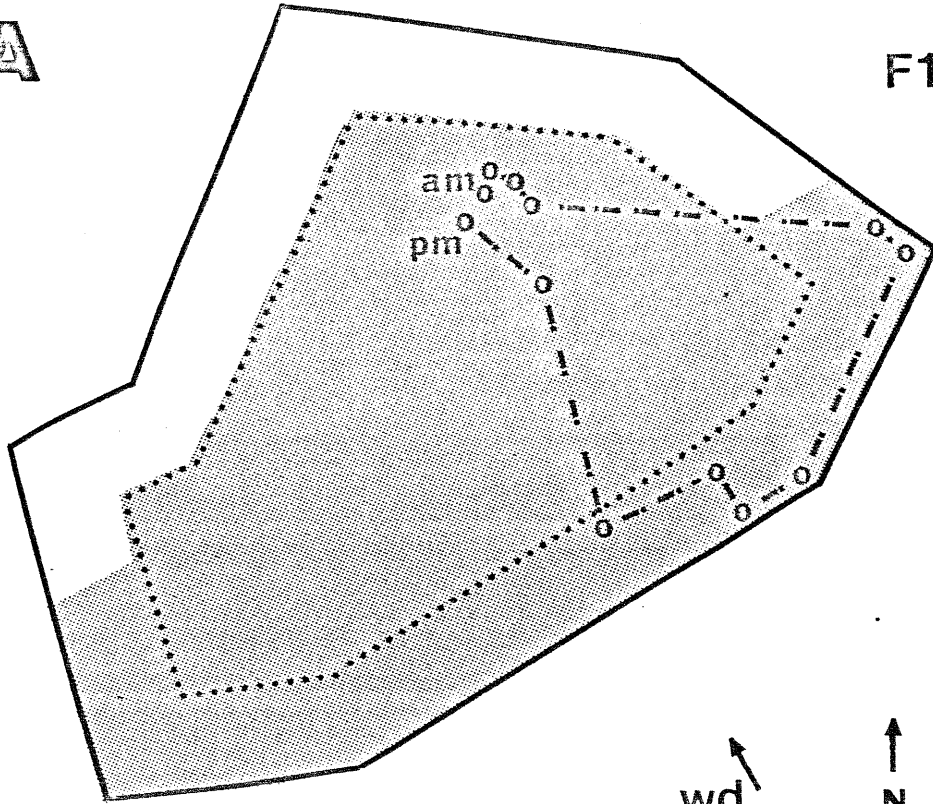


Fig. 4. Typical movement patterns of adult coyotes with type I ranges relative to wind direction (wd). Shaded portions denote frontside of range, circles denote hourly radio locations, and pm and am indicate first and last locations of the tracking shift, respectively.

**A**

**F15**



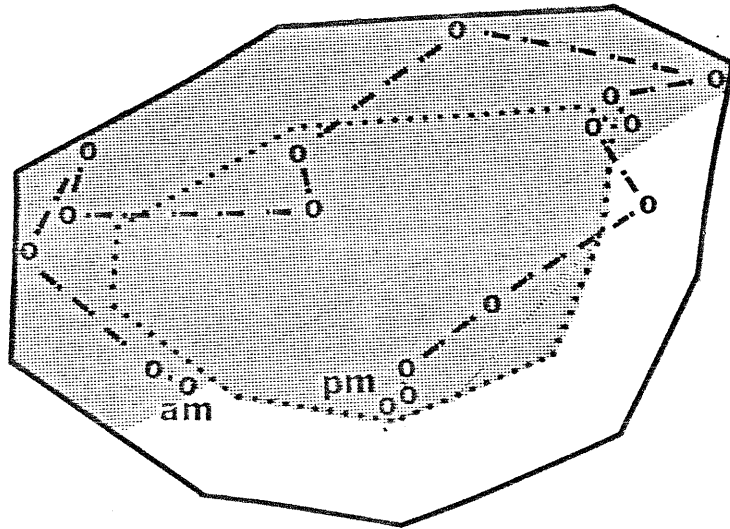
**B**

wd

wd

N

1 km



**F14**

Fig. 5. Movement pattern of adult F26 showing nightly travels relative to wind direction (wd). Home range is outlined by solid black line; shaded portions denote areas of intense use (type II home range); circles denote hourly radio locations; and pm and am indicate first and last locations of tracking shift, respectively.

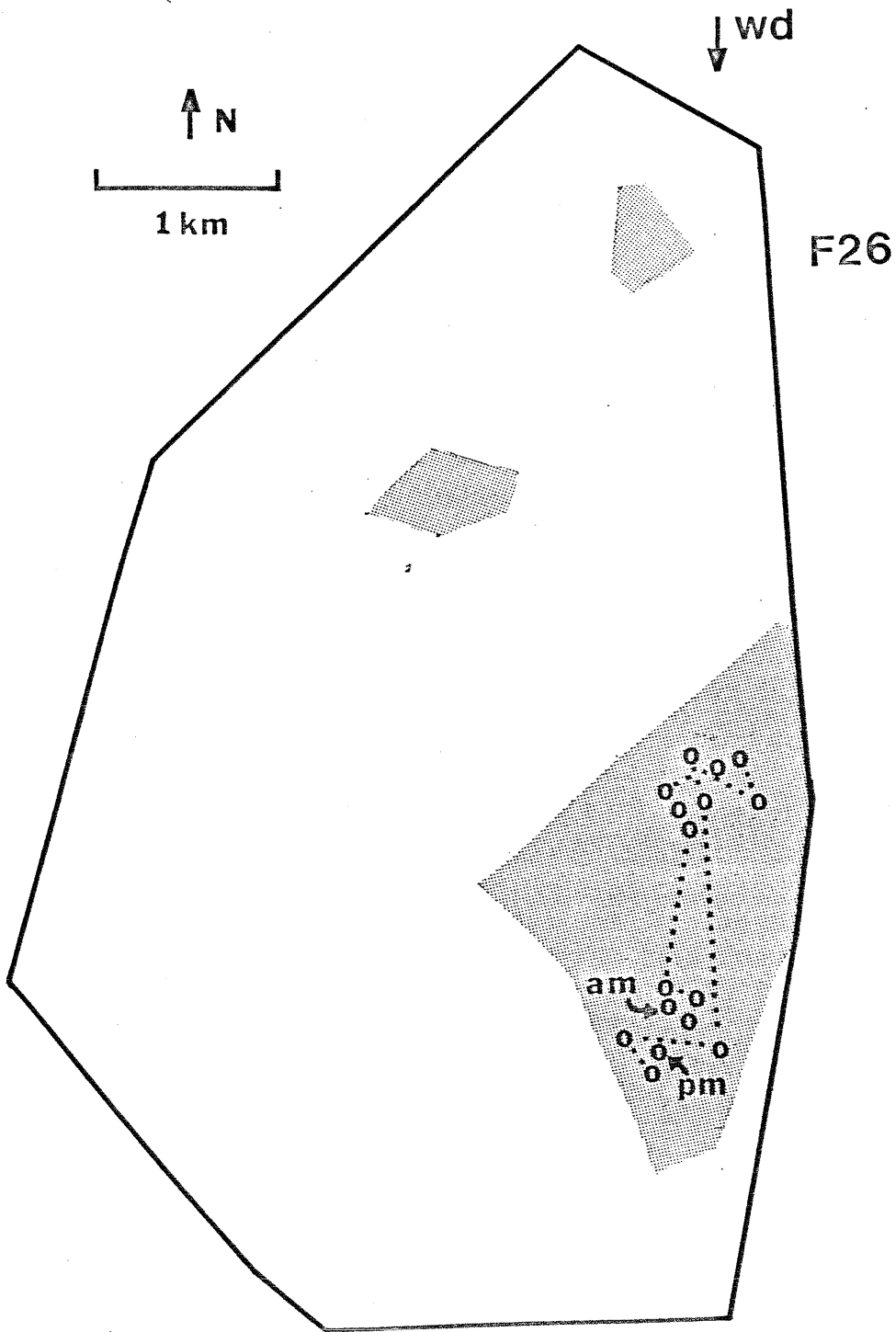


Fig. 6. Movement pattern of yearling F12 showing overall movement into the wind (wd) and on edges of coyote ranges (type I). Circles denote hourly radio locations and pm and am indicate first and last locations of tracking shift, respectively.



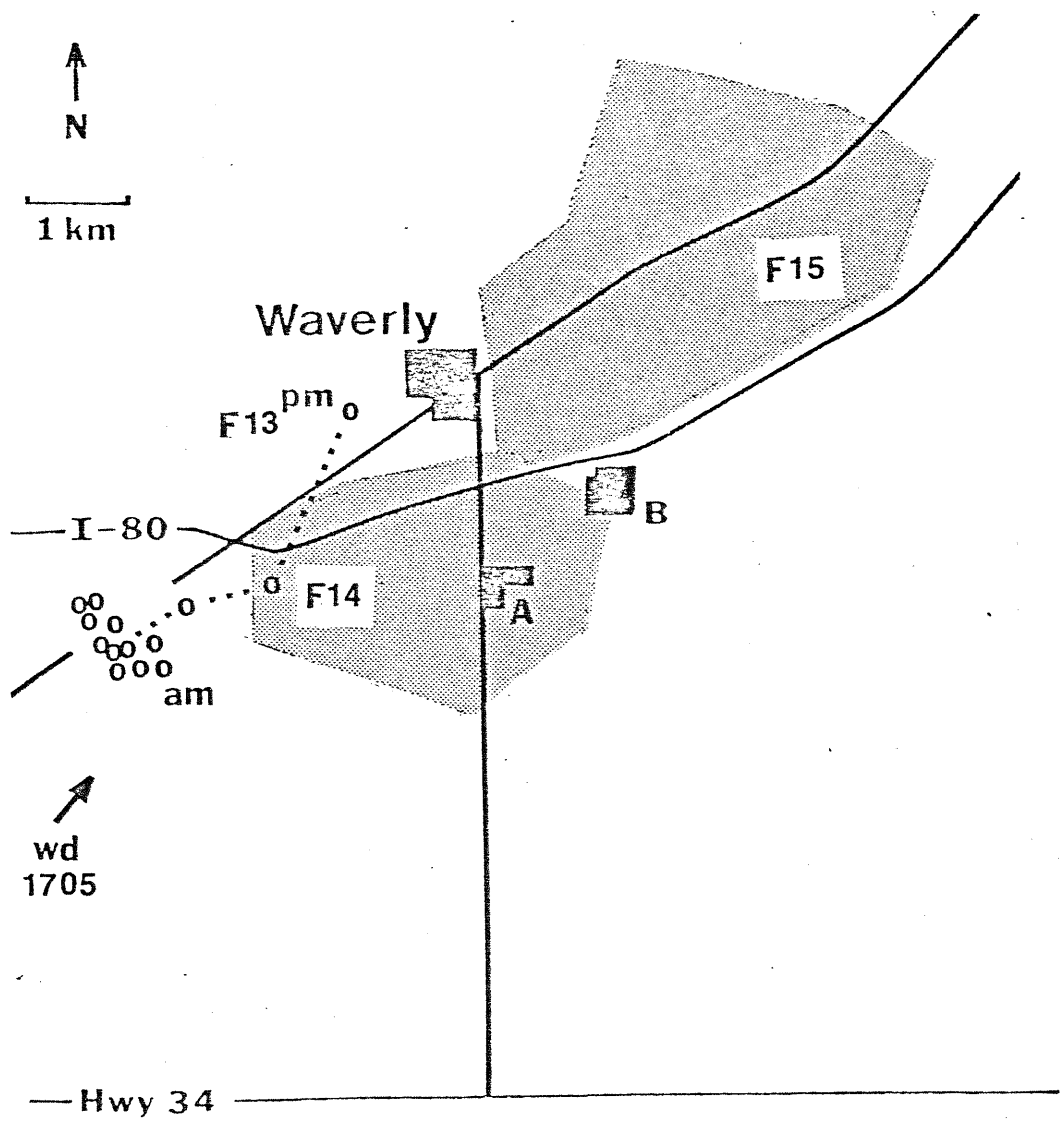


Fig. 7. Movements of neighboring coyotes F32 and M33 on night of 28 September 1977, showing effect of changes in wind direction (wd) on home range use. Each coyote visited area A but at different times. Initial hourly radio locations were taken at 1810 and 1815 for M33 (O) and F32 (●), respectively. First and last locations are denoted by pm and am, respectively. F32 visited A from 2100 to 2210, M33 visited A from 2400 to 0100.

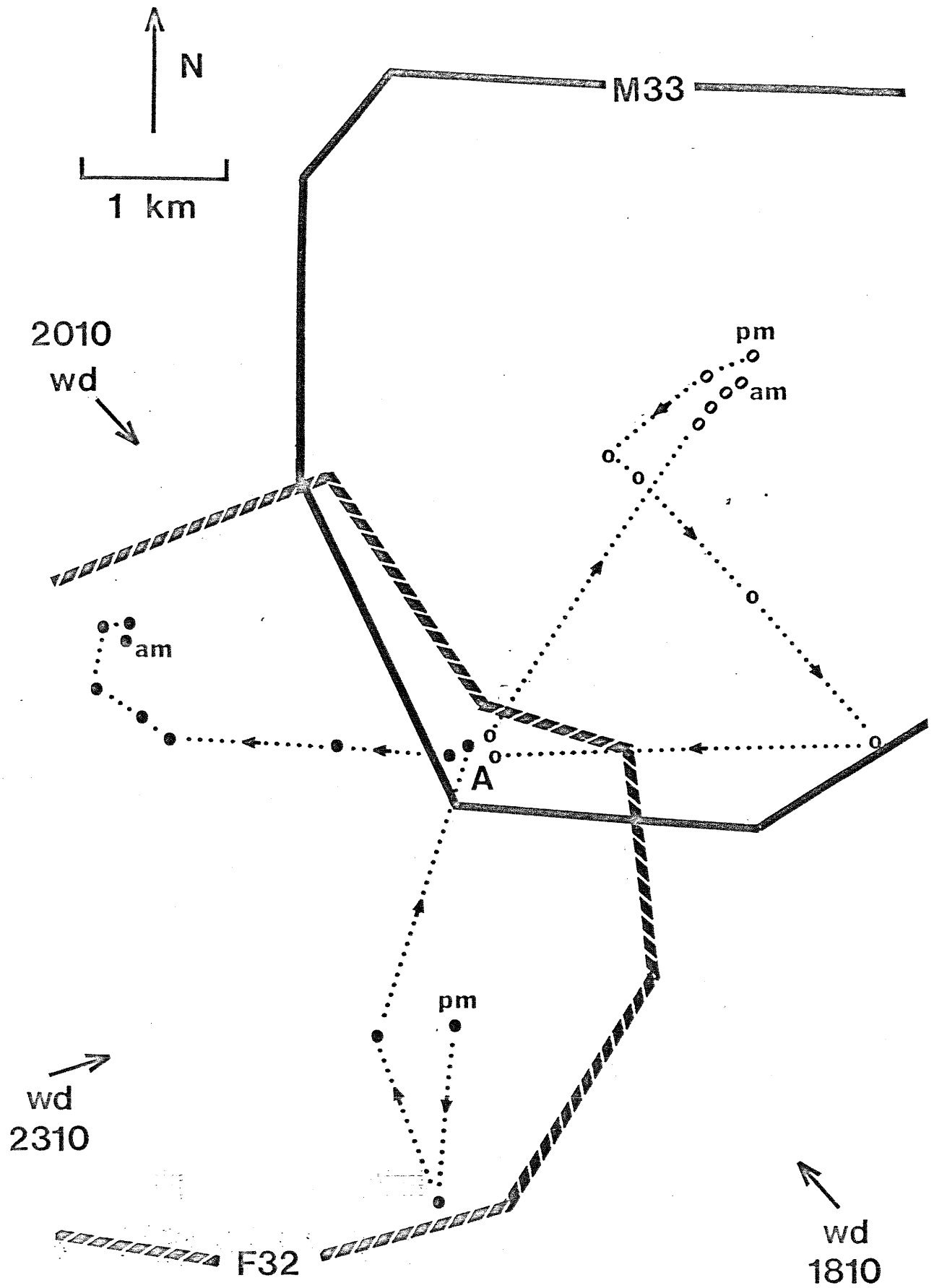


Fig. 8. Spatial distribution of type I home ranges of adults M11, F13, F14, F15 and M22, and yearling F24 in 1976. See Table 1 for period each coyote was monitored. A and B denote location of turkey production sites.

1976

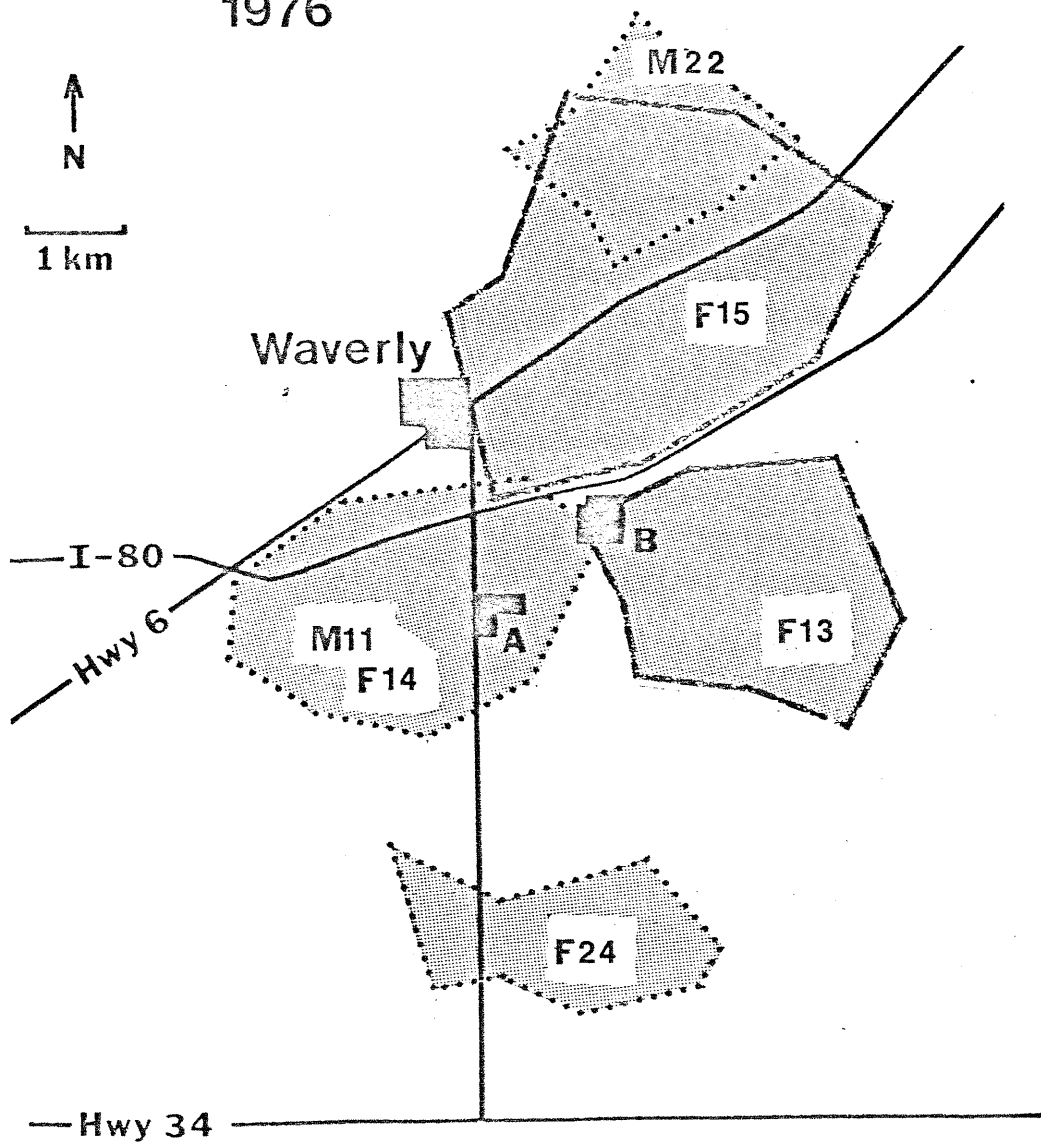


Fig. 9. Spatial distribution of type I home ranges of adults F14, F15, F25, F29, M33, and F34, and yearling F32 in 1977. See Table 1 for period each coyote was monitored. A and B denote locations of turkey production sites.

1977

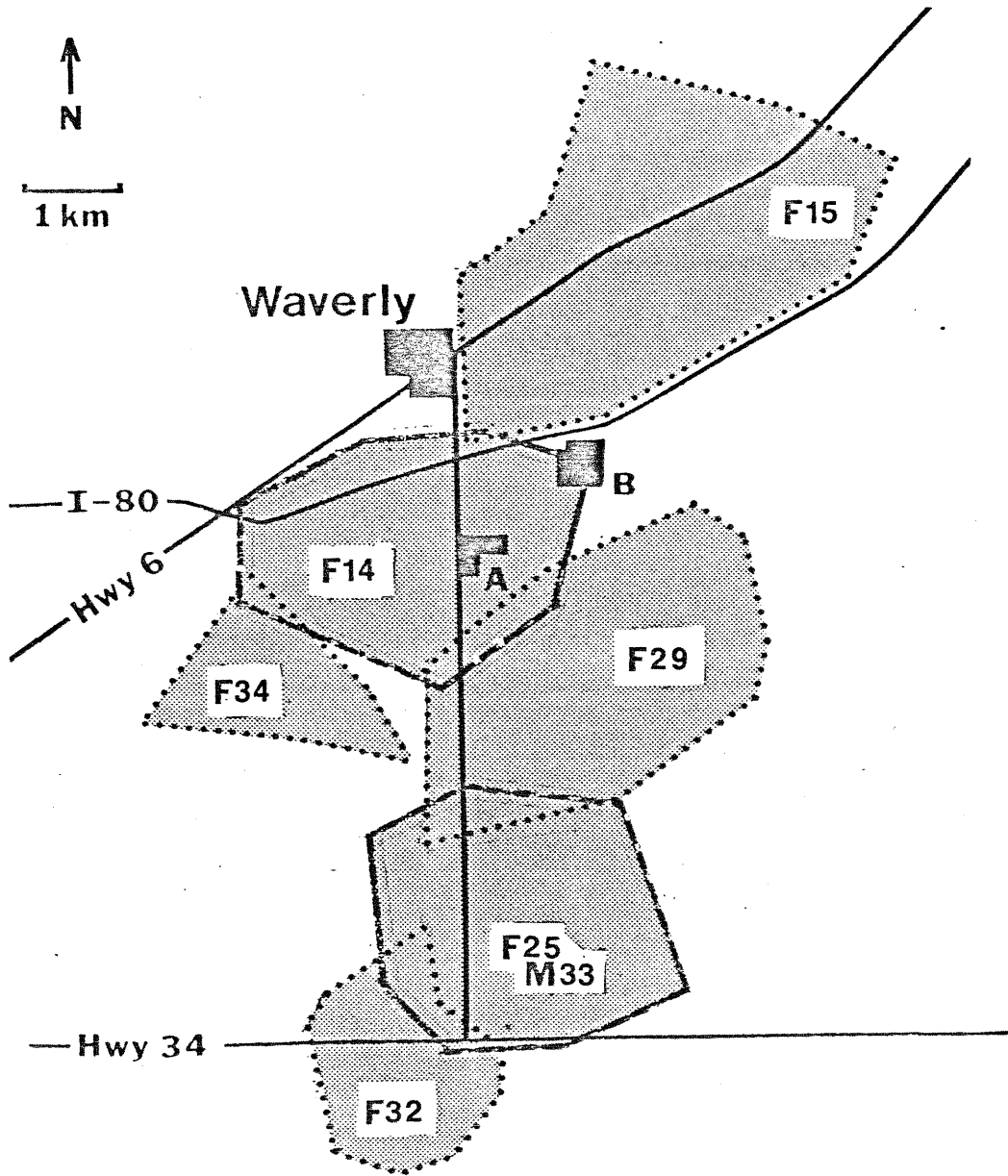
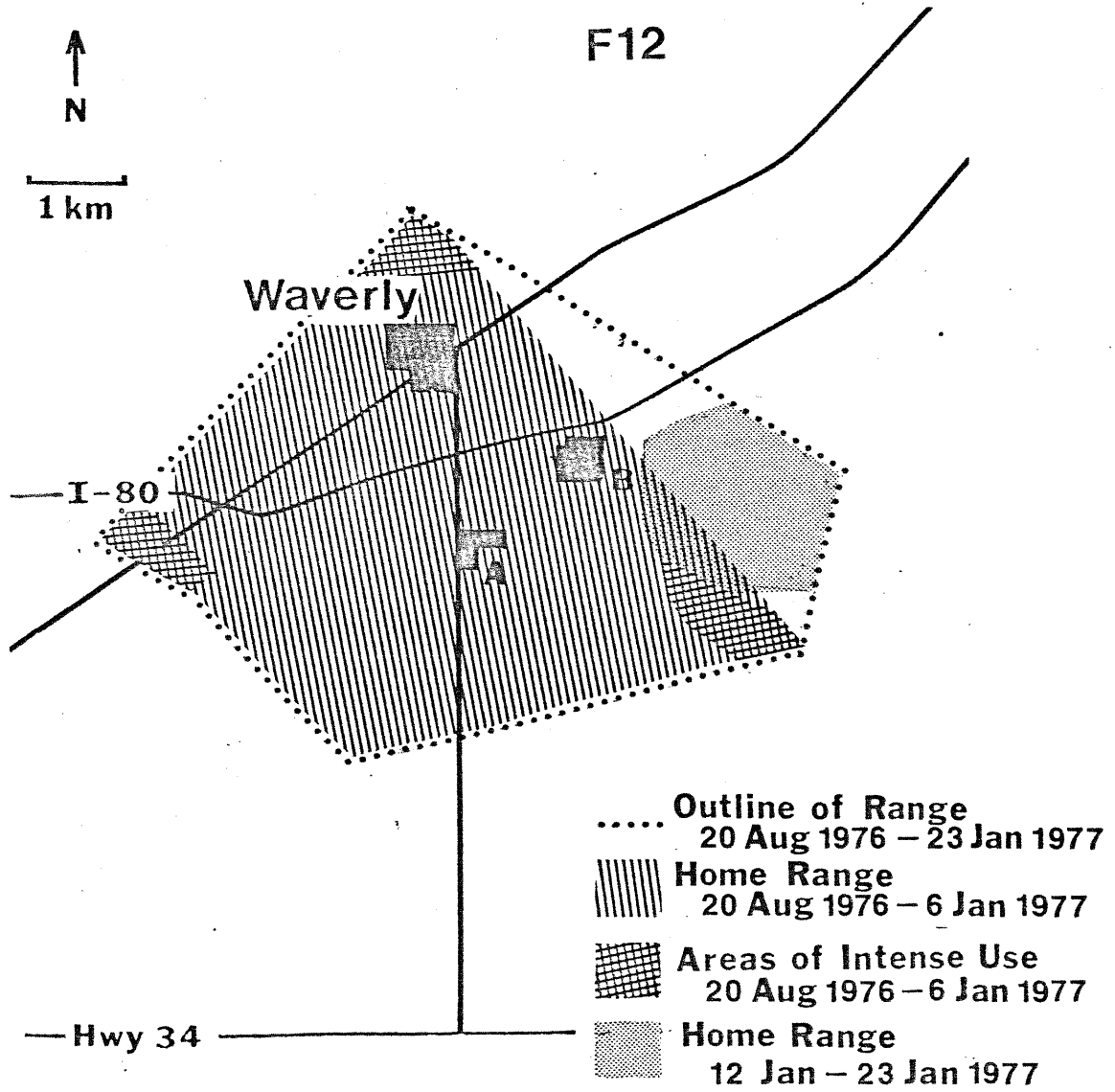


Fig. 10. Changes in home range use observed for yearling F12 (a) and adult F26 (b). A and B denote location of turkey production sites.





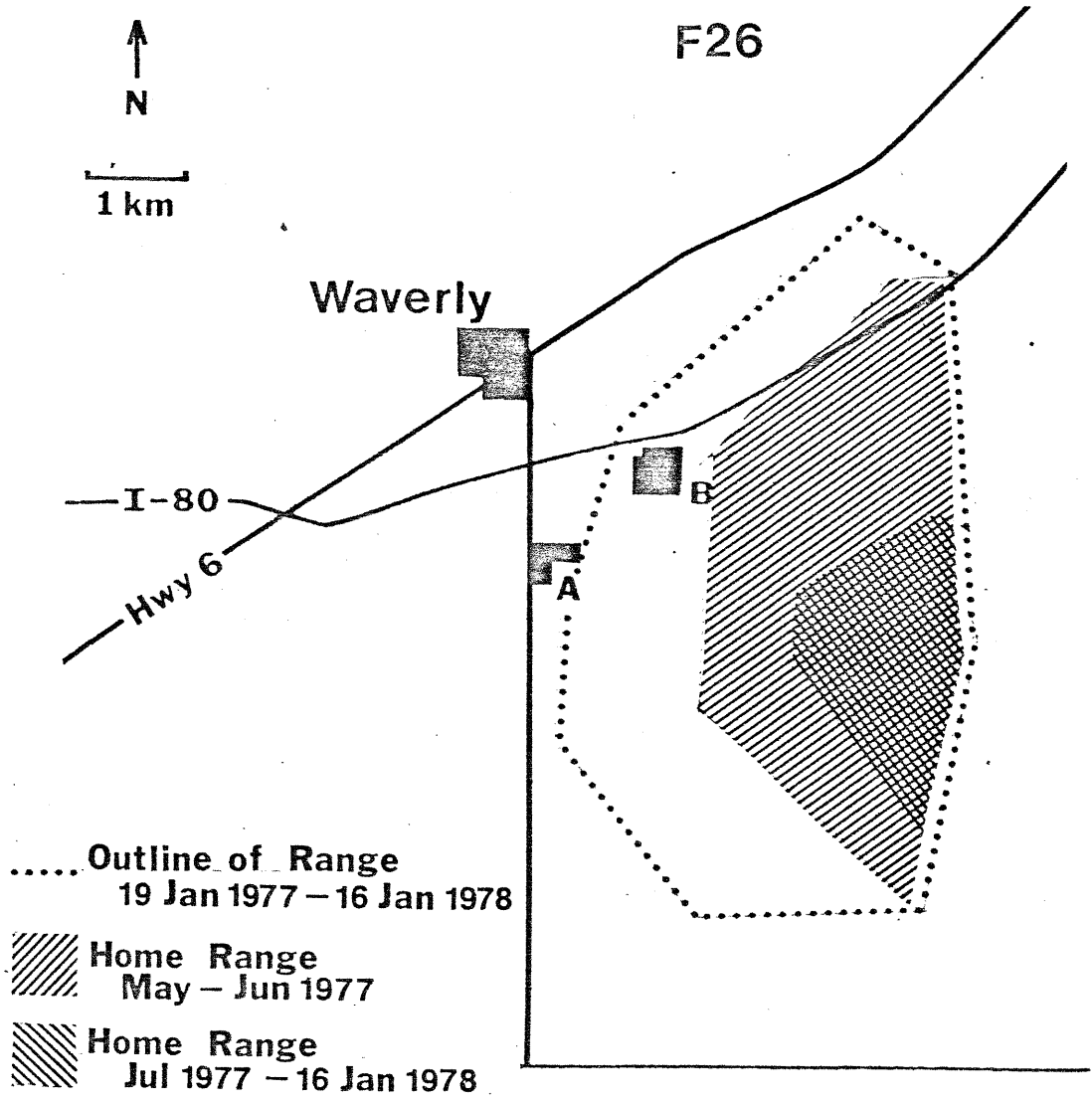
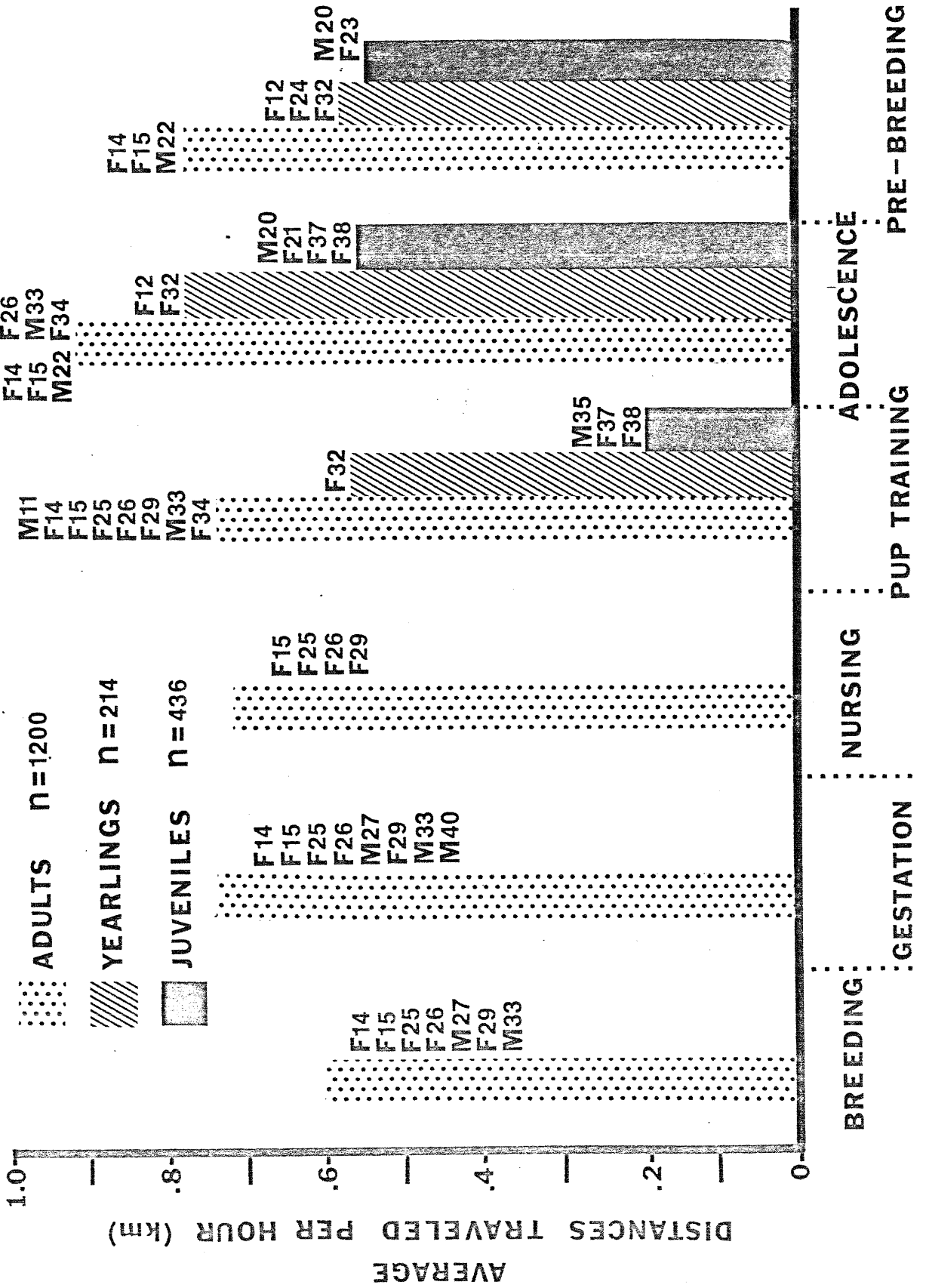


Fig. 11. Average hourly distances traveled (km) for all-night tracking shifts by adults, yearlings and juveniles during six biological seasons.



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COYOTE FAMILY SPATIAL RELATIONSHIPS WITH REFERENCE TO POULTRY LOSSES<sup>1</sup>

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Abstract: Seven breeding adult coyotes (Canis latrans) and six pups were radio-tracked for various periods from August to November. Adult home ranges and nightly movements were more extensive than noted for pups. Interaction between adult females and their pups was infrequent during nightly activities. Although some breeding adults were known damagers, there was no evidence that pups were directly responsible for poultry losses.

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Little is known about the relationships of breeding adult coyotes and their pups with respect to home range use, interactions, and movements. Ryden (1975) observed interactions at the den site during the first few months of pup development. Hallet (1977) obtained limited data from radio-tagged pups in Missouri during the early stages of pup life. Additional information detailing social and spatial relationships during the pup training period may be useful in evaluating and improving damage control efforts.

This paper reports on field research of movements and interactions of coyote pups and breeding adults, specifically during late summer and fall. Objectives were to document adult and pup movements and interactions, especially with respect to domestic poultry losses.

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#### STUDY AREA

Field work was conducted in eastern Lancaster and western Cass Counties near Waverly, Nebraska. Topography consisted of low rolling hills. Row crops of grain sorghum (Sorghum vulgare), corn (Zea mays),

wheat (Triticum aestivum), and oats (Avena sativa) and forage crops of brome grass (Bromus inermis), alfalfa (Medicago sativa), and native grasses comprised most of the vegetation in the area. Waterways were planted to brome or native grasses with most woody vegetation occurring along creek bottoms and fence rows.

The Bevans Turkey Farm, consisting of range production sites A and B, was located in the northern portion of the study area. Site A was 48 ha (hectares), site B 61 ha. Both were enclosed by 2 m (meter) high woven wire fence with exception of the northwest portion of site A where the 1 m high fence was badly deteriorated. Semi-confinement houses on site A and portable range sheds on A and B housed turkeys. Each flock was confined in a 1-3 ha pen of 2 m high woven wire fence, in addition to the 2 m high perimeter fence.

#### METHODS AND MATERIALS

Coyotes were captured with snares and number 3 steel traps. Traps were set intermittently from 20 August 1976 through 13 February 1978 over the entire area. During the periods 20 August-22 October 1976 and 12 May-26 August 1977 traps and snares were set by the perimeter fence of turkey production sites. Most captured coyotes were toe-clipped (Andelt 1976), ear-tagged with monel metal tags, and outfitted with 151 MHz radio telemetry collars. Radio signals were received on portable receiver (Model LA-12, AVM Instrument Co., Champaign, Ill.) using a car-top mounted null-peak antenna system.

Telemetry procedures and tracking schedules are described in another paper (Althoff and Gipson, in preparation). Accuracy of

fixes was  $\pm 2^{\circ}$  with most fixes being taken within 1.5 km (kilometers) of the coyote.

Domestic turkeys were placed in semiconfinement or range pens from April–November 1976 and April–October 1977. About 120,000 turkeys were raised each year. Losses were recorded daily by the producer and periodically by the senior author. Usually dead turkeys, whether a result of predation or other causes, were removed daily from the production sites to a disposal pit on site A. Sheep were grazed for various periods on both sites and on some nearby farms.

Methods of home range and movements analysis are described in another paper (Althoff and Gipson, in preparation). Data were processed using programs developed at the University of Arkansas and University of Nebraska, on an IBM 360 computer.

## RESULTS

Data for 7 adults and 6 pups radio-tagged with respect to sex, age, social relationships, period monitored, number of locations and number of all-night tracking shifts are summarized in Table 1. Home range and movement data are analyzed for the July–December periods of 1976 and 1977. In addition, 14 other coyotes, yearling and non-breeding adults, were radio-tagged but data related to these coyotes are presented in another paper (Althoff and Gipson, in preparation).

### Pup Movements and Interactions

Fig. 1 depicts the distribution of minimum hourly distances traveled by all pups while confined to the natal range (August–November), representing 21 tracking shifts on 13 nights. Mean hourly



distances traveled was 0.45 km (n=302). Overall trend was for pups to confine their nightly movements to about 0.5 to 1.5 km<sup>2</sup>. Most locations appeared to be in grass patches, along fence rows and near creek bottoms. Activity patterns (Fig. 2) indicated that greatest changes in locations occurred during hours circa sunset.

Littermates M20 (M= male) and F21 (F=female) were located within 0.4 km of each other on 60 of 66 hourly intervals. A mean distance of 0.14 km apart suggest they interacted considerably. They first departed together from the natal range on 3 November 1976. The pair moved to an area about 5.6 km west of their natal range that night and remained in that vicinity until 7 November when they were located back in the natal range. Radio contact was maintained with only M20 after 7 November. From 3 November 1976 through 24 January 1977 (last day located) M20 traveled outside his natal range a minimum of 4 times for periods of 4-36 days. Greatest distance a bedsite was located from the natal range was 11.2 km on 21 December. He was located in the natal range again 12 January 1977. Most of his locations outside the natal range were on the edge of ranges of other radio-tagged coyotes. On 6 December 1977, he was captured and shot by a trapper 37.6 km southeast of his natal range. F21 was trapped on 14 January 1977, 17.6 km south of her natal range.

Mean hourly distance traveled by pup F23 was 0.36 km (n=33). She was never located outside of her natal range during the November period she was monitored. She was hit by an auto on 9 December 1976, on the north edge of her mother's home range.

Mean hourly distance traveled by pup M35 was 0.22 km (n=47). He was never located outside his natal range during the August-September period he was monitored. On 2 February 1977 he was shot by a local hunter but the location of his kill site was not determined.

Littermates F37 and F38 were farther than 0.4 km apart on 45 of 70 hourly intervals suggesting they may not have interacted to the same degree as observed for littermates M20 and F21. Usually they did not bed near each other or occupy the same 1 km<sup>2</sup> area during the night. Radio contact was lost with F37 after 23 October 1977 and with F38 after 31 October 1977. Until these dates both pups remained within their natal ranges. On 22 January 1978, F37 was shot by a hunter 18.4 km southeast of her natal range.

#### Adult Movements and Interactions

Distribution of minimum hourly distances traveled by all breeding adults during the August-November period is shown in Fig. 1. Mean minimum hourly distance traveled was 0.80 km (n=375). Activity patterns (Fig. 2) indicated that greatest distances traveled usually occurred between 1800-2100 and 0100-0300. From sunset to midnight adults were located near the periphery of their ranges more often than during morning hours.

Mates M11 and F14, and F25 and M33 were monitored simultaneously during 20 August-22 October 1976 and 19 July-12 August 1977, respectively. Distribution of distances apart (n=55) for the two pairs combined was as follows: <0.4 km, 17 (30.0%); 0.4-0.8 km, 9 (16.4%); 0.8-1.2 km, 5 (9.1%); 1.2-1.6 km, 6 (10.9%); >1.6 km,

18 (32.7%). Average distance apart was 1.06 km for both pairs combined. Pairs were located within 0.8 km of each other on 26 observations (47.3%) and greater than 0.8 km 29 times (52.7%). Based on 13 late morning or early evening locations, mates' bedsites average distance apart was 0.90 km (range 0.02-2.39 km).

Radio contact was lost with M11 in late October 1976 and none of his toe-clipped tracks were observed in the study area after 22 October. No hunters reported shooting this animal. Toe-clipped tracks of F14, his mate in 1976, were observed on 24 and 27 January, and 5 and 31 May 1977, along side tracks of another unmarked coyote suggesting she had a different mate in 1977.

Little or no range overlap was observed for neighboring adults in either year (Fig. 3). Most overlap was noted near turkey production site B. Mates M11 and F14 were consistent damagers at site A (Andelt 1976 and this study) and sporadically at site B in 1976 (see Appendix A, Table 1). In 1977, F14 was taking domestic turkeys at both sites. No other coyotes, marked or unmarked were known to use site A in either year. Although F13 and F15 were captured adjacent to site B neither was a suspected damager.

#### Adult-Pup Interactions

Fig. 3 shows the range relationships of family groups M11-F14-F23, and F13-M20-F21, and F15 in 1976. Fig. 4 depicts range relationships of groups F14-F37-F38 and F25-M33, F15, F34, and M35 in 1977. In each instance the adult ranges exceeded the pup's range. Average home range size of breeding adults for the August-November period was 13.6 km<sup>2</sup>

(range 6.8-24.3 km<sup>2</sup>), for pups during the same period ranges averaged 4.9 km<sup>2</sup> (range 1.5-9.47 km<sup>2</sup>).

Distribution of distances apart of pups from adult females is depicted in Fig. 5. Average distance apart of pups M20 and F21 from F13 was 1.36 km (n=153) as compared to 1.62 km (n=125) for F37 and F38 from F14. Based on late morning or early evening locations, average distances between bedsites was 1.24 km (n=40) for M20 and F21 from F13, and 1.49 km (n=31) from F37 and F38 from F14.

Only on the night of 27 October 1976, did littermates M20 and F21 accompany adult F13 on her travels to the edge of her range. On all three previous tracking shifts, F13 moved to the edge of her range in the early evening for 1 to 6 hours before rendezvousing with her pups. F14 was never accompanied on her nightly travels by F37 or F38. On no occasions did any radio-tagged pups venture closer than 0.4 km to either turkey enclosure during either year, nor were any other pups trapped by the pens.

#### Depredations

Andelt's (1976) and our data (see Appendix A, Table 1) indicate that the producer's records provided a reasonably accurate estimate of predator losses. Our examination of 133 predator-killed turkeys (known domestic dog kills were not included) indicate that coyotes were responsible for about 95% of the losses (see Appendix A, Table 2). Fig. 6 shows the number of days each month that one or more predator kills was reported by the producer. Considerable differences between years for the month of June were noted. Heavy predation in

July, August, and September was observed in both years. More than one turkey was killed on 112 of 137 days losses occurred (both years combined).

Sheep were grazed on both production areas and on nearby farms but no predator losses were reported during our study.

#### DISCUSSION

Pup movements were confined to smaller areas than breeding adults as reflected by home range size and hourly distances traveled. With pups almost reaching the size of adults in late September through October one might expect their home ranges to increase and to accompany adults on ventures from the core of the adult's range. However, salient differences in distances traveled for the two groups (Fig. 1) and limited interactions (Fig. 4) were noted. Over 82% of hourly distances traveled by pups as compared to less than 55% by adults were less than 0.8 km (Fig. 1). In all cases, adult ranges were larger than corresponding pup ranges (Figs. 3 and 4).

Activity patterns observed for adults were similar to those reported by Andelt (1976). Similar data for pups have not been reported, however, considerable differences were detected for their activity patterns in comparison with breeding adults (Fig. 2). Limited sample size precludes generalizing to any extent about mate relationships, other than to speculate that their traveling or resting near (<0.4 km) each other may be rather infrequent. Further observations are needed during the period from August to November and especially to determine mate associations during the remainder of the

coyote breeding cycle.

Post-natal range movements observed for coyotes M20 and F21 may have reflected dispersal behavior. Interestingly, they departed from the natal range together. Gipson and Sealander (1972) noted a pair of female littermates maintaining a close association in late fall. Hallet (1977) reported recovering 10 tagged pups from August through December and only one (a female trapped in December 1976, 6.0 km from its original capture site) appeared to have dispersed from the family range. M20's return trips to the natal range from November through January suggest that dispersal may take several months to complete. Andelt (1976) and Hibler (1977) both observed home ranges of juveniles and yearlings overlapping with ranges of breeding adults, and roaming type movements throughout the year. Ryden (1975) suspected subadults observed at a breeding pair's den site were offspring of the pair.

The non-overlapping ranges we observed for adults are consistent with data presented by Andelt (1976), Chesness and Bremicker (1974) and Hibler (1977). Territoriality appears to be evident, but is manifested most probably through non-aggressive behavior such as scent marking.

We hypothesized that heavy coyote predation of domestic poultry in the late summer and fall was a result of pups learning to kill. However, we found no evidence that offspring of damaging or non-damaging adults were in any way directly responsible for poultry losses. It is noteworthy that adult coyotes, including the parents

of some radio-tagged pups, were responsible for numerous poultry losses during the summer and fall (Fig. 5). Many instances were noted during the August-November period when two or more turkeys were killed, little or none of which was consumed (see Appendix A, Table 2). It is our evaluation that variation of killing behavior among adult coyotes, especially when confronted with easily taken prey, was responsible for variability in numbers of turkeys killed.

Table 1. Summary of data collected on radio-tagged coyote pups and breeding adults.

No.	Sex	Age <sup>1</sup>	Social Relationship(s)	Period Monitored	No. Locations	No. Tracking Shifts
11	M	A	14's mate, 1976; parent of 23	8-20-76/10-22-76 <sup>2</sup>	31	3
13	F	A	parent of 20 & 21	8-20-76/11-6-76 <sup>3</sup>	119	6
14	F	A	mate of 11, 1976; parent of 23 (1976) and 37 & 38 (1977)	8-20-76/3-16-78 <sup>4</sup>	370	21
15	F	A	offspring of 13, littermate of 21	8-21-76/6-10-77	309	17
20	M	J	offspring of 13, littermate of 20	10-1-76/1-24-77	216	10
21	F	J	offspring of 13, littermate of 20	10-10-76/11-6-77	108	6
23	F	J	offspring of 11 & 14	11-13-76/12-9-76	45	2
25	F	A	mate of 33	1-16-77/3-16-78	259	14
33	M	A	mate of 25	7-20-77/3-31-78	125	7
34	F	A		8-1-77/9-29-77	39	2
35	M	J		8-1-77/9-19-77	71	4
37	F	J	offspring of 14, littermate of 38	8-25-77/10-20-77	75	4
38	F	J	offspring of 14, littermate of 37	8-26-77/10-31-77	75	4

<sup>1</sup>A=adult (1 year or older), J=juvenile (less than 1 year old)

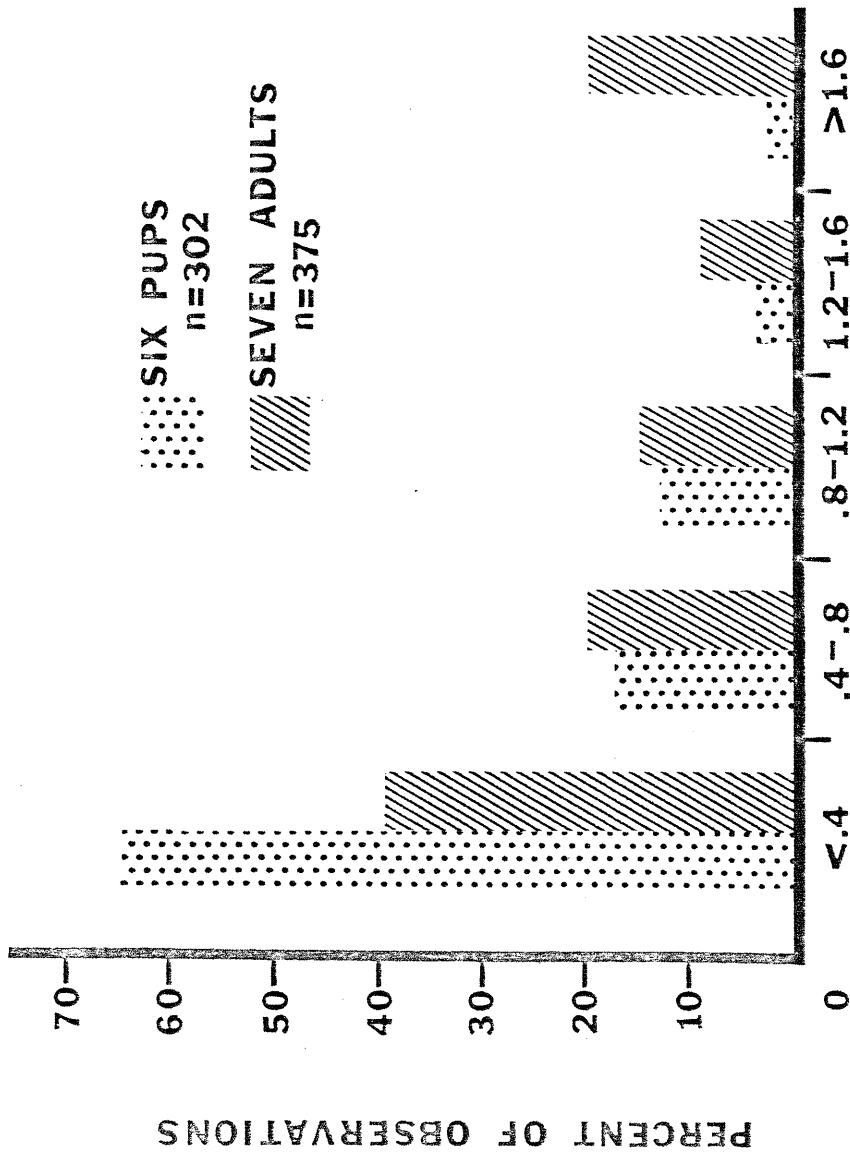
<sup>2</sup>Andelt(1976) monitored from 12-3-75 to 8-19-76

<sup>3</sup>Andelt(1976) monitored from 1-23-76 to 8-19-76

<sup>4</sup>Andelt(1976) monitored from 4-3-76 to 8-19-76



Fig. 1. Distribution of minimum hourly distances traveled (km) by breeding adults and pups from August to November, 1976 and 1977.



**MINIMUM HOURLY DISTANCES TRAVELED**  
(km)

Fig. 2. Mean activity patterns of breeding adults and pups from approximately sunset to sunrise. Observations for August to November, 1976 and 1977.

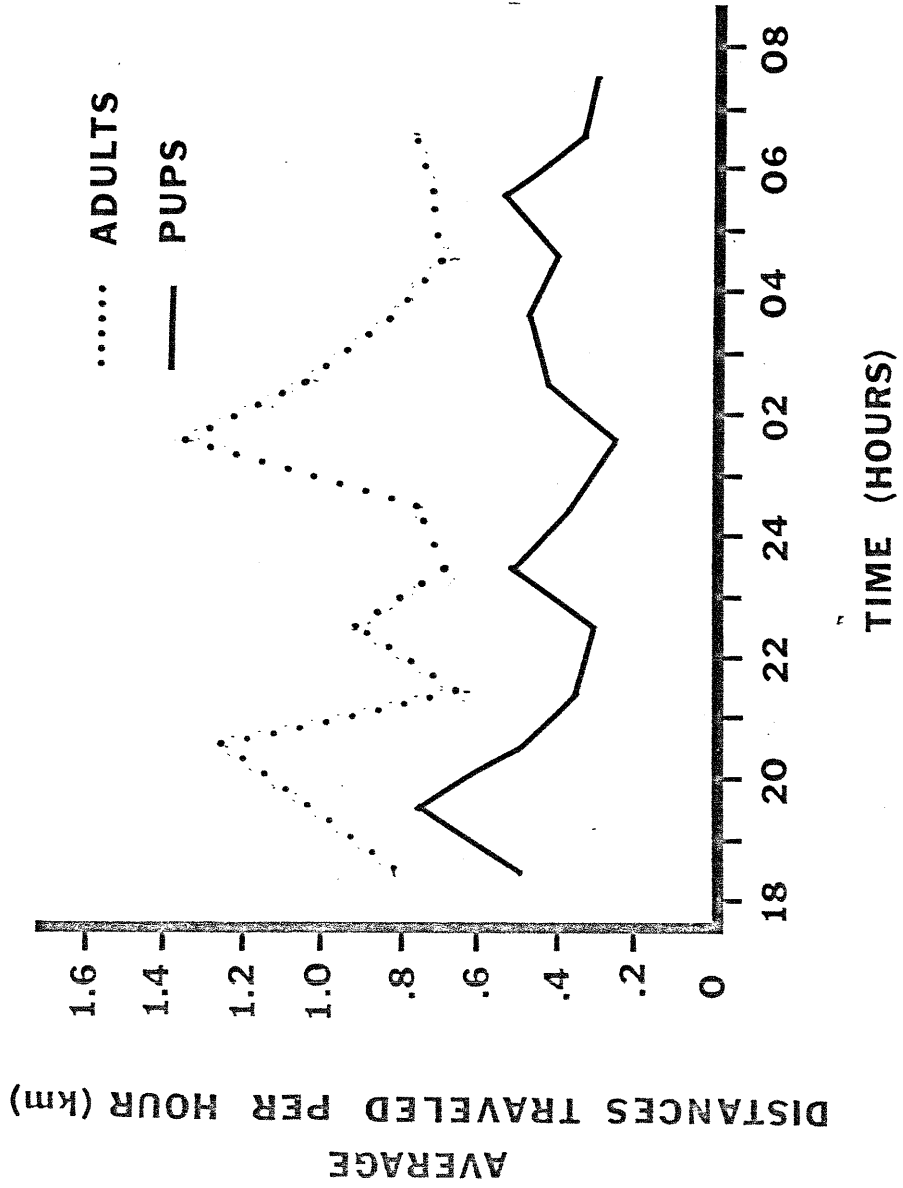


Fig. 3. Home range relationships of breeding adults and pups in 1976. A and B denote turkey production sites.

1976

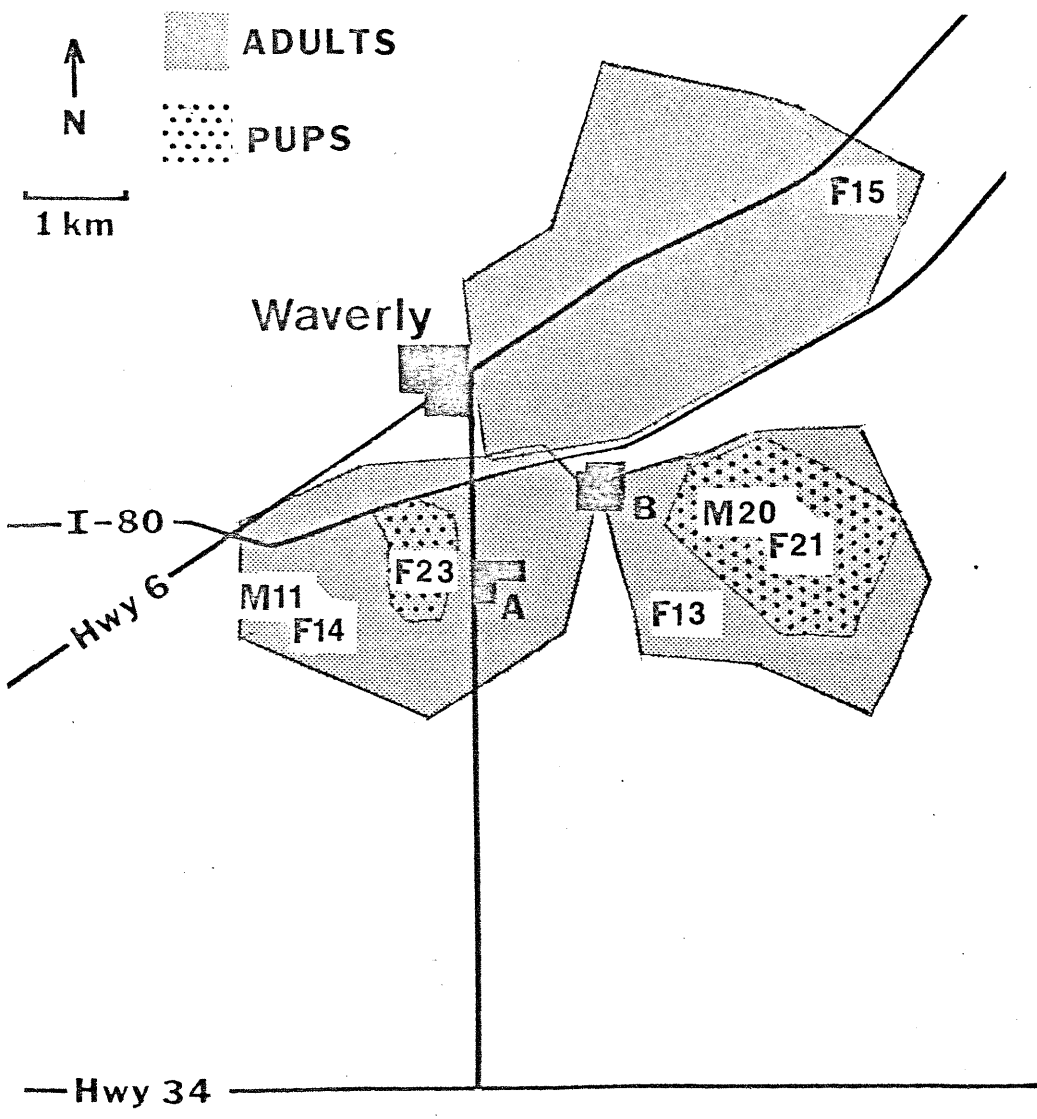
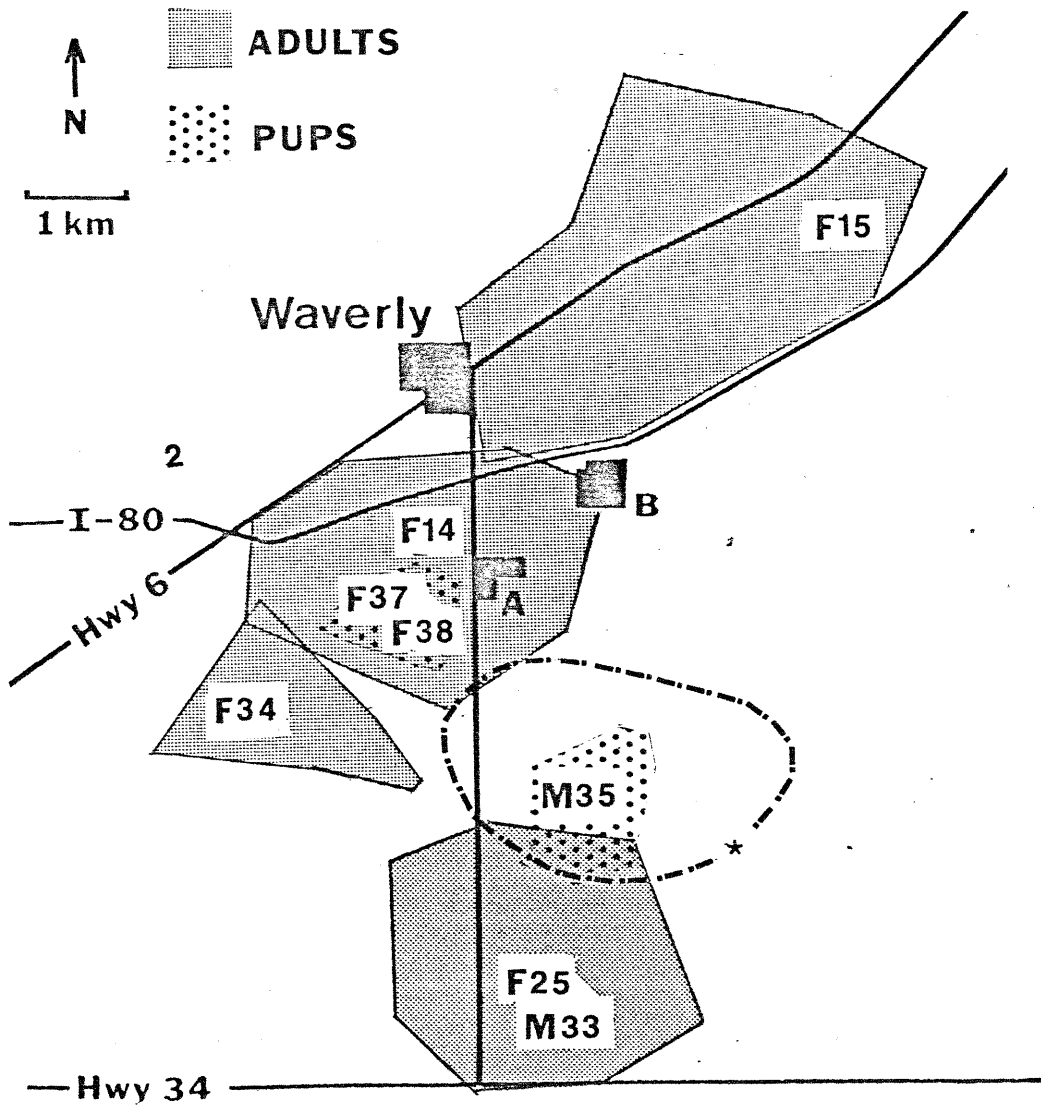


Fig. 5. Distribution of distances between adult females (F13 and F14) and their pups (M20 and F21, and F37 and F38, respectively), based on hourly intervals for late August to early November.

1977





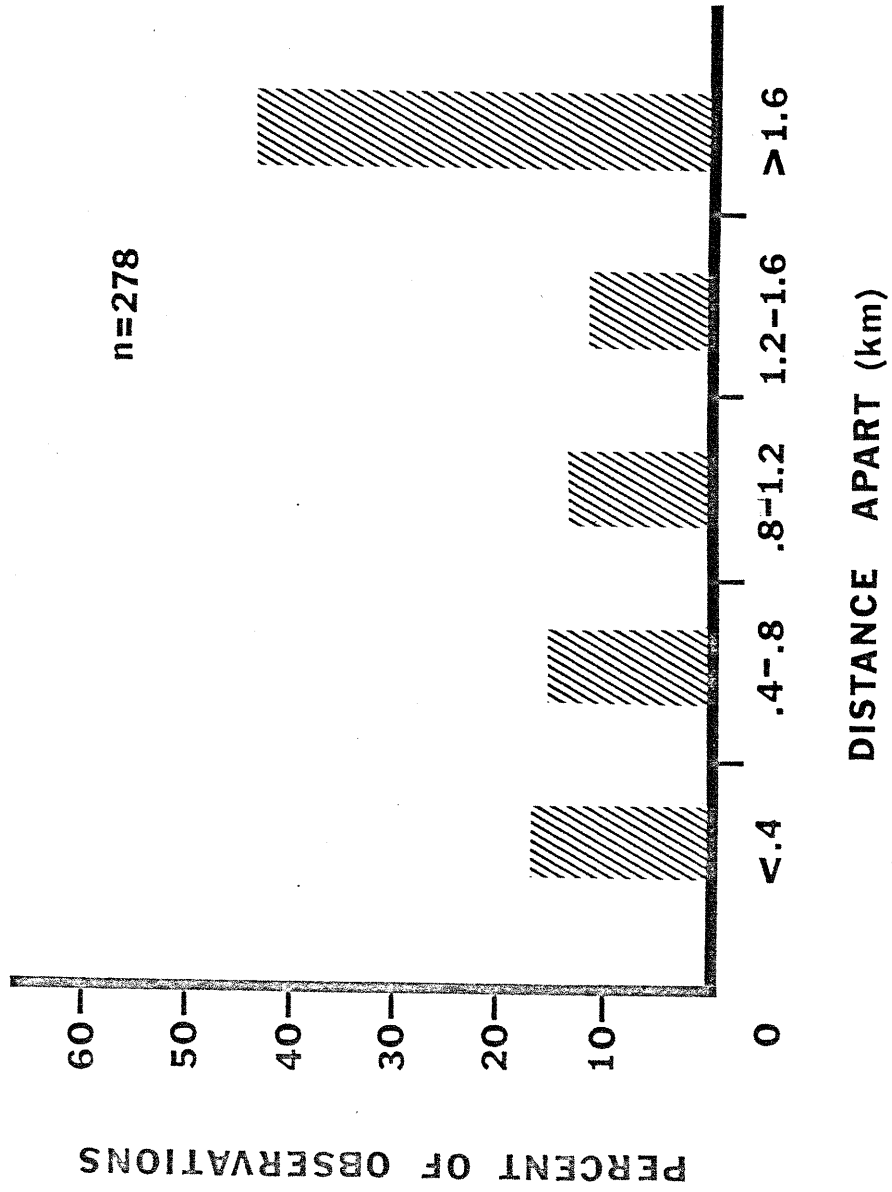
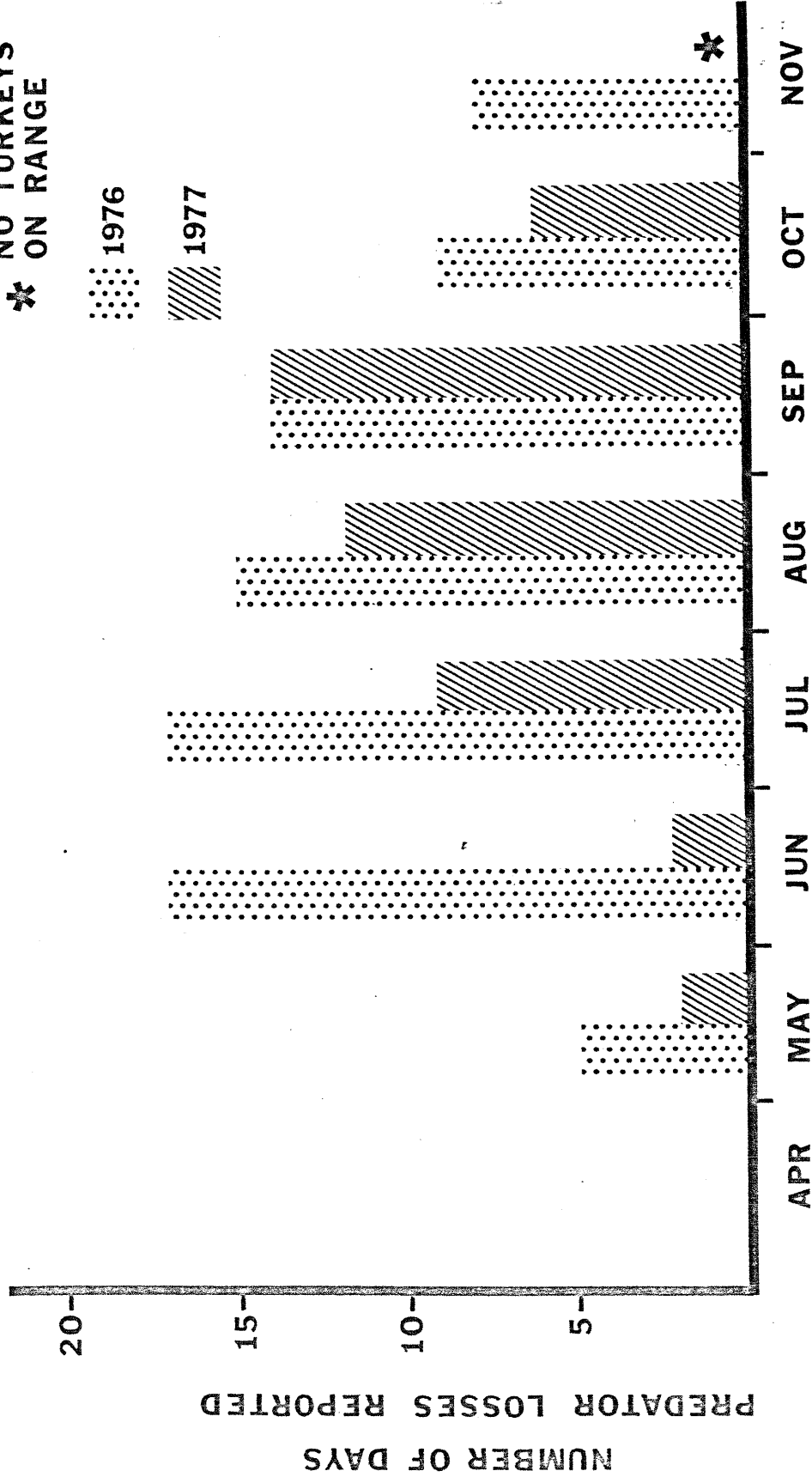


Fig. 6. Number of days per month predator losses reported by the producer in 1976 and 1977.

NO TURKEYS  
ON RANGE



MONTHS TURKEYS ON RANGE