COYOTES
In Kansas

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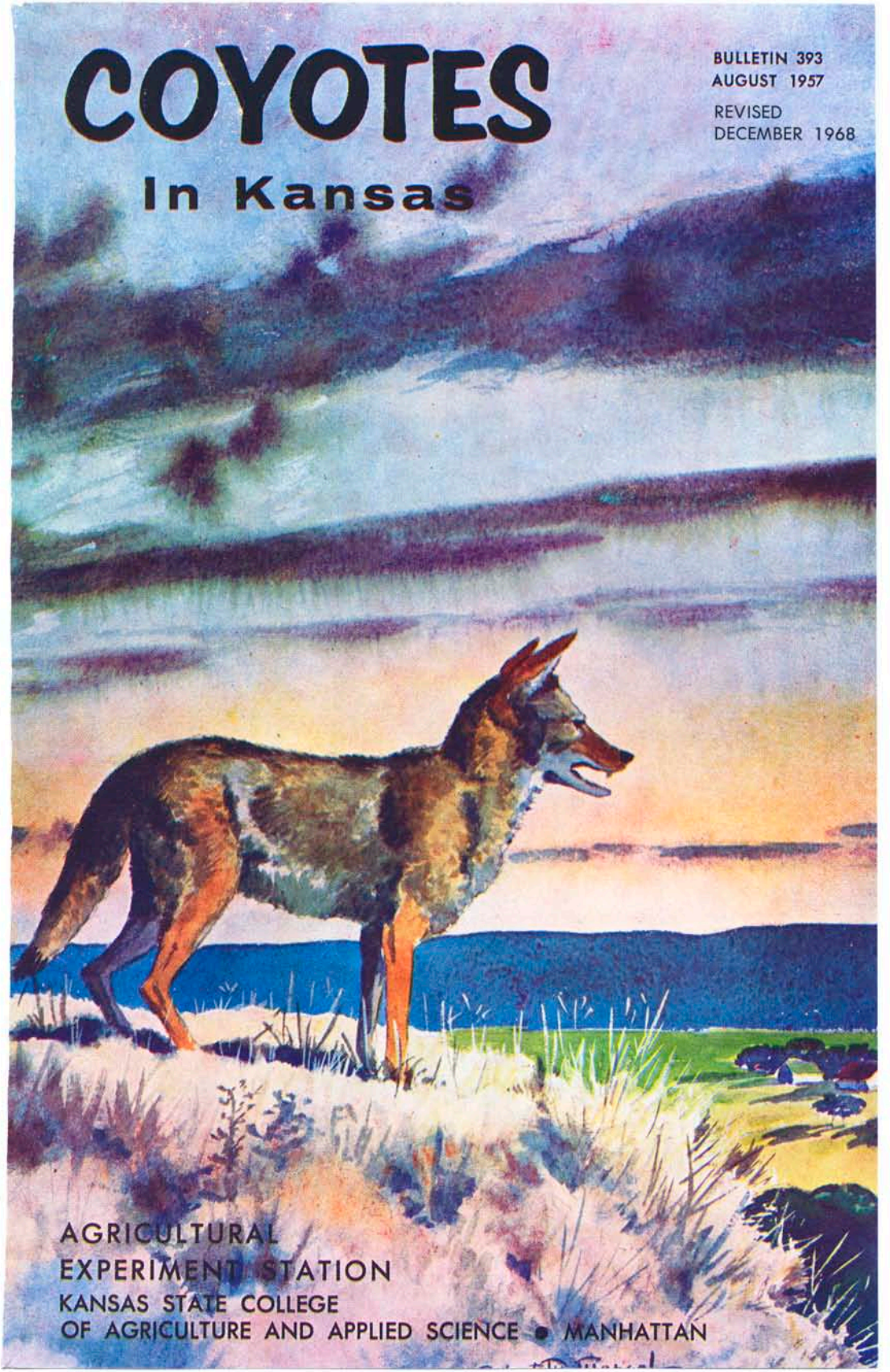

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Fig. 1. Coyotes go to college. A load of coyotes delivered by Hunt Captains C. J. Ryder (left) of Arma and Floyd Tewell (right) of Girard to the author (center) at the Kansas Agricultural Experiment Station. Coyote carcasses brought in from throughout the state constituted the basis for this report. The hunt club led by Ryder and Tewell regularly accounted for 100 or more coyotes a year, mainly from Crawford County.

COYOTES IN KANSAS

By H.T. GIER

Revised December 1968

AGRICULTURAL EXPERIMENT STATION
KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE
MANHATTAN

FLOYD W. SMITH, Associate Director

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Coyotes in Kansas[1]

H. T. Gier[2]

INTRODUCTION

The coyote, "prairie wolf" or "brush wolf" has been a native of the plains of central North America for many centuries (1). Its abundance is indicated by the important part it played in the Indian lore of the region (2) and the frequency with which it is mentioned in the reports of the early explorers and guides. Undoubtedly the coming of homesteaders to the plains restricted the activities of the coyotes and forced the plains coyotes to become adapted to live with the intruder, move out, or perish. Their presence today is evidence that many were able to change with the changing environment.

Coyotes were recognized by pioneer farmers as a possible cause of livestock losses, and measures were taken to eliminate or reduce such losses. In 1877, the Kansas legislature enacted a law requiring the County Commissioners to pay a bounty of $1 for each wolf or coyote scalp presented with evidence that the animal had been killed in the county. The $1 bounty, plus $1 to $10, that the pelt brought encouraged farm boys and trappers to take up and continue coyote hunting until recent years.

Although coyotes did some damage to sheep, raided turkey pens, and consistently took chickens from some farm lots, the general losses of livestock to coyotes in Kansas were not severe before 1942, so far as records show. Lantz (3) indicted the coyote as a chicken thief and sheep-killer wherever it might be. The shortage of ammunition and available man power from 1942 through 1945 greatly curtailed hunting, and the drop in value of pelts practically eliminated trapping coyotes for profit. These factors, combined with successively good seasons for coyote reproduction, resulted in an increase in coyote numbers until populations reached as high a level as is indicated for any time in the past. At the same time, climatic conditions and excessive predation adversely affected rabbit populations. Consequently, a larger proportion of coyotes than normal turned to domestic animals and became a real threat to the prosperity of sheep growers and poultry raisers throughout

1. Contribution No. 994, Department of Zoology, Kansas Agricultural Experiment Station, Manhattan. A partial report on Project No. 280.

2. Embryologist, Kansas Agricultural Experiment Station, Manhattan.

The help of many persons is gratefully acknowledged. Particular thanks are due Dr. D. J. Ameel for consistent support of the project and active supervision of the parasite study the first six years of the project; to Dr. Otto W. Tiemeier for aid in the project in general and analysis of the stomach contents 1948-54; to Dave Leahy, game protectors, and other employees of the Kansas Forestry, Fish and Game Commission for support, encouragement, and aid in obtaining specimens; to the many hunt captains who were instrumental in providing material for the study; to hundreds of individual hunters who cooperated; to ranchers, farmers, and sportsmen who supplied information; and to numerous students who assisted in studying material, analyzing and tabulating data, and in other ways aided with the study.

the region, thus focusing attention on the coyotes and their depredations and serving as the stimulus for this study.

Classification. Kansas coyotes were divided by Jackson (4) into two subspecies: **Canis latrans thamnos** in the northeastern corner of Kansas and **Canis latrans latrans** throughout the remainder of the state. Cockrum (5) recognized **Canis latrans latrans** in the eastern part of the state and **Canis latrans nebrascensis** in the western part, with the dividing line through Republic and Sumner Counties. Hall (6), following different authorities, considered **Canis latrans frustror** to occupy the eastern-southeastern quarter of the state and **Canis l. latrans** the remainder of the state, with the dividing line from Brown County in the northeast through Sumner County in the south. The divisions of the coyote into subspecies are based on differences in size, color, and skull characteristics, and may be debated among qualified taxonomists for some time.

In this study, no consistent differences could be detected between the coyotes from Doniphan, Crawford, Scott, or Norton Counties and those taken in Riley County. For all practical purposes, all coyotes in Kansas may be considered to be the same form.

Characteristics. The coyote is a rather shaggy, doglike animal, somewhat smaller than a Collie dog, with erect, pointed ears and bushy, drooping tail. Coyotes are gray with a rusty or yellowish tint on the neck and along the sides, particularly in the flanks. Distinct black patches occur on the front of the forefeet, at the base of the tail, and on the tip of the tail. The under side of the animal is pale gray, usually with a yellowish tint. The "average" mature male coyote weighs 30 pounds, is 48 inches from nose tip to tip of tail, and stands 21 inches high at the shoulder. The feet are small for an animal of this size: the track made by the front foot is 2.3 x 1.8 inches and that made by the hind foot 2.4 x 1.5 inches. Average mature females are slightly smaller. The largest coyote encountered in this study weighed 43 pounds, was 53 inches long, and 23 inches high at the shoulder.

Skull characteristics are shown in Figure 2. Skulls of mature male coyotes, cleaned and dried, weigh 170 to 210 gm (av. 175), are 180 to 205 mm long (av. 190) from the tip of the premaxilla to the posterior rim of the cranial crest. The tooth row (from the anterior edge of the first premolar to the posterior edge of the last molar, on the maxilla) is 69 to 75 mm (av. 70.3), the distance between the upper premolars is 17 to 22 mm (av.

Fig. 2 (page 5).—Coyote and dog skulls compared. Coyote skull, dorsal view (A) and lateral view (B), and skull of a 30-pound fox hound, dorsal view (C) and lateral view (D). All photographs were taken at the same setting and with the centimeter rule in the center, so the pictures are directly comparable. The main characteristics that distinguish coyote from dog are: nose longer and thinner, teeth more widely spaced, forehead flatter, and cranial crest narrower.

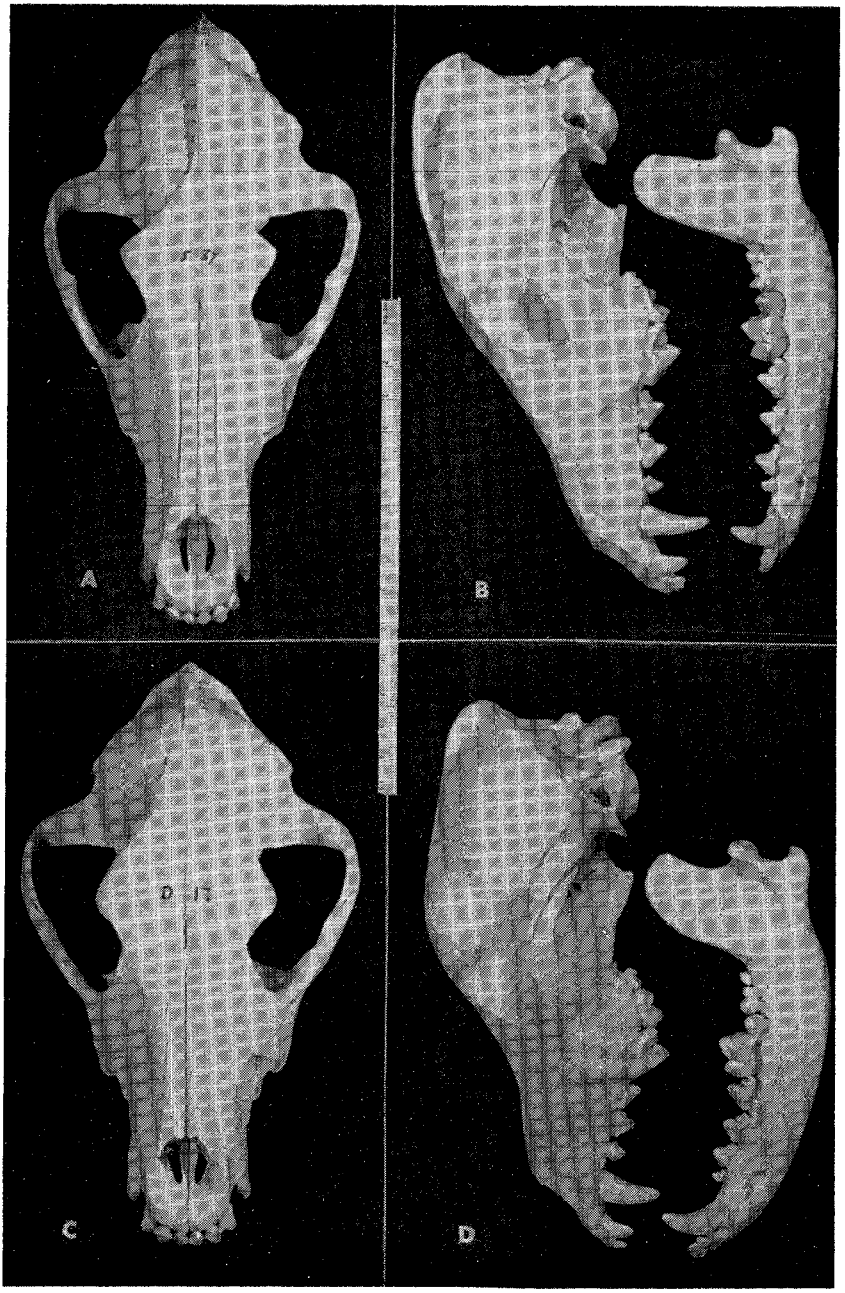


Fig. 2 (see bottom page 4).

20.1) and the premolar width tooth row is 0.24 to 0.31. The upper surface of the face is essentially straight, with no noticeable "stop" at the internasal-frontal bone junction. Skulls of female coyotes are slightly smaller but maintain the same proportions. Skulls from 52 dogs that weighed 25 to 40 lbs. varied much more. The dog skulls weighed 98 to 235 gm, were 125 to 302 mm long; the tooth row was 24 to 71 mm, distance between premolars 17 to 28 mm, and the ratio of premolar width tooth row was 0.35 to 0.48, indicating shorter jaws and broader palate. Collie and wolfhound skulls approach the measurements and proportions of coyote skulls. Most dog skulls appear broader and shorter, and there is a distinct "stop" in the forehead at the junction of prenasal and frontal bones.

Skulls of coyote x dog hybrids range from fairly typical coyote to dog proportions. The premolar width tooth row ratio of 32 mature hybrids examined ranged from 0.26 to 0.40. Most of the hybrid skulls had a fairly distinct "stop" in the forehead, and excluding the collie x coyote hybrids, their skulls were all shorter and thicker than coyote skulls. Only by considering many characteristics is it possible to distinguish some dog x coyote hybrids from coyotes (7).

Although the gray wolf, timber wolf, or Lobo formerly occupied most of Kansas, and the red wolf occurred in Cherokee County during the past century, there have been no authentic records of either of these wolves in Kansas for nearly 50 years.

Foxes of three species (red, gray, and swift) occur within the borders of Kansas (8). Because of the scarcity of foxes over most of the state and the vast differences in size, appearance, and specific behaviors, they present problems and require answers different from those presented by coyotes.

This report is concerned with the biology of Kansas coyotes: how the coyotes affect the economy of Kansas; factors that produce large or small populations; and possible methods of controlling coyote populations and coyote depredations.

COLLECTING THE INFORMATION

Facts about coyotes were collected from many sources. Laboratory examination of coyotes collected during the winter months constituted the basic part of the study. A considerable amount of information was derived from direct observation of coyotes and their surroundings, and still more from personal interviews and correspondence with farmers and sportsmen. Also records in county and state offices, the USDA Division of Agricultural Statistics, and published reports were used.

Coyote carcasses were received for study from sportsmen, game protectors and county agents throughout the state during January, February, and March, 1948 through 1951. During succeeding seasons, most of the carcasses examined were from within 50 miles of Manhattan except for 29 carcasses from Lyon County, 15 from Osage County, 16 from Crawford and

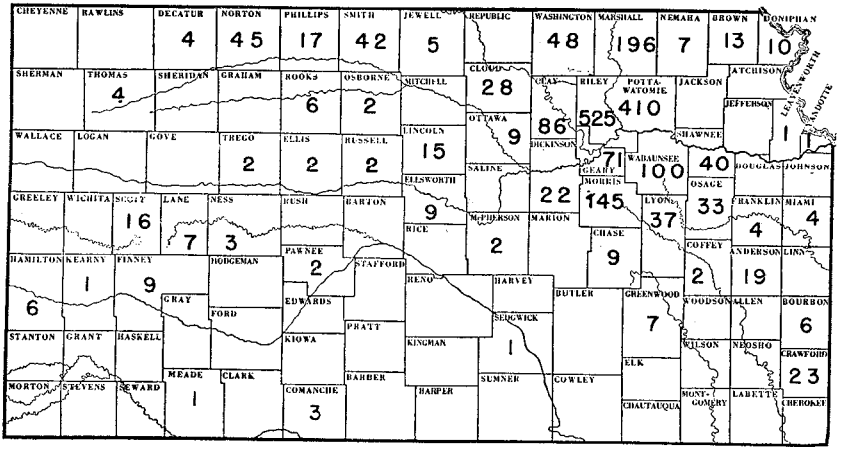


Fig. 3.—Source of coyotes used in this study. Numbers indicate the carcasses received from the county. After 1952 most of the animals came from the six-county area around Manhattan.

Bourbon Counties (Fig. 1) and smaller numbers from Thomas, Coffey, Greenwood, Kearny, Jackson, and Shawnee Counties. Most of the carcasses were obtained from organized hunts and from hunters and trappers in Riley, Pottawatomie, Marshall, Wabaunsee, and Morris Counties. A total of 2090 animals were received from 53 counties (Fig. 3). Yearly and monthly distributions of the receipts are given in Table 1.

Estimates of amounts and kinds of damage by coyotes were assembled by Boles (9) from personal interviews and correspondence with county agents and sportsmen. Questions were included in the 1949 agricultural census (taken in March, 1950) to get more complete information relative to coyote damage directly from the farmers involved. The results of the census

Table 1.—Distribution by months and years of coyotes received, Kansas Agricultural Experiment Station, Manhattan.

	1948*	'49	'50	'51	'52	'53	'54	'55	'56	'57	'58	'59	'60	'61	'62	Total
Oct.	0	0	0	0	1	1	1	1	6	0				1	1	12
Nov.	0	1	1	2	2	0	2	17	22	9	9	4	4	5	13	91
Dec.	0	12	15	33	3	13	1	25	28	50	16	16	7	10	3	232
Jan.	12	32	147	64	93	67	45	7	55	20	36	22	14	15	18	647
Feb.	164	119	168	56	53	20	34	12	42	47	25	21	26	8	30	825
Mar.	20	46	10	28	29	27	4	8	6	4	5	5	21	1	8	222
Apr.	1	10	1	14	2	0	3	6	0	0	2		3			42
May	0	2	0	0	0	1	0	0	0	0						3
Total	197	222	342	197	183	129	90	76	159	130	93	68	75	40	73	2074**

* Research year 1948 includes October, 1947, through May, 1948.

** Sixteen carcasses received during summers not included.

were tabulated and analyzed; then questionnaires were sent to representative farmers who had reported losses. From the replies, a fairly reasonable distribution of losses was deduced. These results are discussed under "Economic Considerations."

Early in the study it became obvious that one of the most pressing phases of the work was the problem of control. Consequently, formerly available information on coyote control, plus information gathered from hunters and trappers in Kansas, was assembled by Gusey (10). Much of his report is used in the section on "Coyote Control," plus any additional material that has become available since that time.

Population densities are particularly important in cases of high concentrations of economically important predators. Bounty records constitute the only official records indicative of the number of coyotes in Kansas. Early records are incomplete, but since 1941, approximately 100 counties have reported at least the annual total bounties to the state auditor. This information is discussed under "Populations" and "Control." Other than by bounty payment records, population densities can be estimated, in a comparative measure at least, by results of hunting and trapping. With this in mind, records have been kept on results of "wolf hunts" in the same areas over successive years, as well as getting "impressions" of numbers from sportsmen. This information was used to expand bounty records into estimates of population.

FOOD OF KANSAS COYOTES

The importance of wild animals to man is determined by what these animals destroy that is of positive or negative value. Predators such as coyotes are primarily meat-eaters and in many cases are in direct competition with man for food, although they may kill a considerable number of animals that are detrimental to man's interests.

Coyotes have been condemned by some because they kill poultry, livestock, and game birds. At the same time they have been exonerated by others because they destroy rabbits and rodents. Both sides of the conflict have been repeatedly expressed, with little reason and few facts to back them up.

The food habits of coyotes were exhaustively studied by Sperry (11) with the examination of 14,129 coyote stomachs collected during a five-year period in 17 states by technicians of the Biological Survey. In 1955, Tiemeier (12) reported on the analysis of 1,280 stomachs taken during the first six years of the present study. In 1955 Fichter, Schildman, and Sather (13) reported on the analysis of 844 coyote stomachs and 2,500 coyote scats collected in Nebraska during 1947, '48, and '49. Korschgen (14) followed with the analysis of contents of 770 coyote stomachs and 326 scats collected in Missouri 1947 through 1956, with considerable numbers from each season.

In the following discussion of coyote food habits, these four reports will be used and augmented by data collected during 1954-62. Differences in food habits reported by Sperry and by Fichter and those noted here are probably due to the areas involved. Both Sperry and Fichter worked with coyotes taken primarily in national forests or similar areas. The coyotes in the present study were, with few exceptions, killed in agricultural areas, where they had ready access to chickens and livestock.

Food habits of an animal may be determined by direct observation, by examination of stomach contents, or by analysis of fecal pellets (scats). With the coyote, direct observation is time consuming, at best gives incomplete results, and is practical only as an incidental tool. For example, if a farmer sees a coyote catch a chicken and carry it away, the addition of that chicken to the coyote's food is a foregone conclusion; or remains of a rabbit or a quail with coyote tracks around are evidence enough that the coyote had a meal.

Examination of stomach contents shows positively what that animal had eaten shortly before it was killed, but it has not been known how rapidly food is digested and how long undigestible substances remain in the stomach. Also, coyote stomachs are readily obtained only during the hunting season, resulting in an insufficient number of stomachs during half of the year.

Fecal pellet examination is the least satisfactory of the three

methods because only nonfood remains are studied and although qualitative analysis can be fairly accurate, numerical relationships are meaningless. This method has one advantage: scats can be collected at any time desired in any area where coyotes are present. The basic food habit determinations for this study were by stomach analysis, with direct observations and analysis of scats used secondarily to extend or interpret the results of stomach analysis.

In an effort to help interpret results obtained by the study of food habits from stomach analysis, a series of experiments was run with captive coyotes. Each animal was fed a quantity of easily recognizable material at a predetermined time before the animal was to be killed, then the digestive tract was examined to determine how far the material had gone. Results are summarized in Table 2. No materials were passed out of the stomach in less than 5 hours, no food material was left in the stomach more than 12 hours and no remnants of feathers or hair after 20 hours. Some of the nondigestible material reached the colon within 16 hours, and some was defecated at 22 hours. Practically all of the remains were in the colon before 24 hours, and had been eliminated before 30 hours. A meadow mouse, for example, regularly passed through as a unit and was eliminated in one scat in about 24 hours if the stomach was relatively empty. A chicken, on the other hand, might be separated enough to be eliminated in three or four scats over a 12-hour period (24 to 35 hours after feeding).

Table 2.—Laboratory-adapted coyotes were fed readily recognizable food materials at predetermined times before the animals were to be killed. During the postmortem examinations the position of the material was located in the digestive tract, weighed, and designated as a percentage of the original weight. Twenty-six tests were made, duplicates being omitted from the table.

Food material	Time, hrs.	Location of remnants of food, %			
		Stomach	Small intestine	Colon	Eliminated as feces
Chicken	2	95			
Chicken	3	85			
Chicken	4	65			
White rat	5	50			
Squirrel	6	40	05		
Field mouse	7	35	10		
Chicken	8	20	20		
Chicken	10	15	15		
Field mouse	12	15	10		
Squirrel	16	05	10	05	
White rat	20	01	05	10	
Chicken	22	01	05	10	05
Field mouse	22	00	00	00	10
Squirrel	24	00	00	05	05
Chicken	28	00	00	02	10

Correlation of this information with the feeding habits of coyotes gives a better understanding of results from stomach analysis. Most coyotes are nocturnal feeders, coming out at dusk, feeding on whatever they can find in the evening, or possibly continuing to hunt throughout the night before satisfying their hunger. Prey animals eaten early during the evening would be completely digested and out of the stomach by daylight. Animals eaten late in the night would be digested by noon and would have only undigestible remnants in the stomach by late afternoon. Substantial amounts of food materials are found only in the stomachs of coyotes killed during the night or early in the morning, or in the afternoon kills of the unusual coyotes that fed during the day.

Results of the feeding experiments indicate that only those stomachs examined within the first four hours after a meal should be used for quantitative calculation of proportional intake, since at about four hours the digestible materials are passing rapidly from the stomach, leaving a disproportionate amount of bones, hair, and feathers. This study was completed too late to note degree of digestion of stomach contents, so is not applicable to our stomach analyses. Consistent use of weights of all materials in the stomach, however, should give comparable data year after year, even though it does not give a true picture of the food intake.

The coyotes used in this study were mostly quick-killed. Only 9% were caught in steel traps, and the bait material was not considered in food determinations. Ten percent were either killed by dogs or shot ahead of the dogs on the chase. Cyanide guns accounted for 25%, and organized hunts provided 56%. Coyotes caught in steel traps frequently had only remnants of food materials other than station bait in their

Table 3.—Distribution by months of coyote stomachs and contents examined during the 15-year study. Stomach contents were weighed in grams (454 grams = 1 pound). Total weight of the contents divided by number of stomachs containing the material gives an "average" content per stomach. This tabulation includes the material reported by Tiemeier.

	Number of stomachs		Weight of contents, grams	
	Total	Containing food	Total	Average
Oct.	15	11	1,896	172
Nov.	79	68	8,466	125
Dec.	227	186	32,986	177
Jan.	642	464	96,993	208
Feb.	785	543	126,814	233
Mar.	201	146	26,725	183
Apr.	39	30	8,050	268
Total	1,988	1,448	301,930	197

stomachs. Cyanide guns apparently are most effective early in the night before the coyotes have found food, and again late in the night after the coyotes have eaten and are playful. Coyotes killed on the chase are rather frequently killed during the morning, and have a high proportion of well-filled stomachs. Organized hunts provided rather unsatisfactory food-study material because most of the kills were made in the afternoon when the stomachs were essentially empty.

During the 15 years of this study, 1988 stomachs were examined, including the 1280 reported by Tiemeier (12), with monthly and yearly distribution essentially the same as the coyotes studied (Table 1). Total monthly distribution and contents are summarized in Table 3. The number of stomachs taken in October is inadequate for significant evaluation; the number in November and April borders on inadequacy and must be considered to show trends only. A total of 537 stomachs (27%) were empty or contained only station bait or debris swallowed during the death spasms.

Occurrence of items in the stomachs is given in Table 4. This shows that during the first 15 years of the study rabbits occurred most frequently, 54.3% of the stomachs containing some rabbit remains. Carrion, including all forms of domestic

Table 4.—Occurrence of food items found in 1948 coyote stomachs.

	'48	'49	'50	'51	'52	'53	'54	'55	'56	'57	'58-'62	Total
Rabbit	84	103	120	72	82	50	27	26	59	56	111	790
Chicken	17	24	40	23	17	8	11	9	22	16	17	204
Carrion	42	76	88	42	17	27	42	29	53	38	93	547
Game Birds	2	12	5	6		2	1	2	10	4	21	65
Quail	1	1		2		1	1	2	6	3	16	33
Prairie chicken						1			4	1	5	11
Pheasant	1	11	5	4								21
Other Birds	11	12	5	5	7	4	1	2	4	15	24	90
Unidentified	4	7	4	2	6	2	1	1	1	2		30
Red-tailed hawk		1									1	2
Ring-neck duck									1		1	2
Flicker	1									1	1	3
Guinea hen									1			1
Horned lark	1	1		1						1		4
Crow			1	1							1	3
Carolina wren										1		1
Starling		1										1
Meadowlark	2	2		1	1				1	1	7	15
Red-wing blackbird						2			1	3	1	7
Cardinal										1	1	2
Junco	2							1	1	5	4	13
Field sparrow	1											1
Tree sparrow											6	6

Table 4 (concluded)

	'48	'49	'50	'51	'52	'53	'54	'55	'56	'57	'58-'62	Total
Rodents	55	43	53	63	69	27	14	22	39	48	170	603
Meadow mouse	23	16	29	42	47	16	3	4	7	15	62	264
Harvest mouse	1	2	4	9	8	3		8	12	11	22	80
Cotton rat			1	5	14	1	2	2	1	3	39	68
Fox squirrel	3		2	1		2				1	2	11
Pine mouse	6	2	1									9
Lemming			1								2	3
Pocket mouse							1	1	4	7		13
Wood rat	3	3	2	2						3		13
White-footed mouse	12	17	13	3		2	7	7	13	15	43	132
Prairie dog	1											1
Norway rat	2	1										3
Kangaroo rat	2	2								1		5
Gopher	1			1		3			1	2		8
Muskrat	1						1		1		1	4
Other mammals	3	2	2				2	7	8	2	4	30
Mole								1				1
Shrew	1											1
Skunk		1	1				1	4	7	1	1	16
Opossum	1	1								1	1	4
Raccoon							1	1	1		2	5
Miscellaneous	4	4	2	1	1	4	9	26	25	15	30	121
Crayfish	2				1				1			4
Insects							1	6	7	4	5	23
Lizards									1			1
Snakes	1	1		1		1	1		1	2	2	10
Blackberry								1	1		1	3
Apple						1		1			1	3
Pear									2		4	6
Persimmon	1						1	1	1		1	5
Wild plum							1	2	1			4
Watermelon									2			2
Wild grape								2	1		2	5
Hackberry		3					1	7		1	2	14
Prickly pear						1						1
Corn						1	1		1	1	6	10
Sorghum							1	1	2	2	2	8
Wheat								2	4	2	2	10
Cotton cake							1	1	2	2	2	8
Osage-orange apple										1		1

livestock and chicken that was distinctly not freshly killed, occurred in 37.5%, rodents in 41.5% and chicken in 13.8%. Station bait in stomachs of trapped animals was excluded from the tabulations. Individual items will be discussed later.

Relationship between occurrence and quantity of items found in the stomachs is shown graphically in Figure 4. Rabbit not only occurred most frequently, but made up more than half of the total contents by weight. The category "other mammals" includes all the mammals listed in Table 4 under "rodents"

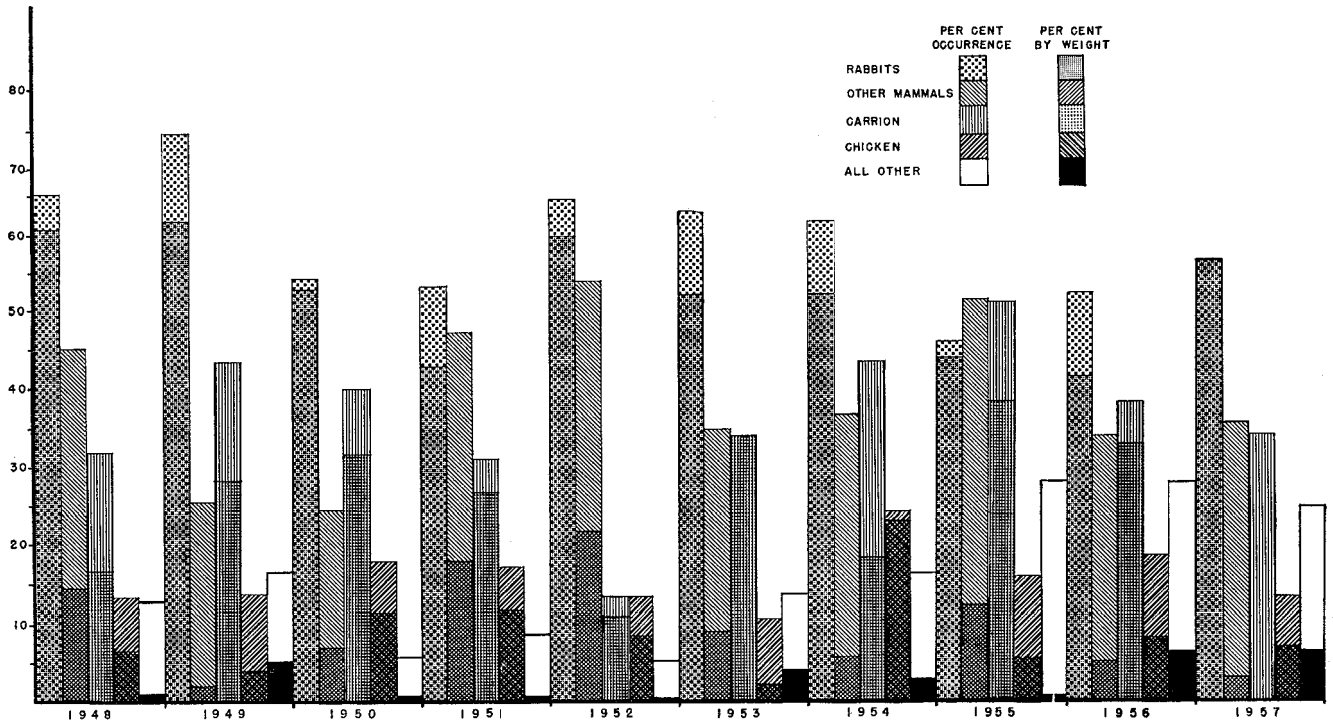


Fig. 4.—Food of coyotes as determined by examination of 1948 stomachs. Each of the five major groups of food items is shown as percentages of the stomachs that contained that group and as the percentage of the total weight of stomach contents made by that group. There was no separation of domestic livestock that the coyotes may have killed from that taken as carrion.

and "other mammals," and in some years constitutes the second most frequent group, while in other years it is replaced by "carrion" in the second place. "Other mammals" as a group, however, never exceeded 21% of the annual contents, and averaged only 14%, including rather large quantities of raccoon and opossum. "Carrion" was either third or second in occurrence and always second in weight. "Chicken," comprising all chicken remains except rotten material and trap bait, was consistently fourth in occurrence and usually third in importance in weight, ranking between "carrion" and "other mammals." "Game birds," "other birds," and "miscellaneous" categories of Table 4 are combined here as "all other" because no one item was consistently large enough to show on a chart of this size. The detailed monthly and annual fluctuations of these food items were discussed by Tiemeier (12), and did not change appreciably in the additional years of this study except for reduction in occurrence of chicken.

The "average" winter food of Kansas coyotes, based on the weights of contents, consists of rabbit, 54%; carrion, 26%; chicken, 7%; rodents, 8%; other mammals, 0.8%; wild birds, 0.7%; game birds, 1.4%; fruits, berries, grain, and all others, 2.1%.

At present, it is impossible to tell how closely these weights reflect the food intake or how much the relationship is distorted by including the undigestible remains found in the stomach. This distortion results from the disproportion between a freshly ingested animal with flesh, bone, and feathers or hair and the undigestible remnants of feathers or hair so frequently found in coyotes killed during the afternoon. Whatever these distortions are they can be of relatively little significance in understanding the total food intake of the coyote.

SPECIFIC FOODS OF KANSAS COYOTES

Although adequate data are not available for satisfactory analysis of coyote food habits throughout the year, there is enough to indicate trends (Fig. 5). The food groups and their importance will be discussed in the following paragraphs.

Rabbit. In Kansas, throughout the years of this study, rabbits have been the most important item in the coyote diet. During January and February, particularly when there is snow protecting the rodents and covering most other food materials, rabbit remains occurred in 60 to 80% of the stomachs and made up considerably over half of the contents. As other foods became available in the spring, consumption of rabbit decreased slightly, then increased again in midsummer as the rabbit population increased. Cottontails seem to be the favorite food of Kansas coyotes, but jack rabbits are taken when available. The occurrence of rabbit in coyote stomachs (Fig. 4) has followed closely the cottontail population in the Manhattan

area. The number of rabbits killed by coyotes can be estimated with the following information: a coyote requires 1½ pounds of meat each day, or approximately 550 pounds a year, 54% of which is rabbit. Cottontails average 2¼ pounds each and jack rabbits average 7¼ pounds. If rabbits are scarce and the coyote eats all of every rabbit killed, 140 cottontails will be required to fill the minimum annual requirement. If rabbits are more common, coyotes do not eat all of every kill, but kill another rabbit for each meal. One coyote for each 3 square miles in an area would kill an average of 47 cottontails per square mile each year: fewer when rabbits are scarce, more when they are plentiful. Jack rabbit kills would be considerably less, but not in proportion to the size of the rabbit. A coyote cannot regularly eat all of a jack rabbit at one time; and before the coyote would come back for the rest of the rabbit, if he did, some other scavenger would have eaten it. Whether the destruction

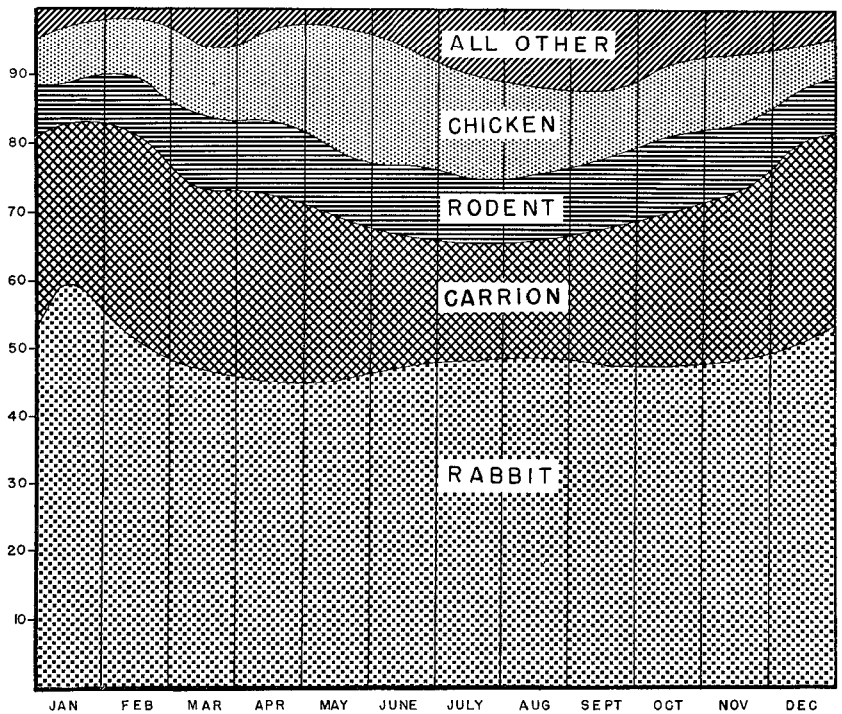


Fig. 5.—Average annual food of Kansas coyotes as determined from available data. "Rabbit," including cottontails and jack rabbits, is the staple food. "Carrion" includes all domestic livestock, however acquired, plus other decaying meat. "Rodent" here designated includes all mice, rats, and other small mammals. "Chicken" indicates all poultry whether picked up dead or killed by the coyotes. "All other" indicates fruits, grain, insects, snakes, and other food items consumed.

of rabbits by coyotes is good or bad depends on whether the value of rabbits as game animals is greater than the damage the rabbits do. During 1954-58, the jack rabbit population was so high in parts of western Kansas that sportsmen were encouraged to kill jack rabbits, killing coyotes was discouraged and the bounty on coyotes was removed.[3]

Stomach contents indicate that coyotes may actually hunt for rabbit nests, and once the nest is found, the entire litter is eaten. If rabbits were not so prolific, they could not keep pace with the coyotes. It appears that the coyote population was so high from 1944 through 1952 that rabbits were held in close check during that time by excessive predation. With the extreme reduction of coyotes in 1953 and 1954 by natural and artificial means, this brake on rabbit populations was released and jackrabbits again became numerous on the plains where reduction of coyote populations was greatest.

Korschgen (14) found that Missouri coyotes, like Kansas coyotes, had an average consumption of almost 54% rabbit, with 48.6% in spring, 35.2% summer, 47.7% fall, and 58.1% winter.

Carrion. Remains of all domestic animals, including cattle, sheep, hogs, and horses, were grouped together as "carrion." Chicken that was rotten or that contained maggots was put in this category by Tiemeier (12) but was not so included since then. Cattle remains were found most frequently: in 20% of the last 700 stomachs examined. Sheep remains, usually small pieces of skin or clumps of wool, were found in less than 1% of the stomachs studied. Hog remains, usually hair, skin, or refuse from butchering, were found in 3%, and horse hide and hair were found only three times. This reflects closely the proportions of these animals that might have been available to coyotes during the winter months. No attempt was made to distinguish between remains of animals that the coyotes may have killed and those that were already dead, but most of this material was long dead: some was in advanced stages of decay, some was filled with maggots, and some was dried and hard. Cow hooves, hog ears, sheep hocks, and horse hide were obviously carrion. Calf flesh and lamb skin might have been from direct kills but were found too infrequently to be of any significance.

Carrion regularly constituted 15 to 40% of the stomach contents throughout this study. On an annual basis, carrion consumption was highest in February and March. The utilization

3. Between September, 1955, and June, 1956, payment of coyote bounties was revoked by at least the following counties: Comanche, Finney, Grant, Gray, and Kearny. Hamilton, Haskell, and Stanton Counties had no bounty reports during 1956, so may be presumed to have stopped payments. Scott County joined the no-bounty group January 1, 1957. Grant, Kearny, and Finney Counties paid 5 or 10 cents bounty on jackrabbits for at least part of 1956 and 1957. Progressively, more counties removed the bounty until in January, 1961, only 56 counties were paying. In February, 1961, the Kansas legislature again made a $2 bounty mandatory. Most counties complied for a time, but in 1966, 15 counties had revoked bounty payments.

of carrion reflects its ready availability and the relative scarcity of preferred food items such as rabbits, mice, or poultry. However, coyotes have been observed to return repeatedly to an old carcass and chew off bits of skin and ligaments until the skeleton is completely disassembled, which, in some cases, may be a year after the animal died. Part of this chewing may be considered a pastime for the coyote, as bone-chewing is for the domestic dog.

Korschgen (14) reported a total of 5.8% carrion and 8.9% livestock in stomachs of Missouri coyotes, with slightly more of these materials during spring and summer than in fall and winter. The lower proportions of domestic mammal remains in the Missouri coyotes reflect the less intensive livestock efforts in Missouri, plus lower coyote population per unit farm.

The damage done by coyotes in killing livestock will be considered in the chapter, "Economic Considerations." In some localities a few individual coyotes possibly get a large proportion of their food by killing lambs, sheep, pigs, or calves. Utilization of livestock is included in the charts (Figs. 4 and 5) without attempting to separate freshly killed from long-dead animals.

Chicken and other domestic birds, principally turkey and duck, made up about 7% of the total food of Kansas coyotes. Poultry, in contrast to large domestic mammals, is regularly taken by coyotes whenever available and may be considered as a favored food. An undetermined part of the poultry eaten by coyotes is actually carrion, picked up by the coyotes after the farmer throws the dead birds over the fence, drops them along the roadside, or hauls them to a back field. It is considered by Scott (15) and Fichter (13) that predators are "taught" to eat poultry by careless disposal of dead birds. Probably most of the chicken found in the coyote stomachs in this winter study was not killed by the coyotes: chickens kept in pens are not available to coyotes.

Most of the reports of coyotes killing chickens, turkeys, geese, or ducks are received during the summer while the poultry is on the range, or the birds stray into cornfields or weeds where the coyotes can lie in wait without being detected. In Figure 5 this increased summer kill is indicated by the increased width of the "chicken" band.

Korschgen (14) found two to three times as much poultry in summer-collected stomachs as in winter-collected stomachs, comparable to the estimate for increased summer take of chickens by Kansas coyotes.

Rodents. Nearly all species of small mammals known to live in the area from which the coyotes were taken were found in stomachs (Table 4). Annual percentage occurrence and percentage by weight are shown in Figure 4. Most rodents were taken for food in approximate proportion to numbers

available to the coyotes (Fig. 6). Short-tailed meadow mice (**Microtus ochrogaster**) appear to be a preferred food of coyotes, as they occurred rather frequently in stomach contents even when not caught in traps set especially for them. During the winter and early spring, coyotes hunt meadow mice intensively, and at times dig out long runways to get at the mice. Meadow mice were plentiful over the state in 1950-52, and again in the fall of 1955 and 1958, with relatively few caught or occurring in coyote stomachs in 1953, 1954, 1956 and 1957 (16). Trends in rodent populations (Fig. 6) closely paralleled the presence of rodents in coyote stomachs.

Similarly, cotton rats (**Sigmodon hispidus**) were found in coyote stomachs during the same winters they were caught in the traps. Harvest mice (**Reithrodontomys sp.**) and white-footed mice (**Peromyscus sp.**) are regularly taken in small numbers. Wood rats (**Neotoma floridana**) did not occur in the stomachs in proportion to known populations. Field observations indicate that wood rats, even though fairly numerous at times, are not readily caught by coyotes.

Gophers (**Geomys bursarius**), too, seem not to be available to coyotes in most of Kansas, even though Fichter (13) found gophers to be a regular and important item in the food of coyotes in the sand hills of Nebraska. Prairie dogs and kangaroo rats listed (Table 4) were in coyote stomachs from Scott, Kearny, and Lane Counties, but even there do not seem to have been important food items during the years coyotes were re-

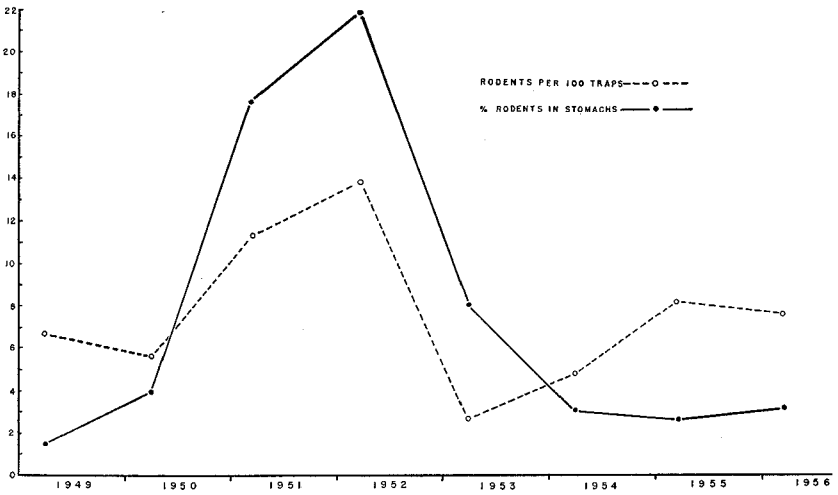


Fig. 6.—Comparison of rodents caught in trap lines, reduced to rodents per 100 traps per night, with the percentage of rodents in coyote stomachs. The rodent increase indicated by trap lines in 1955 did not correlate with coyote-stomach contents primarily because the trapping areas were selected as maximal rodent habitats.

ceived from that part of the state. House mice and Norway rats seem not to be on the regular menu for coyotes. Other workers (3, 11) have found ground squirrels, kangaroo rats, and prairie dogs to be staple items in the coyote diet wherever these animals were common.

Small mammals other than rodents play a minor role in the coyote food schedule (Table 4). Remains of opossum and raccoon were found frequently enough and in large enough quantities to indicate acceptability. It is doubtful that a coyote could kill a raccoon, and most of the opossum remains found was definitely not from freshly killed animals. Moles, shrews and skunks seem to be avoided by coyotes. There is no evidence that coyotes eat other coyotes, although coyote toes were found in the stomachs of some coyotes caught in steel traps, and Murie (17) stated that coyotes in the Yellowstone were somewhat cannibalistic.

The consumption of rodents, principally meadow mice and cotton rats, by coyotes can be of considerable importance to man. Stomachs from coyotes killed in areas having high concentrations of these two rodents regularly have as high as 75% occurrence and may average 4 or 5 rodents each. As many as 24 field mice have been found in one coyote stomach, and the presence of 8 to 16 mice in one coyote stomach is not uncommon (Fig. 7).

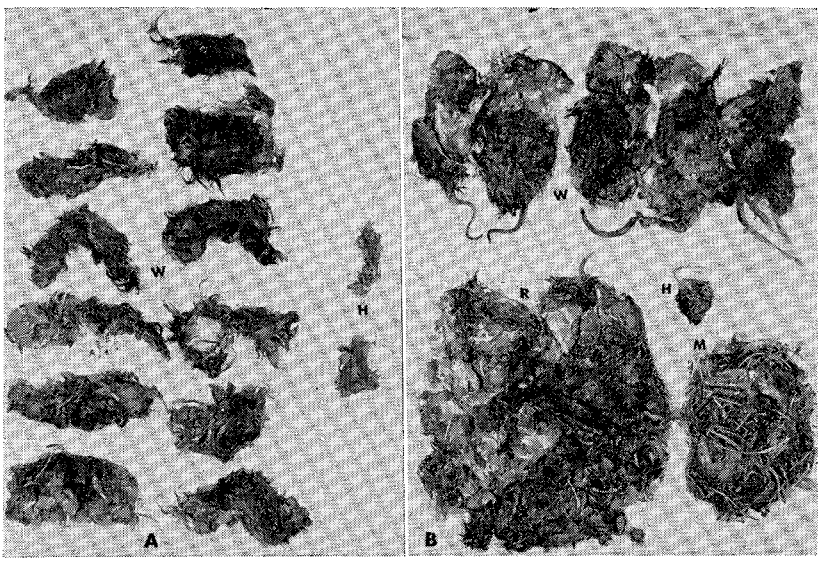


Fig. 7.—Contents of coyote stomach. A. 12 white-footed mice (W) and 2 harvest mice (H) from the stomach of a coyote taken in Lyon County, February, 1950. B. 5 white-footed mice (W), 1 harvest mouse (H), remains of a meadowlark (M) and rabbit (R), from the stomach of a coyote taken in Riley County, March, 1951.

Birds, contrary to popular opinion, do not constitute an important part of the food of Kansas coyotes. Game birds have been found infrequently among the stomach contents, and most of those during or immediately following the hunting season and following severe storms. Quail were found in small numbers nearly every year (Table 4). Pheasant remains were found only in a small proportion of those coyotes received from the northwest part of the state where they are plentiful. Prairie chicken remains were found in only 11 stomachs, although they were fairly abundant in the immediate vicinities in Pottawatomie, Wabaunsee, and Morris Counties, from which large numbers of coyotes were examined. In February, 1956, three coyotes killed within one square mile during a hunt in Wabaunsee County had a few feathers and dried skin of prairie chicken in their stomachs.

Fichter (13) found up to 8.4% of contents of coyote stomachs taken in western Nebraska to be grouse (sharp-tail and prairie chicken), and 20% of the coyote stomachs taken in central Nebraska contained pheasant. Fichter observed coyotes bypassing pheasants for mice or chickens, and concluded that only crippled or dead birds were regularly eaten. Also, in their study of effects of predation, they found that although coyotes occasionally destroyed pheasant nests, they did not actively search for nests or brooding hens. Kansas evidence adds to that of the Nebraska study, indicating slight predation on game birds with probably a greater service than damage in forcing a prolonged nesting season. There is no evidence **at present** that coyotes adversely affect Kansas game bird populations at any time of the year; however, intensive study of this problem during May and June is needed.

Wild birds other than game birds seem to be "incidental" foods. During the years of this study, no evidence has been found of coyotes actively hunting any birds, and contrarily, there is no evidence that a coyote ever declines a chance to eat any bird that is available. The list of birds identified in the stomach contents (Table 4) indicates the spread—and the infrequency—of utilization of birds by coyotes. In the areas around Manhattan (where observation of coyotes has been most intense) quail, meadowlarks, horned larks, dickcissels, and grasshopper sparrows nest in abundance with no evidence of interference by the coyotes.

Invertebrates have been found in stomachs infrequently, as would be expected in a winter study. Crayfish possibly are eaten in numbers during wet seasons when they are on the surface in shallow water. Insects, principally grasshoppers, crickets, and large beetles, are known from direct observation and scat analysis to constitute a major portion of the food of some coyotes during the summer. June beetles have been found to constitute entire scats during the early summer. Grasshop-

pers are found in scats throughout the summer, and become particularly prevalent after the first few frosts in the fall. Large caterpillars, such as the larvae of the alfalfa butterfly **(Colias eurytheme),** are eaten in considerable numbers when available. Although coyotes cannot be considered as economically important insect eradicators, insects do at times constitute a proportion of the coyote food, and so take the pressure off other prey.

Cold-blooded vertebrates are eaten, but apparently not hunted intensively. Fichter (13) reported lizards were well represented in coyote scats picked up in central Nebraska. In the present study, remains of a fence lizard, **Sceloporus undulatus,** were found in November, 1955, and snake remains, mostly bull snake, black snake, and ground snake, were found infrequently throughout the winter (Table 4). Probably only a fraction of 1% of the food of coyotes in any month is composed of lizards and snakes.

Fruits are eaten in quantities by some if not most coyotes. Repeated evidence indicates that coyotes eat strawberries and blackberries. A coyote shot near Blue Rapids in July, 1955, had more than a pound of blackberries in its stomach, and the colon was packed with blackberry seeds. Scats examined during July attest to considerable utilization of blackberries.

Apples, pears, and peaches are eaten, but data are insufficient for quantitative determinations. Apples have been found in stomachs only twice, but have been observed in intestinal contents and in scats on several other occasions. Pear was found in two stomachs in December, 1955, with more than two pounds in one stomach. Pear seeds and skins have been found in several scats in November and December. Peach skins have been identified in several scats in August and September, but have not been found in the stomach contents. Persimmons and pawpaws are eaten in quantities when available, mostly in October and November. Wild plums are eaten when available from the time they first ripen (August) until no dried plums remain.

Watermelon seems to be a favorite food of some coyotes, and melon farmers around Manhattan at times complain about the number of melons that are ruined by coyotes. A melon-eating coyote regularly selects a nice ripe melon, splits it open, and gorges on the red meat. Watermelon seeds have been found in several scats, but only twice (January, 1956) in stomachs.

Wild grapes, hackberry, pokeberry, choke cherry, wild cherry, and other such fruits are eaten on occasion, but apparently not in significant quantities. Prickly pear apples possibly are eaten more frequently than shown in Table 4, as they ripen in August and September, when no stomachs were collected.

Grains, particularly corn, sorghums, and wheat, have been

found in several coyote stomachs, intestines, and scats, but not in quantities exceeding a few grams. Stomachs of two coyotes killed in Morris County in December, 1955, contained several sprouted wheat seeds. These may be considered as emergency foods and not winter staples as found in the gray fox (Gier, unpublished data).

Green grass, including blades of oats, wheat, and barley, was found in about 5% of the stomachs taken during winter months, and Fichter (13) reported a considerable increase during early summer. Although coyotes may not digest much of this grass, it may serve a function as tonic, source of vitamins, or vermicide.

Extraneous items, such as harness leather, rubber scraps, paper, pieces of rope, and dry grass, found in coyote stomachs must be considered as incidental or accidental ingestions, swallowed with real food materials or during play. Quantities of dirt, dead leaves, twigs, and dry grass are frequently swallowed during the death spasms of the coyote, and cannot be considered as food items.

Cottoncake was found in three stomachs, with 1½ pounds in one; cow manure, apparently eaten fresh, was found in three stomachs; and cow afterbirth was found in four stomachs. These findings indicate that coyotes at times associate rather closely with cattle on the ranges, and personal observations strengthen this assumption. On several occasions, a coyote has been seen to move into a herd of cattle, passing through the herd without molesting the animals or being bothered by them. On two occasions, the coyote came out from the herd running, being chased by apparently inquisitive cattle.

After careful consideration of the data given in the past few pages, a few generalizations concerning coyote feeding habits may be made:

1. Within broad limits of selection, coyotes eat the flesh that is most readily available to them.

2. Rabbits, field mice, cotton rats, and poultry seem to be preferred foods, with most other wild mammals and birds being taken on the basis of availability and need.

3. Game birds do not appear to be seriously hurt by coyote predation. Moles, shrews, skunks, house mice, and Norway rats seem to be avoided.

4. Large insects, particularly grasshoppers, crickets, and June beetles, are eaten as available.

5. Fruits, berries, and melons in season are eaten in quantity by at least some coyotes.

6. Sheep, pigs, and calves are killed by some coyotes but most of the livestock eaten by coyotes is in the form of carrion.

7. **Coyotes may be encouraged or even taught to kill poultry and other farm animals by farmers discarding dead animals where coyotes can find them.**

ECONOMIC CONSIDERATIONS

AMOUNT OF LOSS TO COYOTES

Many farmers, ranchers, and sportsmen condemn coyotes as being detrimental to their interests. This idea stems from the fact that at times coyotes kill livestock and game birds, and it is augmented by various fantasies that have developed around the secretive and cunning nature of coyotes. In consideration of such condemnation, various methods other than stomach analyses were employed to determine the damage actually done to Kansas livestock.

Collecting the information. Official information on the subject of coyote depredations was found to be almost nonexistent. In 1945 the Kansas secretary of agriculture, Mr. J. C. Mohler, collected data on livestock losses due to coyotes by means of the annual agricultural census (Table 5). Although total losses were listed as nearly $1.5 million, no analysis of the losses was attempted. Some evidences of predation were recorded by Sperry (11), and Fichter (13) added some cases.

During the first year of this study, farmers, ranchers, and sportsmen were questioned for specific cases of losses due to coyotes. In several instances, sizeable losses were attributed directly to coyotes, but nothing quantitative could be derived.

Boles (9) contacted every county agricultural agent in Kansas and one or two other individuals in most of the counties to get information on coyote damage. Total damage in the state as determined by this survey was estimated at $350,000. It was obvious from the replies that, although a few county agents had made some effort to gather the desired information, most of the estimates were no more than guesses.

In an effort to get the most accurate tabulation of coyote damage possible, arrangements were made through the Division of Agricultural Statistics to get data on coyote and dog damage during 1949 directly from the farmers involved via the agricultural census. Although separation was requested, most farmers failed to differentiate between coyote and dog damage and attributed all losses to coyotes. Failure of census-takers resulted in no information from one third of the townships, involving all of Greeley, Haskell, and Stanton Counties, and parts of most other counties. Only Norton, Clark, Comanche, and Wabaunsee Counties had reports from every township.

To calculate total damage, a county unit was used. Barber County, for example, has 19 townships, with 767 farm units reporting on the 1950 census. Seventeen townships, comprising 662 farms, reported $20,016 losses, or an average of $30.15 per farm. Since the townships not reporting were widely separated and the only obvious difference among townships in Barber County is size, it was assumed that the nonreporting townships had proportional losses and that the lack of data was due

Table 5.—Losses due to coyotes as reported in the Agricultural Census of 1945 and 1949. See text for explanations.

County	1945 Reported loss	1949 Reported loss	1949 Av. loss per farm[1]	1949 Calculated loss[2]
Cheyenne	$ 12,823	$ 9,465	$18.70	$ 14,800
Decatur	24,424	20,873	23.60	21,700
Graham	12,205	8,991	16.40	11,800
Norton	23,724	19,830	19.30	19,900
Rawlins	25,334	21,228	28.50	24,600
Sheridan	9,880	7,543	11.50	8,900
Sherman	11,156	1,233	6.80	4,500
Thomas	10,204	3,847	16.10	11,000
Dist. 1 total	$129,750	$ 92,920	$19.30	$124,000
Gove	5,541	5,523	15.30	9,700
Greeley	2,890			
Lane	3,715	2,332	11.70	4,900
Logan	13,066	5,232	19.00	6,400
Ness	3,084	4,801	13.80	12,200
Scott	3,140	1,664	9.50	3,800
Trego	8,292	7,486	14.40	11,100
Wallace	6,478	1,697	6.65	2,400
Wichita	2,802	468	5.10	1,800
Dist. 4 total	$ 49,008	$ 29,203	$13.20	$ 52,300
Clark	20,329	22,114	45.75	22,100
Finney	9,734	7,533	18.40	13,700
Ford	11,756	4,720	7.00	7,300
Grant	7,187	947	7.95	2,000
Gray	5,168	2,234	10.60	7,200
Hamilton	11,521	3,659	17.20	6,000
Haskell	1,367			
Hodgeman	8,401	4,553	12.60	7,600
Kearny	9,533	4,475	16.50	6,100
Meade	14,758	14,609	27.80	18,300
Morton	7,246	985	12.40	3,500
Seward	9,695	10,225	44.00	16,100
Stanton	1,595			
Stevens	7,375	2,605	9.70	4,300
Dist. 7 total	$125,665	$ 78,695	$20.40	$114,200
Clay	14,132	12,470	11.00	14,900
Cloud	12,989	13,872	11.60	15,400
Jewell	23,924	12,795	11.15	18,400
Mitchell	15,576	11,830	12.70	14,000
Osborne	20,569	14,470	21.15	21,100
Ottawa	19,279	9,828	11.80	13,100
Phillips	19,726	16,709	15.60	19,300
Republic	15,446	14,700	10.30	18,200
Rooks	20,408	15,451	19.50	18,600
Smith	15,413	6,420	8.70	11,000
Washington	13,451	18,463	11.00	21,800
Dist. 2 total	$190,913	$147,008	$12.05	$185,800
Barton	6,825	1,808	4.90	7,300
Dickinson	13,736	8,560	7.00	13,000
Ellis	12,772	10,995	16.50	17,500

1. Average loss per farm was taken as the total reported loss divided by the number of farms in the townships reporting.

2. Calculated losses for each county were determined by multiplying the average loss by the number of farms in the county,

Table 5 (continued)

County	1945 Reported loss	1949 Reported loss	1949 Av. loss per farm[1]	1949 Calculated loss[2]
Ellsworth	18,720	8,098	12.50	11,500
Lincoln	20,803	4,586	8.20	8,800
McPherson	15,858	7,246	7.30	16,600
Marion	10,107	9,966	9.50	18,200
Rice	11,609	5,514	8.35	9,900
Rush	8,654	1,775	3.55	3,600
Russell	13,305	9,837	14.20	14,100
Saline	15,082	8,070	9.00	11,700
Dist. 5 total	$147,471	$ 76,455	$ 9.25	$132,200
Barber	27,515	20,016	30.15	23,100
Comanche	12,994	13,178	32.00	13,200
Edwards	8,687	3,282	8.80	5,600
Harper	17,279	6,655	7.35	9,000
Harvey	10,994	1,615	7.00	8,900
Kingman	18,017	9,851	11.40	14,800
Kiowa	11,062	9,890	22.00	12,100
Pawnee	6,366	1,721	4.30	4,000
Pratt	8,425	3,596	5.95	5,300
Reno	16,318	8,604	10.70	24,900
Sedgwick	13,370	3,697	5.80	14,400
Stafford	10,117	2,433	8.35	8,800
Sumner	17,239	3,803	5.25	11,200
Dist. 8 total	$178,383	$ 88,341	$11.95	$155,300
Atchison	20,382	13,111	11.85	15,900
Brown	10,803	5,954	6.50	10,600
Doniphan	19,936	14,474	14.10	17,100
Jackson	17,589	10,511	9.70	16,300
Jefferson	20,095	9,658	10.40	15,400
Leavenworth	20,125	11,094	10.00	14,100
Marshall	27,056	22,713	11.60	33,700
Nemaha	22,952	13,192	9.40	16,800
Pottawatomie	25,033	19,530	14.60	22,400
Riley	17,462	13,450	15.35	15,400
Wyandotte	2,189	1,159	6.50	1,200
Dist. 3 total	$203,622	$134,846	$11.50	$178,700
Anderson	10,440	7,398	7.55	9,900
Chase	12,917	10,225	17.80	11,500
Coffey	8,973	12,403	11.25	16,800
Douglas	9,133	6,615	6.60	8,700
Franklin	13,008	10,738	10.00	16,100
Geary	16,167	8,572	17.50	9,500
Johnson	9,780	3,210	3.80	4,800
Linn	9,876	16,109	16.25	24,900
Lyon	19,480	18,880	18.00	30,500
Miami	15,106	12,113	8.45	13,400
Morris	17,625	12,356	13.55	15,000
Osage	15,359	21,598	13.65	23,300
Shawnee	10,236	5,772	8.65	9,200
Wabaunsee	24,783	18,322	14.50	18,300
Dist. 6 total	$192,883	$164,211	$11.75	$211,000

1. Average loss per farm was taken as the total reported loss divided by the number of farms in the townships reporting.

2. Calculated losses for each county were determined by multiplying the average loss by the number of farms in the county.

Table 5 (concluded)

County	1945 Reported loss	1949 Reported loss	1949 Av. loss per farm[1]	1949 Calculated loss[2]
Allen	9,157	8,872	9.20	13,300
Bourbon	14,836	10,544	7.70	13,900
Butler	22,075	21,790	15.35	28,900
Chautauqua	13,330	7,541	10.60	9,300
Cherokee	9,587	6,321	5.40	8,600
Cowley	25,443	22,914	12.70	25,200
Crawford	17,996	5,993	5.20	7,900
Elk	14,079	9,349	11.55	10,400
Greenwood	29,490	23,580	20.15	26,600
Labette	13,089	8,384	6.10	11,900
Montgomery	8,098	4,774	7.50	11,300
Neosho	9,419	6,272	6.95	10,600
Wilson	10,581	6,785	7.35	8,900
Woodson	8,800	8,940	11.25	10,200
Dist. ? total	205,980	152,059	10.00	204,000
Grand total	$1,423,675	$965,808	$12.35	$1,357,500

1. Average loss per farm was taken as the total reported loss divided by the number of farms in the townships reporting.

2. Calculated losses for each county were determined by multiplying the average loss by the number of farms in the county.

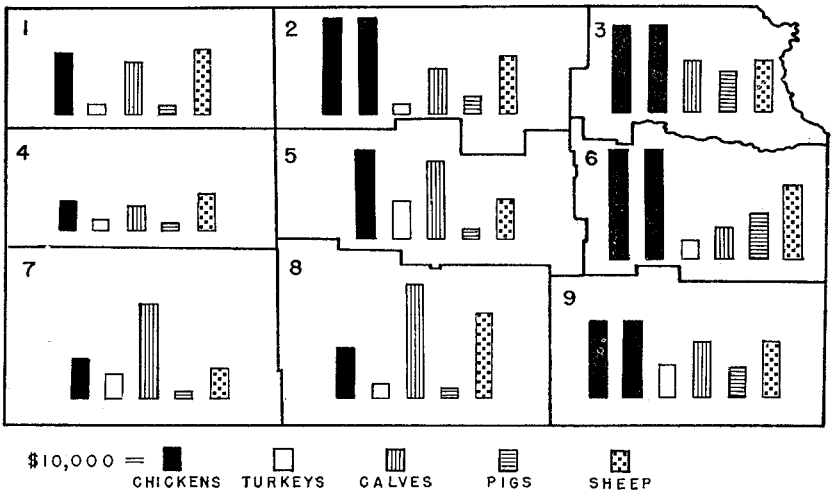
to failure of the census-taker. The average loss of $30.15 per farm was applied to the entire county, giving a calculated total loss of $23,100.

No correction was attempted for farms in a township in which some farmers reported on the coyote-dog questions, as there was no way to determine whether the question had been asked or if there was no loss to report. Also, townships or portions of townships consisting of urban areas were eliminated from the calculations. Thus, the tabulations from the agricultural census constituted approximately 75% of the calculated total, which is ultra-conservative.

Average losses per farm ranged from lows of $5.10 in Wichita County and $5.20 in Crawford County to highs of $45.75 in Clark and $44 in Seward Counties. Actually, only one third of the farms reported any losses, so the average losses for the farms reporting losses were $24.51 for Crawford, $28.25 for Wichita, $102.38 for Clark, and $123.20 for Seward. "Average" losses do not indicate extremes. Twenty-three losses of more than $800 were reported, with $2000 the highest. All the high reports were from western counties, and most of them involved calves. Several ranchers from Thomas, Clark, and Seward Counties reported losses of more than $500 in sheep. Extreme losses in the eastern counties consisted mainly of poultry. The greatest individual losses in any part of the state regularly involved the animals that constituted the major losses for the area (Fig. 8).

The results of the census and the corrections made for census failures are given in Table 5. The reported losses for 1949

were consistently lower than those reported for 1945; the calculated losses for 1949 approximated the reported losses for 1945. This would indicate that either the coyotes were not so bad or that some farmers had taken measures to reduce losses. The decreased losses and the decreased bounty payments in 1949 reflect a reduced pressure on livestock for that year.



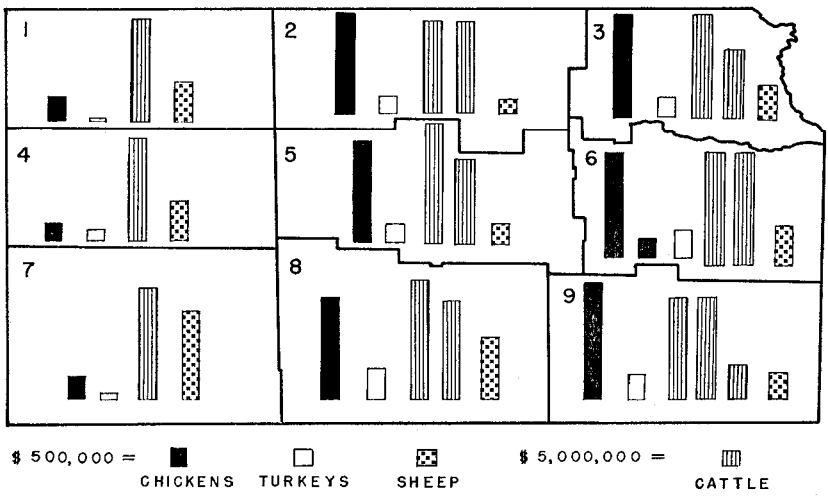


Fig. 8.—(Top) Kind and amount of losses to coyotes suffered by Kansas farmers in 1949 as determined by the Agricultural Census and follow-up questionnaires. Losses are designated by length of bars.

(Bottom) Value of chickens, turkeys, cattle, and sheep in each of the agricultural districts in Kansas, taken from the Kansas Crop and Livestock Statistics Annual Summary, 1949.

Types of losses. To learn what was lost, 2200 questionnaires were sent to individuals who reported losses of $10 or more. At least 20 questionnaires were sent into each county that had reports on the census. A few replies indicated census errors and the losses listed on the 851 returns amounted to 15% more than the total for those same individuals on the census tabulations. Replies were tabulated on the basis of agricultural districts (Table 6), and the percentage losses thus established were applied to the total calculated losses as listed in Table 5 to determine the types of losses (Fig. 8A). From this chart, comparative losses over the state are determinable. In the eastern part of the state, chickens comprised the main loss; in the western, calves. Sheep losses were greatest in the southwest and south-central (Districts 7 and 8) but were quite general throughout the state, nearly proportional to the number of lambs raised. Turkey losses were most severe in the central (District 5) part of the state, although there were considerable turkey losses in the southeast (District 9).

Losses of different kinds of livestock in the nine districts closely parallel numbers of that kind of livestock in the respective areas as reported in the 1949 Kansas Crop and Livestock Annual Summary (18) (Fig. 8B). About the same percentage of chickens was lost to coyotes in Greenwood County as in Norton, Wichita, or Clark Counties. Greenwood County suffered a greater loss of chickens than Norton County, not because the coyotes were worse, but because there were more chickens available in Greenwood County. Minor factors of management practices in various parts of the state modify slightly the proportional coyote take.

ANALYSIS OF LOSSES

Some of the ways losses occur have been learned from census data, county agent reports, and information from farmers and stockmen.

Chicken losses occur mostly during the summer when heavy vegetation (corn, sorghum, wheat, or weeds) is close enough to chicken yards that chickens regularly range into this cover. Such cover enables a coyote to lie in wait until a chicken comes within reach. In many cases catches were made day after day until the flock was noticeably reduced and measures taken to stop the losses. If two or three coyotes find cover around the same chicken yard, the losses from that yard may be 100 or more chickens a year. Losses of chickens during the winter occur principally in flocks that are not housed or are permitted to be out early in the morning. There have been few reports of coyotes entering chicken houses at night, and then only one or a few chickens were killed. Night kills are more likely to be the work of raccoon, opossum, or fox.

During the course of this study, drastic changes have occurred in the farming industry. Between 1947 and 1967, the

Table 6.—Analysis of losses reported for 1949 in the 1950 Agricultural Census on the basis of returns from 2,200 questionnaires.

Dist.	Returns	Chicken		Turkey		Calves		Pigs		Sheep		Other	
		%	Total	%	Total	%	Total	%	Total	%	Total	%	Total
1	42	29.6	$ 34,600	3.4	$ 3,980	29.2	$ 34,200	4.1	$ 4,600	33.5	$ 39,200	.2	$ 8,749
2	166	62.8	116,200	1.7	3,160	12.8	23,400	4.5	8,360	17.8	32,850	.4	745
3	103	56.9	101,000			15.5	27,500	12.	21,400	15.6	27,500		
4	48	25.5	13,500	9.2	4,860	21.	11,000	2.2	1,150	42.1	22,000		
5	96	38.3	52,000	14.8	19,600	33.	43,800	.7	930	12.8	17,000	.4	530
6	128	57.5	121,500	3.4	7,200	8.	16,900	10.7	22,600	20.	42,900	.2	420
7	57	18.6	21,230	11.8	13,500	54.7	62,500	1.1	1,260	13.1	14,900	.7	800
8	129	15.	23,200	4.6	7,150	45.1	70,000	1.5	2,330	32.6	50,800	1.2	1,870
9	82	46.1	90,700	9.7	19,100	17.5	34,500	8.9	17,500	17.	33,500	.8	1,550
Totals	851	42.4	$573,930	5.8	$ 78,550	24.0	$323,800	5.9	$ 80,130	20.8	$280,650	1.1	$ 14,664

number of farms in Kansas has been reduced from 142,000 to 92,000 and with this, the proportion of farms with flocks of chickens was reduced from 45% to 14% and the number of chickens on farms January 1 as well as the total product was reduced almost half (Fig. 9). The reduction in availability of chicken to coyotes by elimination of numerous farm flocks

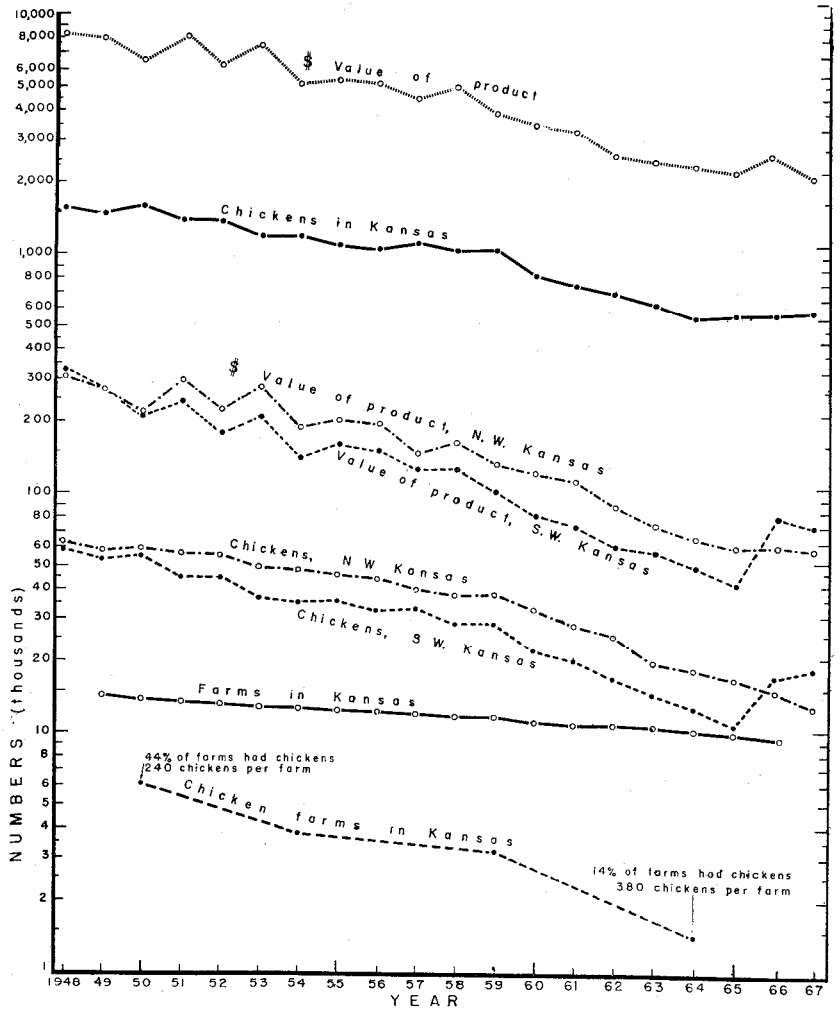


Fig. 9.—Chickens in Kansas, 1948-1957. Value of product represents the total sale value of chickens and eggs from farms. Number of chickens is the January 1 inventory for each year. Northwest Kansas is Agricultural District 1 and southwest Kansas is District 7. Number of farms with chickens was taken from the five-year Federal Agricultural Census. All other data from the annual reports of the Kansas Board of Agriculture.

showed in the reduced proportion of chicken in coyote stomachs 1950 to 1962 (Table 4). Reduction in numbers of farms with chickens and increase in number of chickens per flock have progressed at a regular rate since 1948 (Fig. 9) and there is no indication that the end of this trend is near. Fewer flocks mean availability of chickens to fewer coyotes. Increased size of flocks usually is accompanied by better care and closer penning, even to battery culture, further reducing availability of chickens. Numerous contacts with poultrymen and county agricultural agents provided information indicative of possibly half the proportionate chicken loss to coyotes in 1966 as occurred in 1949, or about one-fourth as many chickens taken. Those farmers who continue to allow chickens free range of the farm likewise continue to feed coyotes.

Special attention was given to the trends of chicken, turkey and sheep in the northwest and southwest agricultural districts (Districts 1 and 7, Fig. 8) because a high proportion of the complaints of coyote damage came from those districts. The numbers of chickens listed in the Kansas agricultural census for January 1, 1965, were 26% and 18% of those listed for January 1, 1948, for the northwest and southwest districts, respectively, but there was a sharp rise in the chicken industry in the southwest district 1965-1968 (Fig. 9) regardless of continued complaints of severe coyote predation. The rate of decrease in the chicken industry in most districts closely paralleled that of the entire state. These facts, plus numerous personal contacts, indicate that the low margin of profit on chickens, coupled with greater returns on effort and capital in other endeavors, constitutes the main reasons for reduction of farm flocks, rather than excessive losses by coyote predation.

Turkeys seem to be especially attractive to coyotes, and are liable to coyote predation any time coyotes can get at them. Contrary to coyote behavior with sheep and chickens, a coyote in a turkey pen is likely to kill several turkeys. Coyotes may climb over or dig under fences that satisfactorily restrain turkeys, so turkey pens must be protected by floodlights, steel traps, cyanide guns, or detonating mechanisms to insure safety to the flock. Predation problems, coupled with the low margin of profit and decreased man power on Kansas farms, have resulted in a disproportionate reduction in numbers of turkey farms (2,311 in 1949, 544 in 1964; Fig. 10) but the number of turkeys marketed fluctuated around 800,000 during the same period by increase of turkeys per farm from an average of 325 in 1949 to 1500 in 1964. Turkey raising in the northwest agricultural district held up fairly well until 1959, but dropped to 1000 birds marketed in 1966. On the contrary, the southwest district showed a slight increase 1957-60, then tripled production in 1961 and has maintained production over 120,000 since. According to records available, coyotes are no worse in

one district than in the other, but other factors—economic and environmental—have made possible this great increase in turkey raising in southwest Kansas, in spite of coyotes. With the present trend toward fewer, larger, better protected turkey flocks, predatory losses have been and will continue to be reduced, until they are of no consequence to the state as a whole, only to some of the 500 turkey raisers.

There is no question but that lambs constitute a favored food of coyotes, and coyotes will take lambs whenever they are available. Success in raising lambs in Kansas, then, depends on careful penning practices coupled with specific coyote con-

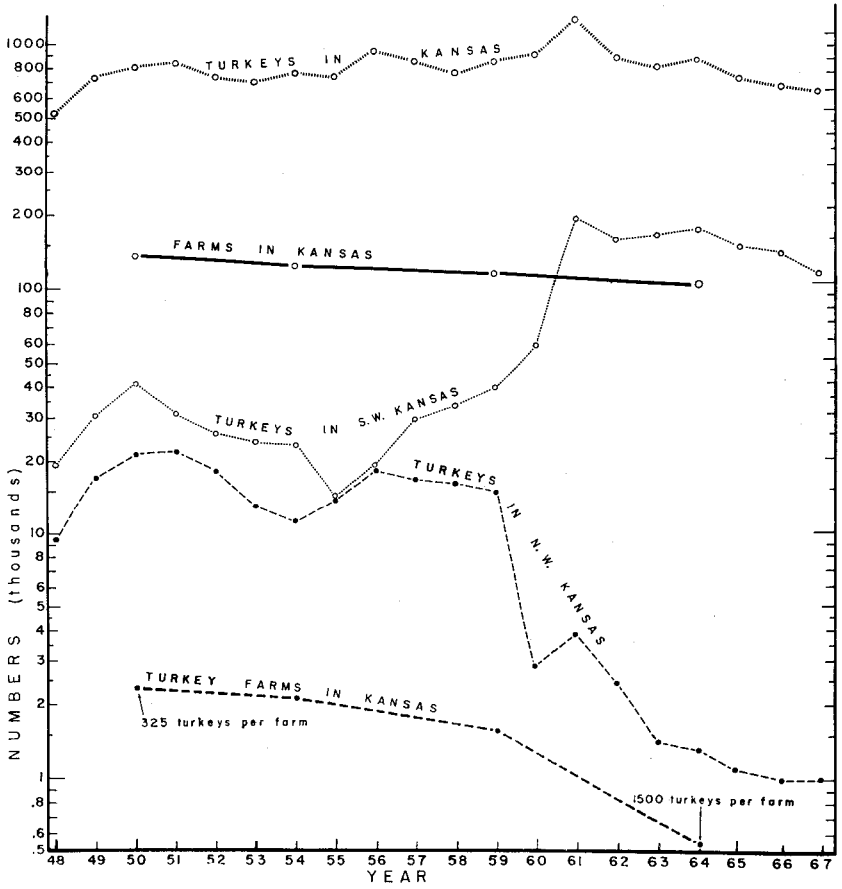


Fig. 10.—Turkeys in Kansas, 1948-1957, as given by the annual reports of the Kansas Board of Agriculture for number and value of turkeys produced and sold in the state and in the northwest and southwest agricultural districts. Number of farms with turkeys was taken from the five-year Federal Agricultural Census.

trol. Many operators keep ewes with lambs continuously in fenced lots with floodlights at night and steel traps, cyanide guns, or carbide cannons set around the pen. Others practice more aggressive control, and let the ewes with lambs out in the pastures after 8:00 in the morning. Even with these precautions some losses may occur. Older sheep cannot be listed among the favored food of coyotes, but some coyotes develop sheep-killing technics that provide them with a fairly steady diet of mutton.

Reported losses of sheep to coyotes (Table 6) were highest in Cloud County where approximately 3% of the entire evaluation of sheep was lost during the year. The losses were primarily lambs, during May and June, when coyotes were providing food for young in the dens. In some cases, lambs were taken during the day while they followed their mothers in brushy pastures, but more frequently they were taken from unguarded pens at night. Some coyotes learn to lie in wait for the lambs to be turned to pasture early in the morning, but will rarely persist later than eight o'clock.

Although coyotes may kill sheep in many different ways, the descriptions most often repeated by Kansas sheep growers indicate the following pattern. Sheep killing by coyotes probably begins with the taking of lambs, which may be accomplished by the coyote overrunning the lamb and grabbing it directly by the head. This method probably is continued until the lambs become too heavy to be carried and the skull is too hard for easy penetration. When the lamb gets too big for the "head-puncturing" technic, the coyote changes its tactics, then running alongside the intended victim and lunging at the throat, which usually results in a deep gash and a cleanly severed jugular vein. Some coyotes seem to prefer to catch the victim in the shoulder, throwing it on its back, and slicing its throat from below. Rarely is there evidence that a coyote bites into the flank, back, or rump the way dogs do. Few cases were reported of a coyote killing more than two sheep in a flock at one sortie. A sheep-killing coyote, however, often returns to the same flock for repeated kills.

In contrast to the pattern generally followed by sheep-killing coyotes, dogs are more liable to take up sheep-killing as a sport, destroying several sheep at one foray. Dogs frequently run in packs, ranging several miles from home for their "fun," and limiting their sheep-killing activities to the hours of darkness. In making the kill, dogs catch wherever they can and frequently tear the body in several places. However, none of these criteria is absolute and in some cases it is impossible to determine by the remains whether coyotes or dogs did the damage. From information accumulated, it appears that many serious losses sustained by sheep raisers were from dogs rather than coyotes. However, many sheep losses are definitely due

to coyotes. Total losses of sheep calculated from the 1950 census were more than $350,000. This is a small item in the farm budget only by comparison with the $15,680,000 income of the industry for that year (1949 Kansas Crop and Livestock Statistics).

Data obtained from the annual reports of the Kansas State Board of Agriculture provide some interesting sidelights to the problems of sheep and coyote predation. The number of Kansas farms with sheep dropped from 7208 in 1950 to 6800 in 1959 to 5280 in 1964 while the total number of farms was reduced from 145,000 to 100,000 in the same period, or the reduction of sheep farms was considerably less than the reduction of other farms (Fig. 11).

A comparison of the sheep industry in Kansas with that in Colorado, where coyote control is intensively practiced, and in Missouri, where there is a high bounty and specific control of

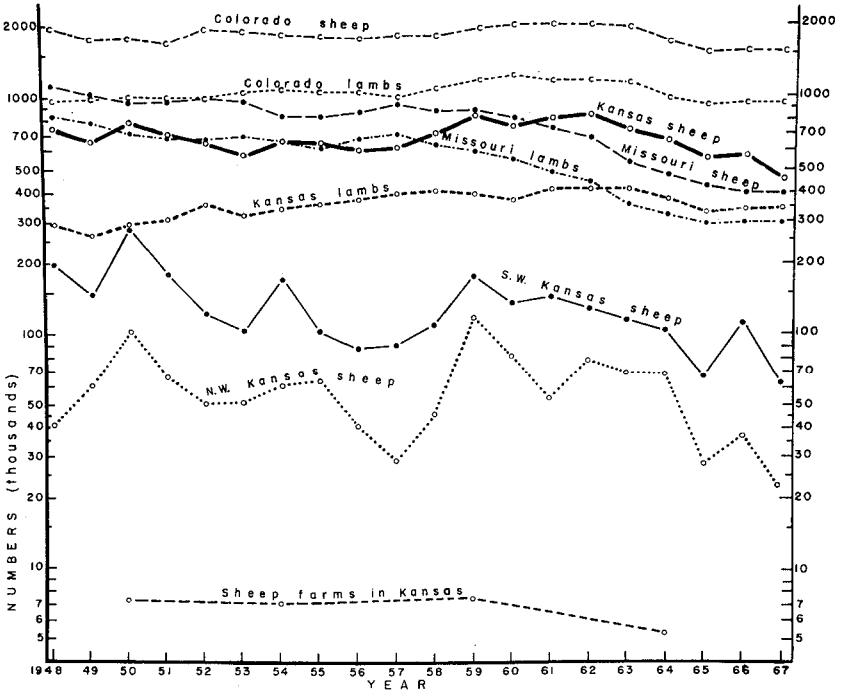


Fig. 11.—Sheep and lambs in Kansas, Colorado, and Missouri, representing respectively a state with basically no coyote control, one with intensive control, and one with high bounty and functional extension trapper system. Numbers of sheep graphed represent the January 1 inventory, and the number of lambs is the total sold before, or on farms, June 1 of the given year. No correlation could be found between coyote control system and the trend in sheep industry. All data provided by Kansas Crop and Livestock Reporting Service, Topeka.

killer coyotes (Fig. 11), shows no correlation with coyote control methods.

The total number of sheep reported on the January 1 inventory, 1948-1967, fluctuated around 800,000, then fell to 450,000 by 1967 (Fig. 11). In the same period, sheep in Colorado were maintained slightly under 2,000,000 until 1964, then dropped to 1,500,000. Sheep in Missouri, meantime, were reduced from over 1,000,000 to 400,000, with the drop continuous after 1960. Similarly, the lamb crop in Kansas has remained constant at 300,000 to 400,000 animals marketed before, or maintained until June 1. The Colorado lamb crop was maintained at almost twice the level of the Kansas crop, with only a 20% variation from 1,000,000. The Missouri lamb crop, on the contrary, has been reduced irregularly from over 800,000 to less than 300,000. The peak production of lambs in Colorado and Kansas occurred 1958-64, at which time the coyote population in Kansas was increasing rapidly (Fig. 11).

Sheep raising is rather spotted in Kansas, being most intensive in the western part of the state, with local concentrations in the Flint Hills (Fig. 8) and other scattered areas. The sheep industry in Kansas has three distinct phases: (1) wool, a by-product of those animals that are maintained through the winter, (2) lamb crop, which is closely correlated with the January 1 inventory and specifically designated in the agricultural census reports as marketed before or surviving on June 1, and (3) contract feeders, brought into the state primarily to take advantage of the abundant wheat pasture, for which there is no consistent record. For the purpose of this study, we are limited to the January inventory and the lamb crop records.

A sizeable portion of the Kansas sheep industry consists of contract pasturing of sheep, both in fall and in spring, on wheat fields, particularly in western Kansas. Most of those sheep are shipped in from the Rocky Mountain states, from Montana to Arizona, for one to five months pasture. Most of this group does not show on Figure 11, because they are not owned by the Kansas ranchers, or are not in the state on January 1. This segment of the industry has closely paralleled the total sheep industry, with a reduction from 422,000 in 1963 to 170,000 in 1966. Reported losses in this segment of the industry have been considerable in some instances and indicate activities of a few "killer" coyotes.

Only the January 1 inventory was available for the various districts of Kansas. Fluctuations in inventory were greater in the northwest and southwest agricultural districts, but maintained the same trend as the state (Fig. 11). It is interesting, but not necessarily significant, that in both districts, minimal inventories were maintained 1956-58 at which time the most intensive coyote control in history was practiced in much of

the southwest and part of the northwest district, and the coyote population in Kansas was at the lowest level in 15 years.

No attempt has been made to determine state-wide losses of sheep since 1949, but the same kinds of reports continue to come in. A few sheep growers reported severe losses (up to 10% of their lambs) to the extent that they have abandoned the effort. Others reported moderate losses, while some have had no such losses. Reports of losses fluctuate in proportion to the population density of coyotes and inversely to rabbit-rodent populations, although some coyotes continue to take lambs even when other food is plentiful.

Beyond doubt, predation is an important factor in the success or failure of ventures in raising sheep, turkeys, or chickens, but all evidence points to the conclusion that raising these animals is a matter of personal preference, and market for the product constitutes the greatest factor in the maintenance of flocks. Closer coyote control with resultant reduced predation might result in survival of some marginal operations, and would increase the profits of some of those operators who are currently successful. Serious consideration must be given also to increasing predation by dogs, bobcats, and foxes.

Calves. Loss of calves to coyotes, the survey indicated, was more than $400,000. This is 0.09% of the value of cattle in the state or 0.17% of the cattle sold during the year. The average value of calves lost was given as $50, so about 8,000 calves were presumed lost to coyotes during the year. During that same year 1,347,000 calves were reported to have been born in Kansas, of which 78,000 died before they were six months old. If the same proportions held for 1967, of the 2,200,000 calves born, about 125,000 would have died from all causes, and about 12,000 could have been taken by coyotes. In reality, at least half of the reported coyote kills that have been checked were cases of death by other causes, with coyotes, or dogs, coming in later and devouring part of the carcass.

Several ranchers emphasized that they had never known of a calf being killed by coyotes. Others told of coyotes following the herd and feeding on "afterbirth" and possibly devouring calves born dead. Still other ranchers described in some detail how the coyotes that develop a taste for "afterbirth" become bolder as they gain experience, at times actually pulling the calf from the cow, or attacking and killing the calf before it gains enough strength to resist. Other cases have been reported of coyotes keeping the cow on the move, never letting her stop to give birth until the calf was dead. Others described attacks by a small number of coyotes, which may be successfully warded off by a healthy mother—with horns. Several recent reports indicate that some calves may become so frightened by the attack that they "freeze" and are literally eaten alive. Still others have described what appears to be more sport than

food-getting: a single coyote may chase a calf, nipping its heels or grabbing for its tail, frequently resulting in a bob-tailed calf, but a lucky strike by the coyote may so incapacitate the calf that it can no longer run, so it becomes another casualty. The only information obtained on coyotes killing cattle more than a few months old was a few reports of cows being attacked while calving.

Possibly more important than the circumstantial evidences of calf-killing by coyotes is the recent documentation by the Kansas Livestock Breeders Association that up to 40% of the first-calving heifers require human aid to successfully give birth to a living calf. Too many of the reports against coyotes involve first-calving heifers—on the range, which under the circumstances consists of poor husbandry, and most of the calves that are lost would have died without coyote interference.

Thus, the new-born calf and the cow at calving time are particularly vulnerable to coyote predation when they are left on the range with no protection. Calves up to a month old that became separated from their mothers have been reportedly killed by coyotes in several parts of the state, particularly during periods when much of the coyote food is covered by ice or snow.

Another phase of coyote damage to cattle has been ignored. Several reports have come to my attention of coyotes stampeding herds, which then may break down fences, injuring one or more animals. In one case on record, a herd of Angus yearlings stampeded, broke out onto the highway, and seven of them were killed by one truck. Of course, these were not primarily coyote kills, but they add to the total damage.

The economics of coyotes in the cattle industry is still confused. The man who loses a calf to predation considers this to be an unnecessary loss, and in many cases declares all-out war on the coyotes. On the other hand, even the **reported** loss to coyotes is an insignificant amount with regard to the $700,000,000 worth of beef produced in Kansas each year, and accounts at most for possibly 5% of the deaths of calves in the state, or 0.5% of the calves born in the state. The cost of reducing those losses significantly may be greater than the losses themselves, although much can be saved by specific "killer-coyote" control (see section on "Coyote Control").

Other animals. Some pigs were reported taken by coyotes in the eastern part of the state, but these losses seem never to be severe. A number of reports have been received of coyotes jumping over or digging under fences around the pig pens and carrying off pigs up to a few weeks old. It seems from the reports that a 4-foot fence provides reasonable protection, but a 3-foot fence does not. Ducks and geese seem to be special delicacies for coyotes, and a few new-born colts were reported

killed by coyotes. Monetary losses, although of considerable importance to the farmers involved, are not serious to the state's economy because so few of these animals are involved.

Numbers vs. losses. There is a common idea that losses due to coyotes are closely correlated with numbers of coyotes: that is, the more coyotes the more losses. Few facts are available to substantiate or refute this idea. Nagel (19) reported no relationship between number of coyotes bountied in an area and complaints of losses. Some correlations may be drawn by tabulating bounty payments and losses from the same counties (Table 7). Clark County, for example, reported a slight increase in losses from 1945 to 1949, although the bounties dropped 40%. Lyon County losses increased more than 50% while bounties paid decreased 24%. On the other hand, losses in Wilson County decreased while bounties increased 66%. Unfortunately, the 1945 and 1950 census were not analyzed on the same basis, and the conditions controlling hunting were not comparable, so correlations or lack thereof between bounties and losses cannot be made on the available data.

During the 20 years since this study began, however, there has been a surprising correlation between the overall bounty payment in Kansas and the number of complaints of damage. Complaints were high in 1948-50, and again in 1964-66, when bounty payments were highest. Conversely, during the low bounty-payment period of 1953-60, there were extremely few complaints, to the extent that organized coyote control and bounty payments were progressively discontinued in many counties (see section on "Control of Coyotes").

Utilization of domestic animals by coyotes as a source of food is indeterminate. It is established that some individual coyotes draw regularly on poultry, and a few become persistent sheep-killers. Whether any coyotes depend entirely on domestic animals is not known. The proportion of coyotes that occasionally take chickens or lambs is likewise not known.

Table 7.—Bounties paid and losses reported for a typical county in each agricultural district. The losses for 1945 and 1949 were obtained by the Agricultural Census; those for 1948 were obtained from estimates by county agents.

	1945		1948		1949	
County	Loss	Bounties	Loss	Bounties	Loss	Bounties
Clark	$20,329	373	Heavy	278	$22,100	224
Comanche	12,994	426	Moderate	379	13,200	353
Decatur	24,424	765	Heavy	364	21,700	412
Logan	13,066	231	Moderate	173	6,400	206
Lyon	19,480	532	Light	414	30,500	403
Marshall	27,056	616	Moderate	581	33,700	409
Mitchell	15,576	406	Moderate	356	14,000	299
Russell	13,300	636	Heavy	348	14,100	366
Wilson	10,581	189	Light	342	9,000	314

Some poultrymen insist that a large proportion of Kansas coyotes take chickens during May and June. Available evidence indicates that whenever coyote populations are high while rabbit-rodent populations are low, the loss of chickens is high. As shown later, the average breeding population of coyotes in Kansas is about 40,000. Each adult animal, not considering pups, requires 1.5 pounds of meat each day or 45 pounds a month. If 7% (the winter average) of the total coyote food in April were chickens, then 140,000 pounds of chicken would be consumed during the month. Feeding pups would possibly double the consumption in June and July. Comparable takes from April through October would account for most of the $600,000 loss calculated for 1949.

During the past 14 years, a "Wildlife Extension Specialist" (George Halazon) carefully checked many cases of reported coyote damage on the spot within a few days of the report. Repeatedly, he found that blame to coyotes connected with the death of calves or sheep was only circumstantial at best. In many instances he seriously doubted that coyotes were in any way instrumental in killing the animals—but were blamed because they came in and fed on the carcasses. There are undoubtedly cases of coyotes killing sheep and calves, but our conclusions are that considerably less than half of the reported losses due to coyotes resulted from coyote activities.

The trend in poultry raising over the past decade has been away from small farm flocks and to large commercial flocks, maintained strictly inside buildings, on wire floors. This trend has been of such extreme nature in Kansas that in some areas as many as 80% of the farm flocks have disappeared (Figs. 9, 10). With removal of a formerly staple food, Kansas coyotes have been forced to search more diligently for rodents. The change was particularly evident in the change in stomach contents from 1954 to 1962.

Summation of damage. On the negative side, Kansas coyotes may (according to the 1950 agricultural census) be charged annually with some $500,000 worth of chickens, $400,000 of calves, $300,000 of lambs, and $150,000 worth of other poultry and livestock. In addition there are special management costs made necessary to keep real losses from being higher. These costs include such items as extra guards for sheep, keeping sheep and poultry penned late in the mornings, special fencing, and even cost of trapping. Coyotes also destroy game animals, but there is no evidence that coyotes are more than moderately detrimental to Kansas game birds or fur bearers, and rabbits are of questionable or negative value.

Detrimental effects of coyote predation are still not clear. There are those who regard accumulated data, such as the 1950 agricultural census, as worthless, and substitute personal observations indicating much less damage. Others are just as

certain the census data do not tell the whole story, and the coyote is much worse than depicted. The truth undoubtedly lies between, and the evidence at hand indicates that the 1950 census gives a somewhat high estimate for losses in 1949, and that losses to coyotes since 1952 definitely have been lower than they were from 1944 to 1952. With coyote populations drastically reduced from 1954 to 1959, there were few reports of more than an isolated calf, lamb, or chicken loss, but with increased numbers from 1959 to 1964, complaints were somewhat more numerous, but not reaching the 1949-50 level.

Rabbit control. Rabbits are the staple food item of Kansas coyotes the year around, and are replaced by other foods only when rabbits are unavailable in adequate numbers. When rabbits are scarce, coyotes hunt them intensely, even close to farm dwellings. Under average conditions each coyote requires approximately 300 pounds (140 cottontails) of rabbit meat a year or one rabbit from each 14 acres of his range. When rabbits are plentiful many more are killed, and when scarce, fewer are taken. There is no Kansas record of high populations of rabbits occurring simultaneously with plentiful coyotes. Although jackrabbits have shown cycles of approximately 7 years[4] during the past half century, the peaks in 1939 and 1947 were low, while the coyote population was high. The extremely high jackrabbit populations in 1935 and in 1956 accompanied low periods in the coyote cycles.

Vorhies (24) estimated that 15 jackrabbits require as much forage as a sheep and 74 as much as a mature cow. With rabbits thus in competition with cattle for grass, and the present price of pasturing a 2-year-old steer in the Flint Hills being $25 per season, it follows that it costs about 30 cents to pasture a jackrabbit through the summer, and at least as much more the remainder of the year. Two cottontails require approximately the same forage as a jackrabbit, to say nothing of their damage to shrubs and fruit trees.

An average coyote in an average year saves a farmer about $12 worth of grass by removal of rabbits. Add to that an average 1000 mice per year at 2 cents each, and the rabbit-rodent removal value of an average coyote is $32 per year. In high infestation years, when the average coyote takes twice the average number of rabbits or rodents, his value is comparably greater.

The value of coyotes as game animals must not be overlooked. Although the fur is presently worthless, thousands of Kansas

4. Although there has been no formal data maintained on the cycles of jackrabbits and cottontails in Kansas, personal memories bolstered particularly by pointers from Dr. L. D. Wooster of Hays and Leo Brown of Ashland place peaks in jackrabbit populations at: 1914-16, 1919-20, 1924-27, 1932-35, 1939-40, 1947-48, and 1955-56. A detailed study of jackrabbit biology, including some data on populations, was published by Tiemeier (23). Cottontail peaks are not so clear, but there were definitely higher populations in 1949, 1953 and 1956 than in intervening years in the Manhattan area.

men and women derive a large part of their winter sport by hunting coyotes. An attempt was made in 1950 to determine the number of dog packs that are kept in the state specifically for hunting coyotes. Although an accurate number could not be determined, and the number fluctuates, there are between 400 and 800 packs of coyote hounds, averaging five hounds per pack in the state.

Regularly, two to five **families** participate in hunts with each pack, many of the hunts being family or neighborhood affairs, with men, women, and children alike enjoying the chase. Many persons consider a coyote chase the ultimate in sport. Others derive considerable enjoyment and recreation from coyote hunting in various forms: individual shooting, chasing with horses, or in community "round-up" hunts. Much hunting is done under the guise of "coyote control" but is nevertheless purely recreational.

Aesthetic value. Besides the values of coyotes in rodent and rabbit control and as a game animal, some people are sentimental enough to like the coyote for his daring, cunning, and shyness. They like his gracefulness, his seemingly endless enthusiasm for life, and his nightly yipping. To this group of people, the coyote is as important a part of Western wildlife as is the antelope, deer, or black bear, and many feel strongly against wanton destruction of coyotes.

BENEFITS FROM COYOTES

Kansas coyotes have less tangible, but at times great values. These values consist mainly of (1) removal of excess rabbits and rodents, (2) their fitness as game animals, and (3) aesthetic value to biologists and nature lovers.

Rodent control. In the chapter on food habits, rodents were shown to comprise 3 to 20% (average 8%) of the winter food of Kansas coyotes. Available evidence indicates a similar or even increased utilization of rodents throughout the summer and fall. Although white-footed mice (**Peromyscus**), harvest mice (**Reithrodontomys**), and pocket mice (**Perognathous**) are of relatively little economic importance, meadow mice (**Microtus**) and cotton rats (**Sigmodon**) are highly detrimental to hay, pasture, and stored forage crops. **Microtus** and **Sigmodon** are both preferred coyote foods and are hunted intensively, with many coyotes eating little else when these rodents are available. According to Eadie (20), each meadow mouse in a pasture or hay meadow eats approximately its own weight of grass each day and so destroys as much as 25 pounds of grass plus winter damage to shrubs, trees, and stored grain. With 50 mice per acre, the total loss may be considerable. During periods of low **Microtus** populations, there may be an average of only two mice per acre, with insignificant losses, but every mouse taken reduces the breeding potential and post-

pones the inevitable increase. **Sigmodon,** averaging three times the size of **Microtus,** are relatively more destructive to grass, do more damage to trees and shrubs, and destroy sod by excessive burrows and mounds. There is little information on populations, but trapping data (16, 21) indicated local concentrations of more than 50 cotton rats per acre in many areas in eastern Kansas during the peaks in 1952, 1956, and 1958.

Errington (22) has shown that, at least where muskrats are concerned, removal of prey animals may be partially compensated by increased reproduction and partially offset by reduced population losses from other causes. If this principle is applicable to meadow mice, those taken by coyotes cannot be considered on a value-per-mouse basis. However, a coyote in an area with a high mouse population may average 16 **Microtus** or five **Sigmodon** per day over long periods, thus accounting for up to 5850 **Microtus** or 1800 **Sigmodon** per year. The average annual consumption is possibly 1000 **Microtus** and 300 **Sigmodon** in areas where these rodents are available. Probably the greatest value arises from the intensive hunting of mice during late winter, thus positively reducing the breeding population. Possibly the removal of these rodents is partially compensated by increased reproduction of the ones left, but the highest concentration of **Microtus** and **Sigmodon** has been observed in areas fairly well protected from coyotes. When **Microtus** and **Sigmodon** populations are low, coyotes hunt for them, even to extensive digging of burrows.

Gophers, ground squirrels, pack rats, and prairie dogs are taken in some numbers by coyotes; but the habits of these animals make them relatively inaccessible to coyotes.

REPRODUCTION AND GROWTH

During this study, the reproductive tracts from 1064 male and 995 female coyotes were removed for examination. From these tracts could be determined the time and success of breeding. Results supported and extended the previous study of Hamlett (25). Details of reproduction were established in the laboratory with coyotes and dogs and will be published separately.

Breeding season of the male coyote corresponds to that of the female but is a little longer. Old males are capable of mating by early January and continue in breeding condition until early March; young males can breed from late January to mid-March. Only 15 male coyotes were found during the breeding season that, by the condition of the testes, could be considered to be nonbreeders.

Pregnant female coyotes were encountered from early February to May. By determining the age of a set of embryos, the time of breeding could be estimated within a few days (Fig. 12), and the breeding pattern for any one year established. The earliest ovulation time among pregnant coyotes examined was February 2, and the latest was March 26. The range of breeding times varied from year to year, but no factor responsible for this variation was found.

Development of coyote and dog embryos differs in no real way. Ovulation occurs about 3 days before the end of estrus.

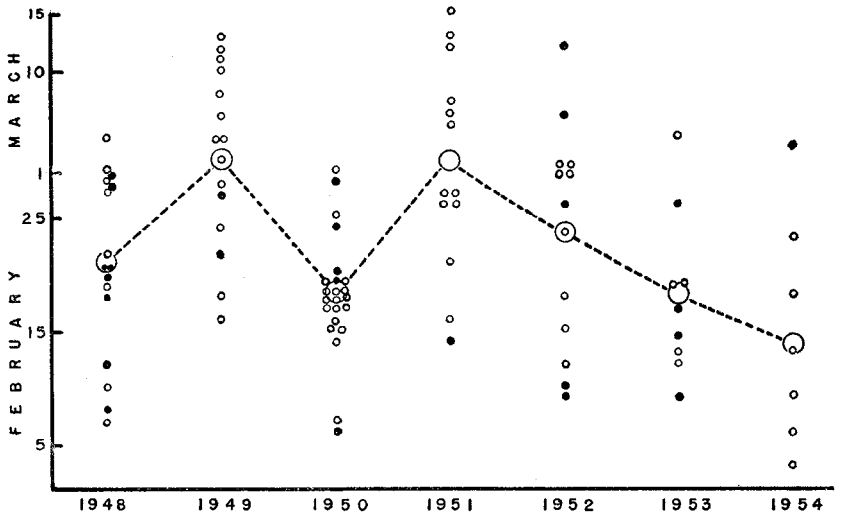


Fig. 12.—Ovulation time of coyotes. Each black dot represents one female coyote taken within four days after ovulation; each circle represents the ovulation time of a pregnant bitch determined by embryonic measurements. The large circles connected by the broken line represent average ovulation time and show the annual fluctuation. "Heat" in the coyote lasts 10 to 30 days and ends about three days after ovulation.

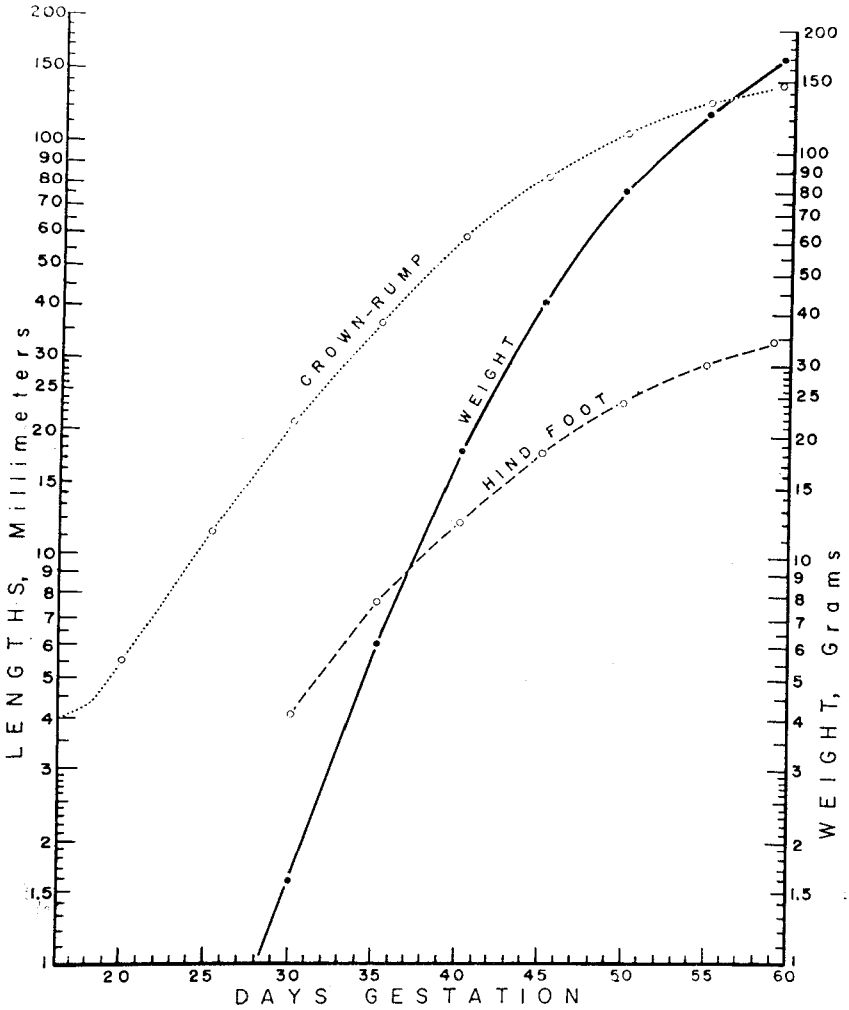


Fig. 13.—Growth of embryos from first measurable condition to birth. Six sets of coyotes of known age (18, 35, 40, 55, 58 and 60 days gestation) were recovered and measured. In addition, over 60 sets of known age dog embryos were recovered and measured. After 40 days gestation embryos from dog bitches weighing 25 to 35 pounds tended to be slightly heavier than coyote embryos of the same age. Otherwise, there was no difference between dog and coyote embryos. The graphs were drawn from combined dog and coyote measurements, the weight curve adjusted downward by 25 grams at parturition, to match the 58- and 60-day coyote fetuses, then translated to the chart reproduced here with dots at five-day intervals rather than including the 250+ dots from the original graph. The first-formed embryo (neural plate—early somite stage) occurs at 16 days. The hind foot is differentiated on the limb bud at 27-28 days, and the embryo exceeds 1 gram weight at 28-29 days. Parturition occurs at 59-60 days after ovulation, or 56-57 days after the end of receptive heat.

Fertilization occurs within a few hours; the first cleavage is completed early in the third day. The embryos reach the uterus during the fifth or sixth day. A trophocoel appears during the ninth day; the trophocyst expands to 1 mm. diameter by the end of the tenth day, 2.5 mm. during the thirteenth day when the **zona pellucida** is broken and the embryonic vesicle expands to 4 x 5 mm. by mid-day 14. Then embryonic swellings are visible on the uterus. Endoderm is differentiated during day 11 and the endodermal vesicle is complete by the end of day 13. Mesoderm is first detectable in properly prepared material late in day 12, becomes continuous within the blastocoel by late day 15 and the first mesodermal somites form by mid-day 16. Neural plate is established early in day 16, neural tube formed and parts of the brain differentiated by the end of day 17. The heart begins to beat early in day 17. Placentation begins with the fusion of trophoderm and uterine epithelium early in day 16, amnion is complete during day 19, allantois appears on day 19, a chorioallantoic placenta has its beginning on day 22; the placenta is complete on day 30. The length of the embryo, from the anteriormost surface of the head to the posterior limit of the body (crown-rump measurement), is first determinable at 17 days, and serves as the main criterion for age determination of the embryo and fetus (Fig. 13). Weight of the embryo increases from a few milligrams at 16 days to one gram at about 28 days, to 175-200 grams at birth (Fig. 13). Limb buds appear during day 21, ankle and knee joints are formed by day 28, toes are distinct by day 30, and claws by day 38. After the foot is differentiated, length from the heel to the tip of the longest toes on the hind foot serves as an excellent criterion for age determination (Fig. 13).

Size of litters was determined by examination of the uterus. Whenever an embryo is attached to the uterus, a pigmented band, which remains distinct for at least two years, is formed in the wall of the uterus (Fig. 14). Any coyote uterus examined between whelping time and the next breeding season shows how many pups were produced and how many were lost before "scars" were established (Table 8). The range in numbers of "placental scars" was 2 to 12. The number of pups removed from dens compared favorably with the number determined from counts of placental scars. Wooster (26) found that 28 litters taken in Ellis County in 1932 averaged 6.14 pups each and ranged from 3 to 12 in a litter. A check of litter size, from men submitting pups for bounty in Greenwood County in 1950, showed a range of 3 to 10 and an average of 5.9. Similar information on 43 litters in Greenwood, Morris, Washington, and Riley Counties in 1954 showed an average of 5.6, with the same range of litter size as in 1950. The presence of two litters in one den in several instances indicates that den "litter" sizes are somewhat higher than true litter size.

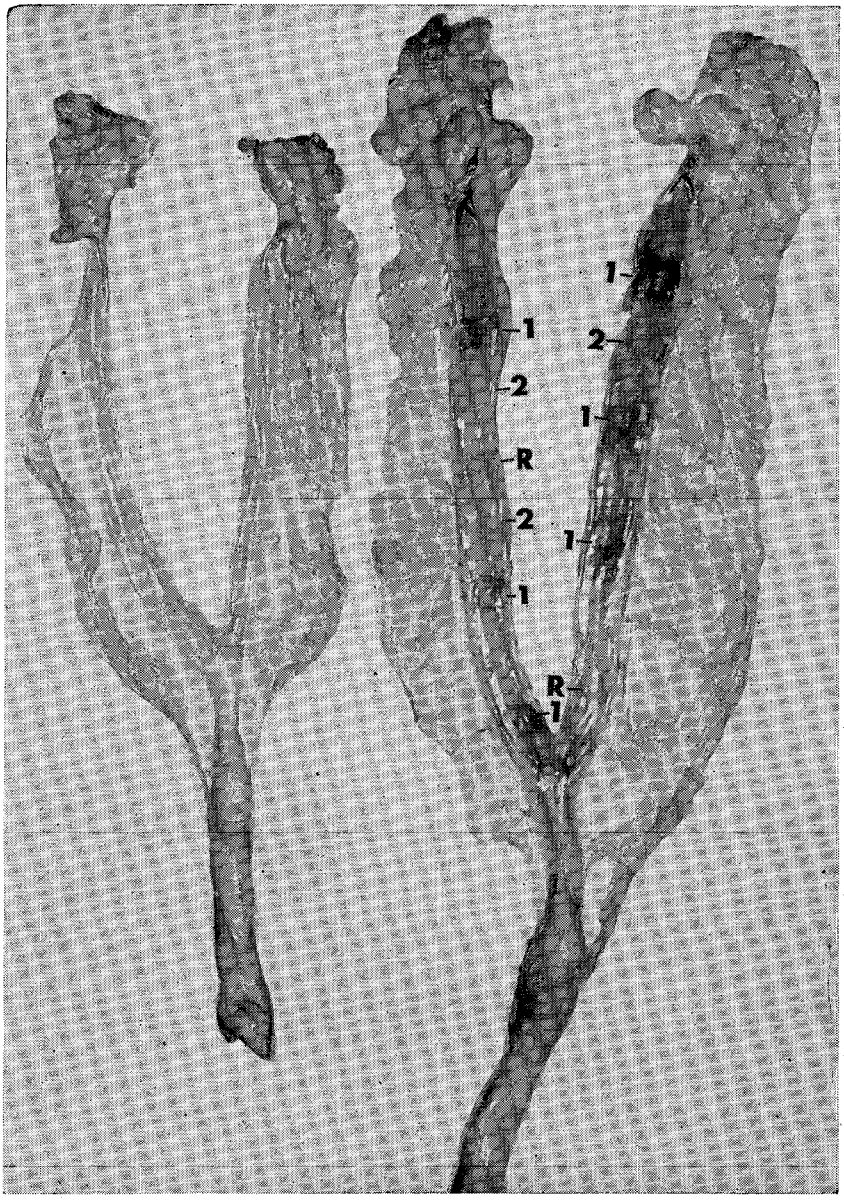


Fig. 14.—Reproductive tracts of two female coyotes with the uterine horns open. The tract of a yearling (left) shows no marks on the lining. The multiparous tract, on the right, shows six full-term scars (1), two resorption scars (R), and at least three two-year scars (2). These uteri were removed the same day, opened, spread, and photographed together while fresh.

Table 8.—Numbers of placental scars and corpora rubra in 23 individual coyotes taken in January and February, 1951, to show correlation of corpora rubra with full-term scars, resorption scars, and two-year scars.

	Placental scars in uterus			Corpora rubra in ovaries	
	One-year				
	Term	Resorption	Two-year	One-year	Two-year
	0	3	6	6	
	8	1	6	9	7
	7			7	
	7	2		7	
	9			10	
	7	1		6	
	6		8	10	
	6			6	
	12	1	12	14	13
	3	2		9	
	3	4		9	
	8			12	
	8		6	8	6
	9	1	5	9	8
	7			8	
	6	1		7	
	6	1		7	
	7		2	9	8
	8	1		10	
	8		4	10	5
	2	5	3	8	7
	0	6		6	
	5	2		9	
Total	142	31	46	196	62
Average	6.15	1.34	5.7	8.4	8.05

Reproductive capacity. Capabilities of coyotes for reproduction have been seriously underestimated on the basis of data provided by Seton (1). On the basis of examination of the testes of over 1000 adult male coyotes for sperm, males over a year old begin active spermatogenesis in November, have mature sperm in the epididymis by late December or early January and are capable of breeding by mid-January. Active breeding capacity is maintained for approximately two months, then the testes become inactive and greatly reduced in size. Males of the year reach breeding condition about the first week in February. So far as could be determined, all male coyotes are capable of siring pups, barring serious disease or accident. Getting a mate apparently depends on the vigor and durability of the male to cope with the competition for the lesser number of breeding females.

Seton (1) and Hamlett (25) considered that breeding females were all two years or more old, and that yearlings are not capable of successful breeding. Of the 922 female coyotes examined in this study, 81% (69 to 86% variation between years) of the females two years and older were either pregnant at the time, or had produced young. During 1948-1951 and 1958-

1963 at least 50% of the short-yearling females were in breeding condition or the ovaries were active with growing follicles when the animals were killed in January or February. Of the short two-year-old females taken during those same years, 60 to 70% had placental scars, evidence of having produced litters at the time they were approximately 12 months old. During 1952-1957, however, less than 10% of the yearlings reproduced. No appreciable difference was detectable in numbers of ova produced or pups produced by the reproducing yearling females and the older animals. Neither could a difference be found between the females in the prime reproductive age (2 to 5 years) and those few females that survived beyond 5 years.

Considering the average of 40% of all the females in the breeding population to be yearlings (35 to 45% variations between years) the potential may be calculated. In a good reproductive year, then, 83% of the 60% (50 per 100) old females produce pups and 65% of the 40% (26 per 100) young females would produce, or 75 of each 100 females in the population produce pups. Under the same good conditions, the average litter could be 6.4; thus each 100 females would produce 450 pups. If conditions remain good, a high proportion of those

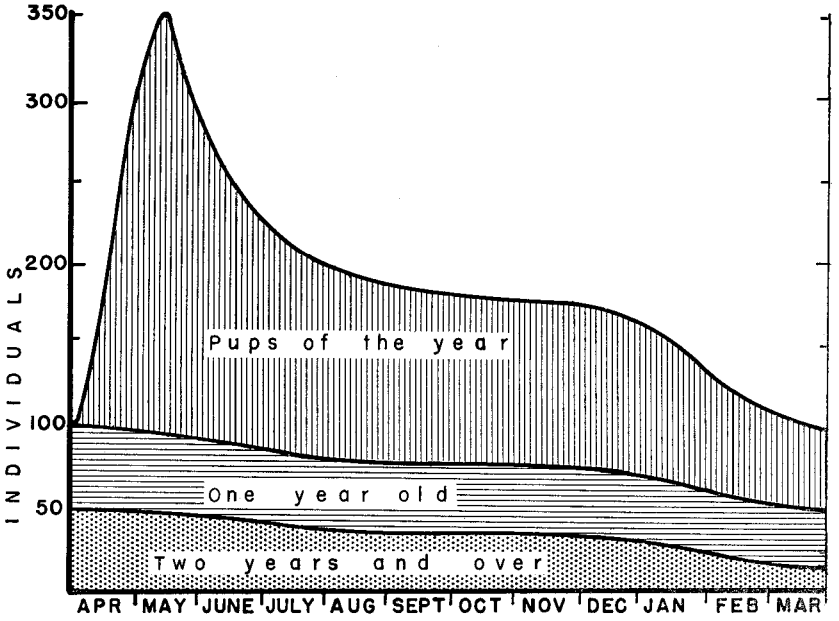


Fig. 15.—Population fluctuation throughout a typical year. April 1, approximately 50% of the population is composed of yearlings. Each 100 individuals (50 pairs) will produce an average of 250 young by mid-May. Decrease is rapid through May, June and July, then stabilizes until the winter hunting season. By the next March, again approximately half of the coyotes are yearlings.

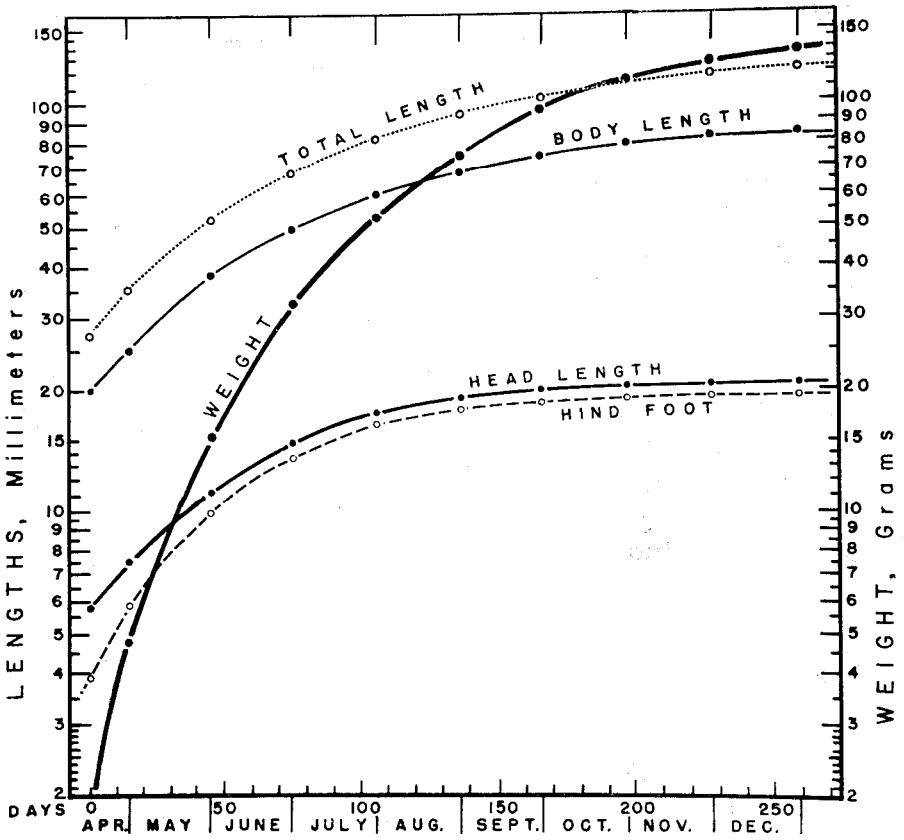


Fig. 16.—Growth of coyotes from birth to maturity. Two to 15 measurements were made on each of 32 coyote pups of known age maintained in the laboratory from one to six months, supplemented by 46 field-killed animals. Although whelping occurs from the last few days of March to May 10, the best correlation between laboratory and field-killed animals occurred when birth was considered to be April 15. Weight was taken in grams (454 grams = one pound) and measurements in millimeters. Total length was taken by measuring from tip of nose to tip of tail, with the animal stretched flat on its back. "Body length" is total length less tail length, or from tip of nose to posterior edge of hip. Tail length varies considerably more than, and semi-independently from body length. Tail length in mature animals is 290 to 380 mm. (average 335 mm.). Hind foot measurement was taken from the heel to the tip of the longest claws, with the foot pressed firmly on the measuring block. Head length was measured with calipers from the tip of the snout to the crest of the head back of the ears. Sex differences first become evident at 100 to 125 days, and by 250 days (mid-December) most female weights and measurements fell below the "average" lines on the chart, and those of males above the line. Linear measurements reach adult proportions by early December, and weights, by early January. The measurements shown here are critical measurements for age determinations.

pups could survive. On the other hand, in a poor reproductive year (severe winter, low rodent availability), none of the yearlings reproduce, and only 60% of the older females produce young, 36 of each 100 females in the population would produce, an average of 4.5 young per litter, for a total production of 162 pups per 100 females. If conditions remain unfavorable (low rodent availability, excessive rain, high parasite and disease incidence) a high proportion of those pups would succumb. The average annual population constituents, increase, and decrease are graphed in Figure 15.

Most of the time, productivity falls between these extremes as cited for 1950 and 1956, with an average of 48 to 50% of the females producing an average litter of 5.6 for a total production of 280 pups.

Pups. As the gestation period for coyotes is approximately 60 days, pups are whelped in April and early May. Reports from the field indicate that a few litters may be born during the last week of March, particularly in southeastern Kansas. Because yearling females breed later than older animals, yearlings whelp later, and most of the May litters on which data are available were from yearling females.

The pups are able to crawl about within two or three days after birth, can walk when they are 8 or 10 days old and can run fairly well before they are a month old. Their eyes open at 10 to 12 days and the ears begin to point before three weeks. The first teeth come through at about two weeks and the milk teeth are replaced by permanent teeth at four to six months.

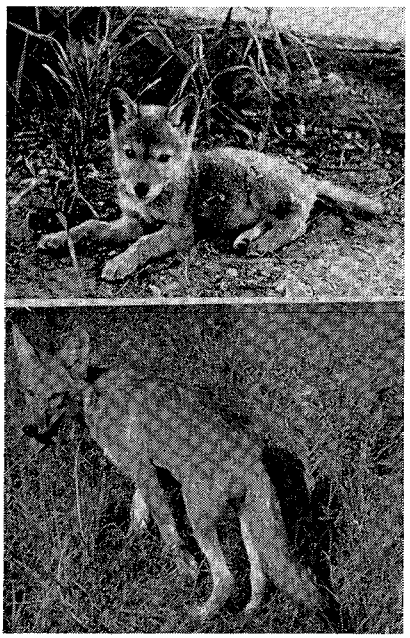


Fig. 17.—Coyote pups: Top, about 6 weeks old. Bottom, 5 months old.

Coyote pups at birth weigh approximately a half pound. They double their weight in about eight days. A pup born April 15 would weigh 2 pounds by early May, 4 pounds by June, 7 pounds by July, 12 pounds by August, 17 pounds by September, 22 pounds by October, and 26 pounds by November (Figs. 16, 17). No weight differential is detectable between coyotes of different ages in December.

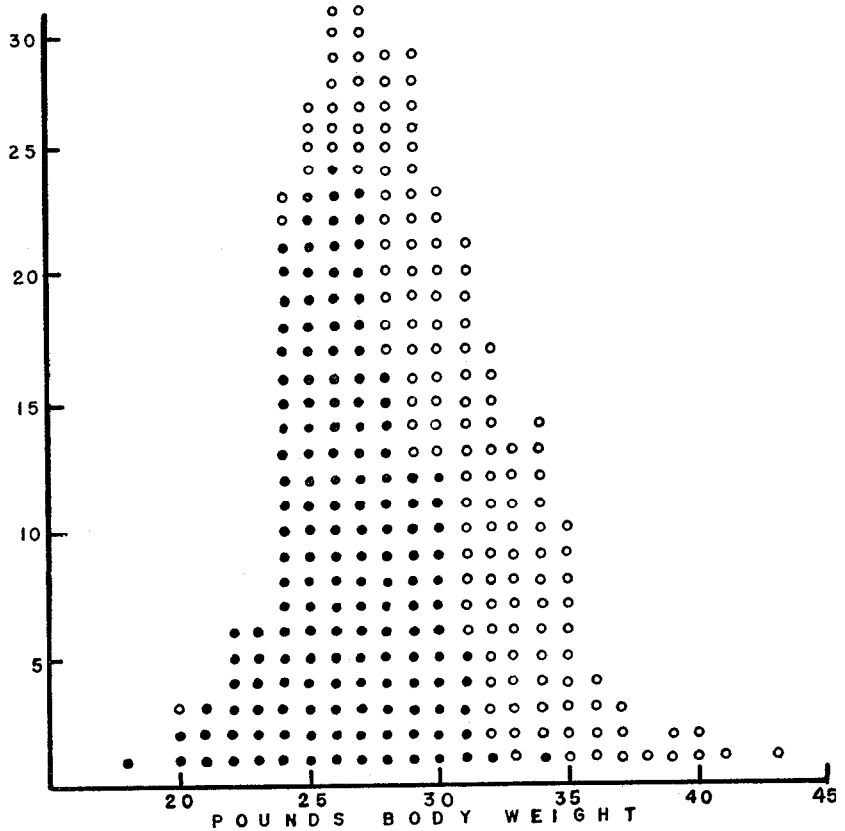


Fig. 18.—Weights of adult coyotes received during January and February, 1952 and 1953. Each dot represents the weight of one female and each circle represents the weight of one male.

Adult weight. Individual weights of adult coyotes received in the laboratory ranged from 18 to 43 pounds. No significant variation in weights of adult coyotes was found during various seasons or different years. The males averaged 30.7 pounds and females 26.0 pounds. The only adult 18-pound animal taken was a male, killed February 22, 1951. On the same hunt two 38-pound males were killed. The weights of 300 coyotes killed during January, February, and March, 1951 and 1952, are plotted in Figure 18. This shows the range of weights found typical for all seasons of the study.

Dens. Coyote dens or nests may be any place that gives the coyotes a sense of security. Most pairs of coyotes go "house hunting" during or shortly after the breeding season so that by whelping time several possible dens have been cleaned out or other suitable spots located. Favorite

sites include brush-covered slopes, steep banks with or without brush, nearly level areas with thickets partially surrounding openings, knolls or slopes in open prairie, fence rows, rock ledges, hollow logs, or even under granaries or log piles. In the region around Manhattan, it is doubtful that some coyotes ever have dens, as many pups are found in thickets or under brush piles.

Dens vary greatly in construction and depth. Some dens extend straight back in a bank; others go straight down 2 or 3 feet, then level off; while others descend at an angle for variable depths before leveling off to the nest. Some dens are only a few feet long, others extend far into the earth and may be branched. The length seems to depend to a large extent on the ease with which the earth can be removed. One den, dug out by Ed Coffey of Manhattan, had its opening on a steep slope of a sandy bank and extended horizontally and almost straight for nearly 30 feet. This den had the nest near the end, and had two short side branches.

Most of the dens observed were on south slopes or in a bank facing south, or, if on the level, were open to the south. Less frequently, dens opened to the west, and only a few were seen opening to the east. Some of the dens used by coyotes are undoubtedly dug by other animals and are only cleaned out and possibly enlarged by coyotes. Other coyotes certainly dig their own dens.

Any disturbance of the surroundings, or signs that a man has been near the den or nest after whelping time, usually results in the pups being moved to a new location. Even if the den is not disturbed, it appears likely that in most cases the pups are moved to a new location at intervals (27). There seldom are excessive tracks or any large accumulation of food remains around a den as would be expected if the den were used several weeks. At any rate, the pups probably do not stay in the dens much more than a month. There are only a few reports of digging coyotes from dens in Kansas during June, but many pups are taken from thickets and brush piles during May and June.

Feeding the pups. Pups are fed solely on milk for about two weeks. Nursing was continued by the bitches kept in the laboratory for at least three months and, in one case, for more than four months. At about the time the pups open their eyes, they are able to eat solid food that is carried in by the mother (Fig. 19). How much of the food supplied to the young pups is fresh, and how much is regurgitated was not determined.

In the laboratory the coyote and coyote-dog hybrid bitches began, in a small way, to feed their pups by regurgitation when they were about a month old. Feeding by regurgitation was continued until the pups were nearly 5 months old and well able to tear meat for themselves. If this behavior indicates

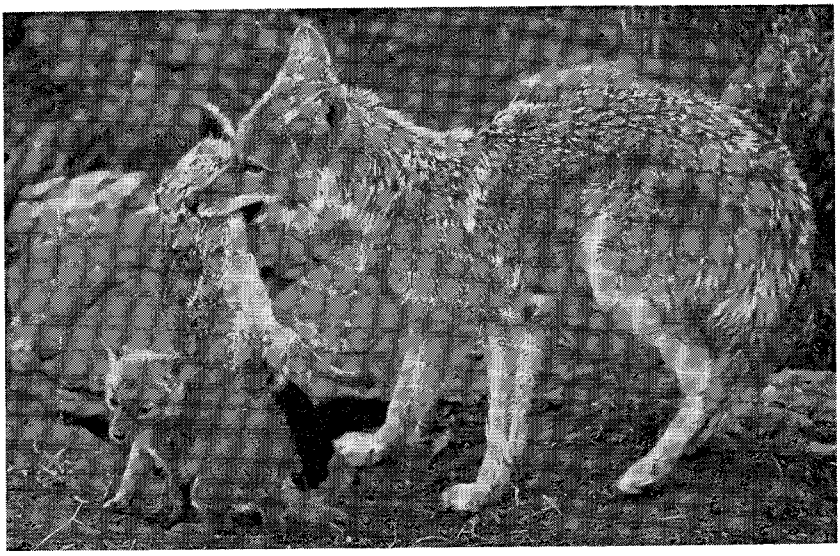


Fig. 19.—Coyote bitch carrying food to pups. (Photo by E. R. Kalmback, Fish and Wildlife Service.)

what happens in the wild, it may mean that regurgitation of food materials is more important in the transfer of food than in digestion. For example, a bitch can gorge herself at the source of the food and carry it to the young much better in her stomach than in her mouth. Actually it would be nearly impossible for a coyote to carry enough meat from a cow carcass to feed her pups, but transfer of such food in her stomach is relatively simple. Food so carried may be partially digested when it is delivered to the pups. Partial digestion is not necessary for regurgitation, as bitches were observed on numerous occasions to eat, then go directly to the pups and regurgitate. In the laboratory, males as well as females were stimulated by the pups to regurgitate.

Age of coyotes. Few Kansas coyotes live long enough to have any old-age difficulties. Age was determined by size of the uterus (Fig. 14) on all female coyotes received in the laboratory. The history of reproduction was shown by placental scars in the uterus and **corpora rubra** in the ovaries. During 1953-63, ages were verified by characteristics of the teeth (Fig. 20). Almost half of all animals examined were yearlings, one third were 2 years old, and one fourth, more than 2 years old. This may not give a true picture of the population proportions because the coyotes killed during the fall and early winter are predominately young. As the winter progresses and the young animals are selectively eliminated. the proportion of yearlings decreases. The age groups among winter popula-

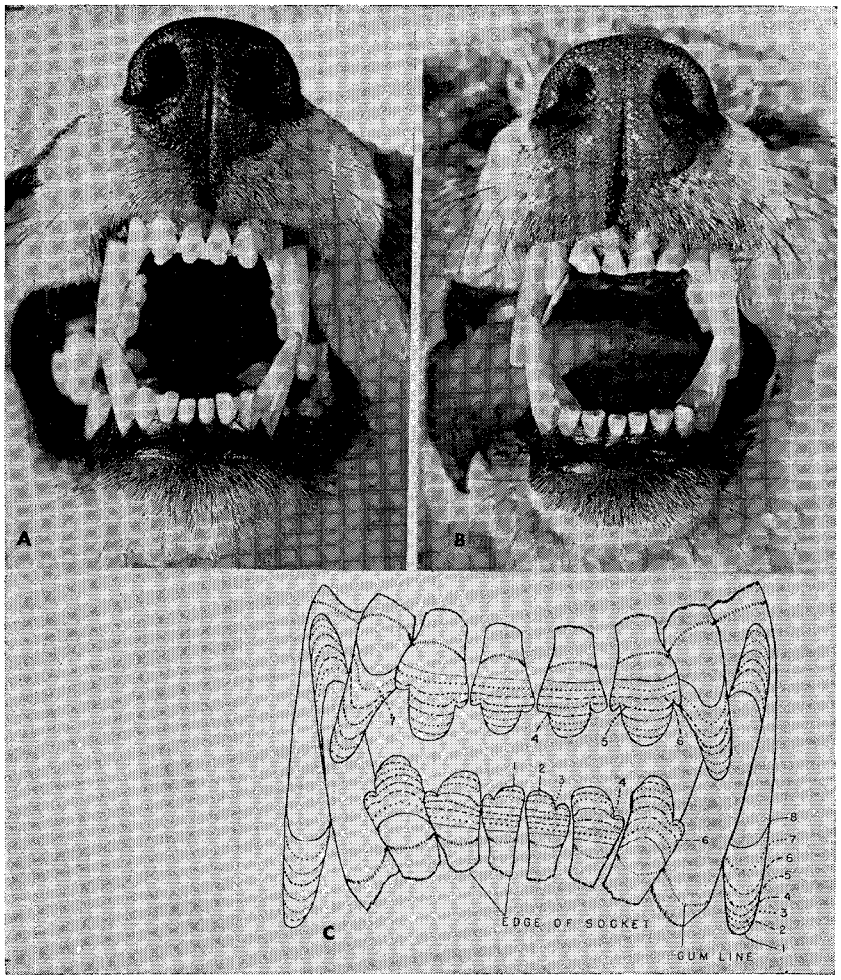


Fig. 20.—Determination of age of coyotes by tooth wear. Frontal views of the teeth of coyotes aged: A. 2 years, B. 5 years, and C. composite drawing made by superimposing pictures like A and B to show extent of annual wear. The animals from which these preparations were made were killed in February and were selected as being typical of their age groups.

tions of coyotes in Kansas are shown in Figure 21. Only a few animals were examined that could possibly have been more than 6 years old, notwithstanding citations (1) of coyotes living to be 10 to 14 years old.

Hybrids. Crosses between coyotes and dogs occur, although authentic reports of such crosses are scarce. Seton cited several cases of coyote-dog hybridization. Bee and Hall (28) reported

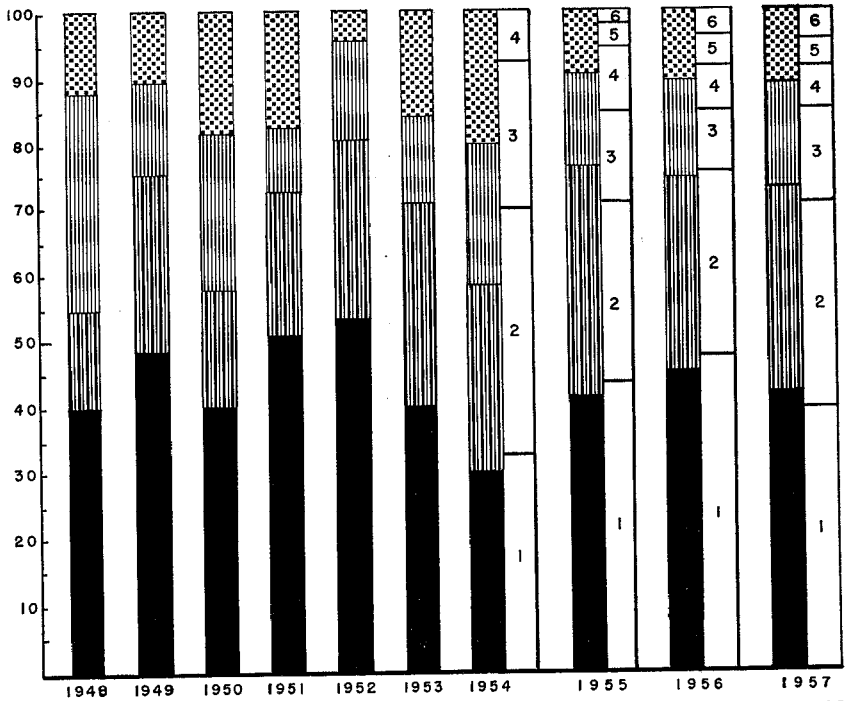


Fig. 21.—Age distribution of coyotes studied 1948-1957. The solid black bars represent yearlings, as determined by the length and condition of the uterus; alternating heavy and light lines indicate animals more than 1 year old that had not produced a litter; uniform lines represent the proportion of females that had produced one litter; and the squares indicate the proportion that had borne two or more litters. In 1954-57 age determinations were made by tooth and skull characteristics and the age groups are indicated by numbers, with the percentage of each age group indicated by the length of the box.

two such animals killed near Lawrence. Garland Gideon,[5] Paxico, Kansas, reported that he had killed at least 25 dog-coyote crosses between 1945 and 1951. He described these hybrids as being of two distinct types: one with long ears and pointed nose, the other with short ears, wide head, and short nose, both types being gray with no coyote yellow or brown. Several of these animals were too large for coyotes, weighing more than 50 pounds. "One weighed 83 pounds and was 29½ inches high at the shoulder. Another weighed 74 pounds and was 29 inches high." Such animals can result only from crossing large dogs with coyotes, and the differences noted in the shape of the head undoubtedly reflect the characteristics of the sire.

The question of coyote-dog crosses led to the breeding of coyotes in the laboratory.[6] Three different coyote bitches were

5. Personal communication, February 6, 1951.
6. Details of the hybridization experiments will be published separately.

Fig. 22.—Coyote x dog hybrids. A. A tan, coyotelike hybrid resulting from a cross between a Collie male and a coyote bitch. B. Black, silver-foxlike hybrids resulting from a cross between a black Labrador Retriever male and a coyote bitch.

bred and four litters of hybrid pups were raised. Three litters were by a Collie male and the fourth by a black Labrador-mix male. One cross was obtained between a coyote male and a Terrier female. The Collie-coyote crosses showed essentially coyote characteristics, with shorter hair and tail not so bushy (Fig. 22A). The Labrador-coyote cross resulted in four **black** pups (Fig. 22B). The female hybrids that lived to maturity proved to be fertile, but they all had breeding seasons different from that of coyotes. Most of them bred in October and November. One bred again in May, reverting to dog cycles. The males that were raised to maturity also had a fall breeding season, and consequently could not breed a coyote bitch.

These laboratory crosses of dogs and coyotes prove that such crosses are possible, that the only requisite for this cross is that the male and female be together at the proper time, and that the offspring are not infertile. Many reports of dog-coyote crosses in the wild are probably true, even in the occurrence of black or spotted "coyotes" or brown coyotes with white neck rings. During the 16 years of this study only one litter of hybrid pups and 10 adult coyote-dog hybrids were obtained for study even though all cooperators were alerted to the desirability of securing every possible animal that might have been a hybrid. By comparison with laboratory results, however, it would seem improbable that these hybrids would become integrated with the coyote population to any extent because of the change in breeding season, even if the hybrids were as strong as the parent animals. Vigilance must be obtained to make certain that a race of "superdog-coyotes" does not become established in Kansas, as has been reported by Cook (29) in New York.

PARASITES AND DISEASES OF KANSAS COYOTES

Each coyote carcass brought into the laboratory was carefully checked for parasites and diseases, with special emphasis on intestinal parasites. The results of the first six years of the parasite study were published by Ameel (30) and details of the entire study have been published separately (31).

Tapeworms, mostly the dog tapeworm **Taenia pisiformis** (Fig. 23A), were found in 95% of the coyotes examined. The average infection was nine mature worms, 15 immature worms, and 30 scoleces. As many as 150 mature worms and 500 scoleces were found in a few animals. Coyotes become infected with tapeworms by eating rabbits that contain the larval stage of the worms.

Another tapeworm, **Mesocestoides corti,** was recovered from the intestines of six coyotes in 1958-62 from various localities in north-central Kansas. This tapeworm is smaller than **T. pisiformis,** occurs in smaller numbers, more commonly parasitizes skunks and opossum, and its larval stage is spent in various small birds.

Roundworms of five species were found. Stomach worms, **Physaloptera rara** (Fig. 23B), were found in nearly half of the stomachs, with as many as 65 worms in one stomach, an average of nine. Petri (32) presumed that coyotes become infected with stomach worms by eating insects infected with larval stages of the worms.

The intestinal worm, **Toxascaris leonina** (Fig. 23C), occurred in 33% of the coyotes in numbers up to 70, but averaged nine. Coyotes become infected with Toxascaris by eating foods contaminated with feces.

The dog hookworm, **Ancylostoma caninum** (Fig. 23D), was found in 28% of the coyotes examined, usually in small numbers, but occasionally more than 50 occurred in a coyote. Coyotes become infected with hookworms by walking on or eating soil containing infectious larvae. Hookworms are much more abundant in coyotes during wet springs than in dry years. Coyotes caught in river flood plains carried heavier hookworm loads than those caught in upland prairies. Hookworms are particularly deadly to pups and, as they can pass through the placenta into the fetus, the newborn pup may have a lethal load of worms at birth.

Whipworms **(Trichuris vulpis)** were found in fewer than 6% of 550 coyotes examined especially for them. Infection

Fig. 23 (page 59).—Parasites of coyotes, photographed soon after removal from the coyotes. The millimeter rule photographed with the parasite shows size. A. The tapeworm **(Taenia pisiformis)** in several growth stages, from small scoleces through immature stages to large mature worm. B. The intestinal worm **(Toxascaris leonina).** C. The stomach worm **(Physaloptera rara).** D. The hookworm **(Ancylostoma caninum).** E. The whipworm **(Trichuris vulpis).**

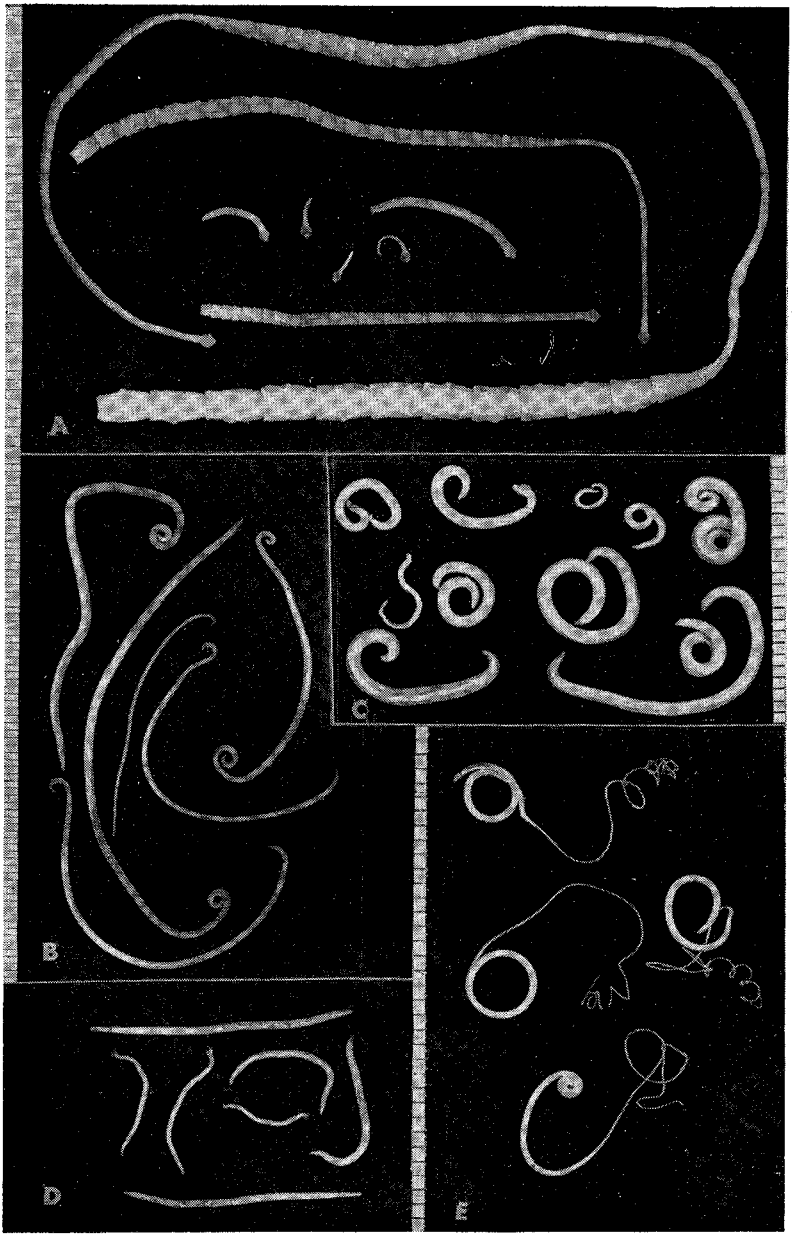


Fig. 23 (see bottom page 58).

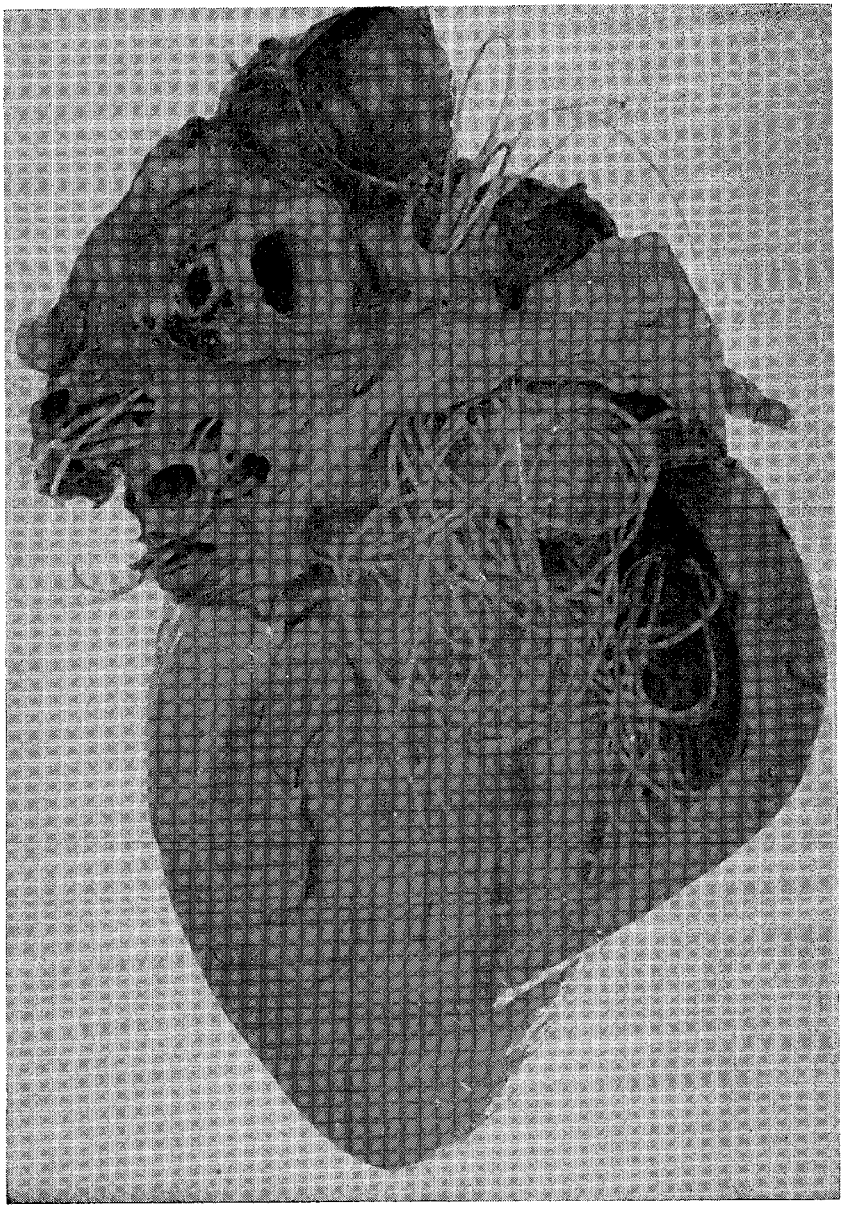


Fig. 24.—Heartworms **(Dirofilaria immitis)** in a coyote heart. The wall of the right ventricle was removed to show the mass of worms within the heart cavity. Some of the worms extended out of the ventricle through the pulmonary arteries and can be seen in the top center and left of the dissection.

with whipworms occurs by the coyote eating foods contaminated with feces that contain whipworm eggs.

Heartworms, **Dirofilaria immitis** (Fig. 24), were found in only 10 of 1790 coyotes examined for them. The larval form of these worms is transferred from the blood of one animal to that of another by blood-sucking parasites, probably mosquitoes. Deleterious effects of heartworms are obvious, and coyotes infected with enough of them have their efficiency and their chances of survival reduced.

External parasites were found on every coyote checked. All coyotes apparently are infested with fleas, mostly the pellucid flea, **Pulex simulans.** A large proportion of the coyotes examined during the winter of 1956-57 had a few ticks **(Ixodes kingi).** Most coyotes examined from June through September had ticks, **Dermacentor variabilis,** and fewer fleas than found in winter. No ticks were recovered from any winter-killed coyotes since February, 1958, and occurrence of **P. simulans** was greatly reduced while the rabbit fleas, **Hoplopsyllus affinis** and **Cediopsylla simplex,** and the raccoon flea, **Chaetopsylla lotoris,** continued to be found in small numbers.

Lice **(Demidectes)** were found in large numbers on two coyotes in 1951, two in 1957, and three in 1961. Mange was observed on only a few coyotes, and mange mites were recovered from only two.

Diseases of coyotes are difficult to observe because few sick coyotes are found. Two diseases, however, are of particular importance.

Distemper has been reported (33) to be one of the most devastating of the diseases of coyotes. Coyote pups brought into the laboratory were extremely susceptible to distemper. This disease is probably one of the factors that control coyote populations.

Rabies affects coyotes in the same manner as it does dogs: after the animal is exposed, there is an incubation period of 10 to 60 days, then an infective period of about 10 days during which the rabid animal bites anything that gets in its way. Near the end of the infective stage, the rabid animal becomes paralyzed or too weak to fight, then it dies. There have been no more than sporadic occurrences of rabies in Kansas, but the threat of a rabies epizootic is always real whenever there is a high population of any carnivore. Rabies outbreaks among coyotes in the past have been of short duration (34) but the rabies epizootic that began among the foxes of the Adirondacks in 1942 was yet serious after 15 years (35).

Tularemia apparently is not a serious disease for coyotes. Although it has been noted (36), no case suggesting tularemia has been observed in this study.

Respiratory infections, similar to pneumonia, have been noted only six times during the 15 years of study.

Wounds and broken bones are more easily observed than are parasites and diseases. Several coyotes were received that had completely knitted breaks in their bones (Fig. 25). Besides those pictured, one had the dorsal spine of a thoracic vertebra broken, apparently by gunshot, and healed as a knob, with all attached muscles normal. One had a hind leg broken below the knee, but the bones had fused solidly although a little crooked. One had a front leg broken below the elbow, and, although the bones had slipped so the ends overlapped nearly an inch, fusion was complete.

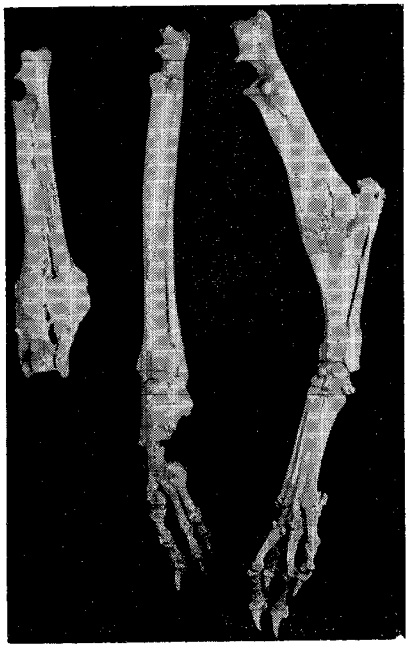


Fig. 25.—Broken bones of coyotes. Left, Forearm, broken but healed straight. Center, Right front foot with the hand bones (carpals) incomplete except one. This foot appears to have been shot and nearly severed. Right, Forearm, both bones broken across the middle, overlapped about an inch, and healed with a bend in it.

Only one nonfused, broken bone was observed: a hind leg that had been broken above the ankle. The lower bone had slipped up behind the upper bone almost 2 inches, so the ends were too far from contact for fusion. The bones were tied together rather firmly by ligaments but the foot was turned back and the animal was walking on the stub and what should have been the top of the foot. Six animals were examined that had one foot missing, apparently broken off in traps. Four of them each lacked one front foot and the others had each lost a hind foot. In all cases, the animal had survived the injury and adjusted its living as necessary to secure adequate food.

It was not uncommon to find shot or even bullets healed into the wounds that they had made. The only visible damage done by this accumulation of lead was when a shot was found in the testis. In three such cases, the testis had shriveled and become completely nonfunctional. One coyote that had been caught in a steel trap and killed with a rifle shot in the head was found to have a number of rather fresh wounds. Several shot had penetrated the large intestine, but the injuries had been closed by shifting of the layers so that the holes in successive layers were offset. There had been a coyote hunt

in the vicinity where this wounded coyote was taken only three days before it was caught. This animal apparently had survived the hunt and was well on its way to recovery when trapped.

Though there is little direct evidence of fatalities among coyotes because of disease, parasites, or injuries not serious in themselves, it must be remembered that these animals lead a harsh life, with competition severe and food hard to get. Anything that lowers the resistance of a coyote invites and facilitates the establishment of bacterial or virus infection. Any factor that weakens a coyote increases the difficulties of obtaining food and meeting competition, which may further weaken it or result directly in its destruction by other more vigorous coyotes.

That coyotes continue to roam the prairie is evidence enough that they are hardy creatures and can recover from rather severe injury without lasting weaknesses resulting.

COYOTE POPULATIONS AND THE BALANCE OF NATURE

DATA FROM BOUNTY RECORDS

Anyone who has had experience with coyotes in Kansas understands that there are large numbers of the animals present. Few persons, however, realize how large those numbers are. Hunters may insist that there are only a few coyotes in each township, while sheep raisers and poultry growers are certain there are two or three coyotes in each square mile around their farms. These differences of opinion make definite information desirable as a basis of control.

Records of fur dealers, usually valuable as an index of fur-bearer populations, proved to be of no value in this case because of duplication of purchases, purchase of pelts by Kansas dealers from outside the state, and, finally, the decline in value of coyote pelts to the point where there is no longer a uniform traffic in them. Cockrum (5) compiled some information from dealers' records but was unable to derive usable population relationships from it.

Bounty payments apparently have the same correlation with populations as exists between pelts and populations of fur bearers, when the incentives are high enough to induce consistent taking of the animals. With a low bounty in Kansas there are relatively few coyotes taken specifically for the bounty, but coyotes are killed for various reasons, irrespective of possible monetary returns. When a high proportion of the coyotes killed are presented for bounty, as they have been in Kansas, the bounty is as satisfactory an index of populations as fur purchases would be. Bennitt (37) and Wooster (26) thought that bounty payments represented a true index of total population in that the annual take,"[7] represented by the bounty payment, must approximate the annual increase in the population. If the "take" is greater than the increase, the breeding stock is reduced and the "take" the next year is thereby reduced. On the other hand, if the annual "take" is less than the yearly increase, there are more individuals left to reproduce, and so the total population can increase. This idea, of course, is strictly applicable only if the "take" as shown by the bounty is the limiting factor in the population.

Bounty payment records provide the only consistent source of information to establish comparative numbers for different years. Some of these records are available from 1880, but the early records are incomplete. Lantz (3) listed by counties the bounties paid on coyotes July 1, 1903, to June 30, 1904, as totaling 19,514, with 10 counties not paying bounties and one not reporting. He further stated that "most of the counties of the state have for many years paid bounties for killing coyotes,

7. Throughout the discussion, "take" or "kill" designates the number of animals killed by man. "Population losses" include "take" plus natural losses due to disease, predators, and internal strife.

and conditions have been reached where there is little fluctuation in the total amount paid from year to year." Wooster (26) reported the bounties paid by Ellis County from 1914 through 1932. Cockrum (5) assembled similar information for five counties, mostly from 1900 to 1951. The available data indicate that annual bounty payments have fluctuated between 50 and 650 per county during the past 40 years. The fluctuations did not necessarily coincide in all parts of the state, nor did they show any indication of rhythmic cycles.

Fluctuations of bounties. The bounty records cited by Cockrum (5) show the same sort of random fluctuations for every county listed, and the same lack of correlation of high and low payments is apparent for Ellis and Comanche Counties (Fig. 26). In an effort to find the reasons for these fluctuations, bounty payments for the past 25 years were analyzed carefully, and additional information was derived from questionnaires to bounty recipients and county treasurers.

The total bounties paid (Fig. 27) have varied from less than 24,000 in 1949, '54, and '55 to more than 41,000 in 1946, '63, '64, '65, and '67. In each of those years, not more than six counties failed to report. According to questionnaires sent to more than 200 sportsmen in 1951, the proportion of coyotes that are submitted for bounty is fairly constant at about 90% of the coyotes

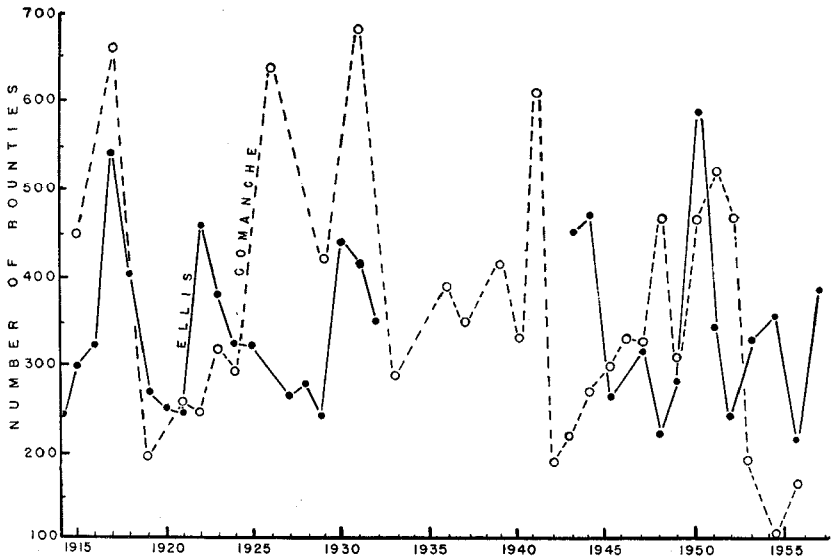


Fig. 26.—Bounties paid on coyotes in Comanche and Ellis Counties 1914-56, from records available. The records from Ellis County 1914-32 are from Wooster's (1939) report, and those from Comanche County 1914-42 are from Cockrum (1952). Data for both counties 1943-56 are from state auditor's records.

killed. Since the bounty in Kansas is not high enough to encourage illicit traffic into the state, illegal bounty payments could only further increase the differential between kill and bounty payments in Kansas. Thus, even considering possible errors, the total numbers given are conservative for coyotes killed during those years.

The bounty records given by Cockrum (5) substantiate the general consensus that there was a relatively low coyote population in Kansas from 1932 through 1940. Bounties in 1941 totaled 19,209, with nine counties not reporting, and in 1942

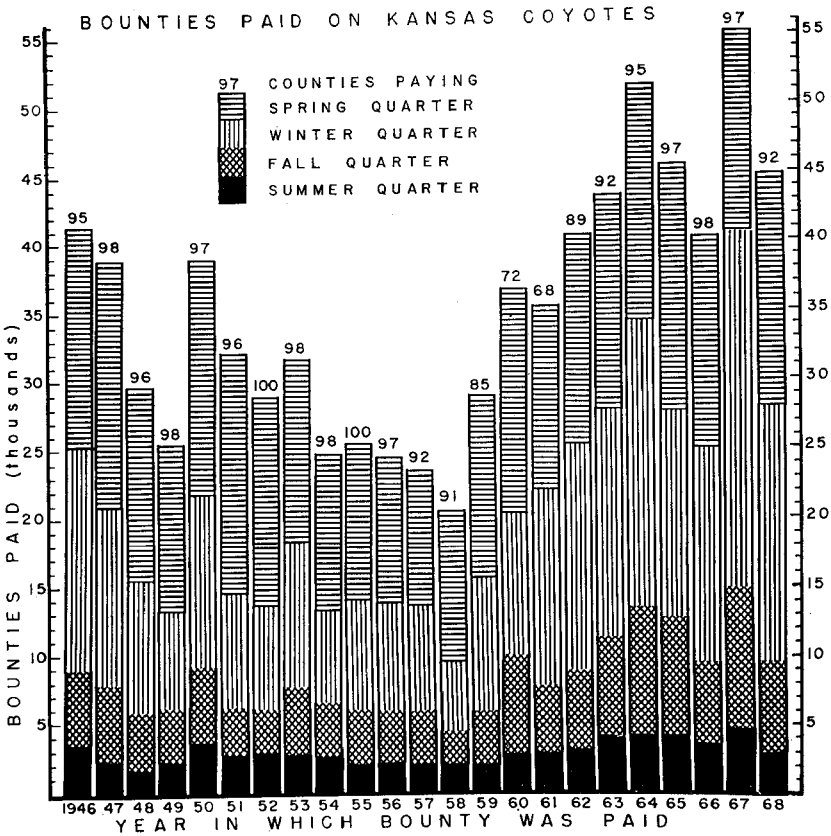


Fig. 27.—Thousands of bounties paid on coyotes July, 1942, through June, 1968, as determined from records in the auditor's office in Topeka. Each bar represents bounties in a fiscal year divided into quarters. "Summer" quarter is July-September; "fall," October-December; "winter," January-March; and "spring," April-June. The fiscal year 1943 was July 1, 1942, to June 30, 1943. In most years, not more than three counties in the state failed to report until 1959 when 10 counties did not report and 1960 when 21 did not report, and presumably did not pay bounties.

there were 15,791, with four counties not reporting. The increase began in 1943, reached a peak in 1946, then dropped to the 1943 level in 1949. The increased number of bounty payments in 1950 may have been partially stimulated by the increased bounty.[8] However, the 1953-54 and subsequent bounties dropped below the 1949 level in spite of high hunting pressure, indicating unusually small winter populations. The drop continued until the 15-year low was reached in 1958 followed by a definite increase in population and in bounties paid in 1959 and in 1960 despite 20 counties failing to pay bounties in 1959 and 30 in 1960.

A veritable population explosion began in 1960, reached an all-time high of 52,000 bounties paid in 1964, then subsided to fewer than 40,000 in 1966. State-wide bounty payments were reinstated in 1960, and were in effect in 1961, so the greatly increased payments in 1962-64 were not the result of resumption of bounty payments. Rather, the bounty increases directly reflected an overall population increase as indicated by increased hunting efficiency, more numerous coyote sightings, and increased reports of coyote damage. Again in 1966, bounty payments were discontinued by an increasing number of counties, so the drop from 1965 to 1966 (Fig. 27) is slightly exaggerated, although there are strong indications that approximately half of the scalps that are refused bounty in one county are bountied in adjoining counties.

The graph of coyote bounties (Fig. 27) indicates a rather simple rise and decline of coyote numbers 1958-66, but the 1966-67 bounty showed a reverse in the trend, with the total bounties exceeding 55,000 and six counties not paying bounties in the period. Because the Kansas small mammal census was closed in 1964, no data are available on rodent numbers, so no correlation can be continued as was done 1950-63 (Fig. 6). Nevertheless, the bounties were increased by almost 40% when expectations indicated further decline. The same thing happened in 1949-50, with an increase of 50%. Both of these drastic increases were accompanied by increased complaints from stockmen. In both cases, it appears now that efforts at controlling coyotes were relaxed too soon (in 1949 and 1966), leaving too many breeding coyotes which found conditions favorable for reproduction.

Bounties by counties. Considering that 1946-47 was a fairly typical "high" year, some idea of the distribution of coyote concentrations in Kansas can be obtained from Figure 28A: Greatest numbers of coyotes were taken in the Flint Hills from Greenwood to Washington County, with a secondary concentration in the north and northwest and another in the south-

8. Senate Bill No. 169, 1949 (19-2320): "The board of county commissioners of each county shall by resolution place and pay a bounty of two dollars ($2) for the scalp with both ears attached of each coyote or wolf caught and killed in such county. . . ."

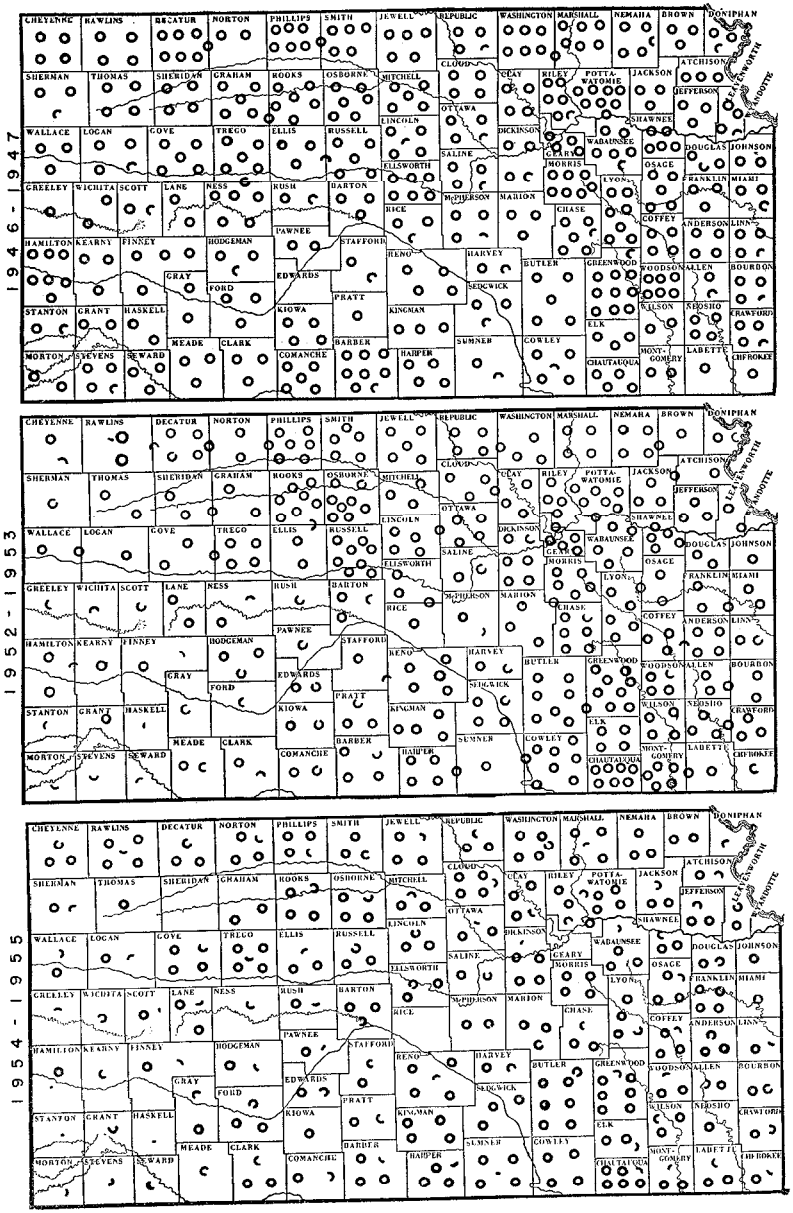


Fig. 28.—Coyote bounties paid in Kansas, by counties, in a year of extremely high coyote population (1946-47) and in two years of declining populations (1952-53 and 1954-55). Each O represents 100 bounties paid, and the partial circles represent proportional parts of 100. A pattern of regression can be seen from the top chart to the bottom, with the drop in bounties first showing in the west and southwest, then spreading eastward.

west, leaving essentially the Arkansas River Valley reporting few coyotes.

The pattern of payments in 1952-53 (Fig. 28B), however, is quite different. Cowley, Chautauqua, and Montgomery Counties showed a considerable increase over 1947. Rooks, Osborne, and Russell Counties showed a slight increase; most of the Flint Hills counties were approximately the same; and the remainder of the state showed a decided decrease.

There are a few tangible reasons for the decrease in some counties. For example, many of the coyotes in the eastern tier of counties undoubtedly were taken across the border for the $30 bounty being paid by Missouri. A disproportionate number of coyotes were killed in some of the counties in the southwestern part of the state during 1951 and 1952 by a poisoning program which unquestionably reduced the coyote population in those counties. At the same time, however, bounty payments were reduced by at least 50% in several counties that were neither close to Missouri nor among those with special control measures. The counties with the unexplained drastic reduction include McPherson, Rice, Ness, Graham, Sheridan, Thomas, Decatur, Rawlins, and Cheyenne. In addition, the counties (Grant, Kearny, and Hamilton) in which the poison program was first used during 1952-53 had at least a 50% drop in bounty payments that year, although bounty payments had regularly increased somewhat in other counties during the first season of poisoning. Stanton and Haskell Counties showed the same reduction as the adjoining counties that poisoned their coyotes. This indicates that throughout western and southwestern Kansas, coyote populations decreased considerably, whether or not special control measures were in effect.

Reduction of numbers continued generally over the state until a relatively stable "low" was attained in 1954-55 (Fig. 28C). This shows an elimination of all the high bounty payments throughout the state, with as much as 50% reduction in some counties. A few counties in central and western Kansas showed a slight increase from the extreme lows of 1952-53, despite continued use of 1080 and other "organized" controls. Reports on hunting success indicate that the number of coyotes bountied is directly proportional to the number of animals present.

The total picture in southwestern Kansas became somewhat confused in 1956. Six counties (Comanche, Finney, Grant, Gray, Kearny, and Scott) officially discontinued bounty payments late in 1955 or in 1956, and three others failed to file bounty payments with the State Auditor and may be assumed to have discontinued payments. Most of the counties that continued payments showed an increase of 10 to 60% in 1956 over the 1955 payments. Part of the increase undoubtedly was

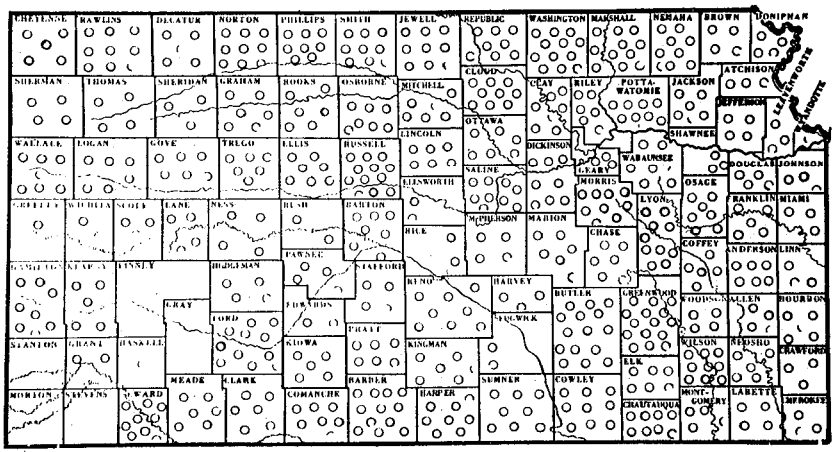


Fig. 29.—Bounties paid in Kansas by counties in the fiscal year 1966-67. Each circle represents payments on 100 coyotes. No mark indicates no payment.

for scalps transferred from counties not paying bounties, but the general consensus was that coyote populations definitely increased. Population concentrations changed little in the eastern half of the state between 1954 and 1956, but dropped distinctly in 1958 before another rise began in 1959 and 1960.

Bounties reached a peak in 1964, dropped off about 10% per year for two years, then went to an all-time high in 1967. Analysis of bounties for 1967 showed that five counties paid no bounties and six others failed to pay at least one quarter. Nearly all counties that paid all four quarters matched or exceeded previous high records. Seven counties paid bounties on 1000 to 1500 coyotes, 30 counties paid 600 to 1000, 39 paid 300 to 600, and only 15 paid less than 299 bounties (Fig. 29). The pattern of bounty payments was essentially the same as that during the high period of 1946-48, with the High Plains and part of the Arkansas River drainage again constituting the low bounty area. Since that is the region from which come many of the complaints of severe predation, the question arises as to whether proportionate numbers of coyotes are harvested. It might be noted that in many cases, counties adjoining non-paying counties pay more bounties than do those in the same region completely surrounded by paying counties.

Bounty on pups. In the summer of 1949, questionnaires were sent to 200 individuals in Greenwood, Chautauqua, and Washington Counties who had collected bounties for coyotes during the spring quarter of that year. Replies showed that 89% of those bounties had been collected on pups, most of which had

Table 9.—Bounties paid on pups in relation to total bounties paid by 45 representative counties in April, May, and June, 1951.

County reporting	Number of bounties	Number of pups	% pups
Anderson	336	303	90
Atchison	74	30	41
Bourbon	100	100	100
Butler	383	350	91
Cherokee	55	12	22
Cheyenne	86	82	95
Cloud	280	190	68
Decatur	164	25	15
Dickinson	148	14	10
Edwards	41	26	63
Ellsworth	230	185	80
Finney	108	4	4
Franklin	301	238	79
Gray	20	6	30
Greeley	4	0	0
Greenwood	555	396	71
Jackson	405	355	88
Kingman	101	80	80
Labette	95	70	74
Lane	114	38	33
Leavenworth	112	73	65
Linn	124	60	48
Marion	246	196	80
Marshall	310	204	66
McPherson	81	67	83
Montgomery	252	12	5
Morton	35	24	69
Nemaha	302	275	91
Norton	206	101	49
Osage	193	142	74
Ottawa	125	80	64
Phillips	3	0	0
Pottawatomie	456	438	96
Pratt	115	40	35
Republic	170	157	92
Reno	103	5	5
Saline	156	53	34
Stevens	18	10	56
Thomas	60	8	13
Trego	256	196	77
Wabaunsee	237	110	46
Washington	362	325	90
Wichita	3	0	0
Wilson	423	395	93
Woodson	178	155	87
Total	8,126	5,630	69

been dug from dens.[9] In the spring of 1951, special forms were sent to 60 of the county treasurers in Kansas requesting that they tabulate in appropriate columns: adult coyotes, pups, and how they were taken. Forty-five recorded the desired informa-

9. Kansas law (32-158) specifically prohibits the destruction of dens of any fur-bearing animal, forcing of smoke or deadly gas into such dens, or attempting to kill fur-bearing animals with poison. At present, the coyote is not considered to be a "fur-bearing animal," so the restrictions do not apply.

tion and returned the forms. All sections of the state were represented in the returns (Table 9). In reports from the Flint Hills and eastward, 78% of all coyotes presented for bounty during April, May, and June were pups. Considering the reports returned as representative for the entire state, 69% of all coyote bounties paid in this quarter were on pups. Throughout the year of this study, approximately 50% of all bounties paid each year were paid in the spring quarter, and spot checks in 1956 and 1959 showed a continuation of 65 to 72% of the spring bounties were for pups. Thus, approximately 35% of all bounties paid were pup bounties.

Quarterly bounties. Consistently the quarterly breakdown of bounty payments (Fig. 27) showed that nearly 50% of the total payments were made during the spring quarter, 30% during the winter quarter, 13% in the fall quarter, and 7% in the summer quarter. Spot checks in 1949 and 1951 indicated little holdover of scalps from one quarter to the next.

An analysis of quarterly payments shows a high correlation between hunting effort and bounty payments not only from year to year but throughout the year. From June through October, there is little consistent effort expended on hunting coyotes, so that coyotes presented for bounty are usually killed incidentally. It is too late for den hunting, too early for hunting with dogs, and there is too much food available for successful bait-trapping, so the kill is low. Hunting with dogs and sport shooting get under way in late October; organized hunts begin in November or December; and some traps are set during December. Throughout January and February, and usually well into March, hunting with dogs, organized hunts, sport shooting, and trapping are all in full swing. During the quarter the kill averages 10,000 animals in the state and as many as 200 in some counties. It is during April and May, however, that the greatest take occurs, particularly in the eastern half of the state. During this time den hunting is the only consistent means of taking coyotes and, in addition to the incidental take of adults, the pups taken total nearly as many individuals as are taken during the winter quarter.

POPULATIONS

With bounty data as a guide to population trends, and information given in the section of this report on the reproduction of coyotes, speculation on population dynamics is possible.

Population calculations. For a hypothetical situation, consider a group of 100 pairs of coyotes that survived the rigors of at least one year. Of the 100 pairs, 50 probably would breed and produce litters averaging six pups each in a normal year, so the total pup production of the 100 pairs would be 300, making a total of 500 coyotes after the pups are born. During the first three months of their existence, there is a high loss

Table 10.—Calculation of breeding population in a six-county area (Geary, Marshall, Morris, Pottawatomie, Riley, and Wabaunsee) comprising 4282 square miles. Bounty payments are given as totals for the six counties by quarters and years (B). Population losses (R) beyond bounties (B) are estimatel as 0.5B when reproduction was high and as low as 0.3 when reproduction was low. The "weighted loss" is B + R. The percent (P) of breeding females multiplied by litter size (L) gives the average increase per female (P × L). The breeding population (N) is calculated from the formula $L \times P \times N/2 = B + R$, which reduces to $N = \frac{2\ (B + R).}{P \times L}$ The total population at the end of the whelping season (T) is equal to $N + (P \times L \times N/2) = N + B + R$.

Year	Bounties				B Year total	R Factor	B + R Weighted loss	P	L	P × L	N= 2 (B + R) / P × L	T= N + B + R
	Spring	Summer	Fall	Winter								
1948-49	1,643	139	240	540	2,562	0.5	3,850	46	5.4	2.8	2,720	6,570
1949-50	1,400	217	506	1,415	3,538	0.5	5,300	61	6.4	3.9	2,730	8.030
1950-51	1,802	265	314	809	3,190	0.5	4,800	54	5.8	3.13	3,080	7,880
1951-52	1,512	189	204	854	2,759	0.5	4,150	54	6.2	3.35	2,480	6,630
1952-53	1,652	213	330	1,150	3,335	0.35	4,500	44	5.0	2.20	4,100	8,600
1953-54	1,505	218	314	727	2,744	0.35	3,700	33	5.5	1.82	4,100	7,800
1954-55	1,207	182	376	702	2,467	0.3	3,200	30	4.5	1.4	4,580	7,780
1955-56	901	154	428	873	2,356	0.3	3,000	32	5.5	1.76	3,420	6,420
1956-57	939	163	359	770	2,231	0.3	2,900	33	5.0	1.65	3,520	6,420
1957-58	860	153	305	480	1,798	0.35	2,430	38	5.4	2.05	2,380	4,810
1958-59	1,163	246	255	765	2,429	0.4	3,400	33	5.7	1.88	3,780	7,180
1959-60	1,344	270	406	950	2,970	0.4	4,150	57	6.0	3.42	2,430	6,580
1960-61	1,550	300	893	1,073	3,816	0.45	5,540	60	5.6	3.36	3,320	8,860
Total	17,578	2,709	4,930	11,108	36,323		51,600				40,640	93,560
Average	1,353	208	380	855	2,800	0.40	3,980	44	5.5	2.50	3,130	7,120
% of B	48.5	7.5	13.6	30.4	100							

among the pups, some of them being killed by the old males, some by other bitches, some by dogs, some by parasites and diseases, and more by man (Fig. 15).

Although there is no definite information as to the extent of these losses, one half the pup crop seems to be a reasonable estimate. During the same time, one fourth to one sixth of the old coyotes died while securing food for or defending their young, or possibly by disease or accident. These losses reduce the 500 coyotes by perhaps 150 pups and 40 adults, leaving about 310 by late July. If the pups live through July, they have a good chance of living until December. The winter hunting season regularly brings on further reduction of numbers so that by April the remaining population approximates that of the previous April, and the cycle is complete.

Application of the above principles of population dynamics to the total population bring in still other variables and leaves much to be desired. For example, there is no way of determining with any degree of accuracy how many coyotes are present at the breeding season; the natural losses can only be conjectured, and the relationship between bounties and remaining population can be determined only by the following year's production. The data established during 10 years of this study, however, have reasonable constancy and fit well in a six-county area in determining population fluctuations for the years 1949 through 1956 (Table 10).

The annual increase obviously can be derived by multiplying the average size litter by the number of pairs of breeding animals. This may be expressed as: Increase $= L \times P \times N/2$ in which L is the average litter, P is the percentage of adult animals involved in reproduction, and N is the number of adults present at whelping season. The total population (T) at the end of the whelping season would then be: $T = N + (L \times P \times N/2)$ less losses that had occurred in the meantime. Calculations are simplified if all losses are considered as occurring after whelping is completed.

Population vs. bounty. Since bounty payments constitute the only concrete data available on numbers, they must be used as the basis for calculations even though they do not represent the total loss to the coyote population. Possibly 10% of the coyotes killed by hunters are not presented for bounty. There is no measure of natural losses, but personal observations and reports from hunters indicate that such losses must be about half the total number taken by hunters. If one considers the coyote population during any year in which the numbers at the beginning of whelping season approximate the numbers a year later, it is obvious that the year's loss equals the year's increase. For such a year we may derive a relationship between the adults (N) at whelping time, and the bounty payments (B) for the next year, if we consider natural

losses (R) in addition to bountied animals as part of the constant reduction of the population. Then, L x P x N/2 = B + R. As L, P, and R all vary from year to year, N will have different values in relation to B. If the average litter is 6.0, 48% of the females breed and R = 0.5B, then N = 1.04B, or the breeding stock approximates the bounties paid during the year. Natural losses (R) constitute the unknown variable by which the next year's breeding stock is regulated. If R is greater than average, fewer than the average number of coyotes will live through the year, or if R is low, more animals live through and the next year's increase is potentially above average. If, however, L = 4.5, P = 45, and R = 0.7B, then N = 1.68B, or there were 168 adult animals in the breeding population for each 100 animals bountied. If on the other extreme, L = 6.4, P = 75, and R = 0.3B, then N = 0.54B, or it was possible that there were only 54 adult animals to produce a harvest of 100 animals.

Obviously, the animals taken by man (B) plus natural losses (R) must equal the annual production, or the breeding population must fluctuate. The assumption by Errington (39, 40) and Presnall (41) that environmental factors will control the population has no bearing on the problem of coyote numbers because man has kept the coyote population below the carrying capacity of the land for nearly a century, and we have no factual information as to what the natural limit for Kansas would be. The increase in bounties in 1967 to 55,500 indicates that the limit has not yet been reached.

Area population. Application of the above formulae to calculate breeding stock and total populations presents no particular problems for the nine years plotted in Figure 30. This

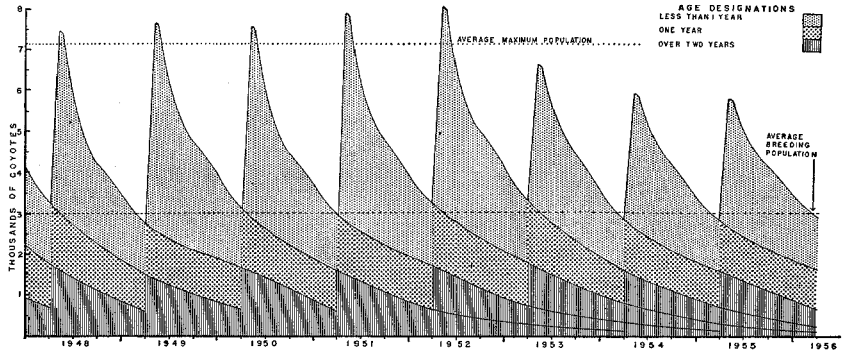


Fig. 30.—Population trends and composition as determined for a six-county area in northeastern Kansas (Marshall, Riley, Pottawatomie, Geary, Wabaunsee, and Morris Counties). These counties comprise 4282 square miles and supplied 68% of the coyote carcasses studied (Fig. 3). The age groups were determined as described in Figure 17, and the calculations for breeding populations, pup crop, and annual increase are shown in Table 10.

indicates an average breeding population of approximately 3,000 coyotes for the six-county area (4282 square miles) and a maximum population at the end of the whelping season of about 8,500. This means that there is an average during late winter of one adult coyote to each 1.5 square miles, with an average of one litter produced in each 6 square miles.

By similar calculations on a state basis, the average breeding population is 40,000 and the average maximum at the end of whelping season 100,000, with a litter produced for each 8 square miles. For some parts of the state, such as Wallace, Greeley, Atchison, and Cherokee Counties, that number is undoubtedly high. The breeding population that provided the 35,000 harvest in 1958 could have been as low as 22,000 under excellent reproductive conditions (L = 6.3, P = 70%, R = .4B) or as high as 70,000 under continuously adverse situations (L = 5, P = 45%, R = .6B). Similarly, breeding population that provided the 55,500 harvest in 1967 could have been as high as 100,000 under poor reproductive conditions (L = 4.5, P = 40%, R = .6B) or as low as 34,000 under good conditions (L = 6, P = 70%, R = .4B). Only a knowledge of the conditions existing at the time can give any basis for a decision as to what factors to use.

The same formulae can be applied to a county population with more definite results. Russell County, for example, paid bounties on 500 coyotes in 1953. Calculating from averages (L = 5.9, P = 0.48, increase = 1.5B), there would have been 530 adult coyotes in the county during the whelping season. A variation of 25% would not significantly change the problem nor the control measures necessary so far as population densities are concerned.

Concentrations of coyotes in some localities become extremely high (Table 11). For example, the hunt on the Fort Riley Reservation in 1948 covered 72 square miles, 20 of which had been recently burned. Fifty-six coyotes were killed on the hunt and at least 25 escaped through the lines. In January, 1949, a hunt in Marshall County covering 150 square miles resulted in a kill of 52 animals with "several" escaping. The next day after the hunt in Marshall County, a hunt in Riley County covering 64 square miles resulted in a kill of 24 coyotes. In March, 1953, during a circle hunt of 12 square miles in Riley County, near Stockdale, five coyotes were killed and 21 were reported by line captains as having been seen going through the lines. Kills of 12 to 20 coyotes in a 36-square-mile hunt are not uncommon, but coyote hunts usually cover the best coyote habitat in the vicinity and are not representative of the entire county.

Comparative populations. Both the observed and calculated populations in Kansas are high compared with reported populations. Seton (1) estimated that coyote populations ap-

proached one animal per square mile in 1898, calculated on the basis that not more than 20% of the animals could be killed and a stable population level maintained. This estimate is at least double the actual population, as it now seems probable that the regular take is at least 40% and possibly 50% of the maximum population.

Young (4) reported that Leonard F. Miller, by use of traps and strychnine, took 458 coyotes in the Hualpai Valley (900 square miles) in northwestern Arizona between April 9, 1945, and April 8, 1946. The Hualpai Valley is so enclosed by moun-

Table 11.—Success of coyote drives. Material for this table was selected to represent annual hunts, conducted by the same group over approximately the same area at comparable times in the year. Note the consistent drop in kill from 1950 to 1954.

Place of hunt (county)	Date	Coyotes killed	Area (square miles)	Number men
Clay	1-1-50	22	49	1,000
Clay	1-1-51	4	36	500
Clay	1-26-52	11	64	700
Clay	1-27-52	12	72	600
Clay	2-4-51	10	36	250
Marshall	1-22-50	52	150	3,000
Marshall	1-24-51	43	150	1,500
Marshall	1-20-52	33	150	1,200
Marshall	1-24-53	23	150	1,000
Marshall	1-31-54	19	150	2,000
Marshall	1-29-56	9	150	800
Morris	3-13-49	11	36	700
Morris	1-21-50	23	36	800
Morris	1-14-51	11	49	550
Morris	1-27-52	7	49	300
Morris	1-25-53	12	49	200
Morris	1-17-54	4	36	225
Morris	2-5-50	11	36	300
Morris	2-22-53	6	36	250
Morris	1-3-54	11	36	350
Morris	1-1-56	9	36	400
Riley	3-5-50	4	9	300
Riley	2-11-51	9	30	500
Riley	3-16-52	6	36	700
Riley	3-15-53	4	16	300
Wabaunsee	3-27-49	9	48	400
Wabaunsee	2-20-50	14	36	500
Wabaunsee	2-14-54	10	64	500
Wabaunsee	2-13-55	6	64	500
Wabaunsee	2-12-56	4	64	400
Washington	1-23-50	24	64	1,000
Washington	1-19-51	12	64	400
Washington	11-24-55	19	49	700
Washington	11-22-56	9	49	600
Fort Riley Reservation	2-22-48	56	72	2,500
Fort Riley Reservation	3-8-53	17	40	1,500
Total		546	2,261	27,425
Average		15	63	765

tains that drift into the area is not great. A. B. Bynum (4), with 325 cyanide guns, took 536 coyotes in 375 square miles in Maverick County, Texas, during October, 1946. Three months later, he took 340 coyotes in 255 square miles within the original area. There were no barriers around the area that would exclude coyotes from surrounding areas, so part of the first and most of the second catch could have been nonresident coyotes.

Fichter (13) reported that 70 counties comprising 58,653 square miles, or 76% of the state of Nebraska, paid bounties on 67,639 coyotes during three years, 1948-50. This is an annual average of 38.4 coyotes for each 100 square miles. In a six-county area in central Nebraska, an annual average of 69 coyotes was bountied per 100 square miles, while the two counties within the study area bountied 78.4 coyotes per 100 square miles. On the basis of the present report, the Nebraska data may be interpreted to indicate a fall population of 60-65 coyotes per 100 square miles, and a study-area concentration of 100-115 coyotes per 100 square miles. Bennitt (37) estimated that in the area of Missouri with the highest coyote density—the midwestern section of the state—there was one coyote for each 1.77 square miles.

Comparison of regional bounties. The number of bounties paid in Nebraska, by counties, 1960 and 1961, was made available through the courtesy of Mr. Ken Johnson, Assistant Chief, Game Division, Nebraska Game, Forestation and Parks Commission. During the two years, bounties were paid on 35,585 coyotes at $2.50 each. Sixty-six counties paid both years, seven paid one of the two years, and 18 paid no bounties, for 76% coverage. During the same two years, Kansas paid bounties on 71,903 with a 76% county coverage. As Kansas and Nebraska encompass approximately the same area, there were twice as many coyotes presented for bounty in Kansas as in Nebraska. A closer look at the bounties from adjacent counties in Kansas and Nebraska, however, shows greater similarities. During the two years, in Nebraska only Hitchcock County failed to pay bounties one year, and the 13 Nebraska counties directly adjoining Kansas paid bounties on 12,046 coyotes while adjacent counties in Kansas paid 10,221 bounties, with Republic and Marshall counties failing to pay one year. The bounties **paid** in the two tiers of counties averaged 71 per 100 square miles in Nebraska and 59 per 100 square miles in Kansas. The difference in bounty pay, $2 in Kansas, $2.50 in Nebraska, is not enough to entice any appreciable movement of scalps across the state line, so in those two years, it must be concluded, there were a few more coyotes in southern Nebraska than in northern Kansas.

Comparisons with Missouri bounty payments provide basis for more definite conclusions. Data on Missouri bounties were obtained from the Missouri Fur Bearer Studies provided by

Frank W. Sampson, Game Research Biologist, Missouri Department of Conservation. Total coyote bounties paid in Missouri for the past 20 years (Fig. 31) show fluctuations from 4,700 to 11,300 that closely parallel the much greater number of bounties paid in Kansas. The major discrepancies occurred in 1952, 1960 and 1962. In 1952, Missouri attempted an eradication program with a $30 bounty, and although some counties paid no more than $15 per scalp, there was an unmistakable flow of coyotes from Kansas to Missouri. If the estimated 1000 Kansas coyote scalps were subtracted from the Missouri total and added to the Kansas total for the year, there would appear a slight increase in bounties in both states. In 1960, there was a definite increase in coyote numbers in Kansas, but 30 counties failed to pay any bounties and 14 paid only half of the year. If the unbountied coyote kill from those 44 counties was added to the tabulations, the Kansas record would have shown a peak similar to that in Missouri. The drop in bounties in Missouri in 1961-62 has no obvious explanation, nor does the drop in Kansas bounties in 1965, but since 1962 there has been a con-

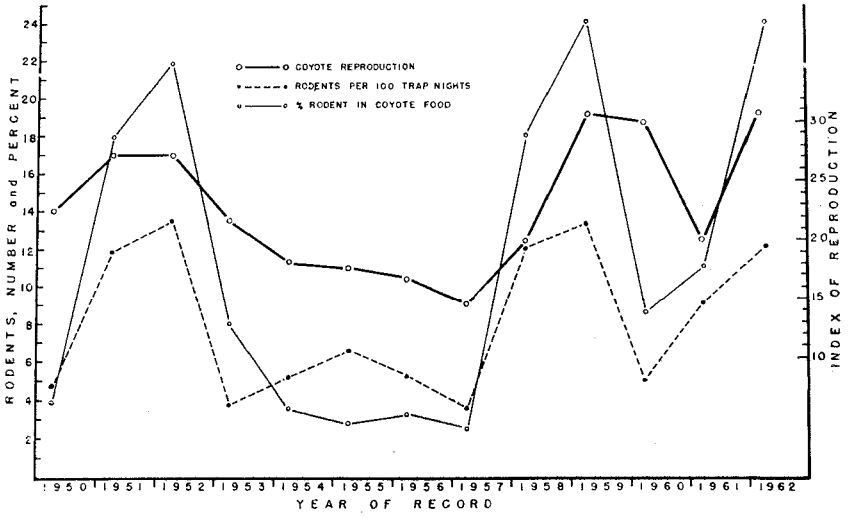


Fig. 31.—Correlation of rodents caught in trap lines, rodents in coyote food and index of coyote reproduction. The dotted line represents rodents caught per trap night in the Manhattan area during the given winters and designated with March as the end of winter. Rodent in coyote food is given as percent of weight of rodents in stomach contents for the winter preceding the reproductive season. The index of coyote reproduction, designated by the heavy line, is calculated as percent of females reproducing multiplied by the average litter size. Slight variations between rodents in coyote food and rodents trapped may reflect our selection of the best habitats for trapping. Undoubtedly there are other factors involved in establishing the reproductive index but the parallel between reproductive index and available rodents undoubtedly bears a causative relationship.

tinuous increase in coyote populations in both states to an all-time high in 1967.

Analysis of adjacent county bounties for Missouri and Kansas shows that Kansas counties consistently pay two to three times as many bounties as the counties directly across the Missouri River, but comparable numbers in the counties south of the river. In 1965, the six Kansas counties adjoining Missouri paid 1501 bounties while the adjacent six Missouri counties paid 1454. In 1966, the numbers were 1722 and 2039 respectively. It is odd that the next tier of counties west in-

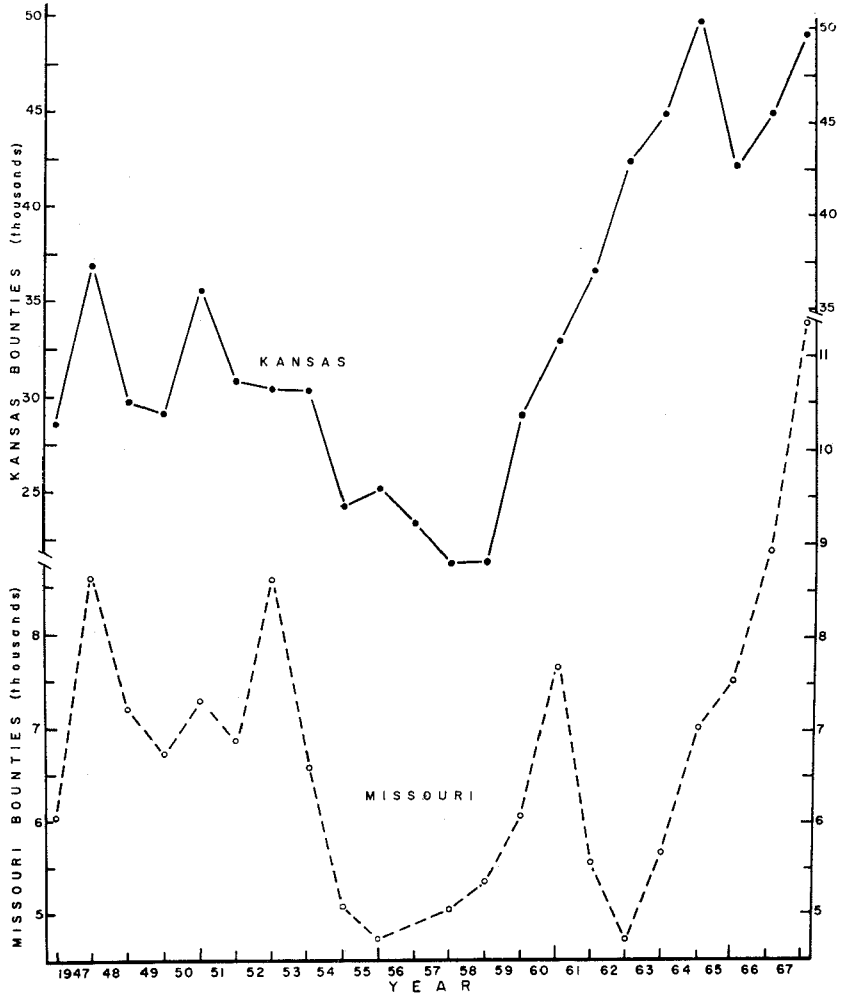


Fig. 32.—Bounties paid in Kansas and Missouri, 1947-1967. Closely parallel payments in the two states are remarkable.

creased from 2101 in 1966 to 2635 in 1967 (25%) while the tier adjoining Missouri increased by 15% and the Missouri counties increased by 40%. Both the payments and local rumors indicate considerable movement of scalps, even for the $5 or $6 bounties paid by most of Missouri counties adjoining Kansas. Jackson County, Missouri, stands out as a special case, with over twice the bounties paid by adjoining Johnson County, Kansas, reflecting the practical difference between $15 and $2 bounties. Jackson County, even though not a particularly good coyote habitat, is ideally situated for traffic.

Comparisons of bounties with adjoining states strengthen the concept that coyote scalps are presented for bounty in proportion to the number of coyotes present, and so bounties represent a usable index of actual populations. Local variations due to specific habitat changes, hunter attitudes, or movement of scalps for bounty differential become of little consequence when a greater region is considered.

In Kansas, with equal bounties on pups and adult coyotes, the number of pups bountied has been maintained consistently at about 40% of the total bounties paid. In Missouri, before 1950, pup bounty payments were one-third to one-half those for adult coyotes, and the number of pups fluctuated from 38 to 45% of the total bounty payments. With the authorized increase of bounties on adult coyotes to $30 in 1951, reduced to $15 in 1952, the bounty on pups was frozen at $2.50. The result has been an almost total elimination of pups from the bounty payments, with only 7 to 8% of the total bounties on pups. Many of the coyote hunters in both states refuse to kill coyote bitches after February or coyote pups on the premise that those animals provide the sport (and bounty) for the next year.

Reproduction rate and populations. From the material given on reproduction and on populations, it becomes increasingly clear that the number of coyotes present any one year depends as much on the immediate condition existing during the breeding and whelping seasons as on the number of coyotes surviving from previous years. For example, if 40,000 coyotes survive until breeding season but only 40% breed and the average litter is 4.2, fewer pups are whelped than would result from 60% of 20,000 producing litters of 6.3. If, however, 40,000 coyotes survived and conditions were good during the breeding and whelping season, an excessive production could result!

Reproductive success or failure in any one season is determined by many factors. These factors may be grouped under three headings: (1) climatic factors, (2) parasites and disease, and (3) food supply.

Climatic factors within the range of those found in Kansas have not been observed to directly affect the health of coyotes. The most important climatic factors with respect to reproduction are those that regulate food and parasites. Any period of

persistent snow reduces the food supply and so may weaken the animals by partial starvation. Long-continued chilly, damp weather may bring on conditions that would be favorable for respiratory diseases, including distemper. Cloudy, damp weather during the spring particularly favors hookworms and to a lesser extent may favor the spread of ascarid worms. Any of these climatic conditions coupled with a poor food supply can, theoretically at least, have serious effects on reproduction and on pup survival.

Parasites and disease have a double limiting action on reproduction: first on the adult, and later on the pups. Factors that reduce the vitality of the female also reduce the probability of breeding and the number and strength of the pups.

Distemper or similar diseases during the fall months definitely precluded reproduction the following season in laboratory coyotes, and probably does likewise among the wild.

Larvae of hookworms and roundworms of the genera **Ancylostoma** and **Toxocara** pass through the placentae of dogs, thus infecting the embryos in the uterus and destroying many pups during the first month after birth (38). Although we have not identified **Toxocara** in coyotes, hookworms are prevalent enough that some pup loss must occur by intrauterine infection. **Toxascaris** (Fig. 23) kills dog pups and coyote pups in the laboratory by packing the gut, and **Physaloptera** (Fig. 23) weakens or kills pups by drawing blood and inducing lesions in the stomach lining. Both of these worms, found in considerable numbers in coyote pups, probably account directly or indirectly for pup losses.

Food supply is probably the most important factor in determination of breeding success of coyotes in Kansas. The condition of the adult animals as they enter the breeding season determines the proportion of females that will breed and the number of ova produced by the ovaries. Environmental factors, along with available food and incidence of parasites, determine intrauterine losses and survival rate of the pups. A correlation of stomach contents, rodent trapping success, and reproductive success (Fig. 32) indicates that a high population of rodents and/or rabbits insures the necessary food for proper reproduction and pup survival.

The correlation between reproductive success and availability of rodents over the 15 years of this study has been extremely high (Fig. 32). When rodent remains constituted less than 3% of the stomach contents during the winter, none of the yearling females bred, and as few as 60% of the old females produced young. In winters when rodents constituted 5% or more of the stomach contents, one half or more of the yearling females and up to 80% of the old females produced litters.

The litters produced during good "mouse years" averaged

5.8 to 6.2 young per litter, while those in poor "mouse years" averaged between 5.4 and 4.4. There was no evidence during the years of poor reproduction that there was any general malnutrition—the average weight of adults did not vary more than half a pound from the average weights during good reproductive years and the animals appeared to be in good condition.

Without mice in their diets, however, regardless of apparent condition, ovulation was short or lacking and there was a greater than usual death of embryos in the uterus. Whether or not there is a stimulating factor in the mice, such as vitamin B from the contents of the mouse stomach, or whether the coyotes are only responding to the same factors that stimulate mouse reproduction has not been proved. However, it is clear that carrion, or even rabbit, does not provide the necessary stimulus for full reproduction.

A scarcity of both rodents and rabbits throws more coyote stress on carrion and livestock. Usually there is not enough carrion in Kansas to feed many of the coyotes present. When there are not enough rodents, rabbits, or carrion for all coyotes, they then seek farmyard animals, which increases efforts of man to destroy coyotes. However one looks at the situation, the results are the same; when rodents and rabbits are scarce, coyote numbers are reduced. So as rodents increase, coyotes will increase proportionally during the next breeding season. With the possibility of 75% of all the females producing litters, the increase can be tremendous.

The balance of nature. From the material given in the preceding pages, a clearer concept of the place of coyotes in the "balance of nature" may be forthcoming. If the rodent or rabbit population increases during the summer and remains high through the fall and winter, many of the coyotes turn to this source of food, resulting in fewer domestic animals killed and hunting pressure on the coyotes reduced.

Proper food during the winter results in large litters from a high proportion of the coyotes and, if the food supply holds out, a high survival of pups is probable. As long as climatic conditions and the food supply permit, both the reproductive rate and survival are high and the population continues to increase year after year. However, neither rabbits nor rodents maintain high populations for more than three consecutive years. **If both rodents and rabbits hit the "low" in their cycles at the same time, a high population of coyotes will be left without adequate food supply and they are thrown again onto carrion and domestic animals for sustenance.** This condition results in increased hunting pressure, and, within the year, in a reduced birth rate and greater mortality among the young, again bringing the coyote population in line with the available food supply after several months lag.

INTERCOMPENSATIONS

With present knowledge, it is not safe to neglect the principle of "population intercompensations" propounded so ably by Errington (22, 39, 40). The principle is: as animals are removed from a population, the remainder find living easier and reproduce more abundantly; excess population is doomed and if not removed by predators will succumb to diseases or interspecific strife. Errington has shown that in muskrat colonies reproduction is repressed to one or two litters a year when the animals are overcrowded. Removal of a high proportion of the animals by trapping, predation, drought, or disease results in high production the following year to such an extent that the population at the end of the breeding season is essentially constant regardless of the early spring population, habitat permitting. The fall population is usually in excess of the winter habitat capacity, or at times the winter survival exceeds the breeding space. The excess succumbs to starvation, predation, disease, or interspecific strife to the level that can live in that habitat. The means by which the reduction occurs is of no consequence; if predators do not remove the excess, some other factor will. Errington considers predation usually to be incidental and only an aid to the general reduction that will occur.

Just how far the principle of intercompensations applies to coyotes is not clear. Some biologists (41, 42) insist that the "take" of predators represents only surplus animals that would have succumbed to natural enemies before the end of the year, and hence bounties and other general population control measures are of no avail. Similarly, it has been argued (43) that rodents and rabbits removed by coyotes and other predators are of no consequence, because they are doomed to destruction anyway. Such an interpretation is violently contradicted by recent studies of rodent populations in Europe in which Frank (44) showed that **in absence of control by predation**, population fluctuations are extreme.

With the present knowledge of the principle of intercompensations, it would be foolhardy to either condemn the predators to extinction or to relax population control measures until their interrelationships are more thoroughly understood. The wrong action in either direction would be extremely costly in terms of future control of rabbits and rodents on the one hand or excess predators on the other. Reduction of populations certainly should be attempted wherever the number of coyotes is excessive in relation to the natural food supply.

LIMITING FACTORS FOR POPULATIONS

Errington (38) has been rather specific in his statements that natural factors, other than contagious diseases, interact to remove excess populations and are effective in repressing reproduction only as the population nears the limit of cover,

food, or crowding tolerance. Cover for coyotes is abundantly present in most parts of Kansas. The effects of food on reproduction have been previously discussed.

Tolerance of one coyote or a pair of coyotes for others of their kind is not known. However, when the coyote population in the Fort Riley Military Reservation exceeded one coyote per square mile during late winter while surrounding areas supported less than half that concentration, crowding obviously was not the limiting factor. In this and other instances, in undisturbed areas, local concentrations of a pair of coyotes per square mile have been observed—at least twice any general population concentration. In the laboratory (close confinement) coyote males are extremely intolerant of other males during breeding season, and bitches likewise are intolerant of other bitches. Some male coyotes were tolerant of pups, others were not. All bitches observed were solicitous of their own pups but killed all other pups possible. This behavior was so consistent in laboratory coyotes that it must have a natural basis.

Home ranges of coyotes have not been adequately studied, but there must be a space limitation closer than which one pair of coyotes will not tolerate the encroachment of another pair. Whether this limit is a half mile or a mile or variable according to conditions of food and cover will remain for future investigations. Although there may be some internal strife and some pups killed by other coyotes under conditions nearing habitat saturation, it is doubtful that this factor plays any considerable part in limiting breeding populations to less than one coyote per square mile.

The real limiting factors in coyote populations under present conditions, then, are: (1) food supply determines litter size and the proportion of females that will breed; (2) parasites, disease, and internal strife remove a certain amount of excess population; and (3) man removes coyotes selectively or en masse to make the final determination of how many coyotes are left at breeding time.

If part of the money and effort being expended at present for mass reduction of coyotes were to be properly directed, coyotes could become a real asset in rodent-rabbit control rather than a controversial "he is good-he is bad" creature. To effect such results, first a reasonably workable system must be established for determining coyote numbers—not just damage done. Second, a similar survey of natural food for coyotes (rodent-rabbit population studies) must be conducted continuously. Lastly, a control system must be maintained for continuous removal of coyotes that become "killers" of domestic livestock and for general population reduction at critical times. With such information available, decisions could be properly derived whether to protect or reduce the coyote population that year.

CONTROL OF COYOTES

This section deals with specific control measures, including when, where, and how they should be applied. Man has the power to control damage; to regulate the extent of overpopulation; and, with such control, limit damage that results from consecutively "good years" for coyote survival. Men who are to control losses and populations, however, should understand the principles involved, not merely how to kill coyotes. The first principle is that "control" implies a selective regulation of individuals and numbers such that their damage does not exceed their value. "Control" does not necessitate extinction or even drastic reduction of the animals involved, in most cases.

Natural factors such as disease, parasites, internal strife, and lack of food continually function to reduce the number of coyotes, and, in a measure, reduce losses by eliminating part of the population. On the other hand, lack of natural food turns coyotes to domestic animals for sustenance. Whenever the coyote population exceeds the food supply, man must either reduce that population or suffer the losses that may result. **More important, in many cases, is the destruction of habitual or consistent "killer" coyotes that repeatedly raid farmers' stock pens.**

Although there is little dissension on the necessity for control, there has been continued controversy as to the best method and the extent of control. A critical review of methods is in order.

BOUNTIES

History. The need to control coyotes was recognized early in Kansas, and the killing of coyotes was encouraged by bounties. In 1877 a law was enacted by the Kansas legislature requiring County Commissioners to issue county warrants for extermination of wild animals—$1 for each coyote, wolf, wildcat, or fox, and 5 cents for each rabbit. In 1885, the bounty was changed to $3 for coyotes and wolves and payment made optional with the County Commissioners. In 1904, Lantz (3) found that 94 counties were paying bounties, 10 were not paying, and one did not reply to his questionnaire. In 1907, the bounty payment was again made compulsory, at $1 for each wolf or coyote. In 1941, the state legislature appropriated $25,000 to pay bounties at the rate of $1 for each coyote to aid in eradication of coyotes. State funds were reappropriated yearly and used by the counties in lieu of county funds.

The authorized bounty continued at $1 until 1949, when Senate Bill 169 raised it to $2 per scalp, half of which was to be paid from the county treasury and half from state funds. There has been repeated agitation to raise the bounty to $5

or even to $10 on the assumption that a higher bounty would result in more active hunting of coyotes. Authorization for increased bounty was not given until the 1957 legislature which made optional with the County Commissioners payment of coyote bounties up to $5, but held the state bounty to $1. During the period (1954-1960) of relatively few coyotes, progressively more counties ignored the mandate to pay bounties until by the end of 1960, 56 counties had revoked the bounty. The subject of bounties was seriously debated by the Kansas legislature in 1961, and bounties were reinstated in all but four counties during the year. A few counties again stopped payments in 1966 and 1967.

The numbers of bounties paid from 1943 through 1962 are shown in Figure 23. In those 20 years, bounties were paid on more than 600,000 coyotes. If we may estimate from partial data, annual bounty payments have averaged 25,000 for nearly 70 years.

Not adequate control. Bounties alone do not constitute an effective control measure. Even at $35 per scalp, the number of coyotes increased consistently in Michigan (45). The $30 bounty attempted by Missouri in 1952 proved to be too great a drain on the public purse, encouraged too much fraud, and was not effective in reducing losses. After one year that bounty was reduced to $15, which still seems excessive. Such bounties stimulate coyote hunting but result in taking mainly the young unwary animals.

Much hunting and some trapping would be done without a bounty. However, pup hunting is specifically for the bounty, and some trap lines and "gas-gun" sets are maintained with the idea that the bounty will pay the major expenses of the sets. Without these deterrents, there are possibilities of coyote populations increasing beyond reasonable limits. Natural factors **might** maintain a balance comparable to that existing at the present time, but few persons who take the brunt of the losses are willing to chance that possibility.

Bounties as a means of controlling predators have fallen into disrepute during recent years and have been abandoned in many states (46). In all cases of abandonment of bounties, other means, usually much more expensive, have been substituted, either in the form of state trappers or federal control. In both Michigan and Missouri, the state "extension trapper" system is functioning, on top of an excessive bounty, so those two states have an overall population control about as great as bounties can provide, plus specific "killer" control. Too many proponents of the extension trapper system ignore the bounty effects and consider only the "killer" control as influential. Yet no "killer" control system has been successful in any state without some numerical control.

DEN HUNTING

Den hunting has proved to be the most effective, least expensive, and most extensively practiced way to reduce coyote numbers (47). Questionnaires to bounty recipients in Chautauqua, Greenwood, and Washington Counties established that in April, May, and June of 1950, 78% of the bounties were paid on pups. Records kept by clerks of 45 counties (Table 9) showed 69% of the bounties paid in April, May, and June, 1951, were on pups. Calculations for the entire state on this basis indicate that approximately 11,000 coyote pups were turned in for bounty in 1951. Just what effect the removal of that many pups has on the total population for the following winter can only be estimated, but information available indicates that despite a considerable natural loss of pups, **such removal is worth while when it is necessary to reduce an excessive number of the animals.**

Skill required. As with all other kinds of hunting, certain skills are involved in locating coyotes' dens. Any hunter who knows his community can have most of the dens located by the end of March. Regular locations for dens were described in the section on reproduction. Dens of poultry-killing coyotes are easily identified by the presence of feathers, but sheep-killers rarely leave comparable evidence around dens.

Active pup hunting should not begin before the middle of April and can continue throughout May. Dens that previously have shown signs of activity may be checked at intervals of not to exceed two weeks. These checks should be made from horse or motor vehicle, as tampering with the den frequently results in the bitch abandoning the den even if moving the pups is involved. A well-worn opening with fresh signs is sufficient justification for closer examination.

If the dens of an area have not been previously located, or if the bitch prepares a new den at whelping time, all likely den sites should be investigated. A horse and a small dog are excellent adjuncts in this search. The hunter can see new diggings farther from horseback than he can when on foot, and a small dog that will range widely is excellent to attract coyotes. One or both of the coyote pair almost invariably will chase a small dog away from the den area, but they are much less likely to chase a larger dog or a dog that stays close to the hunter. Once the general locale of the den is established, an intense search of the area usually reveals the den or nest.

An occupied den. When a prospective den has been located, presence or absence of pups can usually be determined by closer examination. If the den is in use, there will be fresh tracks around and in the den. Regularly there can be found clumps of fur that were scraped from the bitch as she went in and out of the opening.

During the first few weeks of life, the pups are rarely quiet for many minutes at a time. They whine, growl, or grunt on the least provocation. Any disturbance outside the den is likely to start a new series of commotions within. A rhythmic thumping at the den opening has been reported to be particularly effective in arousing pups.

After the pups are about three weeks old, they often will come to the opening to investigate unusual noises, but they are easily frightened. Also at about this same age, pups come out of the den and range farther from the den daily, leaving tracks, shredded vegetation, droppings, and, at times, bones or other fragments of food. If the "signs" are read carefully, much time and energy can be saved in not digging unoccupied dens.

Extraction. In many cases it is not necessary to destroy the den to get the pups. Some dens extend only 3 or 4 feet horizontally and are unbranched. The pups can usually be seen or heard and may be extracted from such a den by twisting a split stick or a length of barbed wire in the den and entangling the fur. A length of wire cable frayed on the end makes an excellent "extractor" (4). If the old coyote is in the den, she usually will bite at anything pushed into the hole and so make her presence known. If the hole is straight, she may be shot and then dragged out; otherwise, digging is necessary.

When an active den is located, it should not be left until the pups have been removed, unless it is possible to completely block all openings. Some coyotes will not return to the den for several hours after it has been investigated, but most of them will remove the pups from the den as soon as the intruder leaves. Pups under five weeks old are carried, one by one, to a new hiding place—a few yards or a mile from the disturbed den. Older pups may be called out and persuaded to follow the parent to the new location. In any case, a den that has been discovered to contain pups is likely to have no pups in it within an hour if left unattended.

Before digging is begun, a careful search should be made for a secondary exit. If a "back door" is present, it should be closely watched by a man with a gun, steel traps set in the opening, or the opening solidly blocked. An adult coyote in a den is likely to make a break for freedom soon after digging starts, although in some instances she remains with the pups until the top is dug off the nest. As soon as the nest is opened, the old coyote and the pups, if they are old enough, explode from the den and scatter. Usually a stout club is adequate for dispatching the pups, but a shotgun is quite essential for the old animals.

Smoking pups out of the dens has not proved satisfactory, although a few hunters have reported success. As the pups

ordinarily will not pass the source of the smoke, the only way to get them out is with a commercial smoke bomb that can be pushed to the back of the den, or by attaching a tube, such as a garden hose, to the smoker and pushing the tube to the back of the den. Sulphur on burlap or old cloth in a bellows smoker seems to get the best results. Even then some of the pups may get in a side passage and not come out. Pups driven from the nest by smoke are likely to come to the opening of the den, see the hunter, and disappear again into the den.

Coyotes may be killed by cyanide or motor exhaust in dens that cannot be dug. Cyanide, in the form of calcium cyanide or sodium cyanide powder, may be placed in the den, the opening sealed airtight, and left to finish the job. **Cyanide in any form is extremely dangerous and should be used cautiously.** Exhaust can be used from any gasoline motor by running a hose from the exhaust pipe to the back end of the den. This is nearly as effective as cyanide.

Catching adults. The parent coyotes that escape usually return within 24 hours, perhaps within an hour after the hunters leave. They may be caught by steel traps set around the original opening. Several blind sets should be made, in the path, on the mound of diggings, or at a scent post (see p. 98). A pup buried with one foot sticking out is excellent bait for catching the parents.

SPORT HUNTING

Next to den hunting, the various forms of hunting for the satisfaction of the chase or making the kill regularly account for the largest take of coyotes in Kansas. Although there are some persistent hunters, in general all forms of sport hunting are self-regulatory. When there are many animals to hunt, there are many hunters, but when coyotes are scarce, few people hunt for them.

Organized hunts accounted for an average of 8,000 mature coyotes each winter in Kansas 1948 to 1954. In the eastern half of the state, these organized hunts regularly take the form of a "circle hunt," commonly called a "wolf hunt" or "coyote drive." In some localities, as Crawford and Wabaunsee Counties, organized hunt-clubs sponsored a hunt nearly every Sunday throughout January and February, possibly beginning as early as Thanksgiving Day and continuing as late as Easter Sunday. In most of the counties, however, the hunt enthusiasts are able to stimulate only a few hunts during the winter.

Successful circle hunts may be conducted on any size area from one square mile to half a county, if the organization and number of hunters are sufficient. Inexperienced groups have greatest success on hunts of 3 to 6 miles square. Experienced hunting groups may prefer two or three small hunts

during the same day, while others get ambitious and go all out on hunts covering 10 or 12 miles on a side. Small hunts require perfect organization and timing. Oversized hunts require many men and close line supervision. Either must be well organized to be more than moderately successful, and a failure usually means the end of such hunts in that community for the season.

Organization. For a successful hunt, a good area where coyotes are known to frequent should be selected. The area must have passable roads most of the way around and must not include uncrossable streams, extensive woodlands, or heavy brush.

An organizational meeting is desirable at which farmers and sportsmen who know the area can be briefed on the plan of the hunt and discuss problems that may arise. At this meeting, line captains should be appointed, and the necessity of maintaining evenly spaced lines stressed. If the meeting is no more than a pep meeting, it usually is worth the time and effort.

Transportation, preferably trucks, must be arranged, with meeting place and time for assembly set. Permission of the landowners is always desirable.[10] As hunters are essential to the success of the hunt, an extensive advertising campaign is usually necessary—newspapers, radio, and handbills are effective.

At the appointed time, the hunters should be loaded into trucks, and distributed evenly all around the area. To be effective, the line must have hunters at not more than 100-yard intervals. In tall grass or brush, the spacing must be closer. Any line with guns more than 150 yards apart is not a "line" and cannot be considered as a good start on a hunt. Some coyotes will break from cover when the hunters are too far away to shoot, but others "freeze" until the "line" passes and then break for freedom behind the hunters.

As the hunters move in, the lines are shortened and, if properly supervised, the lines that were too open on the start can be made more compact and continuously more effective. There is always a tendency for hunters to group at the corners even to the extent of leaving large gaps in the middle of the lines. Line supervision is best done by a coordinator in a small plane with a loudspeaker; line captains on horses can do an effective job of directing the lines, but line captains on foot must know the terrain and the men to do more than add confusion.

Rifles should be barred from all "drives" and shotguns should carry no larger than "0" shot. Number 2 shot in a 12-

10. Kansas laws (32-138) make hunting without permission of the landowner a misdemeanor, even though another law (32-158) includes "Provided, it shall not be unlawful to chase, trap, or take coyotes, moles, or gophers at any time."

or 16-gauge shotgun is the most satisfactory load both for safety and effective killing of coyotes.

Costly control. The drive method of hunting is one of the most costly methods of "control." Table 11 shows that it takes an average of 50 men on such a hunt to kill one coyote. Actually, this is low because unsuccessful hunts were omitted. If the hunt costs each hunter $3, which is conservative considering transportation, ammunition, and equipment, each coyote costs $150. Despite the cost, the hunts are popular social events.

Organized hunts waste wildlife resources, as too many hunters shoot at any hawk, owl, rabbit, pheasant, or quail that comes within range. In many cases the destruction of beneficial predators and game birds exceeds the damage the coyotes were doing. Many "organized" hunts also result in broken fences, scattered livestock, and dead poultry when so-called "sportsmen" show no respect for farmers' property.

Organized coyote hunts were popular from 1945 through 1954, with as many as three separate hunts occurring in a county on a holiday from January 1 to April 1. The popularity of hunts decreased rapidly after 1953. Many announced hunts were cancelled or drastically modified for lack of man power. Although such hunts were conducted in every part of Kansas, they have never been so common in western as in eastern Kansas. Few "circle hunts" have been conducted since 1960.

Round-up hunts involving hunters armed with clubs, whether on foot or horseback, with or without dogs, have no place in coyote control. They must be recognized as social or sporting events, and the coyotes killed as incidental.

Hunting with dogs is a favorite sport with many ranchers, farmers, and urban sportsmen, and regularly results in destruction of 3,000 to 5,000 coyotes a year in Kansas. This was the chief control in western Kansas until mass poisoning. It still is practiced extensively where poisoning has not been used, and has returned to near its original popularity in counties that have abandoned mass poisoning. Hunting coyotes with dogs is a sport that aids materially in keeping coyote populations under control (Fig. 33).

Some prefer to use trail hounds—"walkers" being the most popular—which can be released in a likely area to find a recent trail. These hounds can follow the trail best on snow or moist ground. They have great difficulty keeping a trail on dusty fields. Some packs are quite successful in catching coyotes, many owners reporting kills on nearly every hunt. Some of the hunters who are most successful in killing coyotes follow the dogs in a car, then maneuver into position and shoot the coyote ahead of the packs.

Some prefer coursing or sight hounds, principally grey-

hounds and wolfhounds. These dogs usually are hauled in specially prepared cars and released only after a coyote has been seen. In some instances the driver of the "coyote wagon" drives over likely territory until a coyote is flushed.

Some hunters use a light plane to spot the coyotes and inform the driver of the location. Others use trail hounds to locate the coyote, then discharge the coursers to make the kill. Although some dog packs kill only a few coyotes annually, others are extremely efficient in catching large numbers of coyotes or in destroying specific wrongdoers (Table 12).

The cost of keeping a hunting dog averages at least $50 per year. Considering that most of the dogs cost the owner up to

Fig. 33.—(Upper) A coyote-chasing club with a week's catch. This group, composed of Harold Wolters, Walker Rexpoat, Floyd Brumbaugh, Laverle Walters, Russel Wolters and Chet Tetlow of Portis, Kansas, are probably the leading coyote hunters in the state. They account for at least 200 coyotes each year, and have caught more than 6000 coyotes in the past 25 years. (Photo by Smith County Pioneer.)

(Lower). Typical ending of a round-up or circle hunt (photo loaned by Fred Geyer, Pittsburg).

$400 each by the time they are old enough to join the chase, and that the "coyote wagon" costs must be added, coyote hunting with dogs is an expensive hobby. Most of the cost must be charged to sport rather than to coyote control.

Table 12.—Success of some of the leading coyote hunters using dog packs. Representative cases were selected from several hundred available to represent different parts of the state.

Pack owner	Location (county)	Year	Coyotes killed	Dogs No.	Dogs Kind	No. hunts	No. men
Ball, Raymond	Manhattan	50–51	36	6	trail	25	3
	Pottawatomie	51–52	30	7		30	3
		52–53	35	8		40	3
		53–54	27	6		35	3
		54–55	24	7		35	3
		55–56	26	5		40	3
Barnes, J. R.	Piedmont	50–51	14	3	sight	20	
	Greenwood	51–52	8	4			
		52–53	2	4			
Britt, James	White City	50–51	50	4	sight	30	2
	Morris	51–52	68	4–6		32	2
		52–53	28	4–6		28	2
		53–54	38	4–6		28	2
		54–55	44	4–5		27	2
		55–56	50	4–6		35	2
Burgess, Robert	Wheaton	50–51	16	3	trail	25	6
	Pottawatomie	51–52	53	5		30	5–10
		53–54	27	4		50	5–10
		54–55	45	3–4		50	5–10
		55–56	34	6		45	5–10
		56–57	57	7		40	5–12
Cheatum, F. M.	Syracuse	50–51	34	6	sight	30	2
	Wallace	54–55	8	3		12	2
		55–56	28	3		22	2
Gideon, Garland	Paxico	50–51	35	5	sight	35	3
	Wabaunsee	51–52	30	4		40	3
		52–53	60	4		40	3
		53–54	50	5		30	3
		54–55	35	4		50	3
		55–56	28	3		40	2
Kemble, Roy A.	Dover	54–55	60	12	sight	20	4
	Shawnee	55–56	80	16		20	4
		56–57	46	16		12	4
Voss, Louis	Densmore	49–50	102	3	sight	50	2
	Norton-Smith	50–51	63	4		40	2
		51–52	110	5		50	2
		52–53	120	6		55	2
		53–54	35	6		40	2
Wolters, L. O.	Portis	50–51	300	25	sight	75	6–8
	Osborne	51–52	400	25		75	6–8
		52–53	350	25		75	6–8
		53–54	300	25		75	6–8
		54–55	275	25		75	6–8
		55–56	250	25		75	6–8

Shooting coyotes from airplanes has been indulged in by a few pilots, but this sport has proved costly in planes and human lives. It is possible to spot coyotes readily from the air, and a good pilot can get close enough for a companion to shoot the animals with a shotgun. John Crow, Attica, and Charles Bevens, Summerfield, have reported kills of 15 in one day's hunt. Plane hunting has not increased in popularity, as was predicted a few years ago. Planes have a valuable function as an aid in directing lines in circle hunts and in spotting coyotes for chasing. Since 1960, increasing use of two-way radios between pilot and hunters has greatly improved the efficiency of both.

Sport shooting accounts for several hundred coyotes each year in Kansas. A common practice is to drive over areas where coyotes are known to be until one is sighted. By maneuvering carefully, one may bring the coyote within rifle range. When the coyote starts to run, a low whistle from the hunter may induce the animal to stop just long enough for a shot. A recently developed coyote call that sounds like a rabbit squealing has been reported to be effective in enticing coyotes within shooting range (48). Rifles of many kinds are used for such shooting: 22 hornets, 25's, 270's, 30-06's, and even army carbines and M-1's. All rifles should be confined to individual hunts and never be permitted on group hunts.

Various other methods of killing coyotes have been reported. Some men consider lariating coyotes from a horse to be the ultimate in sport. Others prefer to run the coyote down with a horse and finish him at close range with a stick or a pistol. Others delight in chasing coyotes with a jeep or stripped-down car. These methods of hunting may be good sport but play little part in the general control of coyotes.

TRAPS

Steel traps have long been the main instrument for capturing mammals either for furs or to eliminate damage. They still have an important place in the control of coyote damage. Long trap lines and professional trappers disappeared from Kansas only a few years ago when the price of furs made trapping unprofitable. Then the use of traps for control was greatly reduced. Although trapping is not as exciting as organized hunts or hunting with dogs, it is the most certain, safe, and economical method of coyote control.

An "extension trapper" program in Missouri the past several years (49) demonstrated repeatedly that only a few coyotes are responsible for most losses, and that the removal of the one or two killer coyotes in a community consistently stops the losses in the area when the coyote population density is relatively low. The offending coyotes are caught by studying the habits of the killers and setting traps specifically for them.

Other coyotes may be caught, but persistence with traps usually results in catching the offender within a few days or, at most, a few weeks.

Not complicated. Trapping coyotes in Kansas does not involve many of the complications encountered in sparsely inhabited areas. Coyotes in most of Kansas are accustomed to odors of men, machines, and rusting iron. Consequently, reasonable care against spreading unusual scents or introducing new scenery usually is sufficient precaution against arousing suspicions of the animals. Coyotes are inquisitive and playful, and cautiously investigate new objects and odors within their normal surroundings. These characteristics make the slightly unusual sets successful and eliminate the necessity of complete camouflage in preparing trap sets for most coyotes.

Scott's set. At present, there are relatively few successful coyote trappers in the state (Table 13). Some have devised simple and effective sets. For example, Pat Scott owned a farm in and above the Kaw River Valley, with low ridges extending, from the hills beyond, well into his tract. Coyotes came down from the hills and consistently threatened his poultry. Several years ago he started trapping to reduce his losses and found it easy and satisfactory. He used four or five double-spring No. 3 or 4 (No. 4 preferred) steel traps with short chains, all wired securely to an iron stake 2 to 4 feet long. After selecting the place for the set, the stake was driven solidly into the ground, leaving a few inches above the surface. The traps were then set around the stake, 15 to 18 inches out, and worked into the ground until they did not tip easily (Fig. 34, Upper). A dead chicken was wired to the stake, then a basket of litter from the chicken house carefully spread over the traps so that every trap was completely covered (Fig. 34, Middle). Heavy sticks that might prevent the traps from closing were eliminated

Table 13.—Results of trapping coyotes with steel traps.

Trapper	Address	Year	No. of sets	Traps per set	Total traps	Coyotes caught
Asbury, Earl	Winfield	50-51	15	3	45	65
Fechner, Karl	Manhattan	49-50	1	4	4	16
Fechner, Karl	Manhattan	50-51	1	4	4	7
Gideon, Garland	Paxico	50-51	4	3	12	29
Hall, John	Olathe	50-51	1	3	3	26
Sanders, Jay	Sedan	50-51	4	4	16	5
Scott, Pat	Manhattan	48-49	2	4	8	17
Scott, Pat	Manhattan	49-50	2	4	8	16
Scott, Pat	Manhattan	50-51	2	4	8	26
Scott, Pat	Manhattan	51-52	1	5	5	23
Scott, Pat	Manhattan	52-53	1	5	5	17
Scott, Pat	Manhattan	53-54	1	5	5	18
Sowell, Richard	Manhattan	50-51	1	3	3	8
Sturgis, Charles	Sedan	50-51	3	2	6	10
Walsh, Robert	Blue Rapids	53-54	20	2	40	32
Zolak, R. W.	Burden	50-51	16	2	32	16

from the cover. Such a set was maintained effectively on the ridge overlooking the chicken pens (Fig. 34, Bottom) from November to April for at least seven years with an average of 12 coyotes per year caught in this one set. Scott caught 97 coyotes in six years with rarely more than two sets at a time.

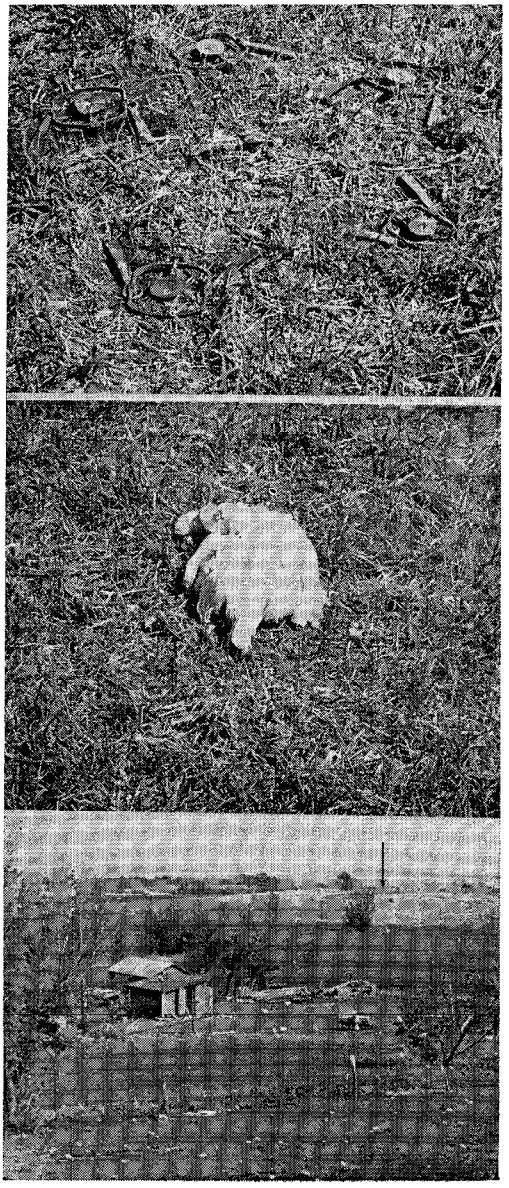


Fig. 34.—Pat Scott's steel-trap set in which 96 coyotes were caught in six winters. Top, 5 traps (No. 4 Victor, long-spring) set in a 3-foot circle around a steel stake with the chains all fastened securely to the stake. The traps must be worked into the ground enough so they sit solidly and will not tip if the jaw or spring is stepped on.

Center, The traps are covered with chicken house litter, care being taken that no sticks are in position to hold the jaws open when the trap is sprung. A dead chicken is tied to the stake so that it effectively covers the stake and so a coyote cannot walk off with it.

Coyote urine sprinkled around any part of the set may help attract coyotes. A light cover of straw over the bait will greatly reduce the number of hawks and owls caught.

Bottom, The knoll on which Scott maintained the set is indicated by the arrow. The knoll is approximately 200 yards from the chicken house and was apparently used by coyotes as a vantage point for reconnoitering before coming closer.

During this time he had few chickens taken, and most of those were lost when corn was planted close to the chicken pen.

Essentially the same set has been modified effectively by using horse manure, instead of chicken litter, and entrails of cattle, sheep, or hogs for bait. Sheep-chasing coyotes are more readily caught if the traps are covered with litter from the sheep barn and baited with some part of a sheep. In some instances, traps set on top of manure piles or shocks of hay have been successful with or without bait. Some trappers use only one or two traps in a set, on the premise that they catch more animals with the same number of traps if more sets are used.

Exposed baits are sometimes attractive to other predators, particularly great-horned owls and red-tailed hawks, both of which should be protected for their part in rodent control. If the bait is covered lightly, the birds will not be able to find it, yet it will be attractive to coyotes, as they locate food mostly by smell.

Summer trapping. If trapping is necessary during the summer to stop losses of chickens or sheep, a blind set may be made or live bait used. A lamb or a chicken in a cage is usually effective bait, and traps set around the cage often catch the animal that has been doing the damage. A live rooster, tied by one leg to the top of a 5- or 6-foot post, has been reported to attract coyotes that have cultivated a liking for chickens. Two or three traps, well concealed, about 2 feet from the post usually do the job.

Drags rather than stakes are preferred by some trappers to secure traps. A "drag" usually is a fence post or pole of similar size that will give when the coyote lunges and thus reduce his chances of pulling out of the trap. A trapped coyote is able to pull the "drag" away from the trap site, but, in so doing, gradually wears himself out so he quits struggling (Fig. 35C). In brushy areas, a drag hook may be preferable to a log. A satisfactory hook may be made from a 5-foot length of ⅜-inch iron rod doubled upon itself, with both ends curved to make an oversized, two-pronged fish hook (Fig. 35A). Drag hooks must be completely hidden (Fig. 35B).

Blind sets may be made successfully in trails where coyotes go through fences or regularly go to drink. They are best made at a natural "scent post." The "scent post" is a post, bush, weed, bone, or any other object that has been used as a urinal by coyotes. They are commonly found near watering places, cross trails, loafing places, old carcasses, or any other spot that is visited frequently by coyotes. Few coyotes will pass a "scent post" without stopping to investigate it. These "scent posts" can be located by the presence of dung, claw marks, or by disarranged vegetation. Dogs, particularly males,

also are attracted to coyote "scent posts" and may be used successfully in locating the spot.

A trap set at a "scent post" must be completely hidden and

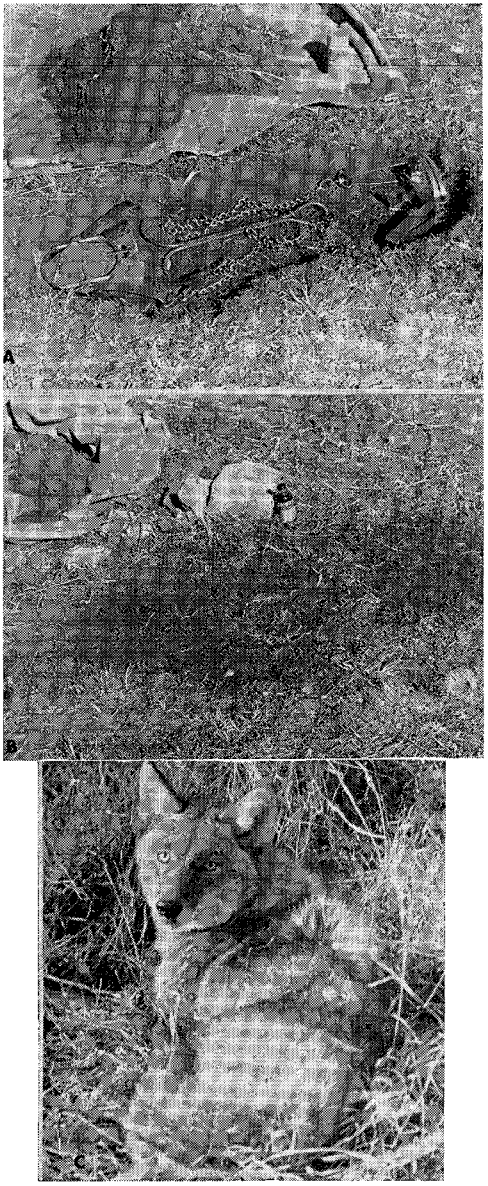


Fig. 35.—A blind set with traps anchored to a drag hook. Equipment needed for making this set includes: two No. 3 or No. 4 long-spring steel traps; a 4-inch square of canvas for a trigger pad; a drag hook made of a 5-foot length of ⅜-inch rod, or an adequate stake; a hand ax or hatchet; a garden trowel; a 3-foot square of canvas to kneel on while making the set and to pile the dirt on; a bottle of prepared scent or other suitable bait; and a sieve made of ⅛-inch hail screen through which the dirt may be sifted onto the traps, to remove clods, sticks, or stones that might prevent proper closure of the jaws.

A. A trench is dug about 30 inches long, 8 inches wide, and 2½ inches deep and all dirt placed on the canvas. The drag hook (some prefer a stake) is placed in the middle of the trench with a trap at each end. Traps must be set firmly so they will not tip. A pan pad of cloth or waxed paper is put over the trigger pan, as shown on trap at the left, so dirt cannot get under it.

B. Dirt is sifted over the traps and smoothed over with a stick or brush. Excess dirt, shown here on the canvas, is carried at least 20 yards away and scattered. The lure is then sprinkled on a stone, bone, or other object between but to the off-trail side of the traps. Some trappers have excellent success by burying a piece of rabbit, house cat, or other bait in a shallow pit on the off-trail side of the set.

C. Coyote caught in a blind set with trap on a drag. (Photo by Paul Anderson, Osage City.)

all signs of human disturbance removed if the set is to be successful. After the "scent post" is located, a hole about 30 inches long, 8 inches wide, and 2 inches deep is dug on the side of the "post" next to the trail (Fig. 35A). The drag hook is fitted into the bottom of the hole, the trap set in the hole, a "pan-pad" of canvas or waxed paper placed over the trap pan so that no dirt can get under the pan, then the entire trap covered with loose soil so that the pan and jaws are covered ¼ to ½ inch deep. The surface over the trap should be carefully smoothed to appear as natural as possible, and all excess dirt removed from the immediate vicinity (Fig. 35B). The "scent post" may be made even more attractive by the addition of a few drops of a scent bait made of coyote urine with or without glands, fish oil, or other additive.[11]

Selecting the spot. Probably the most important principle in trapping coyotes is to get the set where the coyotes will find it without seeing the traps. A coyote raiding chicken pens may be caught at two possible places: where it stops to look the place over before coming in close, and in the path used for approach.

Again Pat Scott's farm serves admirably as an example. There is a small knoll that overlooks the entire farmyard, about 200 yards from the chicken pen (Fig. 34). Following a ditch, coyotes can approach within 50 yards of the chicken pen under good cover. If a good trap set is on the knoll, the raid does not materialize. If that trap is missed, the coyote may be caught by a secondary set in the ditch.

If no such natural lookout point is present, a good set can be made on a pile of hay or manure that has been placed for the purpose. Most coyotes will follow stock trails, service roads, or dry ditches rather than cross untracked areas when approaching a farmyard. By closely observing these places, a farmer often may know that a coyote is working too close to his stock pens even before any damage has been done. Then appropriate sets may be made.

Catch the killer. So long as the coyotes stay in the back pastures and do not molest stock, they should not be bothered —they are paying for their keep by destroying rodents. But if one or more start killing sheep or calves, their habits must be observed until traps can be set that will catch the wrongdoers, without taking all the coyotes of the area. Blind sets or scented sets made at cross trails, lookout areas, salt licks, or gateways often can be established to take specific animals.

Cyanide guns, commonly known as gas guns and commercially as "Coyote Getters," kill the animal instead of catching

11. Some trappers recommend coyote anal glands, gall bladders, and ovaries ground fine and mixed with coyote urine as the ideal scent post anointment. The mixture may be used fresh, preserved by adding one part corrosive sublimate per 100 parts of the mixture, or let ripen in a glass container covered with cloth to exclude flies. Others prefer fish, mule flesh, rabbit, house cat, or various mixtures, fresh or "ripe."

Table 14.—Results of cyanide guns by some successful users in destroying coyotes.

Cooperator	Address	Year	No. of guns used	No. of coyotes killed
Beiter, Lester	Manhattan	50-51	6	14
Burt, George R.	Concordia	50-51	5	26
Ehm, Paul	Manhattan	49-50	4	17
Ehm, Paul	Manhattan	50-51	4	6
Ehm, Paul	Manhattan	51-52	7	22
Ehm, Paul	Manhattan	52-53	5	28
Ehm, Paul	Manhattan	54-55	5	12
Ehm, Paul	Manhattan	55-56	6	10
Evans, Roy	Ramona	47-48	6	30
Evans, Roy	Ramona	48-49	6	16
Glotzbach, V.	Paxico	50-51	10	17
Heidel, Wayne	Manhattan	54-55	8	32
Heidel, Wayne	Manhattan	55-56	6	26
Hittle, Harlan	Winfield	50-51	1	11
Hofman, Jack	Manhattan	48-49	6	17
Hofman, Jack	Manhattan	49-50	6	29
Kleiner, Wendell	Keats	49-50	6	17
Kleiner, Wendell	Keats	50-51	6	22
Lauer, Glenn	Westmoreland	47-48	15	18
Lauer, Glenn	Westmoreland	48-49	15	24
Lauer, Glenn	Westmoreland	49-50	15	42
Lauer, Glenn	Westmoreland	50-51	15	30
Lauer, Glenn	Westmoreland	51-52	16	30
Lauer, Carroll	Westmoreland	55-56	12	15
McInteer, Allen	Manhattan	48-49	6	34
O'Toole, Albert	Arnold	50-51	20	34
Rau, Roy R.	Wakefield	50-51	25	21
Southard, R. C.	Council Grove	48-49	20	80
Thomas, M. N.	Coldwater	50-51	38	24
Total			300	704
Average			10	24

it. This device was introduced in 1937 (50) and has been used with considerable success (Table 14). Cyanide guns may be set any place that a steel trap set might be made. A good scent is essential for results, as bait can be used only in small amounts directly on the cap of the set.[12] Trappers who are after coyotes in general may use several guns, setting them at intervals of approximately ¼ mile. As the animals are killed almost immediately, it is necessary to run the line only often enough to pick up the dead animals and make the necessary resets—once a week in winter is often enough. The guns are most effectively used in small numbers placed where coyotes that are bothering will be most likely to find them.

Cyanide guns should be set off the trail, not in wooded areas, and care must be taken that livestock cannot get at

12. The urine and urine mixture scents recommended for steel traps are good as attractants, but a fish oil or similar bait must be used directly on the cap of the "getter." With time-tested baits available from fur companies and the makers of the "Coyote Getters," few trappers can afford to experiment with home-made baits. Further information may be obtained from Coyote-Getter, Inc., Pueblo, Colo.

them. The best spots are the same as for traps: at the "lookout"; in or near the approach to the farmyards; at cross trails in the pasture; near a gateway, particularly through a woven-wire fence; or near a "scent post."

Dogs are attracted generally by the same scents and baits that attract coyotes, and cyanide is just as deadly for dogs as for coyotes. Sheep, cattle, horses, and mules also have been reported killed by cyanide guns.

No cyanide guns, or any other poison, should be placed without a public announcement stating the area that is to be covered and the time the sets will be maintained. Cyanide guns should never be set in pastures that hold livestock at the time. Incidental stock losses from cyanide guns can be mostly eliminated by placing a flat rock, 3 to 4 inches thick, about 1½ inches from the gun. The rock prevents the gun being reached by a cow or horse, but sheep or a dog can get at it if a coyote can.

Specific control. Cyanide guns can be used for specific control close to farm buildings if special precautions are taken. The most likely spots for getting the coyotes should be selected, and the tube or "stake" of the gun set. The top of the tube should be plugged with a stick or corncob to give the same appearance as the fully set gun. After a few days, all livestock, including dogs, should be excluded from the area in which the sets are made, the firing mechanism set, and proper scent added. If the culprit is not taken within a week, new sets should be made.

Information for making sets as well as the chemical shells and scent baits are supplied by the makers of cyanide guns. In most counties a few men who are proficient in using the guns are willing to show others how to get results.

In response to persistent complaints from loss of dogs and sheep to cyanide guns, bolstered by pleas from "humanitarians," the Kansas Legislature restricted use of cyanide guns, during the 1961 season.[13] If the user could be certain, which he cannot, that the guns would kill only coyotes, he could use them without the designated permission. Restrictions on shipping loaded cartridges, lack of dealers in the state, and the general attitude of conservationists, dog owners, and stockmen further limit use of cyanide guns, so that, for all practical purposes, they have been eliminated from use in Kansas.

13. Chapter 222, Laws of Kansas, 1961. Sec. 32-158 (in part): "No person shall use ferrets or employ any smoke gun or other device for forcing smoke or any asphyxiating or deadly gas or liquid into the holes, dens, runways or houses of any fur-bearing animals or shall kill or attempt to kill such animals with poison; nor shall any person set or use at any time any cyanide gas gun, bomb or other similar device, using cyanide gas or other poisonous gas as the lethal agent, for the purpose of killing such animals at any time except upon a written permit issued and signed by the director of the forestry, fish and game commission stating the time and place when and where such device may be used; Provided, It shall not be unlawful to chase, trap or take coyotes, moles or gophers at any time."

POISON BAITS

Poisons have not been used extensively to kill coyotes in Kansas, but certain ones are worth mentioning.

Strychnine, so much used by predator control men in the Rocky Mountain area, has been used in Kansas only in a few isolated cases. Strychnine mixed with fat or inserted into small pieces of meat and left along trails, around water holes, or on "look-out" points has been used effectively to destroy most of the coyotes in some localities (4). It also kills many of the other meat eaters in the same area, and poison baits that are not taken by wild animals may be picked up by sheep or cattle. Because of these complications, strychnine is no longer used except for special cases after other methods have failed.

Thallium sulfate, so far as available records show, has not been used in Kansas. Probably the greatest objection to this poison is that it retains its toxicity indefinitely, and its effects are cumulative, i.e., successively small doses are fatal, resulting in the poisoning of animals that eat victims of the poison.

Warfarin, so successfully used as a rodent poison, has been used very little for coyotes. From the results of preliminary experiments conducted by the College of Veterinary Medicine at Kansas State University supplementing work by Prof. Karl Link, at the University of Wisconsin, it would appear that 65 mg. of warfarin a day should kill a coyote in four or five days, and 100 mg. a day should kill in two or three doses. Since most commercial preparations contain only 0.5% of warfarin, approximately 20 gm. (⅔ oz.) of commercial warfarin should be used in each bait, with provisions made for replacing all baits daily. No records of use of warfarin for specific control have come to the attention of the author. A report from California (51) indicates poor results from the use of warfarin in mass control efforts.

Sodium fluoroacetate, better known as Compound 1080, was developed as a rodent poison, then was determined to be better for killing canids (coyotes, dogs, etc.). After some preliminary trials, the material was released to the U.S. Fish and Wildlife Service Rodent and Predator Control Section for field trials. Trials proved this poison to be more efficient than any other for killing coyotes and wolves—far too effective in the opinion of most biologists. It kills in extremely small doses: 4 mg. in a single dose will kill a coyote or dog.

Application and effect. Compound 1080 is placed in meat, either by intravenous injection into the bait animal, or by injection with a long needle into a piece of meat. One half ounce of the poison is used in a 1,000-pound horse; or 1 gram in 100 pounds of meat. Two ounces of meat impregnated with 1080 at the recommended level will kill a coyote. A piece of meat, properly poisoned, is staked in a favorable place for coyotes to find and is left there all winter if not eaten.

Most other animals are not so sensitive to this poison as are coyotes and dogs. Laboratory tests conducted by Ward and Spencer (52) indicate it would be impossible to kill a cow or a vulture with 1080 in standard coyote doses. Pheasants, hawks, raccoons, and opossums would have to gorge themselves to get enough of the poison to be killed. There is, however, a rather high fatality among minks, weasels, skunks, and dogs that frequent the vicinity of the bait stations.

Use in Kansas. Compound 1080 was first brought to Kansas in 1950 by the Rodent and Predator Control Section of the Fish and Wildlife Service by contract with Seward, Comanche, and Clark County authorities. Approximately 20 poison stations with 200 pounds of meat at each station were established in each county in December; a few stations were rebaited in January and the left-over bait was removed in late March. By the quantity of bait taken, it was possible that 1,000 to 4,000 coyotes had been killed in the three counties.

During the winter of 1951-52, 10 counties (Fig. 36) availed themselves of the predator control service and had 180 bait stations placed, and 20 stations rebaited. As bait, 39 horses (weighing a total of 39,150 pounds) were used. It was estimated that 85% of the station material was eaten by coyotes. In 1952-53, 13 counties used 78 poison stations, each with approximately 200 pounds of meat. Replacements and results were comparable to those of the preceding year. Only six counties contracted for the poison program in 1953-54 and these reported low usage of the bait stations. Again in 1954-55, six counties used 1080, and in 1955-56, five counties used it. Sporadic use of 1080 was continued until 1960, particularly in the counties adjoining Oklahoma. General reduction of coyotes and a population explosion of jack rabbits made coyote destruction programs unpopular after 1955.

Limitations. The use of Compound 1080 has been limited by a ruling of the Department of the Interior to the "range lands" of the western part of the United States. The eastern limit of the "range lands" was established by the 74th Congress, 2nd session, to include the westernmost counties of Kansas, including Rawlins in the northwest to Barber County in the south (Fig. 36). Use can be extended eastward only by special permission from the Fish and Wildlife Service. Furthermore, 1080 is not available on the open market, so its use is limited to technicians of the Fish and Wildlife Service and other professional exterminators.[14] Because of its extreme toxicity, limitations on the use of Compound 1080 are warranted.

Coyote reduction. Work done by Stanley Guenther, biolo-

14. Chapter 222, Laws of Kansas, 1961. Sec. 32-158 (in part): " . . . The use of chemical 'sodium fluoroacetate' commonly called 'compound 1080' is absolutely prohibited for rodent or wildlife liquidation except by an agent predator or rodent exterminator as permitted by the state forestry, fish and game director."

gist, Department of Game, Spokane, Wash., and summarized for us in a letter (January 2, 1952) stated that in an experimental poisoning program 75% of the coyotes within an area of 25 square miles were removed in one season and the coyote population was reduced during the second winter to 10 to 15% of the original.

Reports from counties in Kansas where the poison was used indicated similar results. In most cases where 1080 use is indicated, thorough coverage for one winter usually is sufficient, with remaining killer-coyotes removed individually by traps or cyanide guns. In some cases, to be determined by the predator control specialist, a second year of poisoning may be desirable, but it is inconceivable that worthwhile results could be attained from a third consecutive winter of poisoning in

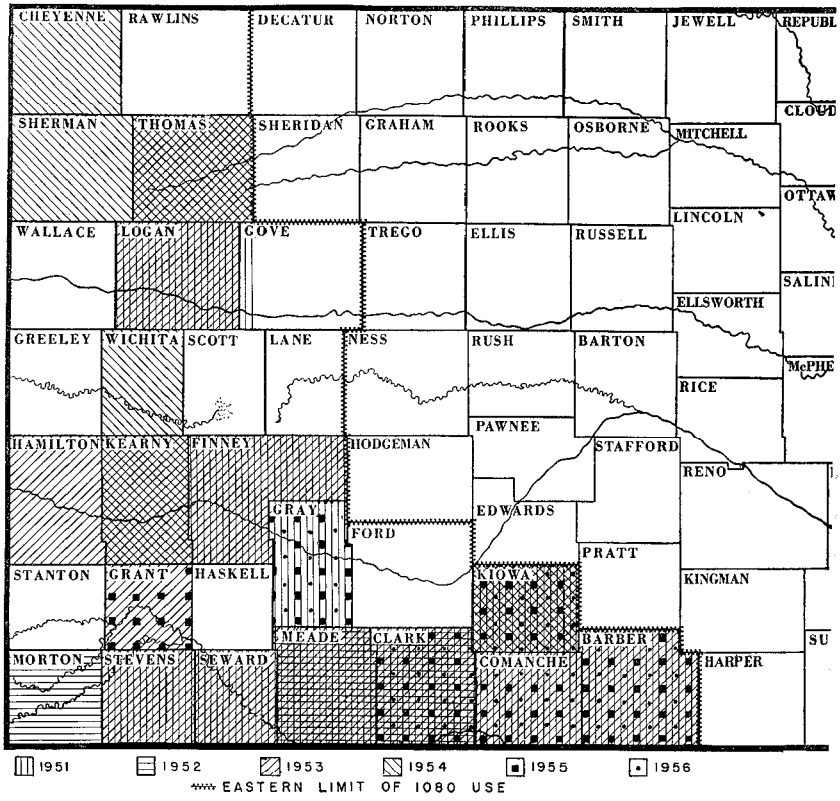


Fig. 36.—Use of Compound 1080 in Kansas, 1951-56. By checking annual patterns, usage or nonusage of 1080 can be seen. Usually 12 to 20 poison stations were established in the contracting county and maintained from December through February. Use of Compound 1080 is restricted to technicians of the Fish and Wildlife Service or other certified persons.

the same area, unless large numbers of coyotes drift in from the surrounding regions.

Contract for 1080 use. From 1951 to 1960 the Fish and Wildlife Service made its technicians available for the 1080 program in Kansas by contract between some agency in the county with the regional office in Oklahoma City. Because Kansas has no legally established policy for cooperating with the Fish and Wildlife Service on predator control work, any agency willing to assume the responsibility could contract for that service if technicians were available. In most cases, contracts were made by Farm Bureau, the County Agricultural Extension Council, or the County Commissioners. Because of the numerous conflicts arising from the 1080 programs, most of the County Commissioners withdrew from the field, leaving such action entirely to farmers' organizations.

Results of the 1080 program were not determined. Coyote numbers were drastically reduced in the counties using the poison, but, as shown in the section on "Populations," there was a like reduction of coyotes in many counties that did not use poison. Possibly the 1080 in this case assisted nature in removing excess population and so avoided drastic reduction by a general scarcity of food or other natural factors.

The poison removed many dogs, including pets, stock dogs, and hunting dogs, but some of the poisoned dogs undoubtedly were as bad as the coyotes the poison was intended to kill. No inventory has been taken of the other forms of wildlife, so there is speculation that large numbers of raccoons, skunks, minks, hawks, and pheasants were killed. Only time can tell what the long-term effects of such poisoning will be.

Complaints of rodent and rabbit damage increased from all of the counties that used 1080 two or more years in succession, but possibly conditions were right for an increase in the rodent population. Similarly, the jack rabbit population in western Kansas increased greatly during 1954 and 1955 (23) but there is no direct evidence that the rabbit increase was or was not a result of the coyote decrease. Lack of proper follow-up on this, as on other cases of mass destruction of predators, has resulted in no factual correlation between the action and the resulting changes in animal populations.

Use controversial. The value and desirability of using Compound 1080 has been repeatedly challenged by biologists and stockmen. In July, 1953, the "Toponas Grasslands Protective Association" was organized at Toponas, Colo. (53), to protect coyotes and prohibit, or at least retard, continued use of 1080 because of the devastating increase of rodents following the reduction of coyote population. Sheepmen of the area opposed restrictions on 1080 use, considering it better to have mice destroy the range than to have coyotes prey on their flocks. In the Kansas counties that used 1080, there have been bitter con-

troversies over its use. Some oppose its use as immoral; others because of its obvious danger to dogs; and others on the thesis that rabbit and rodent damage without coyotes as a check would exceed the damage done by coyotes.

Precautions. Stanley Guenther ended his report[15] on 1080 with the following simple rules. He thinks that if these rules were followed, the loss of other wildlife would be no greater than with any other poison:

1. Use no more than ½ ounce of poison in a 1,000-pound horse.

2. Place no poison adjacent to streams. This will prevent consumption by fur-bearing animals that commonly travel near streams.

3. Place all poison at a reasonable distance from farm houses and traveled roads.

4. Dispose of all poison material as soon as possible in the spring.

Unfortunately, too many operators are so interested in getting maximum coyote kill that they disregard such simple safety precautions and thus provide fuel for the increasing resistance to 1080, or other, violent nonselective poisons.

Promising control methods. Recent studies on antifertility agents show some real promise for control of predator numbers. Balser (54) reported favorably on preliminary studies with diethylstilbestrol blocking pregnancy in coyotes. Drop-baits consisting of 100 mg. stilbestrol in ½ oz. tallow were distributed over an experimental area March 5-15, 1963. After three weeks, coyotes were collected from the experimental area and from a similar area 25 miles away. Of 20 mature females from the experimental area, only four had normal embryos, while the other 16 had ovulated but had failed to conceive or had resorbed their embryos. All of 13 females from the control area that had ovulated were carrying normal litters of live embryos.

Additional studies are under way both in Mr. Balser's laboratories in Denver, and in the laboratories of Dr. William Hansel of Cornell University on use of other antifertility agents, in both males and females. The general idea is to block reproduction and thus reduce the pup crop for that year but leave the older animals in control of their respective territories. That prevents other reproducing pairs from extending their territories and taking advantage of abandoned territories as when one member of a pair is killed.

The technique of temporary sterilization to reduce reproductive success for a year is relatively new, but it has potential. If we can determine when reproductive probability exceeds available food, then we could distribute the antifertility

15. Personal communications, January 2, 1952.

agents, at relatively low cost, to reduce reproduction as much as desired. Pairs of coyotes (or foxes) hold their established territories against encroachment by normally reproducing animals, which positively reduces reproductive success of the species and allows for little "intercompensation." Antifertility agents may play a major role in predator control in the future because (1) they do not kill outright, so dogs, farm animals, and fur bearers would be saved; (2) results are temporary: the agents block only the reproduction for that cycle, which in the coyote is a year; in the dog, six months and in the cow, 20 days; (3) results are positive, even though delayed, and (4) such a method avoids the cry of cruelty and of wanton slaughter.

SUMMATION OF POPULATION CONTROL

Numerous factors interact to affect natural control of coyotes in an area. This study indicates that adequate rodents and rabbits are essential for good health and successful reproduction of coyotes. When the rodent-rabbit population drops, the reproductive success of coyotes likewise goes down. Undoubtedly weather conditions play some part in population dynamics, but the effect is probably on the parasites and prey rather than directly on the coyotes. If an adequate check system could be established for determining populations of rodents, rabbits, and coyotes in any given area, the necessity for and extent of control measures for that area could be calculated a few months in advance.

A few coyotes become habitual predators on domestic stock just as a few men become thieves. These coyotes are a definite liability to the individual farmer and to the economy of the state, and should be removed by any means available. This can best be done by special trapping for the individual animals. Steel traps, cyanide guns, or poison baits can be so placed that the offending animal is destroyed without getting an undue number of helpful animals.

In Kansas, during the past century, there has evolved a highly versatile and adaptable race of coyotes, along with, and possibly resulting from, increasingly efficient means of killing coyotes. The bounty system, operating over three quarters of a century, has provided some incentive for killing coyotes when fur prices were low. Sport hunting has had some effect, and excessive losses have stimulated farmers and ranchers to wage war on individual coyotes or on coyotes as a species. With steel traps, cyanide guns, high-powered rifles, and cooperative dog owners available for specific control, reliance on "government" for reduction of poultry and livestock losses is a poor recommendation for the resourcefulness and independence of Kansas farmers. However, with increased dependence of all phases of human endeavor on governmental "control," there has been a trend sponsored by a vociferous minority to

get federal intervention in the problem of coyote control. The legislature of the State of Kansas has steadfastly refused to officially sanction the operation of the Predator and Rodent Control Section of the Fish and Wildlife Service within the state. The Fish and Wildlife Service, however, has operated in the state sporadically by contract with county groups, specifically on the 1080 program recently functioning in southwestern Kansas.

During the past few years an Extension Predator Control Program has been developed in Missouri (19, 49) by the Missouri Conservation Commission and the Agricultural Extension Service. On request from local groups, training meetings are arranged by the county agricultural agent at which the extension trapper instructs farmers and sportsmen how to catch the specific predator that is doing the damage. With this system the damage done by coyotes, foxes, and bobcats has been reduced to about one fourth what it was before the system was inaugurated. The extension trapper system in Missouri has not yet had a chance to function without the aid of the general population reduction afforded by a high bounty. Results of this program have proved, however, that in most cases local losses are due to the depredations of one or a few coyotes, and when these individuals are destroyed, the losses stop.

The legislature of Kansas enacted a law in 1949 that established the framework for a program of coyote control. An appropriation was made in 1953 that permitted Kansas State University to perform part of the functions delegated by the 1949 law. In April, 1954, a rodent and predator control specialist was added to the staff of the Kansas State College Extension Service, charged with developing and implementing a workable program to control coyote and rodent damage within the state. This program is being developed as a modification of the extension trapper system that has been successfully used in Missouri. This program was inaugurated at a time of low and decreasing coyote population and has functioned in conjunction with established numerical control by bounties and sport hunting. It has continuously reduced damages due to coyotes as more farmers learn to trap specifically for "killer" coyotes. In 1968 a second man (Robert Henderson) was employed as an "Extension Trapper" to train farmers and sportsmen in trapping techniques and otherwise further a predator control program, with the goal of eliminating a major part of losses to predators.

The very principle of predator "control" has been seriously challenged in recent years on the basis of Errington's (40) principles of intercompensations, with natural destruction of excess populations. Available evidence, however, seems incontrovertible that at least "killer" control is mandatory, and that

as the predator population approaches the limit of its food supply, excessive predation on livestock may be prevented by a general reduction program.

Kansas has dallied with ineffectual, wasteful controls too long, and the time for action is now. There are several alternatives for immediate action:

1. Follow Missouri into the high-bounty bracket to encourage greater coyote kill. It would take a minimal bounty of $5 per animal to appreciably stimulate coyote hunting, bringing the total annual cost to about $250,000. Results: a salve for some of the operators who suffer predator losses, and continued fluctuation of populations, as has been abundantly illustrated in Michigan (45) and Missouri (49).

2. Turn the entire problem over to the Bureau of Sports, Fisheries and Wildlife, and let the Federal government take care of the details. All that would be required of Kansas would be to pay the salaries and expenses of the 10 to 20 predator control specialists who would be with us from now on. Again, the cost for the predator control could exceed $200,000 annually, and with the extreme reduction of predators that has been the rule with the Bureau, we could well expect comparable amounts for rodent control.

3. Extend the Extension Trapper service that has been building for the past 14 years, for the control of "killer coyotes," and simultaneously remove the bounty. The cost of this program would be less than the present bounty. Available evidence indicates that this program would be totally adequate for years of declining or stable low populations, but with our present knowledge, we would be gambling against rather high odds during periods of expanding populations or following rabbit-rodent population crashes.

4. Declare the coyote a "fur bearer" or "game animal" and charge the Kansas Forestry, Fish and Game Commission with maintaining a proper balance as has been done with the deer. The value of the coyote is primarily rabbit-rodent control. A secondary value, which could be greatly expanded, is that of a game animal, which should be controlled by the Kansas Forestry, Fish and Game Commission.

The control program that is indicated for Kansas should consist of more than killing coyotes. It should include (1) a continuing survey of all factors that influence coyote populations; (2) education and direction for controlling coyote populations and the damage resulting from excess populations and habitual killers; and at the same time, (3) maintenance of the sovereignty of the individual farmer and sportsman. Such a program, judiciously supervised, should result in an advantageous balance. The basis of this program has been established in Missouri, with favorable results (54).

The control program that appears most applicable for Kansas consists of:

1. Officially make the coyote, along with the fox, lynx, and raccoon, a "fur bearer," under the jurisdiction of the Kansas Forestry, Fish and Game Commission and remove all bounties. This would necessitate a total revision of Kansas game laws. It would place the coyote on the restricted list, and permit controlled hunting, with resultant reduced take when the population is down and increased take when the population is up. The Commission should have the authority to use other means for general reduction if the population gets too high. Cost of special control measures should be borne by the state or recipient counties.

2. Establish a funded project for a continuous study of predator numbers, behavior, and relationship to rabbits, rodents, and farm animals. This project could be vested within the Agricultural Experiment Station, but must be cooperative between the Experiment Station, the Extension Service, and the Kansas Forestry, Fish and Game Commission, with the charge to conduct the necessary studies and make recommendations to the three cooperating organizations at yearly intervals, or more frequently if conditions demand immediate action.

3. Maintain "Wildlife Specialists" within the Kansas Agricultural Extension Service to work with county agricultural agents and directly with farmers, poultrymen and stockmen on predation problems, specifically to prevent predation and destroy those predators that have established "killer" traits. This part of the recommendation is operating satisfactorily in Michigan and Missouri, but has been so seriously understaffed in Kansas that its value has been restricted. The present two "Wildlife Specialists" may be adequate, but in some trouble years, a third or even a fourth man may be necessary. A resident extension trapper is seriously needed in southwest Kansas.

These recommendations, if implemented, would make possible a capitalization on the coyote as an asset, for best utlilization in rabbit-rodent control and as a game animal. Only by a continuous, closely applied study, not an incidental, now-and-then type as the one that provided the basis for this book, can the details necessary for intelligent use of predators be established. The necessary research can best be done in the Experiment Station, where the basic problems can be attacked from zoological, animal industry, and agricultural economic viewpoints, correlated with the game values. The Extension Service has a staff of approximately 150 county agents and farm specialists, all of whom should work well with the wildlife specialists. And the Forestry, Fish and Game Commission has the trained personnel for administration of such a program. If any of the proposed cooperating agencies find such an arrangement intol-

erable, the entire program could be vested in the Commission, as it is in Missouri.

The cost of the proposed program should be considerably less than the present bounties ($111,000 in 1957). Increased hunting license revenue should take care of the added expense to the Kansas Forestry, Fish and Game Commission for supervision. Special control expenses will occur no more than one year out of five and may not be necessary at all, but if or when necessary, must be borne by the state or counties involved. The continuing research program must be state supported, at possibly $20,000 annually, and the Extension wildlife specialists should be allotted $40,000 to $60,000 to cover salaries, travel, and necessary additional man power.

This proposal has been formulated after exhaustive study of hunting trends, bounty results, various "control" systems, and farm economics, only a small portion of which have been included in this report. I am convinced that this program, inaugurated in toto, will give results most satisfactory to all concerned.

SUMMARY

Coyotes have been long-time residents of Kansas and have become adapted to live with modern civilization as it exists over much of the state. Likewise, most farmers and ranchers have accepted the coyote as part of the normal environment and have developed management practices that permit the coexistence of this predator and modern farming.

Although the coyotes of Kansas may be subdivided into two or three subspecies, there is no practical line for such subdivision and all are treated as one form.

The normal winter food of coyotes was determined from the examination of stomachs collected between October and May, 1947 to 1962. Most of the animals were quick killed and bait from trapped animals was not included in the results. Stomach contents comprised 54% rabbit, 26% carrion, 7% chicken, 8% rodents, 1.5% birds, 1.4% fruits, and 0.2% insects. These items occurred in the following percentages of the stomachs: 27% empty, 54.3% rabbit, 37.5% carrion, 13.8% chicken, 41.5% rodents, 4.8% birds, 5% fruits and grain, 1% insects.

Stomach analysis indicated that: (1) coyotes eat the most readily available meat; (2) rabbits and field mice are the generally preferred foods; and (3) poultry, livestock, insects, and fruits are utilized to meet the requirements for food above that supplied by rabbits, rodents, and carrion.

According to results from the Kansas Agricultural Census, approximately a $1,350,000 loss was charged to coyotes during 1949. This loss was divided into $574,000, chickens; $324,000, cattle; $280,000, sheep; and $172,000, pigs, turkeys, ducks, and all other items. Most of the chickens were taken during early summer as they wandered into heavy vegetation around the chicken yard.

Cattle losses consisted mostly of new-born calves, although some older calves were reported to have been killed by coyotes. Sheep losses were mostly lambs taken during the spring and early summer, but some depredation continued throughout the year on unattended flocks. Poultry and livestock losses appear to be roughly inversely proportionate to the rabbit-rodent availability.

Conflicts arise when the number of coyotes in any locality exceeds the natural food supply, or when new ventures are initiated that are vulnerable to coyote predation. These two reasons for losses to coyotes are fundamentally different and they call for different remedies.

The average benefits derived from coyotes in controlling rabbits and rodents exceed the average losses due to predation on poultry and livestock. If the individual "killer" coyotes could be destroyed, the benefits would greatly exceed the damage.

Coyotes breed during February and March, have a gestation

period of approximately 60 days, and whelp mostly in April. Old females breed early in the season; yearlings breed late, if at all. When conditions are good for reproduction, 80% of the females may breed, but when rodents are insufficient, as low as 30% produce litters. Under good conditions, litters are large, averaging six or more pups per litter. Under poor breeding conditions, litters are reduced to approximately four pups.

Pups begin to eat solid foods before they are a month old, leave the den before two months, and are nearly grown by six months. There is no size difference between young and old coyotes in December. Mature male coyotes have a weight range of 18 to 43 pounds, average 30. Female coyotes vary from 18 to 38 pounds and average 26. During the winter 47% of the coyotes killed are young of the last breeding season, 30% are two years old, 16% are three years old, and 7% are four years and older. Few coyotes were found more than six years old.

About 97% of the coyotes had intestinal parasites: 95% had tapeworms (**Taenia pisiformis**) averaging 50 worms each; 45% had stomach worms (**Physaloptera rara**); 38% had intestinal worms (**Toxascaris leonina**); 25% had hookworms (**Ancylostoma caninum**); and 7% had whipworms (**Trichuris vulpis**). Heartworms (**Dirofilaria immitis**) were found in fewer than 1%. Fleas (mostly **Pulex simulans**) were present on all coyotes, and ticks (**Ixodes kingi** and **Dermacentor variabilis**) were found on coyotes examined during the summer.

Although distemper, rabies, and tularemia are known to occur in coyotes, no cases of those diseases were recognized in the animals examined. Several animals were examined that had survived broken bones and amputated feet, indicating great capacity for overcoming adversities.

Bounty records were used to calculate population numbers. The population loss is the number killed for bounty (B) plus losses from disease, parasites, accidents, and intraspecific strife (R). The increase during the breeding season is the number of breeding females (N/2 x percent breeding) multiplied by the average litter size (L). In the equation: population increase = population loss, $N/2 \times P \times L = B + R$. The percentage of females that produce litters (P) and the average litter size (L) are determined by examination, bounties (B) are on record, and natural losses (R) can be estimated within reasonable limits; thus the breeding population (N) can be calculated as $N = \frac{2 \times (B + R)}{P \times L}$

Control of coyote damage consists of two distinct phases: (1) reduction of populations in excess of the natural food supply, and (2) destruction of individual coyotes that consistently take poultry and livestock.

Reduction of excess numbers is most satisfactorily done by den hunting, supplemented by sport hunting, chasing, and

trapping. Reduction by mass poisoning is effective, but results in too much destruction of other animals and too much dissension within the groups of people concerned to be considered satisfactory or desirable in any but extreme cases of overpopulation in range country where little other wildlife and few people are involved.

Control of losses from "killer" coyotes is best done by the use of steel traps or cyanide guns set specifically for the coyotes that are doing the damage. Some dog packs are effective in catching "killer" coyotes.

Hunting coyotes, whether with dogs, by the "round-up" method, or in sport hunting, must be considered as sport, and as an aid in removing excess numbers. Such hunting has a high cost per coyote killed and in general is self-limiting: enthusiasm for hunting is directly proportional to hunting success.

If left alone, coyote populations tend to become balanced with the habitat, especially the food supply. There is almost invariably a lag of several months, possibly a year, between reduction of the natural food supply and compensation within the coyote population. In such cases, reduction measures may be necessary over wide sections of the state. Individual efforts at control must be coordinated, and possibly supplemented by general measures, to be effective. Specific control of "killer" coyotes must accompany and follow any general reduction program to be effective in reducing livestock losses.

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