SOME ECOLOGICAL STUDIES OF THE BLACK-TAILED JACK RABBIT (*Lepus californicus melanotis*, Mearns) IN SOUTHWESTERN KANSAS

by

DALE LEROY TAYLOR

B. S., Kansas State University, 1958

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Zoology

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1960

TABLE OF CONTENTS

INTRODUCTION AND REVIEW OF LITERATURE 1

MATERIALS AND METHODS 4

Study Area 5

Home Range 9

Reproduction 12

Census 13

RESULTS 14

Home Range 14

Nesting, Habits and Development of Young 27

Weight Fluctuations of Adults 33

Aging 36

Reproduction 46

Suckling 57

Census 58

Predation 62

Behavior 63

DISCUSSION 66

SUMMARY 70

ACKNOWLEDGEMENTS 76

LITERATURE CITED 77

APPENDIX 84

INTRODUCTION AND REVIEW OF LITERATURE

Some game species are so tied to the original primeval wilderness that their presence is practically synonymous with such wilderness. The jack rabbit, however, is capable of living in a substitute environment (Grange, 1949).

In Kansas a change from open prairie to cultivated land seemed to favor black-tailed jack rabbits in adjusting to the new agricultural environment (Brown, 1947a). As more of the short grass region land was cultivated, favorable habitat was available for a greater number of jack rabbits. Precipitation was low in the short grass region of Kansas and droughts were a common occurrence. In this setting, jack rabbit fluctuations of major consequence occurred.

Bronson (1957) stated that the jack rabbit is probably not cyclic in Kansas but is subject to population irruptions during drought periods due to a change in carrying capacity of the land. Others have held varying viewpoints on why jack rabbit fluctuations occurred. Hall (1955) stated that Kansas hares increase for a varying number of years, then in a period of a few months, the animals die off. Cahalane (1947) wrote that jack rabbit populations in most regions tended to fluctuate at an average seven year cycle but varied from five to ten years. Other states in which population fluctuations of consequence have been mentioned are California (Palmer, 1897), New Mexico (Bailey, 1931), Texas (Taylor, 1948), Utah (Nelson, 1951 and Durrent, 1952), and Nevada (Hall, 1946).

A five-year drought ended in Kansas in 1957-1958. During the drought years jack rabbit populations were high in local areas. In July 1956,

Bronson (1957) initiated a study of the black-tailed jack rabbit (Lepus californicus melanotis, Mearns) in southwestern Kansas. The purpose of his study was to obtain information on the population dynamics and other basic ecological factors. Such basic knowledge of this subspecies was unknown for the central region of the United States. Bronson's work was directed toward an attempt to understand the basic causes underlying jack rabbit population fluctuations. An attempt was made to correlate drought conditions with certain aspects of jack rabbit ecology because jack rabbit population increases of consequence have apparently occurred only during drought periods (Bronson, 1957).

Another phase of Bronson's investigations was an attempt to correlate precipitation and population fluctuations (Bronson and Tiemeier, 1959). Data were also presented on reproduction and age distribution, some aspects of behavior, crop damage (Bronson and Tiemeier, 1958b), mortality and past fluctuations of jack rabbit numbers.

When Bronson's research ended, it was realized that data obtained in one year were not enough. "Studies in biology can never be up-to-date. Nature's great equation is always changing. Factors are dropped out here and there; others are introduced. It is obvious that many human enterprises affect jack rabbit status--- among them: (1) bringing new lands under irrigation; (2) grazing by livestock; (3) predatory animal and rodent control. The research job, in biology, is never done. Published books and papers are at best progress reports...." (Vorhies and Taylor, 1933).

In June 1958, the author began a study that was continued from Bronson's work. The study was to include censusing, reproduction and the use of various aging techniques. Data were also to be collected on home range

size, a phenomenon unknown for the black-tailed jack rabbit in the central region of the United States.

Aside from Bronson's work, few other comprehensive studies on the black-tailed jack rabbit have been made. Palmer (1897) wrote about the early history of jack rabbit drives and hunts, historical information which probably cannot be found elsewhere. He included information on food habits, depredations and an attempt at classification. Jack rabbit damage and methods of control were reviewed. Information on reproduction was limited in extent.

Dickerson (1917) recorded notes on the care of a litter of jack rabbits (Lepus californicus).

Burnett and McCampbell (1926) discussed the reproduction, behavior, crop damage and control of L. c. melanotis in Colorado.

Seton (1929) wrote of personal observation of jack rabbits, some in Kansas. He recorded observations on mating, predation and behavior, and the approximate home range size obtained by tracking one animal.

The classical studies on jack rabbits were made by Vorhies and Taylor (1933) in Arizona. Their studies were based on the life history of the jack rabbits (Lepus californicus, and L.alleni) in relation to grazing. Behavior, food habits, reproduction, predation, parasitism, and population fluctuations were also studied.

Taylor, Vorhies and Lister (1935) and Vorhies (1936) presented additional information on the relationship of jack rabbits to grazing in southern Arizona. During those studies, they presented the concept of jack rabbits being animal weeds, that is, jack rabbits increased as a result of overgrazing.

Wooster (1935) studied the effect of drought on jack rabbit populations in the western half of Kansas. In 1939 he reported on a jack rabbit population functioning as a predatee (Wooster, 1939).

Carter (1939) and Brown (1940, 1947a, 1947b) relied on reports of early Kansas settlers to obtain a history of changes in jack rabbit populations. They reported a shift in range of the black-tailed (L.c.melanotis) and white-tailed (L. townsendi) jack rabbits.

Reigel (1941, 1942) studied native vegetation eaten by jack rabbits when normal plant cover was not available. Timmons (1942) and Brown (1947b) reported on the utilization and dissemination of native plants by jack rabbits.

Cow-jack rabbit equivalents were established in a forage consumption experiment in Arizona (Arnold, 1942). The amount of native forage consumed by jack rabbits, preferences of forage plants and the amount of competition between jack rabbits and domestic livestock were established.

Haskell and Reynolds (1947) investigated growth, developmental food requirements and breeding activity of L.c. americus.

A more recent study of jack rabbits (Lechleitner, 1955) was made on Lepus californicus californicus. Data were obtained on reproduction, population density, parasites and diseases. The use of the epiphyseal closure technique for aging mammals was extended. Home range was calculated for the subspecies by trapping and tagging a number of individuals.

MATERIALS AND METHODS

One week-end during each of the months of September through May was spent making collections in Kearny County, Kansas. Occasional trips in addition to these were made to obtain census data or for home range

observations. A total of 118 field days were spent at the study area in the summers of 1958 and 1959.

The hares were weighed and measured. The reproductive material (uterus, ovaries and testes) was removed and preserved in 10 percent formalin. The left humerus was removed. During the latter part of the study, one or both eyes were removed and preserved in 10 per cent formalin. All the material was returned to the laboratory at Manhattan for further study and dissection.

Study Area

The study area was located northwest of Lakin, in Kearny County. The type of land and farming methods were assumed to be fairly typical of southwestern Kansas exclusive of the sand hills. The area consisted of 640 acres of short grass (R-37-W T-23-S sect.-15), and 960 acres of farmland (R-37-W T-23-S sect.-14 & N½ sect.-22).

According to Goke (1954), soils on the area were moderately deep, light-colored soils with moderately friable, slightly compact, silty to clayey subsoils and were classified in the Brown Soil Zone. The dominant surface texture was silty loam. Slope of the land was from 0 to 3 per cent.

The land was Class IV land according to capability classification, but the soils were good, with good topography and fit well into the large-scale agricultural practices. In years when rains were seasonal and above normal the soils could have been called Class III or II. Crop failures due to drought and wind erosion hazards were greatest of any place in the state (Goke, 1954).

About 320 acres of the study area was in the Conservation Reserve Program of the Soil Bank in 1958 (Fig. 1). The remaining area was under the typical farming practice of southwestern Kansas, that is, fallow, wheat

or milo, followed the succeeding year with a rotation of fallow, wheat or milo.

In the following description of the vegetation on the study area, the names of the various fields are according to the study area map (Fig. 1). Vegetation of the buffalo grass pasture for both 1958 and 1959 was buffalo grass (Buchloe dactyloides), grama (Boutaloua sp.), and various small forbs. In the summer of 1958 the vegetation was almost atypical due to the lack of dense sunflowers (Helianthus annuus). Other pastures were almost devoid of grass in Kearny County but had dense growths of sunflower that averaged four to six feet in height. The difference between the study area and surrounding area pastures was apparently due to different grazing pressure.

The one-half section of summer fallow was "clean farmed" during the summer of 1958. When the weeds attained a growth of one to two inches in height, the field was one-wayed, harrowed, or "gram-homed." The above practice was followed except for late July 1958, when heavy rainfall prohibited farming operations. Weeds, mostly rough pigweed (Amaranthus retroflexus) grew four to six inches in height. Wheat was sowed in the fall of 1958. After harvest in July of 1959, a dense stubble was present throughout the remainder of the study period.

The area designated Soil Bank Field A had been in the soil bank program for the previous year (1957). When the study was begun in June 1958, average height of weeds on the area was less than six inches. By late July, the weeds had grown to a height of three to six feet. Dominant species were sunflower (Helianthus annuus), lambs quarter (Chenopodium album) and russian thistle (Salsola pestifer). In late spring of 1959, the

area was disced and sowed to grass according to United States Department of Agriculture specifications. No grass grew, leaving the field with a sparse covering of low growing forbs (Plate I, Fig. 2).

Soil Bank Field B was an area similar to Soil Bank Field A. Soil Bank Field B was not re-seeded to grass, consequently, the vegetation was about the same for the two summers. Lack of rainfall in 1959 apparently caused the vegetation to be limited in growth, as it did not attain the height of the previous summer.

The area designated as "sand hill" on the study area (Fig. 1) was a wasteland area. The more common plants were bunches of buffalo grass, grama grass, sunflower and yucca (Yucca glauca).

The northeast corner of the study area had been planted to wheat in 1958. The field was fallowed in 1959. Wheat had originally been planted along the east edge of the sand hill but it was destroyed by high winds in late winter of 1958. Milo was then planted in the spring of 1958 and again in 1959.

About five acres of Wheat Field B were destroyed by high winds or covered with shifting sand. Puncture vine (Tribulus terrestis) and russian thistle were the principle weeds. After the wheat was harvested from Wheat Field B, the area was placed in the soil bank program. Along with the wheat stubble, weeds (lambs quarters, puncture vine, sunflower, and russian thistle) were the dominant vegetation.

Three excellent feeding areas for jack rabbits were present on the study area. One was in Soil Bank Field A to the east and south of the gas well. A second feeding area was in the northwest corner of Wheat Field B where puncture vine had grown after the wheat had been destroyed. The third

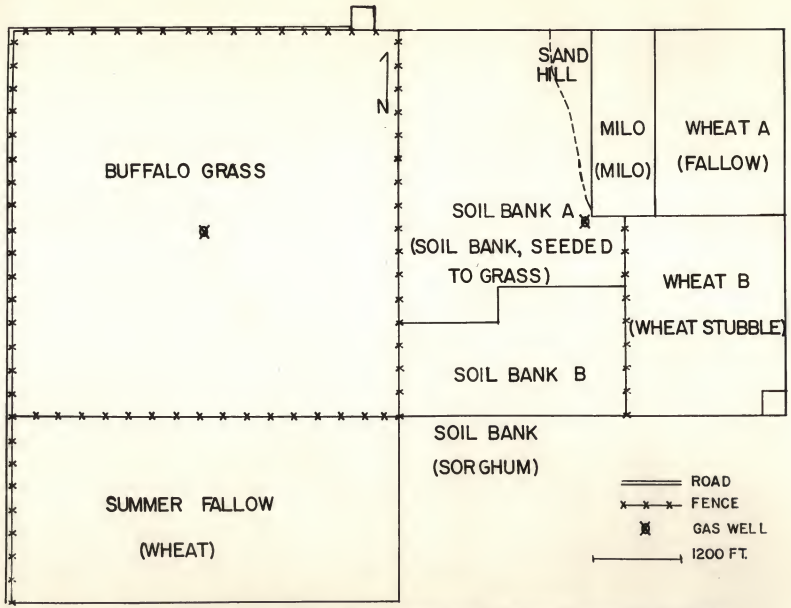

Fig. 1. Map of the two and one-half section study area. Farming practices for 1958 are the first listed and 1959 farming practices are in parentheses.

feeding area was at the corners of the three sections (Fig. 1). A poor stand of sorghum in the northwest corner of the field had been invaded by puncture vine (Plate I, Fig. 1).

Home Range

A program for studying the home range of jack rabbits was initiated in June 1959. Nine traps of original design (Plate II, Fig. 1 & 2) were constructed by the author and co-worker M.H. Bartel. A tenth trap which had been used by Lechleitner (1958), was obtained from Gray Lodge Waterfowl Refuge in California.

The nine traps were constructed from a 48-inch roll of one-inch mesh welded wire. An 18 inch square frame 48 inches long was made. Doors were 28 inches long and were hinged on the top side 18 inches from the end of the trap. This arrangement allowed maximum space inside the trap when the doors were closed.

For a trigger mechanism, a steel jaw trap (size No. 1) was fastened on the top of the trap one-half the distance between each of the doors. When tripped the wires to the door catches would be pulled simultaneously, allowing the doors to fall. A 26-gauge trip wire was fastened to the jaw-trap-pan and extended to the edge of the welded wire frame, down the side of the trap and across the bottom of the trap.

The traps were set along field borders or in paths made by jack rabbits. Late afternoons and evenings were spent setting the traps. Lechleitner (1958) conducted a trapping experiment with different baits and found that apples were the most acceptable by jack rabbits. In this study, one-half an apple was placed in each trap on the nights the traps were set.

The traps were checked each morning by 6 A.M. and the captured animals removed, tagged and released or returned to the laboratory for 24 to 48 hours. Blood samples were taken and checked for the presence of microfilariae (Bartel, 1960). The animals caged at the laboratory were returned to the field, usually within 24 hours, and tagged and released at the site of capture.

Plastic collars have been used for marking birds (Balham and Elder, 1953; Helm, 1955; Craighead, 1956) and mammals (Ealey, 1956; Progulske, 1957). Ealey (1956) used "Scotchlite" reflective tape to individually mark marsupials. Duerre (1958) ear tagged deer by using cellulose acetate covered "Scotchlite" reflective tape. Lechleitner (1958a) used plastic discs with glow beads to ear tag jack rabbits in California.

In this study eight colors of Scotchlite Reflective Sheeting were tried for comparative reflection and silver was found to give the brightest reflection. Numbers, letters, dots, bars, and triangles, all the same size, were cut from silver scotchlite and used in combination on the tags. A strip of red upholstery plastic two and one-half inches square was used for each tag. The tag was laid on a table and the identifying combination of symbols was applied, one set on each side of the tag. When the tag was folded around the jack rabbit's ear, it could be read from in front and from behind the jack rabbit (Plate III, Fig. 1).

When a jack rabbit was caught, a tag was fastened to the ear by folding the plastic between the scotchlite symbols. It was then sewed to the ear with nylon thread. A curved surgical needle was used for punching a hole through the plastic tag, through the ear, and through the tag on the opposite side of the ear. Stitches were made completely around the tag in this

manner (Plate III, Fig. 2). A monel metal ear tag 10 millimeters in diameter was placed in the opposite ear. The metal tags were stamped with KSU; ZOOL; number; MANHATN.

Observations on movements and activity of hares were made in the late evening or early morning hours. These observations were made from the bed of a pickup truck as it was driven across the study area and from observation points. Nocturnal observations were made by shining a twelve-volt spotlight mounted on a tripod beside a 20-power interchangeable to 30-power telescope (Plate IV, Fig. 2) or an eight-power binoculars and observing the reflections from the tape on the ear tags.

The results of the observations were plotted on maps of the study area (Fig. 2,3,4,5,6), using letters as designations for specific hares. These letters used for specific hares corresponded to the small metal ear tag (Table 1). On the maps, arabic numerals were used to designate locations at which animals were trapped. Higher numbers indicated successive observations. The number 1 (one) was used to designate the location where the animal was originally trapped and the letter z as recaptured. This pattern of recording home ranges was followed with the following two exceptions: (1) animal V, (No. 70, Table 1) an adult male, was captured at trap eight (V_1, Fig. 3) and released one-half mile from its original capture. In this case, the site of release was designated as V_2 and the first observation was recorded as V_3. (2) Two recaptures of adult female P (No. 47, Table 1) were not plotted at trap 1 (same as Y_1, z4, Fig. 3) and at trap 7 (Y_2, Fig. 3).

Only home ranges of those animals observed three or more times were plotted on maps. A Compensating Polar Planimeter was used to measure the

home range from the maps. With the exception of two nights spent during November observing hares, the home range phase of the study was terminated at the end of August.

Reproduction

Specimens were usually collected within an area of 10 square miles north of Lakin in Kearny County. All animals were collected by shooting with a .22 caliber rifle and occasionally a 12 guage shot-gun.

The reproductive tracts of the females and the testes of the males were removed at Lakin and preserved in 10 per cent formalin. All materials were returned to Manhattan for dissection. Sperm smears of one testis and the cauda epididymis were taken. A phase microscope was used to estimate the presence of sperm on the basis of 0= no sperm; 1= occasional sperm; 2= frequently found; 3= sperm everywhere; 4= masses of sperm. Only those animals with sperm smears of 3 to 4 were considered capable of breeding. The epididymis was stripped off and the testes were weighed as pairs.

A measurement of each ovary was made. Rupture sites were counted and recorded. The ovaries were sliced into sections about two millimeters in width. The larger peripheral follicles and corpora lutea were counted. No attempt was made to record placental scars and corpora albicantia because they quickly faded after the litter was born (Bronson, 1957). The animal was designated as parous if the uterus was longitudinally striated. Lechleitner (1959) stated that the striations developed as a result of pregnancy and were retained throughout life. The macroscopic embryos were counted in each horn of the uterus. The crown rump measurement was taken and those embryos of 90 millimeters or over were sexed.

Census

Many different methods have been used to count jack rabbits on a particular area. Jack rabbit drives were used by Palmer (1897), Vorhies and Taylor (1933), Wooster (1935), and Woodbury (1955). Carter (1939) and Brown (1940, 1947), sent questionaires to residents of a certain area and used the results to estimate the population. Vorhies and Taylor (1933), Phillips (1936) and Arnold and Reynolds (1943) used results of pellet counts to estimate jack rabbit populations.

While all of these methods have some merit each has a major draw-back. Either there was not enough known about the subspecies of jack rabbit used in this study, or the cost of the method was limiting, consequently a search was made for another method.

The "King Grid" census has been used for estimating animal populations (Trippensee, 1948). Webb (1942) presented a description of the King census method for snowshoe hares. The method was as follows. The observer should walk lines about one-quarter mile apart to fairly sample the area. For all hares seen, the observer should determine the jumping angle in degrees of arc, and the jumping distance in yards. Computations were then similar to those of King (1937).

Hayne (1949) pointed out some of the errors of the King method. One inherent error was made in assuming that the mean flushing distance was reliable. Two other errors were that the observer could not see all flushed animals and that animals moved out of the path of the censuser.

Lechleitner (1958a) used strip-counts based on a modification of the method described by Webb. This method was adopted for use in this study. Strips spaced one-quarter of a mile apart and one mile long were used. Only

those animals flushed within 50 feet of either side of the observer were counted. When there was a doubt as to whether the animal was flushed within 50 feet, the distance was measured.

Several conditions under which counts for indices were to be made were established in an attempt to make each indexing period as environmentally equal as possible. Counts were made only between 10 A.M. and 3 P.M. when few hares were moving. Counting was to be done only when weather was normal; that is, the wind was at a minimum, the ground was dry or relatively so and the temperature normal for the season. Two days were required to complete the census.

Ten stripe each a mile long were walked to conduct the census. Two stripe were walked on the summer fallow field, four on the buffalo grass and four on the farmland section (Fig. 1).

RESULTS

Home Range

In 461 trap nights, 87 jack rabbits, 31 cottontails (Sylvilagus sp.), two kangroo rats (Dipodomys ordii), two burrowing owls (Speotyto cunicularia), and one owl of undetermined species for a total of 123 animals were captured. Of the 87 jack rabbits captured, nine were recaptures, seven died or were killed in trapping, nine were held and not tagged, and five escaped after being trapped. Fifty-seven jack rabbits were tagged and released.

The author made several attempts to observe the hares upon release, immediately after they were tagged. The general reaction was to bound away into the first available cover. On some occasions, a hare would hop 25 to

Table 1. Sex, age, trap caught and number of times 57 tagged hares were seen. Home range size is of 25 individuals.

Jack Rabbits Numbers	Sex	Age	Date Caught	Disposal	Times Seen	Recaptured Date	Recaptured Trap	Mapped on Figure -	Home Range Size (Acres)	Letter on Map
0	-	Juv.	6-14	R	7			2	27	A
2	♀	Juv.	7-11	R	7			3	35	B
6	♂	Ad.	7-16	H-24 hrs.	0					
7	♀	Ad.	8-10	H-36 hrs.	0					
10	♂	Ad.	8-17	H-24 hrs.	0					
11	♀	Ad.	7-8	R	1					
13	♂	Ad.	7-25	R	4			4	72	C
14	♂	Juv.	6-28	R	Captured and killed after release because of a trap injury.					
16	♀	Juv.	7-28	R	0	7-31 8-1 8-3	10 10 6	2	--	D
17	♀	Ad.	7-25	R	1					
19	♂	Ad.	7-17	H-72 hrs.	0					
20	♀	Juv.	8-3	R	8			5	43	E
21	♂	Juv.	7-11	R	2					
22	♂	Ad.	7-11	R	5			2	30	F
23	♀	Ad.	6-28	R	1	7-9 7-14 7-18	7 2 1	3	--	Y

Table 1 (Cont.).

Jack Rabbit Number	Sex	Age	Date Caught	Disposal	Times Seen	Recaptured Date	Recaptured Trap	Mapped on Figure -	Home Range Size (Acres)	Letter on Map
24	♂	Ad.	6-14	R	6			5	45	G
25	♀	Juv.	7-8	R	8			6	29	H
26	♀	Juv.	7-8	R	4			5	58	I
27	♀	Juv.	7-11	R	2					
29	♂	Juv.	8-25	R	2					
30	♂	Juv.	8-3	R	5			5	14	J
31	♀	Juv.	7-9	R	3			6	32	K
32	♂	Juv.	7-9	R	1					
34	♂	Ad.	7-9	R	5			6	29	M
35	♂	Juv.	7-10	R	0					
36	♂	Ad.	8-5	R	4			5	32	N
38	♂	Juv.	8-28	R	1					
39	♂	Ad.	6-30	R	5	8-19	4	2	18	L
40	♂	Juv.	7-15	R	0					
44	♀	Ad.	7-23	H-24 hrs.	3			5	194	O
45	♂	Ad.	7-27	H-48 hrs.	2					

Table 1 (cont.).

Jack Rabbit Number	Sex	Age	Date Caught	Disposal	Times Seen	Recaptured Date	Recaptured Trap	Home Range Mapped on Figure	Home Range Size (Acres)	Letter on Map
46	♂	Juv.	8-3	R	2					
47	♀	Ad.	7-25	R	6	7-29	1	3	52	P
49	♀	Juv.	7-16	R	1					
50	♀	Juv.	7-27	R	0					
52	♂	Ad.	7-30	H-36 hrs.	3			2	10	Q
54	♂	Ad.	6-27	R	4 (Collected 9-26; Plate IV, Fig. 1)			2	30	R
55	♀	Ad.	7-12	R	4			5	47	S
57	♀	Juv.	8-12	R	6			4	68	T
64	♀	Juv.	7-10	R	1					
67	♂	Juv.	7-1	R	1					
68	♂	Ad.	7-9	R	1					
69	♂	Juv.	7-26	R	4			3	21	U
70	♂	Ad.	7-12	H-24 hrs.	8	3		3	99	V
71	♀	Juv.	7-15	R	1					
72	♂	Ad.	7-13	R	2					

Table 1 (concl.).

Jack Rabbit Number	Sex	Age	Date Counts	Disposal	Times Seen	Recaptured Date	Recaptured Trap	Mapped on Figure -	Home Range Size (Acres)	Home Range Letter on Map
73	♂	Juv.	7-1	R	0					
75	♀	Ad.	8-26	H-24 hrs.	0					
76	♀	Juv.	6-15	R	0					
79	♂	Juv.	8-3	R	0					
83	♂	Ad.	8-9	H-24 hrs.	4			4	63	W
84	♂	Juv.	7-29	R	1					
85	♂	Ad.	7-24	H-24 hrs.	6			2	88	X
90	♂	Juv.	7-16	R	0					
92	♂	Ad.	7-21	R	1					
94	♂	Juv.	8-10	R	1					
97	♂	Juv.	7-18	R	0					

R is released at the time of capture.
H is held for a varying number of hours at the laboratory.

50 yards away, then stop and sit on its haunches for a few minutes before bounding to cover. Apparently, there was no animosity toward the tag. Occasionally, a hare would shake its ear for a few minutes, but after it was accustomed to the tag there was never any observed reaction toward it.

The age ratio of captures was 31 juvenile hares to 26 adults (Table 1). Adult sex ratio was 18 males to 8 females. This would indicate that males have a greater tendency to roam about than females and were more subject to capture.

Fourteen of the 57 tagged hares were never seen after release. Twenty-one of the 26 adults were found at least once and 22 of the 31 juveniles were seen. The 18 adult males were seen 82 times compared to 16 sightings of the adult females.

One jack rabbit was noted only in retrapping and one was killed two days after release because of an unnoticed trap injury. The remaining 43 animals were observed 144 times.

Tagged hares were difficult to observe during daylight hours. When driving or walking through the study area, the hares flushed and were quickly out of sight, consequently, few data were obtained. While sitting at an observation point of good advantage during the evenings, it was noticed that hares were not concerned with the presence of a human. On several occasions, jack rabbits came to within a few feet of the observation point. Lechleitner (1958a) conducted a home range study of L.c.californicus during daylight hours. As this study progressed, it was found that hares were most easily observed during darkness. Jack rabbits were usually timid and unconcerned when the spotlight was shown on them. At times, as long as 30 minutes was spent trying to read an ear tag on one individual. Slamming the pickup door or other loud noises would usually evoke only a slight response.

Home range is defined as the area, usually around a home site, over which the animal normally travels in food gathering, mating, and caring for young (Burt, 1943). Observations during the summer of 1959 indicated that the black-tailed jack rabbit tended to stay within rather well defined areas. Home ranges, calculated from movements of 23 individuals, averaged 49 acres. Ten adult males had an average home range of 49 acres, while that for three females averaged 97 acres. The larger range noted for females probably was the result of the few times females were observed or from the observed movements of adult female No. 44 (Table 1; O, Fig. 5). These animals ranged in 52 and 47 acres.

In general, young animals range less widely than adults of the same species (Fitch, 1958). This is probably applicable to the jack rabbit. The average for juvenile females, based on four hares was 66 acres, and for juvenile males based on 3 individuals was 21 acres.

With one exception, weedy fence rows had little affect as a barrier to movement. The one exception was No. 69 (Table 1; U, Fig. 3), a juvenile male that was caught on the west edge of Soil Bank Field B fence row and seen four successive times without having crossed the barrier. It did cross from Soil Bank Field B into the sorghum field.

Apparently, jack rabbits may return to their original home range. Adult male No. 70 (Table 1; V, Fig. 3) was released one-half mile east of where it was captured. Twenty-seven days later, the animal was seen less than one-half mile south of the capture site. It was then seen eight times in proximity of the area of capture. The greatest distance moved was over one mile from where it was released.

Distances moved by jack rabbits varied with individual animals. Adult female No. 44 (Table 1; O, Fig. 5) was captured at trap one and held at the

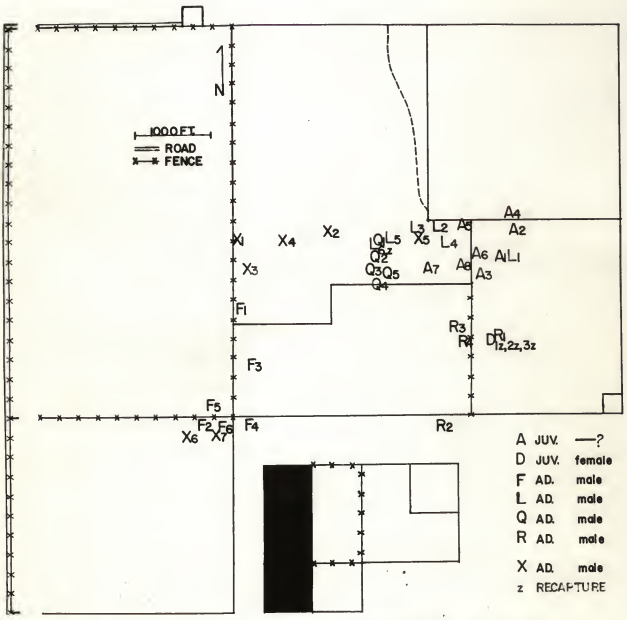

Fig. 2. Known movements of seven jack rabbits. Arabic number 1 indicates the site of capture and release. Black inset is that part of the study area not drawn on the home range map.

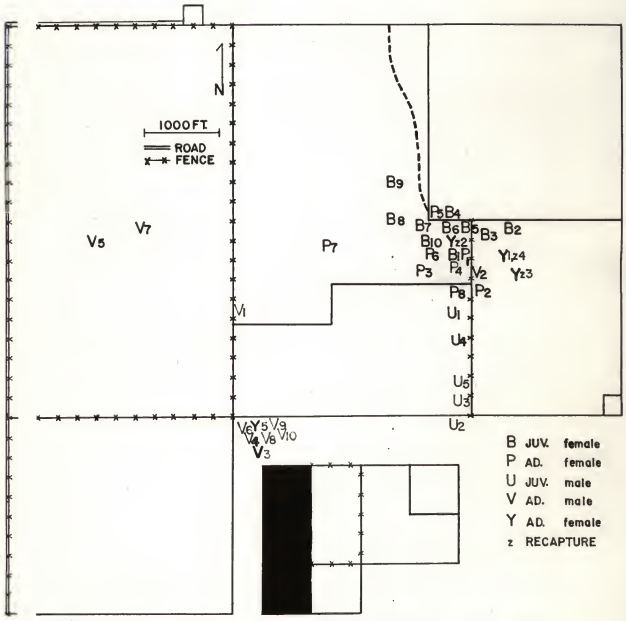

Fig. 3. Known ranges of five marked jack rabbits. Arabic number 1 indicates the site of capture and release, z is recapture. Black inset is that part of the study area not drawn on the home range map.

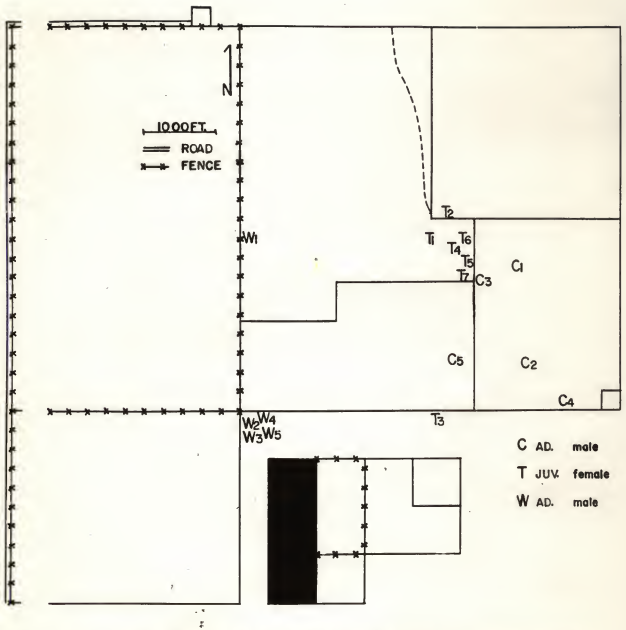

Fig. 4. Known location of three marked jack rabbits. Arabic number 1 indicates the site of capture and release. Black inset is that part of the study area not drawn on the home range map.

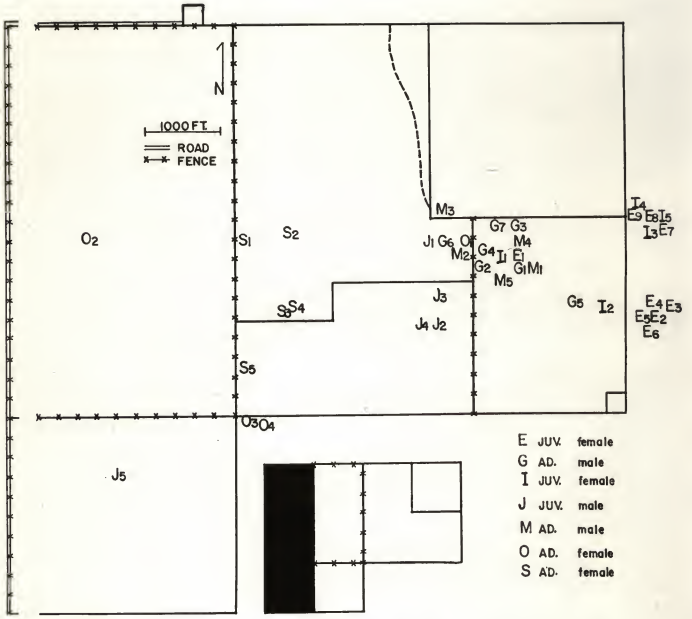

Fig. 5. Movements of seven marked jack rabbits. Observation J_5 was in November 1959. Black inset is that part of the study area not drawn on the home range map.

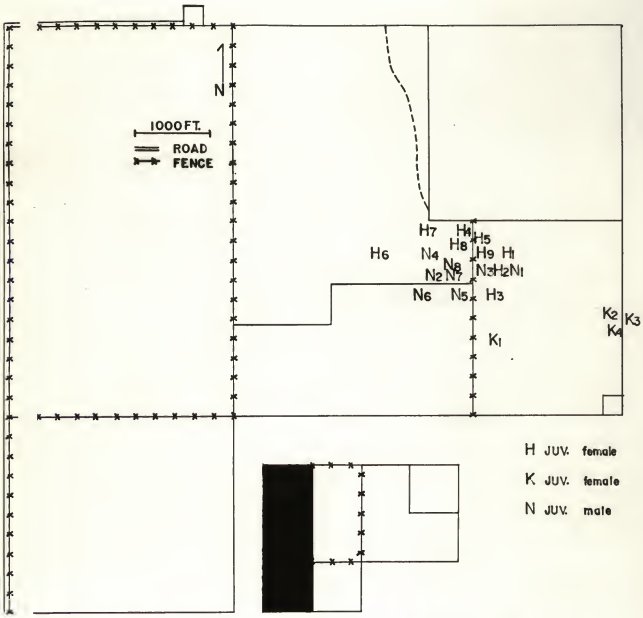

Fig. 6. Known movements of three marked jack rabbits. Black inset is that part of the study area not drawn on the home range map.

laboratory during the daylight hours before it was released. Thirty-eight days elapsed before the animal was again seen a distance of one mile from the area of capture and release. Later, observations were made about three-quarters of a mile from the site of capture. Since this individual had the largest home range when the site of capture was included (194 acres) it was postulated that this hare was captured when away from its home range and returned after release.

Adult female No. 23 (Table 1; Y, Fig. 3) was captured, tagged, released and recaptured three times before the final observation was made in late summer. At the last observation, she had moved three-quarters of a mile from the area of capture. An adult male, No. 13 (Table 1; C, Fig. 4), was found in the Wheat Stubble Field (Fig. 1) during the summer. In December, a hunter shot the hare about one mile north of the capture sight. Adult female No. 11, (Table 1) was seen only once after release at trap two. The one observation was three-quarters of a mile from capture.

In only one case recorded on the home range maps was movement by a juvenile beyond the expected home range area. The one case was juvenile male No. 30 (Table 1; J, Fig. 5). He had remained in the same general area during the summer of 1959, but in November had moved over one mile from capture and home range area. This hare may have left its home range in the late fall in search of a new food source.

Juvenile male 32 (Table 1) was seen only once about one mile east of its capture and release site. Juvenile hare 84 (Table 1) moved three-quarters of a mile from the site of release.

Adult males No. 24 (Table 1; G, Fig. 5) and No. 39 (Table 1; L, Fig. 1) were shot in December and the tags given to the state game protector. No specific location for collection of these hares was given to the author other than being on the study area.

Only one tag was known to have been lost. Juvenile male No. 38 (Table 1) was tagged on August 28 and shot on November 21. At necropsy, the monel metal tag was present in the right ear but the plastic tag and part of the ear had been torn out of the left ear.

Adult male 54 (Table 1) was tagged 91 days before it was collected. Part of the scotchlite numbers were gone from the plastic tag, and the monel metal tag was gone from the hare's right ear (Plate IV, Fig. 1). The plastic tag was so well anchored to the ear by the nylon string that it had to be cut off. A large hole was present in the ear under the tag. It was thought that the hole was from a reaction caused by hitting a blood vessel with the needle when the animal was tagged. All other tags given to the author were in excellent condition.

Nesting, habits and development of young

Seton (1929) described the black-tailed jack rabbit nest as the nest that has never been seen. He believed that jack rabbits scattered their young at birth rather than make a nest. Vorhies and Taylor (1933) concluded from authentic reports that the jack rabbit does make a nest. They felt the jack rabbit nest was similar to one made by the cottontail. Others who have worked with jack rabbits believe that a nest is made, but they had never found one (Nautin, 1946; Bronson, 1957).

A nest can be defined as a settled and often concealed place in which young animals are reared (Neilson, 1949). With this as the qualifying definition, the term nest can, but with limits, be used for jack rabbits as evidenced from observations of this study.

During the past two years, two jack rabbit nests were found. One nest with one young was found while walking through the study area. After

flushing a jack rabbit, a form was examined at the base of a russian thistle plant. The young jack rabbit was present in the form. He was capable of moving about, although movement was slight.

A second nest was found in which four jack rabbits were huddled (Plate V, Fig. 1). After marking the area, the author walked to the car for a camera. Upon return, one of the hares had moved about six feet from the form and the other three had moved into the weeds at the edge of the form. They were all placed back in their original position and pictures were taken. Two of them were then removed and the remaining two began to move. They tripped over sticks and ran into weeds.

Available evidence indicated that these hares were less than twenty-four hours old when they were found. About one-half inch of rain had fallen during the night before the nest was discovered. The form had been dug after the precipitation had fallen because the soil particles were not consolidated as they normally would be after a rain. Blood was still present on the front of the form.

Measurements were taken the same day the hares were found (Table 2). Average measurements in millimeters were: total length 173; tail 28; hind foot 49; and ear 30. These measurements are greater than reported by Vorhies and Taylor (1933) in Arizona.

Table 2. Measurements of four jack rabbits estimated to be one day old.

Measurement	Number 1	Number 2	Number 3	Number 4	Average
Total Length	175	170	173	173	173
Tail	27	27	30	27	28
Hind Foot	50	49	48	49	49
Ear	30	31	30	29	30

Precocity of these young hares was evident when they were measured at the laboratory. Two of them were out of the box at the same time. They suddenly ran in the opposite directions across the lawn. One was easily caught but the other was not found until after an hour of intensive searching. It had moved about 50 yards across the lawn, through a hedge, across a road, and was found under a lilac bush.

Additional evidence that young jack rabbits are mobile was found when a small jack rabbit (not much larger than those found in the nest) was seen in a small form in the field. When an attempt was made to capture it, it ran under a yucca plant. The animal could not be found in or about the plant, and when the plant was removed, the young hare was not located.

It is not known how long jack rabbits stay in their nest. The ability of the hares to move so easily at birth suggests that shortly after parturition they leave their birthplace. While hunting at night in mid-June of 1959, a group of three or four small jack rabbits crossed the road in front of the car. Only two of the hares were captured. They were both of the same size and apparently from the same litter. Measurements of one of the jack rabbits were: total length 197; hind foot 62; tail 32; and ear 42 millimeters. On the basis of the size of the one-day-old litter (Table 2), these two individuals were believed to be about one week old.

One small hare was found along an area that had been driven across two times daily as the traps were checked. The closest form was 100 feet away. Another young jack rabbit was found on the grass shoulder of the highway near the study area. Average measurements of the two were: total length 150; hind foot 55; ear 30; and tail 32 millimeters.

A hare that measured 195 millimeters in length was found in Soil Bank Field A of the study area (Fig. 1). No form was observed within 100 feet of the animal.

While collecting specimens near Shields, Kansas, a young jack rabbit was caught. Since the total length was 180 millimeters, this hare was considered to be less than one week old. It was raised to 10 weeks of age (Table 3).

These observations lead to the following conclusions: (1) litters are dropped in forms with no preparation for a nest, or no form is dug at all; (2) the young leave the form shortly after birth, perhaps on the same day they are born; (3) the litter may stay together for a week or more after leaving the form.

Aldous (1937), working with the snowshoe hare reported similar observations. He stated that the young hares were dropped in the form used by the female, but just as frequently, they were found whenever cover was available. Hair, fur, grass or leaves were not used as a lining or blanket (Aldous, 1937).

Numerous attempts were made to raise young jack rabbits found in the field or taken by caesarean section. Diets of milk diluted with varying amounts of water, milk and honey or oatmeal grout were used. Fresh alfalfa was given to the hares each day. The young rabbits would eat for about one week to ten days, then become sick and die. Vorhies (1921), and Vorhies and Taylor(1933), experienced the same difficulty. Their conclusion was that from the dietetic standpoint feeding was not simple, a point in which the author concurs.

While feeding jack rabbits, Vorhies and Taylor (1933) noticed two instincts in the young. One was called the following instinct, exhibited by the young following a human about at night. The author noticed this phenomenon in a litter taken by caesarean section. When boots were moved about on the floor, the hares would begin clambering about in an attempt to climb upon them. If the author was sitting on the floor or lawn while

this litter was out of its cage, they would unceasingly attempt to climb upon his boots and legs into his lap. This type of behavior was evident only in the litter taken by caesarean, consequently, the author felt that this may have been a case of imprinting.

A second instinct described by Vorhies and Taylor (1933) was that of accepting food only at night. In the author's experience, young jack rabbits accepted food any time of the day or night. During the attempts to raise young hares a schedule of feeding was set up with food being given at 6 to 8 A.M., 11 A.M. to 1 P.M., 6 to 8 P.M., and about 11 P.M. There was no apparent difference in willingness to accept or reject food at these hours.

Five other animals were captured in the field or in traps and raised to various ages during the summer of 1959 (Table 3). The approximate age of these hares at capture was estimated using the day old litter found in the nest (Table 2) as the base size and age. As these animals grew, external measurements were taken; consequently, as additional hares were captured, they were aged on the basis of their size (length, ear and hind foot).

Table 3. Sex, age and measurements at necropsy of five jack rabbits raised in captivity, length in millimeters, weight in grams.

Jack Rabbit Number	Sex	Total Length	Weight	Ear Length	Hind Foot Length	Age Class	Estimated Age in Weeks
48	♂	465	1418	105	118	I	10
28	♂	480	1340	105	115	I	11
53	♀	512	1608	117	120	II	14.5
33	♀	560	1944	?	?	II	26
78	♂	547	2112	115	130	III	38

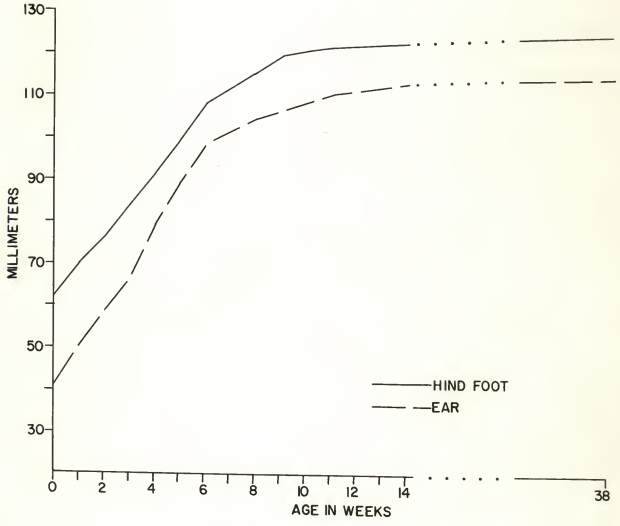

Fig. 7. Average hind foot and ear length of the black-tailed jack rabbit from birth to an estimated age of 38 weeks.

The standard external measurements are total length, hind-foot length, and ear length (Blair, et al., 1957). Attempts to measure the total length of a living animal will result in considerable error, therefore, total length was not used as an age criterion.

Ear length is measured from the deepest part of the notch on the external border to tip of the pinna and hind-foot is measured from the heel to the tip of the longest claw (Blair, et al., 1957). Because of the ease in taking these measurements and the relative accuracy obtained on both living and dead animals, ear length and hind-foot measurements were used for plotting a growth curve. A five-point moving average was used to establish a smooth curve. It should be pointed out that these data are approximate and should be used only as a guide.

Bronson (1958) found there was no difference in the hind-foot and ear length measurements of adult males and females, therefore pooled measurement data were graphed. The hind-foot of 26 adult males and 19 adult females averaged 126 millimeters and the ear 106 millimeters (Bronson, 1958). On the basis of the growth data from five individuals, it would appear that the hind foot grows to mature size at about 12 weeks of age and the ear at about 10 weeks of age (Fig. 7). Haskell and Reynolds (1947) gave 15 weeks as the date of maturity for the ear and hind foot of L.c. americus.

Weight fluctuations of adults

Two recent mammalian studies presented monthly weights for an entire year. Rowan and Keith (1959) presented monthly weights of snowshoe hares and Reynolds (1960) graphed weight differences for adult male and female kangaroo rats (Dipodomys merriami).

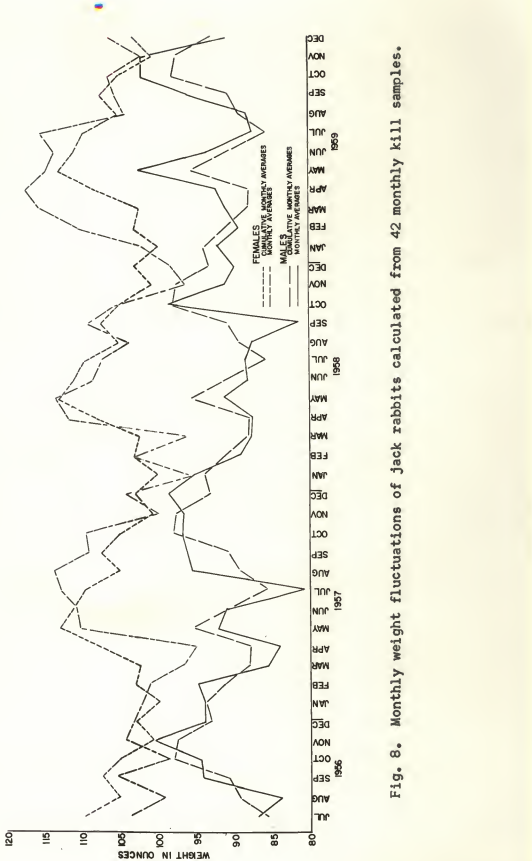

Fig. 8. Monthly weight fluctuations of jack rabbits calculated from 42 monthly kill samples.

Monthly weight fluctuations for the jack rabbit were calculated for the three and one-half years of this study. Cumulative monthly average data were graphed for each sex. This was calculated by averaging the weight for each July, for example, and plotting the average July weight. Individual monthly average data for each month were plotted to determine if there was a difference in the different years.

As the breeding season began, the spread in weight between the sexes increased until a maximum was reached in midsummer. At the end of the breeding season in late summer, the males began to gain weight and the females lost weight. By mid winter, the weights were about the same for the sexes (Fig. 8).

The greatest weight for the females was reached during the middle part of the breeding season, April through July. Males reached their maximum weight in October and November the quiescent part of the breeding season. Males also made a noticeable gain in weight during April, May and June, the period of the year when vegetation was becoming green.

The cause of weight differences between males and females would appear to be directly related to breeding activity. Males lost weight while actively seeking mates and females gained weight during pregnancy. By using the lower confidence limit on the mean ($\bar{d} - t_{41}\, s_{\bar{D}}$; $t_{.05} = 2.014$; 45 D.F.), it was shown that weights of males and females were significantly different in January through September and in December of some years. In March 1958, a part of the breeding season, there was no significant difference between the weights of the sexes (Table 4).

November was the only month in which males and females consistently weighed the same. This was opposite the findings of Rowan (1959) in the

Table 4. Monthly differences in weights of adult male and female jack rabbits. Plus denotes a significant difference, and the minus shows the months in which there was no difference in weight.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1956							+	+	+	-	-	-
1957	+	-	+	+	+	+	+	+	+	+	-	-
1958	-	+	-	+	+	+	+	+	+	-	-	-
1959	+	+	+	+	+	+	+	+	+	-	-	+

snowshoe hare. He found the only significant difference in weight between the sexes of snowshoe hares occurred in November when females were heavier than males.

Aging

Many varied techniques have been used for aging mammals. Green and Evans (1940) used a trap, tag and release technique to determine the age of snowshoe hares. Adams (1959) used the color of the hind feet of snowshoe hares to separate the young from adults. Test size, length of the penis and presence or absence of vaginal membrane were used for aging cottontails (Petrides, 1951).

Epiphyseal closure has become one of the most commonly used methods for aging rabbits. This method was originated by Thomsen and Mortenson (1946), and has been used by Hale (1949), Petrides (1951), Watson and Tyndale-Biscoe (1953), Lechleitner (1959), and Bronson and Tiemeier (1958a).

There are limits to the use of the epiphyseal closure technique. Bronson (1957) felt that young of the year could be successfully aged only until all traces of the closure were gone in members of the earlier born litters. He

believed this closure occurred at eight to nine months of age. He thought this aging technique was of limited value during the months of November and December and, consequently the size and condition of the reproductive organs were used in addition to the epiphyseal closure. Males were becoming sexually mature in December and by January, all males were considered adults. Bronson believed that young-of-the-year females could be aged through January by the size and condition of the uterus, ovaries and external genitalia.

In this study, it was arbitrarily decided that since a new breeding season was beginning in January, all animals collected in January would be classified as adults (Fig. 9). The young males were becoming sexually mature and difficult to distinguish from the adults. The genital organs of all females were small and shrunken until January when pregnant females were found. Non-parous females would indicate juveniles (Lechleitner, 1959) but this would be of no value after the first litter was produced. Because 80 per cent of the females were pregnant in January of one year, this method would be of no value by late February.

The age distribution using this "field aging" technique fluctuated seasonally (Fig. 9). Juveniles were more numerous in September and October of each year. Juveniles were usually collected in May for the first time after a new breeding season started. In 1959, a juvenile was collected as early as March.

The smallest male collected by shooting weighed 16 ounces and the smallest female weighed 24 ounces. This would indicate that young hares are not collected by shooting until they reach three to four weeks of age.

Lechleitner (1959) revised the epiphyseal closure technique by classifying L. c. californicus into three age classes. The three age classes were as

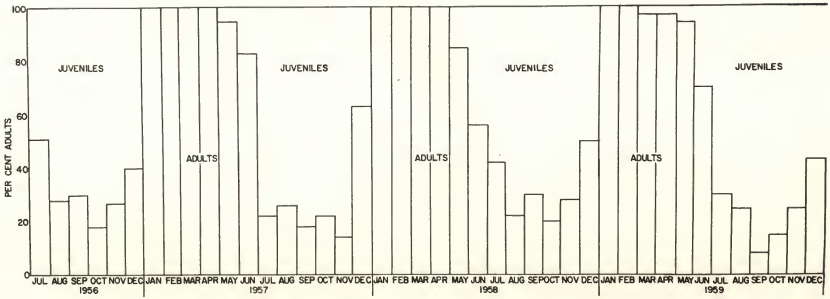

Fig. 9. Monthly age distribution of 2,037 jack rabbits in the kill samples.

follows: Age Class I included those animals in which the epiphyseal area was represented by a definite groove because the cartilage was not replaced by bone; Age Class II included those animals in which the epiphyseal plate was essentially closed and all cartilage was replaced by bone, but the bony trabeculae were not organized and a definite line could be seen on the surface indicating the place of closure; Age Class III included those in which there was no indication of an epiphyseal line.

Lechleitner considered the average age of each age class to be as follows: Age Class I was from two to nine months of age; Age Class II was from 10 to 12 months of age and those listed as Age Class III were over one year. This method was used in the present study from January 1957 through 1959 (Fig. 10). Humeri for May 1957 were missing.

The percentage of hares in Age Class I and II was zero for some months in Kansas. In California, about 8 per cent was the lowest percentage recorded for Age Class I and 23 per cent for Age Class II (Lechleitner, 1959). The difference in the data from the two states was apparently due to seasonal breeding in Kansas jack rabbits compared to year round breeding by L.c. californicus in California.

Age Class I individuals were not collected until May of 1957 and 1958 (Fig. 10). The fact that members of Age Class I were collected earlier in 1959 coincided directly with the percentage of females collected in January. For example, less than 10 per cent of the females were pregnant in January of 1957 and about 20 per cent were pregnant in 1958. In January 1959, over 80 per cent of the adult females were pregnant (Fig. 11).

Individuals of Age Class I first appeared in May of each year and were prevalent through August. Generally by November and December members of Age

Class I individuals were not in the kill samples. The time at which Age Class I individuals were no longer in the collection was used to establish the age at which Age Class I reached Age Class II. By counting from November or December back to the last reproductive month, August or September, it was determined that Age Class I individuals reached the age of Age Class II in two to three months (Fig. 10). Lechleitner (1959) considered Age Class I to be from two to nine months of age. Data from Kansas jack rabbits raised in captivity show that the epiphyseal cartilage closed to Age Class II at 11 to 15 weeks of age (Table 3), or at three months (Fig. 10) according to kill samples.

The time when Age Class II disappeared from the population was used as evidence for the age at which the epiphyseal cartilage closed to Age Class III. The kill sample was almost all Age Class I and III nine months from the end of the breeding season. Individual variation probably accounted for the collection of Age Class II in June 1957 (1 of 29) and June and July of 1958 (3 of 78 and 3 of 79 were Age Class II). No Age Class II individuals were in the collection in June or July of 1959. This would indicate that the epiphyseal plate closed at about nine months of age. The one animal raised to 38 weeks of age was considered Age Class III (Table 3). These data agree with the age of epiphyseal closure to Age Class III as listed by Lechleitner (1959).

Aging techniques used for mammals include the use of body weight for raccoons (Sanderson, 1950), beavers (Buckley, 1955), muskrats (Alexander, 1951; Schofield, 1955), snowshoe hares (Severaid, 1942) and jack rabbits (Lechleitner, 1959). In general, body weight was of limited use as an age criterion. Lechleitner (1959), assumed that body weight would indicate age

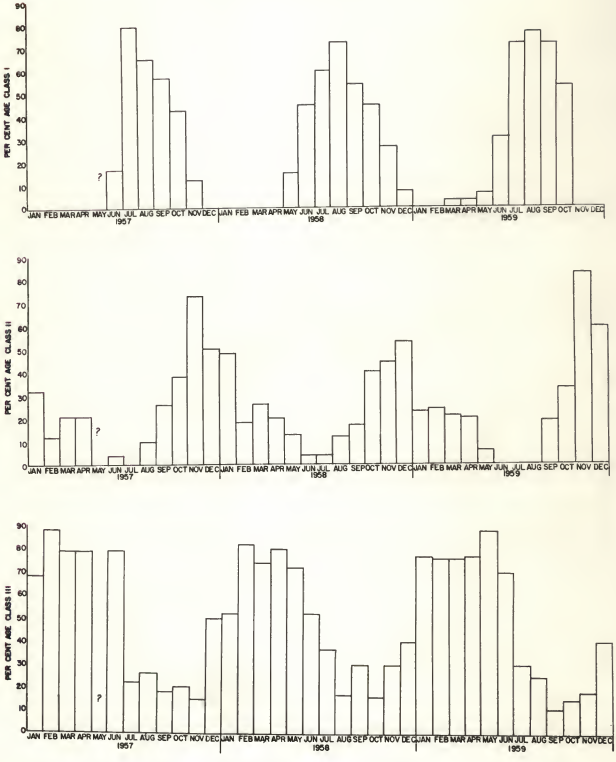

Fig. 10. Age classes in the kill sample expressed as a per cent of the monthly kill for three years. Data for May 1957 are missing.

with an accuracy within two months of age until the jack rabbit was seven months old. At about seven months of age, some hares attained a weight which was within the range of variation of much older animals.

In the present study there was a significant difference in the weights of both males and females for the three age classes (Table 5). Average weight of Age Class I did not overlap with that for Age Class II, consequently weight could be used as an age criterion until the jack rabbit reached three months of age (Age Class I hares were two to three months old). There was considerable overlapping of Age Class II with Age Class III (Table 6), therefore, for those hares that were Age Class II or III weight would be of no value as an age criterion. It is also evident from the seasonal weight fluctuations of adults that weight would be limited as an age criterion (Fig. 8).

Table 5. Values of t for tests of body weight, body length, and humerus length between Age Classes I, II, III for males and females. ($t_{.05} = 1.96$; infinite D.F.).

Tested Criterion	Sex	AGE CLASS I vs. II	I vs. III	II vs. III
Body Weight	♂	10.14	16.56	1.98
	♀	10.99	18.71	4.56
Body Length	♂	6.98	11.63	2.84
	♀	8.86	12.68	1.33
Humerus Length	♂	8.69	12.86	0.93
	♀	2.01	12.14	1.15

Body length would not fluctuate during the different seasons. Because there was a significant difference for all Age Classes except Age Class II

Table 6. Weights of three age classes of jack rabbits from southwestern Kansas.

Age Class	Sex	Number	Mean Weight in Grams	Standard Error
I	♂	122	1832	28.7
	♀	78	1948	74.1
II	♂	59	2437	77.5
	♀	58	2746	111.0
III	♂	125	2562	15.6
	♀	114	3010	26.7

Table 7. Body lengths of three age classes of jack rabbits from southwestern Kansas.

Age Class	Sex	Number	Mean Length in Millimeters	Standard Error
I	♂	122	495.2	3.33
	♀	78	505.5	6.86
II	♂	59	542.0	6.29
	♀	58	564.0	9.99
III	♂	125	552.2	1.48
	♀	114	568.9	2.12

Table 8. Length of the humerus of three age classes of jack rabbits from southwestern Kansas.

Age Class	Sex	Number	Mean Length in Millimeters	Standard Error
I	♂	122	80.4	0.45
	♀	78	81.4	1.11
II	♂	59	88.5	0.94
	♀	58	89.0	1.06
III	♂	125	88.9	0.20
	♀	114	90.5	0.26

and III of the females (Table 5), body length should be of some value as an age criterion. The greatest amount of overlapping in length between the three age classes occurred between the females of Age Class II and III (Table 7). In this case, Age Class II females were sometimes larger than Age Class III females. Body length would appear to be applicable as an aging technique between Age Classes I and II, and Age Class III of the males, but when tried, there was so much individual variation that the use of body length as an age criterion was unreliable.

An attempt was made to use humerus length as an age criterion. Statistical analysis of the humerus length showed there was no difference between Age Class II and III of both males and females (Table 5). This is the age (nine months) at which epiphyseal closure takes place. Humerus length would then appear to be of value as an aging technique up to that time since there was no overlapping in length between Age Class I and II (Table 8). However, individual variation within the age classes was so great that humerus length was not a reliable technique for aging jack rabbits.

The dry weight of the lens of the eye has been used as an indicator of age (Lord, 1959). Data presented for the use of this technique in aging jack rabbits is in the stage of a progress report since a complete growth curve has not been worked out.

Statistically, there was no difference in the dry weight of the left and right lenses (Table 9). The correlation coefficients were near one except for Age Class II females. It was felt that the correlation of .89 for Age Class II females was due to a bad sample since all other correlations were near perfect.

Table 9. Correlation coefficients between weights of right and left lenses of male and female jack rabbits.

	AGE CLASS					
	I		II		III	
	♂	♀	♂	♀	♂	♀
Correlation Coefficient	.98	.99	.92	.89	.94	.97

Heavier lenses were found as the jack rabbits became older (Table 10). Statistical analysis of the three age classes showed that there was some overlapping of weights between Age Class II and III. This should be expected since animals of various ages were included in the two groups.

Table 10. Tolerance limits on dry lenses weights for different Age Classes of jack rabbits.

Age Class	Sex	Number	Tolerance Limits Dry Weights (mg.)
I	♂	77	136.74± 62.52
	♀	70	137.01± 54.62
II	♂	28	196.75± 28.04
	♀	25	209.96± 60.31
III	♂	42	273.48± 50.81
	♀	50	282.46± 101.98

The base point for the growth curve has been established from the litter found in the nest. Additional points have been established from animals raised from seven days to 38 weeks of age (Table 11).

Table 11. Dry weight of jack rabbit lenses.

	ESTIMATED AGE IN DAYS								
	1	7	9	16	70	77	100	182	266
Weight in Milligrams	26	34	36	47	103	123	142	196	219

Reproduction

A total of 2,037 jack rabbits were collected during the three and one-half year study. Of this number, 1065 were males and 972 females. A Chi-square test showed this difference to be significant (X^2= 4.24; $X^2_{.05}$= 3.84, 1 D.F.). There was no difference in the sex ratios of the collections for 1956, 1957, and 1959 (X^2_{1956}= 2.76; X^2_{1957}= 0.50; X^2_{1959}= 1.22). There was a significant difference in the 1958 collection (X^2_{1958}= 4.14), and this difference was apparently large enough to make a significant difference in the sex ratio for the entire sample (Table 12). On the per hundred basis, the sex ratio was 110 males to 100 females.

A prenatal sex ratio was calculated from 213 fetuses with a crown rump length of 90 millimeters or greater. A Chi-square test showed there was no sex ratio difference between the 109 males and 104 females (X^2= .122; $X^2_{.05}$= 3.84, 1 D.F.).

A definite annual breeding cycle was evident from reproductive data (Fig. 11). Testes weight fluctuated from a seasonal high in April, May and June to a low in September and October. The peak in weight was reached about May each year.

The presence of the testes in the scrotum corresponded with the higher testes weights. Testes were scrotal from late December and January through July. Beginning in August, testes of some of the animals were in the inguinal

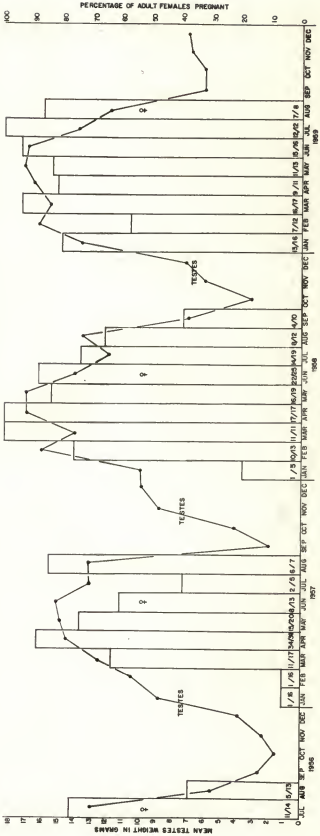

Fig. 11. Mean testes weight and per cent of females pregnant in 42 monthly collections.

Table 12. Sex and age composition of 42 monthly collections totaling 2,037 specimens.

Month	Adult Male	Juvenile Male	Adult Female	Juvenile Female	Total
July '56	23	20	14	15	72
Aug.	12	38	13	27	90
Sept.	10	24	13	29	76
Oct.	7	30	6	28	71
Nov.	12	23	11	15	61
Dec.	8	26	12	10	50
TOTAL	72	155	69	124	420
Jan. '57	26	0	27	0	53
Feb.	25	0	26	0	52
Mar.	21	0	17	0	38
April	28	0	38	0	66
May	16	1	20	1	38
June	11	1	13	4	29
July	1	10	5	11	27
Aug.	4	18	7	13	42
Sept.	3	16	4	16	39
Oct.	7	24	4	14	49
Nov.	4	20	3	24	51
Dec.	10	3	11	8	32
TOTAL	157	93	175	91	516
Jan. '58	18	0	13	0	31
Feb.	20	0	13	0	33
Mar.	14	0	11	0	25
April	29	0	17	0	46
May	20	3	19	4	46
June	19	20	25	14	78
July	14	29	19	17	79
Aug.	14	53	12	40	119
Sept.	3	17	10	13	43
Oct.	3	16	6	20	45
Nov.	8	23	7	16	54
Dec.	7	9	7	5	28
TOTAL	169	170	159	129	627
Jan. '59	15	0	16	0	31
Feb.	26	0	12	0	38
Mar.	17	1	17	0	34
April	19	0	11	1	31
May	19	0	13	2	34
June	21	10	16	6	53
July	9	23	12	25	71
Aug.	6	21	8	21	55
Sept.	1	15	2	18	36
Oct.	1	18	4	10	33
Nov.	4	10	3	11	28
Dec.	3	10	10	7	30
TOTAL	141	108	124	101	424
GRAND TOTAL	539	527	526	445	2037

Table 13. Per cent of adult males showing sperm in testicular smears and comparative sperm counts of three or four in epididymal smears.

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Epididymal												
1956	---------- No data ----------						100	54	10	0	0	15
1957	72	100	100	100	100	100	100	100	0	14	50	10
1958	33	65	86	97	100	100	100	100	66	0	25	50
1959	100	100	100	100	100	100	100	100	0	0	50	33
Testicular												
1956	---------- No data ----------						100	31	0	0	0	15
1957	88	100	100	100	100	100	100	75	0	28	75	80
1958	83	70	92	100	90	100	100	100	66	0	38	33
1959	100	100	100	94	100	100	100	100	0	0	50	66

to abdominal position. In October the testes were small and flaccid and were inguinal or abdominal. They began to descend in November and the cycle was completed in December.

Epididymal and testicular sperm counts fluctuated seasonally (Table 13). There was a gradual increase in sperm production through December and January. Almost all adult males had sperm in their testes from February until late August. There was little spermatogenesis in September and October.

The number of sperm in the epididymis, a criterion used to determine if the animal was capable of breeding, fluctuated in a pattern differing little from the presence of sperm in the testes. Because sperm are stored in the epididymis, there was a short lag in time after they appeared in the testis before they were found in epididymal smears. A greater number of sperm was thus found in the epididymis later in the season.

Occasionally an individual classified as a juvenile had an epididymal sperm count of 3 or 4. This was noted during the month of August, and because breeding ceased in August few juvenile males were able to reproduce during their first year. The onset of sperm production coincided with the period of the year when young hares were reaching adult size and body weight. All hares were considered adults in January because they were sexually mature (Fig. 9).

Watery cysts ranging from two to ten millimeters in size were found on both the cauda and capit epididymis of some animals. One cyst was sectioned and examined microscopically and another of five millimeters was examined macroscopically. No evidence was found from these examinations that would help explain the pathology of the cysts.

Only one case of breeding in December was recorded for the three-and-one-half-year study. One fetus collected on January 27, 1959 was 120 millimeters in length. The embryo was near term and considering the gestation period as 43 days (Haskell and Reynolds, 1947), the female was bred in December. No pregnant females were found in December. A pregnant female was collected as early as January 11, 1958, and on January 27, 1959, seven pregnant females had embryos that were 20 or more millimeters in length. It seems logical, therefore, to arbitrarily set the breeding season as beginning with January.

In September of 1959, 40 per cent (4 of 10) adult females were pregnant. The fetuses were all near term indicating that conception had occurred in August. Pregnant females were collected in only one of the four Septembers studied, therefore, the whole month was not included in the definition of the breeding season. The first 10 days of September were arbitrarily included.

An eight month and 10 day period of January through part of September or 252 days constituted the breeding season of the black-tailed jack rabbit in southwestern Kansas (Fig. 11). This was 40 days longer than reported by Bronson (1957). Breeding in the black-tailed jack rabbit in southwestern Kansas commenced much earlier than reported by Esch, et al. (1959) for southeastern Colorado. They reported gravid females in late February with the normal breeding season extending from May into September.

Studies on ovaries followed the description by Cheatum (1949) for deer. Ovaries and uteri were put in 10 per cent formalin for preservation and hardening. The gross procedure of macroscopic study was to slice the ovary on the long axis with cuts about two millimeters apart. Each side of the slice was examined on both surfaces. The large follicles and new corpora lutea were easily recognized. The biggest error in determining incidence of ovulation was in counting unruptured luteinized follicles (Cheatum, 1949).

A striking phenomenon of jack rabbit reproduction was the monthly fluctuation in the number of embryos per litter (Table 14). The number fluctuated from 1.0 per litter in January to a high usually in May of 3.3 to 4.1. Thereafter, until reproduction ended, the number of hares per litter decreased gradually each month. This factor must be considered when considering the average number of young produced per litter (Lechleitner, 1959).

The over-all number of young per litter for 284 pregnancies and 803 embryos averaged 2.8. When the fluctuation in the number of young per month was considered, the weighted component did not change from the over-all average. The weighted component also showed an average of 2.8 hares per litter (Table 14).

Table 14. Average number of young per litter and per cent of adult females pregnant in 42 monthly collections.

Month	% of Females Pregnant	Coefficient for Weighting Litter Size [1]	Average Litter Size	Weighted Component of mean Litter Size [2]
July '56	78.6	.04	2.7	.11
Aug.	38.4	.02	2.9	.04
Sept.	0.0	.00	0.0	.00
Jan. '57	6.2	.003	1.0	.003
Feb.	6.2	.003	1.0	.003
Mar.	64.7	.04	1.8	.07
April	89.5	.05	2.5	.13
May	75.0	.04	3.3	.13
June	61.5	.03	2.9	.09
July	40.0	.02	2.0	.04
Aug.	85.7	.05	3.0	.15
Sept.	0.0	.00	0.0	.00
Jan. '58	20.0	.01	1.0	.01
Feb.	76.9	.04	1.5	.06
Mar.	100.0	.05	3.3	.17
April	100.0	.05	4.0	.20
May	84.2	.05	4.1	.21
June	88.0	.05	3.3	.17
July	73.6	.04	2.3	.09
Aug.	66.6	.04	2.4	.09
Sept.	40.0	.02	3.0	.06
Jan. '59	81.2	.04	1.3	.05
Feb.	58.3	.03	1.7	.05
Mar.	94.0	.05	3.5	.18
April	81.8	.04	3.1	.12
May	84.6	.05	3.7	.19
June	93.7	.05	3.2	.16
July	100.0	.05	2.5	.13
Aug.	85.7	.05	2.5	.13
Sept.	0.0	.00	0.0	.00
TOTAL	1874.4	1.006	2.8	2.8

(1) Calculated by dividing the total per cent females pregnant (1874.4) into the per cent of the females pregnant each month.

(2) Coefficient for weighting litter size times average litter size.

Bronson (1957), for the first year of the study found an average of 2.5 young per litter. The increase in the average number of young per litter was apparently due to the larger litters found in 1958 and 1959. Bronson (1957) found that the average litter size of embryos having a crown-rump length of less than 40 millimeters was 2.6 compared to 2.4 per litter for those litters over 40 millimeters. In this study, the analysis of 284 pregnancies showed an average of 2.8 young per litter for litters less than 40 millimeters and also for all litters, and 2.9 for litters greater than one-half term (Table 15). This difference could be attributed to sample variation ($x^2 = .47$; $X^2 = 3.84$, 1 D.F.) when a ratio of one to one embryo of each size was expected.

Table 15. Average yearly litter size for litters less than half term, over half term and for all embryos.

Year	Less than 40 mm. Embryos	Lit-ters	Average per litt.	Over 40 mm. Embryos	Lit-ters	Average per Litt.	All Embryos Embryos	Lit-ters	Average per Litt.
1956*	27	10	2.7	13	6	2.2	40	16	2.5
1957	117	46	2.5	83	32	2.6	200	78	2.6
1958	174	52	3.3	140	48	2.9	314	100	3.1
1959	98	43	2.3	151	47	3.2	249	90	2.8
Total	416	151	2.8	387	133	2.9	803	284	2.8

*Represents only two reproductive months.

In 38 pregnancies affected by resorption, 13 of the litters had fetuses of over 40 millimeters undergoing resorption. In the remaining 25 of the pregnancies affected by resorption, the embryos were less than 40 millimeters

in size (Table 16). In a pregnancy of two fetuses, 128 millimeters in length, one embryo was being resorbed and the other had an umbilical hernia. Resorption affected 6.2 per cent of all embryos (Table 16).

This loss was only part of the entire prenatal loss. Loss of ova before implantation evidently accounted for 9.4 per cent of the ova shed. For 284 pregnancies, 886 ova were shed with 803 embryos present. The 9.4 per cent loss apparently varied little during the study. Bronson (1957) reported a loss of 9.5 per cent of the ova for the first year of the study. The total prenatal loss would appear to be 15.6 per cent (6.2 % + 9.4 %) of the original ova shed.

Brambell (1944) estimated that 60 per cent of all litters conceived were lost due to death and resorption of all the embryos. Lechleitner (1959) found the total loss of all ova to be approximately 47.4 per cent. Loss of entire litters after implantation was calculated to account for 39.4 per cent of the loss.

Litter loss was calculated in the same manner as described by Lechleitner (1959). There were 151 early cases of pregnancy to 133 pregnancies half term or over (Table 15). On the per hundred basis, this becomes 100 to 88. The difference between the two figures, 12 per cent should represent

Table 16. Number of litters and litter size affected by resorption.

Embryo Size	Number of Litters	Number of Embryos	Litter Average	Number Resorbing	% of all Embryos	Total
Less 40 mm.	25	56	2.2	34	34/803=4.2	50/803=6.2%
Over 40 mm.	13	47	3.6	16	16/803=1.9	

the loss of litters after implantation because a one to one ratio was expected. A Chi-square value of .57 showed that the loss could be attributed to chance ($X^2 = .57$; $X^2_{.05} = 3.84$, 1 D.F.). This study indicated that there was an apparent loss of only 15.6 per cent in the jack rabbit.

By assuming that all litters conceived were successful, Lechleitner (1959) was able to determine the number of litters produced during any breeding season by a continuously breeding female. The following formula was used:

$$N_s = \frac{L}{G}$$

where N_s = the number of litters produced during the season,

L = the length of the breeding season in days, and

G = the length of gestation in days.

Using the formula and substituting the data:

$$N_s = \frac{252}{43} = 5.86$$

This figure multiplied by the average number of young per litter gives the total possible production of a continuously breeding female during the eight month breeding season (Lechleitner, 1959). For the Kansas hares this equals 16.4 (5.86 x 2.8) young.

By compensating for litters lost entirely, the number of litters produced by a female in one season can be calculated (Lechleitner, 1959). Because the per cent of litters lost entirely was zero for Kansas jack rabbits, (12% loss attributed to chance), there would be no difference between this figure and a continuously breeding female.

An annual production of 16.4 young per female is high because no consideration was given for the total length of time required to produce one

litter. Bronson and Tiemeier (1958a) found that an average of 58 days was required to produce one litter. This figure was calculated from the per cent of adult females not pregnant multiplied by the 43-day gestation period of jack rabbits (Haskell and Reynolds, 1947). In the 42 months of this study, 73 per cent of the adult females collected were pregnant. By multiplying the 27 per cent not pregnant by the 43-day gestation period, it was found that an average period of 55 (43 + 12) days was required to produce one litter.

Dividing the breeding season (252 days) by the time required to produce one litter (55 days), it was estimated that 4.6 litters were produced per female per year. The average annual production would be 4.6 x 2.8 = 12.9 young instead of the 16.4.

Unruptured, luteinized follicles (accessory corpora lutea or corpora lutea stretica) have been described from the jack rabbit (Lechleitner, 1959), porcupine (Mossman and Judas, 1949), white-tailed deer (Cheatum, 1949), Norway rat (Hall, 1932), and domestic rabbit (Brambell, 1944). From January through December 1959, only three cases of suspected corpora lutea stretica were found. These were considerably smaller than regular corpora lutea, and lacked rupture sites. The number of corpora lutea stretica found in this study was small (3 compared to 886 ovulation), consequently, they were disregarded in figuring jack rabbit reproduction.

Cross over of ova may occur in the jack rabbit. The uterus is of the duplex type, therefore, transmigration of ova must take place by transperitoneal migration from one ovary to the opposite ostium. Three such cases were found in this study (specimens 1048, 1142, and 1613). Allen, Brambell and Mills (1947) reported such a migration in the European rabbit

(Oryctolagus cuniculus) that affected two per cent of the litters. Lechleitner (1959) found one case of migration of ova in L.c.californicus.

One case of polyovulation was found (specimen 1306) in which three embryos were present and only two corpora lutea.

Bronson and Tiemeier (1958a) found a significant difference in the numbers of embryos present in the left and right horns of the uterus. They found 137 embryos in the left horn and 103 in the right uterine horn. The Chi-square test revealed a significant difference when a ratio of 50:50 was expected ($X^2 = 4.8$; $X^2_{.05} = 3.84$, 1 D.F.).

In the present study, which included Bronson's work, a significant difference was found between 433 embryos in the left and 366 in the right uterine horn ($X^2 = 5.6$, 1 D.F.). This phenonemon is apparently a characteristic of mammalian reproduction. Asdell (1946) reported percentages of ova shed in the right and left horns of many mammals. Those which were investigated, the percentage occurrence was greatest in the left horn. These included, among others, the domestic rabbit, rat, guinea pig, and the domestic pig. None of the percentages was over 55 per cent of the ova in the left horn. Valentincic (1956) reported the left horn of the European hare (Lepus europaeus) as gravid more often than the right horn of the uterus. Moseman (1955) found 24 embryos in the right horn of the brush rabbit (Sylvilagus bachmani) compared to 29 in the left horn.

Suckling

Bronson (1957) used the per cent of adult females showing evidence of suckling during the study period multiplied by the average number of days required to produce one litter to equal the suckling period. This was found to be 13 days.

Some data on suckling were gathered from the trapping study. Adult female Y was captured on June 28. The hair around the teats was matted and milk was present in the mammary gland indicating she was being suckled. On July 9 and July 14, the same female was caught with the same indications. When captured on July 18, she was not recorded as suckling. How long she had been suckling prior to June 28 was unknown, but the recapture data shows that sometime between 17 and 20 days she ceased being suckled.

A second female, adult female P, captured on July 25 had matted hair around the teats and milk could be expressed from the mammary gland. When recaptured on July 29, she was recorded as being suckled. On August 8, she was not suckling when recaptured. This individual had apparently been suckling for some time before her first capture, since she ceased suckling sometime between 5 and 13 days after the original capture.

Census

Bronson (1957) studied a population which declined steadily from July 1956 through the winter and reached a low in June 1957. This decline resulted from jack rabbits having concentrated along the Arkansas River valley during the drought. When rainfall was again normal, the hares migrated back into their original range within the sandhills.

There was no large area like the sand-hills for the hares to migrate into in the present study. The study area was located in an area where all the surrounding land had the same land use.

From June 1958 through 1959, eleven population estimates were made (Table 17). Generally, the vegetation was short enough to allow the censuser to see all hares that were flushed. The exceptions were on

certain areas in July and August. In 1958, Soil Bank Field A had grown to tall sunflowers. Obviously, hares could not be seen in such vegetation, but observations within the dense weeds indicated that fewer forms and fewer fresh pellets were present than in the first part of the study period. In an evening of observation from an observation point in late July, only three jack rabbits were seen. This small number of hares was directly opposite the count of three weeks earlier in which hares were seen in groups of four or two in many places and solitary ones scattered over the entire area.

In 1959, the wheat stubble area had isolated patches of dense stands of lambs quarters and sunflower in which hares could not be seen.

The density of 0.3 to 0.5 jack rabbit per acre was an average density estimate when compared with the reports in the literature. Vorhies and Taylor (1933) estimated the population of their study area in southern Arizona as averaging 0.5 jack rabbit per acre. Wooster (1939) recorded a density of 0.3 per acre for a one-square mile plot of mixed prairie in Ellsworth County, Kansas. Lechleitner (1955) found a density of 1.2 jack rabbits per acre on a waterfowl refuge in California. Bronson (1957) estimated that a population in the sand-hills area of Kearny County fluctuated from a high of 0.7 jack rabbit per acre in the sand-hills to a low of 0.02 per acre on cropland.

Flushing distance for jack rabbits was variable. The average flushing distance was about 60 feet, but flushing distance varied from 0 to 210 feet when two flushing averages were recorded. Hares would sometimes flush as much as 300 feet ahead of the censuser, and others would not flush until the censuser had passed. On some occasions hares were observed to "freeze" in their forms. When the censuser had approached to within 15 or 20 feet, they would bound away.

Table 17. Farmland population and density estimates based on numbers of animals flushed on indexing stripe.

Indexing Period	Buffalo Grass	Fallow and Wheat	Farmland (Soil Bank) Section	Total and Average for the Area
June '58:				
Number flushed	29	0	36	65
Population est.	377	0	468	845
Density estimate	.59	0	.73	.52
Early July:				
Number flushed	29	0	34	63
Population est.	377	0	442	819
Density estimate	.59	0	.69	.51
Late July:				
Number flushed	25	10	30	65
Population est.	325	130	390	845
Density estimate	.51	.41	.61	.52
August:				
Number flushed	22	0	21	43
Population est.	286	0	273	559
Density estimate	.44	0	.42	.35
November:				
Number flushed	6	0	27	33
Population est.	78	0	351	429
Density estimate	.12	0	.55	.27
January '59:				
Number flushed	18	0	18	36
Population est.	234	0	234	468
Density estimate	.36	0	.36	.29
May:				
Number flushed	21	0	29	50
Population est.	273	0	377	650
Density estimate	.43	0	.58	.41
June:				
Number flushed	19	0	26	45
Population est.	247	0	338	585
Density estimate	.39	0	.53	.36
July:				
Number flushed	15	1	29	45
Population est.	195	13	377	585
Density estimate	.30	.04	.58	.36
August:				
Number flushed	13	1	19	33
Population est.	169	13	247	429
Density estimate	.26	.04	.39	.27
November:				
Number flushed	9	4	9	22
Population est.	117	52	117	296
Density estimate	.17	.16	.17	.17

There was a seasonal fluctuation in jack rabbit numbers on the study area. The peak population, according to the census figures, was in May, June or July. There was a gradual decline until late winter and in the spring, as indicated by the 1959 census, there was an upswing in numbers. The increase in the spring followed the pattern of juveniles appearing in the collection. A low in population numbers occurred during the winter months.

The gradual decline in population numbers could be explained by a combination of two events: (1) a mortality was experienced by the population beginning in August, or (2) there was a migration of animals.

If one assumes that seasonal movements of limited extent take place in accordance with the changing food supply (Vorhies and Taylor, 1933), the decline could result from migration. The trapping studies revealed that hares tended to remain in fairly stable home ranges until late summer. In the early fall there was evidence that some migration might have taken place.

The owner of the milo land on the study area (Fig. 1) had attempted to poison jack rabbits during October and early November of 1959. He had told the local townspeople that the jack rabbit population was high on his land. Hunters were being paid 15 to 20 cents per animal by a local buyer in the winters of 1958 and 1959, consequently, mortality from hunting was probably high. The late summer and fall population density change probably resulted from a combination of migration and mortality.

Apparently, there was no winter mortality from November 1958 to January 1959. The density estimates of .27 for November and .29 for January were about the same, but there was a shift from farmland to grass (Table 17).

Predation

Only limited observations on predation were made in this study. With man's mechanization, that is, automobile, spotlight, and rifle or shot gun, he was probably the greatest cause of mortality in jack rabbits. Automobile tracks over the study area and the fact that tags from jack rabbits were returned from four different hunters indicate a heavy mortality caused by man.

Coyotes (Canis latrans) were seen on the study area occasionally and were heard almost nightly while making observations of tagged animals. However, no estimate of the coyote population was made.

Some authors list hawks, badgers and rattlesnakes as predators of young jack rabbits. During the two summers spent in the field, only two cases of hawk predation were noted. A Swainson's hawk (Buteo swainsoni) had a nest in a tree on the north edge of the study area. The nest, containing a young hawk, was examined occasionally for evidence of predation. When the fledgling hawk was about half grown, a small dead jack rabbit was found in the nest.

A marsh hawk (Circus cyaneus) flushed in a field had been feeding on a young jack rabbit. Only the thoracic viscera had been eaten. The blood had not coagulated and the body was still warm, indicating the young hare was recently killed.

While making observations one evening, a marsh hawk flew low over the area and as it approached, four or five adult jack rabbits ran into wheat for cover, but the majority of the hares did not move.

Badgers (Taxidea taxis) were seen on the study area about twice each week during the summers. While conducting the census in November 1958, four

badgers were seen together at the same hole. Evidence that badgers preyed on jack rabbits was looked for in conjunction with a badger parasite survey (Bartel, 1960). In one of seven badgers examined, only one badger stomach contained a scalp of a young jack rabbit.

Seton (1929) and Vorhies and Taylor (1933), suggested that rattlesnakes can be important enemies of jack rabbits. During the summer of 1959, 14 rattlesnakes (Crotalus viridis) were examined for parasites. No evidence of predation on jack rabbits was found, although one rattlesnake had swallowed a small cottontail (Sylvilagus sp.). Apparently, there was a high population of rattlesnakes within the study area region. In early fall of 1959, farmer Melvin Saure killed about 200 rattlesnakes from holes in his pasture located within one mile of the study area.

Behavior

Lechleitner (1958b) described certain aspects of behavior of the black-tailed jack rabbit. Jack rabbits like to feed in open areas where there is a good supply of small succulent plants. In the summers of 1958 and 1959, the greatest amount of feeding was on areas where puncture vine (Tribulus terrestis) was present.

Jack rabbits are crepuscular to nocturnal. Hares would move onto the feeding areas about one to two hours before sundown and feed throughout the night. The jack rabbits would begin leaving the feeding area for resting places during early morning and usually by 7 A.M., few remained. Trails were made where a number of hares would come to and leave the feeding area.

Jack rabbits were considerably more wary in the early morning hours than at twilight or at night. Unusual noises in the early morning, such as loud talking, or dropping metal on metal would cause what appeared to be spread-

ing fright as the animals ran to the nearest vegetative cover. In the evening when an unusual sound was created, reactions were either flight by a few individuals, freezing in an alert position looking in the direction of the disturbance or only a casual look and then resume feeding.

Aggressive behavior toward a human was not found in the handling of a wounded animal in the field. Hares that were handled after they were trapped behaved much the same way. Their behavior in either circumstance seemed to be individualistic, as no two hares acted alike. Sometimes the wounded and trapped animals would emit a high pitched alarm scream during the entire time they were handled. Other individuals would scream for a few minutes, then quit, but their muscles would remain tense. Some individuals made no sound at all, but always remained tense while being handled, and still others would relax somewhat while being handled.

Only caged animals expressed an aggressive action toward a human. Caged jack rabbits would paw with their front feet at any foreign object stuck into their cage. While frantically pawing, they would emit a low pitched grunting sound.

Occasionally, when the spotlight was shown on a jack rabbit, he would jump straight into the air about two or three feet. He would land on all four feet and either stand as he had landed or bound away.

While held in captivity, one jack rabbit jumped over a five foot fence that was next to a barn. He jumped about three feet up the side of the barn and scratched and clawed his way over the remaining distance. It took three successive tries before the jump was completed.

Few instances of antagonism toward other hares were observed in the field. The few that did occur, occurred when an individual approached too

close to another. The hare that was intruded upon would whirl around for the challenge, and they would "face off". The intruder would sometimes leave the area immediately or the two hares would jump into the air and "box" vigorously with their front feet until the intruder was chased away. All the time they were boxing, they would both emit a low grunting sound. Bronson (1957) observed this same behavior.

A mating act was never observed. On several occasions, one or two hares were seen following one another, zig-zagging around over the feeding area.

Wind has an affect on jack rabbit activity. This was shown by the following observations: about 6:15 P.M., only about five jack rabbits were visible. By 6:40 jack rabbits had come out and ranged from four in a group with two in many places and solitary ones scattered over the entire area. About 7:30 a strong wind, with blowing dust was noted. Immediately, the number of jack rabbits in view decreased. Only two hares could be counted at 7:45 P.M.

Interspecific actions were observed. A hen pheasant (Phesianus colchicus) took her brood of chicks across a corner of a wheat field into a pasture. She passed within a few feet of some jack rabbits, but each was undisturbed by the others presence. About one-half hour later, a cock pheasant flew into the area. The cock walked past one jack rabbit and then toward another. When the pheasant was within three feet of him, the jack rabbit moved. The cock then walked toward another jack rabbit that was foraging and it moved out of the cocks way. The pattern of behavior continued for about 30 minutes when the pheasant flew away.

The cock pheasant had made aggressive advances toward almost every jack rabbit present, though in no particular pattern. The hares would move out of its way when the cock was within two or three feet of them, but otherwise, they seemed undisturbed.

DISCUSSION

A population has various characteristics which are the unique possessions of the group and are not characteristic of the individuals in the group. Some of these properties are: density, natality, mortality, age distribution, biotic potential, dispersion and growth form (Odum, 1953). Many of these factors have been examined for the jack rabbit in southwestern Kansas.

An examination of the natality factors shows that the jack rabbit population should have been increasing. While the number of young per litter increased from 2.5 in the first year of the study to 2.8 in the last year of the study, the percentage of adult females pregnant increased during the entire study period. The average per cent of females pregnant was as follows: 1956= 59; 1957= 59; 1958= 79; 1959= 86.

Entire mortality was not computed, but Petrides (1949) stated that juvenile mortality can be obtained by comparing the adult female to juvenile ratios, after reproduction has ceased, with the number of young produced. Reproduction did not end until September, therefore the adult female to juvenile ratios for October and November were used to compute juvenile mortality. It has been shown that each female produced about 13 young during the breeding season.

The percentages of juveniles lost was calculated by obtaining a ratio between the expected young and the loss of young (Table 18).

Table 18. Mortality of juvenile jack rabbits for the fall of the year. Age ratios were calculated from the October and November collections.

Year	Adult Females	Young	Total Young Expected	Loss[2]	Per Cent Loss[3]	Female to Young Ratio
1956	17	96	221	125	57	1:5.6
1957	10	82	130	48	37	1:8.2
1958	13	75	169	94	56	1:5.8
1959	7	49	91	42	46	1:7.0

2. Total young expected less the young in the collection.
3. Ratio of the total young expected and the loss of young.

There was a 57 per cent loss of young in 1956, the dryest year of the study and a 56 per cent loss in 1958, the wettest year. In 1959 when an almost normal amount of precipitation was received, the loss was 46 per cent. The lowest number of juveniles lost was 37 per cent in 1957, a year when slightly above normal precipitation was received.

The four year average loss from the beginning of the breeding season (January) through November was about 51 per cent of the maximum young produced.

The adult female to young ratio (Table 18) indicates that the population should have been low in the summers of 1957 and 1959 and high in the summers of 1958 and 1960. This was because of the differential survival of young. Census data for 1957 and 1960 were not available but an examination of the census figures for 1958 and 1959 shows that the population estimates were higher in 1958 than in 1959. These were the results that should be expected from the evidence of the fall mortality data.

Table 19. Average monthly and yearly precipitation and deviations from the mean precipitation for 42 months. Average annual precipitation is 16.42 inches. *

Month	1956		1957		1958		1959	
	Moisture Received	Deviation from mean	Moisture Received	Deviation from mean	Moisture Received	Deviation from mean	Moisture Received	Deviation from mean
Jan.			.05	- .42	.64	.17	.43	- .04
Feb.			.11	- .36	.25	- .22	T	- .47
March			2.51	1.66	2.33	1.48	.60	- .25
April			.75	- .91	1.36	- .30	.94	- .72
May			4.75	2.06	6.55	3.86	2.84	.15
June			6.56	3.98	3.31	.73	1.48	-1.10
July	2.67	.71	1.08	- .88	6.76	4.80	1.37	- .59
Aug.	.56	-1.86	.80	-1.62	2.27	- .15	2.11	- .31
Sept.	0.00	-1.22	1.85	.63	.63	- .59	1.10	- .12
Oct.	.10	- .95	1.17	.12	.19	- .86	4.15	3.10
Nov.	.18	- .46	.70	.06	.58	- .06	T	- .64
Dec.	T	- .41	T	- .41	T	- .41	.08	- .33
Annual	7.53	-8.89	20.33	3.91	24.87	8.45	15.10	-1.32

* From Climitological Data: Kansas Annual Survey 1956-1959.

Table 20. Winter mortality of juvenile jack rabbits. The age ratios were from the January collection.

Year	Females Age Class III	Young Age Class II	Total Age Class II Expected	% Loss	Females to Age Class II
1957	17	17	221	88	1:1
1958	8	15	104	86	1:1.8
1959	12	7	156	96	1:0.6
Average	37	39	481	92	

Winter mortality was calculated by using the Age Class aging technique on the January collection. This technique has limitations because all animals born prior to May were probably classified as adults. No individuals were classified as belonging to Age Class I in the month of January, consequently only Age Class II and Age Class III were considered in the winter mortality calculations (Table 20).

As was pointed out previously, part of the high per cent loss of Age Class II could be accounted for because some of the hares born in the early part of the breeding season were considered as Age Class III. The average annual loss of young hares due to mortality was calculated to be 92 per cent of the maximum number of young that were produced (Table 20). The per cent loss for the three different years indicated that regardless of the number of young hares that go into the winter, only a small number will survive. The adult female to Age Class II ratios show that the number surviving fluctuates in the different years, but probably over a long span of time, these fluctuations would balance out and a stable population would result.

Marked increases in jack rabbit numbers apparently accompany drought periods (Wooster, 1935). Wooster felt there were three possible explanations

for the increase: (1) actual increase in the number of young produced; (2) lower than usual mortality rate, especially of young; (3) or immigration of hares from other regions.

The data presented in this study show that there is a higher number of young per litter and a greater number of females pregnant in a wet year compared to a dry year (Table 14).

Mortality losses of young hares in the fall of the year was higher in a dry year than in normal years. Evidence from Bronson and Tiemeiers' (1959) study indicates that of the theories presented, the immigration of hares from other areas is at present the best answer. They found an inverse relationship between the monthly precipitation and the abundance of jack rabbits, apparently caused by drought and overgrazing resulting in a depletion of jack rabbit food supply. When the drought ended and food was again available, the hares dispersed throughout their normal range.

The home range study indicated that jack rabbits tended to stay in fairly well defined areas. This study was conducted during a summer when a fairly normal amount of precipitation was received and food supply was not a problem. Under drought conditions it is conceivable that jack rabbits would shift to areas with a better food supply.

SUMMARY

A literature review revealed that there were few comprehensive studies on the black-tailed jack rabbit. A study was begun by Frank Bronson in 1956 when a population of jack rabbits was at a high in southwestern Kansas. This study, which was begun in June 1958, was a continuation of the work done by Bronson from July 1956 through 1957. The study was continued in an

attempt to evaluate inconsistencies in reproductive data, to improve on aging techniques, and to collect information on population densities and home range size.

Data collected over 42 months, including Bronson's data, were analyzed for this study. One-hundred eighteen field days were spent in the summers at the study area near Lakin in Kearny County, Kansas. Field trips for collecting reproductive data, were made once each month during the months of September through May.

Beginning in June 1959, ten live traps were used to capture jack rabbits. Plastic ear tags with Scotchlite Reflective tape symbols were sewed to the ear with nylon thread. A monel metal ear tag was fastened in the opposite ear. Movements were observed at night with a 20 power or 30 power telescope mounted beside a 12-volt spotlight.

A total of 481 trap nights resulted in the capture of 87 jack rabbits. Of these 57 were tagged and released. There was apparently no antagonism to the tags. Only one tag was known to have been completely lost. Age ratio of captures was 31 juveniles to 26 adults. Adult sex ratio was 18 males to 8 females.

Numerous observations were made on the tagged hares during the summer of 1959. Average home range of 23 individuals indicated that they tended to stay within rather well defined areas of about 49 acres. The home range size for the different ages of hares was: 10 adult males, 49 acres; 3 adult females, 97 acres; 4 juvenile females, 66 acres; and 3 juvenile males, 21 acres. Weedy fence rows had little effect as a barrier to movement. Evidence from one individual indicated that jack rabbits can find their

original home range. Distances moved by jack rabbits varied from a few yards to over one mile.

Two jack rabbit nests were described. Average measurements of four 24-hour-old young present in one nest were: total length 173; tail 28; hind foot 49; and ear 30 millimeters.

The two nests combined with observations on five additional young jack rabbits found in the field and on three 197 millimeter hares that were captured after they had crossed the road in front of the car indicated that: (1) litters are dropped in forms with no preparation for a nest, or no form is dug at all; (2) the young leave the form shortly after birth, perhaps on the same day they are born; (3) the litter may stay together for a week or more before leaving the form.

All attempts to raise young jack rabbits found in the field or taken by caesarean section failed. Five larger jack rabbits that were captured in the field or in traps were raised for 10 to 38 weeks of age. Hind feet matured to adult size of 126 millimeters in about 12 weeks and the ear matured to adult size of 106 millimeters in about 10 weeks.

Monthly weight fluctuations were calculated for adults for 42 months. Females were usually statistically heavier than males in all months except November. Females attained the greatest weight in April and May. Males reached their maximum weight in October and November.

Epiphyseal closure techniques were used to separate adults and juveniles. The technique was of little value in January. Young of the year first appeared in the kill samples in May of 1957, 1958 and in March of 1959. Epiphyseal closure data were used to divide the collection into three age classes.

Age Class I was determined to be less than three months of age; Age Class II was found to be nine months of age or less; and Age Class III was over nine months of age.

Body weight could be used as an aging technique up to about three months, but was of no value for aging hares over that age. Statistical analysis of body length and humerus length showed that these techniques may be of some value for aging jack rabbits, but the techniques were unreliable because of individual variation. Data presented for the use of the lens as an aging technique were in the form of a progress report. There was no difference between the right and left lenses. A heavier lens was found as the animal became older. Ten points, ranging from one day to 266 days of age have been established for the growth curve.

A total of 2,037 jack rabbits was collected for reproductive analyses. A significant difference was found in the sex ratio of 1,065 males and 972 females. There was no difference in the prenatal sex ratio between males and females. A 282-day breeding period was found.

Some testes were scrotal in late December through August. Epididymal and testicular sperm counts fluctuated seasonally. Epididymal sperm counts were found 100 per cent of the time from January or February through August. Sperm from testicular smears were recorded in 100 per cent of the hares from January or February through August. Few juvenile males were capable of breeding during the breeding season in which they were born.

Pregnant females were found from January through September. The average percentage of adult females pregnant increased from 59% in 1956 to 86% in 1959. The number of young per litter fluctuated from a low of 1.0 in January to a high of 3.3 to 4.1 in May, and then dropped to 2.4 to 3.0 in

August. Eight-hundred-three embryos in 284 pregnancies gave an average of 2.8 young per litter. Litters with less than one-half term embryos averaged 2.8 young and litters with fetuses over half term averaged 2.9. The number of young per litter increased from 2.5 in 1956 to 2.8 in 1959.

Resorption affected 6.2 per cent of the pregnancies. Litters with embryos of less than 40 millimeter crown rump length were resorbing 4.2 per cent of the time and 1.9 per cent of those litters with embryos of over 40 millimeters crown rump were recorded as resorbing. There was a 9.4 per cent loss of ova before implantation. The apparent 12 per cent loss of entire litters after implantation was attributed to sample variation, therefore, total prenatal loss was 15.6 per cent of the original ova shed.

A continuously breeding female could produce 5.86 litters per year or 16.4 young per year. By determining the time required to produce one litter as being 55 days, the average annual production was 4.6 litters per year with 12.9 young produced. Three corpora lutea stretica were recorded. Three cases of cross over of ova were recorded, one polyovulation was found, and a significant difference was noted between the number of embryos in the left and right uterine horns.

Observations on one adult female showed that she suckled her young for 17 to 20 days.

By using a modified King Grid census, eleven population estimates showed the average jack rabbit density to vary from 0.3 to 0.5 jack rabbit per acre. This was about average for the densities reported in the literature. From the density estimates, it was determined that the jack rabbit population was decreasing. Flushing distance varied from 0 to 210 feet and averaged 60 feet. The seasonal fluctuation showed the high in population numbers

occurred in May, June or July, and the low occurred during the winter months. Seasonal migration and/or a man-caused mortality probably caused a fall drop in jack rabbit numbers.

Limited observations were made on predation. Predators were man, coyote, badgers, marsh and Swainson's hawks, and possibly rattlesnakes.

Jack rabbits moved to their feeding areas in the evenings and fed throughout the night. By 7 A.M., few jack rabbits remained on the feeding areas. Jack rabbits were more wary in early morning hours than at night. Aggressive behavior toward a human was found only in caged animals. The behavior of hares that were trapped or wounded by shooting and aggressive behavior of jack rabbits in the field were described.

Age ratios for October and November were used to compute juvenile survival in the fall, and age ratios in January were used to compute winter survival. These data show that the percentage survival was poorest in the fall of a dry year with the next poorest survival in the wettest year. The two years in which precipitation was near normal showed the best juvenile survival. From the beginning of the breeding season to November, there was a juvenile mortality of about 51%.

ACKNOWLEDGEMENTS

The author wishes to acknowledge his major professor, Dr. Otto W. Tiemeier, for his advice and guidance during the past two years.

Mr. and Mrs. Jack Wilkin and son Joe of Lakin, Kansas were helpful in supplying a place to work, and in giving many hours of fellowship.

Appreciation is expressed to Monroe M. Bartel for giving much time and effort to help build the traps. He was a helpful companion in both school and field work.

The study was made possible by Project No. 5596 of the Department of Zoology, Kansas State University, United States Public Health Service, Kansas Forestry Fish and Game Commission, and Project No. 488 of Kansas State University Agricultural Experiment Station.

Dr. Stanley Wearden was helpful in interpretating statistical data, and state game protector Alvin Michael gave considerable time and effort to the study. To these people and to fellow graduate students Richard E. Bowen, Eli Pagan, and Nels Anderson, the author expresses his thanks.

LITERATURE CITED

Adams, Lowell.
An analysis of a population of snowshoe hares in Northwestern Montana. Ecol. Monog. 29 (2): 141-170. 1959.

Alexander, Maurice M.
The aging of muskrats on the montezuma National wildlife refuge, Jour. Wildl. Mgmt. 15 (2): 175-186. 1951.

Allen, P., Brambell, F.W.R., and Mills, I.H.
Studies on sterility and prenatal mortality in wild rabbits. Jour. Exp. Biol. 23: 312-331. 1947.

Aldous, C.M.
Notes on the life history of the snow-shoe hare. Jour. Mamm. 18 (1): 46-57. 1937.

Arnold, J.F.
Forage consumption and preferences of experimentally fed Arizona and antelope jack rabbits. Univ. Ariz. Coll. Tech. Bull. 98:50-86. 1942.

Arnold, J.F. and Reynolds, Hudson G.
Droppings of Arizona and antelope jack rabbits and the "pellet census." Jour. wildl. Mgmt. 7 (3): 322-327. 1943.

Asdell, S.A.
Pattern of mammalian reproduction. New York: Comstock. 1946. p. 437.

Bailey, Vernon.
Mammals of New Mexico. North Amer. Fauna 53. U.S.D.A. Bureau of Biological Survey. 1931. 413 p.

Balham, Ronald W. and Elder, William H.
Colored leg bands for waterfowl. Jour. Wildl. Mgmt. 17 (4): 446-449. 1953.

Bartel, Monroe H.
Studies on Micinsella brevicauda Lyons, 1958 a filarid of the black-tailed jack rabbit (Lepus californicus melanotis Mearns), with notes on the helminth parasites of the jack rabbit. Unpublished M.S. Thesis. Kansas State Univ. 1960.

Blair, W. Frank, Blair, Albert P., Brodkorb, Pierce, Cagle, Fred R., Moore, George A.
Vertebrates of the United States. New York: McGraw Hill. 1957. 819 p.

Brambell, F.A. Rogers.
The reproduction of the wild rabbit Oryctolagus cuniculus (L.). Proc. Zool. Soc. 114: 1-45. 1944.

Bronson, Franklin H.
The ecology of the black-tailed jack rabbit (Lepus californicus melanotis, Mearns) in southwestern Kansas. Unpublished M.S. Thesis. Kansas State University. 1957.

Bronson, Franklin H.
Notes on body size of black-tailed jack rabbits. Kans. Acad. Sci. Trns. 61 (1): 109. 1958.

Bronson, Franklin H., and Tiemeier, Otto W.
Reproduction and age distribution of black-tailed jack rabbits in Kansas. Jour. Wildl. Mgmt. 22 (4): 409-414. 1958a.

Bronson, Franklin H., and Tiemeier, Otto W.
Notes on crop damage by jack rabbits. Kans. Acad. Sci. Trans. 61 (2): 226-229. 1958b.

Bronson, Franklin H., and Tiemeier, Otto W.
The relationship of precipitation and black-tailed jack rabbit populations in Kansas. Ecology. 40 (2): 194-198. 1959.

Brown, H. Leo.
Why has the white-tailed jack rabbit (Lepus townsendii) become scarce in Kansas? Kans. Acad. Sci. Trans. 49:455-456. 1947a.

Brown, H. Leo.
Coaction of jack rabbit, cottontail, and vegetation in mixed prairie. Kans. Acad. Sci. Trans. 50:28-44. 1947b.

Brown, H. Leo.
Distribution of white-tailed jack rabbits. Kans. Acad. Sci. Trans. 43:385-389. 1940.

Buckley, John L., and Libby, W.L.
Growth rates and age determination in Alaskan beaver. Trans. Twentieth North Amer. Wildl. Conf. 495-507. 1955.

Burnett, W.L. and McCambell, Sam C.
Jack rabbits of Eastern Colorado. Colo. Agri. Coll. Circ. No. 52. Fort Collins, Colo. 1926.

Burt, William H.
Territoriality and home range concepts as applied to mammals. Jour. Mamm. 24 (3):346-352. 1943.

Cahalane, Victor H.
Mammals of North America. New York: Macmillan. 1947. 682 p.

Carter, F.L.
Study of jack rabbit shifts in range in western Kansas. Kans. Acad. Sci. Trans. 42: 431-435. 1939.

Cheatum, E.L.
The use of corpora lutea for determining ovulation incidence and variation in the fertility of white-tailed deer. Cornell Vet. 39 (3): 282-291. 1949.

Craighead, John J. and Stockstad, Dwight S.
A colored neckband for marking birds. Jour. Wildl. Mgmt. 20 (3): 331-332. 1956.

Dickerson, Mary C.
The jack rabbit of California. Amer. Mus. Jour. 1: 71-75. 1917.

Duerre, Donald C.
A technique of marking deer for nocturnal observations. Midwest Wildl. Conf. Columbus, Ohio. Dec., 1958.

Durrant, Stephen D.
Mammals of Utah, taxonomy and distribution. Univ. Kans. Museum of Natl. Hist. Publ. 6: 1-549. 1952.

Ealey, E.H.M. and Dunnet, G.M.
Plastic collars with patterns of reflective tape for marking nocturnal mammals. C.S.I.R.O. Wildl. Res. 1(1): 59-62. 1956.

Esch, Gerald W., Beidleman, Richard G., and Long, Larry E.
Early breeding of the black-tailed jack rabbit in southeastern Colorado. Jour. Mamm. 40 (3): 442-443. 1959.

Fitch, Harry S.
Home ranges, territories, and seasonal movements of vertebrates of the natural history reservation. Univ. Kans. Mus. Natl. Hist. 11(3): 63-326. 1958.

Goke, A.W.
Physical land conditions affecting use, conservation, and management of land resources. Kearny County, Kansas. U.S.D.A. and Kansas Agri. Exp. Sta. Manhattan, Kansas. Mimeo. 24 pp. 1954.

Grange, Wallace B.
The way to game abundance. New York: Scribner's. 1949. 365 p.

Green, R.G. and Evans, C.A.
Studies on a population cycle of snowshoe hares on the Lake Alexander area. I. Gross annual censuses, 1932-1939. Jour. Wildl. Mgmt. 4:220-238.

Hale, J.B.
Aging cottontail rabbits by bone growth. Jour. Wildl. Mgmt. 13:216-225. 1949.

Hall, E. Raymond.
Mammals of Nevada. Berkley: U. of Cal. Press. 1946. 710 p.

Hall, E. Raymond.
Handbook of mammals of Kansas. Univ. Kans. Mus. Natl. Hist. Misc. Publ. 7. 1955, 303 p.

Hall, O.
Accessory corpora lutea in the wild Norway rat. Texas Report on Biology and Medicine. 10 (1): 32-38. 1952.

Haskell, H.S. and Reynolds, H.G.
Growth, developmental food requirements and breeding activity of California jack rabbit. Jour. Mamm. 28 (2): 129-136. 1947.

Hayne, Don W.
An examination of the strip census method for estimating animal populations. Jour. Wildl. Mgmt. 13(2):145-157. 1949.

Helm, Lewis G.
Plastic collars for marking geese. Jour. Wildl. Mgmt. 19(2): 316-317. 1955.

Kelson, Keith R.
Fluctuations in populations of small mammals in Utah. Jour. Mamm. 32:113-114. 1951.

King, Ralph T.
Ruffed grouse management. Jour. Forestry. 35 (6): 523-532. 1937.

Lechleitner, R.R.
The black-tailed jack rabbit on the Gray Lodge Waterfowl Area, California. Unpublished PhD Thesis. University California. 1955.

Lechleitner, R.R.
Movements, density, and mortality in a black-tailed jack rabbit population. Jour. Wildl. Mgmt. 22: 371-384. 1958a.

Lechleitner, R.R.
Certain aspects of behavior of the black-tailed jack rabbit. Amer. Midl. Nat. 60(1): 145-155. 1958b.

Lechleitner, R.R.
Sex ratio, age classes and reproduction of the black-tailed jack rabbit. Jour. Mamm. 40(1): 63-81. 1959.

Lord, Rexford D.
The lens as an indicator of age in cottontail rabbits. Jour. Wildl. Mgmt. 23 (3): 358-360. 1959.

Mossman, H.W., and Judas, Ilse.
Accessory corpora lutea, lutein cell origin and the ovarian cycle in the Canadian porcupine. Amer. Jour. Anat. 85: 1-40. 1949.

Odum, Eugene P.
Fundamentals of ecology. Phil: Saunders. 1953. 384 p.

Palmer, T.S.
Jack rabbits of U.S. U.S. Dept. Agric. Biol. Surv. Bull. 8:1-88. 1897.

Petrides, G.A.
View points on the analysis of open season sex and age ratios. Trans. Fourteenth North Amer. Wildl. Conf.: 391. 1949.

Petrides, G.A.
The determination of sex and age ratios in the cottontail rabbit. Amer. Mid. Nat. 46:312-336. 1951.

Phillips, Paul.
The distribution of rodents in overgrazed and normal grasslands in central Oklahoma. Ecology. 17: 673-679. 1936.

Progulske, Donald R.
A collar for identification of big game. Jour. Wildl. Mgmt. 21(2): 251-252. 1957.

Reynolds, Hudson G.
Life history notes on Merriam's kangaroo rat in southern Arizona. Jour. Mamm. 41 (1): 48-58. 1960.

Riegel, D.A.
Some coactions of rabbits and rodents with cactus. Kans. Acad. Sci. Trans. 44:96-103. 1941.

Reigel, D.A.
Observations of food coactions of jack rabbits in western Kansas during periods of stress. Kans. Acad. Sci. Trans. 45:369-375. 1942.

Rowan, William, and Keith, Lloyd B.
Monthly weights of snowshoe hares from north-central Canada. Jour. Mamm. 40(2): 221-226. 1959.

Sanderson, Glen.
Methods of measuring productivity in raccoons. Jour. Wildl. Mgmt. 14(4): 389-402. 1950.

Schofield, Raymond D.
Analysis of muskrat age determination methods and their application in Michigan. Jour. Wildl. Mgmt. 19(4): 463-466. 1955.

Seton, E.T.
Lives of game animals. Vol. 4. New York: the Literary Guild of America. 1929. p. 441-949.

Severaid, J.H.
The snowshoe hare: its life history and artificial propagation. Maine Dept. Inland Fisheries and Game, Augusta. 1942 95 p.

Taylor, W.P.
Experiencing a population "high" in the Trans-Pecos region, Texas. Jour. Mamm. 29:186-187. 1948.

Taylor, Walter P., Vorhies, Charles T., and Lister, P.B.
Relation of jack rabbits to grazing in southern Arizona. Jour. Forestry. 33 (5): 490-498. 1935.

Timmons, F.L.
Dissemination of prickly pear seed by jack rabbits. Jour. Amer. Soc. Agron. 34:513-520. 1942.

Thomsen, Hans P., and Mortensen, Otto A.
Bone growth as an age criterion in the cottontail rabbit. Jour. Wildl. Mgmt. 10:171-174. 1946.

Trippensee, R.E.
Wildlife Management. New York: McGraw Hill. 1948. 479 p.

Valentincic, S.I.
Results of a two-year study of ideal increase of European hare on the island "Biserni Otok". Z. jagdwissenshc. 2 (3): 152-160. 1956. In Wildlife Review No. 87. 1956.

Vorhies, Charles T.
Caesarian operation on Lepus alleni, and notes on the young. Jour. Mamm. 2(2): 114-116. 1921.

Vorhies, Charles T.
Rodents and conservation. Nature Mag. 23:363. 1936.

Vorhies, Charles T., and Taylor, W.P.
The life histories and ecology of jack rabbits, Lepus alleni and Lepus californicus in relation to grazing in Arizona. U. of Ariz. Tech. Bull. 49: 467-587. 1933.

Watson, J.S. and Tyndale-Biscoe, C.H.
The epophyseal line as an age indicator for the wild rabbit, Oryctolagus cuniculus (L.). New Zeal. Jour. Sci. and Tech., sec. B. 34(6): 427-435. 1953.

Wautin, R.W.
Biotic communities of the northern desert shrub biome in western Utah. Ecol. Monog. 16:253-310. 1946.

Webb, William L.
Notes on a method for censusing snowshoe hare populations. Jour. Wildl. Mgmt. 6(1): 67-69. 1942.

Woodbury, Angus M.
Ecology of the Great Salt Lake Desert. I. An annual cycle of the desert jack rabbit. Ecol. 36 (2): 353-356. 1955.

Wooster, L.D.
Notes on the effect of drought on animal populations in western Kansas. Kans. Acad. Sci. Trans. 38:351-352. 1935.

Wooster, L.D.
An ecological evaluation of predatees on a mixed prairie area in western Kansas. Kans. Acad Sci. Trans. 42:515-517. 1939.

APPENDIX

EXPLANATION OF PLATE I

Fig. 1. An excellent feeding area where puncture vine invaded a sorghum field. Late summer 1959.

Fig. 2. View looking across Soil Bank Field A area. Summer of 1959.

Plate I

Fig. 1

Fig. 2

EXPLANATION OF PLATE II

Fig. 1. Live trap built by author and co-worker M.H. Bartel. Traps were set at night with one-half an apple as bait.

Fig. 2. An adult female black-tailed jack rabbit. One of the three times the individual was captured.

Plate II

Fig. 1

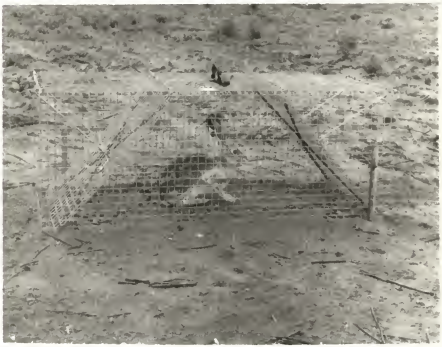

Fig. 2

EXPLANATION OF PLATE III

Fig. 1. The method of application of the plastic ear tag with Scotchlite numbers.

Fig. 2. The tag as it looked after it was applied.

Plate III

Fig. 1

Fig. 2

EXPLANATION OF PLATE IV

Fig. 1. A tag recovered 91 days after application. Note the large hole in the left ear, and that the small metal tag is absent from the right ear.

Fig. 2. Spotlight and 60 mm. telescope as used in the field for nocturnal observations.

Plate IV

Fig. 1

Fig. 2

EXPLANATION OF PLATE V

Fig. 1. A nest of four one-day-old jack rabbits.

Fig. 2. A full grown juvenile jack rabbit at rest.

Plate V

Fig. 1

Fig. 2

SOME ECOLOGICAL STUDIES OF THE BLACK-TAILED JACK RABBIT (*Lepus californicus melanotis*, Mearns) IN SOUTHWESTERN KANSAS

by

DALE LEROY TAYLOR

B. S., Kansas State University, 1958

An Abstract of

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Zoology

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1960

A study was begun in June 1958 on the black-tailed jack rabbit population in Kansas. Data collected by Frank Bronson from July 1956 through November 1957 were included in the results. One-hundred-eighteen field days were spent at the study area near Lakin, Kansas in the summer months of 1958 and 1959. Two days were spent each winter month in making collections.

Ten live traps were used to capture jack rabbits. A metal tag was fastened to one ear and a plastic tag with Scotchlite Reflective tape symbols was sewed to the other ear. Nocturnal movements were observed with a 20 power or 30 power telescope mounted with a 12-volt spotlight.

Eighty-seven jack rabbits were captured in 481 trap nights of which 57 were tagged and released. Average observed home range of 23 individuals was 49 acres. Home range of females was larger than for males of the same age group. Evidence from one individual indicated that jack rabbits may return to their original home range. Greatest distance moved by a jack rabbit was about one mile. One tag was known to have been lost.

Two jack rabbit nests were found and described. Observations on young hares found in the field or nest indicated: (1) litters were dropped in forms with no preparation for a nest, or no form was dug; (2) young leave the form shortly after birth, perhaps on the same day they were born; (3) the litter may stay together for a week or more after leaving the form.

Measurements of jack rabbits raised in captivity showed the hind foot matured at 12 weeks and the ear matured at 10 weeks. Monthly weight fluctuations for 42 months showed females were statistically heavier in all months except November. Females were at their maximum weight in April through May and males attained their greatest weight in October and November.

The epiphyseal closure technique of the humerus was used: (1) as a field aging technique to separate adults from juveniles, and (2) to divide the kill samples into three age classes. Age class I was determined to be about three months of age; Age Class II was less than nine months of age; and Age Class III was over nine months. Results from the kill samples were used to graph the age distribution for the 42 months.

Body weight, body length, and humerus length were of little value for aging jack rabbits. Data on the use of the lenses for aging jack rabbits were presented in the form of a progress report. There was no difference in the weight of the right or left lenses and the lenses were heavier as the animals became older.

Data from 2,037 jack rabbits were included in the reproductive analyses. A 252-day breeding season was tabulated. Epididymal and testicular sperm were present in 100 per cent of the adults from January or February through August. Pregnant females were collected from January through September. Average annual percentages in the number of females pregnant increased from 59 per cent in 1956 to 86 per cent in 1959. Number of young per litter varied from 1.0 in January to 3.3 to 4.1 in May, and then dropped from 2.4 to 3.0 in August. An average of 2.8 young per litter was obtained from data of eight-hundred-three embryos in 284 pregnancies. Litters less than half term averaged 2.8 young and litters over half term averaged 2.9 young. Number of young per litter increased from 2.5 in 1956 to 2.8 in 1959.

Prenatal loss accounted for 15.7 per cent of the potential production of young. Resorption accounted for 6.2 per cent of the loss and 9.4 per cent of the ova were lost before implantation. Apparently, there was no loss of entire litters after implantation.

Fifty-five days were required to produce one litter. Average annual production of 4.6 litters was 12.9. Three corpora lutea atretica were found. Three cases of cross-over of ova were recorded, and one instance of polyovulation was noted. A significant difference was found in the number of embryos in the left and right uterine horn.

Eleven population estimates indicated an average density of 0.3 to 0.5 jack rabbit per acre. Density estimates indicated the population was decreasing. The highest population was May through July and the lowest was in the winter months. Observations on crepuscular, nocturnal, and early morning feeding and behavior were presented.

Fall and winter age ratios of adult females and young were used to compute juvenile survival. The percentage survival was poorest in the fall and winter following a dry year and the next poorest survival was in the wettest year. The two years in which precipitation was near normal showed the best juvenile survival. The four year average juvenile mortality from January through November was calculated to be 51 per cent.