ECOLOGICAL INVESTIGATIONS OF THE BLACK-TAILED JACK RABBIT (*Lepus californicus melanotis*, Mearns) IN SOUTHWESTERN KANSAS, INCLUDING DATA FROM 1956 THROUGH 1961.

by

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INTRODUCTION AND REVIEW OF LITERATURE

The jack rabbit is both harmful and beneficial on its native range. Vorhies and Taylor (1933) stated that the jack rabbit, in its place, is a picturesque and to some extent a useful citizen. Alfalfa fields or other crop lands are probably not proper places. The more favorable effects of the jack rabbit are affording sustenance to a variety of flesh eating mammals, which otherwise might prey upon poultry, lambs, calves or game birds. Throughout the recorded history of the western United States, several authors have commented on the amount of crop damage and the large numbers characteristic of population increases.

Several studies have been conducted on population dynamics of jack rabbits in Kansas. Wooster (1935) studied the effect of drought on jack rabbit populations in the western half of Kansas. 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 (Lepus californicus melanotis, Mearns) and the white-tailed (Lepus townsendi, Bachman) jack rabbits. An increase in the amount of cultivation was the reason given by Brown for the reduction in white-tail range, while this same practice has been beneficial to the black-tailed jack rabbit.

The black-tailed jack rabbit is distributed throughout Kansas, but is generally uncommon east of the Flint Hills region, Black (1938). In Kansas, Hall (1955) stated: "..... the numbers of the black-tailed jack rabbits would increase for several years and then in a period of only a few months or less the animals would die off". Cahalane (1947) reported that jack rabbit populations in most regions tended to fluctuate at an average seven-

year cycle, but varied from five to ten years. Bronson (1957) postulated that the jack rabbit is probably not cyclic in Kansas, but is subject to population changes during drought periods due to a change in carrying capacity of the land. Population fluctuations have been recorded or mentioned by Palmer (1897) in California, Bailey (1931) in New Mexico, Taylor (1948) in Texas, and Kelson (1951) and Durrant (1952) in Utah and Hall (1946) in Nevada.

A five-year drought in Kansas ended in 1957-1958. During the drought years jack rabbit populations were high in Kearny County. Bronson (1957) initiated a study of the black-tailed jack rabbit in southwestern Kansas. The purpose of his study was to obtain information on the population dynamics and the basic ecological factors. Such basic ecological knowledge of this subspecies was unknown for the central region of the United States. His 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 have apparently occurred only during drought periods (Bronson, 1957).

The amount of precipitation in relation to population fluctuation was correlated by Bronson and Tiemeier (1959). Data were presented on reproduction and age distribution, some aspects of behavior, crop damage (Bronson and Tiemeier, 1958b), mortality and past fluctuations of jack rabbit numbers.

In June, 1958, Taylor (1960) began a study that was similar to Bronson's and included censusing, reproduction and age determination techniques. Data were also collected on home range and movements within the home range. The home range of the black-tailed jack rabbit was unknown in the central region of the United States.

Aside from Bronson's and Taylor'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, hunts, and historical information which probably cannot be found elsewhere. He included information on food habits, depredations and classification.

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

Seton (1929) recorded observations on mating, predation, behavior, and postulated home ranges by tracking jack rabbits.

Vorhies and Taylor (1933), working with L. californicus spp. and L. alleni alleni, studied reproduction, habits, food, parasitism, predation, behavior, population fluctuations, and the effect of hares upon rangelands.

Taylor, et al., (1935) Vorhies (1936), presented additional information on the relationship of jack rabbits to grazing in southern Arizona. An important outgrowth of this study was the concept of the jack rabbit as an "animal weed", that is, jack rabbits increased as a result of overgrazing. They found that overgrazing on an area, unless severe, was usually accompanied by an increase of jack rabbits on that area and suggested that secondary succession stages were more suitable habitat than the climax. Additional evidence that jack rabbits prefer moderately grazed rangeland was found by Phillips (1936) and Taylor and Lay (1944). Reigel (1941, 1942) studied native Kansas 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.

Haskell and Reynolds (1947) working in Arizona with pen-raised L. c. americus studied growth, behavior and developmental food requirements and breeding activity. Lechleitner (1955) studied reproduction, population

density, parasites, diseases and home range on L. c. californicus in California. The use of the epiphyseal closure technique for determining age of mammals was extended.

Bider (1961) conducted a recent study in which data on the snowshoe rabbit (L. americanus) were obtained on feeding habits, movement, home range and territoriality.

In June, 1960, I began a study on movements, population fluctuations, reproduction, and attempted to develop various age determination techniques for the black-tailed jack rabbit. One of the techniques was to age jack rabbits by using the dry weight of the lens. This technique was developed by Lord (1959) on the cottontail rabbit (Sylvilagus floridanus). The lens technique had not been previously employed for determining the age of jack rabbits.

Numerous studies have been initiated to develop techniques for determining age of mammals. Green and Evans (1940) used the trap, tag release and recapture technique to determine the age of snowshoe rabbits. Adams (1959) used the color of the hind feet on snowshoe rabbits to separate the young from adults. Teat size, length of the penis and presence or absence of vaginal membrane were used to determine the age of cottontails (Petrides, 1951). The time of epiphyseal closure has become one of the more commonly used methods to determine the age of rabbits. This method was originated by Thomsen and Mortenson (1946) and used by Watson and Tyndale-Biscoe (1953), Bronson and Tiemeier (1958b), Lechleitner (1959), and Taylor (1960).

MATERIALS AND METHODS

One weekend during each of the months of September through May was spent making collections near Lakin in Kearny County, Kansas. Occasional trips in

addition to these were made to obtain census data or for observations on movements of the hares. During the summers of 1960 and 1961, 176 field days were spent at the study area.

Specimens were collected with a .22 caliber rifle or a 12-gauge shotgun between the hours of 3:00 P.M. and 3:00 A.M. The hares were taken to Lakin where they were processed and later were returned to the laboratory at Manhattan for further study and dissection.

Study Area

The study area was located northwest of Lakin, in Kearny County, Kansas. The area consisted of 1,920 acres of grassland and cropland in Sect's 14-15-23 of R-37-W, T-23-S.

In the following description of the terrain and vegetation on the study area, the names of various fields and vegetation types are according to the study area map (Fig. 1).

The area designated as A, is section 14 and consisted of heavily grazed native buffalo grass (Buchloe dactyloides) and various forbs. The east one-fourth of the pasture was densely covered with snake weed, (Guttierrezia sarothrae). There was no noticeable change in vegetation during the summers of 1960 and 1961.

The area designated as Area B (Fig. 1) is section 15 and consisted of land in the Soil Bank Conservation Reserve Program, fallow and sand hills. The area designated as B_1 consisted of about 200 acres which was in the Soil Bank Program and seeded with a mixture of grass in 1958. Taylor (1960) reported that the dominant species of vegetation in 1958 were sunflowers (Helianthus annuus), lambs quarters (Chenopodium album), and russian thistle (Salsola pestifer), and the average height of these was less than six inches.

In late spring of 1959, the area was disced and again sowed to grass. No grass grew, leaving the field with a sparse cover of low growing forbs (Plate 1, Fig. 1). During the summer of 1960, only scattered bunches of grass had grown on the area. The dominant vegetation was sunflower, russian thistle and lambs quarters that grew to a height of 10-18 inches (Plate 1, Fig. 2). The spring rains of 1961 permitted an early growth and abundance of grass. Grasshoppers stripped the leaves of the annual weeds and the plants withered by mid-summer. The dominant vegetation was short perennial forbs, ragweed (Ambrosia sp.), sowed grasses, drop seed (Sporobolus sp.) and switchgrass (Panicum virgatum).

The area designated as "sand hill" on the study area (Fig. 1) was a wasteland area with bunches of buffalo grass, grama grass (Bouteloua sp.) and soapweed (Yucca glanca) being the dominant vegetation. The northeast corner of the study area marked B_2 had been sowed to wheat and alternated each year with summer fallow since 1957. The other field labeled milo was sowed to wheat in 1957 and planted to milo annually since 1958. The west end of field B_3 was seeded to grass in 1957. The dominant species present were sideoats grama, switchgrass, and buffalo grass. Few weeds were present in this area. The east end of the field contained two small sand blown hills, now covered densely with buffalo grass, switchgrass and soapweed. The landowner stated that this area had not been farmed since the late 1940's.

The area marked B_4 was seeded to wheat in 1958. However, high winds caused partial crop failure. Taylor (1960) reported that puncture vine (Tribulus terrestis) and russian thistle were the principal weeds covering the blow area. The puncture vine areas were excellent feeding areas for jack rabbits. The area was disced and placed in the Soil Bank Program in 1959, with wheat stubble, weeds, lambs quarters, fleabane (Eriqeron ramosus),

sunflowers, and russian thistle being the dominant vegetation. The area was much the same during 1960. In the summer of 1961, the early spring rains permitted an excellent growth of the sowed grass and few annual weeds.

The area marked C_1 on the study area map (Fig. 1) was planted to sorghum in 1959. After the sorghum was harvested, the area was placed into the Soil Bank Program without seeding of grass. The dominant vegetation was sunflowers with a few scattered pinweed plants (Lechea tenuifolia). The sunflower averaged about 30 inches in height. There was a slight increase in pinweeds in 1961, but the sunflowers were still the dominant vegetation.

The area marked C_2 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.

The area directly west of Area C on the study area map (Fig. 1) was also a wheat field summer fallow area, and served as an excellent feeding area for jack rabbits during the fall and spring months.

Goke (1954) reported that the soils of the area were moderately deep, light colored soils with 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 capability classification on production was Class IV, where Class I would be the best soil. The soils and topography for the area were well adapted for large-scale agricultural practices. In years when rains were seasonally distributed and above normal, the soils could have been called Classes III or II. The average annual rainfall data are misleading because sixteen inches properly distributed and conserved for use by crops is enough if received at the right time. Sometimes four or five inches of the annual average will fall in 24 hours which is more than the average rolling upland

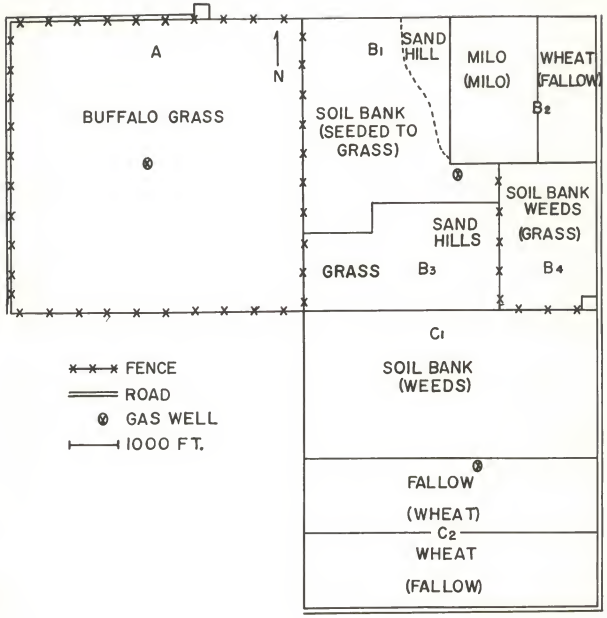


Fig. 1. Map of the 1,920-acre study area. Farming practices without parentheses are for 1960 and those for 1961 are with parentheses.

soil can absorb unless a thick mulch of straw or other residue is on the surface. If the rain comes when the land is bare, the farmers have the problem of conserving their soils, as well as moisture. Crop failures due to drought and wind erosion hazards were greatest in the Kearny County area than any place in Kansas (Goke, 1954).

Reproduction

Jack rabbits were collected within an area of 10 square miles north of Lakin in Kearny County. Specimens were taken to the field laboratory at Lakin where they were measured and weighed. The females were examined for condition of the mammary glands. If the hair was matted around the teats the animal was considered suckling. The presence or absence of milk was determined by squeezing the nipples. The males were examined for the presence or absence of the testes in the scrotum.

The reproductive tracts of males and females were removed. The left eyeball was removed and placed in 10 per cent formalin in order to harden the lens for the age determination study. The left humerus was removed from each hare, cleaned, and labeled.

All materials were returned to Manhattan for dissection. A mean index of the ovary size was obtained for each specimen by using measurements taken with calipers on the width and length of each ovary. The ovaries were sectioned with a razor blade and the diameter of the larger peripheral follicles, number of rupture sites, corpora lutea and corpora albicantia were recorded. The animal was designed as parous if the uterus appeared to be longitudinally striated. Lechleitner (1958) stated that the striations develop as a result of pregnancy and were retained throughout life. The macrosopic embryos in each uterine horn were counted. The embryos 90 millimeters and longer were sexed and the crown-rump measurement was recorded.

Each pair of testes was weighed after removal of the epididymides. Smears of sperm from one testis and the cauda epididymis were taken. A phase microscope was used to estimate the presence or absence of sperm on the basis that 0 = no sperm; 1 = occasional sperm; 2 = frequently found; 3 = sperm everywhere; 4 = masses of sperm. The male was considered capable of breeding if a count of three or four was obtained.

Live Trapping

A program for studying the movement range of jack rabbits was conducted throughout the present study. The study was initiated during the summer of 1959 by Taylor (1960). Nine traps of original design were constructed in 1959 (Plate II, Fig. 1 and 2) and one was obtained from Lechleitner (1958), from Gray Lodge Waterfowl Refuge in California. Five more traps were constructed in June of 1960.

The traps were constructed from a 48-inch roll of one-inch mesh welded wire. The dimensions were 48" long, 18" high, and 18" wide. The doors were 28 inches long and hinged on the top side 18 inches from the end of the trap.

A No. 1 steel jaw trap used as the trigger mechanism was fastened on top of the wire trap one-half the distance between each of the doors. Wires were attached to each jaw of the steel trap and extended through the doors. When the doors were raised the catch wires were snapped over the trap frame, holding the doors open. When tripped the wires from the doors would be pulled simultaneously, allowing the doors to fall. A catch was put on each end of the trap to keep the hare from raising the doors to escape. The trip wires were 26-gauge wire 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. Trip wires were placed about six inches apart, with the

bait in the middle so the jack rabbit would have to trip one or the other wires to get to the bait, depending on which end of the trap the hare entered.

The traps were placed in paths made by jack rabbits or along field borders where the vegetation was less than one foot tall. Traps were baited and reset each afternoon or early evening. If the traps were baited too early in the day, insects would consume the bait. Lechleitner (1955), trapping jack rabbits in California, found that apples were the most acceptable bait. Bider (1961), while conducting trapping methods in Canada on the snowshoe rabbit (Lepus americanus), found that celery was the best bait. In the present study, apples, celery, lettuce, milo and potatoes were used as baits. No data were collected on bait preference. In some cases when the ground was too wet to get to the study area, the traps were not baited, and on several of these occasions hares were captured. Curiousity of the animal may have resulted in its capture rather than being lured into the trap by various baits.

The traps were checked each morning by 6 A.M. or shortly thereafter, depending on the weather. The captured animals were removed by crawling on hands and knees into one end of the trap and grabbing the hare gently. Animals were classified as adults or juveniles, sexed, tagged and released. Adult animals were taken to the laboratory and a sample of blood obtained. The blood was checked for the presence of micro-filariae (Bartel, 1960). If none was found, the hares were returned to the field, tagged and released.

Summer Movement Range

Home range is the area utilized by an animal in its normal activities (Burt, 1943). A hare's normal activities are resting (under cover), moving to a browsing area, then returning to cover. Courtship and caring for young

are also normal hare activities in the breeding season. The summer range of the jack rabbit was calculated, and will be referred to hereafter as movement range.

Many basic concepts of home range and territorialism were developed during the periods from 1937 through 1961. Authors such as Aldous (1937), Blair (1940, 1942, 1943), Burt (1943), Dalke (1942), Haugen (1942), Balham and Elder (1953), Helm (1955), Craighead (1956), Ealey (1956), Progulske (1957), Duerre (1958), Lechleitner (1958), and Bider (1961) collected various materials and devised their own techniques for calculating movements. The techniques and materials for marking animals were plastic colors, plastic discs, "scotchlite" reflective tape, inks, dyes, and ribbons. In this study silver scotchlite reflective tape gave the brightest reflection during nocturnal observations.

During the summer of 1960 a combination of two numbers from 1 to 7 was cut from the scotchlite. During the summer of 1961 a combination of numbers over letters was used (Plate III, Fig. 1), example ($\frac{2}{H}$). A strip of red upholstery plastic two and one-half inches square was used for each tag. Two sets of scotchlite figures were applied to one side of the tag. When the tag was folded around the jack rabbit's ear, it could be read from in front and behind the jack rabbit (Plate III, Fig. 2).

The tag was sewed to the animal's ear by folding the plastic between the scotchlite symbols and stitching it with nylon thread. A curved surgical needle was used for punching the 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 (Plate III, Fig. 2). A monel metal ear tag 10 millimeters in diameter stamped with KSU; ZOOL; the number; MNHATN, was placed in the opposite ear.

Observations on movements and activity of hares were made in the late evening or occasionally early morning hours. These observations were made with a 12-volt spotlight mounted on a tripod with a 20-power interchangeable to 30-power telescope (Plate IV, Fig. 1). The tripod was placed on the hood of the truck while the observer sat on the cab. The observations were generally conducted by two persons, one driving the vehicle, the other sitting on the top of the cab to observe the tagged animals.

Only movement range of those animals observed five or more times were plotted on the maps. A Compensating Polor Planimeter was used to measure the movement range from the maps. The movement range study was terminated the end of August in 1960, and in mid-September in 1961.

Census

Population studies were conducted on Areas A, B, and C (Fig. 1). The area was censused in order to establish a monthly and seasonally trend on fluctuations of the population of hares.

Many different methods have been used to count jack rabbits. Drives were used by Palmer (1897), Vorhies and Taylor (1933), Wooster (1935) and Woodbury (1955). Carter (1939) and Brown (1940, 1947) sent questionnaires 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.

Cost, available help, and size of area are important factors in choosing a census method for a particular animal. 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 rabbits.

Hayne (1949) noted some of the errors of the King method. A common error was made by assuming that the mean flushing distance was reliable; also, the observer could not see all flushed animals, or the animals moved out of the path of the censuser.

The census method used in this study was based on a modification of the method described by Webb. Strips spaced one quarter of a mile apart and one mile long were used. Only those animals flushed within 50 feet on either side of the observer were counted. Several conditions under which counts for indices were to be made were established at the beginning of the study 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 the hares were resting. Counting was done only when weather conditions were normal; that is, the wind was at a minimum, the ground dry or relatively so and the temperature normal for the season. One to two days were required to complete the census.

Age Determination Techniques

Throughout the study three different age determination techniques were used. When the animals were collected by shooting or trapping, they were classified as juveniles or adults based on general body size, weight, and total length. This technique had limited use, and was used only for determining approximate age of jack rabbits in the field.

The degree of closure of the epiphyses of the long bones has become a common method used for determining age of lagomorphs. This method was originated by Thomsen and Mortensen (1946), and used by many authors. The left humerus, unless too badly fractured by shooting, was collected from each jack rabbit during the monthly collections.

Lechleitner (1959) revised the epiphyseal closure technique by classifying L. c. californicus into three age classes. The three age classes were as follows: Age Class I included those animals, two to nine months old, in which the epiphyseal area was represented by a definite groove of cartilage that had not been replaced by bone. Age Class II included those animals from 10 to 12 months old in which the epiphyseal plate was nearly closed and all cartilage was replaced by bone. 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 individuals older than one year in which there was no indication of an epiphyseal line (Table IV, Fig. 2).

From June 1959 through 1961 the left eyeball was collected from all animals. The eyeball was placed in 10 per cent buffered formalin to harden the lens, and make it easier to separate the lens from the vitreus humor. A period of one week was found to be sufficient for the fixing.

After fixing, the lens was removed from the eye and placed in an oven heated to 90°C. The lens was considered dry when repeated weighings, with intervals of drying, resulted in no additional loss in weight. The lenses were usually dry in 12 to 16 hours. Because the dried lenses are hygroscopic, they were weighed immediately after removal from the oven. A Fisher Gramatic precision balance was sufficiently accurate to weigh the lenses.

Forty-seven jack rabbits of known age were raised in the laboratory, and killed at various intervals to establish a growth curve on the basis of weight of the dry lens.

Jack rabbits will not breed in captivity, therefore, the young hares were obtained by performing caesarian operations on pregnant females shot while making the monthly collections. Twenty-five hares were obtained in 1960, and 22 during the summer of 1961. The baby hares were fed a mixture

of one part of evaporated milk and two parts water from a medicine dropper three times daily. Fresh grass and a balanced ration of commercial rabbit pellets were constantly available to the rabbits.

The milk diet was discontinued at approximately two weeks of age when the hares were mature enough to feed. Young hares caught in the field were immediately placed in a cage and given a supplemented ration of rabbit pellets and a pan of water. Data on length of hind foot, length of ear from tip to notch, and weight were made and recorded each week.

A schedule for killing the hares was followed as closely as possible (Table 10). When the jack rabbits were killed the left eyeball was removed immediately and placed in 10 per cent formalin. After sufficient oven drying the lens was weighed and plotted on the growth rate curve chart. The oldest hare raised in the laboratory was 21 months old.

RESULTS

Size and Weight Fluctuation of Adults

During the five and one-half years 2,627 jack rabbits were collected. Of these 1,340 were males and 1,287 females or a ratio of 104 males to 100 females. A chi-square test showed that there was no significant sex ratio difference throughout the study ($x^2 = .001$, $x^2.05 = 3.84$, 1 D.F.). There was no significant difference in sex ratios of the collections from 1956 through 1961 with the exception of 1958 ($x^2_{1956} = 2.76$; $x^2_{1957} = 0.50$; $x^2_{1959} = 1.22$; $x^2_{1960} = 1.70$; $x^2_{1961} = 1.03$).

There was a significant difference in the 1958 collection ($x^2_{1958} = 4.14$). This difference apparently was not large enough to make a significant difference in the sex ratio for the entire sample (Table 1).

Table 1. Sex and age composition of the five and one-half year study totaling 2,627 specimens. Humerus bones were not collected until January, 1957.

Month	Age Class I Male	Age Class I Female	Age Class II Male	Age Class II Female	Age Class III Male	Age Class III Female	Total Male	Total Female	Bones Missing	Grand Total
July '56							43	29	0	72
Aug.							50	40	0	90
Sept.	----------	----------	No Data	----------	----------	----------	34	42	0	76
Oct.							37	34	0	71
Nov.							35	26	0	61
Dec.							28	22	0	50
TOTAL FOR 1956							227	193	0	420
Jan. '57	0	0	7	10	19	17	26	27	0	53
Feb.	0	0	2	4	24	22	26	26	0	52
Mar.	0	0	5	3	16	14	21	17	0	38
Apr.	0	0	3	11	22	30	25	41	0	66
May	----------	----------	No Data	----------	----------	----------	17	21	0	38
June	1	4	0	1	11	12	12	17	0	29
July	9	12	0	0	1	5	10	17	0	27
Aug.	15	12	3	1	4	7	22	20	0	42
Sept.	13	10	3	6	3	4	19	20	0	39
Oct.	13	7	12	6	6	4	31	17	1	49
Nov.	3	3	16	21	4	4	23	28	0	51
Dec.	0	0	8	8	5	11	13	19	0	32
TOTAL FOR 1957	54	48	59	71	115	130	245	270	1	516
Jan. '58	0	0	10	5	8	8	18	13	0	31
Feb.	0	0	3	3	17	10	20	13	0	33
Mar.	0	0	4	2	8	9	12	11	2	25
Apr.	0	0	4	5	25	12	29	17	0	46
May	3	4	4	2	15	18	22	24	0	46
June	19	15	2	1	19	22	40	38	0	78
July	29	18	2	1	14	15	45	34	0	79
Aug.	50	35	8	6	10	9	68	50	1	119
Sept.	14	9	3	4	3	10	20	23	0	43
Oct.	13	7	2	16	4	3	19	26	0	45
Nov.	9	5	15	9	8	8	32	22	0	54
Dec.	2	0	8	7	6	5	16	12	0	28
TOTAL FOR 1958	139	93	65	61	137	129	341	283	3	627
Jan. '59	0	0	3	4	12	12	15	16	0	31
Feb.	0	0	8	1	18	11	26	12	0	38
Mar.	1	0	4	3	11	15	16	18	1	35
Apr.	0	1	4	2	13	10	17	13	1	31
May	0	2	1	1	18	12	19	15	0	34
June	10	6	2	2	9	24	21	32	0	53
July	24	25	5	2	4	9	33	36	0	69

Table 1 (concl.).

Month	Age Class I Male	Age Class I Female	Age Class II Male	Age Class II Female	Age Class III Male	Age Class III Female	Total Male	Total Female	Bones Missing	Grand Total
Aug.	21	20	2	2	5	6	28	28	0	56
Sept.	12	17	3	2	0	1	15	20	1	36
Oct.	9	8	9	3	1	3	19	14	0	33
Nov.	1	0	10	12	3	1	14	13	1	28
Dec.	0	0	10	6	3	10	13	16	1	30
TOTAL FOR 1959	78	79	61	40	97	114	236	233	5	474
Jan. '60	0	0	6	13	6	9	12	22	3	37
Feb.	1	0	6	4	10	7	17	11	0	28
Mar.	0	0	6	6	6	6	12	12	0	24
Apr.	0	0	7	5	5	3	12	8	0	20
May	0	0	6	6	4	8	10	14	0	24
June	3	3	3	4	6	6	12	13	1	26
July	5	9	3	5	4	3	12	17	1	30
Aug.	9	11	1	4	1	2	11	17	1	29
Sept.	12	3	1	4	4	5	17	12	1	30
Oct.	5	8	4	1	3	5	2	14	1	25
Nov.	1	1	4	5	5	7	10	13	2	25
Dec.	1	0	2	2	1	5	4	7	0	11
TOTAL FOR 1960	37	35	49	59	55	66	141	160	10	311
Jan. '61	0	0	3	8	6	5	9	13	0	22
Feb.	0	0	5	2	4	4	9	6	0	15
Mar.	0	0	12	7	6	5	18	12	0	30
Apr.	0	1	5	7	4	4	9	12	0	21
May	0	2	3	6	2	8	5	16	0	21
June	9	0	2	2	6	7	17	9	0	26
July	7	12	1	3	2	6	10	21	0	31
Aug.	6	9	1	3	2	3	9	15	1	25
Sept.	9	9	3	1	2	1	14	11	2	27
Oct.	6	8	2	5	3	2	11	15	0	26
Nov.	3	2	7	5	3	1	13	8	0	21
Dec.	1	2	2	5	1	3	4	10	0	14
TOTAL FOR 1961	41	45	46	54	41	49	128	148	3	279
TOTAL	349	300	280	285	445	488	1318	1287	22	2627

A prenatal sex ratio was calculated from 262 fetuses with a crown-rump length of 90 millimeters or greater. A chi-square test showed there was no significant sex ratio difference between the 127 males and 135 females (x^2 = 2.44, $x^2.05$ = 3.84, 1 D.F.).

Monthly fluctuations in the weight of jack rabbits were calculated from the five and one-half year study. Cumulative monthly average data were graphed for each sex (Fig. 2). This was calculated by averaging the weight of the animals for each month and plotting the average months weight. Individual monthly average data for each month were plotted to determine the annual difference. There was a definite sexual dimorphism in weight and total length of adult jack rabbits (Table 2). This difference in weight was evident during the non-breeding as well as the breeding season, and was not the result of including pregnant females in the averages. The mean weight of 654 adult males was 91.5 ounces, and of 664 adult females 104.3 ounces. The mean total length of 654 adult males was 552 millimeters, and of 664 adult females 667 millimeters (Table 2).

As the breeding season began, the difference in weight between the males and females increased until a maximum was reached by mid-summer. Toward the end of the breeding season in late summer, the males began to gain weight and the females lost weight. Shortly after the breeding season ended, the weights were nearly the same for the sexes (Fig. 2).

The heavier females were collected during the middle part of the breeding season, April through July. Males attained their maximum weight in October and November after the end of the breeding season. Males also gained weight during April, May and July.

The weight of males and females were significantly different in January through September of each year. In March, 1958, a part of the breeding season, there was no significant difference in weight (Table 3).

October and November were the only months in which there was not a constant significant difference in weight of males and females (Table 3).

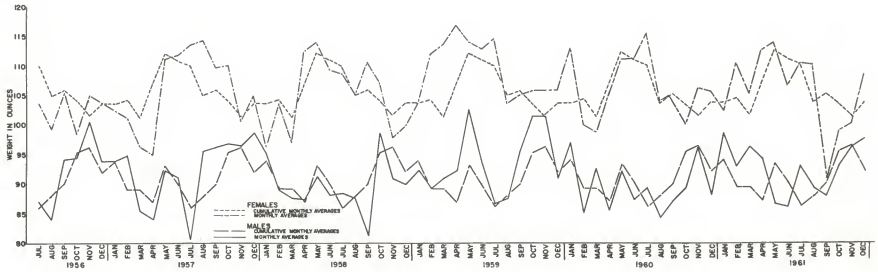


Fig. 2. Monthly weight fluctuations of jack rabbits calculated from 66 monthly kill samples.

Table 2. Average weight and length of adult males and females.

Measurement	Total Adults	Mean	Range
Weight			
Male	654	91.5 oz.	81.0-102.6 oz.
Female	664	104.3 oz.	90.8-117.2 oz.
Total length			
Male	654	552 mm.	521-571 mm.
Female	664	567 mm.	517-585 mm.

Reproduction

A definite annual breeding cycle was evident from the reproductive data (Fig. 3). Males demonstrated this cycle by both an increase or decrease in average weight of testes (Fig. 3), and in monthly comparison of testicular activity (Table 4). Testes were in the scrotum from late December and January through August. Males taken during the non-breeding season had shrunken, flaccid and non-scrotal testes. From a comparison of the monthly mean weight of testes, the peak in male breeding efficiency was in May.

Table 3. Monthly difference in average 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	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1956	----------		No data		----------		+	+	+	-	-	-
1957	+	-	+	+	+	+	+	+	+	+	-	-
1958	-	+	-	+	+	+	+	+	+	-	-	-
1959	+	+	+	+	+	+	+	+	+	-	-	+
1960	+	+	+	+	+	+	+	+	+	-	-	+
1961	-	+	+	+	+	+	+	+	-	-	-	+

Epididymal and testicular sperm counts fluctuated seasonally (Table 4). There was a gradual increase in sperm production through December and January. All adult males had sperm in their testes from December until late August.

Table 4. Per cent of adult males showing sperm in smears of testicular material and comparative sperm counts of three or four in smears of epididymal material.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	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	65	0	25	50
1959	100	100	100	100	100	100	100	100	0	0	50	33
1960	45	100	100	100	100	100	86	25	55	0	0	50
1961	88	100	100	100	100	100	100	100	0	0	0	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
1960	54	85	100	91	100	100	71	50	11	0	0	75
1961	100	100	100	100	100	100	100	100	0	0	0	33

The number of sperm in the epididymis was used as a criterion to determine capability of breeding. Occasionally male hares born early in the breeding season had an epididymal sperm count of three or four in August, when they were six months old.

Pregnant females were observed in five of the six January collections. The earliest collection was made on 9 January 1961, and all of the fetuses

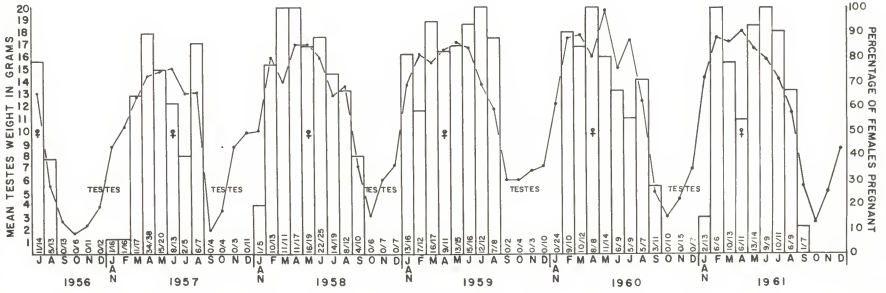


Fig. 3. Mean testes weight and per cent of females pregnant in 66 monthly collections.

were under one-half term. Considering the gestation period as 43 days (Haskell and Reynolds, 1947), conception took place around the first of the month. Pregnant females were also collected in three of the six September collections. The collections were made the first one-half of each September, the 26th in 1959. The fetuses taken were older than one-half term, indicating conception had occurred in late August. Therefore, the breeding season extended from January through August or 240 days.

Seventy-two per cent of all adult females collected for the entire study were pregnant. The mean litter size fluctuated from 1.0 per litter in January to a high of 4.2, usually in May, and then decreased until the breeding season ended. A mean of 2.8 young per litter was noted in 404 litters consisting of 1,135 embryos (Table 5).

The average number per litter was also calculated for litters younger or older than one-half term. A crown-rump measurement of 40 millimeters was assumed to be one-half term (Lechleitner, 1955). The analyses of data obtained on 404 pregnancies indicated an average of 2.7 young per litters less than 40 millimeters and 2.9 young in litters greater than one-half term (Table 6).

In 44 pregnancies affected by resorption, 15 of the litters had fetuses more than 40 millimeters long. In the remaining 29 pregnancies affected by resorption, the embryos were less than 40 millimeters long (Table 7). Occasionally toward the end of the breeding season, entire litters would be resorbed. In the September 1961 collection only one pregnant female was collected, and the litter of 2.0 showed evidence of resorption. Resorption occurred in 5.1 per cent of the embryos taken during the study (Table 7).

Resorption loss was only part of the entire prenatal loss. In 404 pregnancies, 1,207 ova were shed and 1,135 embryos were present, or a loss

Table 5. Average number of young per litter and per cent of adult females pregnant during the breeding season.

Month	Per cent females pregnant	Mean litter size	Month	Per cent females pregnant	Mean litter size
Jan. 1956			Jan. 1959	81.2	1.3
Feb.			Feb.	76.9	1.5
Mar.			Mar.	94.0	3.5
Apr.	--------- No data ---------		Apr.	81.8	3.1
May			May	84.6	3.7
June			June	93.7	3.2
July	78.6	2.7	July	100.0	2.5
Aug.	38.4	2.3	Aug.	85.7	2.5
Sept.	00.0	0.0	Sept.	00.0	0.0
Oct.	00.0	0.0	Oct.	00.0	0.0
Nov.	00.0	0.0	Nov.	00.0	0.0
Dec.	00.0	0.0	Dec.	00.0	0.0
MEAN FOR 1956	53.6	2.5	MEAN FOR 1959	84.9	2.8
Jan. 1957	6.2	1.0	Jan. 1960	00.0	0.0
Feb.	6.2	1.0	Feb.	90.0	1.4
Mar.	64.7	1.8	Mar.	83.3	2.5
Apr.	89.5	2.5	Apr.	100.0	3.3
May	75.0	3.3	May	78.5	4.1
June	61.5	2.9	June	66.6	2.3
July	40.0	2.0	July	55.5	2.6
Aug.	85.7	3.0	Aug.	71.4	2.0
Sept.	00.0	0.0	Sept.	27.2	1.6
Oct.	00.0	0.0	Oct.	00.0	0.0
Nov.	00.0	0.0	Nov.	00.0	0.0
Dec.	00.0	0.0	Dec.	00.0	0.0
MEAN FOR 1957	53.6	2.6	MEAN FOR 1960	71.5	2.6
Jan. 1958	20.0	1.0	Jan. 1961	15.3	1.5
Feb.	76.9	1.5	Feb.	100.0	1.0
Mar.	100.0	3.3	Mar.	76.9	2.9
Apr.	100.0	4.0	Apr.	54.5	2.8
May	84.2	4.1	May	92.8	4.2
June	88.0	3.3	June	100.0	2.6
July	73.6	2.3	July	90.0	2.7
Aug.	66.6	2.4	Aug.	66.6	2.5
Sept.	40.0	3.0	Sept.	14.2	2.0
Oct.	00.0	0.0	Oct.	00.0	0.0
Nov.	00.0	0.0	Nov.	00.0	0.0
Dec.	00.0	0.0	Dec.	00.0	0.0
MEAN FOR 1958	72.1	3.1	MEAN FOR 1961	74.0	2.9
MEAN FOR THE ENTIRE STUDY				72.0	2.8

Table 6. Average annual litter size of embryos less than half term, over half term and for all embryos.

Year	Less than 40 mm.			Over 40 mm.			All embryos		
	Embryos	Litters	Av. per litter	Embryos	Litters	Av. per litter	Embryos	Litters	Av. per litter
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
1960	60	22	2.7	88	35	2.5	148	57	2.6
1961	123	46	2.7	61	17	3.5	184	63	2.9
TOTAL	599	219	2.7	536	185	2.9	1135	404	2.8

* Represents only two months of the breeding season.

of 9.4 per cent of the ova before implantation. The total prenatal loss including the loss in resorption was 14.5 per cent (5.1% + 9.4%) of the original ova shed.

A significant difference in the number of embryos present in the left and right uterine horns were found during five and one-half years of this study. Six-hundred and two embryos were found in the left and 535 in the right uterine horn ($x^2.05 = 3.94$, 1 D.F.).

Table 7. Number of litters and the percentage of embryos suffering loss according to the embryo size.

Embryo size	Number of litters	Number of embryos	Mean litter size	Number resorbing	Per cent of all embryos	Total
Less 40 mm.	29	64	2.2	39	39/1135=3.4	58/1135=5.1
Over 40 mm.	15	52	3.4	19	19/1135=1.7	

Jack rabbits are born completely covered with hair, eyes open and able to hop. There has been much debate as to whether a female jack rabbit gives birth to her young in a nest.

During the periods of 1960 to 1961 no evidence was found indicating young jack rabbits were born in nests. A nest can be defined as a settled and often concealed place in which young hares are reared. Three young hares were found on the study area and after an exhausting chase, all three were caught and taken to the laboratory. Examination revealed that the umbilical cord had not completely dried. The measurements in millimeters were; total length 175; tail 29; hind foot 50; and ear 35. The area in which the hares were caught was examined thoroughly, and the nearest form was 50 yards from the area in which the young hares were captured.

Seven other young hares ranging from one to seven days old were caught during the study. Each capture site was carefully examined and no evidence of nests or birth places were found.

Taylor (1960) reported that two jack rabbit nests were found. One young hare was found in a form after the adult was flushed. The young hare was capable of moving about, although movement was slight.

A second nest was found in which four jack rabbits were huddled. Available evidence indicated that these hares were less than 24 hours old when they were found. Measurements were taken the same day the hares were found, and the average in millimeters for total length was 173; tail 28; hind foot 49; and ear 30.

Live Trapping

Ninety-seven jack rabbits were trapped during the summers of 1960 and 1961 and of these 14 were recaptures, three died or were killed when removed from the trap, six escaped after being trapped, and 14 were not tagged. Sixty jack rabbits were tagged and released.

Injuries received by jack rabbits while inside the trap were not uncommon. The hares would remain calm in the trap until approached to be released, but would then frantically jump into the sides of the trap and injure their nose and forehead. Occasionally hares would be held overnight in the laboratory to allow the wound to scab over. They would be tagged and released the following day.

Care was taken in handling the hares when removing them from the traps. Young and old hares may be lifted and carried comfortably by grasping the loin region gently, but firmly, the heel of the hand being toward the tail of the animal. This method prevents bruising or tearing the animal's skin.

It also keeps the animal's legs swinging freely, and prevents the handler from being scratched.

An attempt was made to observe the behavior and reaction of the hares immediately after they were tagged and released. The general reactions would be to pause, and after some coaxing, leap away to the first available cover and stop. They would generally shake their heads from side to side, and the ear of young jack rabbits with attached plastic tag generally hung to the side of the animal's head.

The ages of tagged jack rabbits were 30 juveniles and 30 adults and the sex was 28 males to 32 females (Table 8).

Summer Movement Range

Eight tagged jack rabbits were not observed after they had been released. Thirty-four jack rabbits were seen more than five times. Data on hares observed five or more times were used to calculate the movement range. The 34 tagged jack rabbits were observed 384 times. The most frequent observations of 32 were made on a juvenile male.

The results of the observations were plotted on maps of the study area (Fig. 4,5,6,7,8,9) using symbols as designations of specific hares which corresponded to the small metal ear tags (Table 8). On the maps the solid symbols indicate location of capture and release of the animal. Two animals were not released at the capture site, and an arabic numeral R was placed inside the symbol on the maps.

Occasionally tagged hares were flushed while driving or walking through the study area during daylight hours. The tags were difficult to observe before the hares were out of sight. The reflecting type tag was most easily observed during darkness. On moonlight nights the jack rabbits would seek

cover in the dense vegetation when the beam of light was shone on them. On quiet clear nights hares were spotted and the numbers on the tags could be seen from 500 yards. Adeptness with the scope and knowledge of the hare's movements facilitated prompt reading of the tag.

Observations indicated that the black-tailed jack rabbit remained within rather defined areas throughout the summer months and migrated to areas where young succulent vegetation was available during the winter months. During the winter months of 1960, three jack rabbits were noted nearly two miles from their summer range. Juvenile female numbered No. 148 (Table 8, Fig. 4) was observed 26 times on the study area during the summer of 1960. While making the monthly collection in December the hare was observed two miles north of its summer range. Hares numbered 105 and 155 (Table 8, Fig. 6) were shot by local hunters approximately one and one-half miles east of their recorded summer range.

Observations on the 34 tagged jack rabbits indicated a summer movement range of 31.3 acres (Fig. 4,5,6,7,8,9). Three adult males had an average movement range of 32.3 acres and the range of 11 females averaged 30.5 acres. The movement range of juvenile hares varied from 10 to 70 acres with a mean of 32.5. The movement range of adults varied 13 to 67 acres with a mean of 30.9.

Jack rabbits may return to their original range. Hare numbered 139 (Table 8, Fig. 7) was caught on 19 July 1960 and released one mile from the capture site. The animal was not seen again in 1960, but during the summer of 1961 it was observed 22 times near the original area. The plastic ear tag and scotchlite numbers were in perfect condition. Hare numbered 29 (Table 8) was captured by Taylor (1960) in August of 1959 and observed one year later. However, identification was impossible because the scotchlite

Table 8. Sex, age and number of times 60 tagged jack rabbits were observed. Summer range size based on 34 individuals.

Jack rabbit number	Sex	Age	Date caught	Times observed	Summer range	
					Mapped on figure	Size (acres)
29	M	Ad.	8-25-59	4	(Shot on 8-30-60)	
82	F	Ad.	6-23-60	5	7	14
101	F	Ad.	8-21-60	3		
102	M	Ad.	8-18-60	1		
103	M	Juv.	8-23-60	0		
104	F	Ad.	8-27-60	3		
105	F	Juv.	8-21-60	6	5	27
106	M	Juv.	7- 5-61	10	7	20
108	F	Ad.	8- 2-60	2		
109	M	Ad.	8- 2-60	2	(Dead 8-5-60)	
113	M	Juv.	6-15-61	22	9	33
116	M	Juv.	6-19-60	0		
117	M	Ad.	8-10-61	10	8	23
121	F	Ad.	6-22-60	1		
122	M	Juv.	8- 9-60	3		
125	F	Ad.	8-15-60	0		
126	F	Juv.	8- 1-60	1		
127	F	Ad.	8-15-60	0		
129	M	Juv.	8- 4-60	16	7	20
130	M	Juv.	8-15-61	18	9	15
132	M	Ad.	6-29-61	3		
136	M	Juv.	8-26-60	5	5	19
139	F	Juv.	7-19-60	0 (in 1960)		
				22 (in 1961)	7	67
142	F	Juv.	8- 1-60	1		
143	F	Juv.	8-16-61	14	9	16
147	F	Juv.	8-23-61	7	6	14
148	F	Juv.	6-29-60	25	4	47
149	M	Ad.	7-10-61	8	8	57
152	F	Ad.	8-10-60	8	7	13
155	F	Juv.	8-10-60	8	6	55
165	F	Ad.	7-17-60	0		
166	F	Ad.	7-26-60	1		
167	M	Juv.	7-28-61	6	5	20
168	M	Juv.	8- 7-60	2		
169	?	Juv.	8-19-60	0		
175	F	Ad.	7-25-60	6	8	23
177	F	Ad.	6-14-61	3		
179	F	Juv.	7-18-60	9	8	70
181	F	Ad.	6-26-61	13	4	25
182	F	Juv.	8-23-61	8	9	20
183	F	Ad.	7-27-61	7	8	25
186	F	Juv.	8-28-60	2		
187	F	Ad.	8-30-60	2		
188	F	Juv.	8-21-61	1		
189	F	Juv.	8-24-60	5	7	29

Table 8 (concl.).

Jack rabbit number	Sex	Age	Date caught	Times observed	Summer range: Mapped on figure	Summer range: Size (acres)
191	M	Juv.	8-11-60	7	6	64
192	F	Ad.	8-14-61	7	4	27
193	M	Juv.	6-30-60	15	8	66
195	F	Ad.	6-25-60	11	4	25
199	F	Juv.	8-18-60	5	4	13
201	M	Juv.	7-15-61	26	4	68
202	F	Juv.	7-24-61	12	5	30
206	F	Ad.	8-11-61	7	5	48
207	M	Juv.	7-16-61	32	6	29
208	F	Ad.	7-18-61	0		
214	F	Juv.	7-15-61	11	4	12
222	M	Juv.	8-31-61	7	9	10
263	M	Ad.	9- 1-61	6	5	20
275	M	Ad.	7-25-60	0	(Dead 8-8-61)	
303	M	Ad.	7-10-61	0		

symbols were lost. The hare was shot on 30 August 1960 and the monel metal tag was noted in the right ear. However, the plastic tag and part of the ear had been torn from the left ear.

Adult female numbered 195 (Table 8, Fig. 4) was released one-half mile from the site of capture. The symbol with the number (1) inside was the site of the first observation. Twenty days elapsed before the animal was again seen at the original capture site.

Census

From June, 1958 through 1961, 23 population estimates were conducted (Table 9) on the study area (Fig. 1). Generally the vegetation was sparse enough to allow the observer to see the flushed hares, but on certain areas during the summer months as in the milo field (Area B_2) a dense stand of milo 18 to 20 inches high hindered observations. Observations made in areas of tall vegetation, however, revealed fewer forms and fresher pellets than in areas of newly sprouted milo.

The density estimate was 0.5 hares per acre in 1958 and steadily decreased to 0.1 in 1961. The flushing distance varied from three to 300 feet with a mean distance of 50 feet. On some occasions the hares would not move from their forms until nearly stepped on.

There was a seasonal fluctuation in jack rabbit numbers on the study area. The peak population numbers, according to the census data occurred in June or July and the low generally occurred during the months of October and November (Table 9).

Age Determination

The mean length of the hind foot was 128 millimeters and the ear 111 millimeters on 83 adult males and 100 adult females taken during monthly collections. The length of the laboratory-reared animals had a mean of 127 millimeters for the hind foot and 112 millimeters for the ear. On the basis of the growth data taken on 47 individuals, the hind foot matures at about 14 weeks and the ear at about 12 weeks of age (Fig. 10). There was no significant difference in the length of the hind foot and ear of adult males and females.

In summer trapping studies, hares were classified as adults or juveniles on the basis of body size and weight. An adult was defined as an animal that had attained mature weight.

The dry weight of the eye lens as an age determining criterion was used because the lens weight increases as jack rabbits become older.

A growth rate curve was established from the weights of the lenses of laboratory-reared hares using the base point of the curve as the weight of lenses taken during caesarian sections. Additional points were plotted from animals reared to 650 days in the laboratory (Table 10). A three-point moving average was used to establish a smooth curve (Fig. 11).

Table 9. Population and density estimates based on number of animals flushed on indexing strips.

Indexing period	Area A Buffalo grass	Area B Farmland Soil Bank	Area C Soil Bank	Total and average for the area
June 1958				
Number flushed	29	0	36	65
Population est.	377	0	468	845
Density estimate	.59		.73	.52
Early July:				
Number flushed	29	0	34	63
Population est.	377	0	442	819
Density estimate	.59		.69	.51
Late July:				
Number flushed	25	10	30	65
Population est.	325	130	390	559
Density estimate	.51	.41	.61	.52
August:				
Number flushed	22	0	21	43
Population est.	286	0	273	559
Density estimate	.44		.42	.35
November:				
Number flushed	6	0	27	33
Population est.	78	0	351	429
Density estimate	.12		.55	.27
January 1959				
Number flushed	18	0	18	36
Population est.	234	0	234	468
Density estimate	.36		.36	.29
May:				
Number flushed	21	0	29	50
Population est.	273	0	377	650
Density estimate	.43		.58	.41
June:				
Number flushed	19	0	26	45
Population est.	247	0	338	585
Density estimate	.39		.53	.36
July:				
Number flushed	15	1	29	45
Population est.	195	13	377	585
Density estimate	.30	.04	.58	.36
August:				
Number flushed	15	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	.18	.17

Table 9 (concl.).

Indexing period	Area A Buffalo grass	Area B Farmland Soil Bank	Area C Soil Bank	Total and average for the area
June 16, 1960				
Number flushed	13	6	7	26
Population est.	169	78	53	300
Density estimate	.26	.12	.15	.18
June 30:				
Number flushed	4	10	9	23
Population est.	52	130	58	240
Density estimate	.08	.27	.18	.14
July 19:				
Number flushed	7	3	12	20
Population est.	91	59	78	228
Density estimate	.14	.06	.24	.14
July 27:				
Number flushed	16	4	2	22
Population est.	208	52	13	273
Density estimate	.32	.08	.04	.14
August 13:				
Number flushed	10	6	4	20
Population est.	130	78	26	234
Density estimate	.20	.12	.08	.13
August 29:				
Number flushed	10	5	4	19
Population est.	130	65	26	221
Density estimate	.20	.10	.08	.13
November 23:				
Number flushed	3	5	3	11
Population est.	39	65	20	126
Density estimate	.05	.01	.06	.08
June 16, 1961				
Number flushed	4	13	5	22
Population est.	52	169	38	259
Density estimate	.08	.26	.12	.18
July 10:				
Number flushed	5	14	3	22
Population est.	65	182	22	269
Density estimate	.11	.28	.07	.15
July 27:				
Number flushed	3	10	4	17
Population est.	39	130	28	199
Density estimate	.08	.20	.09	.12
August 9:				
Number flushed	7	7	3	17
Population est.	91	91	20	207
Density estimate	.14	.14	.06	.11
August 26:				
Number flushed	8	6	4	18
Population est.	104	78	30	212
Density estimate	.16	.12	.09	.13

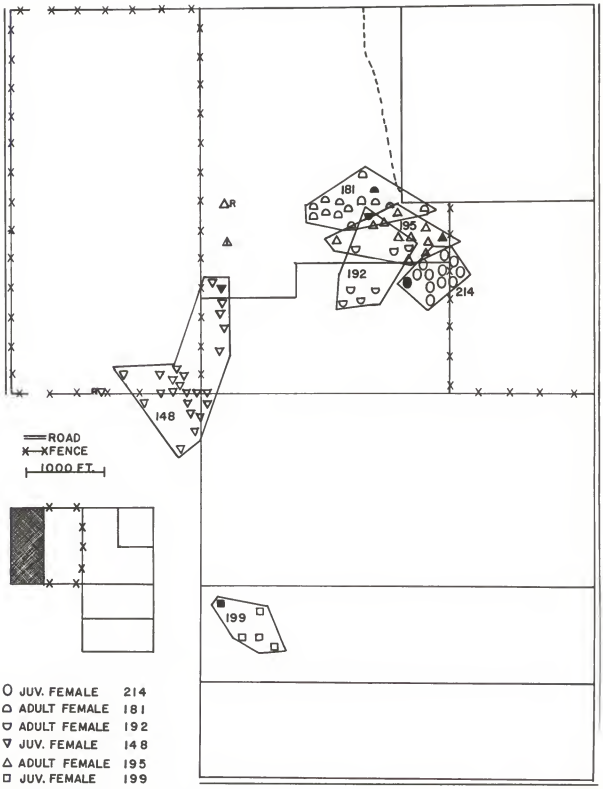


Fig. 4. Known movements of six tagged jack rabbits. Solid symbol indicates site of capture and release. Letter R indicates release area and arabic number 1 first observation when hares were not released at capture site. Black inset is that part of the study area map not drawn on the summer movement range map.

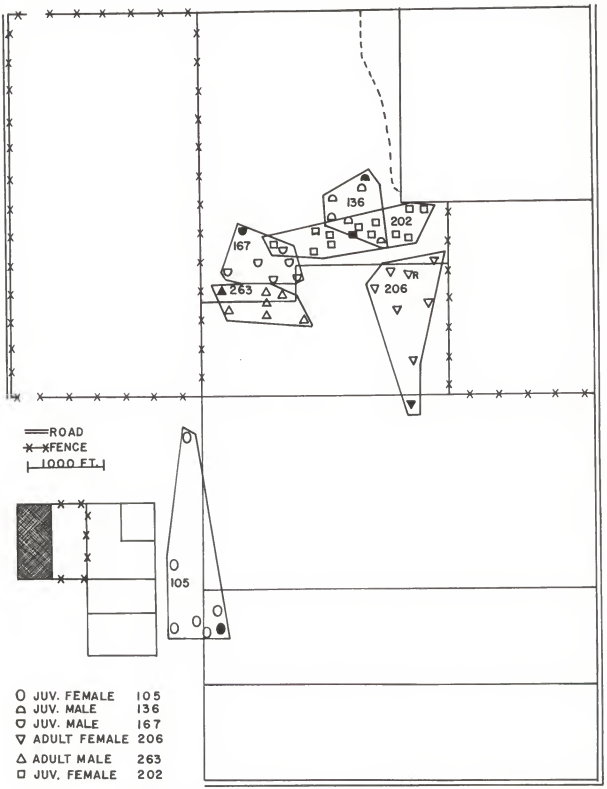


Fig. 5. Known movements of six tagged jack rabbits. Solid symbol indicates site of capture and release. Letter R indicates release area when hares were not released at capture site.

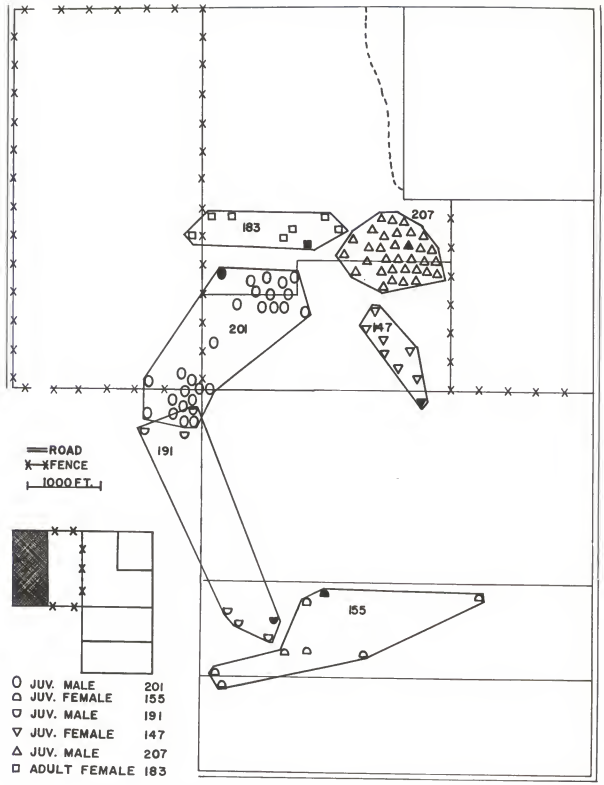


Fig. 6. Known movements of six tagged jack rabbits. Solid symbol indicates site of original capture and release.

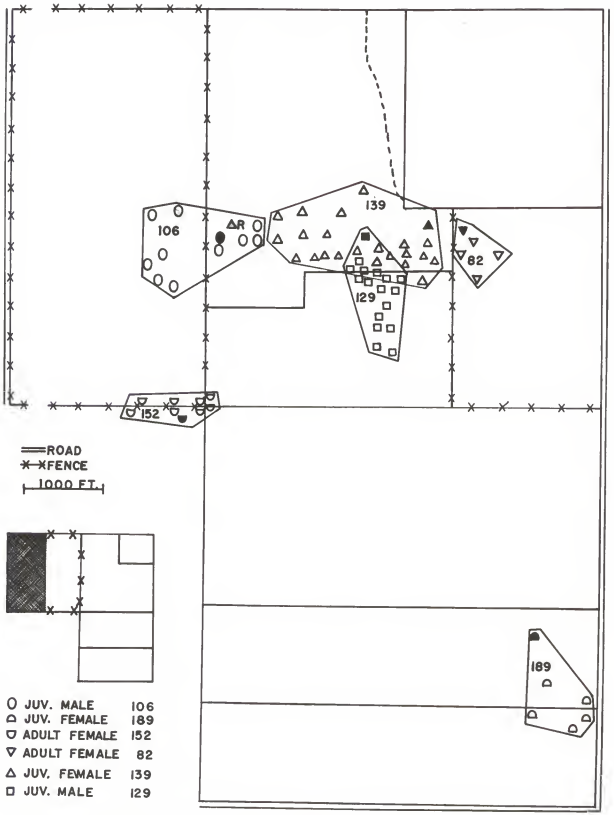


Fig. 7. Known movements of six tagged jack rabbits. Solid symbol indicates site of original capture and release. Letter R indicates release area when hares were not released at capture site.

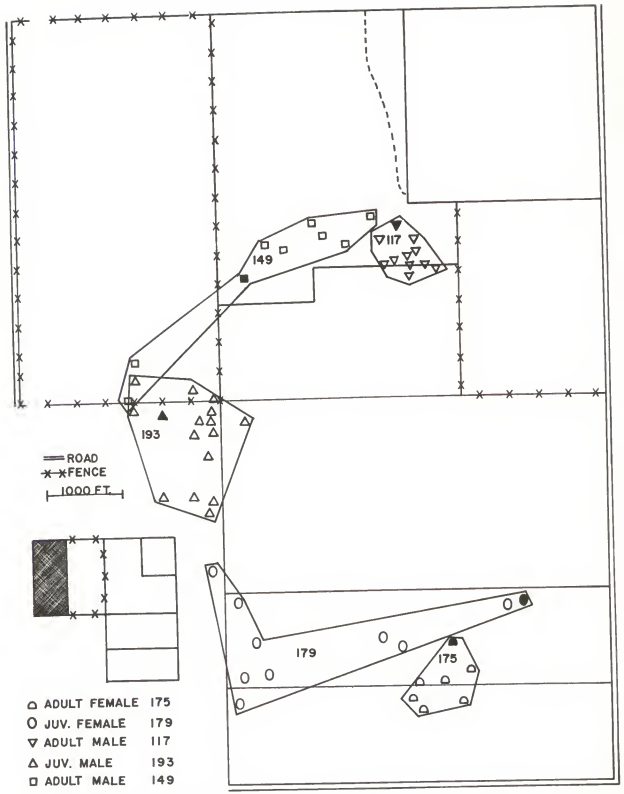


Fig. 8. Known movements of five jack rabbits. Solid symbol indicates site of original capture and release.

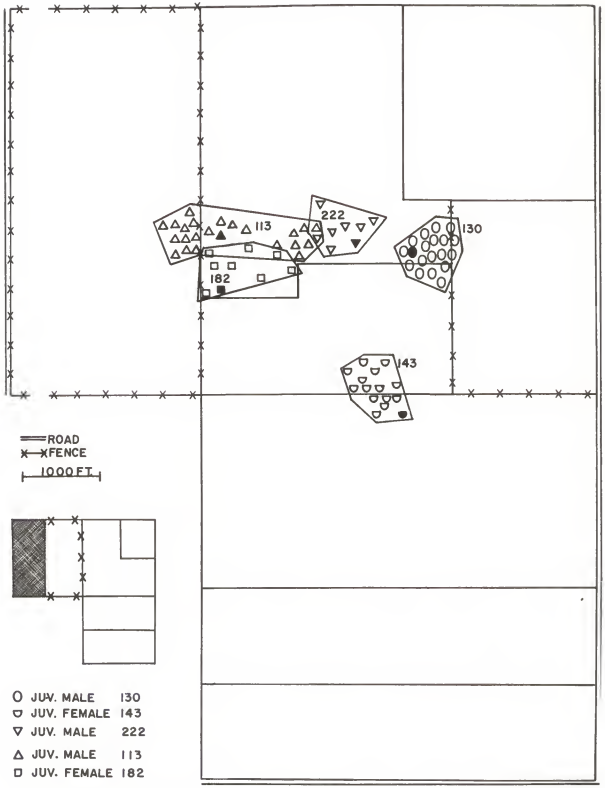


Fig. 9. Known movements of five jack rabbits. Solid symbol indicates site of original capture and release.

The weight of the lens ranged from 26 milligrams of a one-day old hare to 300 milligrams of an animal 650 days old (Table 10). The slope of the curve indicated that there was an extremely rapid growth from birth until 120 days of age. As the age of the hares increased to 240 days of age the weight of the lens increased only 50 milligrams. Between 240 and 480 days of age the weight of the lens increased approximately 75 milligrams and from 480 days to 650 days the lens only increased 25 milligrams.

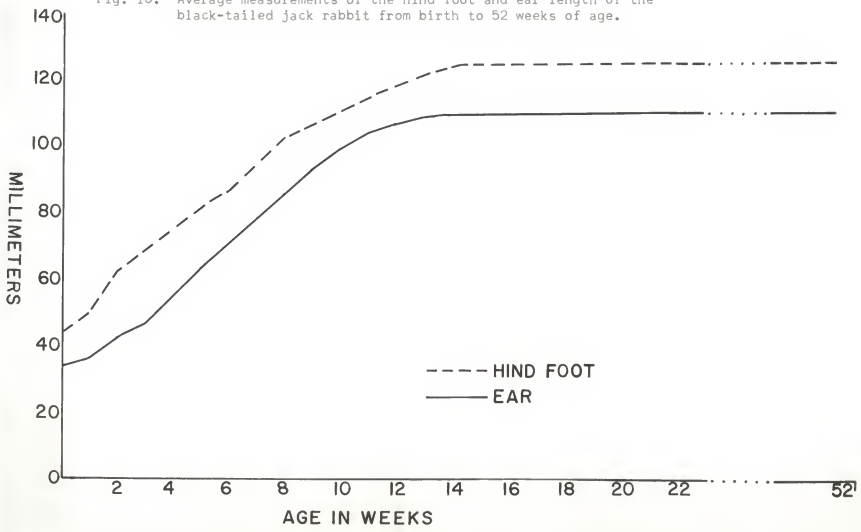
Nine-hundred and six lenses were collected from jack rabbits during the monthly kill samples. The dry weights of the lenses were compared to the known age graph (Fig. 11), to determine the age of the animals. The oldest animal collected in the kill sample was estimated at 43 months with a lens weight of 386 milligrams.

The weights of the lenses were correlated with the three age classes to determine the actual age limit of each age class (Fig. 12). A sudden break in age at which one class became another class was not expected, therefore, the data were tested statistically to determine the probability of overlap in the weight of the lenses between the age classes.

Mann and Whitney (1947) devised a statistical test to determine whether one of two random samples was larger than the other. The formula as adapted to this study was $P = U/N_I N_{II}$, where U represents the number of times N_{II} is greater than an N_I.

The age distribution of the weight of the lenses in each age class is shown in (Fig. 12). From Age Class I to Age Class II the months of September through November experienced lenses weight overlap. For 1959 the only overlap was in October, and the probability of Age Class II lenses weighing more than Age Class I was less than one per cent ($P = .0098$). For 1960 the overlap resulted in September, with a probability of five per cent ($P = .05$).

Fig. 10. Average measurements of the hind foot and ear length of the black-tailed jack rabbit from birth to 52 weeks of age.



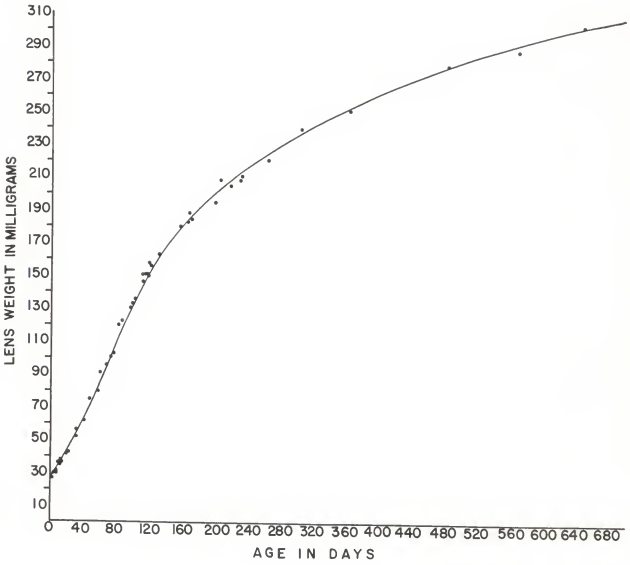


Fig. 11. The dry-weight, growth-rate curve of the lens of the eye, based on 47 jack rabbits of known age.

Table 10. The dry weight of the lenses and measurements of the hind foot and ear of known-age jack rabbits.

Age in days	Lens weight milligrams	Ear length millimeters	Hind foot millimeters
1	26	30	48
5	30	33	55
7	31	33	50
7	30	33	50
10	36	34	54
11	36	35	55
12	35	45	58
12	37	42	60
20	42	45	65
22	42	46	62
33	52	55	68
33	56	60	75
46	62	85	100
49	76	70	93
57	80	100	110
60	91	85	102
70	96	102	109
77	102	101	118
78	103	100	115
81	120	100	115
84	122	96	112
98	131	110	125
100	133	105	120
102	135	112	116
112	146	114	125
116	151	98	120
118	151	115	122
119	151	103	130
119	150	107	120
120	158	105	125
121	156	106	115
133	163	115	133
157	180	115	131
166	183	110	124
168	189	115	132
173	182	112	125
202	193	115	125
206	210	105	126
224	205	112	124
235	210	114	126
236	207	110	124
267	220	105	118
308	240	112	128
367	250	110	123
485	277	110	124
570	285	113	128
650	300	115	132

For 1961, overlap was noted in October and November with a probability of eight per cent and one per cent respectfully (P = October .083, November = .013). Age Class I individuals became Age Class II at about five months when the weight of the lens was 180 milligrams (Fig. 12).

The probability of overlap between the weight of the lenses of Age Class II and Age Class III in 1959 occurred in June .019, July .054, August .050, October .020. For 1960 the months of May .020 and June .022 experienced overlap between Age Class II and III. For 1961 the average probability was about .02 per cent overlap (P = February .037, March .019, May .024). The average probability that Age Class III lenses weigh more than Age Class II lenses was about .03 per cent.

The age at which Age Class II changed to Age Class III was determined to be about 14 months, with the lenses weighing 260 milligrams (Fig. 12).

Age Distribution

The age distribution of collected specimens was biased because animals too young to be foraging for food were not shot. The lens weight of the smallest animal collected was 60 milligrams indicating that young hares were seldom collected by shooting until they reached three or four weeks of age.

Young-of-the-year (Age Class I) were usually collected the first time in June during a new breeding season. In 1960 a young hare was collected as early as February. The lens weighed 165 milligrams indicating the hare was about five months old (Fig. 11), therefore, dating birth to the end of the 1959 breeding season.

Age Class I individuals gradually increased in numbers until a high of 65 per cent was obtained in August and September. From October or November a gradual decrease resulted and generally by December Age Class I individuals were no longer collected.

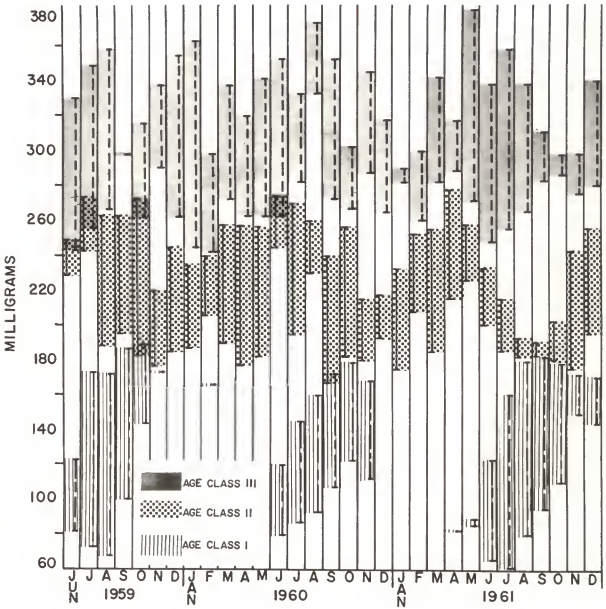


Fig. 12. Lenses weight distribution according to the degree of epiphyseal closure of the humerus bones. Sample from 906 jack rabbits taken during monthly collections.

Hares classified as Age Class II were collected in all of the monthly collections during the five and one-half year study, with exception of July, 1957. The average monthly collections of Age Class II varied from 12 per cent in June to a high of 57 per cent of the population in November. Two months later 80 per cent of the population collected was Age Class III and the remaining 20 per cent Age Class II. Age Class III animals were collected in every monthly collection and ranged from 14 per cent in September to 60 per cent in January. A gradual decrease was noted in July and August when the offspring from the new breeding season began to appear in the monthly kill samples (Fig. 13).

The data indicate that few Age Class III individuals survive the winter months (Fig. 13). The greatest percentage of Age Class III found in January and February were from Age Class II the previous year.

Predation

During the present study only limited observations on predation were made. Man, with automobile, spotlight and guns was probably the greatest cause of mortality in jack rabbits. Hunters were paid 20 cents per animal by a local buyer during the winter months. One farmer estimated 1,800 jack rabbits were shot on the study area during the winter of 1959. Landowners made several attempts to poison jack rabbits on the eastern end of the study area.

Coyotes (Canis latrans) were seen on the study area occasionally and were heard almost nightly while making observations of tagged animals. The stomach contents of two coyotes were analyzed and both contained jack rabbits. To what extent the fluctuations of jack rabbit population varied with the increase or decrease of coyotes was not known because coyote population estimates were not made.

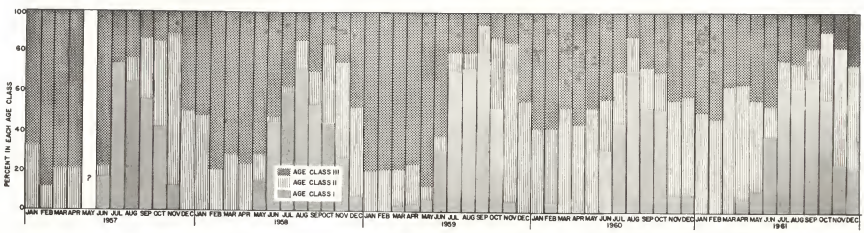


Fig. 13. Age classes in the kill sample, expressed as a per cent of the monthly kill for five years. Data for May, 1957 are missing.

During the summers of 1960 and 1961, nine badger (Taxidea taxis) stomachs were examined. Five of the nine contained rabbit remains, and all contained mice or rats. On three different occasions, traps on the study area were turned over and jack rabbit remains scattered about the area. Badgers were suspected in all of the cases because of the fresh diggings and claw marks in the soil. One morning when the traps were checked earlier than usual, a badger was observed feeding on a dead jack rabbit which was presumably taken from the trap.

Seton (1929) and Vorhies and Taylor (1933), suggested that rattlesnakes can be important enemies of jack rabbits. During the summers of 1960 and 1961, 30 rattlesnake (Crotalus viridis) stomachs were examined but no evidence of jack rabbit remains was found.

Habits

Jack rabbits moved into areas where young and succulent vegetation was available shortly before sunset to feed and remained there through the night. At dawn they quit feeding and moved back into denser and taller vegetation. Throughout the summer months the greatest amount of feeding took place on fields adjoining the study area. The areas were generally summer fallowed and disced frequently which kept the vegetation size at a minimum. During the winter months, hares were observed most frequently feeding on wheat fields. No apparent crop damage was noted during this study.

Jack rabbits spend the mid-day hours resting in their forms with a minimum amount of activity. A form is a depression dug by the jack rabbit at the base of some vegetation offering some protection from the weather and a place to rest (Vorhies and Taylor, 1933). The form varied in size from approximately one-half to three inches deep by six to 18 inches long, and

three to eight inches wide (West et al., 1961). Jack rabbits sat in their forms facing outward from the vegetation, presumably in readiness to escape should the need arise.

The habit of dusting by jack rabbits was observed commonly. Hares dug shallow depressions in the loose sand and rolled over and over in them. When the dusting process was finished the hares would squat on their hind legs and lick their front paws. With continuous licking, they would brush the side of their head.

The mating act as described by Vorhies and Taylor (1933), was not observed. During the early part of the breeding season hares were generally observed in pairs. When both were shot, it was found that they were male and female.

Another phenomenon in jack rabbits was the reingestion of soft pellets. Southern (1940) showed that reingestion was a normal part of the biology of wild rabbits. Lechleitner (1957) reported reingestion in American lagomorphs. Observations on reingestion were made on caged animals. While in a squatting position young hares would bend their head down between the hind legs and take feces. Taking soft feces was never continuous, but frequently interrupted by pauses during which the hares assumed their normal position.

DISCUSSION

A continuous five and one-half year study was initiated in 1956 and continued through 1961. Certain factors which effect jack rabbit populations became apparent during the course of the 66-month investigation in southwestern Kansas.

Bronson (1959) studied county agent records and interviewed local residents about past population fluctuation. From the evidence available in

publications, it was found that these animals are not cyclic in Kansas, but rather increase markedly only during dry periods. In 1956 when the study began the jack rabbit population was higher than at any other time during the study. In 1956 jack rabbits concentrated along the sand hill area south of Lakin but with a three-fold increase in annual precipitation in 1957 over that received in 1956, the jack rabbits were not present in the sand hill area.

The census data indicated a steady decrease in jack rabbit numbers on the study area. Vorhies and Taylor (1933) stated that seasonal fluctuations were a result of migrations due to changing food supply. The tagging studies revealed that hares tended to remain in fairly stable movement ranges until late summer. In early fall they migrated to areas where young and succulent vegetation was available.

Rowan and Keith (1959) stated that changes in weight, other than those brought about by the initial growth of the animal or during pregnancy, are generally thought to represent vacillations in body fat.

The reproductive data collected on the black-tailed jack rabbit was different in many respects from that of similar studies in Arizona and California. Vorhies and Taylor (1933) reported that jack rabbits bred in all but two months of the year in Arizona and estimated seasonal production at eight young per female. Lechleitner (1959) found pregnant females in all months and calculated a seasonal production of 9.8 young in California as compared to 12.3 in this study.

The prenatal loss was calculated by adding the percentage affected by resorption to the percentage of ova loss before implantation. The total prenatal loss including the loss in resorption was 14.5 per cent (5.1% + 9.4%) of the original ova shed.

Litter loss was also calculated by taking the difference between the early cases of pregnancy and the pregnancies half-term or older. The difference would represent the loss of litters after implantation because a one to one ratio was expected. There were 219 early stages of pregnancy and 185 pregnancies half-term or older or a ratio of 100 to 89. The difference would represent 11 per cent litter loss, 3.5 per cent less than the actual calculated figure of 14.5 per cent.

Lechleitner (1959) described unruptured, luteinized follicles (accessory corpora lutea or corpora lutea atretica) in jack rabbits. The same phenomenon has been described for porcupine, deer, Norway rat, and domestic rabbit. Several cases of suspected corpora lutea atretica were found in this study, and were disregarded in figuring jack rabbit reproduction.

Four cases of ova migration from one ovary to the opposite ostium was found in this study. Brambell (1944) reported that cross over of ova may occur because the uterus is of the duplex type. Therefore, transmigration of ova must take place by transperitoneal migration from one ovary to the opposite ostium. Brambell (1944) reported that such cases affected two per cent of the litters in the European rabbit (Oryctolagus cuniculus). Lechleitner (1959) found only one case of ova migration in California jack rabbits.

A striking phenomenon of jack rabbit reproduction was the monthly fluctuation in the number of embryos per litter. The number fluctuated from 1.0 per litter in January to a high of 4.2 usually in May. Thereafter, the number gradually decreased each month until reproduction ended. Lechleitner (1959) stated that this phenomenon was attributed to the age of the female or possible availability of nutrition. Other authors have confirmed this as a common occurrence in mammalian reproduction. This factor

must be considered when calculating the average number of young produced per litter (Lechleitner, 1959).

A significant difference of 602 embryos in the left and 535 in the right uterine horns was found during five and one-half years of this study. This phenomenon is apparently characteristic of mammalian reproduction. Asdell (1946) reported that the percentage of ova shed in the left horn was greater than in the right horn in the domestic rabbit, rat, guinea pig, and domestic pig. Valentincic (1956) reported the left uterine horn of the European hare (Lepus europeus) was gravid more often than the right uterine horn. Mossman (1955) found 2.4 embryos in the right uterine horn of the bush rabbit (Sylvilagus buchmani) compared to 2.9 in the left horn.

By assuming that all litters conceived were successful, Lechleitner (1959) calculated the total number of litters produced by a single female during a breeding season. The following formula was used:

$$Ns = \frac{2L}{G} \times \frac{1-a}{2-a}$$

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

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

G = the length of the gestation period in days

a = the per cent of litters lost as units.

Using the formula and substituting the data from this study, the number of successful litters per female per year was:

$$Ns = \frac{2(240)}{43} \times \frac{1-.11}{2-.11} = 4.7 \text{ litters per year}$$

This figure multiplied by the average number of young per year gives the total possible production of a continuously breeding female during the

eight-month breeding season. For southwestern Kansas this product was 13.1 (4.7 x 2.8) young.

An annual production of 13.1 young per female was too high because the length of time required to produce one litter was not considered. 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. In the 66-month study 72 per cent of the adult females collected were pregnant. By multiplying the 28 per cent not pregnant by the 43-day gestation period, it was found that an average period of 54 (43 + 11) days was required to produce one litter. Dividing the breeding season (240 days) by the time required to produce one litter (54 days) it was estimated that 4.4 litters were produced annually by each adult female. The average annual production would be 4.4 x 2.8 = 12.3 young instead of 13.1.

An examination of the natality data shows that the jack rabbit population should have been increasing. The average number of young per litter increased from 2.5 in the first year of the study to 2.9 in the last year. The average per cent of females pregnant varied from 54 per cent in 1957 to 74 per cent in 1961, with an average of 72 per cent for the five breeding seasons.

On the assumption that the population being sampled was stable, Petrides (1949) gave a formula for computing the life span of an animal.

The average life span of an animal can be calculated by the formula:

$$L = \frac{1}{J}$$

where L = the average life span of those jack rabbits which will survive until they reach the end of the first year, and

J = the per cent of young (under 14 months) in the population.

The annual averages of monthly percentages were 55 per cent young and 45 per cent adults. Therefore, the average life span would be:

$$L = \frac{1}{55} = 1.8 \text{ years}$$

The same formula was used to determine the life span of jack rabbits from year to year (Table 11). The life span was 2.0 years in 1957, and decreased steadily to 1.5 years in 1961.

The lens age determination technique was also used to determine the life span of jack rabbits. It was found that less than one per cent (9 of 906) of the hares collected were older than 3.0 years (Table 12). The data also indicate that 91 per cent (814 of 906) of the kill sample were under two years old, and 78 per cent (706 of 906) were under 1.5 years of age. The fact that 91 per cent of the population in the kill samples was less than two years old would indicate that the calculated life span was nearly correct.

The juvenile mortality was computed (Petrides, 1949) by comparing the adult female to juvenile ratios after reproduction had ceased. Reproduction did not end until September, therefore, the adult female to juvenile ratios for October through December were used to compute juvenile mortality. It has been shown that each female produced about 12 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 13). These estimates of juvenile mortality from reproductive and age ratio data assume that no appreciable adult mortality occurs between the time the young become independent and the time the age ratio was calculated.

Juvenile mortality was high during the months of October through December. The fall ratios should, therefore, be a reliable index to the number of young-of-the-year that lived from the time they were born to the beginning of the critical winter period. The fall age ratio for the entire study was 101 female adults to 453 juveniles or approximately a ratio of one

Table 11. The calculated life span in years of jack rabbits for each year of the study and the average life span for the entire study.

Year	Per cent young under 14 months	Per cent adults	Life span in years
1957	48	52	2.0
1958	49	51	2.0
1959	54	46	1.8
1960	57	43	1.7
1961	66	34	1.5
Average	55	45	1.8

adult to 4.5 juveniles. If the population had not been subject to mortality, there would have been a ratio of one adult to 12 juveniles during the fall months. There was a juvenile mortality during the breeding season of 62 per cent for the entire study period (Table 13). A juvenile mortality of 86% in 1960 produced a ratio of one adult female to 1.8 juvenile.

Taylor (1960) stated that juvenile mortality may be influenced by precipitation. There was little difference in the amount of annual precipitation received in 1960 and 1961 (Table 14) and small amounts of precipitation were received during the winter months of both years.

Observations indicated that tagged hares remained for long periods in the vicinity of the traps but the hares were not readily recaptured. Seven per cent (7 of 97) of the total number originally caught were recaptured. Statistically there was no sex or age difference in capture rate during the present study. Taylor (1960) reported that males had a greater tendency to roam about than females and were more subject to capture.

Only that range which was utilized during the summer months was calculated during the course of this study and not the total home range. The

Table 12. Estimated age, distribution of the weights of the lenses in each age class, and the cumulative per cent of each age group within the age class of 906 jack rabbits taken during monthly collections.

Age Class	Age in months	Number collected	Cumulative per cent	Lens weight distribution
	1 to 2	9	1	60 to 89
I	2 to 3	86	10	81 to 120
	3 to 4	95	20	121 to 150
	4 to 6	94	30	151 to 175
Sub total		316	32	
	6 to 8	151	48	176 to 210
II	8 to 10	72	56	211 to 230
	10 to 12	75	64	231 to 250
	12 to 15	63	71	251 to 265
Sub total		361	40	
	15 to 19	61	78	266 to 280
	19 to 23	108	91	281 to 305
	23 to 27	41	95	306 to 320
III	27 to 31	31	98	321 to 340
	31 to 35	11	99	341 to 350
	35 to 39	7	99.7	351 to 370
	39 to 43	2	99.9	371 to 390
Sub total		261	28	
Total		906	100	

summer movement range study indicated that jack rabbits tended to stay in fairly well defined areas of about 31 acres. The study was conducted during the summer months when normal amounts of precipitation was received and food supply was abundant. A statistical analysis indicated sex and age of hares were not factors which influenced the movement range size.

The data collected on hare movements does not conform with the findings of other authors. Fitch (1958) stated that, in general, young animals range less widely than adults of the same species. Lechleitner (1959) found the home range of L. c. californicus was less than 50 acres in California, and that males had a larger range than the females. Taylor (1960) calculated a

Table 13. The calculated percentage of juvenile mortality at the end of each year and the total loss for the five and one-half year study. Age ratios were calculated from collections made in October, November and December.

Year	Adult females	Young	Total young expected	Loss[2]	Per cent loss[3]	Female to young ratio
1956	29	116	377	261	69	1:4.7
1957	18	98	234	136	57	1:5.4
1958	16	92	208	116	55	1:5.7
1959	13	65	169	104	61	1:5.0
1960	19	34	247	213	86	1:1.8
1961	6	48	78	30	38	1:8.0
TOTAL	101	435	1,313	860	62	1:4.5

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

mean summer movement range of 49 acres for 23 individuals. Bider (1961) calculated a mean home range of 25 acres for adult male snowshoe rabbits and 19 acres for adult females.

Observations on the degree of epiphyseal closure of the long bones has often been used to determine the age of lagomorphs. This technique has certain limitations because young-of-the-year can be aged only until all traces of this closure are gone in members of the earliest born litters. After this time, animals born in the first litters cannot be separated from adults. Bronson (1957) stated that this aging technique was of limited value during the months of November and December because the closure occurred at eight to nine months of age. Lechleitner (1959) reported that the closure resulted at about 10 months in California jack rabbits.

Table 14. Average monthly, annual precipitation and deviations from the mean precipitation of July 1956 to January 1962. Average annual precipitation is 16.42 inches.* Column I = moisture received, II = deviation from mean.

Month	1956		1957		1958		1959		1960		1961	
	I	II	I	II	I	II	I	II	I	II	I	II
Jan.			.05	- .42	.64	.17	.43	- .04	.62	.15	T	- .47
Feb.			.11	- .36	.25	- .22	T	- .47	2.00	1.53	.20	- .27
Mar.	---- No data ---		2.51	1.66	2.33	1.48	.60	- .25	.62	- .23	.71	- .14
Apr.			.75	- .91	1.36	- .30	.94	- .72	1.23	- .43	.93	- .73
May			4.75	2.06	6.55	3.86	2.84	.15	1.09	-1.60	2.25	- .44
June			6.54	3.98	3.31	.73	1.48	-1.10	4.72	2.14	1.76	- .82
July	2.67	- .71	1.08	- .88	6.76	4.80	1.37	- .59	1.68	- .28	3.65	1.69
Aug.	.56	-1.86	.80	-1.62	2.27	- .15	2.11	- .31	.33	-2.09	1.73	- .62
Sept.	0.00	-1.22	1.85	.63	- .63	- .59	1.10	- .12	2.35	1.13	1.54	.32
Oct.	.10	- .95	1.17	.12	.19	- .86	4.15	3.10	.98	- .07	1.40	.35
Nov.	.18	- .46	.70	.06	.58	- .06	T	- .64	.20	- .44	1.48	.48
Dec.	T	- .41	T	- .41	T	- .41	.08	- .33	.48	.07	.12	?
Annual	7.53	-8.89	20.33	+3.91	24.87	+8.45	15.10	-1.32	16.30	- .12	15.77	- .65

*From Climitological Data: Kansas Annual Survey 1956-1961.

The weights of dried lenses have been used as an indicator of age in cottontails (Lord, 1959); raccoons (Procyon lotor), (Sanderson, 1961); gray fox (Urocyon cinereoargenteus), (Lord, 1961); and pronghorn antelope (Antilocapra americana), (Kolenasky and Miller, 1962).

Weighing the lenses to determine the age of jack rabbits was an improvement over determination of age by the body size and weight and the epiphyseal-closure technique. The lens growth curve permitted determination of the month of birth for younger jack rabbits, and the year and month of birth for those animals older than one year.

The lenses of most mammals may grow throughout life (Lord, 1959). It was found that in jack rabbits of known-age the lenses increased in weight as the animals became older. Data indicated that individual variations in lenses were slight and that weights of dry lenses was an excellent indicator of age.

SUMMARY

A literature review revealed many studies on lagomorphs, but only a few comprehensive studies on the black-tailed jack rabbit. This study began in June, 1960, was a continuation of the work of Bronson from July, 1956 through 1957, and that of Taylor from 1958 through May, 1960. The study was continued to correlate the reproductive data from year to year and to collect more information on population fluctuations, movements (summer range), and to develop certain age determination techniques.

A 1,920 acre study area located northwest of Lakin, Kansas was utilized to study summer range movements and population estimates. The area consisted of cropland, grassland and summer fallow area located on typical southwestern Kansas soils.

Data collected during 66 months of observations, including Bronson's and Taylor's work, were analyzed for this study. Monthly collections of 2,627 specimens were made for reproduction and age determination studies. No significant difference was found in the sex ratio of 1,340 males and 1,287 females. There also was no significant difference in the prenatal sex ratio of 127 males and 135 females.

Sexual dimorphism was noted in the total length and weight of adults. Statistically, females were heavier and larger than males in all months except October and November.

An annual breeding cycle was evident from the data on reproduction. Some testes were scrotal in late December through August. Sperm counts taken from epididymides and testes smears fluctuated seasonally. An average of 96 per cent epididymal sperm counts of three or four were found from January or February through August. Few juvenile males were considered capable of breeding during the breeding season in which they were born if the smears revealed the presence of sperm.

The breeding season extended from January through August, or 240 days. The average percentage of adult females pregnant increased from 53 per cent in 1956 to 74 per cent in 1961. The mean number of young per litter fluctuated from 1.0 in January to 3.5 to 4.2 in May, and dropped to 1.6 to 2.0 in August. A mean of 2.8 young per litter was noted in 404 litters consisting of 1,135 embryos. The number of embryos in litters less than one-half term averaged 2.9. The number of young per litter increased from 2.5 in 1956 to 2.9 in 1961.

The total prenatal loss was 14.4 per cent of the original ova shed 9.3 per cent before implantation and 5.1 per cent by resorption. A continuously breeding female could produce 4.4 litters or 12.3 young per year.

A significant difference was noted between the number of embryos in the left and right uterine horn.

Sixty of the 97 captured hares were tagged and released. Thirty were juveniles and 30 were adults, and of these 28 were males and 32 females.

Thirty-four hares were seen more than five times, and were used to calculate the movement range. The 34 tagged hares were observed 384 times or a mean of 11.3 observations per animal. The most frequent observations of 32 were made on a juvenile male. Average summer range of 34 individuals indicated that they stayed within rather well defined areas of about 31 acres.

Statistically, sex and age were not factors influencing the size of the summer range. Jack rabbits do return to their original summer range because three jack rabbits released approximately one mile from their capture site returned to the same area.

Forty-seven hares of known age were raised in the laboratory. The growth rate curve was established from animals raised from one to 650 days of age. Heavier lenses were found as the hares became older. There was no statistical difference in weight between the right and left lenses.

The lens age determination technique supplied data to determine the age at which jack rabbits reach maturity. It was determined that jack rabbits became Age Class II at about five months and Age Class III at about 14 months of age.

There was apparently no sexual dimorphism in hind foot and ear length. The hind foot of adult animals taken during the monthly collections averaged 128 millimeters and the ear 111 millimeters. The hind foot of the laboratory-reared animals averaged 127 millimeters in length and the ear 112 millimeters. The comparison suggests no abnormal development caused by

confinement. Measurements of jack rabbits raised in captivity indicated the hind foot achieved mature length when the animals were 14 weeks old and the ear when they were 12 weeks old. The calculated life span of jack rabbits was approximately 1.8 years.

The modified King Grid census method based on 23 estimates showed the average population densities varied from 0.1 to 0.5 jack rabbits per acre and that the population of jack rabbits decreased during the years of 1958 to 1961. Flushing distance varied from three to 300 feet and averaged 50 feet.

Jack rabbits moved into areas where young succulent vegetation was available shortly before sunset, ate and remained there through the night. Activity was minimal during daylight hours and most of the time was spent resting in forms.

Dusting areas were utilized by jack rabbits. Jack rabbits in cages were observed reingesting soft pellets.

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APPENDIX

EXPLANATION OF PLATE I

Fig. 1. View looking across Soil Bank Field Area A. Late summer of 1959.

Fig. 2. The same area in 1961 consisting of various grasses and weeds.

Plate I

Fig. 1

Fig. 2

EXPLANATION OF PLATE II

Fig. 1. One of fifteen traps used to capture live jack rabbits for the tag release study.

Fig. 2. Side view of trap, illustrating the closed doors and door catch to hold the doors down after the jack rabbit was captured.

Plate II

Fig. 1

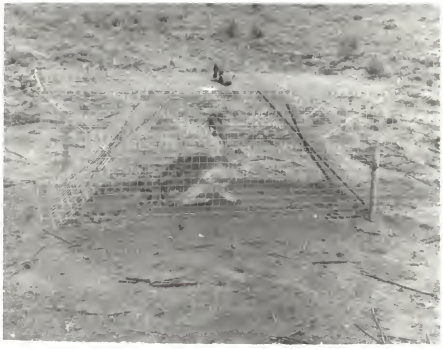

Fig. 2

EXPLANATION OF PLATE III

Fig. 1. The tag as it looked before it was sewed to the jack rabbits ear.

Fig. 2. The tag when folded around the ear, and method of application.

Plate III

Fig. 1

Fig. 2

EXPLANATION OF PLATE IV

Fig. 1. Spotlight and the telescope as it was used in the field for nocturnal observations.

Fig. 2. Humeri bones from jack rabbits, illustrating the degree of closure of the epiphyseal cartilage for the three age classes. In humerus of a young jack rabbit (left), epiphysis open and external cartilage groove wide and distinct. In humerus of nearly mature jack rabbit (center), epiphysis is smaller, although still open and cartilage groove is becoming distinct. Humerus of adult (right) has a closed epiphysis, and no cartilage groove present.

Plate IV

Fig. 1

Fig. 2

ECOLOGICAL INVESTIGATIONS OF THE BLACK-TAILED JACK RABBIT (*Lepus californicus melanotis*, Mearns) IN SOUTHWESTERN KANSAS, INCLUDING DATA FROM 1956 THROUGH 1961.

by

MARVIN LEO PLENERT

B. S., Kansas State University, 1960

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A study began in June, 1960 on the black-tailed jack rabbit in southwestern Kansas. Data collected by Frank H. Bronson and Dale L. Taylor from July, 1956 through May, 1960 were included in the results. Two days during each of the months of September through May were spent in Kearny County collecting data. One-hundred seventy-six days were spent at the study area during the summers of 1960 and 1961.

Five complete reproductive cycles were reported. A 240-day breeding season was computed. Average annual percentages in the number of females pregnant increased from 53 per cent in 1956 to 74 per cent in 1961. Number of young per litter varied from 1.0 in January to 3.5 to 4.2 in May, and then dropped to 1.6 to 2.0 in August. The average number per litter was 2.8 and the average number of litters per year was 4.4 or an average production per female per year of 12.3 young. Litters less than half term contained 2.7 young and litters older than half term contained 2.9 young. Number of young per litter increased from 2.5 in 1956 to 2.9 in 1961.

No significant difference was found in the sex ratio of 1,340 males and 1,287 females. There was also no difference in prenatal sex ratio. The prenatal loss was 14.4 per cent (5.1 per cent of embryos resorbed and 9.3 per cent of ova lost) of the potential production of young. A significant difference of 602 embryos was found in the left uterine horn and 535 in the right uterine horn. Smears made from the epididymis and testes indicated sperm were present in nearly all adult males collected from January or February through August.

Fifteen traps were used to capture live jack rabbits. A monel metal tag was fastened in one ear and a plastic tag with scotchlite reflective tape numbers and letters was sewed to the other ear. Ninety-seven hares were captured and 60 were tagged and released. The sex and age ratios of

captured animals approached 50:50. Nocturnal movements were observed with a 20-30 power interchangeable telescope and a 12-volt spotlight. The 384 observations were made on 34 animals or a mean of 11.3 per tagged animal. Data on hares observed five or more times were used to compute the summer movement range. The mean summer range of 34 individuals indicated that they remained within a rather well defined area of about 31 acres.

The epiphyseal closure age determination technique used on the humerus bone served to separate the kill samples into three age classes. The lens weight technique for aging was used as a more accurate method to determine jack rabbit age. Forty-seven hares of known age were raised in the laboratory to establish a growth rate curve. Heavier lenses were found as the jack rabbits became older. The growth curve was established from animals raised from one to 650 days of age. There was no statistical difference in weight between the right and left lenses. The lens age determination technique supplied data to determine the age at which jack rabbits reached maturity. Age Class I was determined to be about five months; Age Class II was from six to 14 months; and Age Class III was over 14 months. Body weight and total length were of little value for aging, but sexual dimorphism was evident.

Measurements of jack rabbits raised in captivity indicated that the size of the hind foot was as long as that of adults at 14 weeks and the ear at 12 weeks. Monthly fluctuations in weight of adults for the 66 month study showed females were statistically heavier than males in all months except November.

Twenty-three population estimates indicated an average of 0.1 to 0.5 jack rabbits per acre. Density estimates indicated the population was decreasing on the study area from 1958 through 1961. Data on age ratios

taken from October through December were used to compute juvenile survival in the winter. The juvenile mortality rates varied from a low of 38 per cent in 1961 to a high of 86 per cent in 1960 an average of 62 per cent for the entire study.

The calculated life span for jack rabbits was 1.8 years. By determining the life span with the dry lens weight technique, it was found that less than one per cent of the animals collected were over 3.0 years old, and 78 per cent were less than 1.5 years old.