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plowed in the past year. One such area, long used by biologists at Ames, lies between the Chicago and Northwestern Railroad and Highway 30 east of Boone. Negotiations for preserving it by agreement with the railroad and the State are in progress. Many other fine areas of this type might well be preserved in the same way, perhaps with an option to buy if the railroad discontinues its line. Cooperation of this kind, between public and private organizations and individuals, can lead to the preservation of many more valuable natural areas in Iowa.

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Notes on the Biology of the Jackrabbit in Iowa

PAUL D. KLINE¹

Abstract. White-tailed jackrabbits, *Lepus townsendii campanius* Hollister, are found throughout Iowa with the exception of a few southeastern counties. Over much of their range they are relatively rare. They appear in greatest abundance on the recently glaciated soils in northern and central counties, and on the Missouri loess soils of the west-central counties. Dry growing seasons seem conducive to hare abundance; populations decline during wet seasons. Jackrabbits provide considerable hunting sport during winter. Their pelts are utilized in felt manufacture and their flesh as a staple food for ranch mink. They are known to eat sprouting corn and soybeans, and occasionally damage shrubs and trees. High populations of 114 and 90 jacks per square mile are recorded here. High populations of near 30 jacks per square mile are more common. Average populations over the more favorable portions of their range seem to fall between 5 and 15 per square mile. Average winter weights of 7.5 and 7.9 pounds for males and females respectively are recorded. These contrast with spring weights of 6.8 and 8.3. Sex ratios are essen-

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tially even. Breeding activity begins late in February in most years but may be delayed by deep snow and cold temperatures in March. Two and possibly three or four litters per year are produced per female. Litters average 3.6 young rabbits each, and range from one to five. Corpora lutea average 5.75 per pregnancy and range from three to eight. A considerable loss of ova is suggested by the data.

The white-tailed jackrabbit, *Lepus townsendii campanius* Hollister, is found over all of Iowa except a few southeastern counties (Polder, 1958). Over much of this range is a relatively scarce mammal. It appears in greatest abundance on the recently glaciated soils of northern and central Iowa, and on the Missouri loess soils of the west central counties.

Habitat. The Iowa jackrabbit is a plains mammal. It generally shuns forested areas, although woody cover is used as shelter during severe winter weather. It seems to prefer wide expanses of interspersed pasture and cropland. Sloughs are used for daytime resting during winter. Evidently, cultivation favors the species as high populations often occur on intensely cultivated areas. Occasional high populations occur on both flat and steeply rolling terrain.

Economic Importance. Jackrabbits provide numerous hours of hunting recreation in Iowa during winter when seasons on most other game species are closed. They are taken by all types of firearms. They are commonly hunted with binoculars and shot with high powered rifles. Their white fur together with their habit of lying in fall-plowed fields during winter make them conspicuous targets for hunters who travel rural roads, especially when snow cover is lacking. Some hunters prefer to "walk them up" by searching out likely looking sloughs, picked corn fields, and pastures. A favorite method of hunting involves circle hunts in which promising sections are surrounded by hunters who drive the jacks toward the center where they are shot. These highly organized hunts are a common week-end form of recreation in many communities of northern and western Iowa.

In areas of relatively good populations, jackrabbits are marketed to furbuyers and mink ranchers. They are sold without skinning or other preparation. Prices seem to vary according to competition among buyers—areas having consistently high populations of jacks usually support more buyers and because of competition prices are higher. Prices in Iowa usually range from \$0.25 to \$0.75 per rabbit.

Pelts from the rabbits are baled and shipped to eastern markets for utilization in felt manufacture (Saugstad, 1939). The flesh is ground and mixed with fish and other animal food and fed to ranch mink (Kline, 1957). Nearly 26,000 jacks were known to have been marketed by Iowans during the 1956-57 and 1957-58

seasons. Probably many more reached market, as definite records were difficult to obtain. Since jackrabbits must have their winter pelage to be marketable, the season at which they are hunted for sport generally ranges from mid-December until the close of the hunting season—February during recent years. Iowa jackrabbits molt twice yearly: first during March and early April, when they acquire their summer pelage of gray or brownish-gray; and again in November and early December when they acquire their white winter fur.

Farmers often regard this species as a pest. Jackrabbits are known to eat young corn and soybeans after they sprout (Basler, 1963; Starr, 1963). However, this form of damage seems confined to early spring. Jackrabbits sometimes nip off small trees and denude them of bark during winter stress. Observations by the writer indicate they feed regularly at alfalfa hay stacks during winter when snow covers the ground. Evidently farmers do not notice this or do not consider it as destructive since they do not complain. Waste corn in the fields after harvest appears to be an important winter food. This is not considered as damage. Everything considered, it appears the value of this species as a game animal far outweighs any harm it may do to agriculture.

METHODS

Weights and sexes of nearly 200 jackrabbits were taken during the winter of 1957-58 through 1959-60. These animals had been shot and put in storage prior to marketing. Specimens from Dickinson, Kossuth, Hancock, Boone, Sac, and Chickasaw counties were utilized. These counties represent most variations of habitat found over the primary jackrabbit range in Iowa. All specimens were sexed by external morphological characteristics and weighed to within 0.1 pound.

Many jacks from which spring weights and life history data have been obtained were retrieved as highway victims. A few were shot. Records for each animal included county, date taken, sex, weight, testes development, pregnancy, lactation, number of embryos, head-rump lengths of embryos, and unusual features. Presence and numbers of uterine scars, ova eruption sites, and corpora lutea were recorded for many. Descended testes were considered evidence of sexual activity in males.

Since the gestation period of white-tailed jackrabbits is unknown it was assumed to be like that of the European hare (*L. europaeus*) and the black-tailed jackrabbit (*L. californicus*) of western United States. These species are similar in practically all respects. The gestation period of the European hare averages 42 days (Reynolds and Stinson, 1959; and Stieve, 1952). Haskell and Reynolds (1947) give the average gestation period of black-

tailed jackrabbits as 43 days. For the present study a gestation of 42 days was assumed for *L. townsendii*.

Embryonic age was based on measurement of near-term fetuses and on the work of Schwartz (1942) who described embryonic development of cottontails (*Sylvilagus floridanus mearnsii*). Full-term fetuses were identified by their pelage development and by their ability to open their eyes after caesarean delivery. Age of the embryos had to be adjusted from the size scale developed by Schwartz to a scale based on the longer gestation period of 42 days and to the larger size of full-term jackrabbit fetuses.

Corpora lutea were identified by ovary section technique. Darkened and striated sections of the uterui were used to identify embryo attachment sites.

Much of the data regarding populations and breeding activity is based on correspondence with Iowa State Conservation Commission employees, many of whom recorded their observations after some encouragement from the writer. Other data are based on observations of the writer who has spent many hours afield in jackrabbit territory.

RESULTS

Populations. Mohr and Mohr (1936) write of one section in Minnesota with a winter population of 69 white-tailed jackrabbits. They indicated normal populations ranged from 10 to 20 hares. In the present study the best information on high populations has originated from records of circle hunts. Conservation Officer Frank Starr reported that during the winter of 1960-61, 99 hares were killed and 15 escaped a group of circle hunters on one section during a single hunt within 1½ miles of Storm Lake. Near Lidderdale in Carroll County on February 13, 1960, Conservation Officer James Ripple reported 90 jacks killed on one section. An undisclosed number escaped.

Records of 32 circle hunts are available from the 1959-60 and 1960-61 seasons. Altogether, 105 sections were hunted and 1,801 jackrabbits were killed, a mean of 17.2 jacks killed per section. Conservation Officer James Baldwin reported that during nine circle hunts conducted in Clay County during the winter of 1959-60, 458 jacks were killed and 307 escaped. On the basis of these data an average of approximately 40 per cent of the hares available on any section can be expected to escape circle hunters. Application of this escape factor to the above 32 circle hunts indicates 3,002 jacks resided on 105 sections, an average of 28.6 hares. Doubtlessly these data represent high populations, as most organized circle hunts are conducted on areas where the rabbit population is known to be high. Most populations will average somewhat lower.

The writer is of the opinion that normal populations over the better portions of the range in Iowa will fall between 5 and 15 jackrabbits per section. On an area in Story County, during 1941, Henry (1942) found an average population of 10 per section. Many large areas of range, particularly in Southern Iowa, have much smaller numbers of hares than this.

Summer roadside surveys of rabbits in Iowa indicate a decline in jackrabbit populations during recent years. Indices of jacks seen per 100 miles of survey have dropped from 4.4 in 1959 to 3.3 in 1960, and to 2.0 and 1.1 for 1961 and 1962, respectively.

Precipitation during the growing season for the past 3 years over northern and western Iowa have averaged well above that of the late 1950's. This may have caused the recent population decline. Mohr and Mohr (op. cit.) were of the opinion Minnesota jacks increased during dry growing seasons and declined during wet ones. Wooster (1935) reported a similar phenomena in Kansas hares. Lechleitner (1959) found heavy mortality in black-tailed jackrabbits during a wet spring.

Sex Ratios. The writer found nothing in the literature pertaining to sex ratios in this species. In the black-tailed species Lechleitner (op. cit.) and Bronson and Tiemeier (1958) reported 100:100 ratios of males and females. Vorhies and Taylor (1933) found a preponderance of females in both the black-tailed and antelope (*L. alleni*) jackrabbits. However, they did not believe the differences were significant. In the present study 201 specimens were sexed, 100 of which were males and 101 females.

Weights. Weights of 104 Minnesota jackrabbits are given by Mohr (1943). He found an average of 7.4 pounds for the lot, but apparently did not differentiate the sexes. His heaviest weight recorded was 9.0 pounds. Bailey (1926) wrote of 12 North Dakota white-tailed jackrabbits which averaged 8.0 pounds. He gave a maximum weight of 12 pounds. Differences in average weights of the sexes in black-tailed and antelope jacks are reported by Bronson and Tiemeier (op. cit.) and Vorhies and Taylor (op. cit.) These writers found females averaged heavier than males.

A similar sexual dimorphism was found in this study. Weights of 97 males taken during December and January averaged 7.5 ± 0.12 . They ranged from 5.8 to 9.4 pounds. Winter weights of 101 females averaged 7.9 ± 0.15 pounds and ranged from 5.4 to 9.5 pounds. These differences in average weight were highly significant [$t=3.66$, + (.01)=2.60].

Average weight of 13 males taken March through May was 6.8 ± 0.28 with a range of 6.2 to 7.8 pounds. The reduced spring

weights as compared to winter were highly significant [$t=3.06$, $+ (.01)=2.63$]. Just why male white-tailed jackrabbits weighed less in spring than during winter is not apparent. It may be related to greater activity and consequent loss of condition during the breeding season.

Eleven females killed from March through May averaged 8.3 ± 0.63 pounds with a range of 6.2 to 9.7. Obviously the females, in contrast to males, weigh more in spring than in winter. These differences were not significant [$t=1.43$, $+ (0.5)=1.98$]. The fact that most of the females were in some stage of pregnancy may account for the increase in weight during spring. Statistical comparison of males and females in spring indicated their differences in weight were highly significant [$t=4.30$, $+ (.01)=2.82$].

Breeding Season. Very little has been written of the reproductive biology of this species. Bailey (op. cit.) believed only one litter per female was produced each year in the northern part of its range. He cites a female taken May 31, 1910 which contained 5 full-haired fetuses. Observations of breeding activity in Iowa on April 16, 1941, are cited by Henry (op. cit.).

Unusual daytime activity among populations of white-tailed jackrabbits has been noticed numerous times by the writer. Jacks are seen wandering around the fields with their noses to the ground, alternately slowly hopping, then stopping for observation. They seem to be in search of something. At these times they seem relatively tame. Oftentimes they appear in groups, sometimes alternately chasing one another. These activities most frequently are seen during early morning and late afternoon (after 3:00 P.M.) and have been noticed during all months from February through July. Whether or not they occur after dark is not known.

It is very probably this unusual behavior is related to mating activity. A number of jackrabbits participating in such activity have been shot by the writer and almost invariably they are males. They represent males searching for eligible does; or sometimes, one or more males following or escorting one female.

These nuptial chases seem to fall into peaks of activity. During most years the first occurs late in February or early March; another during mid-April; and still another during the last half of May. A few observations have been recorded in early July.

On March 18, 1960, a pair of hares were seen in the act of copulation near mid-day in Greene County. Much other behavior denoting sexual activity was noted on that date.

In the males it appears the tests descend into the scrotal sac in February or late in January in a few instances. This is often difficult to ascertain, as the jacks seem capable of withdrawing

them from the scrotum at will. During April and May all male jacks examined by the writer had descended testes.

Data from 18 pregnant or parous females have been collected from 1958 through 1963. Information regarding first litters of the season was secured from 17 of these (Table I). Calculated dates of mating based on embryo sizes and assumed gestation of 42 days agree with the peaks of nuptial activity mentioned above.

Table 1. Calculated mean dates of mating and of parturition based on embryo sizes from 16 female white-tailed jackrabbits.

Year	Number of females in sample	Mean date of mating	Range	Mean date of parturition
1958	1	Feb. 25	April 8
1959	1	Febr. 23	April 6
1960	3	March 13	March 11-17	April 24
1961	1	March 2	April 13
1962	1	March 16	April 27
1963	9	Febr. 25	Febr. 21-28	April 8

On the basis of the nuptial activity peaks and known birth dates, it appears the white-tailed jackrabbit is capable of mating immediately after parturition as has been reported for most lagomorphs (Lechleitner, *op. cit.*; and Vorhies and Taylor, *op. cit.*). This supposition is strengthened by one female collected on April 26, 1960. She was lactating; had three placental scars and three corpora lutea, indicating she had recently given birth to a litter of three; and had 7 fresh ova eruption sites. Evidently she had bred within a day or two after the first litter was born. Another, collected on May 20, 1961, had corpora lutea within her ovaries representing two pregnancies. She also held a litter of five, almost full-term fetuses; obviously her second of the season.

A litter of five very young hares was recorded April 15, 1957, by Game Biologist Richard Nomsen. These were found by a farmer who reported they scattered when disturbed. This report serves to confirm the parturition of first litters during early April. Young jackrabbits near cottontail size have been observed by myself in Franklin County on May 23 and 24, 1961. Other young jacks of similar size were reported by Game Biologist James Sieh near Spirit Lake on May 20, 1959. These young jackrabbits represent early born litters.

On the basis of the above information there is little doubt that the breeding season for white-tailed jackrabbits extends from February through early July in Iowa, perhaps longer. Also, females very likely produce two, perhaps even three or four litters each per season. The peaks in mating activity alone indicate second, third and perhaps fourth litters.

No evidence of juvenile breeding was found. All pregnant females had complete epiphyseal closures of the humerus, indicating they were adults. Haskell and Reynolds (op. cit.) and Vorhies and Taylor (op. cit.) did not believe females of *L. californicus* produced young during their first season. Bronson and Tiemeier (op. cit.) also working with the black-tailed jackrabbits found only one case of breeding by a juvenile female.

Reynolds and Stinson (op. cit.) have found the European jackrabbit produces three and possibly four litters in Southern Ontario. Black-tailed jackrabbits produce each season an average of 3.8 litters per female (Bronson and Tiemeier, op. cit.) in Kansas and 4.27 per female in California (Lechleitner, op. cit.).

As Table 1 shows, first litters for 1960 and 1962 were delayed somewhat. Both these winters were characterized by deep snow and abnormal cold which extended into mid-March. It has been reported that breeding of cottontails may be delayed in the spring by severe weather (Wight and Conaway, 1961; and Kline, 1961). Probably jackrabbits are influenced similarly.

Litter Sizes. Litter sizes are reported to vary from 3 to 6 (Bailey, op. cit.) in this species. In the black-tailed variety Bronson and Tiemeier (op. cit.) report 2.6 juveniles per litter; Vorhies and Taylor (op. cit.) 2.24; and Lechleitner (op. cit.) 2.3. The antelope jackrabbit as reported by Vorhies and Taylor (op. cit.) produced 1.93 juveniles per litter in Arizona.

In this study litter sizes from 15 specimens produced a mean of 3.6 ± 0.6 and ranged from 1 to 5. Corpora lutea counts from 12 females averaged 5.75 ± 0.94 and varied from 3 to 8.

From 9 females both corpora lutea and number of embryos were recorded. These 9 females produced 53 corpora lutea and only 32 fetuses indicating loss of 39.6 per cent. Ranges in loss, based on these 9 females, varies from 0 to 7 with a mean of 2.3 ± 1.54 . However, one of these females with 8 corpora lutea and only 1 embryo had a large 62 x 64 mm. tumor imbedded within one branch of the uterus. This tumor may have been responsible for the loss of 7 ova.

The pre-implantation loss of ova seems high as compared to other authors working with other species. Lechleitner (op. cit.) found a loss of 13 per cent in *L. californicus*. Bronson and Tiemeier (op. cit.) found a 16 per cent loss in the same species. Brambell (1944) reported a loss of 9 to 10 per cent in European rabbits, *Oryctolagus cuniculi*.

Diseases. Two instances of disease were noted during the study. One adult jackrabbit in the terminal stages of an unknown disease was found alongside a rural road on May 24, 1961, in Franklin County. Tularemia was suspected.

One female rabbit collected March 26, 1963, in Greene County had three widely separated papillomas, each less than $\frac{1}{2}$ -inch in length, on the skin of its ventral surface, posterior to the fore-legs. The female carrying three embryos appeared in good physical condition. It was collected well within the geographic range of papillomas reported by Haugen (1960) in cottontails.

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