Proceedings of the Iowa Academy of Science

Volume 78 | Number 1-2 Article 6

1971

Chronology of Reproduction of the Fox Squirrel in Iowa

Richard J. McCloskey
Iowa State University

Paul A. Vohs Jr.
Oregon State University

Chronology of Reproduction of the Fox Squirrel in Iowa[1]

RICHARD J. McCLOSKEY[2] and PAUL A. VOHS, JR.

RICHARD J. McCLOSKEY & PAUL A. VOHS, JR. Chronology of Reproduction of the Fox Squirrel in Iowa. *Proc. Iowa Acad. Sci.*, 78(1):12-15, 1971.

SYNOPSIS. This study was undertaken to increase the information available concerning the chronology of production in the fox squirrel (*Sciurus niger rufiventer* Geoffroy) and the contribution of spring and fall litters to the fall population. Previous reports indicated that two major periods of reproductive activity occurred annually. Our information indicates that only one major period of reproductive activity per year occurred in Iowa during 1966 and 1967. The onset of reproduction occurred in October when females in a state of oestrus were first handled. Parturition began in late December and early January. Young were born in all months from January through August, and 34 percent of all births occurred in March. Embryo, litter and placental scar counts indicated that the average number of young in litters of fox squirrels on the Iowa study area was 3.35. No significant difference was found between the number of young born per female during the period of spring parturition and the period of fall parturition. Coccidia spores were abundant in seven squirrels found dead between June 3 and July 4, 1966. Coccidiosis and mast shortage may have reduced the squirrel populations and resulted in compensatory breeding on the research area in 1966 and 1967.

INDEX DESCRIPTORS: Fox squirrel; *Sciurus;* reproductive chronology; reproductive activity; coccidiosis.

The purpose of this paper is to present information concerning fecundity and the chronology of reproductive events in a population of fox squirrels in central Iowa during 1966 and 1967. Published reports concerned with the species in Iowa apparently are limited to those of Hicks (1942, 1949) and Kline (1964). These studies were not directly concerned with the chronology of production, and a minimum of information is available.

METHODS

Information concerned with chronology of reproduction was obtained in a three-fold manner: (1) Specimens were trapped and examined for signs of oestrus, lactation and pregnancy or ascended or descended testes where appropriate; (2) Reproductive behavior was noted during time-area counts; and (3) Carcasses were obtained by collecting specimens on the study area and examining animals killed by hunters on adjacent areas.

Live squirrels were classified into juvenile, sub-adult and adult age groupings by development of pelage and shape of the tail (Sharp 1958) and by body weight. The ages of juveniles weighing under 400 grams were estimated by weight using the criteria described by Allen (1943) and Uhlig (1955). Size and development of testes were used as additional criteria in classifying males while coloration and appearance of nipples were used as aids in classifying females.

Data obtained in 1966 and 1967 were examined separately, and no difference between years was detected. The data for the two years were pooled.

RESULTS

The majority of the activity associated with reproduction occurred during November through April with the exception of lactation. Lactation was not observed during the apparent height of the breeding season in November, December, January and February (Fig. 1). The occurrence of the peak of mating chases, mode of estimated dates of conception and dates of birth showed expected spatial separations.

Of 67 adult females examined, 17 were lactating (Fig. 1). Lactating females were not observed during November, December, January and February; and the timing complements the absence of conception during August, September, October and November.

Estimates based upon the weight of 35 juvenile squirrels were utilized to determine the time of parturition. Approximately 61 per cent (22 of 36) of all juveniles were estimated to be born between February 16 and April 15. The remainder (39 per cent) were born between April 15 and August 31.

Young fox squirrels were observed foraging for food in early March, early April, and late July 1966, and in late March 1967. Young squirrels were also noted on trees in early and late March 1966 and 1967, respectively. Small squirrels that were still on trees were estimated at 7 or 8 weeks of age, and those squirrels that were beginning to forage for food were estimated at 3 months of age (Allen 1943). Squirrels still on the trees and those beginning to forage were estimated to have been conceived in mid-October and in mid-November and born in late December and early January.

Each of five pregnant females examined had three embryos showing normal development. One female had four embryos in the process of being absorbed in addition to the three developing normally.

The number of placental scars on the uteri of 47 adults examined averaged 3.4 per female (Table 1). In order to determine if the spring litters average larger than fall litters, individuals lactating during January through April were categorized as having borne spring litters while those lactating when collected during June through August were considered to have borne fall litters. Females lactating when examined during May were not included to decrease the chance of including late spring with early fall litters. The number of placental scars averaged 3.76 on uteri of the females that had borne spring litters and 3.17 on uteri of squirrels that had borne fall litters. The difference in mean number of scars per

[1] This investigation was financed by Iowa Conservation Commission, Biology Section, funds as part of project BG-25A.

[2] Instructor, Department of Zoology and Entomology, Ames.

[3] Present address: Department of Fisheries and Wildlife, Oregon State University, Corvallis.

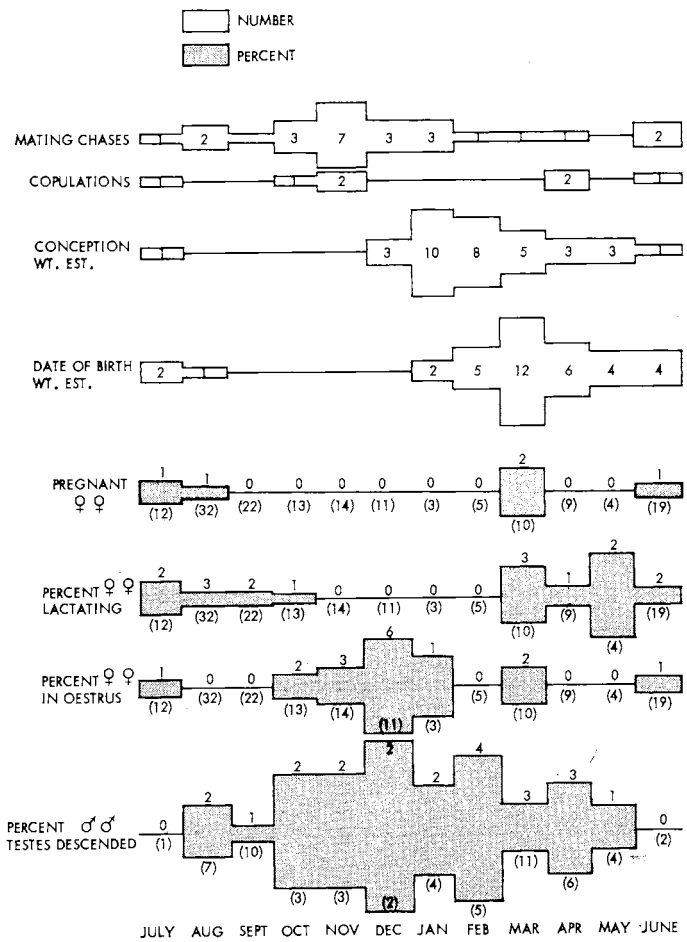

Fig. 1. A summary of reproductive information gathered in Iowa, 1966-1967. Subsample size is given in each column and sample size appears in parentheses.

Table 1. Comparison of average litter size of fox squirrels using different methods, Iowa, 1966-67.

Method	Sample size	Litter size
Scar count	47	3.4
Embryo count	5	3.0
Litter count	1	3.0
Total	53	3.35

Table 2. Comparison of average litter size of fox squirrels in several states.

State	Year	Method*	Sample size	Litter average	Source of data
Iowa	1966-67	LSE	53	3.35	Present study
Kansas	1953-54	LSE	43	2.83	Packard 1956
Texas	1966	SE	109	2.54	Goodrum 1967
Mich.	1937-42	LSE	170	3.02	Allen 1943
Ohio	1937-39	LSE	—	3.19	Baumgartner 1940
Illinois	1941-42	LSE	85	2.51	Brown & Yeager 1945
Missouri	1965-66	E	58	2.47	Christensen 1967
Louisiana	1952-53	LSE	—	2.63	Kidd 1952-53

*Method used in obtaining data:
L—Litter counts
S—Scar counts
E—Embryo and fetus counts

uterus between spring and fall litters was not significant at the 95 per cent level ($t = 1.3436$). The mean number of scars on the uteri of four young-of-the-year animals included in the fall grouping was 2.5 per uterus and was responsible for much of the difference between the means.

Estimates of average production using placental scars from post-partum females, estimates of litter size from field observations, and embryo and fetus counts from pre-partum females have been made for several states (Table 2). The average size of litters of fox squirrels was largest in Iowa closely followed by Ohio and Michigan, while production was lowest in Texas and Illinois. Reported litter sizes tended to be larger in the more northern investigations.

DISCUSSION

Numerous investigators (Seton 1929, D. L. Allen 1943, Brown and Yeager 1945, J. M. Allen 1954, Uhlig 1955, Packard 1956, Kidd 1964, Cornwell and Mosby 1966) have stated that adult fox squirrels are dioestrus. Hoffman and Kirkpatrick (1959) state that mating periods of the gray squirrel (*Sciurus carolinensis*) may vary in relation to latitude, age composition of the female segment of the population, nutrition, climatic conditions and possibly density of the population.

Our information indicated that only one major period of reproductive activity per year occurred in the studied population in Iowa during 1966 and 1967. The number of oestrus females, reproductively active males, mating chases, pregnancies, births and lactating females in most instances occurred in a sequential pattern in Iowa during the current study with the highest occurrence of one type of breeding activity coinciding with, or preceding, the highest occurrence of another type of breeding activity. The single cycle in the reproductive chronology in Iowa was complicated by certain aspects of the breeding cycle which provided minimal indications that two breeding seasons occurred, but in most instances these indications could be explained.

Periods when females were in oestrus separated by periods of anoestrus provided minimal indications that two periods of reproductive activity may have occurred. Brown and Yeager (1945) assumed the period with the highest number of squirrels in a state of oestrus coincided with the period of highest number of matings and stated oestrus periods were most important in determining the periods of highest reproduction. Brown and Yeager further reported the two periods of breeding in Illinois were separated by months when no oestrus females were examined. Two major periods of anoestrus appeared to occur in Iowa and corresponded approximately with reported periods of anoestrus in Illinois. However, it was not known if the periods of anoestrus actually occurred in the Iowa population or were a result of limited data. Observations of mating chases and copulations and estimates of squirrels being conceived indicated that females in oestrus were present during these months but did not occur in the sample examined.

Males in breeding condition were not noted in the sample of squirrels handled during June and July. The apparent lack of reproductively active males might have been interpreted as a separation between mating seasons if it were not for the mating chases and copulations observed and the conceptions estimated to have occurred during the 2 months. The apparent discontinuity in the reproductive condition of the male portion of the squirrel population may have resulted from the size of the available sample.

All other evidence suggested one major period of breeding in Iowa with continuous breeding activity at a much reduced level after this period. Females in oestrus, reproductively active males, mating chases, copulations, pregnancies, births and lactation periods all occurred in an approximately sequential manner, and indications were that the onset of reproduction during 1966 and 1967 occurred in October and November, reached its height in January, February and March and decreased thereafter.

The greatest percentage of lactating females was found during May in data collected from 1966 and 1967. No second period with a large percentage of lactating females occurred.

Shorten (1954) stated there was not any definite season during the year in which all male squirrels were active, or inactive, sexually. Allen (1943) stated some squirrels were born in every month from February through September in Michigan. Brown and Yeager (1945) reported births of squirrels occurred in January in Illinois. Our information indicated squirrels were born in every month from December through August in Iowa.

Fox squirrels in Michigan and Illinois normally do not breed much before they are 10 to 12 months of age (Allen 1943, Brown and Yeager 1945). This situation does not always appear to occur in Iowa. Squirrels born in December, January and February were known to have borne and weaned litters by September. No evidence of parturition was noted in September, October, November or December during the project, and, therefore, it was estimated squirrels born in December, January and February had bred at approximately 8 months of age.

The first opportunity for young squirrels of spring and fall litters to breed following maturation was in the winter breeding season following their birth. Young from both spring and fall litters may have bred initially during the winter breeding season, and this would help explain the presence of squirrels 8 months of age in the breeding population.

The reproductive cycle began earlier in Iowa than in surrounding states. Mating chases, females in a state of oestrus and copulations were known to occur earlier in Iowa than had been previously reported. Allen (1943) reported the earliest birth in Michigan occurred in February. Brown and Yeager (1945) reported parturition began in January in Illinois. Births were known to occur in December and January in Iowa during 1966 and 1967.

Mean size of litters in Iowa during 1966 and 1967 was larger than reported for other states. The higher number of young per female may be indicative of higher average production in Iowa than elsewhere or may be related to another phenomenon occurring in the population.

Errington (1942) reported breeding extended later into the season in a muskrat population that had suffered a high loss of young, and these muskrats produced higher numbers of young than those on another portion of the area that had not suffered severe mortality. Errington termed this response compensatory breeding. Allen (1943) reported that compensatory breeding occurred in fox squirrels on the Swan Creek Research Area in Michigan. Allen found that, in 1941, although no females bore a spring litter of young, all bore young in the summer, and numbers in the population approached normal in the fall. Allen further reported that with no spring yearlings in the breeding population in 1942 a small production of litters was expected, but he found that every female examined, even the summer yearlings 6-8 months old, was pregnant.

Squirrels are reported to produce higher numbers of young per litter under the phenomenon of compensatory breeding or to breed at a younger age than would normally be expected. Evidence of higher numbers of young per female and breeding of subadults at 8 months of age occurred in data gathered in Iowa during 1966 and 1967 and may be related to compensatory breeding on the research area.

Early in the project, squirrels were found dead from coccidia infections. Middleton (1930, 1931) reported coccidiosis was known to cause a widespread decrease in the numbers of red squirrels in Great Britain. Middleton (1932) described coccidiosis as the virulent epidemic disease which caused a reduction in the numbers of gray squirrels in Great Britian in 1923, 1924, and 1930. Bertram (1952) reported gray squirrels were found dead on his research area in Kentucky, and death was attributed to coccidiosis. Shorten (1954) stated coccidiosis was a disease known to be common among rodents. This disease may have been extremely detrimental to squirrel populations examined in 1966 and 1967.

Sick or dying animals usually become secretive in their habits. Dead animals found on the ground may indicate that the population is suffering severe losses. Time-area counts performed in June and July 1966 indicated a decrease in the mean number of observations of squirrels on the area and may, in part, be a result of the squirrels dying. The mean number of observations of squirrels increased in the fall as young squirrels became more prominent in the population.

Brown and Yeager (1945) and Uhlig (1955) reported spring litters of squirrels were larger than fall litters. Counts of scars on uteri separated on the basis of whether they were from squirrels that had borne spring or fall litters in this study showed no significant difference (95 per cent level) in the number of scars. This may indicate that no difference existed between the litters or that females produced lower numbers of young in the spring and higher numbers in the fall than was usual, and again may be related to severe loss and compensation.

Allen (1943) stated that favorable conditions for bearing and rearing young resulted in high squirrel populations with little regard to the number of breeders. However, small breeding stocks proportionately may be expected to produce larger numbers of offspring.

Interpretation of the data on reproduction became confounded by the presence of disease and mast shortage (McCloskey 1968). The information obtained during 1966 and 1967 was too limited by sample size and the other factors mentioned to reflect the average reproductive cycle and chronology of reproduction of the fox squirrel throughout Iowa.

ACKNOWLEDGMENTS

We acknowledge the assistance of Robert Phillips, former game biologist with the Iowa Conservation Commission, who acted as field coordinator of the project. H. L. Harrison and E. D. Klonglan, Iowa Conservation Commission, provided administrative coordination and encouragement.

LITERATURE CITED

ALLEN, D. L. 1943. *Michigan fox squirrel management.* Michigan Dept. Conserv., Game Div. Publ. 100. 404 pp.

ALLEN, J. M. 1954. *Gray and fox squirrel management in Indiana.* Indiana Dept. Conserv. Bull. 1. 112 pp.

BAUMGARTNER, L. L. 1940. The fox squirrel: Its life history and management in Ohio. *Ohio State Univ. Release 138*:1-17.

BETRAM, E. C. 1952. *Kentucky squirrel investigations.* Federal Aid Project 26-R, Frankfort, Kentucky.

BROWN, L. G. & L. E. YEAGER. 1945. Fox squirrels and gray squirrels in Illinois. *Ill. Nat. Hist. Survey 23*(5):449-532.

CHRISTENSEN, D. M. 1967. *An analysis of biological data from squirrels taken by hunters in 1966 and evaluation of harvest and special management practices.* Federal Aid Project 13-R-21, Columbia, Missouri.

CORNWELL, G. W. & H. S. MOSBY. 1966. *The eastern gray squirrel.* Virginia Wildl. Conserv. Notes Circular 109 pp.

ERRINGTON, P. L. 1942. On the analysis of productivity in populations of higher vertebrates. *J. Wildl. Mgmt. 6*:165-181.

GOODRUM, P. D. 1967. Tree squirrel investigations. *Texas Game, Fish and Oyster Comm. Report 2*:50-52.

HICKS, E. A. 1942. Some major factors affecting the use of two inventory methods applicable to the western fox squirrel, *Sciurus niger rufiventer* (Geoffroy). *Iowa State College J. Sci. 16*: 299-305.

_____. 1949. Ecological factors affecting the activity of the western fox squirrel. *Sciurus niger rufiventer* (Geoffroy). *Ecol. Monogr. 19*:287-302.

HOFFMAN, R. A. & C. M. KIRKPATRICK. 1959. Current knowledge of tree squirrel reproductive cycles and development. *Maryland Dept. Res. & Educ. Cont. 162*:363-367.

KIDD, J. B. 1964. Squirrel talk. *La. Conservationist 16,* Nos. 11, 12:10-11.

KLINE, P. D. 1964. Iowa squirrels: hunting statistics, sex and age ratios, and the influence of mast and agriculture. *Proc. Iowa Acad. Sci. 71*:216-227.

MCCLOSKEY, R. J. 1968. *The chronology of reproduction in the fox squirrel in Iowa.* Unpublished M.S. thesis. Iowa State University, Ames. 100 pp.

MIDDLETON, A. D. 1930. The ecology of the American grey squirrel (*Sciurus carolinensis,* Gmelin) in the British Isles. *Proc. Zool. Soc. London* 1930:809-843.

_____. 1931. *The grey squirrel: the introduction and spread of the American grey squirrel in the British Isles, its habits, food, and relations with the native fauna of the country.* Sidgwick and Jackson Co., London, England. 107 pp.

_____. 1932. The grey squirrel (*Sciurus carolinensis*) in the British Isles, 1930-1932. *J. Animal Ecol. 1*:166-167.

PACKARD, R. L. 1956. *The tree squirrels of Kansas: ecology and economic importance.* Univ. Kansas Museum Nat. Hist. Misc. Publ. *11.*

SETON, E. T. 1929. *Lives of game animals.* Vol. 4, pt. 1. Order Rodentia. Hodder and Stoughton Co., London. 440 pp.

SHARP, W. M. 1958. Aging gray squirrels by use of tail-pelage characteristics. *J. Wildl. Mgmt. 22*:29-35.

SHORTEN, M. 1954. *Squirrels.* Collins Clear-Type Press, London.

UHLIG, H. G. 1955. *The gray squirrel, its life history, ecology and population characteristics in West Virginia.* West Virginia Conserv. Comm. P.-R. Project 31-R. 175 pp.