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POPULATION CHARACTERISTICS OF RACCOONS (*PROCYON LOTOR*) ON THE CHUCK SWAN WILDLIFE MANAGEMENT AREA, TENNESSEE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Jerry Wallace Woods

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ABSTRACT

The objective of this study was to collect information on various aspects of the life history and population structure of the raccoon (Procyon lotor) on the Chuck Swan Wildlife Management Area (CSWMA), Tennessee, to aid in the development of sound management practices for this species. Mark-recapture and hunter-kill data from 248 raccoons provided information on weight and length measurements, age, sex, breeding and reproduction, density, mortality, longevity, and movements. Six techniques were used to age raccoons: eye lens weight, body weight, dental annuli, tooth attrition, baculum weight and ossification, and teat size and coloration. The average weight of raccoons was 5.12 kg for adult males, 4.18 kg for adult females, 2.91 kg for juvenile males, and 2.78 kg for juvenile females. The sex ratio was 64 males:100 females for adults and 134 males: 100 females for juveniles. The overall juvenile:adult ratio was 1.2:1. Males and females had age ratios of 1.8:1 and 0.8:1, respectively. Breeding occurred during February and March with most births occurring between April and June. The average litter size was 2.8. The density of raccoons on the area was one per 27.5 ha. Average longevity was 1.8 years. Juvenile mortality before the hunting season was calculated to be 18.2 percent. Eighty-eight percent of the recaptured raccoons were within 1.61 km of their first

capture. Future hunting recommendations include a decrease in hunting pressure, a delay in opening of the hunting season, and a reevaluation of dog training sessions.

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CHAPTER I

INTRODUCTION

An extensive amount of literature is available on the raccoon (Procyon lotor) in North America. Most of these studies have been conducted in the northern states. The more comprehensive studies are those of Stuewer (1943a,b) in Michigan, Sanderson (1950, 1951, 1961b) in Missouri and Illinois, Stains (1956) in Kansas, and Mech et al. (1966, 1968) in Minnesota.

Limited information has been reported concerning the biology of the raccoon in the South. General observations on raccoons in Florida and Louisiana were reported by Ivey (1948) and Cagle (1949). Wood (1954, 1955) obtained information on the food habits and reproduction of raccoons in the Post Oak region of Texas. McKeever (1958, 1959) studied reproduction and habitat preferences in southwestern Georgia and northwestern Florida. Cunningham (1962), working on the Atomic Energy Commission's Savannah River Plant in South Carolina, determined the density and age and sex composition of the raccoon population. Caldwell's (1963) study was primarily concerned with the relationship between raccoon density and habitat type. Soneshine and Winslow (1972) contrasted two populations of raccoons in two distinct habitat types in Virginia. Keeler (1974) reported on the status of the raccoon in Cades Cove within

the Great Smoky Mountains National Park. The most thorough study on the life history of raccoons in the South was conducted in Alabama by Johnson (1970).

The justification for this study stems from the increasing demand for raccoon hunting and the declining hunter success in East Tennessee (Tennessee Wildlife Resources Agency 1975). While the total number of raccoon hunters in Tennessee has been slightly declining, the number of raccoon hunters in East Tennessee has increased from an estimated 2,630 in 1951 to 9,367 in 1969. Raccoon hunter success in East Tennessee during this period has generally been poorer and has fluctuated greater than in the other three small game regions in the state. Success has varied from 0.133 and 0.767 raccoons per trip, whereas statewide success has ranged from 0.409 and 0.700 raccoons per trip. Bag check data indicated that East Tennessee raccoon hunter success dropped from 0.16 raccoons per hour in 1969 to 0.08 raccoons per hour in 1974.

As a result of this declining success, raccoon clubs and hunters have initiated numerous stocking programs. Raccoon importations have not been adequately documented and monitored. The impact of the introductions on native raccoon populations and on raccoon hunting success is unknown.

Also unknown are effective management alternatives to stocking. While much has been written on the biology of

the raccoon, there is a scarcity of literature to assist in the establishment of sound management programs.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

The Chuck Swan Wildlife Management Area (CSWMA) is located 56.32 km northwest of Knoxville, Tennessee, on the Union and Campbell county line (Figure 1). The area is a 10,053.1 ha peninsula between the Clinch and Powell rivers on Norris Reservoir. Access to the area is by secondary road west of State Highway 33, 16.09 km north of Maynardville, Tennessee, in Union County. Major nearby towns include Maynardville in Union County (12.87 km south), Tazewell in Claiborne County (28.97 km northeast), and LaFollette in Campbell County (24.14 km west).

The CSWMA lies within the dolomitic hill area of the Norris Reservoir watershed. It is underlain by cherty and sand dolomitic limestone of the Knox formation (U.S.D.A. 1953). Characteristic of the area are the smooth well-rounded hills and the narrow steep-sided V-shaped valleys. Limestone sinks are common throughout the area, especially on the Clinch River side of the peninsula. Elevations range from 304.88 m along the reservoir shoreline to 512.20 m on Weaver Knob.

The soils are generally low in fertility, low in organic matter and strongly acid. Surface drainage is rapid and internal drainage is variable between good and rapid, according to the soil type.

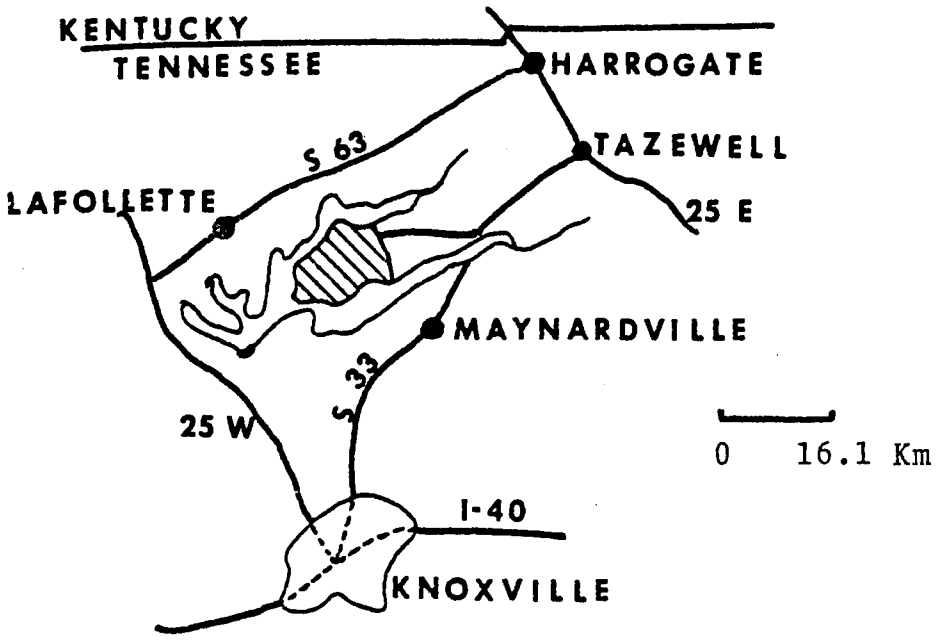


Figure 1. Location of the Chuck Swan Wildlife Management Area in Union and Campbell Counties, Tennessee.

Ninety-two percent of the total area is forested with southern pine (Pinus sp.) as the predominant forest type. However, in the past few years approximately 90 percent of the pines has been killed by the southern pine beetle (Dendroctonus frontalis). The major hardwood species are of the oak-hickory (Quercus sp.-Carya sp.) association. Grassy fields and browse plots represent 2.5 and 4.6 percent of the area, respectively. Ponds cover only 2.02 ha. The area contains four active springs and three major creek systems. At least four cave systems are located on the management area. Other minor caves exist in the various rock outcroppings.

The climate of the Norris Reservoir area is temperate and continental. The mean winter temperature is 2.22° C and the mean summer temperature is 22.78° C. The average frost-free period is 173 days and extends on the average from April 25 to October 16. The average annual precipitation is 127.53 cm. The highest mean monthly rainfall (13.26 cm) occurs in March and the lowest (7.54 cm) falls in October. Snowfall averages 26.57 cm yearly (U.S.D.A. 1953).

Information is limited concerning early raccoon populations on the management area. Safley (1974) reported that the raccoon population did not show a dramatic increase until the area was purchased by the Tennessee Valley Authority (TVA) and protection was made available. Managed

hunts resulted in harvests of 66 to 158 animals until 1962 when range conditions and possible overharvesting caused a decrease in the population. The season was closed in 1965 and remained closed until 1971 when the raccoon population recovered throughout the area. The number of raccoons harvested from 1954-1963 were 70, 66, 78, 104, 75, 158, 96, 121, 85, and 68, respectively.

CHAPTER III

METHODS AND MATERIALS

A. TRAPPING AREAS

In order to increase the efficiency of trapping procedures, the CSWMA was divided into five compartments (Figure 2). The sizes of the compartments are as follows:

1. Compartment I, 2,588.3 ha.
2. Compartment II, 2,517.4 ha.
3. Compartment III, 1,740.9 ha.
4. Compartment IV, 1,918.2 ha.
5. Compartment V, 1,288.3 ha.

Within each compartment a system of grids was established with each grid representing approximately 100 ha. Trapping was conducted in only one compartment at any time. Trap sites were located in most grids of each compartment and activated for a minimum of five nights. Thirty traps were utilized during most trapping sessions, but the number varied between 20 and 40. Criteria for selection of trap sites was accessibility. After all compartments were trapped once, trapping was conducted in specific areas based on previous success.

B. TRAPPING AND MARKING

Trapping and marking, conducted from 16 July to 18 October, 1976, provided data on weight and length

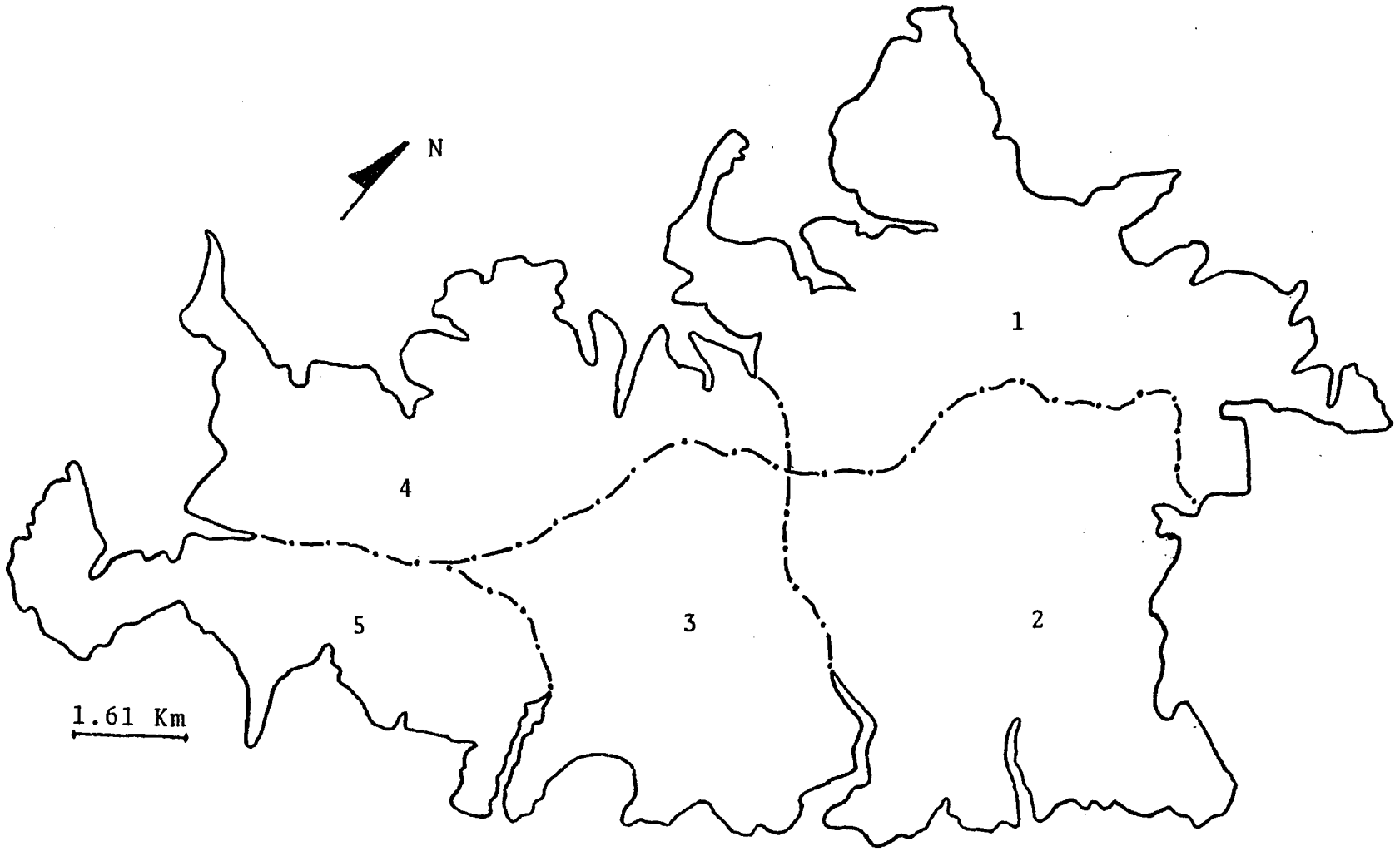


Figure 2. Location of the compartment boundaries, CSWMA.

measurements (total length, tail length, ear length, and hind foot length, including claw), age, sex, breeding and reproduction, density, mortality, longevity, and movements. Traps used were collapsible welded-wire live traps and were baited with sardines. Traps were generally checked each morning and rebaited if necessary. Records were kept of all trapping attempts. Trapped raccoons were immobilized with Sernylan (Phencyclidine hydrochloride) to facilitate handling. Animals were marked with a numbered tag in each ear prior to release.

C. HUNTER-KILL DATA

A total of nine raccoon hunts were conducted on the study area during 25-27 November and 2-4, 9-11 December, 1976. Dogs were used to trail and tree raccoons. Treed raccoons were then shot. Hunting regulations limited the number of raccoons harvested to one per party of hunters. A party consisted of one to several hunters. Records were maintained of the number of hunters and dogs per party and the location of raccoon captures.

Hunters were required to stop at a checking station before leaving the study area. Post-mortem examination of raccoons yielded supplemental data to that obtained by trapping and marking. Eye lenses, canine teeth, and the bacula from males were removed for aging purposes.

Reproductive tracts from females were also removed to provide information on litter size.

D. AGE ESTIMATION OF RACCOONS

Eye lens weight, body weight, dental annuli, tooth attrition, baculum weight and ossification, and teat size and coloration were used as aging criteria. Raccoons could be readily separated as juveniles or adults. Except for tooth attrition, detailed population analysis was difficult with most aging methods.

Terms applied to the different age groups were as follows: (1) juveniles--less than one year old, (2) yearlings--one to two years old, and (3) adults--over two years old. With the exception of teat size and coloration, all other sections on aging techniques categorize yearlings with adults. Non-breeding females older than one year of age are assumed to be yearlings. No distinction between yearling and adult males could be determined.

Eye Lens Weight

The procedure for handling and weighing eye lenses in the present study was similar to that described by Sanderson (1961a) and Johnson (1970). The eyeballs were removed intact and preserved in 10 percent formalin. After hardening for several days the lenses were removed, oven-dried at 45° C for five days, and weighed to the nearest 0.1 mg on a Mettler micro-torsion balance.

Body Weight

The relationship of total animal weight to age was investigated. Total weights of raccoons that were examined during the trapping period and those examined post-mortem during the hunting season were used to construct weight frequency histograms. Animals were classified as either juvenile or adult. Animals in each age category were then grouped into 0.25 kg weight classes.

Dental Annuli

Attempts were made to age raccoons by observing annulations in the cementum of canines prepared by the following procedure:

1. Teeth were decalcified in 20 percent formic acid for 48 to 72 hours.

2. After decalcifying, the teeth were rinsed in running water and placed in a water-filled container to await sectioning.

3. Decalcified teeth were mounted on tissue holders of the microtome-cryostat. Sectioning was done at -29 to -34° C.

4. Longitudinal sections 12 to 16 microns thick were made and those cut through the center of the tooth which showed as much of the pulp cavity as possible were collected.

5. Sections (usually eight per tooth) were mounted on

slides, and the slides were placed on a slide warmer to dry.

6. The teeth were stained for 20-25 minutes in a solution of 1 part Geimsa bloodstain to 25 parts of distilled water.

7. After staining, the slides were rinsed in two baths of distilled water for 15 seconds each.

8. Slides were dried in a vertical position on a slide warmer.

9. After drying, the slides were bathed in xylene for 15 minutes.

10. The slides were then slip-covered, using a glass mount bond.

11. Slides were examined through a Zeiss microscope at 40X to 100X magnification.

12. The number of annuli visible in the tooth sections was counted.

Tooth Attrition

Raccoons were aged by the tooth-wear method described by Grau et al. (1970). This permits placing raccoons into five broad age classes. The age limits for Age Class I are 0-14 months; Class II, 15-38 months; Class III, 39-57 months; Class IV, 58-86 months; and Class V, over 86 months. Grau et al. found that this tooth-wear technique accurately aged 86 of 104 individuals (82.7 percent). In this study Class I includes only juveniles.

Baculum Weight and Ossification

The weight and ossification of the penis bones or bacula of male raccoons were used as a reliable criteria for separating juveniles and adults (Sanderson 1950). All bacula were cleaned and air dried for five days before weighing.

Teat Size and Coloration

The size and pigmentation of the teats provided a useful means of distinguishing females that had been pregnant from those which had not. In the fall and winter, parous adults have longer and usually darker teats than young-of-the-year and nulliparous adults (Stuewer 1943a, Sanderson 1950, 1951).

E. BREEDING AND REPRODUCTION

The birth dates (± 2 months) of juvenile raccoons were estimated from eye lens weights and the lens growth curve established by Sanderson (1961a). Dates of conception were calculated assuming a 63 day gestation period. Litter size was determined from necropsied raccoons by counting the sites of placental attachment on the uterine horns of the reproductive tracts. This is considered by some investigators to be a reliable indicator of the number of young produced (Stuewer 1943a,b, Sanderson 1950, and Johnson 1970).

F. POPULATION ESTIMATION

Population estimates on the study area were derived by use of the Lincoln Index. By this method the total population is computed from the ratio of marked to unmarked animals. The formula is as follows:

$$N = \frac{nT}{t}$$

where T = number of animals marked during the trapping period

t = number of marked animals killed during the hunting period

n = total number of animals killed during the hunting period

N = the population estimate.

To determine the 95 percent confidence limits for the Lincoln Index, the following formula was used:

$$2S.E. \text{ (Standard Error)} = \pm 2 \sqrt{\frac{T^2 n(n-t)}{t^3}}$$

The Lincoln Index involves two basic assumptions: (1) that mortality and recruitment during the period of data collection are negligible and (2) that all members of the population have an equal probability of being counted--that the members of the population are equally trap susceptible, that each member's ability to escape from hunters is the same, that they are distributed randomly through the

population if marked and released, and that they do not group by age, sex, or some other characteristic.

G. MOVEMENTS

Marked raccoons recaptured at different trap locations and/or killed during the hunting season provided information on movements.

CHAPTER IV

RESULTS AND DISCUSSION

A. TRAPPING

One hundred and twelve different raccoons were captured: 20 juvenile males, 17 juvenile females, 31 adult males, and 44 adult females. There were 33 recaptures. A total of 1,628 trapnights resulted in a capture success of one raccoon per 11.23 trapnights or 8.91 percent success (Table 1). Increased trapping success during September and October possibly corresponded to an increase in juvenile activity.

The trapping success for the CSWMA is the highest reported in east Tennessee (Table 2). Another study (Keeler 1974), conducted in Cades Cove, Great Smoky Mountains National Park, an area which has had no hunting since the park was established, indicated a slightly lower trapping success (7.56 percent). This resulted from an outbreak of canine distemper which occurred about midway through Keeler's study. Warr (1977), working on an area in Blount, Loudon, and Monroe Counties, Tennessee, attributed his low trapping success (1.2 percent) to the inadequacy of the habitat to support a large raccoon population and to the heavy hunting pressure occurring throughout the year.

The CSWMA represents an intermediate situation in

Table 1. Trapping success for raccoons on the CSWMA from 16 July to 18 October, 1976

Month	Number of Trapnights	Raccoons Captured	Percentage Success
July	296	20	6.76
August	482	19	3.94
September	542	65	11.99
October	308	41	13.31
Totals	1,628	145*	8.91

*Includes incidences of recapture.

Table 2. Trapping success on the CSWMA from 16 July to 18 October, as compared to the year-round trapping success in Cades Cove, Great Smoky Mountains National Park and an area in Blount, Loudon, and Monroe Counties, Tennessee

Area	Number of Trapnights	Number of Raccoons Captured	Raccoon/ Trapnight	Trapping Success (Percent)
CSWMA	1,628	148*	1/11.23	8.91
Cades Cove	2,870	217*	1/13.23	7.56
Blount, Loudon, and Monroe Counties	3,928	47*	1/83.51	1.20

*Includes incidences of recapture.

east Tennessee regarding the relative protection afforded the raccoon. The implications of a system of restricted hunting and its role in regulating raccoon numbers will be discussed more thoroughly in Chapter IV on Density.

Other species captured in the course of trapping for this study included 191 opossums (Didelphis marsupialis), 1 mink (Mustela vision), 3 woodchucks (Marmota monax), 1 gray fox (Urocyon cinereoargenteus), 3 striped skunks (Mephitis mephitis), 3 spotted skunks (Spilogale putoris), 1 cottontail (Sylvilagus floridanus), 5 dogs (Canis domesticus), 2 cats (Felis domesticus), 8 box turtles (Terrapene carolina), and 1 snapping turtle (Chelydra serpentina).

B. HUNTING

Hunting resulted in a total kill of 136 raccoons, consisting of 61 juvenile males, 41 juvenile females, 10 adult males, and 24 adult females. Approximately 1,516 hunters and 1,849 dogs made up 638 parties for an overall hunting success of 21.3 percent. The average number of hunters and dogs per party was 2.38 and 2.90, respectively. The average number of dogs per hunter was 1.22. Thirty-four previously marked raccoons (14 juvenile males, eight juvenile females, three adult males, and nine adult females) were killed during the hunts (Table 3).

It appears that hunting success may be influenced by

Table 3. Raccoon hunter and harvest data on the CSWMA during 25-27 November and 2-4, 9-11 December, 1976

Date of Harvest	No. of Parties	No. of Hunters	No. of Dogs	No. of Hunters/ Party	No. of Dogs/ Party	No. of Dogs/ Hunter	No. of Raccoons Killed	No. of Marked Raccoons Killed		No. of Adult Raccoons Killed		No. of Juvenile Raccoons Killed		% Hunting Success*
								Male	Female	Male	Female	Male	Female	
11-25-76	143	367	400	2.57	2.80	1.09	34	6	2	0	5	18	11	23.8
11-26-76	72	183	204	2.54	2.83	1.11	28	3	4	4	5	9	10	38.9
11-27-76	108	261	285	2.42	2.64	1.09	25	0	2	0	4	13	8	25.9
Total	323	811	889	2.51	2.75	1.10	87	7	8	4	14	40	29	26.9
12-2-76	53	117	166	2.21	3.13	1.42	10	1	4	1	2	4	3	18.9
12-3-76	61	140	178	2.30	2.92	1.27	7	1	0	0	1	4	2	11.5
12-4-76	64	147	196	2.30	3.06	1.33	5	1	2	1	1	1	2	7.8
Total	178	404	540	2.27	3.03	1.34	22	3	6	2	4	9	7	12.4
12-9-76	30	63	93	2.10	3.10	1.48	7	1	1	0	1	3	3	23.3
12-10-76	62	138	196	2.23	3.16	1.42	13	2	1	1	2	8	2	21.0
12-11-76	45	100	131	2.22	2.91	1.31	7	2	1	3	3	1	0	15.6
Total	137	301	420	2.20	3.07	1.40	27	5	3	4	6	12	5	19.7
Overall Total	638	1516	1849	2.38	2.90	1.22	136	17	17	10	24	61	41	21.3

*Number of raccoons killed x 100 ÷ by number of parties hunting.

rainfall and temperature (Figure 3). Johnson (1970) noted that hunting success dropped on dry nights and when temperatures fell below -3.89° C. Stains (1956) reported that cold weather may restrict the activity of males and females. The increased success during the second hunt (26 November) of the present study may have resulted from the increased activity of raccoons due to a change in weather from dry to rainy. Also, according to raccoon hunters, the scent of a raccoon is much easier to follow by dogs on slightly wet ground than on dry ground. The decrease in success which occurred during 2-4 December may be attributed to a decrease in raccoon activity caused by a drop in temperature. The average nighttime temperature fell from 1.67° C during the first three hunts (25-27 November) to -8.56° C for the second three hunts (2-4 December). No rain occurred during the second three nights of hunting. The amount of time spent hunting also decreased due to cold weather. The increased success for the final three hunts (9-11 December) may be the result of a 52.5 percent average increase in temperature over the second three hunts to -3.55° C. It rained during the final three nights of hunting. Also noted was an increase in the time spent hunting. No quantitative data were obtained on the length of time spent hunting; this impression is based on general observations. No comparative information on the hunting success of raccoons was available from the previous studies reviewed.

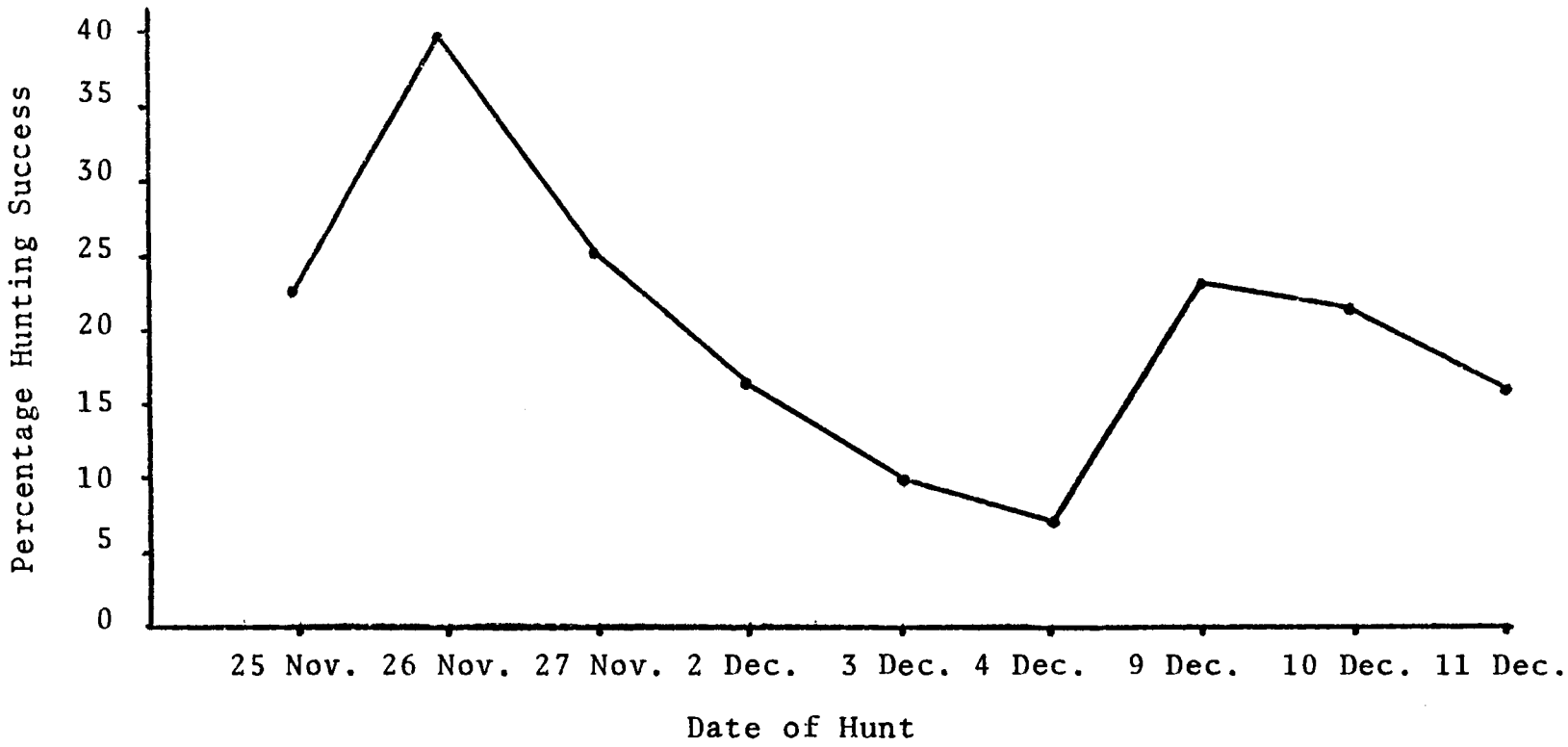


Figure 3. The percentage hunting success of raccoons on the CSWMA during 25-27 November and 2-4, 9-11 December, 1976.

C. AGING TECHNIQUES

Eye Lens Weight

The eye lens in certain mammals has been reported to increase in size and density throughout life. Lord (1959, 1961) described the eye lens as an indicator of age in cottontail rabbits and gray foxes. Sanderson (1961a) established a relationship between the weight of the eye lens and age from 119 raccoons of approximately known ages. He found that the growth rate of the lens in raccoons varies only slightly before 12 months of age and can be used to estimate the age of juvenile raccoons to the nearest month. After 12 months of age, the rate of growth of the lens is much slower and increasingly more variable. Thus, it cannot be used to determine specific year classes of adults. Grau et al. (1970) correlated lens nitrogen content with age and found that raccoon lens nitrogen increased rapidly for the first 12 months. Lens nitrogen increase then slowed so rapidly that its usefulness in aging older age groups became limited. This technique can be used only to separate young of the year from adults. The method described by Sanderson (1961a) is equally as accurate and less expensive.

In the present study the right and left lenses of 129 raccoons were weighed to the nearest 0.1 mg, but no differences were noted. Lord (1959, 1961), Sanderson (1961a),

and Johnson (1970) reported no significant difference between lens weights among sexes.

The lens weight among juvenile raccoons in this study ranged from 59.0 to 100.6 mg. Juveniles and the older age groups had an average lens weight of 85.7 and 139.2 mg, respectively. Only one of 95 juveniles had a lens weight over 100 mg, and zero of 33 adults had a lens weight of less than 100 mg. Johnson (1970) found that only three of 22 juveniles had lens weights over 100 mg. No adults from a sample of 58 had lens weights less than 100 mg. Sanderson (1961a) reported nine of 54 juveniles with lens weights over 100 mg and no older age classes with lens weights less than 100 mg.

The data from the present study indicate that raccoon lens weight is a reliable measure for separating juveniles from adults.

Body Weight

Weights have been used by several investigators to separate raccoons into juvenile and adult age classes (Stuewer 1943b, Sanderson 1950, Johnson 1970). Stuewer (1943b) said that Michigan raccoons weighing less than 6.35 kg in the fall could be considered juvenile. He did not suggest that sex might influence body weight. Sanderson (1950) used 6.80 kg to segregate males into juvenile and adult age classes in Missouri. Only 15 of 155 (9.69 percent) males were placed in the wrong age class. He did

not consider the body weight of females as an adequate aging criterion due to the high degree of variability among females resulting from the "strain of pregnancy and lactation." In southwestern Alabama, Johnson (1970) found that regardless of sex or time of year, only seven of 213 (3.29 percent) raccoons were misclassified if all animals weighing 2.72 kg or less were considered to be immature. His data from east-central Alabama indicated that juveniles and adults were most efficiently separated at 3.40 kg. Thus, 13 of 146 raccoons (3.9 percent) were misclassified. In the present study raccoons were separated into juvenile and adult age classes based on weight as determined from the other aging methods.

Weight data were obtained from 111 raccoons during the trapping period in the present study. Data are pooled without regard to sex (Figure 4). If 3 kg is used to separate juveniles from adults, only one animal (0.9 percent) is misclassified. Similar histograms were plotted with data segregated by sex (Figures 5 and 6). Only one female in 60 (1.7 percent) is misclassified if 3 kg is used to separate juveniles from adults. No males are misclassified at 3 kg.

Histograms were constructed using data on 132 necropsied raccoons obtained during the hunting season. With the age classes divided at 4.25 kg, 11 of 132 raccoons (8.3 percent) were misclassified (Figure 7). Data segregated by

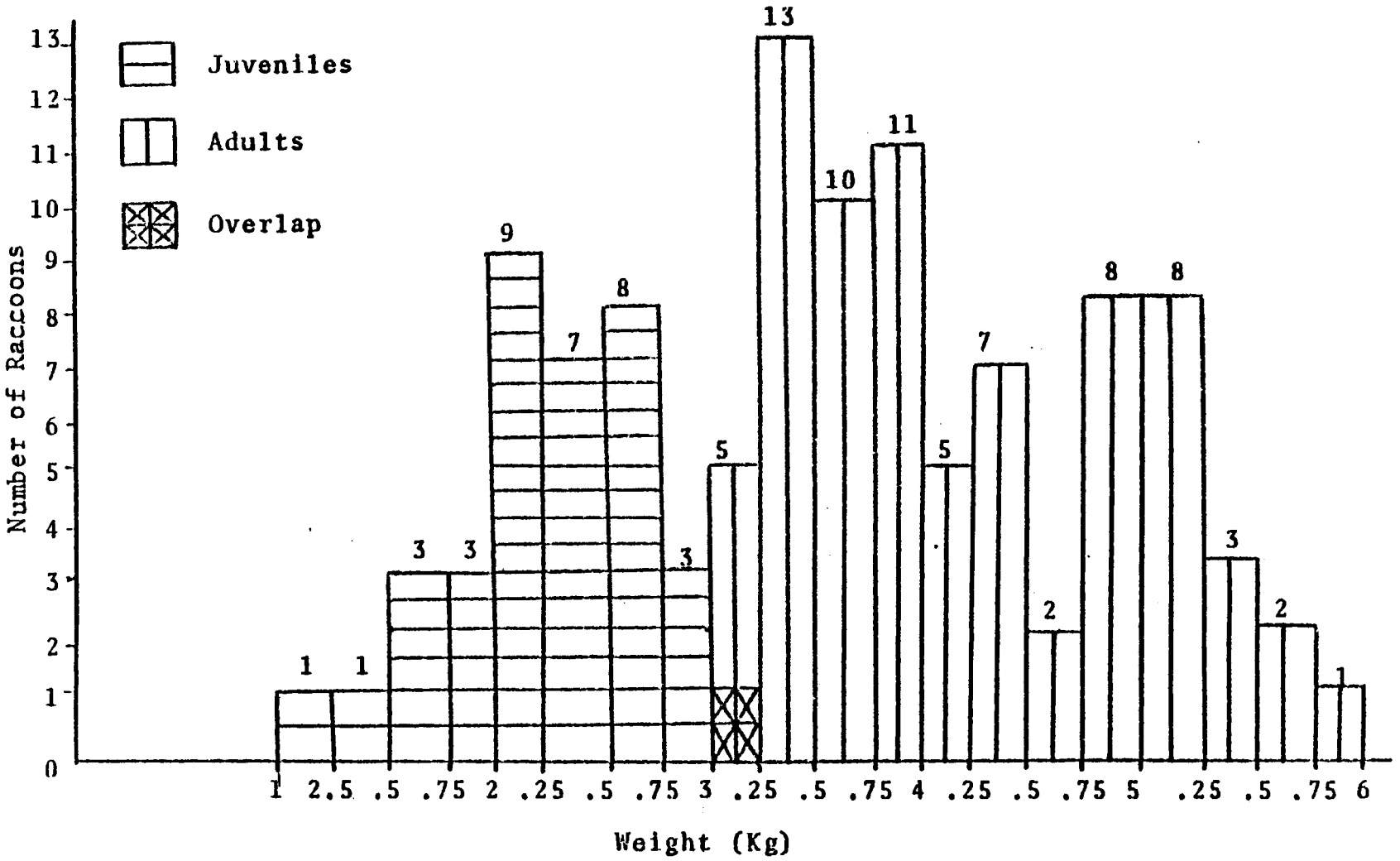


Figure 4. Weight distribution of 111 raccoons of both sexes trapped on the CSWMA from 16 July to 18 October, 1976. The average juvenile and adult weights were 2.27 and 4.23 kg, respectively.

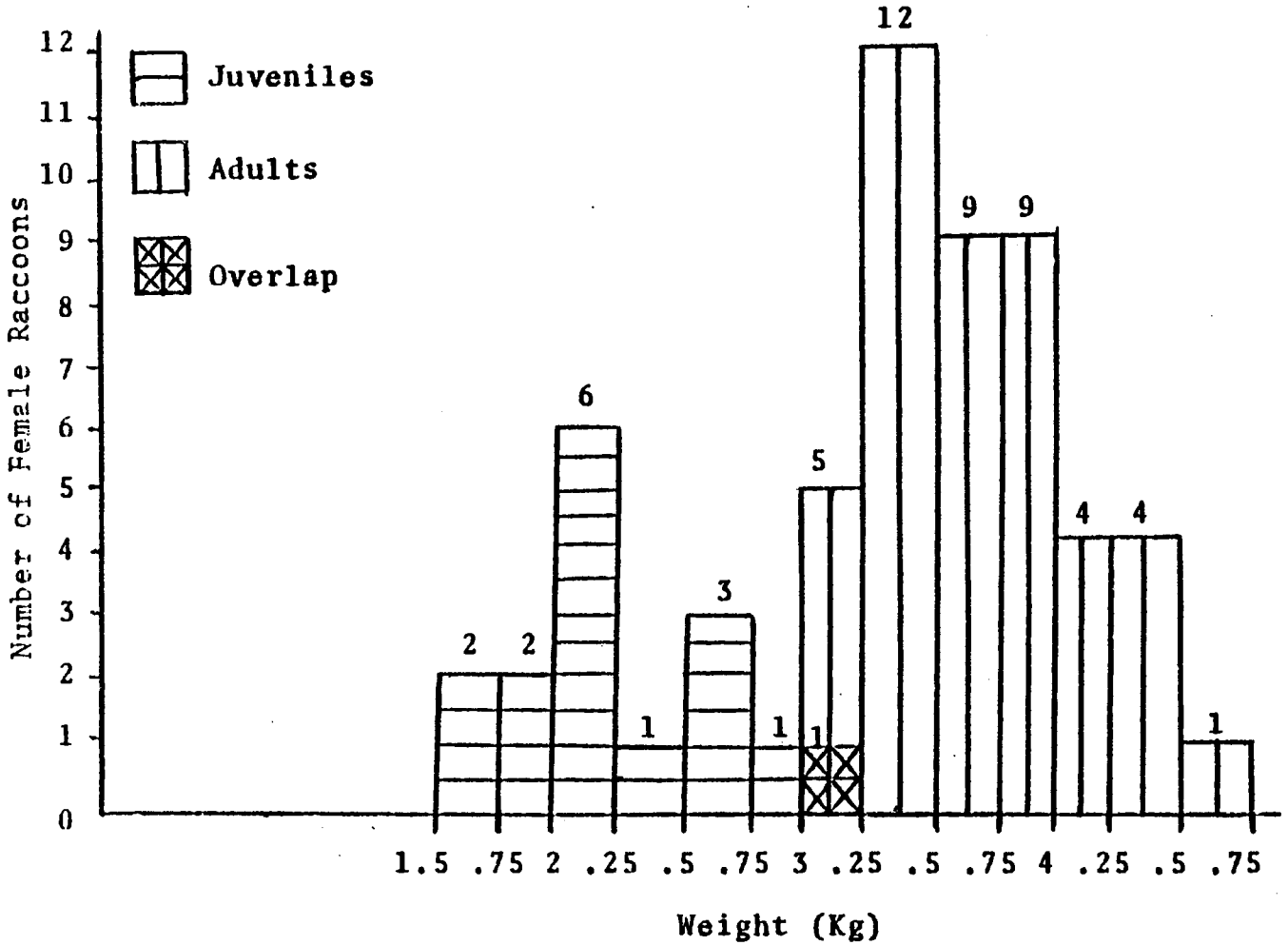


Figure 5. Weight distribution of 60 female raccoons trapped on the CSWMA from 16 July to 18 October, 1976. The average juvenile and adult weights were 2.25 and 4.15 kg, respectively.

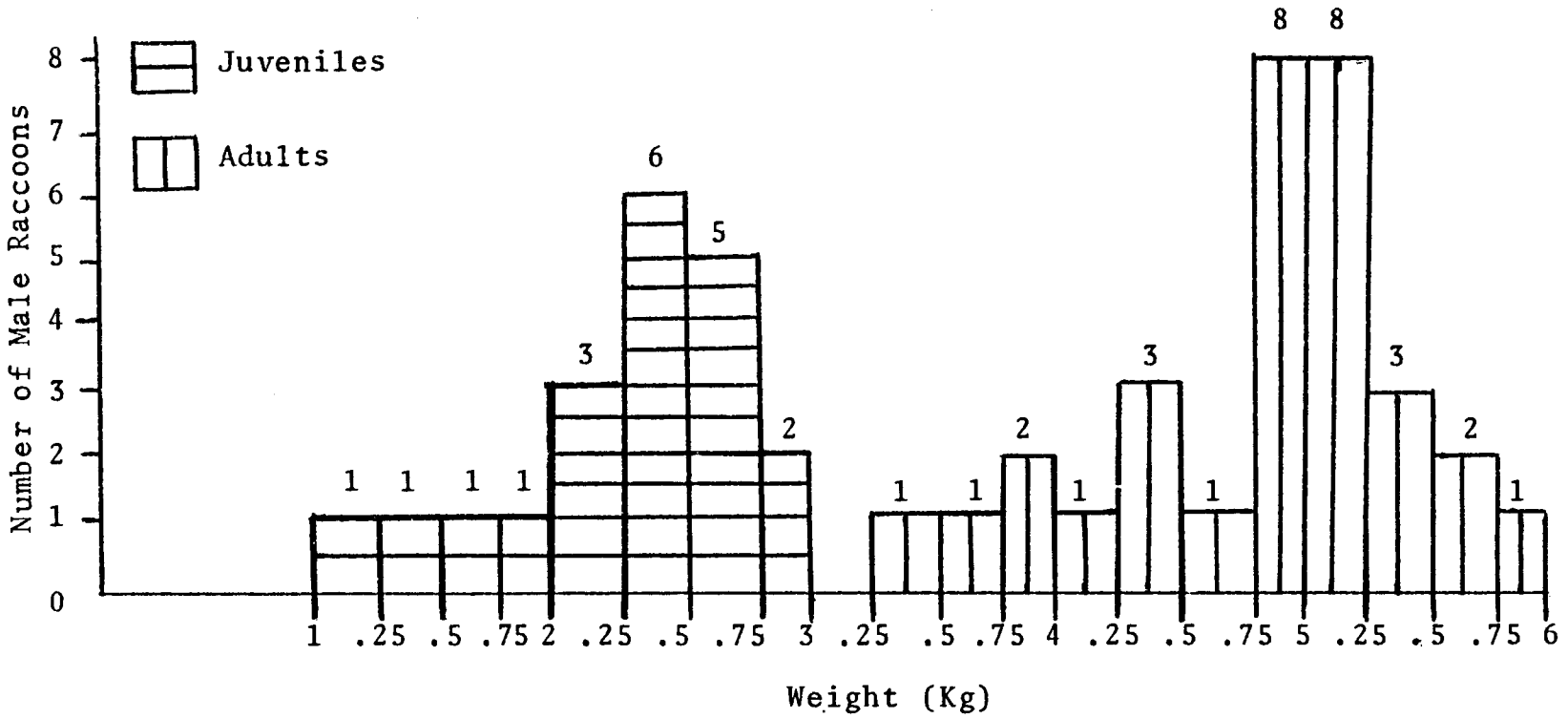


Figure 6. Weight distribution of 51 male raccoons trapped on the CSWMA from 16 July to 18 October, 1976. The average juvenile and adult weights were 2.29 and 4.88 kg, respectively.

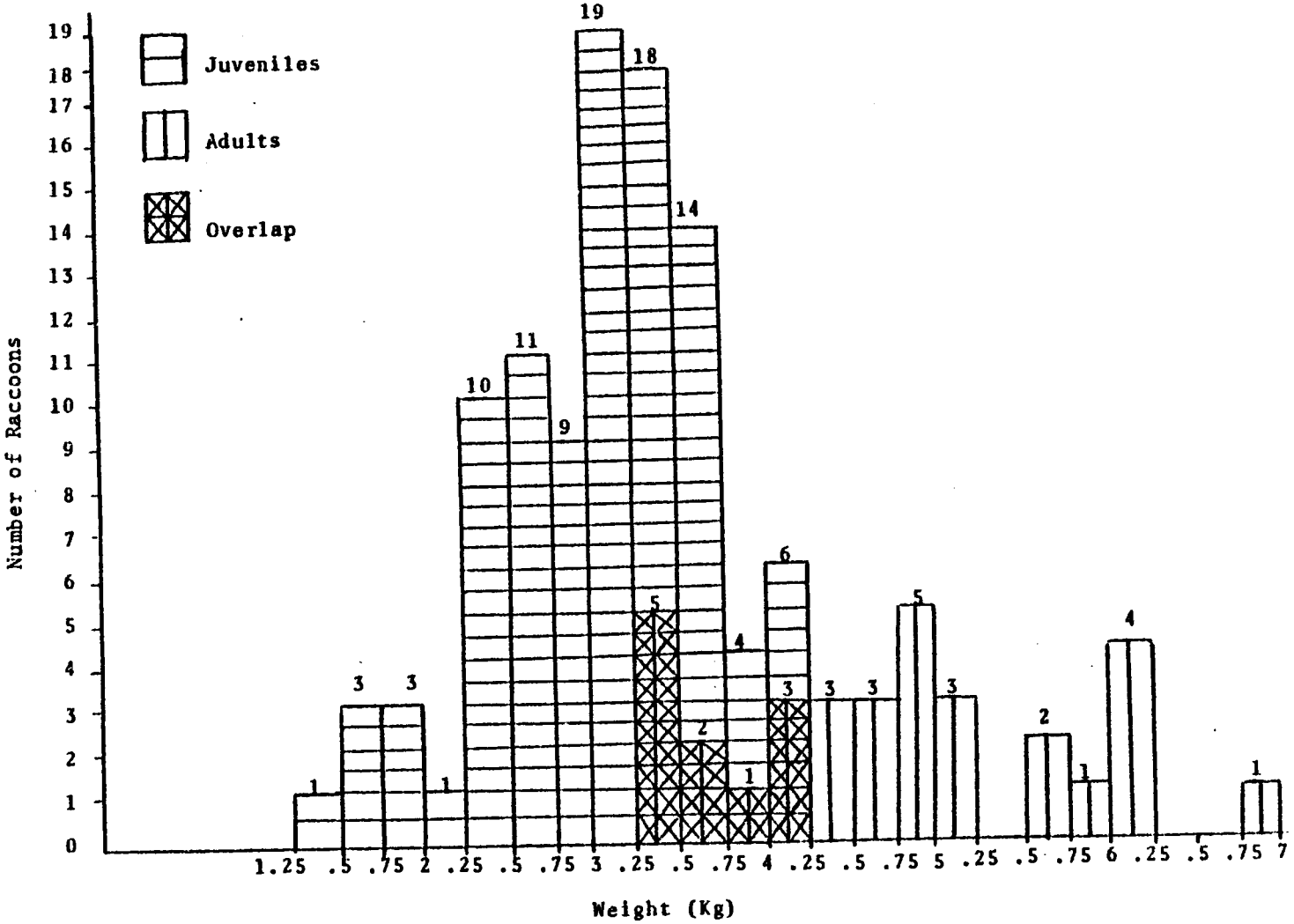


Figure 7. Weight distribution of 132 raccoons of both sexes collected by hunting on the CSWMA during 25-27 November and 2-4, 9-11 December, 1976 and examined post-mortem. The average juvenile and adult weights were 3.07 and 4.11 kg, respectively.

sex reveals that seven of 64 females (10.9 percent) are wrongly aged if 3.75 kg is used to separate the two age groups (Figure 8). No misclassifications occur for males if juveniles and adults are separated at 4.25 kg (Figure 9).

Data were pooled from the trapping and hunting periods. Pooling without regard to sex (Figure 10) resulted in 45 of 253 raccoons (18.5 percent) misclassified when 3.75 kg is used to separate juveniles from adults. Trapping and hunting data combined from females only (Figure 11) shows 17 of 124 animals (13.7 percent) incorrectly aged if 3.25 kg is used as the boundary to separate the two age classes. Combined information on males (Figure 12) reveals that five of 119 (4.2 percent) raccoons are misclassified when 4.25 kg are used as the separation point for juveniles and adults.

Pooling weight data without regard to sex and/or season usually results in increased error for aging raccoons. However, it appears that weight is an accurate measure for separating juvenile from adult male raccoons on the study area from July through December. A high degree of accuracy was also obtained for females during the trapping season. The increased error for aging females during the hunting season may have been the result of several factors: (1) The sample size and ratio of juvenile to adult females varied greatly among the two capture methods, trapping and

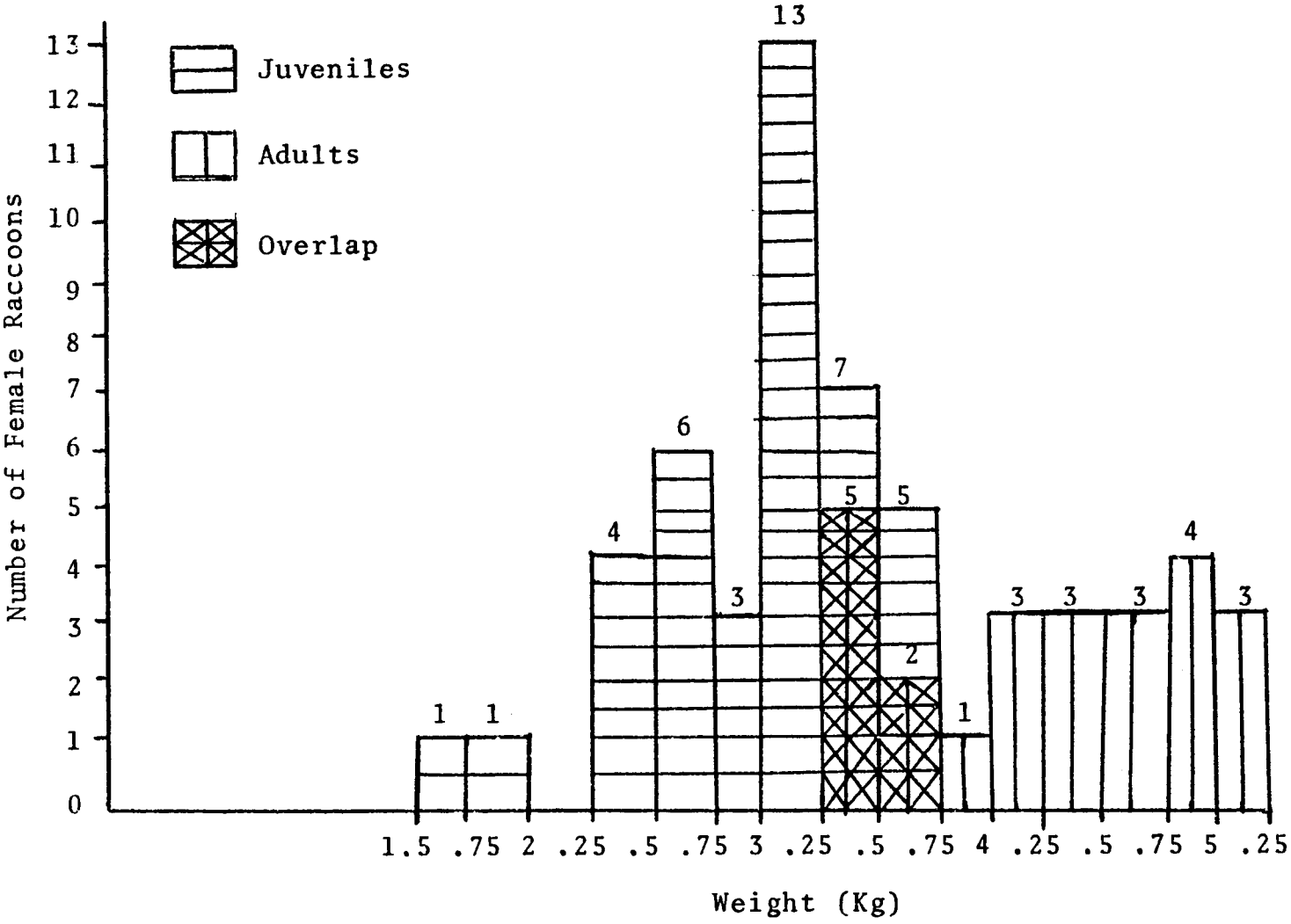


Figure 8. Weight distributicn of 64 female raccoons collected by hunting on the CSWMA during 25-27 November and 2-4, 9-11 December, 1976 and examined post-mortem. The average juvenile and adult weights were 3.00 and 4.24 kg, respectively.

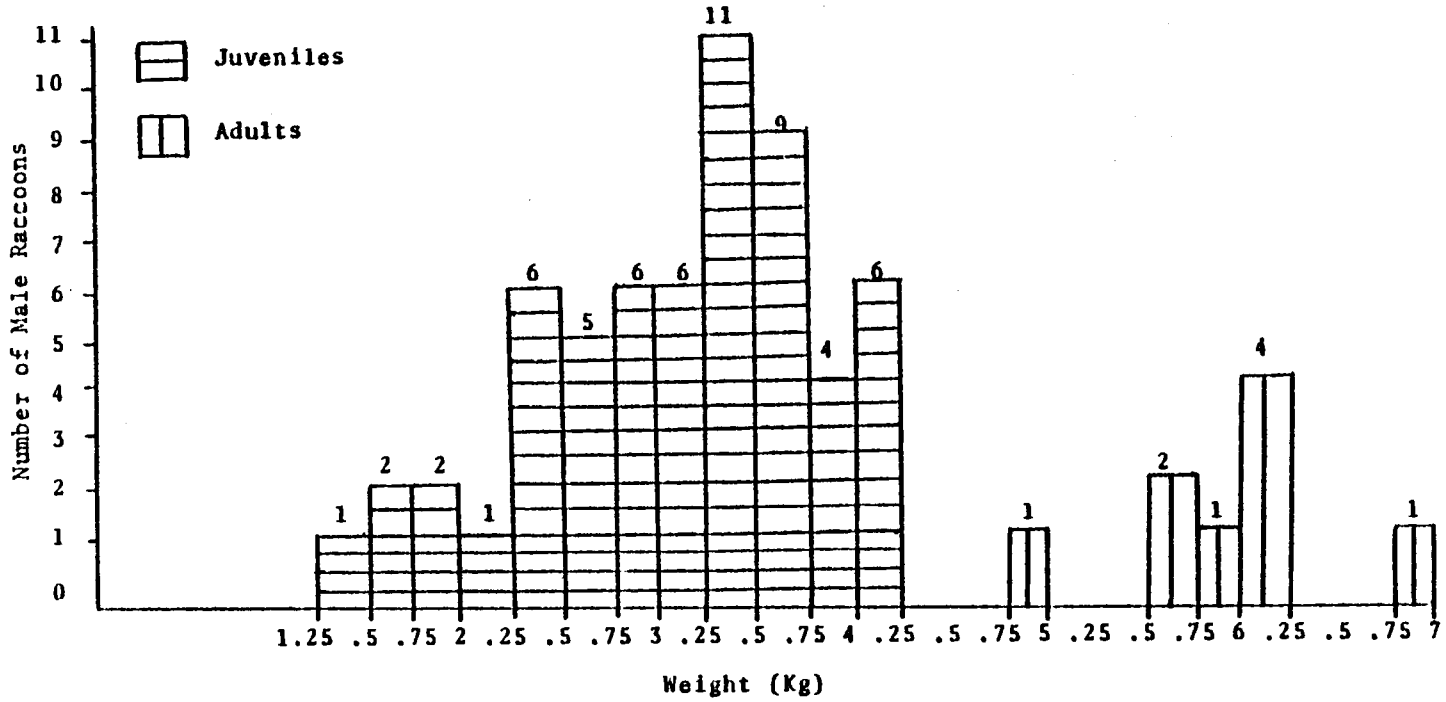


Figure 9. Weight distribution of 68 male raccoons collected by hunting on the CSWMA during 25-27 November and 2-4, 9-11 December, 1976 and examined post-mortem. The average juvenile and adult weights were 3.12 and 5.97 kg, respectively.

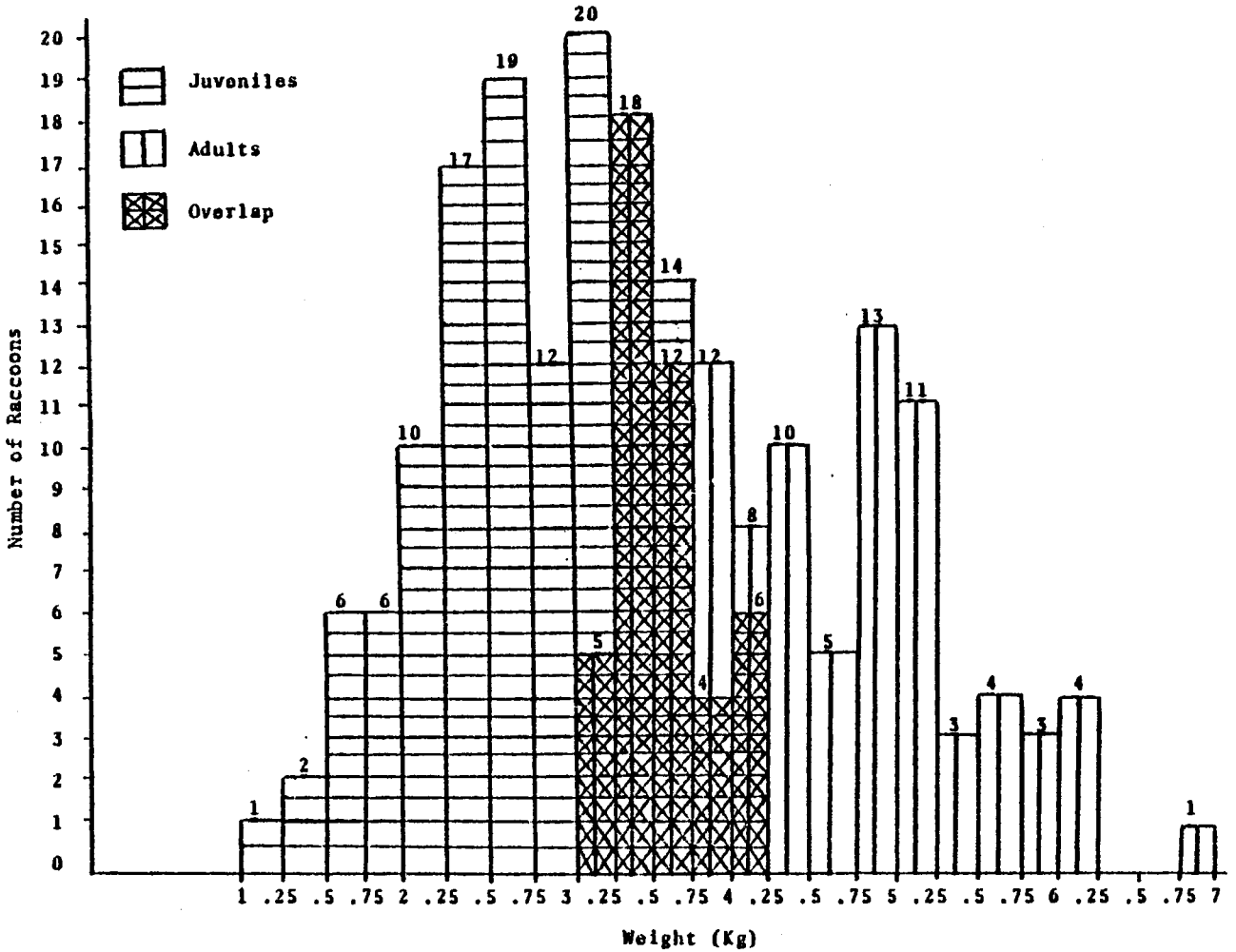


Figure 10. Weight distribution of 243 raccoons of both sexes collected by trapping and hunting on the CSWMA from 16 July to 11 December, 1976. The average juvenile and adult weights were 2.86 and 4.37 kg, respectively. The average weight of all raccoons was 3.53 kg.

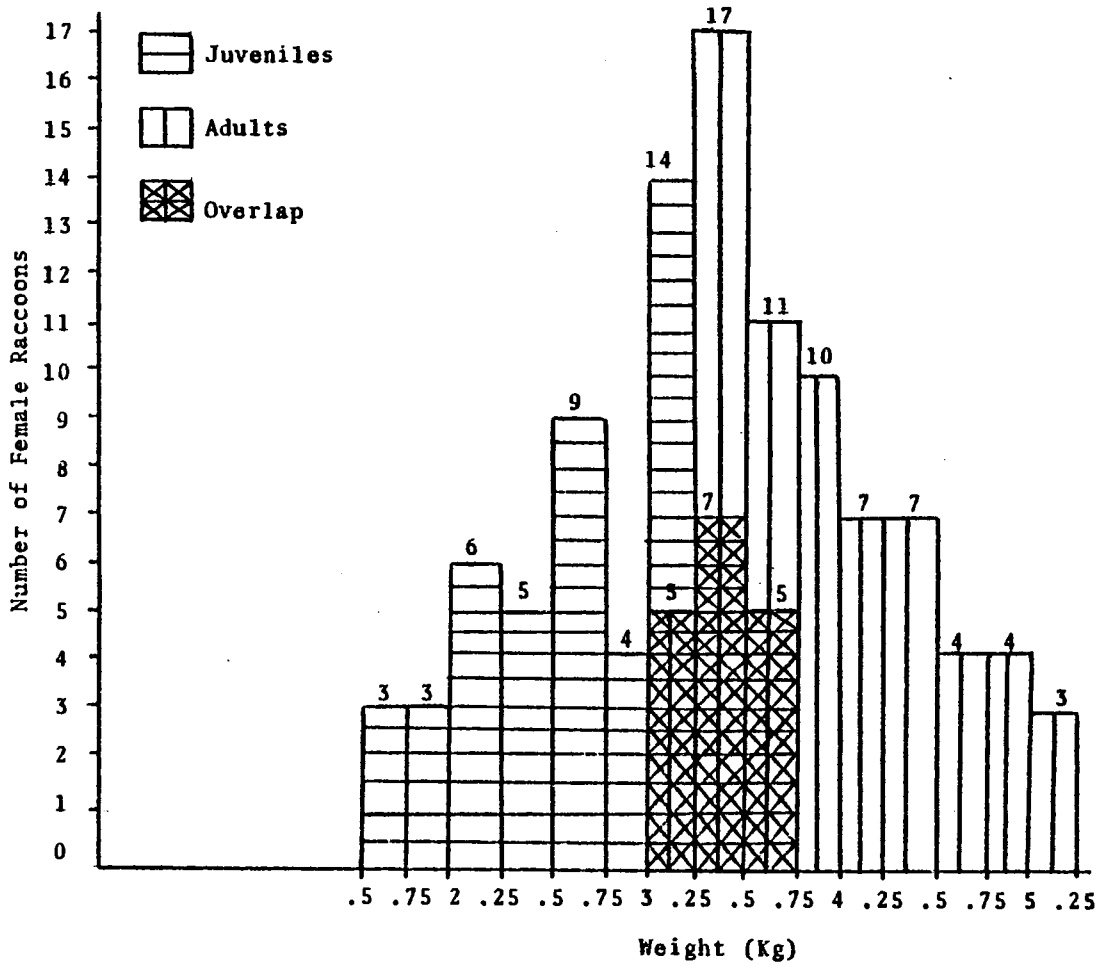


Figure 11. Weight distribution of 124 female raccoons collected by trapping and hunting on the CSWMA from 16 July to 11 December, 1976. The average juvenile and adult weights were 2.78 and 3.93 kg, respectively.

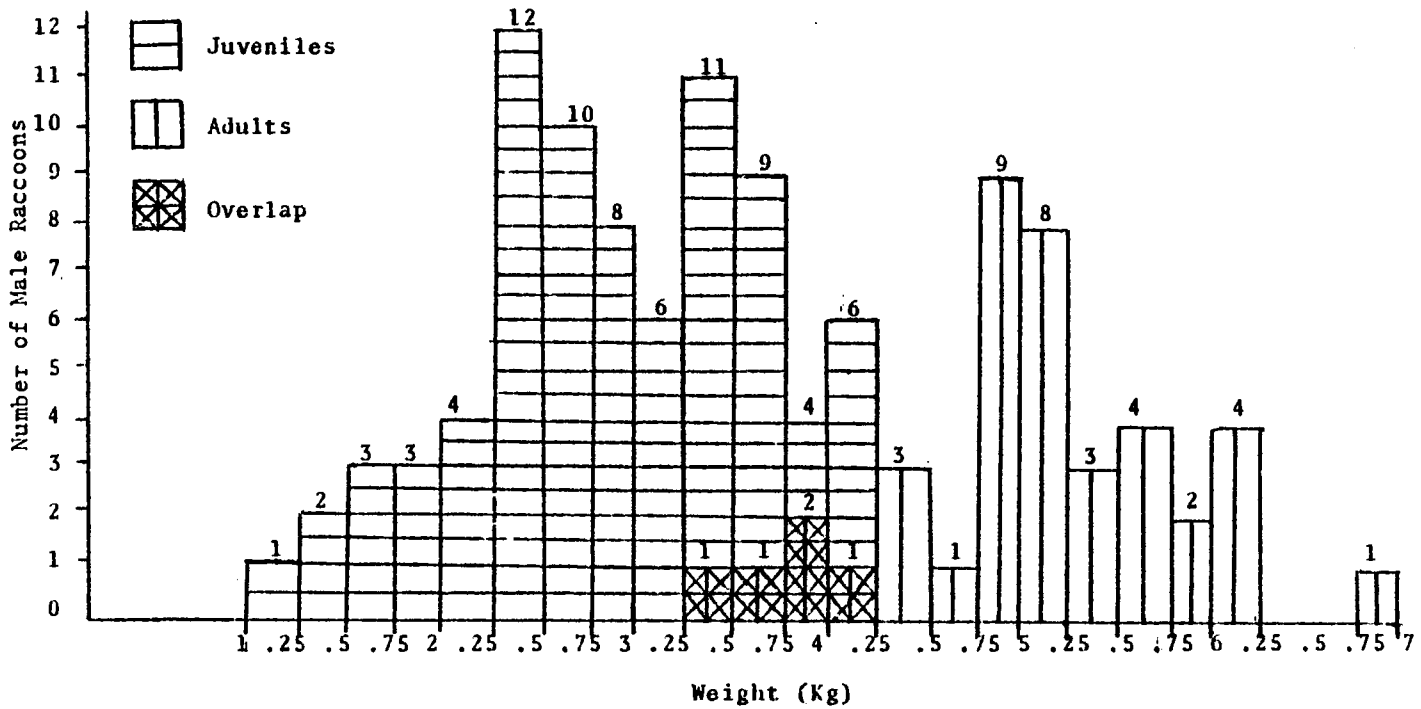


Figure 12. Weight distribution of 119 male raccoons trapped and killed on the CSWMA from 16 July to 11 December, 1976. The average juvenile and adult weights were 2.91 and 5.12 kg, respectively.

hunting; (2) A substantial number of adult females weighed less because of nursing late-born litters; (3) A rapid weight increase of juvenile females at this time of year caused them to exceed the weight of adult females creating a broad overlap in weight.

Dental Annuli

Teeth obtained from raccoons estimated as one year or less did not lend themselves to the aging procedure utilized in the present study. After the decalcification process, all teeth tended to split, and sectioning was not possible. Splitting was probably due to the large size of the pulp cavity. Raccoons less than one year old generally have fragile teeth with large pulp cavities (Johnson 1970).

Annulations in the cementum were distinct in one of the older raccoons. However, the layering in the cementum of all of the other animals was usually indistinct, resulting in subjective interpretation. Johnson (1970) reported difficulty in accurately aging raccoons due to the presence of "false annuli." Grau et al. (1970) found that cementum ring counts were accurate in aging individuals through their fourth year but tended to underestimate the age of animals over four years old. The inaccuracy of this technique might be due to cementum layers which do not form annually and the difficulty in counting cementum layers in older raccoons.

Tooth Attrition

Dental wear has been used by several investigators to differentiate between age classes in raccoons (Stuewer 1943b, Johnson 1970, Grau et al. 1970). Table 4 summarizes the tooth-wear data obtained from trapping and hunting. It should be noted that the criteria for aging proposed by Grau et al. (1970) were developed using captive animals from Missouri. The amount of tooth wear from wild populations from different regions can be expected to differ due to differences in diet (Grau et al. 1970, Johnson 1970).

Baculum Weight and Ossification

Penis bones or bacula have previously been used to separate male raccoons into age classes. Sanderson (1950) used length, weight, and amount of cartilage on the baculum, along with the size of the preputial orifice, to separate males taken during the hunting and trapping seasons in Missouri into young-of-the-year and adults. He reported that the presence of cartilage on the distal end of the baculum during the fall and winter marks an animal less than one year old, while a bony distal end marks an animal more than one year old. He also found when all bacula weighing 2 g or less were considered juvenile, only eight of 548 (1.5 percent) were not in agreement with the cartilage classification. Johnson (1970) reported that 56 of 58

Table 4. Five age classes based on tooth attrition of 214 raccoons from the CSWMA

Tooth-Wear Age Class	Trapping						Hunting						Combined*					
	No. of Males	No. of Females	Total	% Males	% Females	% Total	No. of Males	No. of Females	Total	% Males	% Females	% Total	No. of Males	No. of Females	Total	% Males	% Females	% Total
Class I	20	17	37	54.1	45.8	33.0	61	41	104	57.8	40.2	75.0	67	50	117	57.3	42.7	54.7
Class II	15	16	31	48.4	51.6	27.7	2	7	9	22.2	77.8	6.6	17	20	37	46.0	54.1	17.3
Class III	10	15	25	40.0	60.0	22.3	3	8	11	27.3	2.7	8.1	13	22	35	37.1	62.9	16.3
Class IV	6	8	14	42.9	57.1	12.5	5	6	11	45.5	54.6	2.1	8	11	19	42.1	57.9	8.9
Class V	0	5	5	0	100	4.5	0	3	3	0	100	2.2	0	6	6	0	100	2.8
Total	51	61	112	45.5	54.5	100.0	71	65	136	52.2	47.8	100.0	105	109	214	49.1	50.9	100.0

*Animals marked when trapped and killed during the hunting season are excluded from the combined computations.

(96.6 percent) juvenile raccoons in Alabama and bacula weighing less than 1.2 g.

All 50 juvenile males examined during the present study had bacula weighing less than 1 g. Baculum weights ranged from 0.23 to 0.99 g with an average weight of 0.65 g. The distal end of all juvenile penis bones showed the presence of cartilage. Nine adult bacula were also examined. All weighed over 3 g and ranged from 3.18 to 4.58 g. The average weight was 3.80 g. The distal end of all adult bacula was bony with no cartilage present.

Teat Size and Coloration

Teat size and pigmentation indicated that of 65 necropsied female raccoons, 21 (32.5 percent) were adults that had previously produced offspring. Forty-one (63.1 percent) were classified as juveniles and three (4.6 percent) as yearlings that had not bred. Trapping data revealed that of 60 females, 37 (61.7 percent) were adults that had reproduced. Eighteen (30.0 percent) were categorized as juveniles and five (8.3 percent) as yearlings that had not bred.

D. WEIGHT

Weights were recorded for 108 adults and 135 juveniles (Table 5). The average weight for 40 adult males was 5.12 kg. For 68 adult females, the average weight was 4.18 kg. The maximum weights of adult males

Table 5. Average weight by age and type of capture of 243 raccoons collected on the CSWMA

Age Class and Type of Capture	No. of Males Weighed	No. of Females Weighed	Males		Females	
			Avg. Wt. (Kg)	Max. Wt. (Kg)	Avg. Wt. (Kg)	Max. Wt. (Kg)
Adult						
Trapping	31	44	4.88	6.01	4.15	4.54
Hunting	9	24	5.97	6.80	4.24	5.22
Total	40	68	5.12	6.80	4.18	5.22
Juvenile						
Trapping	20	16	2.29	2.95	2.25	3.18
Hunting	59	40	3.12	4.20	3.00	3.63
Total	79	56	2.91	4.20	2.78	3.63

and females were 6.80 kg and 5.22 kg, respectively.

With the exception of two juveniles, all juveniles and adult males captured more than once increased in weight during the study period (Table 6). The weight of these two juveniles did not change between weighings. Three adult females exhibited a decline in weight. The weight of two others did not change. The bioenergetic demands of late-born young on reproducing females may have resulted in no weight increase in these animals at this time of year.

The greatest weight losses in raccoons normally occur through the winter and spring. Johnson (1970) reported a weight loss of 29 percent for an adult male between November and June. He found that the maximum weight loss of any individual raccoon in Alabama was 32 percent. Mech et al. (1968) and Stuewer (1943b) discovered that weight losses of over 50 percent were common in Minnesota and Michigan. Mech et al. (1968) reported that one adult female lost 62 percent of her total weight (from 8.62 kg in November to 3.29 kg in March) and still produced a litter.

The average monthly weight of males was always greater than the average monthly weight of females (Figure 13). The average weights of adults remained fairly stable during the trapping period. A substantial weight increase for adults and juveniles then occurred between October and November-December. This obvious weight increase during the

Table 6. Weights and percentage weight changes of raccoons tagged and killed on the CSWMA

Dates of Weighing	Juvenile Male (Kg)	Juvenile Male Percent Weight Change	Juvenile Female (Kg)	Juvenile Female Percent Weight Change	Adult Male (Kg)	Adult Male Percent Weight Change	Adult Female (Kg)	Adult Female Percent Weight Change
7/18-12/11					5.67-6.12	7.4		
8/11-11/26							4.31-3.29	23.7
8/13-12/4							3.40-3.40	0.0
8/20-12/2	1.59-2.95	46.1						
9/10-11/26	1.93-3.06	34.9						
9/11-11/26					5.44-6.80	20.0		
9/11-11/27							4.31-5.22	17.4
9/13-11/25	1.36-2.95	53.9						
9/18-11/25							3.97-4.76	16.6
9/20-12/2							3.86-4.76	18.9
9/20-12/4					5.22-6.12	14.7		
9/21-11/27							4.08-4.31	5.3
9/23-12/3	2.04-2.72	25.0						
9/24-11/25			2.04-3.52	42.0				
9/27-11/25	2.72-3.29	17.3						
10/2-11/25	2.83-3.63	22.0						
10/2-12/2			2.15-3.06	29.7				
10/4-11/25	2.49-3.18	21.7						
10/8-11/26			2.61-3.29	20.7				
10/8-12/9			2.04-2.72	25.0				
10/3-12/10	2.72-3.40	20.0						
10/10-12/9	2.95-3.40	13.2						
10/16-11/25	2.49-3.40	26.8						
10/16-11/26	2.15-2.83	24.0						
10/16-12/2							4.54-4.31	5.1
10/16-12/4			1.81-1.81	0.0				
10/17-11/25	2.14-2.38	9.7						
10/17-12/10							3.52-3.29	6.5
10/17-12/11							3.63-3.63	0.0
10/18-12/10	2.61-2.61	0.0						

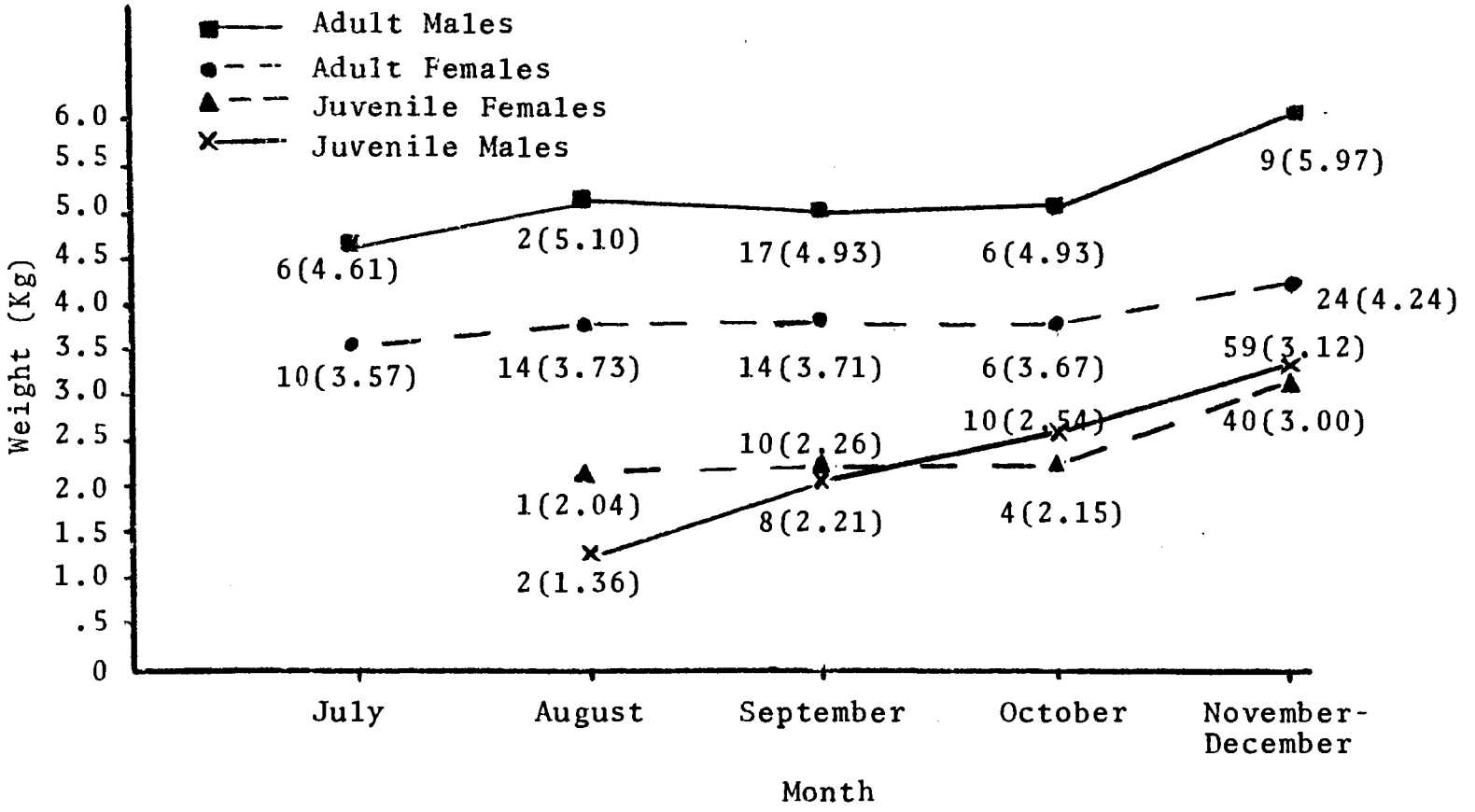


Figure 13. Monthly trends in the average weights of 40 adult male, 88 adult female, 79 juvenile male, and 55 juvenile female raccoons obtained on the CSWMA from 16 July to 11 December, 1976. The number outside the parentheses represents the sample size of raccoons weighed. The number inside the parentheses is the average weight of the sample.

fall and early winter is noted throughout the literature and coincides with the ripening of acorns (Stuewer 1943b, Keeler 1974, Johnson 1970). Stomachs analyzed from necropsied raccoons revealed that acorns were the most important food in the raccoon's diet at this time on the CSWMA. Johnson (1970) reported that acorns were most frequently listed as the most important food of raccoons. It should be noted that the weight of raccoons recorded during November-December is probably conservative due to a loss of blood before being weighed at the checking station.

Raccoon weights have been reported by investigators in various states (Table 7). Some exceptions are apparent, but there is a general tendency for the weights of raccoons to increase with increasing latitude. It is interesting to note that the average weight of male and female raccoons is greater in Tennessee than for other states reported in the Southeast (Alabama, Florida, South Carolina, and Virginia), with the exception of Mississippi. The average weight of raccoons reported from all other states is greater than the average weight reported in this study.

Some studies have tried to relate these differences in body weight between areas to soil fertility. Crawford (1950) described a direct relationship between raccoon weights and soil fertility in Missouri. Stains (1956) found that raccoons in Kansas weighed on the average 1.63 kg

Table 7. Average and maximum weights of raccoons according to location and sex, reported by various investigators

State	Males		Females		Season	Number Weighed	Age	Source
	Avg. Wt. (Kg)	Max. Wt. (Kg)	Avg. Wt. (Kg)	Max. Wt. (Kg)				
Florida (Keys)	2.40	-	-	-	-	5	Adult	Goldman (1950)
Florida (Keys)		2.72	-	-	-	-	Adult	Nelson et al. (1930)
Florida	5.44	8.07	4.72	5.81	Spring, Winter, Fall	67	Adult	Caldwell (1963)
Alabama	4.31	8.80	3.67	5.90	Year Round	451	Adult	Johnson (1970)
Mississippi	-	5.58	4.63	5.22	Spring	16	Adult	Cagle (1949)
S. Carolina	4.85	7.37	4.03	6.49	Year Round	158	Adult	Cunningham (1962)
Tennessee	5.12	6.80	4.18	5.22	Spring, Fall, Winter	108	Adult	This study
Virginia	4.22	5.72	3.12	4.58	Year Round	51	Adult	Soneshine and Winslow (1972)
Virginia	-	7.34	-	-	-	-	Adult	Kellner (1953)
Virginia	4.76	8.98	3.58	5.13	Winter	70	All ages	Shaffer (1948)
Missouri	6.76	15.88	5.94	-	Fall	8000	All ages	Nagel (1943)
Missouri	5.90	9.43	5.03	7.03	Winter	100	All ages	Twitchell and Dill (1949)
Missouri	6.67	-	5.40	-	Fall, Winter	284	All ages	Sanderson (1951)
Kansas	8.57	19.05	7.89	-	Winter	559	All ages	Stains (1956)
Ohio	6.49	8.85	5.67	6.35	?	11	Adult	Preble (1940)
Illinois	7.58	-	-	-	-	426	Adult	Sanderson (1960)
Connecticut	-	10.26	-	-	-	-	Adult	Whitney (1931)
Michigan	6.57	9.80	5.35	8.35	Summer	46	Adult	Stuewer (1943b)
Minnesota	7.58	10.12	6.44	9.12	Summer	24	Adult	Schoonover (1950)
Minnesota	7.94	11.79	6.89	9.89	Summer	59	Adult	Marshall (1956)
Minnesota	-	13.83	-	-	-	-	Adult	Baily (1923)
Wisconsin	-	28.30	-	-	-	-	Adult	Scott (1951)
Washington	5.22	7.71	4.54	6.40	Year Round	60	Adult	Scheffer (1950)
Maine	-	12.25	-	-	-	-	Adult	Whitney (1931)

more on highly fertile soils than on soils of low fertility. This difference, however, was not statistically significant. Johnson (1970) reported that "the differences in body weights of raccoons in Alabama were not related to soil fertility in any obvious way." No attempt has been made to relate weights of raccoons in Tennessee to soil fertility. Due to the frequency and extent of stocking programs in Tennessee, the genetic potential for weight of native raccoons has likely been altered. Therefore, a study relating soil fertility to weight would probably be invalid.

E. AGE STRUCTURE

Ages of 214 raccoons sampled by trapping and hunting exhibited a juvenile:adult ratio of 1.2:1, or a population consisting of 54.7 percent juveniles. The age ratio among males was 1.8:1; females had a ratio of 0.8:1. For a further detailed analysis of these data by sex and type of capture (live trapping vs. hunting), refer to the next section on Sex Ratios (Table 8 and Figure 14).

Juvenile raccoons represented 75 percent of the total kill in this study; this suggests a greater hunting vulnerability of juveniles compared to adults. Other studies in the South indicated a much smaller percentage of juveniles taken with dogs. Cunningham (1962) captured 25 percent juveniles with dogs. Caldwell (1963) reported 37 percent juveniles obtained by dogs in north-central Florida.

Table 8. Sex ratio of 214 juvenile and adult raccoons collected by trapping and hunting on the CSWMA

Method of Collection	Number Taken	Adults				Juveniles				Sex Ratio (Males: 100 Females)	
		# Males	% Males	# Females	% Females	# Males	% Males	# Females	% Females	Adults	Juveniles
Dogs	136	10	29.4	24	70.6	61	59.8	41	40.2	42:100	149:100
Live-traps	112	31	41.3	44	58.7	20	54.1	17	45.0	70:100	118:100
Total*	214	38	39.2	59	60.8	67	57.3	50	42.7	64:100	134:100

*Animals marked when trapped and killed during the hunting season are excluded from the total computations.

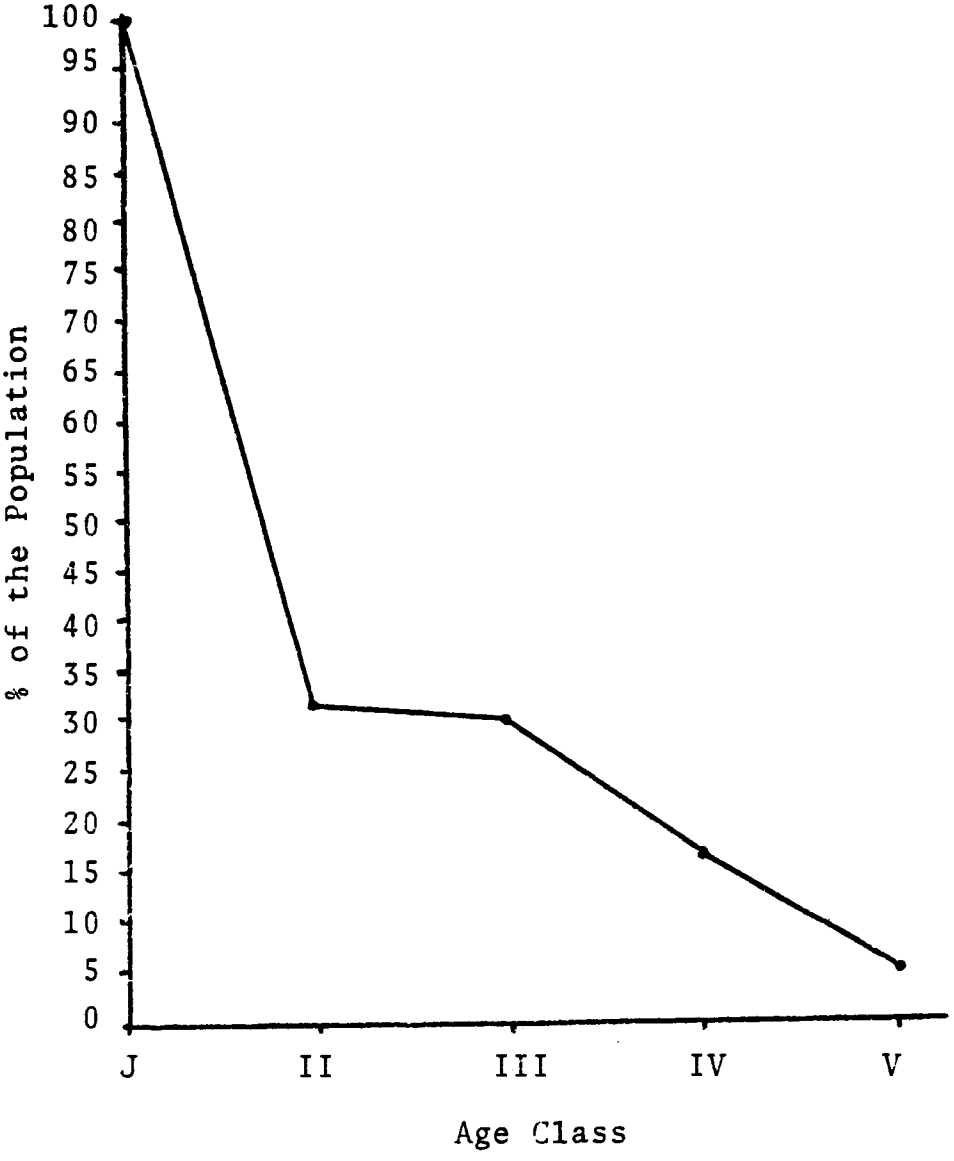


Figure 14. Age structure curve for 214 raccoons obtained on the CSWMA from 16 July to 11 December, 1976, showing approximate survival rates and turnover rates.

Johnson (1970) found that juveniles comprised 41 percent in 1938-1939, 34 percent in 1961, and 47 percent in 1963-1967, of the raccoons sampled by night hunting with dogs in three different areas of Alabama. These studies do not indicate the percentage of juvenile or adult raccoons in the population. Thus, comparisons of the influence of hunting on different age classes between areas cannot be evaluated. It should also be noted that the activity patterns of juveniles and adults under differing environmental conditions and the hunting history and productivity of an area are important aspects that must be considered in making such comparisons.

Sharp and Sharp (1956), studying the nocturnal behavior of raccoons at an artificial feeding station, found that old raccoons became active later at night than juveniles. Adults were noted to be more alert and apprehensive than young animals. Thus, according to Johnson (1970), collection with dogs may be biased if hunting is restricted to the first part of the night. During this study most hunters were hunting by 8:00 p.m. and had checked out of the area by 1:00 a.m. This may in part explain the high percentage of juveniles taken on the CSWMA.

F. SEX RATIOS

The sex ratio among 214 raccoons (105 males and 109 females) was 96 males per 100 females. A breakdown of the

sex composition into adult and juvenile age categories revealed that of 97 adults (38 males and 59 females), the sex ratio was 64:100. The 117 juveniles (67 males and 50 females) sampled showed a sex ratio of 134:100.

A comparison of sex ratios as determined by samples collected with live traps and dogs is presented in Table 8. Of 75 adults and 37 juveniles collected by trapping, the sex ratio was 70 males to 100 females and 118 males to 100 females, respectively. Of 136 animals collected with dogs, the sex ratio was 42 males to 100 females for adults and 149 males to 100 females for juveniles.

Several studies have indicated a live-trapping bias toward males. Urban (1970) reported that of 46 raccoons live-trapped, 30 were males and 16 were females, as compared to 11 males and 14 females using steel traps. Cunningham (1962) and Johnson (1970) found sex ratios much less in favor of males when dogs and guns were used for capturing raccoons instead of live traps. Cunningham concluded that collection with dogs provided a more representative sample of the actual sex composition of the population.

This study revealed that males made up 41.3 percent of the adults sampled by live-traps and 29.4 percent of the adults captured with dogs. This percentage difference indicates a bias toward males when live-traps were used. However, the small sample of 10 adult males collected with dogs may be the reason for the discrepancy between the two

capture methods. Also, only 9.7 percent (three of 31) of the adult males previously marked were recaptured during the hunting period, as compared with 20.5 percent (nine of 44) of the adult females. This suggests that adult males may be less vulnerable to hunting than adult females. According to Johnson (1970), females traveling with their young leave more scent than an individual male, increasing the chance of their trail being discovered by dogs. Thus, a pursued female has less chance of escaping the dogs because of the presence of young and her attachment to them.

Juvenile males made up 54.1 percent of the raccoons captured by live traps and 59.8 percent of the raccoons caught with dogs. Thirteen of 20 (65.0 percent) ear-tagged juvenile males and eight of 17 (47.1 percent) ear-tagged females were killed during the hunting period. There are several possible reasons for this apparent bias toward juvenile males captured with dogs. Sex-selective mortality factors acting on juvenile females between the trapping and hunting period may be responsible for the increase in juvenile males to females. The greater activity of juvenile males caused by the break-up of family groups at this time (Stuewer 1943b), possibly made them more susceptible to capture. Dispersal of juvenile females from the area between the trapping and hunting period may have caused the bias. This is unlikely, since there is no apparent reason why juvenile males would not also have dispersed from the study area.

If the sex ratio obtained from both sample methods are representative of the population, heavy male mortality is occurring. With such a high ratio of males to females among juveniles, one would expect to see approximately the same sex ratio in the adults unless there was sex-selective natural mortality, or dispersal, or some other factor acting on the male segment of the population. Also, if the chance of adult females being taken is greater relative to the proportion of females in the population, normal harvest by trappers and hunters would place much greater mortality on adult females than adult males. Thus, the true sex ratio of the population would be strongly in favor of adult males unless there was sex-selective natural mortality, or dispersal, or some other factor occurring among adult males.

Variability among sex ratios of raccoons has been reported throughout the literature (Table 9). These discrepancies are difficult to explain due to the inconsistencies between collection methods or type of area.

Figure 15 illustrates the monthly variation in sample sex ratios. It is difficult to ascertain the reasons for much of the variability over this time period, but it is apparent that sample size during each month may be important. Johnson (1970) was able to find indications of bias by plotting the same type of information from Alabama over a one year period. He conjectured that the large number of males recorded in February and March reflected greater

Table 9. A comparison of raccoon sex ratios according to season of the year, as reported by previous investigators

Year	Sex Ratio (Males Per 100 Females)	Number Sexed	Season	Location	Source
1956-68	168	248	All year	Alabama	Johnson (1970)
1941	100	256	Fall	Arkansas	Giles (1943)
1961-63	149	117	All year	Florida	Caldwell (1963)
1951	108	79	-	Iowa	Cabalka et al. (1953)
1951-54	150	918	Fall, Winter	Kansas	Stains (1956)
1946	70	34	-	Louisiana	Cagle (1949)
1947-51	80	492	All year	Maryland	Llewellyn (1952)
1939-40	108	256	All year	Michigan	Stuewer (1943a)
1949	114	47	Summer	Minnesota	Schoonover (1950)
1934	127	306	Fall	Missouri	Bennitt & Nagel (1937)
1939	178	-	Winter	Missouri	Dellinger (1954)
1940	150	10,769	Fall, Winter	Missouri	Noren (1941)
1941	190	3,360	Winter	Missouri	Sanderson (1951)
1942	154	10,974	Fall	Missouri	Nagel (1943)
1948	67	100	Winter	Missouri	Twitchell & Dill (1949)
1949	100	956	Winter	Missouri	Sanderson (1951)
1954	92	-	Winter	Missouri	Dellinger (1954)
1939	126	132	Fall	Ohio	Preble (1940)
1948	137	311	Winter	Ohio	Petrides (1950)
1955-56	88	386	All year	Ohio	Sager (1956)
1967-68	187	46	-	Ohio	Urban (1970)
1954-56	170	49	All year	S. Carolina	Wood & Odum (1964)
1961	140	223	Winter, Spring, Summer	S. Carolina	Cunningham (1962)
1973-74	76	111	All year	Tennessee	Keeler (1974)
1975-76	113	32	All year	Tennessee	Warr (1977)
1976	96	248	Summer, Fall	Tennessee	This study
1950-51	93	71	All year	Texas	Wood (1955)
1947	223	84	Winter	Virginia	Shaffer (1948)
1951-52	145	123	All year	Virginia	McLaughlin (1953)
1967-70	164	74	All year	Virginia	Soneshine & Winslow (1972)
1967-70	122	40	All year	Virginia	Soneshine & Winslow (1972)
1946-48	101	123	All year	Washington	Scheffer (1950)

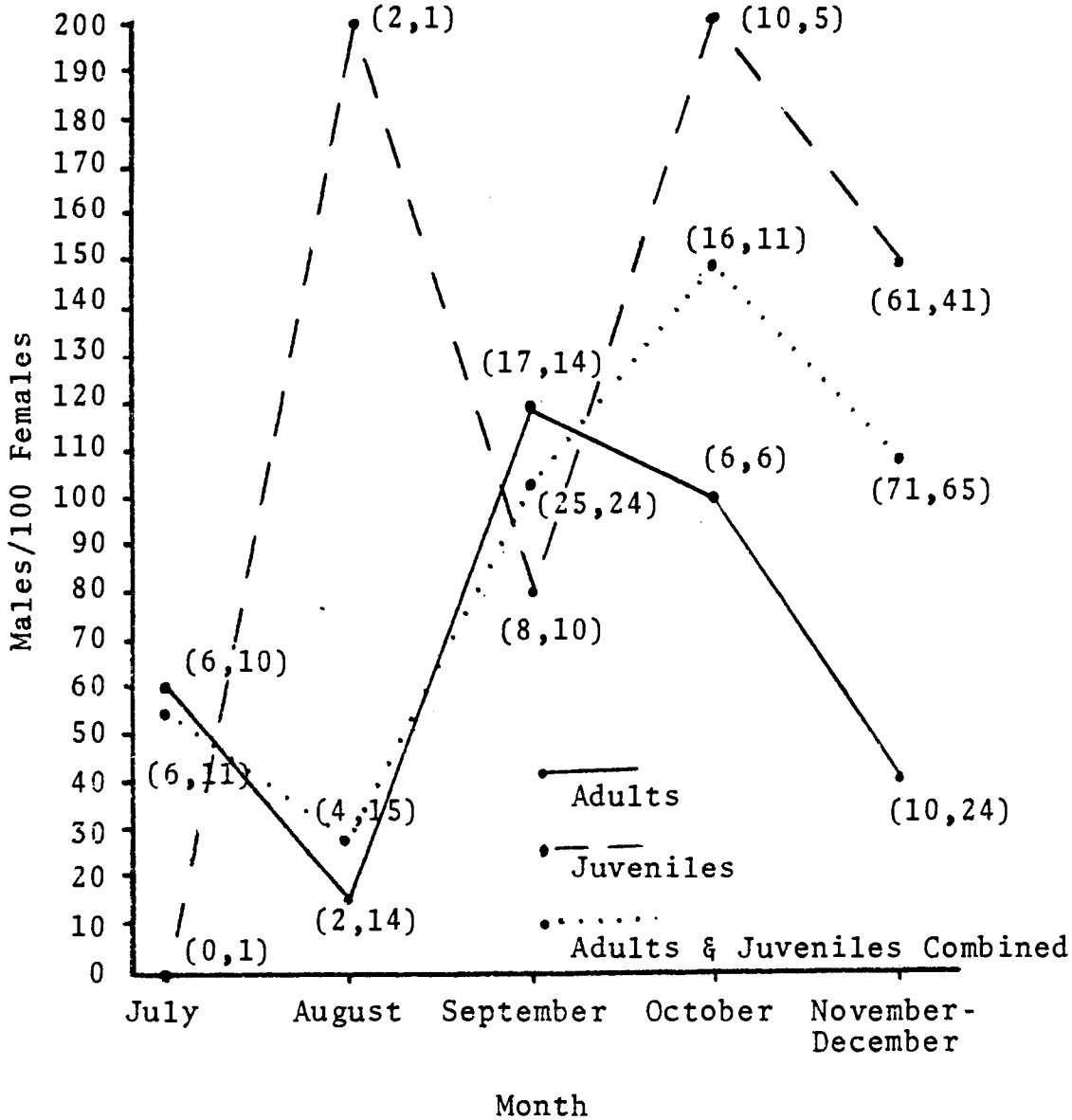


Figure 15. Monthly variation in sex ratios based on 248 raccoons obtained on the CSWMA from 16 July to 11 December, 1976. Numbers in parentheses indicate the number of male and female raccoons examined, respectively. Animals marked when trapped and killed during the hunting season are included in the Adults and Juveniles Combined data.

activity and movement of males visiting females that were sexually active. An extremely high percentage of males (3 to 1) in May and June probably resulted from the reduced activity of pregnant and lactating females.

G. BREEDING AND REPRODUCTION

Sexual Maturity

Assuming all males and females in Age Class II are yearlings, several comparisons about sexual maturity can be made. The size of the baculum of the yearling males is approximately the same size as the baculum of adults. In all cases, however, the juvenile baculum is obviously smaller (see the section on Baculum Size and Ossification). This is in agreement with Stuewer (1943a) and Johnson (1970). Twelve of 20 of the yearling females had produced young or 60 percent had reproduced as juveniles. This is a higher percentage of juveniles producing litters than any reported in the literature. This observation could be verified by obtaining information on marked juvenile females over a two-year period. This information is important in determining the contribution of juveniles to the overall productivity of the population.

Observations on the age at which raccoons become sexually mature apparently vary among investigators. Pope (1944) reported both male and female raccoons mate in captivity during their first year. Stuewer (1943a) stated

that the testes of juvenile males in Michigan did not reach adult size until fall after the first breeding season. He found that females denning with juvenile males did not produce offspring. Stuewer (1943a) also noted that 15 of 28 yearling females produced litters or 53.6 percent had reproduced as juveniles. Whitney and Underwood (1952) reported infertility in males until their second year. Bissonnette and Csech (1938) concluded that most female raccoons in southwestern Washington did not become pregnant during their first breeding season. Sanderson (1951) stated that all males in Missouri are probably sexually mature their first year but not as early in the season as adult males. Later work by Sanderson (1961b) in Illinois revealed that one-half to two-thirds of the juvenile males become sexually active three to four months later than adults. Wood (1955), working in the Post Oak Region of Texas, reported that 40 percent of the yearling females had reproduced as juveniles as evidenced by placental scars, and 20 percent of the one year old males possessed sperm. Johnson (1970) found that less than 10 percent of the yearling females in Alabama had reproduced as juveniles. He further stated that smears from the epididymes of 15 juveniles were all negative for sperm. Five yearlings examined in December were all positive for sperm. The testes of male raccoons were not removed and examined for sperm in the present study. It was assumed

that juvenile males are infertile until the second breeding season as mentioned above.

The above studies indicate that the number of juvenile females producing litters varies between areas. The discrepancies involved in aging female raccoons older than one year may have caused some of this variability. In most cases, juvenile males are not sexually mature during the breeding season but mature later in the summer or fall. Sexual maturity and activity of juveniles may be related to diet or population density or both.

Time of Breeding and Reproduction

The breeding season on the study area was approximated to be in February and March. The estimated birth of 88 young was between April and June. Seven yearlings (collected in December with eye lenses weighing between 54.2 mg and 68.1 mg) were probably born in August ± two months. One female examined in December was lactating. Assuming a normal lactation period of three months (Berard 1952), she could have given birth no earlier than September.

Latitudinal variation in the breeding season of raccoons is discussed throughout the literature. Raccoons generally breed from January to March in the northern states with the peak occurring in February (Hamilton 1936, Sanderson 1951, 1961b, Stuewer 1943b). The average gestation period is about 63 days (Hamilton 1936, Stuewer

1943b) with most births occurring in late April. However, several authors have reported unusually early and late births (Whitney 1931, Hamilton 1936, Stuewer 1943a, George and Stitt 1951, Dorney 1953, Stains 1956, Lehman 1968).

In the colder climates, the early reproductive season is probably an adaptation to cold winters. The contribution to the total productivity of a population from late born young is probably insignificant (Johnson 1970). Juveniles born so late have a poor chance of surviving because of low fat reserves (Mech et al. 1968).

Breeding and reproduction normally occur later in the southern latitudes. In West Virginia, Berard (1952) found a lactating female that he concluded gave birth to young no later than August. Births normally occur there before 15 May; this female would have mated in June. McKeever (1958) examined 241 female raccoons collected from southwestern Georgia and northwestern Florida from January to December. Seventeen were pregnant. From these data, he concluded that breeding occurred from February to August with a peak in March. Young were born from April to October; two peaks in pregnancies occurred, one in March and April and a second, smaller peak in August. This phenomena is probably the result of a second estrous which occurs among some females that do not breed during the regular breeding season (Stuewer 1943b, Whitney 1952, Sanderson 1961b, Bissonnette and Csech 1938). On the

Savannah River Plant in South Carolina, Cunningham (1962) reported March as the peak of the breeding season. Based on the weights of five juveniles captured in November, January, and April, he felt that breeding occurred throughout the year to some extent. From north-central Florida, Caldwell (1963) stated that the breeding season extended from early December to early August, but was probably a year-round occurrence. Arthur (1928) stated that the raccoons of Louisiana give birth to their young during February, March, and early April. He reported a pregnant female captured near Boutte on 9 February which contained four advanced fetuses. Cagle (1949), working less than 160.93 km south of Boutte, found six of seven females collected on 3 May to be pregnant and 10 of 11 females collected on 25 May to be post-partum. Johnson (1970) found that the mean birth date for 18 litters in Alabama was 18 June with the range extending from 4 May to 27 August. It appears that the warmer winters of the southern latitudes may exert less selection pressure for earlier births. More late-born young are able to survive, resulting in greater genetic variability for the time of breeding (Johnson 1970).

The onset of breeding is partially stimulated by increased daylight. Bissonnette and Csech (1938, 1939) were able to obtain two litters from captive animals by artificial lighting of the pens which brought about first matings in December and a second in May or June. In addition,

they showed that a diet high in protein was related to an increase in the length of the breeding season. Tennessee is geographically located to provide a relatively large number of daylight hours, as compared to more northern areas, which may well lengthen the breeding season. Furthermore, the comparatively mild Tennessee climate may provide raccoons with high protein foods in the form of insects, crayfish, frogs, and other animal life for a longer time period than in areas further north. Therefore, such factors as shortening of the photoperiod, shortage of winter protein, and cold weather, any or all of which may restrict the breeding season of northern raccoons, may not greatly influence raccoons in parts of Tennessee and other southern states (Caldwell 1963).

Litter Size

Twenty females that had previously produced offspring were necropsied during the hunting period. Fifteen reproductive tracts contained three placental scars; three contained two scars each; and two contained one and four scars, respectively. The average number of scars per female was 2.8.

Variations in the litter size of raccoons have been reported for many regions of the United States (Table 10). The litter sizes of raccoons are generally larger in the northern latitudes, but several exceptions exist. Several

Table 10. Variation in litter size of raccoons in the United States

Locality	Source	Litter Size	
		Sample	Mean
Alabama	Johnson (1970)	101	2.5
Florida (northeastern coast)	Ivey (1948)	1	5.0
Florida (northeastern) and Georgia (southwestern)	McKeever (1958)	17	3.2
Illinois	Sanderson (1960)	?	3.5
Kansas	Stains (1956)	8	4.6
Louisiana (coast)	Cagle (1949)	6	3.8
Maryland	Llewellyn (1952)	12	2.3
Michigan (southern)	Stuewer (1943a)	11	4.0
Missouri	Sanderson (1950)	22	3.8
New York	Llewellyn (1952)	4	5.0
North Carolina (coast)	Llewellyn (1952)	10	1.9
South Carolina (western)	Cunningham (1962)	13	2.8
Tennessee	This study	20	2.8
Texas (eastern)	Wood (1955)	26	3.4
Virginia	Kellner (1954)	5	4.4
Washington	Scheffer (1950)	7	2.0

explanations for the geographic variability have been proposed.

Litter size is directly related to food quality through soil fertility. The largest litter sizes have generally been reported from the fertile prairie soils. The smallest litter sizes seem to occur on the relatively infertile, leached soils of the Southeast. This appears to be the case for the CSWMA. Stevens (1962) in Ohio and Williams and Caskey (1965) in Missouri reported direct relationships between litter size and soil fertility for the cottontail rabbit. Bissonnette and Csech (1938) showed that protein intake affected the litter size of penned raccoons.

High winter mortality in the northern latitudes (Mech et al. 1968), resulting in a smaller breeding population in late winter, may cause compensating reproductive responses, due to a physiological response to low density (Lord 1960). French et al. (1965) and Errington (1956) reported this inverse relationship between density and the number of offspring produced for blacktailed jackrabbits and muskrats, respectively.

The genetic potential of a species to produce offspring varies because of selective pressures acting differently on populations between areas. Bissonnette and Csech (1938) found that the number of young produced by individual female raccoons of known breeding history

was fairly constant, although there was considerable variation between females in the number of offspring produced. Since all animals were provided the same food, this suggests genetic variability in reproductive capacity. Raccoons of different geographic strains should be reared under standardized conditions to determine the extent to which this variation is genetic. The stocking of raccoons with a comparatively high reproductive potential into areas of low population numbers under restricted hunting conditions may prove effective to increasing population levels in a relatively short period of time. Harvests may also be sustained at higher levels than were previously realized.

H. DENSITY

The population size of raccoons was calculated at 366 or approximately one raccoon per 27.5 ha. This is based on the sum of the number of juveniles (175 $\pm$ 68) and adults (191 $\pm$ 83) of both sexes which was calculated to be 88 $\pm$ 44 for juvenile males, 87 $\pm$ 55 for juvenile females, 78 $\pm$ 60 for adult males, and 113 $\pm$ 59 for adult females. It was felt that this estimate was a more adequate measure of the actual population size than the Lincoln Index calculation (436 $\pm$ 130) since the probability of capture, mortality, or dispersal is more equal among members of the same sex and age class. Fewer assumptions of the Lincoln Index are violated if the population size is figured in

this manner. Raccoon population densities in other parts of the United States have also been reported by several investigators (Table 11).

Several studies indicate that hunting may be extremely influential in regulating raccoon populations. Twitchell and Dill (1949) estimated one raccoon per 0.26 ha for 41.3 ha of excellent habitat and one raccoon per 0.81 ha for 809.7 ha of good habitat in Missouri. This unusually high density was from an area that had been closed to all hunting for 10 years. Cunningham (1962) reported a density of one raccoon per 4 ha on his 1,443.7 ha study area. He found that his efforts at collecting with dogs on the Savannah River Plant study area, which was closed to hunting for 10 years, were five times as successful as on comparable adjacent areas that were hunted. After two years' restriction of hunting, Stuewer (1943b) noted a 17 percent increase in raccoons on his study area. On the 14,170 ha Wheeler National Wildlife Refuge in northern Alabama, Atkeson and Hulse (1953) found that a marked decline in the number of raccoons, indicated by a declining harvest, occurred following removal of about one raccoon per 28.3 ha for three years and one raccoon per 21.5 ha in one year. Johnson (1970) reported that according to harvest records, this population apparently recovered after the season was closed from 1960 through 1965. On the CSWMA, several hunters indicated that the population was much higher after the area was closed to hunting for five years.

Table 11. The density of raccoons reported from different regions of the United States

State	Density	Source
Alabama	1/21.5 ha[1]	Atkeson and Hulse (1953)
Illinois	1/6.1 ha[1]	Yeager and Rennels (1943)
Illinois	1/5.7 ha[2]	Urban (1970)
Michigan	1/6.6 ha[2]	Stuewer (1943a)
	1/12.5 ha[2]	
Missouri	1/0.26 ha[3]	Twitchell and Dill (1949)
	1/0.81 ha[3]	
Ohio	1/2.4 ha[2]	Williams (1936)
Ohio	1/9.6 ha[2]	Butterfield (1954)
	1/10.9 ha[2]	
	1/42.9 ha[2]	
South Carolina	1/4 ha[2]	Cunningham (1962)
Tennessee	1/17.8 ha[2]	Keller (1974)
	1/52.6 ha[2,5]	
Tennessee	1/23.1 ha[2]	This study
Texas	1/10.1 ha[1]	Lay (1939)
	1/16.2 ha[1]	
Virginia	1/5.8 ha[2]	Soneshine and Winslow (1972)
Wisconsin	1/33.2 ha[4]	Dorney (1954)
	1/44.5 ha[4]	

[1]Obtained by the number of raccoons killed on the area.

[2]Obtained by mark-recapture data from trapping.

[3]Obtained by removing raccoons from dens.

[4]Obtained by counting the number of occupied tree dens and assuming 2 raccoons per den.

[5]Obtained after an outbreak of canine distemper.

The density of raccoons on the CSWMA is one of the lowest reported in the literature. Many of these studies show that raccoons have the potential to live under much more crowded conditions than are found on the CSWMA.

I. MORTALITY

Juvenile mortality can be estimated by knowing the number or percentage of the female population that actually breeds and the average litter size. In this study 51 of 109 (46.8 percent) of the sample female population bred. Assuming an average litter size of 2.8 and no juvenile mortality or dispersal from the CSWMA during the time of the study, the fall sample population hypothetically consisted of 143 juveniles (51 x 2.8). The actual number of juveniles in the sample was 117. This difference represents an 18.2 percent mortality $\left(\frac{143-117}{143} \times 100\right)$ of juveniles between the trapping period and the hunting season.

Stuewer (1943b) reported no evidence of natural mortality among juveniles. He felt that populations in Michigan were controlled primarily by hunting and trapping. In Missouri, Sanderson (1950) marked 11 juveniles in the den when they were only a few weeks old. All 11 were still alive at mid-summer or fall. He indicated that natural mortality among juveniles was less than 10 percent. Cunningham (1962) captured 13 family groups in South

Carolina and found 79 percent of the placental scars were accounted for by young with the females, indicating a 79 percent juvenile survival. On the other hand, Llewellyn (1952) reported heavy losses of juveniles by the fall in Maryland. In Minnesota Mech et al. (1968) reported only two of seven litters studied survived through the winter. Most losses occurred in March resulting from starvation and parasitism.

Information on the natural mortality of adults is limited. Johnson (1970) reported that the greatest mortality of raccoons in Alabama occurred during the second year of life. He could not explain this, but assumed that much of the mortality was related to dispersal. Stuewer (1943b), Sanderson (1950), and Johnson (1970) attributed most adult mortality to exploitation by man. Keeler (1974) compared raccoon population densities before and after an outbreak of canine distemper in the Cades Cove area of the Great Smoky Mountains National Park in Tennessee. The density changed from one per 17.8 ha to one per 52.6 ha. Other studies of mortality from canine distemper in raccoons have been reported by Mangold (1951) in Iowa, Sanderson (1960) in Illinois, Mech et al. (1968) in Minnesota, and Johnson (1970) in Alabama. This disease may play a significant role in regulating populations at high densities, but is probably a relatively minor mortality factor at low densities (Johnson 1970).

Due to the frequency of contact, high densities may aid in the spread of some disease resulting in severe mortality. On the CSWMA hunting under certain conditions may deter the spread of disease by reducing population levels, thus allowing the population to be maintained at a higher level for a greater period of time than in areas with no hunting. Except for hunting, no other evidence of adult mortality was found in the present study.

J. LONGEVITY

Petrides (1949) stated that the general equation expressing the relationship between the average longevity (L) of a stable population and its percentage of grown first year animals or mortality rate (j) is:

$$L = \frac{1}{j} .$$

In the present population which consisted of 55 percent juveniles, L equals 1.8 years. The average longevity calculated by Sanderson (1951) and Johnson (1970) was 1.8 years and 3.1 years, respectively. The high hunting pressure on the CSWMA is possibly responsible for the low average longevity of raccoons.

Little information is known concerning the longevity of raccoons in the wild. Haugen (1954) reported a female being shot 12 years and 1 month after initial capture and marking as a juvenile. Flower (1931) reported the potential longevity of raccoons to be about 16 years. In this study

tooth sectioning revealed one female raccoon with 10 to 12 dental annuli.

K. MOVEMENTS

Movement data indicated that about 88 percent of the recaptures (37 of 42) were within 1.61 km of the original capture site. Approximately 12 percent (5 of 42) were between 1.77 and 2.74 km. Hunters reported a juvenile female and adult female taken 3.54 and 6.44 km from the first point of capture. This information is not representative of the sample data and is, therefore, not included in the calculations.

The linear distance traveled by a raccoon on the CSWMA is not representative of the actual distance traveled due to the topography of the area (Table 12). It does, however, allow for comparisons to be made between the sex and age classes. The average distance traveled by an adult raccoon is greater than for juveniles. Adult males on the average traveled 0.22 km farther than adult females. These findings are consistent with most studies reported in the literature.

Before the advent of radio transmitters for animals, trap-retrap and tag-return data provided information about the movements of raccoons. Stuewer (1943b) found the average distance traveled by seven adult males was 1.61 km, with a minimum and maximum distance of 0.40 and 2.41 km.

Table 12. Movement of raccoons as determined from distance between points of capture by trapping and hunting on the CSWMA from 16 July to 11 December, 1976

Linear Distance in Km Traveled Between Captures			
Juvenile		Adult	
Males	Females	Males	Females
1.77	0.97, 0.16[1]	1.77	2.74
1.13	0.32	1.61	0.16
1.45, 0.80, 0.32[1]	0.32	1.61, 0.97, 0.16[1]	0.80
0.80	0.97	1.21	1.29
1.45, 0.64[1]	0.32	1.29	0.80
0.32	1.45, 0.64[1]		0.97
0.40	1.21		0.40
0.32	3.54[2]		6.44[2], 0.97[1]
0.32	0.32		0.48
0.32			0.64
2.41			2.09
0.80			1.61
0.48			1.29
1.29			0.48, 0.16[1]
0.40			
0.64, 0.48[1]			
Avg. 0.84	0.68	1.22	1.00

[1]Represents data from 3 or 4 captures and figured into the average calculation.

[2]Not included in the average calculation because it is unrepresentative of the sample.

Thirteen females averaged 1.21 km, ranging from 0.40 to 3.62 km. Butterfield (1944) retrapped 91 raccoons in Ohio over a two-year period. The greatest distance moved by any one animal did not exceed 1.61 km. The average distance from release site to recapture was slightly greater than 0.40 km. Lueth (1962) reported 448 raccoons caught in steel traps set in permanent locations 0.16 km apart on various game management areas in Alabama. The average distance between recaptures was 1.29 km. The maximum distance was 8.21 km. Cunningham (1962) reported a maximum of 1.42 km between captures of adult males and an average of 0.43 km for adult females.

With the use of radio telemetry to study animal behavior, much knowledge has been gained on the movement of raccoons. Ellis (1964) monitored seven raccoons on two different areas in Illinois for periods up to 18 days. The average estimated home ranges of his raccoons were 54.7 and 68.0 ha. He suggested that in areas of high population density, raccoons move less and occupy smaller home ranges. He also found that movement patterns were affected by available sources of corn. Mech et al. (1966), reporting on 173 daytime resting sites of seven raccoons in Minnesota, found much variation in activity radii and unpredictable shifting of resting sites. His data further suggested that raccoons spaced their daily resting sites so as to maintain a certain minimum distance between them.

Schneider et al. (1966) monitored five adult females and eight young raccoons in Minnesota for eight months. Adult movement ranged from 1.61 to 4.02 km in diameter. Geis (1966) monitored nine raccoons in South Dakota. He noticed significant differences between sex and age groups and an influence of food availability on seasonal ranges. Urban (1970) also observed that the size of the raccoon home range varied, depending on the age-class of the individual. Sunquist (1967) reported on the movements of a family group of four raccoons on an area following a controlled fire. He found that home ranges varied between 64.0 to 95.6 ha. Johnson (1970) studied the winter and spring ranges of a yearling female and adult male raccoon. The female's home range encompassed 46.2 ha as compared to 99.2 for the male. Most movement was along a stream and its tributaries. He also noted that raccoons moved far outside their usual home ranges to establish temporary centers of activity about an especially attractive food source such as a corn field, plum thicket, or abundant supply of persimmons.

Approximately 16.19 ha of corn was planted on the CSWMA during this study. Trapping was conducted in and around these areas, but no raccoons were captured. This indicates that these areas were not extensively used, or that the abundance and/or preference of corn over sardines (used as bait) greatly influenced the raccoons' susceptibility to trapping. The effect of the dispersion of

alternate food sources on the distribution of animals should be considered before plantings are conducted.

A major portion of the trapping effort and captures of raccoons were along water courses and dry creek beds. This reaffirms the work of several investigators (Butterfield 1954, Stuewer 1943b, Johnson 1970, Clements 1972) who found that waterways are used extensively as travel routes by raccoons.

Stuewer (1943b) was the first to report dispersal of young raccoons. He reported that emigration usually occurred during the first fall. However, some juveniles remained over winter, emigrating in the spring, and some did not disperse. The average distance traveled by nine dispersing males was 18.91 km. A maximum of 43.45 km and a minimum of 5.63 km were reported. For five dispersing females, extremes of 25.75 and 7.24 km were recorded, with a mean of 13.28 km. Priewert (1961) and Lynch (1967) reported movements of approximately 265.53 km by two tagged young males in Minnesota and Manitoba. The longest movement recorded for juveniles in the present study was 1.77 km. The average distance traveled was 0.84 km for juvenile males and 0.68 km for juvenile females. These data do not indicate that the dispersal of juvenile raccoons is occurring or has occurred on the CSWMA.

Some researchers have found that stocked raccoons wander many kilometers from release. Giles (1943) reported

on movements in Arkansas of 19 raccoons relocated to new refuge sites. He concluded that the females wandered much less than the males. The farthest movement was by a male which had gone 120.70 km in 75 days. Others had moved from 3.22 to 53.11 km. He felt that the diversity of environmental conditions between the original habitat of the raccoons and the terrain in which they were introduced may well have been the cause of their long and haphazard dispersal. He observed no indication of any directional or homing instinct. Johnson (1970) obtained movement data from only one of 178 transplanted raccoons. It was killed 4.83 km from where it was released. He reasoned that more of these raccoons would have been recovered if they had remained in the area where they were released. Clements (1972) equipped seven raccoons with radio transmitters and released them into unfamiliar territory on the Little River area of southwest Virginia. The period in which they were monitored ranged from one hour to three days with a maximum linear movement of 13.36 km.

Other studies have shown that stocked raccoons may establish residence fairly close to release sites. Stuewer (1943b) reported that 50 raccoons stocked on a refuge in Michigan moved little more than native raccoons. The distances that these raccoons were killed from release locations varied from less than 0.40 to 9.66 km. Adults averaged 3.22 km and juveniles averaged 4.83 km. It should

be noted that these raccoons were pen-reared. Frampton and Webb (1973), following 10 raccoons with radio transmitters, found that released raccoons did not immediately begin a movement over long distances but remained relatively close to their release locations. Movements were somewhat gradual. They suggested that relocating raccoons into areas of low population levels can be successful. Movements of transplanted raccoons over extended periods of time and for long distances have yet to be determined with radio telemetry.

The CSWMA would be an excellent location in which to study the movements of stocked raccoons and to evaluate the effects of such a program on raccoon population levels. Being surrounded on three sides by Norris Lake, raccoons could only disperse by land in one direction from the refuge. Also, the lake may act as a natural barrier to the movement of many animals. As a result, stocked raccoons may become established due to the confining aspects of the area.

L. RECOMMENDED HARVEST STRATEGIES

The continuation of dog training sessions on the CSWMA during September and early October should be reconsidered. This activity may break up family units and, as a result, orphaned young may have a reduced chance of survival (Johnson 1970). During this study several hunters reported that raccoons are killed during these training periods.

According to Johnson (1970) the destruction of family groups may also result if hunting is allowed before 1 December. Reports by hunters during the present study indicated that three to five raccoons were captured up the same tree. This indicates that the family group may not be dissolved at this time and may still play an important role in juvenile survival. A delay in the hunting season until January or early February might provide the necessary time needed for juveniles to become self-sufficient.

It is difficult to anticipate the effects of hunting on this raccoon population with the limited information available. No study to date has assessed the effect of various harvest strategies on a raccoon population. However, now that preliminary population information has been obtained on the CSWMA, an estimate of population size can be determined yearly. This would require setting up a checking station during each hunt and collecting information on the number of hunters and on the sex and age structure of the raccoon population. Different harvest rates could be set and their effects evaluated. The effectiveness of a stocking program could be analyzed.

It is the opinion of the author, based upon the density of raccoons and the reports of hunters on the study area, as well as raccoon densities and the effects of hunting as reported in other studies, that the CSWMA can produce many more raccoons than are now present. By

reducing the hunting season from nine to three nights and allowing a take of two raccoons per party per night instead of one, the harvest rate for the hunting season would be reduced from nine raccoons per party to six raccoons per party. This reduction would probably result in a decrease in the overall harvest the first year or two. The decreased hunting pressure might give the raccoon population a chance to increase. Hunter success should simultaneously increase. An increased amount of hunting time would also be achieved for hunters capturing a raccoon early in the night. A six-night hunting season allowing one raccoon per party should accomplish a similar increase in the raccoon population. It should be stressed that environmental conditions (extreme cold, disease, etc.) can greatly influence raccoon populations. As a result, these recommendations may need to be altered to fit the situation.

Recommendations on habitat improvement have been discussed by Johnson (1970) and Safley (1974).

CHAPTER V

SUMMARY

1. A study of the biology of the raccoon (Procyon lotor) on the CSWMA in east Tennessee was conducted from July 1976 to December 1976. Objectives were to obtain preliminary information on ecologically important aspects of life history and population structure to aid in the establishment of a sound management program for this species.

2. The trapping and marking of 112 raccoons along with necropsy data from 136 raccoons provided information on weight and length measurements, age, sex, breeding and reproduction, density, mortality, longevity, and movements. Published data relating to these various aspects of raccoon biology were synthesized and discussed in relation to the present study.

3. Eye lens weight, body weight, dental annuli, tooth attrition, baculum weight and ossification, and teat size and coloration were used as aging criteria. The eye lenses of all but one juvenile weighed less than 100 mg. The average eye lens weight for juveniles and adults was 85.7 and 139.2 mg, respectively. Weight frequency histograms were constructed from the weights of animals trapped and killed. These provided data that permitted the segregation of animals into two age classes (juveniles and adults)

on the basis of weight. Dental annuli counts could not be used to separate animals into yearly age classes due to the indistinct layering in the cementum. The teeth of all juveniles prepared by this method split and could not be sectioned. Five age classes were established by tooth attrition. The accuracy of this method could not be determined. The baculum of all juveniles weighed less than 1 g with cartilage present on the distal end. Adult bacula weighed greater than 3 g with no cartilage present. The size and pigmentation of the teats provided a useful means for distinguishing juveniles from breeding adult females.

4. Weights were recorded for 108 adults and 135 juveniles. The average weight of 40 adult males was 5.12 kg. For 68 females, the average weight was 4.19 kg. The average weight of 79 juvenile males and 56 juvenile females was 2.19 kg and 2.78 kg, respectively. All juvenile and adult males increased in weight during the present study. Of five adult females, three showed a decline in weight and two others did not change. This may be attributed to the production of late litters. Except for Mississippi, the average weight of male and female raccoons is greater in Tennessee than other states reported in the Southwest.

5. The age structure showed a juvenile:adult ratio of 1.2:1. The age structure among males was 1.8:1. Females had a ratio of 0.8:1. Seventy-five percent of the

animals killed during the hunting season were juveniles, indicating the great vulnerability of juveniles to hunting. Hunting may be biased toward juveniles if hunting is restricted to the first part of the night.

6. The sex ratio among 214 raccoons (105 males and 109 females) was 96 males per 100 females. A breakdown of the sex composition revealed that of 96 adults, 38 were males and 59 were females. Of 117 juveniles, 67 were males and 50 were females. These ratios reveal that sex-selective natural mortality or dispersal or both is probably occurring among male raccoons.

7. A live-trapping bias was noted for adult males. Adult males also appear to be less vulnerable to hunting than adult females. Hunting resulted in a bias toward juvenile males. The sex-selective mortality of juvenile females, the greater activity of juvenile males, or the dispersal of juvenile females from the area may have caused this bias.

8. Hunting data revealed that temperature and rainfall may greatly influence hunter success.

9. The time of breeding as determined from eye lens weight, occurred during February and March. Young were born between April and June. The eye lens weight from seven juveniles indicated late births occurring around August. Possibly 60 percent of the yearling females produced litters. The mean litter size, obtained from

placental scar counts of 20 females, was 2.8.

10. The population size of raccoons on the area was estimated at 366 raccoons or one raccoon per 27.5 ha. Average longevity was calculated to be 1.8 years. Hunting may be extremely influential in regulating raccoon populations. Average longevity is probably reduced on areas with high hunting pressures.

11. Juvenile mortality before the hunting season was calculated to be 18.2 percent. With the exception of hunting, no adult mortality was noted.

12. Movement data revealed that 88 percent of the recaptures were within 1.61 km of the original capture site. The average adult distance traveled was greater than for juveniles. Adult males on the average traveled 0.22 km farther than adult females.

13. Norris Lake, surrounding the CSWMA on three sides, may act as a natural barrier to the movement of stocked raccoons. As a result, they may become established on the area.

14. The continuation of dog training sessions on the CSWMA during September and early October should be reconsidered.

15. A delay in the hunting season until January or early February might prevent the possible destruction of family groups.

16. A decrease in hunting pressure may result in an increased raccoon population and increased hunter success.

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APPENDIX

APPENDIX A

Table 13. Body measurements by sex and age of raccoons collected on the CSWMA

Measurement	Sex-Age Group	Trapping Sample Size	Trapping Mean (mm)	Hunting Sample Size	Hunting Mean (mm)	Combined Sample Size	Combined Mean (mm)
Total length	JF	17	634.25	33	617.72	50	662.94
	JM	20	628.02	43	684.91	63	666.85
	AF	43	711.20	14	739.32	57	718.11
	AM	28	745.67	6	795.78	34	754.51
Tail length	JF	17	200.15	33	201.66	50	201.15
	JM	20	198.12	43	205.86	63	203.40
	AF	43	216.50	14	214.99	57	216.12
	AM	28	227.47	6	213.78	34	225.05
Hind foot length	JF	17	97.54	33	104.10	50	101.87
	JM	20	100.33	43	102.63	63	101.90
	AF	43	102.78	14	103.87	57	103.05
	AM	28	108.63	6	112.18	34	109.26
Ear length	JF	17	53.85	33	55.42	50	54.89
	JM	20	51.05	43	55.53	62	54.12
	AF	43	53.75	14	56.24	57	54.36
	AM	27	55.74	6	61.38	33	56.77

VITA

Jerry Wallace Woods was born in Oklahoma City, Oklahoma, on November 27, 1952. He is the son of Mr. and Mrs. A. Jay Woods. He has two older brothers, Ben and Woodrow, and two younger brothers, Jim and Dan. He is married to the former Cathy Lynn Dutton.

Mr. Woods attended elementary school in Oklahoma City, Oklahoma, then moved to Mansfield, Texas, and graduated from Mansfield High School in May 1971. He entered Texas A & M University in September 1971 and received a degree of Bachelor of Science in Wildlife Science in May 1975. He began studies in the Ecology Program at The University of Tennessee, Knoxville, in September 1975. He received the degree of Master of Science in Ecology in March 1978.

Related work experiences included biologist aid for Texas Parks and Wildlife in Victoria, Texas, student trainee for the Soil Conservation Service in Portales, New Mexico, and crew leader for the Tennessee Valley Authority Youth Conservation Corps Program in Norris, Tennessee.