Reproduction, physiological responses, age structure, and food habits of raccoon in Maryland, USA[1]

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Abstract

Information on reproduction, age structure, physiological responses and food habits was obtained from 493 raccoon carcasses collected in Maryland between July 1975 and June 1978. The reproductive condition of males and females was determined from examination of reproductive tracts. Histological sections of ovaries were examined to detect the presence of corpora lutea and ruptured follicles. In Maryland, most raccoons reach sexual maturity as yearlings (between 1 and 2 years of age) and are in full breeding condition by December. Some juvenile females were found to be capable of mating during their first breeding season. The breeding season extended from February to June with the peak of mating occurring in mid-February. Most births occur during April; however, several unusually late litters were observed during the study. Such litters were thought to have been produced from a second estrous cycle. Mean litter size was 3.2 with juvenile females having a significantly lower mean litter size than adults. Prenatal mortality was estimated at 2.7 %.

The age structure of the population was determined from several methods of age determination including cementum annuli, eye lens weight, epiphysial closure, and tooth wear and development. Over 50 % of the population consisted of juveniles. The mean life span was 1.8 years with a 7.4-year turnover rate.

The adrenal index, condition index, and body fat index were used to assess the physiological response of the raccoon to various environmental and social stimuli. The adrenal index was found to be at its highest point during the breeding season, whereas the condition index and body fat index were at their lowest. This study suggests that raccoons breed while at their lowest body fat and condition indices and while under increased stress. Other factors contributing to the responses exhibited by these indices were dismissed.

Food habits analysis was performed from the stomach contents of 56 individuals. Corn was the dominant plant food and was consumed throughout the year. Predation on mammals and insects comprised most of the animal foods taken.

Introduction

The raccoon *(Procyon lotor)* has been the subject of considerable research throughout most of its range. Some of the more comprehensive studies include those of Stuewer (1943a, 1943b) in Michigan, Stains (1956) in Kansas, Sanderson and Nalbandov (1973) in Illionois, Johnson (1970) in Alabama, Mech et al. (1968) in Minnesota, and Cowan (1973) in Manitoba. No comprehensive study of raccoon ecology has been conducted in Maryland.

Because of the considerable lack of scientific data on the raccoon in Maryland, a study of the raccoon in Maryland was initiated. The main objectives of this study were as follows: 1. To determine the various reproductive parameters for the raccoon in Maryland; 2. To obtain information on population dynamics; 3. To determine the physiological responses of the raccoon as influenced by various environmental factors; and 4. To identify important seasonal foods of the raccoon in Maryland.

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Study areas

During this study raccoons were collected from three regions of Maryland (Fig. 1). The westernmost region is Garrett and Allegany counties and is included in the Appalachian Province of Maryland and is classified as a northern hardwood forest. This is a diverse area with elevations ranging from 180 m in the east to over 1,000 m in the extreme west. Mean annual temperatures range between 8.9 °C and 10.6 °C with 120–150 days per year below

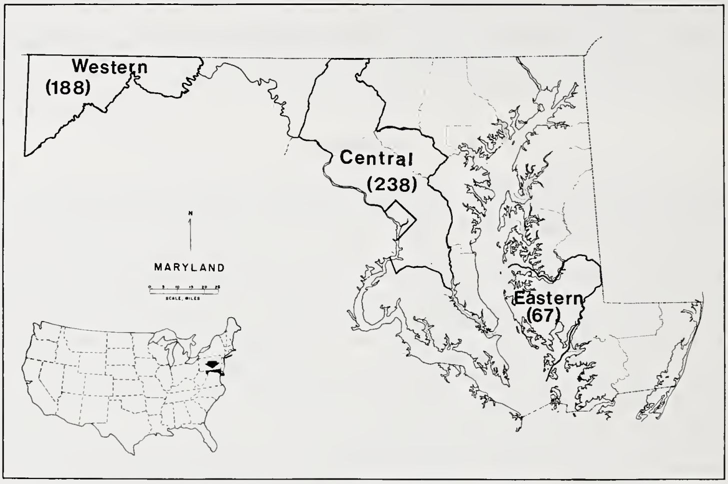

Fig. 1. Number and location of raccoons captured from the three regions of Maryland, 1975–1978

freezing. Average precipitation is 109 cm (Brush et al. 1977). Most of the raccoons from Garrett County were collected in the Savage River State Forest which contains 21,356 ha of woodlands.

The second study area is located in the central part of the state and lies within the Piedmont Province of Maryland with the exception of Prince Georges County, which occurs in the Coastal Plain Province. The counties of Frederick, Montgomery, Howard, and Prince Georges were the primary sites of collection for raccoons. Elevations range from 91 m in Howard County to 335 m in the northwestern part of Frederick County. Mean temperatures range between 11.1 °C and 12.8 °C with an average of 110 days below freezing. Average precipitation for the region is 104 cm (Brush et al. 1977).

The third study area was located entirely within Dorchester County on the eastern shore of Maryland. Elevations range from sea level to 3 m. The mean average temperature is 14 °C and the number of days below freezing averages 100. Annual precipitation averages 109 cm (Brush et al. 1977). Fishing Bay Wildlife Management Area was the primary site for collection of raccoons. This area is dominated by tidal marsh with small areas of woodlands present.

Material and methods

Collection of raccoons

From 1 July 1975 through June 1978, raccoons were collected from the 3 study regions of Maryland. Raccoons were obtained as pelted carcasses from hunters and trappers, road kills, and by trapping with both live traps and steel leghold traps.

Necropsy and laboratory methods

Raccoons were necropsied fresh or after having been frozen. Standard body measurements were taken in millimeters and body weight was recorded to the nearest gram. The heart, spleen, kidneys, adrenal glands, and reproductive organs were weighed to the nearest .001 g on a top-loading Mettler balance (Model P163). Reproductive organs and adrenal glands when removed were preserved in Bouin's fluid for later study.

The reproductive condition of males was determined from testicular and epididymal weights and smears. The right testis was separated from the epididymis and weighed. Smears from the right testis and epididymis were examined with a compound microscope at 40× to estimate the ralative numbers of sperm present. A scale of 0 to 3 was used to describe the relative abundance of sperm as follows: 0 = no sperm present; 1 = infrequent sperm; 2 = frequent sperm; 3 = masses of sperm.

Reproductive tracts of female raccoons were removed and examined for visible signs of pregnancy, resorbing embryos, and placental scars. Vaginal smears were examined with a compound microscope at 40× for the presence of sperm. Ovarian sections 10 microns thick were stained and examined for the presence of corpora lutea and ruptured follicles. Females who had corpora lutea but showed no visible signs of pregnancy were considered to be either pregnant or pseudopregnant.

Ovulation rates were determined by noting the number of corpora lutea per female. Corpora lutea are reliable indications of ovulation in the raccoon since each egg ovulated is immediately followed by the formation of a corpus luteum, regardless of whether the egg is fertilized (Sanderson and Nalbandov 1973). Prenatal mortality was estimated by comparing the number of corpora lutea with the number of viable fetuses present.

Fetuses were removed from the uteri of pregnant females and sexed when possible. Ages of fetuses were determined by measuring the uterine swellings of pregnant females (Sanderson and Nalbandov 1973). Dates of conception and parturition were determined by extrapolating from the age of fetuses using a 63-day gestation period (Llewellyn 1953).

Litter size was determined from the number of fetuses present and by counts of recent placental scars. Placental scars were not counted in pregnant females, since pregnancy tended to obscure the scars. Sanderson and Nalbandov (1973) reported that each embryo that reaches 1 month of age is represented by a scar that persists for 10 to 30 months.

Determination of age

In this study, cementum annuli were used to assign raccoons into year classes (Grau et al. 1970; Johnson 1970). The lower canine tooth was extracted from each raccoon and placed in 5 % nitric acid until fully decalcified. Teeth then were sectioned on a freezing microtome (International Cryostat Model CTL) at −20 °C and stained with Harris Haematoxylin. Sections then were examined under the light microscope at 10×.

The different age classes were defined as follows:

1. Juveniles – less than 1 year of age.
2. Adults – animals 1 year of age or greater. Sometimes it was necessary to analyze yearling age class (between 1 and 2 years of age) separately.

Physiological indices

Three morphological indicators were used to measure the physiological response of the raccoon: the adrenal index, the condition index, and the body fat index. While nothing is known about factors affecting the physiological indices of raccoons, we used three groups: classification variants, reproductive variants, and environmental variants (Chapman et al. 1977). The classification variants investigated were sex, age, and the location of capture. Reproductive variants included paired testes weights, paired testes weight/body weight, and number of fetuses. Environmental variants included mean temperature, mean precipitation, and the number of days above 0 °C during the month of capture. The adrenal index was defined as:

$$\text{Adrenal Index} = \frac{\text{total adrenal weight (g)}}{\text{body weight (g)}} \times 10^4$$

which gives the proportion of adrenal tissues per gram of body weight. This index generally varied between 1 and 10. An individual with a high ratio of adrenal tissue to body weight would, therefore, be experiencing a high degree of stress and vice versa (Chapman et al. 1977).

The condition index used in this study was similar to that used by Chapman et al. (1977) for the cottontail. The condition index was defined as:

$$\text{Condition Index} = \frac{W}{L^3} \times 10^4$$

where W is the weight in grams and L is the maximum body length in decimeters from the tip of the nose to the tip of the middle toe of a fully extended raccoon. The assumption behind the use of the condition index was that as the more weight a raccoon accumulates in proportion to its length, the better its physical condition (JOHNSON 1970).

An index similar to that of JOHNSON (1970) and CHAPMAN et al. (1977) was used to describe the amount of body fat present in the raccoon. Qualitative estimates were based on a scale from 1 to 4 as follows:

1. No fat present on the stomach, mesenteries, or kidneys.
2. Slight amounts of fat present around the kidneys with a small amount on the mesenteries and ventral side of stomach.
3. Moderate amounts of fat surrounding the kidneys, but not totally covered. Moderate amounts of fat on the mesenteries and stomach.
4. Heavy deposits of fat completely covering the kidneys. Mesenteries and stomach covered with fat.

Food habits

The food habits of Maryland raccoons were determined by examing stomach contents. Only the stomachs from those animals that had experienced an instantaneous death (i.e., hunting or roadkills) were used, because trapped raccoons contained large amounts of incidental material and bait. Stomachs were removed from carcasses that were either fresh or had been frozen. Stomach contents then were segregated by species when possible.

Statistical anlysis

The statistical tests used to analyze the physiological indices with the different environmental variants were: two-way analysis of variance with unequal subclasses and Duncan's New Multiple Range Test modified for unequal subclass sizes (STEEL and TORRIE 1960). Other statistical tests included the Chi-square and Student's t-test, as well as Spearman's Rank Correlation test (STEEL and TORRIE 1960). Many of the statistical tests were performed on a Univac 1004 using the Statistical Package for the Social Sciences (SPSS). Statistical tests were considered significant when $P < 0.05$ and highly significant when $P < 0.01$.

Results and discussion

Reproduction

Male reproductive cycle

The reported age at which raccoons first breed is inconsistent. LLEWELLYN (1952) reported that the number of breeding juveniles on the Patuxent Wildlife Refuge in Maryland was insignificant. Similarly, other investigators have concluded that raccoons generally are not

Table 1

Occurrence of sperm in the testes and epididymides of yearling (from 1 to 2 years of age) raccoons collected in Maryland from July 1975 to May 1978

Month	Percent with sperm	N
April	0	1
May	0	7
June	0	9
July	0	10
August	0	5
September	43	7
October	100	2
November	80	5
December	100	6
January	–	0
February	100	6
March	100	6

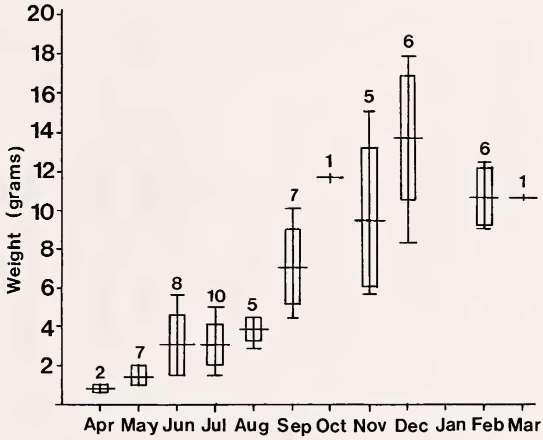

Fig. 2. Monthly variations in the average weight of both testes in yearling raccoons collected from Maryland, 1975–1978. Vertical bars represent standard deviations, vertical lines represent ranges, and numbers are sample sizes

sexually mature until their second breeding season (Stuewer 1943a; Cowan 1973; Fritzell 1978a). However, in Alabama, Johnson (1970) found sperm in the testes and epididymides of a juvenile raccoon in December. Sanderson and Nalbandov (1973: 36) reported that "from one-half to two-thirds of the juvenile male raccoons are sexually mature by the time they are 1 year old . . ." in Illinois, but noted that they became reproductively active 3 to 4 months later than did adults.

In Maryland, the majority of male raccoons reach sexual maturity as yearlings. Most yearlings had reached sexual maturity by December when they were about 20 months of age with maximum testes weights occurring during this month (Table 1, Fig. 2). Sperm was first present in the testes of yearling raccoons when paired testes weights reached 5.0 g; however, it was not determined if such raccoons were capable of fertile matings. Breeding by juvenile males (≤ 12 months of age) was negligible (Table 2, Fig. 3). Only 1 of 71 juveniles examined contained sperm in the testes and/or epididymides. This juvenile was collected in March and its paired testes weighed 10.9 g. A sperm count of one or less taken from the epididymides indicated that the ability for fertile matings was doubtful.

Table 2

Occurrence of sperm in the testes and epididymides of 131 adult and 71 juvenile (< 12 months of age) raccoons collected in Maryland from July 1975 to May 1978

Month	Adults		Juveniles	
	Percent with sperm	N	Percent with sperm	N
January	100	2	0	3
February	100	15	0	12
March	100	9	25	4
April	90	10	0	1
May	50	14	–	0
June	39[1]	18	0	1
July	6	18	0	3
August	0	8	0	7
September	36	11	0	5
October	100	4	0	4
November	92	12	0	19
December	100	10	0	12

[1] One adult male in June had sperm in the testes only and another male had sperm only in the epididymides.

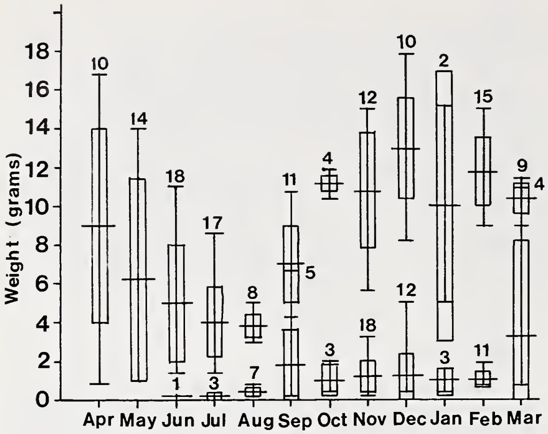

Fig. 3. Monthly variations in the average weight of both testes in adult (> 12 months of age) (top of graph) and juvenile (< 12 months of age) (bottom of graph) raccoons collected from Maryland, 1975–1978. Vertical bars represent standard deviations, vertical lines represent ranges, and numbers are sample sizes

Adult male raccoons in Maryland exhibited a seasonal variation in paired testes weights (Fig. 3). The average weight of paired testes of adult raccoons (≥ 12 month of age) was the lowest during July and August. Testes weights then began increasing during the fall months and reached a maximum of 13.0 g during December. This value was 3.4 times greater than the minimum summer paired testes weight. Most yearling and adult males were probably in breeding condition from October through April as indicated by the presence of sperm (Table 2). Both adult and yearling raccoons obtained their maximum testes weight during December, approximately 2 months prior to the peak of mating (February 16). Sanderson and Nalbandov (1973) and Johnson (1970) also reported maximum weights occurring several weeks prior to the peak of mating. This phenomenon may help to insure that all adult males are in breeding condition well before females and thereby decrease the proportion of females that fail to conceive.

Female reproductive cycle

The ovaries of juvenile (< 12 months of age) nulliparous females showed a uniform rate of increase in weight from birth through October (Fig. 4). The ovaries of juveniles (< 12 months of age) reached their maximum average weight during October, approximately 4

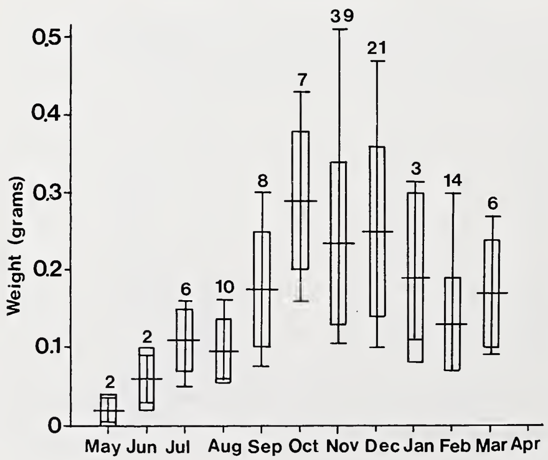

Fig. 4. Monthly variations in the average weight of both ovaries from nulliparous juvenile (< 12 months of age) raccoons collected in Maryland, 1975–1978. Vertical bars represent standard deviations, vertical lines represent ranges, and numbers are sample sizes

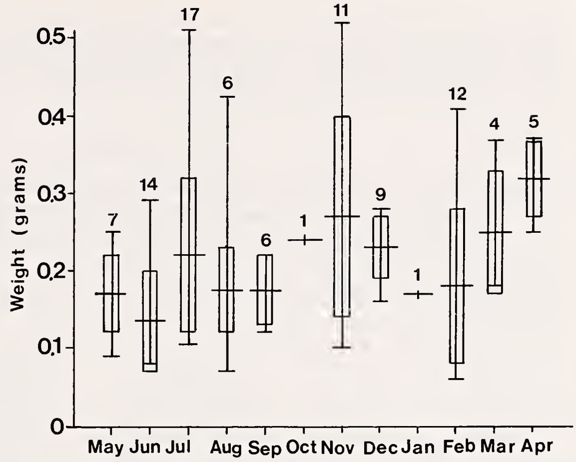

Fig. 5. Monthly variations in the average weight of both ovaries from parous raccoons collected in Maryland, 1975–1978. Vertical bars represent standard deviations, vertical lines represent ranges, and number are sample sizes

months prior to the peak of mating (February 16). A decline in mean ovarian weight then occurred from December to February.

A seasonal variation in the average ovary weight of parous females was evident (Fig. 5). Parous females exhibited two annual peaks in mean ovarian weights. The first occurred in November an was followed by a decline into the peak of the breeding season. The second and highest mean ovarian weight was recorded in April, the month in which the greatest number of litters was produced (Fig. 5).

Some female raccoons are first capable of breeding as juveniles although the proportion breeding varies. STUEWER (1943a) and SAGAR (1956) reported up to 50 % of the females in Michigan and Ohio as having mated during their first year. JUNGI and SANDERSON (1982)

Table 3

Monthly reproductive status of 77 adult (> 12 months of age) and 43 juvenile (< 12 months of age) raccoons collected February–July from the three regions of Maryland

Month	No.	Pregnant or pseudopregnant	Post-partum lactating	Percent pregnant or pseudopregnant
		Adults		
February	18	2	0	11.1
March	4	3	0	75.0
April	8	4	0	50.0
May	9	0	1	0.0
June	19	1	2	5.3
July	19	1	1	5.3
Total	77	11	4	14.3
		Juveniles and yearlings[1]		
February	14	1	0	7.1
March	6	1	0	16.7
April	3	1	0	33.3
May	5	0	0	0.0
June	6	0	0	0.0
July	9	1	2	11.1
Total	43	4	2	9.3

[1] During April (mean birth date April 19), juveniles entered the yearling age class.

found 27 of 37 females (73.0 %) mated successfully before reaching their first birthday. Less than 10 % of the juvenile females in Minnesota (Schoonover 1950) and Alabama (Johnson 1970) had mated. Fritzell (1978a) reported 2 of 14 yearling females collected in North Dakota became pregnant prior to 1 July.

Table 4

Estimated number of days prior to birth, date of birth, and date of conception based on the measurement of uterine swellings in raccoons from Maryland, 1975–1978

Largest measurement of uterine swellings millimeters[1]	Days prior to birth	Date of birth	Date of conception	Region of capture
61 (4)	17	19 April 1976	17 February 1976	Western
95 (3)	1	9 April 1976	7 February 1976	Western
50 (3)	23	28 July 1976	27 May 1976	Western
23 (4)	37	29 August 1976	27 June 1976	Central
81 (4)	8	18 April 1977	15 February 1977	Eastern
8 (3)	55	21 April 1977	18 February 1977	Central
85 (4)	5	5 June 1977	4 April 1977	Western
19 (3)	38	16 April 1978	13 February 1978	Central
35 (3)	33	10 May 1978	8 March 1978	Eastern
95 (2)	1	10 April 1978	7 February 1978	Eastern

[1] Numbers in parentheses indicate number of fetuses in uterus.

Examination of the 43 juvenile and yearling females collected during this study indicated 9.3 % were either pregnant or pseudopregnant (Table 3). Of 77 adult females, 11 (14.3 %) were pregnant or pseudopregnant. The highest percentage of females pregnant or pseudopregnant occurred during March and April for both juvenile and adult females. The percentages of females pregnant or pseudopregnant were low compared to those reported for Illinois (Jungi and Sanderson 1982), Michigan (Stuewer 1943a) and Ohio (Sagar 1956). Live trapping and leg hold trapping were the primary methods used to collect females during the parturition season. This may have biased our sample towards non-pregnant females if pregnant females spent less time foraging or spent more time at den sites.

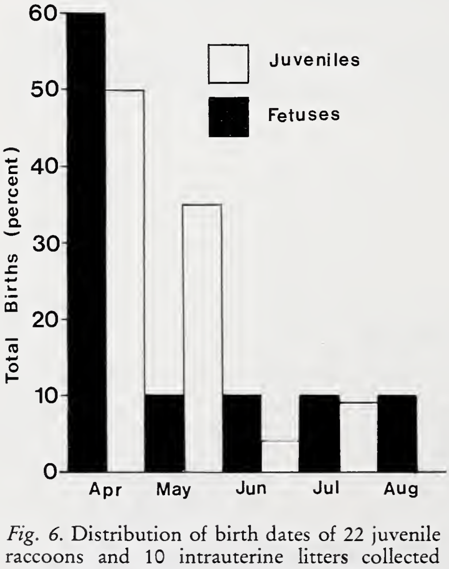

Fig. 6. Distribution of birth dates of 22 juvenile raccoons and 10 intrauterine litters collected from three regions of Maryland, 1975–1978

Duration and onset of breeding

The earliest conception date was February 7 and the latest June 27 (Table 4). The majority of conception occurred during the second and third week of February. The mean birth date for these 10 litters was estimated to be April 19 (excluding 3 late litters). The earliest birth date was April 9; the latest, August 19. The distribution of birth dates based on 22 juveniles from 10 intrauterine litters indicated litters were born from April through August with 50 to 60 % of the total births occurring during April (Fig. 6).

The breeding season in Maryland agrees with that reported for this same general latitude (Sagar 1956; Sanderson and Nalbandov 1973). Due to the small number of breeding adults collected from western Maryland, it was not possible to compare differences in the onset of breeding between regions.

Bissonette and Csech (1938, 1939) have shown that the onset of breeding may be controlled by langthening photoperiod. Also, low temperatures or severe weather may inhibit the onset of breeding by restricting the movements of males in search of estrous females (Sanderson and Nalbandov 1973). If a female fails to mate during her first estrus, aborts, or loses her litter soon after birth, she may go through a second estrus after 80–140 days (Sanderson and Nalbandov 1973). This second estrus will result in unusually late litters being produced. Reports of late litters are numerous in the literature (Berard 1952; Stuewer 1943a; Whitney and Underwood 1952; Sanderson and Nalbandov 1973). During this study, 3 late intrauterine litters were observed during 1976 and 1977. It was estimated these would have given birth June 5, July 28 and August 29. Adverse weather during the early spring of 1976 and 1977 may have prevented conception during the initial estrus, resulting in late born young produced from a second estrous cycle. The majority of births in Maryland occur during April and May. The date of birth is usually late enough to avoid severe weather in the spring and early enough to allow maximum growth of the young before winter. Late born litters probably experience greater mortality rom depletion of fat reserves during the late fall and winter than those born earlier. The timing of birth may be especially critical for litters born in the westernmost counties of Maryland where weather conditions and the availability of food may limit the growth and maturation period. These conclusions are supported by the findings of Mech et al. (1968) for raccoons in Minnesota.

Litter size

Data on litter size was obtained from 10 pregnant females by noting the number of fetuses per female and from recent placental scar counts (Table 5). No significant difference was found between litter size estimated by the number of fetuses present and by placental scars ($P > 0.05$). Thus, these data were combined and the mean litter size based on 84 litters was 3.2.

There is much geographical variation in raccoon litter size with a trend towards larger litters in the more northern latitudes (Llewellyn 1952). Litter sizes range from 4.8 in

Table 5

Mean litter size of raccoons from Maryland as determined by number of embryos and placental scars, 1975–1978

Litter size as indicated by	Number of litters	Mean litter size	Range	Standard deviation
Embryos	10	3.30	2–4	0.675
Placental Scars	74	3.23	1–5	0.837
Embryos and placental scars combined	84	3.24	1–5	0.816

Manitoba and North Dakota (Cowan 1973; Fritzell 1978a) to 1.9 in North Carolina (Llewellyn 1952). In Ohio, Sagar (1956) reported a mean litter size of 3.6, and in Illinois Sanderson (1960) reported a mean litter size of 3.5. In this study, the mean litter size of 3.2 was similar to that reported for this latitude, but was higher than the 2.3 value previously reported by Llewellyn (1952) for the raccoon in Maryland.

Whitney and Underwood (1952) indicated that young female raccoons produce smaller litters during their first parturition than older parous females. Cowan (1973) also found juvenile females to be less fecund than adults. In Maryland, juvenile females also had a significantly lower mean litter size (2.8) than adults (3.4), ($t = -2.86$, df = 67, $P < 0.001$). Smaller litters could be an adaptive mechanism by which younger, smaller females are selected against rearing normal size litters during a period of environmental and social stress. During their first winter, juvenile females may use up most of their fat reserves for growth and development of body tissues and, therefore, have little available during the breeding and parturition season. In the wild rabbit *(Oryctolagus cuniculus)*, Brambell (1948) observed that intrauterine mortality was inversely related to the body weight of the mother during pregnancy. This same phenomenon may also be at work in the raccoon. Smaller body size along with the physical demands of pregnancy may reduce the litter size of those juveniles mating their first year. However, Jungi and Sanderson (1982) found a small ($P < 0.30$) decline with age of litter size in 64, 1- to 3-year-old female raccoons in Illinois.

Ovulations, resorptions, and embryo locations

The mean number of corpora lutea per female for 15 pregnant or pseudopregnant raccoons was 3.33 ± 0.72 (range 2–4). None of the 33 visible embryos examined during this study were in the process of resorption, indicating post-implantation mortality was negligible. Brambell (1948) has shown that mortality estimates obtained from counts of corpora lutea and fetuses may be underestimated, particularly from ova and fetuses collected during the early stages of pregnancy. However, this low mortality figure still suggests that ova and fetal loss is minimal in Maryland raccoons. Johnson (1970) also found no extensive prenatal mortality in Alabama raccoons. In Manitobe, Cowan (1973) estimated prenatal mortality at 8.8 percent for adult females.

Trans-uterine migration has been reported in the raccoon previously (Llewellyn and Enders 1954; Sagar 1956). Trans-uterine migration occurred in a minimum of 5 of the 10 pregnant raccoons examined. A minimum of 7 ova crossed to the opposite uterine horn. In one of these females, there were more corpora lutea than fetuses indicating prenatal mortality had occurred. Sagar (1956) indicated that trans-uterine migration may result in ova loss.

Of the 33 fetuses examined during this study, 16 were implanted in the right uterine horn and 17 in the left uterine horn.

Sex ratio

The sex ratio of 275 raccoons obtained by hunters and trappers was 87 males per 100 females (Table 6). This difference was not statistically significant from a 1:1 ratio ($P > 0.05$). No significant differences were found between the sexes in fetal, juvenile, or adult raccoons. Sex ratios reported in the literature are highly variable and there is no consistent relationship between regions.

Table 6

Sex ratios of fetal, juvenile, and adult raccoons collected from three regions of Maryland, 1975–1978

Age	Male	Female	Males/100 females	Significance level
Fetal	9	11	82	NS
Juvenile[1] (< 1 year)	67	87	77	NS
Adults[1] (> 1 year)	61	60	102	NS
Adults and juveniles[1]	128	147	87	NS

[1] Sex ratios presented are only for those adults and juveniles collected by hunting and trapping from November 15 to March 15.

Table 7

Age distribution by sex of raccoons collected during the hunting and trapping season (November 15 to March 15) from the three regions of Maryland, 1975–1978

Age in years	1975–1976		1976–1977		1977–1978	
	Male	Female	Male	Female	Male	Female
1	5 (33.3)[1]	9 (75.0)	35 (50.7)	48 (55.2)	27 (61.4)	30 (62.5)
1–2	4 (26.7)	1 (8.3)	15 (21.7)	18 (20.7)	7 (15.9)	12 (25.0)
2–3	3 (20.0)	1 (8.3)	14 (20.3)	10 (11.5)	2 (4.5)	2 (4.2)
3–4	2 (13.2)	1 (8.3)	2 (2.9)	7 (8.0)	5 (11.4)	–
4–5	1 (6.7)	–	3 (4.3)	1 (1.1)	1 (2.2)	3 (6.2)
5–6	–	–	–	3 (3.4)	–	1 (2.1)
6	–	–	–	–	2 (4.5)	–

[1] Numbers in parentheses are the percentages of each age group.

Age structure

The age distribution of Maryland raccoons taken by hunters and trappers (November–March, 1975–1978) is presented in Table 7. Over 50 % of that part of the population collected from hunters and trappers were juveniles. Juveniles may have been more vulnerable to this type of mortality and thereby biased the distribution in favor of juveniles. The percentage of juveniles obtained in this study agrees with those reported for the northern half of the raccoon's range where juveniles made up 41 to 70 % of the population (Llewellyn 1952; Sanderson 1951; Stuewer 1943b). In the southern portion of the range, juveniles range form 25 to 37 % of the population (Cunningham 1962; Johnson 1970). This latitudinal difference in age structure during the hunting and trapping season is probably related to the greater production of young in the northern states, and the greater mortality experienced by juveniles from hunting and trapping in the northern regions.

The proportion of juveniles (J) in this sample was 0.56. Using the method of Petrides (1951), the turnover rate was:

$$T = \frac{\log 0.005}{\log (l-J)}\, l = 7.44 \text{ years and the mean life span was: } L = \frac{1}{J}\, 1.8 \text{ years}$$

Therefore, Maryland raccoons lived an average of 1.8 years and it took 7.4 years for the original population of 1000 juveniles to be reduced to five individuals. These are the same figures as those reported for Missouri (Sanderson 1951) and Manitoba (Cowan 1973). In Alabama, where winter mortality is less severe, Johnson (1970) found the average longevity to be 3.1 years with a turnover rate of 10.0 years. The higher mortality rate observed for Maryland raccoons may be compensated for by an increased litter size. Chi-square analysis revealed that the age distributions for both males and females were different during the three raccoon trapping seasons investigated. The age distributions were significantly different between the sexes during the 1975–1976 season ($X^2 = 12.25$, $p < 0.01$). The 1977–1978 age distributions for males were different from both the 1975–1976 and 1976–1977 seasons ($X^2 = 7.19$, $p < 0.05$). Also females exhibited differences in age structure between the 1976– 1977 and 1977–1978 seasons ($X^2 = 12.76$, $p < 0.01$).

Physiological responses

Three morphological indicators were used to assess the physiological responses of the raccoon to various environmental stimuli. These were the adrenal index, condition index, and body fat index. Although little is known about how these indices respond to various stimuli in the raccoon, we assumed such responses would be similar to those reported for various rodents and lagomorphs (Christian 1963; Chapman et al. 1977). Separate analyses were made for males, nonpregnant females and pregnant females, since sex and reproductive status have been shown to affect physiological responses of rodents.

Adrenal index

There were some seasonal variations in the mean adrenal index of both sexes. Mean adrenal indices of males increased significantly to their highest point during the breeding season and then declined significantly to the fall season. Territoriality generally is regarded as being poorly developed in the raccoon (Stuewer 1943a; Urban 1970; Schneider et al. 1971). However, Fritzell (1978b) found evidence of territoriality in North Dakota and stated, "Competition among adult males for access to females appears to be an important function of territoriality in adult male raccoons." Whether territoriality exists or not, generally it is recognized that some kind of social dominance system is at work (Barash 1974; Mech et al. 1966; Johnson 1970). Such social stress among male raccoons competing for females may have caused the higher adrenal indices observed during the breeding season.

Females experienced their highest mean adrenal indices during the summer, but then declined significantly into the fall season. The added stress of lactation and the rearing of young during the summer (May–July) may have resulted in this increase in the adrenal index. Selye (1949) reported enlargement of the adrenal cortex during lactation in mice.

Body fat index

Significant seasonal variations in the mean body fat index of both males and females were apparent. Male and females had significantly higher body fat indices during the winter than the rest of the year. A significant decline occurred in both males and females from winter to spring, and a significant increase was observed from fall to winter. Both sexes had their lowest body fat indices during the breeding season. An inverse correlation was found with the mean temperature during the month of capture ($R = -0.2446$, $p < 0.001$, $df = 221$) for males and nonpregnant females. This probably just reflects the accumulation of body fat during the winter season (November–January) and its subsequent use during late winter and early spring (February–April).

Condition index

A seasonal variation in the mean condition index was observed for both sexes. Both males and females exhibited their lowest mean condition index during the breeding season. Females showed a significant increase in the condition index from fall to winter, and a significant decline from winter to spring. Females obtained their highest values during the winter and males during the fall. Johnson (1970) found the lowest condition indices during the summer in Alabama raccoons. The earlier breeeding season of Maryland raccoons, coupled with a harsher climate may have caused an earlier decline in the condition index than experienced by Alabama raccoons.

Index interrelationships

Significant correlations were found between the different physiological indices in both males and females. The adrenal index was negatively correlated with the condition index and body fat index ($P < 0.002$) for males, nonpregnant females, and pregnant females. The body fat index was positively correlated with the condition index ($P < 0.005$) for the same three groups. This suggests that as the physical condition of a raccoon deteriorates, as evidenced by low condition and body fat indices, the adrenal index increases. However, this may also just be a reflection of seasonal changes in body weight.

Such factors as disease, competition for ood, high population densities and varying environmental conditions have caused adrenal enlargement in mice (Christian 1963). Willner et al. (1979) implicated severe cold as a possible factor contributing to the adrenal responses of nutria in Maryland. In this study, none of the weather variables investigated were correlated with the adrenal index of the raccoon. Therefore, it appears that the raccoon is well adapted to weather conditions in the regions it inha bits since none of the weather variables investigated produced an adrenal response. Unlike the nutria which has only recently been introduced into Maryland, the raccoon enjoys a native status which has allowed it to adapt its physiology to Maryland's climate.

The condition and body fat indices were closely associated. Both indices reached a peak during the winter and then declined sharply to its lowest point during the breeding season. It appears raccoons breed during a period of low physical condition. However, by breeding at this time young are produced in April when conditions are better suited for survival and maximum growth before winter. While raccoons may breed during low physical condition (i.e., low body fat and weight) reproductive condition is at its peak.

Food habits

Animal material was found in approximately half of the stomachs examined. Insects and mammals occupied most of the animal species taken. One of the more important invertebrate species eaten by the raccoon was crayfish *(Cambarus diogenes)*.

Corn was the dominant plant food consumed and was found in stomachs throughout the year. Llewellyn and Uhler (1952) and Stickel and Mitchell (1944) reported on the food habits of the raccoon in Maryland. They similarly found corn to be the major food item especially during the fall and winter months. Other plant foods found in the yearly diet were acorns (*Quercus* sp.), viburnums (*Viburnum* sp.), wild grape (*Vitis* sp.), and persimmon *(Diospyros virginiana)*.

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Zusammenfassung

Reproduktion, physiologischer Zustand, Altersstruktur und Nahrungszusammensetzung von Waschbären (Procyon lotor) in Maryland, USA

Angaben über Reproduktion, Altersstruktur, physiologische Zustände und Nahrungsspektrum wurden an 493 von Juli 1975 bis Juni 1978 in Maryland gesammelten Waschbärkadavern gewonnen. Der Reproduktionszustand von ♂♂ und ♀♀ wurde durch Untersuchungen am Reproduktionstrakt ermittelt. Histologische Schnitte von Ovarien wurden auf Corpora lutea und Sprungfollikel durchgesehen. In Maryland erreichen die meisten Waschbären die sexuelle Reife zwischen dem 1. und dem 2.

Lebensjahr. Sie sind im Dezember voll geschlechtsreif. Einige juvenile Weibchen paaren sich bereits in der 1. Brunftperiode. Die Brunftperiode reicht von Februar bis Juni, Mitte Februar ist die Hauptzeit. Die meisten Geburten geschehen im April, aber einige ungewöhnlich späte Würfe wurden ebenfalls festgestellt. Es wird angenommen, daß diese in einem 2. Östruscyclus entstanden. Die mittlere Wurfgröße beträgt 3,4. Juvenile Weibchen haben signifikant kleinere Wurfgrößen als adulte. Pränatale Mortalität wird auf 2,7 % geschätzt.

Die Alterszusammensetzung der Population wurde über mehrere Parameter zur Altersbestimmung ermittelt (cementum annuli, Augenlinsengewicht, Epiphysenschluß, Bezahnung). Über 50 % der Population bestand aus Jungtieren. Die mittlere Lebenserwartung war 1,8 Jahre.

Nebennieren-, Milz-, Konditions- und Körperfett-Indices wurden ermittelt und bewertet als Anzeiger für physiologische Reaktionen der Tiere auf verschiedene Umwelteinflüsse und soziale Stimuli. Der Nebennieren-Index erreichte ein Maximum während der Ranzzeit, wohingegen Konditions- und Körperfett-Indices in dieser Zeit besonders gering waren. Daraus wird geschlossen, daß Waschbären unter zunehmendem Streß ranzen.

Die Nahrungszusammensetzung wurde an Mageninhalten von 56 Individuen ermittelt. Mais erwies sich als dominierende pflanzliche Nahrung während des ganzen Jahres. Zusätzlich wurden Säugetiere und Insekten nachgewiesen.

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Osteological measurements and some remarks on the evolution of the Svalbard reindeer, *Rangifer tarandus platyrhynchus*

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Abstract

Some measurements of the limb bones of *Ranfiger tarandus platyrhynchus* are presented and a comparison with other reindeer subspecies is made. It is pointed out that the Svalbard reindeer shows an interesting parallel with many pleistocene island ruminants. Some remarks on the possible evolution of the Svalbard reindeer are made.

Introduction

The Svalbard reindeer, *Rangifer tarandus platyrhynchus* Vrolik, 1829 is probably the most clearly distinguishable of all subspecies of *Rangifer tarandus* (L., 1758), the reindeer and caribou. The species is highly variable and many different forms can be distinguished. The taxonomy is far from uniform, but there is no doubt about the subspecific rank of *R. t. platyrhynchus*.

The most striking differences with the other subspecies are its small size and its short legs. In this paper I present some measurements on the limb bones of this animal as well as some remarks on its evolution.

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