BIOLOGY of the RACCOON

(Procyon lotor varius) Nelson and Goldman

in ALABAMA

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IN ALABAMA

A. Sydney Johnson*

A Contribution of the
Alabama Cooperative Wildlife Research Unit

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PREFACE

Although the raccoon is one of the more common mammals in the southeastern United States, little is known about its life history and ecology in this area. The Alabama subspecies (*Procyon lotor varius* Nelson and Goldman) has received little study, and no significant research on the raccoon has been reported from within Alabama.

Recognizing the need for a comprehensive study of the raccoon in Alabama, the Alabama Department of Conservation, Division of Game and Fish, initiated the present study in February 1962, under the provisions of the Federal Aid in Wildlife Restoration (Pittman-Robertson) Act. As a biologist with the Division of Game and Fish, the author was assigned to this study as project leader.

In September 1963, the author accepted a teaching position at Auburn University, and Department of Conservation personnel permitted him to continue work on the project and to use the data to fulfill the dissertation requirements for the Doctor of Philosophy degree.

From September 1965 to September 1968, funds were provided for partial support of the project by the Alabama Cooperative Wildlife Research Unit and by the Auburn University Agricultural Experiment Station. In order for this work to be published in its entirety, the State Department of Conservation contributed $1,000 toward cost of publication. Grateful acknowledgment is made for this financial support.

Many persons have contributed in various ways to this project. Personnel of the Alabama Department of Conservation cooperated in collecting animals for necropsy and assisted in other ways. The author is especially indebted to biologists James Davis and William Hamrick and refuge managers Huey Dykes and Quitman Sherman of Clarke County for the full cooperation given throughout the study. Without their help, significant portions of the study would never have been completed. Francis Lueth, Biologist, kindly permitted the use of data collected by him during his predator and fur-bearer studies.

Many students of Auburn University helped in the collection of animals for necropsy and in other ways. Joseph Caldwell deserves special thanks in this regard. Students Kenneth Burttram and Danny Searcy also aided in the collection of data.

Data on sex, age, and weight of approximately 100 raccoons were provided by the Alabama Cooperative Wildlife Research Unit and Dr. Kirby L. Hays, Professor of Zoology-Entomology at Auburn. Unit leaders Dr. Maurice Baker and Dr. D. W. Speake made facilities available for the study and aided in various other ways. Dr. Speake provided data on growth and development of a pet raccoon.

Thomas Atkeson, Refuge Manager, U.S. Fish and Wildlife Service, permitted the use of records on the harvest of raccoons from the Wheeler National Wildlife Refuge. Philip Wilkinson, biologist for the South Carolina Wildlife Resources Commission, provided information and ideas based on his experience with raccoons in coastal South Carolina.

Thanks are extended to Dr. R. L. Marchinton, School of Forest Resources, University of Georgia, for advice and assistance with telemetry problems.

Dr. Charles S. Roberts, State Veterinary Diagnostic Laboratory, performed pathological examinations on five raccoons.

Most of all, the author is grateful to his wife, Nedra, for many hours of valuable assistance in the field, in the laboratory, and at the typewriter and for the spirit with which she has endured the many inconveniences involved in a study of this type. She also contributed the cover photograph.

This report leaves many questions unanswered, and much remains to be learned about raccoons in Alabama. It is hoped that it will provide a basis for more specific and detailed studies in the future.

A. SYDNEY JOHNSON
May 1969

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INTRODUCTION

A STUDY OF the biology of the raccoon (*Procyon lotor varius* Nelson and Goldman) in Alabama was conducted from February 1962 to August 1968. Information on basic biological characteristics of raccoons in Alabama was acquired, and the role of various factors in regulating numbers of raccoons was examined.

JUSTIFICATION OF THE STUDY

The raccoon is one of those adaptable species that has thrived and increased in numbers as a result of human modification of the environment. It is expanding its natural range *(191)*, and it has been transplanted and established in areas of Europe, Asia, and elsewhere *(3,129,147,172,178)*. Within the range of the raccoon in the United States its numbers have increased greatly *(4,27,163, 164,165)*. It is, therefore, desirable that the ecological role of the raccoon is understood and the specific biological information necessary for management is acquired.

Ecological and Economic Significance of Raccoons

COMMODITY VALUES. The raccoon was once an important fur animal. During the 1920's, when raccoon coats were popular, raccoon pelts brought high prices. But when long-haired furs lost their popularity, fur prices declined drastically and there was a corresponding decrease in the number of raccoons harvested for fur. Nevertheless, 1 to 2 million raccoons are harvested each year in the United States, and the United States exported $7,336,000 worth of raccoon furs in the period 1960-64 *(199)*. The Alabama Department of Conservation reported sales of raccoon pelts by Alabama trappers during the 1966-67 season amounted to $12,690 *(118)*.

Many raccoons are harvested for food, especially in rural areas, but this potential food source is largely untapped.

Although keeping native animals in captivity is illegal in Alabama and many other states, there is much popular interest in raccoons as pets, and they are sometimes sold in pet shops. It has been suggested that this should be legalized, but this is debatable. When young, raccoons make interesting but troublesome pets. Older animals often become vicious.

Raccoons are commonly advertised in hunting magazines for stocking by hunting clubs. These raccoons sell for as much as $15 each.

GAME VALUE. In many areas of the South and Midwest raccoon hunting is a tradition dating back to the pioneers. Raccoon hunting is a distinctly American tradition. American raccoon hunters developed some of the best breeds of treeing hounds because a unique type of dog is required for their sport. Despite declining fur prices and a declining population of rural Americans, raccoon hunting seems to be increasing in popularity. The Alabama Department of Conservation reported that an estimated 25,345 hunters harvested 174,035 (±42,506) raccoons in 214,422 man days of hunting during the 1966-67 season in Alabama *(98)*. The number of raccoon hunters in Alabama compares favorably with estimates of hunters in states noted for raccoon hunting. Neighboring Tennessee, famous for its raccoon hunters, estimated 17,170 hunters harvested 81,442 raccoons in 1961 *(107)* – less than half the harvest claimed by Alabama. In Illinois, which is also reputed to be a major center of interest in raccoon hunting, Sanderson *(165)* estimated the harvest by hunters and trappers as 100,000 raccoons.

Raccoon hunters contribute to the general economy through the money they spend on their sport. Stains *(182)* estimated that raccoon hunters in Kansas spent $240,000 per year on the maintenance of hunting dogs, and Legler *(107)* reported Tennessee raccoon hunters spent $65,712 on food and lodging while on hunting trips.

Raccoon hunting at its best combines traditions and qualities that game managers should encourage. Many sportsmen and game managers have expressed concern over the deteriorating quality of American hunting traditions. These views have been most eloquently expressed by Aldo Leopold *(109)*, who deplored the tendency toward artificiality in game management and the increasing dependence of American sportsmen upon gadgets and gimmicks. The quality of raccoon hunting, however, remains essentially undiluted: a challenge to the endurance of the man and the breeding and training of his hounds. Not polluted and fettered by gadgetry, raccoon hunting has the "split-rail flavor" praised by Leopold. Its more enthusiastic participants display self-reliance and hardiness, pride in a fine dog, self-restraint, and a deep admiration and respect for the game they seek. Many raccoon hunters, like fox hunters, allow the game to go unharmed after the chase has ended.

DEPREDATION AND NUISANCE QUALITIES. In certain agricultural areas depredations by raccoons on crops such as corn, melons, and fruits and on poultry may become a problem. Hunters and practical game managers commonly consider the raccoon a serious predator on the eggs of nesting game birds, especially waterfowl. In some areas they prey heavily on turtle eggs and muskrats.

PUBLIC HEALTH SIGNIFICANCE. Raccoons are known to harbor parasites and disease organisms infective to man and domestic animals. They are, therefore, of potential significance to public health, especially where there is frequent contact with man and his domesticated animals (as with trappers, hunters, and hunting dogs) and in camping areas where raccoons concentrate to feed upon garbage and handouts. Possible contamination of stock-watering ponds and swimming areas has been the cause of concern among some public health workers.

Significance of the Study to Basic Research

Much basic behavioral and ecological work with mammals has been confined to laboratory conditions or to mammals such as rats and mice, which have relatively simple biological patterns. Understandably, ecologists and ethologists have been reluctant to undertake field studies of the more wary species with complex behavioral patterns. Yet, such studies are ultimately necessary if the significance of the former type of work is to be determined, and they may lead to the formation of basic new concepts. Raccoons are excellent subjects for field studies. Among the more intelligent of non-primates, they have very complex behavioral patterns and are extremely adaptable. In many respects their ecology is similar to that of primitive man in the hunter-gatherer stage. It is hoped that this study will contribute to existing knowledge of the biology of this species and, ultimately, to the solution of more fundamental ecological problems.

Need for Study

Although the raccoon has been the subject of considerable research, few comprehensive studies of raccoon ecology have been attempted. Most studies have been restricted in scope to some specific aspect of biology such as food habits, movements, behavior, or parasites and diseases, and most of these studies have been conducted in the northern states. The more comprehensive studies are those of Stuewer *(187,188)* in Michigan, Sanderson *(162,163,165-168)* in Missouri and Illinois, Stains *(182)* in Kansas, and Mech, *et al. (132,133)* in Minnesota.

Relatively little has been reported concerning the biology of raccoons in the Deep South. Cagle *(28)* and Ivey *(92)* reported general observations on raccoons in Louisiana and Florida. McKeever, *et al. (123-128)* studied parasitism and disease, reproduction, and habitat preferences in southwestern Georgia and northwestern Florida. Cunningham *(43)* studied the population density and composition on the Atomic Energy Commission's Savannah River Plant in western South Carolina, and Kinard *(100)* studied the food habits of raccoons on the same area. Caldwell *(29)* studied habitat preferences of raccoons in north-central Florida. Harkema and Miller *(84)* surveyed the helminth parasites of raccoons in the South Atlantic States.

The works of McKeever, *et al.* are the only reports dealing with the subspecies of raccoon found in Alabama, and no specific studies of raccoons have been reported from Alabama.

OBJECTIVES

Because of the total lack of scientific information on raccoons in Alabama and the scarcity of such information for the Southeast in general, it was decided that a study broad in scope would be of greatest immediate value and would provide a basis for determining needs for more detailed inquiry. Specific collateral objectives dealing with various aspects of raccoon biology were as follows:

1. To evaluate ecologically important reproductive and developmental characteristics of raccoons in Alabama.
2. To identify the more important foods and food preferences of raccoons under different ecological conditions in Alabama.
3. To evaluate movement and related activity patterns of raccoons in Alabama.
4. To obtain information on parasitism and disease of raccoons in Alabama.
5. To obtain information on the population dynamics of raccoons in Alabama.
6. To synthesize and interpret existing knowledge of the raccoon, particularly in the Southeast.
7. To make management recommendations on the basis of the findings.

PROCEDURE AND STUDY AREAS

GENERAL PROCEDURE

Most of the methods employed yielded data of use in solving several sub-problems. Following are the major lines of approach and their significance to the study. Details of technique will be discussed throughout this report.

Collection of Animals

Raccoons were collected as opportunity permitted. A systematic sampling of the State was not made because other duties did not permit frequent collecting trips. Many animals were provided by Alabama Department of Conservation personnel and Auburn University students. Methods of collection included trapping with box traps and steel traps, collecting with light and gun from vehicle or boat, hunting with dog and gun, obtaining raccoons caught in deer traps, and picking up those found dead on highways.

Post-Mortem Examinations

Post-mortem examinations provided various data on reproduction, breeding condition, age, weight, measurements, amount of body fat, gross condition, adrenal weights, gastrointestinal contents, and helminth parasites. Animals that could not be examined immediately were generally sealed in plastic bags and frozen until they could be examined.

Trapping and Marking

Trapping and marking studies yielded data on movements, activity, seasonal changes in weight, longevity, population density, and population structure. Traps used were of the drop-door box type, Figure 1, and were baited with sardines canned in brine, sometimes mixed with shelled corn. Traps were generally checked each morning and rebaited each afternoon. An effort was made to distribute traps systematically to provide good coverage, but within a selected sample area traps were placed in specific locations thought most likely to be used by raccoons. Records were kept of all trapping attempts. Trapped raccoons were driven into wire-mesh cones, Figure 2, for handling, ascertaining sex and age, weighing, and tagging. Animals were marked with a numbered tag in each ear prior to release.

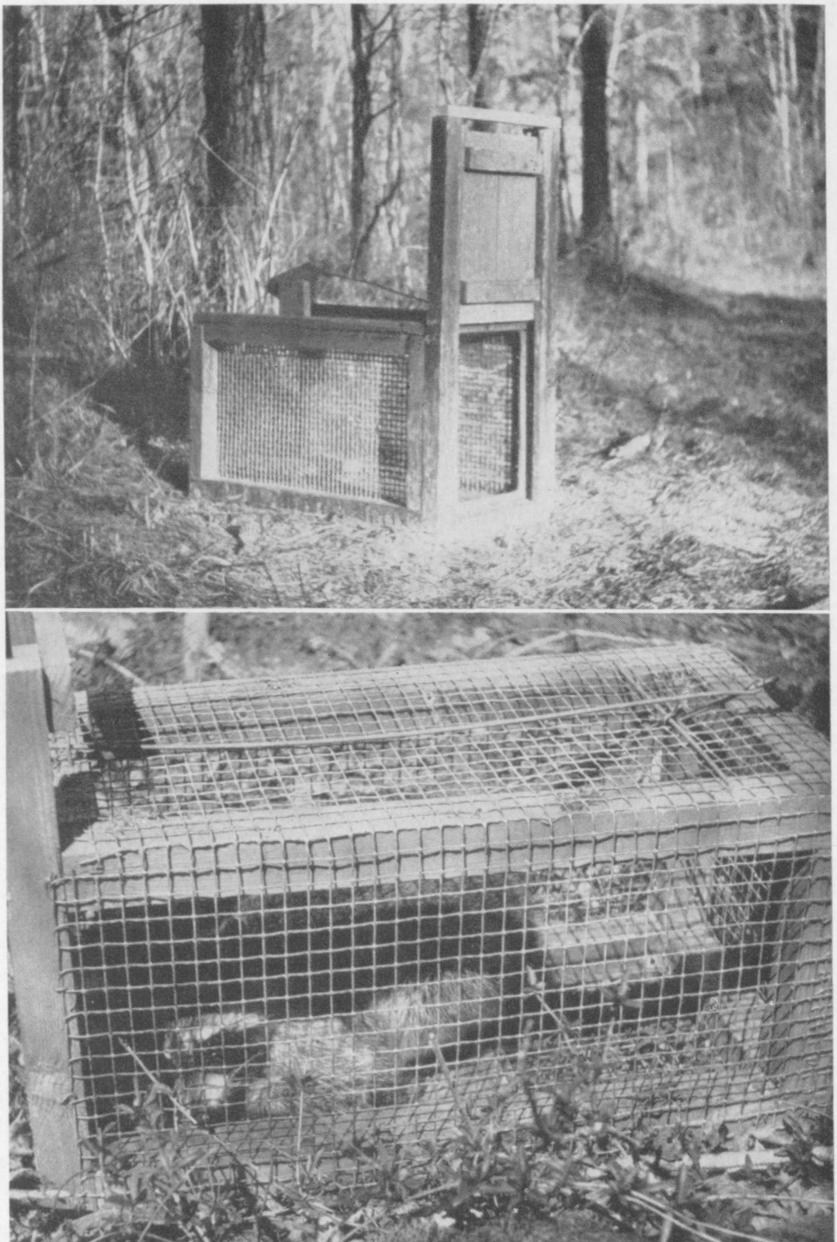


FIG. 1. Two types of box traps used to capture raccoons for marking and release.

FIG. 2. Raccoon in wire handling cone being weighed. The cone permitted safe handling of live animals during sex and age determination, weighing, and tagging.

Hunting With Dogs

Hunting with dogs was primarily for the purpose of collecting raccoons for necropsy. However, hunting also provided data on activity, aggregations, home range, juvenile survival, and refuge preferences. No attempt was made to use hunting success as an indicator of relative abundance, as has been done by others *(29, 94)* because hunting conditions could not be standardized. Records were kept of each hunt, including such information as location, habitat types, length of chase, time and location of strike, kind of refuge tree, sex and age of raccoons treed, and meteorological data.

Radio Telemetry

Radio telemetry was employed primarily for the purpose of determining home range, but information was also obtained by this method on activity, daily resting sites, food, and other aspects of behavior. Three raccoons were equipped with radio transmitter-collars encased in dental acrylic with a loop antenna incorporated into the collar, Figure 3. The entire assembly weighed about 115 grams.

Animals were located by triangulation with loop-type directional antennae, Figure 4.

Because telemetry was employed primarily to obtain data on home range rather than on detailed activity, locations were not determined at regular intervals but were determined irregularly as the work schedule permitted. An effort was made, however, to

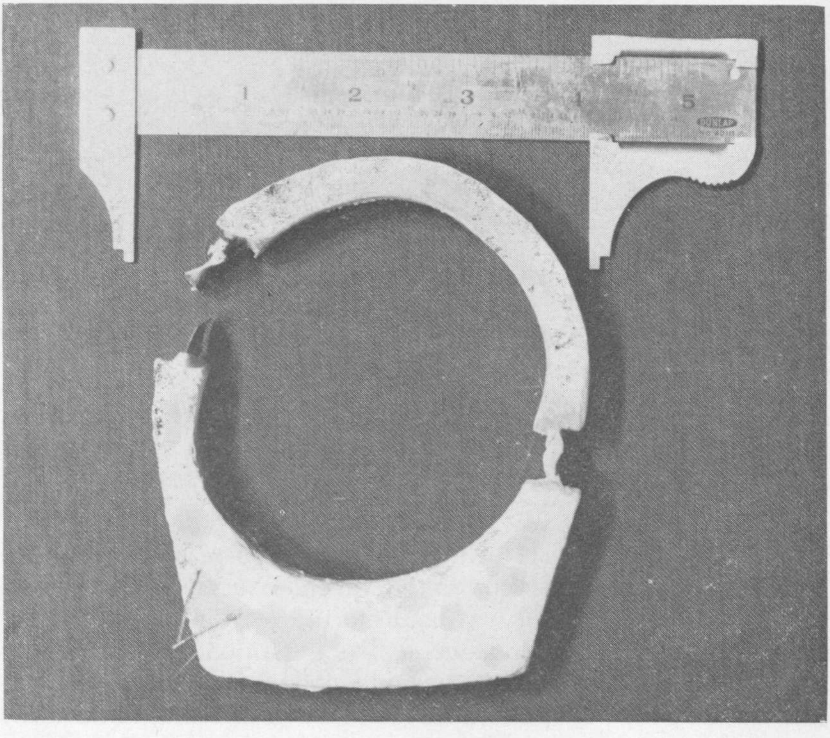


FIG. 3. Radio transmitter-collar of the type used on raccoons in this study. The entire assembly, including transmitter, batteries, and antenna encased in dental acrylic, weighed about 115 gm. The transmitters operated in the 27 mc frequency range.

FIG. 4. Portable receiver and directional antenna used in monitoring raccoons in Lee Co., Alabama.

include all periods of the 24-hour day among locations determined.

Miscellaneous Field Activities

Field observations on feeding, food abundance, denning, litters, social behavior, and resting sites were made as opportunity permitted. Fecal samples were collected for analysis.

Examination and Tagging of Animals to be Relocated

Many raccoons were captured by Alabama Department of Conservation personnel trapping deer. These animals were given to hunting clubs for release in their hunting areas. The author was permitted to examine, weigh, and tag these animals prior to their release. Hunters receiving the raccoons were given a printed request for information on release and recovery of these animals. This procedure yielded data on population composition and movements of relocated animals.

Observations on Captive Animals

Raccoons representing all sex and age groups were maintained as captives for periods varying in length up to 20 months for observations on reproduction, growth and development, and behavior.

HABITAT REGIONS AND STUDY AREAS

Collection sites are shown in Figure 5, and numbers of animals examined are given in Table 1. Figure 6 shows the major forest habitat regions of Alabama based on soil and physiographic features. Preliminary analyses revealed variations in ecology of raccoons between east-central and southwestern Alabama, Figure 5, seemingly unrelated to soil and habitat regions. Hence, most data were grouped into these two categories for analysis. Data on parasites were generally grouped by specific areas. Scientific names of plants and animals mentioned in this report can be found in the Appendix.

An intensive population study was begun on the Fred T. Stimpson Sanctuary in the fall of 1962. This Sanctuary is situated on the Tombigbee River in southern Clarke County, about 50 miles north of Mobile in the Loam Hills habitat region. This area of about 5,000 acres includes an unusually wide variety of species and ecological types. Several hundred acres are in river flood

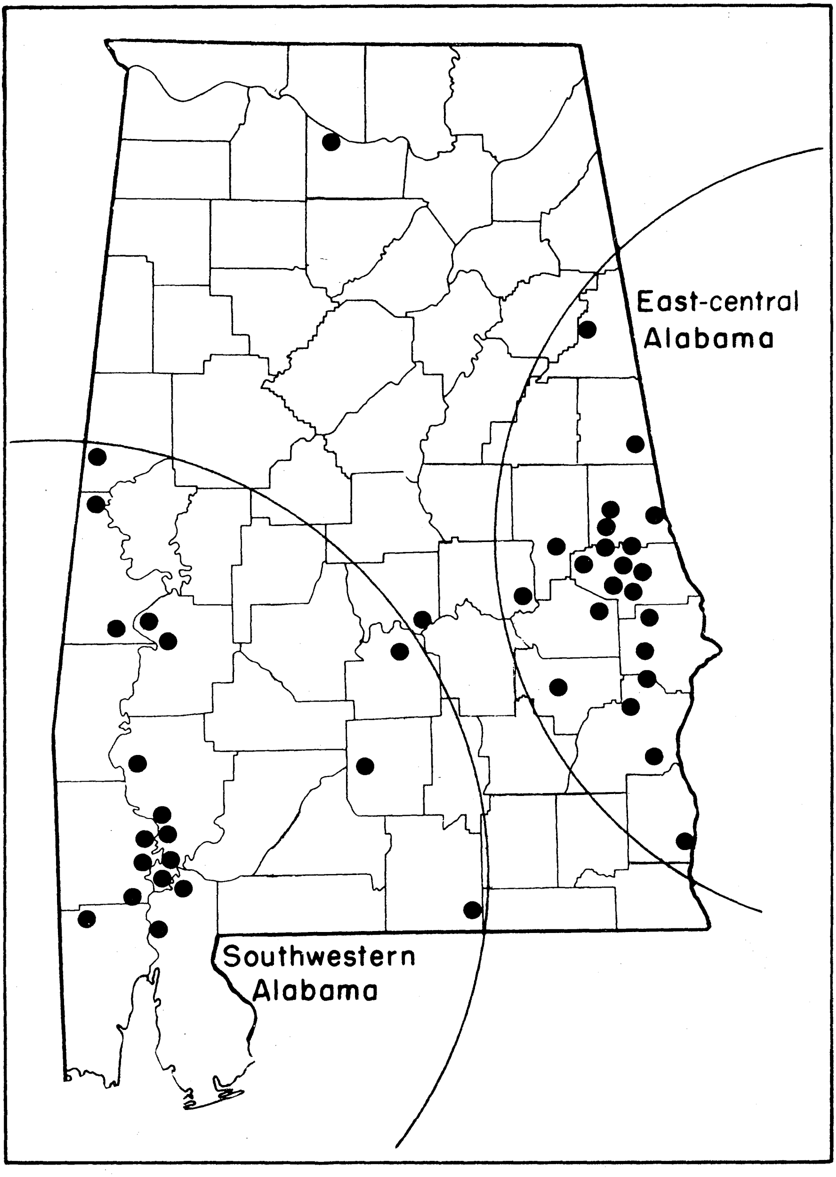


FIG. 5. Localities from which raccoons were examined by the author. Some data from Auburn University files are also included. Raccoons from the area labeled East-central Alabama were found to differ in certain biological characteristics from those taken within the Southwestern Alabama area. Data are generally grouped according to these two regions for analysis and comparison.

TABLE 1. SOURCES OF RACCOONS EXAMINED DURING THIS STUDY

Area	Exam. post-mortem	Exam. alive, tagged, released	Data from others[1]
	No.	*No.*	*No.*
Autauga County			
Prattville vicinity	1	----	----
Baldwin County			
Alabama River	5	----	----
Barbour County			
Barbour Co. W.M.A.	3	13	4
Other	2	----	----
Bullock County			
Union Springs	----	----	1
Butler County			
Butler Co. W.M.A.	27	----	----
Chambers County			
Lafayette vicinity	5	----	----
Waverly, Gold Hill	2	----	7
Clarke County			
Stimpson Game Sanct.	85	56	----
Upper State Game Sanct.	28	9	----
Scotch W.M.A.	18	----	----
Other	2	----	----
Cleburne County			
Choccolocco W.M.A.	16	----	----
Covington County			
Covington Co. W.M.A.	16	----	----
Elmore County			
Tallassee vicinity	1	----	----
Henry County			
Screamer	2	----	----
Lee County			
Coastal Plain	53	----	36
Piedmont	58	23	15
Lowndes County			
Lowndesboro	1	----	----
Macon County			
Tuskegee vicinity	17	----	2
Marengo County			
Bellamy vicinity	----	----	39
Shady Grove	1	68	----
Other	2	----	21
Mobile County			
Escatawpa River	1	----	----
Morgan County			
Wheeler Wildlife Refuge	1	----	----
Randolph County			
Roanoke vicinity	----	----	2
Russell County			
Uchee Creek	----	----	4
Sumter County			
Geiger	2	76	----

(Cont. next page)

TABLE 1. *(Cont.)*

Tallapoosa County			
Walnut Hill	----	----	2
Washington County			
Rob Boykin W.M.A.	13	7	----
Other	3	----	----
Total	365	252	133

[1] Data provided by Dr. Kirby L. Hays and Alabama Cooperative Wildlife Research Unit.

plain. Forests on the older bottoms consist of large overcup and laurel oaks, sugar hackberry, ash, water hickory, river birch, and swamp chestnut oak. Lianas, including muscadine and other wild grapes, rattan-vine, and pepper-vine, are conspicuous in the river bottoms. Cypress trees grow in the small sloughs and are often draped with Spanish moss. The area is situated on a salt dome, and there are several salt springs and a salt lake. The areas around the salt springs and lake are open, and vegetation there consists mostly of grasses and sedges and scattered red-cedar, possum-haw, and sabal palmetto.

Lower ridges support beech, spruce pine, laurel oak, southern magnolia, oak-leaf hydrangea, and thickets of Florida anise. Limestone bluffs rise to over 300 feet above the river swamp. Moist upper slopes support a mixed mesophytic forest.

Dry uplands on the southern portion of the area are characterized by longleaf pine, turkey oak, black-jack oak, post oak, and sparkleberry. The remainder of the dry uplands support mostly shortleaf pine, some loblolly pine, southern red oak, post oak, water oak, dogwood, American holly, and sparkleberry.

Much of the area has been planted to winter pasture and chufas for game animals. The area supports large numbers of wild turkeys and raccoons, and is over-populated with white-tailed deer.

Other areas sampled in the Loam Hills Region were mostly river swamp or infertile uplands characterized by longleaf pine, slash pine, and gallberry.

The Clay Hills Region, characterized by rolling hills, heavy clay soils, and loblolly and shortleaf pine forests, was represented in the sample mainly by raccoons from the Scotch Wildlife Management Area and the Upper State Game Sanctuary (both in Clarke County) and the Butler County Wildlife Management Area. However, a few raccoons were examined from the Clay Hills Region in eastern Alabama.

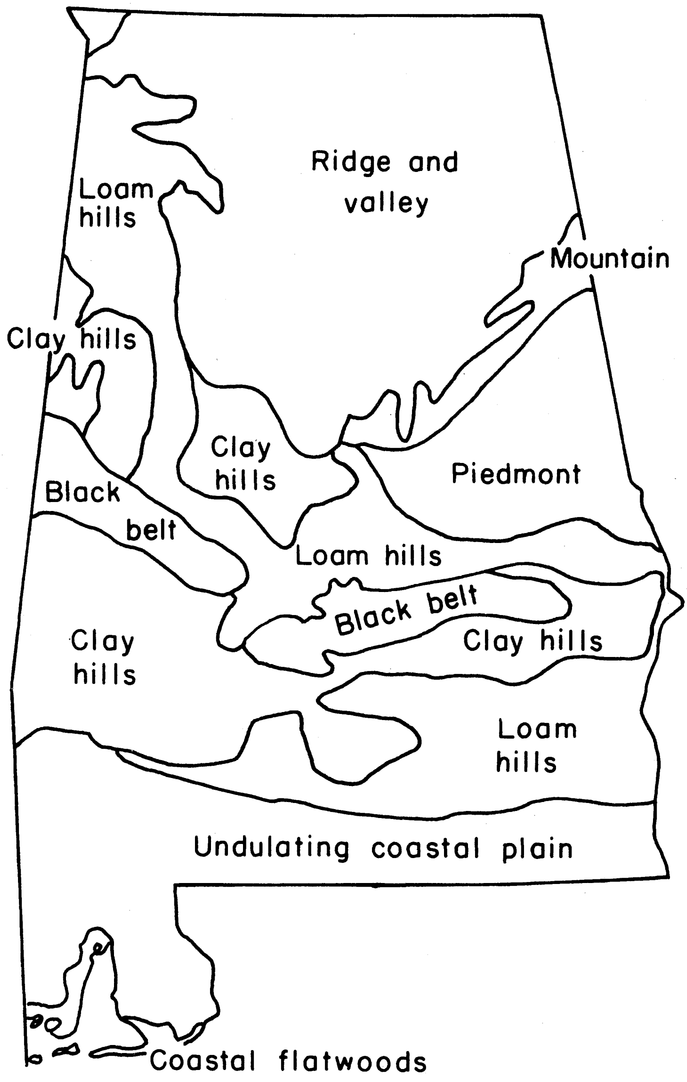


FIG. 6. Habitat regions of Alabama based on physiography and soils. Adapted and redrawn from Anonymous (5) and Hodgkins (90).

Much of the research effort was centered in Lee County in the Piedmont Plateau and Loam Hills regions in east-central Alabama and in adjoining Macon County in the Loam Hills Region. Soils of these regions are mainly sandy loams. Agriculture is more intensively developed than in southwestern Alabama, but much land formerly in agriculture is now in pine and pine-oak-hickory forests. Raccoons and other forest game are generally less abundant in this area than in southwestern Alabama.

The Black Belt is different from other areas of the State. The soils were formed from chalk deposits and are generally heavy and sticky. The uplands probably originally supported natural prairie vegetation. Cattle grazing is the primary use. Reliable data were obtained from only a few raccoons in this area.

Northern Alabama was poorly sampled. Sixteen raccoons were examined from the Mountain Province in Cleburne County. This is a rugged area with infertile soils and much local relief. The area is mostly forested with mixed hardwood and is characterized by Virginia pine and chestnut oak on the ridges and mixed hardwoods along the streams. Only one raccoon was examined from the Limestone Valley Province. It was taken near Decatur, Alabama.

ESTIMATING AGE OF RACCOONS

A combination of methods of ascertaining age of raccoons was used. Most of these have been previously described by Sanderson *(166,167)*. Generally, raccoons could be readily separated into two age classes (immature and mature). But, detailed population analysis requires that more than two age classes be identifiable. Consequently, all characters referable to age were used in an effort to estimate age to the nearest year or, in the case of animals less than 1 year old, to the nearest month. Dental characters and weight of the lens of the eye were the most reliable criteria. Other criteria were used as supporting evidence of age.

Terms applied to different age groups were as follows: (1) *juveniles* – less than 1 year of age, (2) *subadults* – 1 to 2 years of age, and (3) *adults* – 2 years of age or older. When it was not possible to distinguish subadults, animals were classified as *immature* (15 months or less) or *mature*.

WEIGHT OF THE LENS OF THE EYE

The lens of the eye has been reported to increase in size and density throughout life in certain mammals. Lord *(115)* described the eye lens as an indicator of age in cottontail rabbits. Lens growth curves have since been described for several species and have been used with varying degrees of success in estimating age. Sanderson *(167)* established the relationship between age and weight of the lens of 119 raccoons for which approximate ages were known. He concluded that the rate of growth of the lens in raccoons varies little 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 growth rate of the lens is much slower and much more variable, making it impossible to distinguish year classes of adults.

The general procedure for handling and weighing eye lenses in the present study was similar to that described by Lord and Sanderson. The eyeball was removed intact, Figure 7, and preserved in 10 per cent formaldehyde. Eyes that had been frozen were not generally used because freezing is a suspected source of error *(136)*. The eyes were taken out of formaldehyde in 10 to 14 days. Lenses were removed carefully, Figure 8, and allowed to dry. They were then stored in glass bottles with a numbered metal tag. When a convenient number of lenses were accumulated, they were oven-dried at 80°C for 4 days, removed, and weighed immediately to the nearest tenth of a milligram.

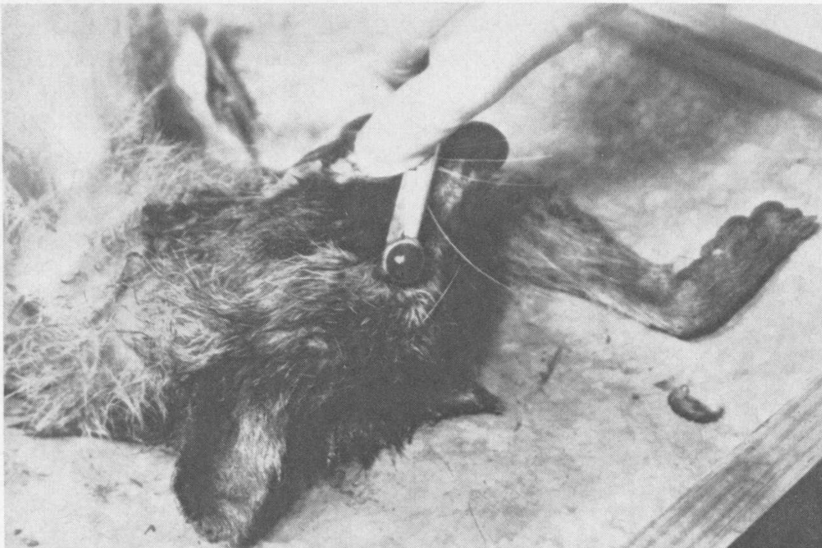


FIG. 7. Removing eyeball from raccoon for age studies.

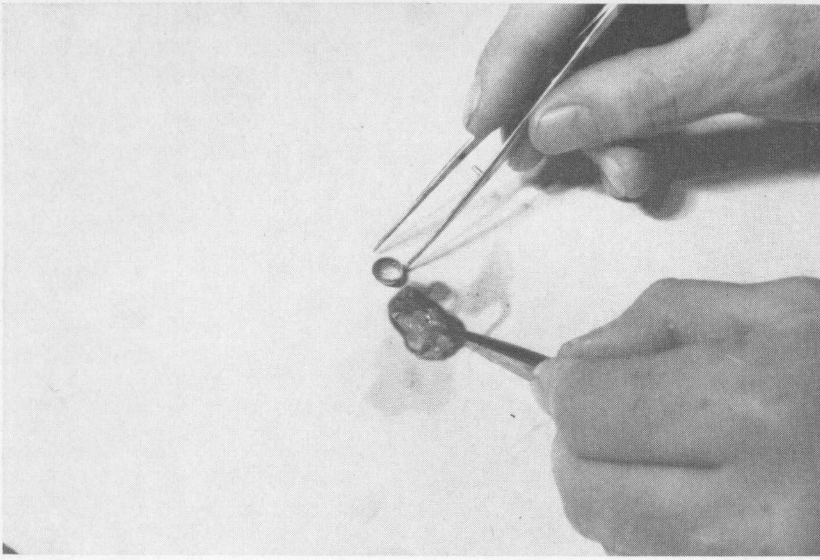


FIG. 8. Lens removed from eye for processing and weighing.

An attempt was made to verify for Alabama the lens growth curve established in Illinois by Sanderson *(167)*. Lens weights were obtained from 80 raccoons of various ages. These animals were placed into three age groups (juveniles, subadults, and adults) based upon other characters discussed in this section. Year classes of adults were estimated from annulations in the dental cementum. All animals were then assigned ages to the nearest month, assuming (see page 43) a June birth date. The relationship between the weight of the lens and age was then established, Figure 9. Some adults could not be classified with confidence as to age. These were not used, and weights of lenses from 23 adult raccoons ranging in age from 30 months to an estimated 10 years are not included. Weights of these lenses ranged from 105 to 164 milligrams. Two raccoons that had been marked and recaptured after long periods of time were known to be at least 8 years old. Two others were known to be at least 4 years old. Lenses of these four animals ranged in weight from 128 to 140 milligrams.

Results from young animals were similar to those of Sanderson, Figure 9. But, after 30 months lenses had an average weight of 130 milligrams and showed no obvious tendency to increase in weight.

The maximum lens weight among juvenile raccoons was 108 milligrams. Only 3 of 22 juveniles had lens weights over 100 milli-

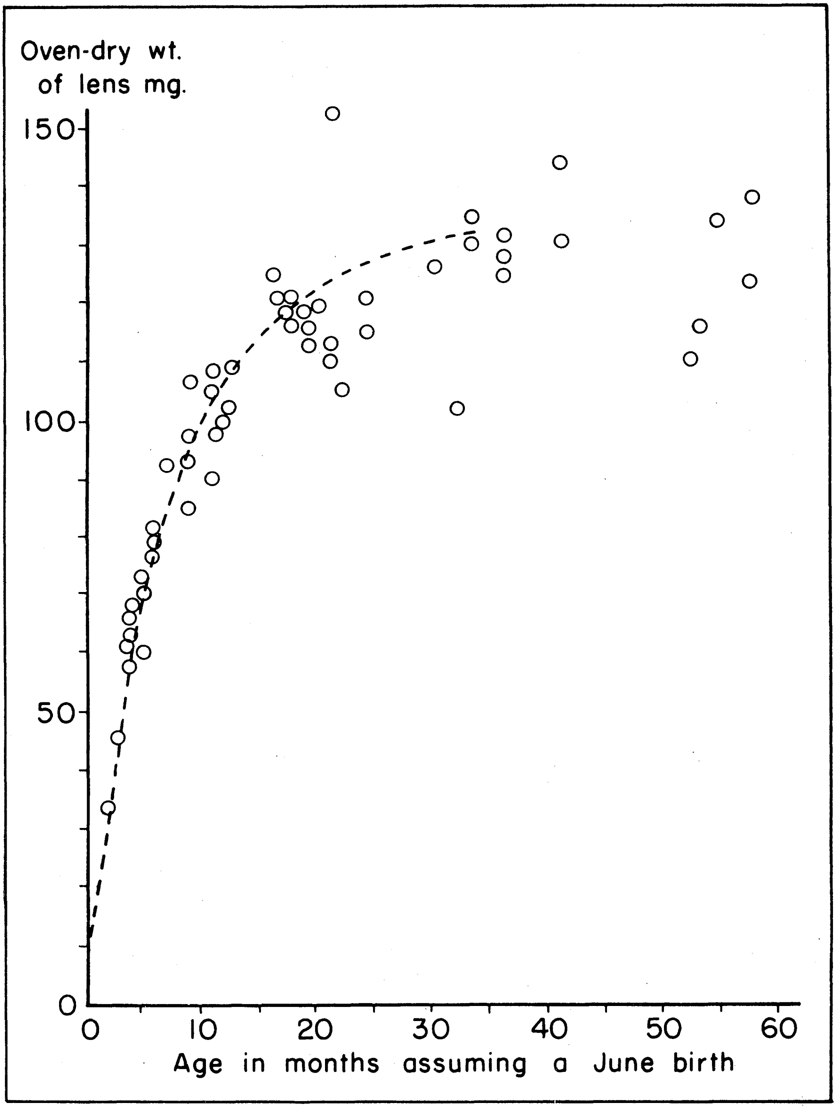


FIG. 9. Relationship between weight of lens of the eye and estimated age of raccoons. Points are weights of lenses from raccoons from Alabama. Curve is that established by Sanderson (167) for 119 raccoons for which approximate ages were known.

grams, and none of 58 subadults and adults had a lens weight of less than 100 milligrams. In general, subadults had lenses weighing 105 to 120 milligrams, Figure 10. However, there was much

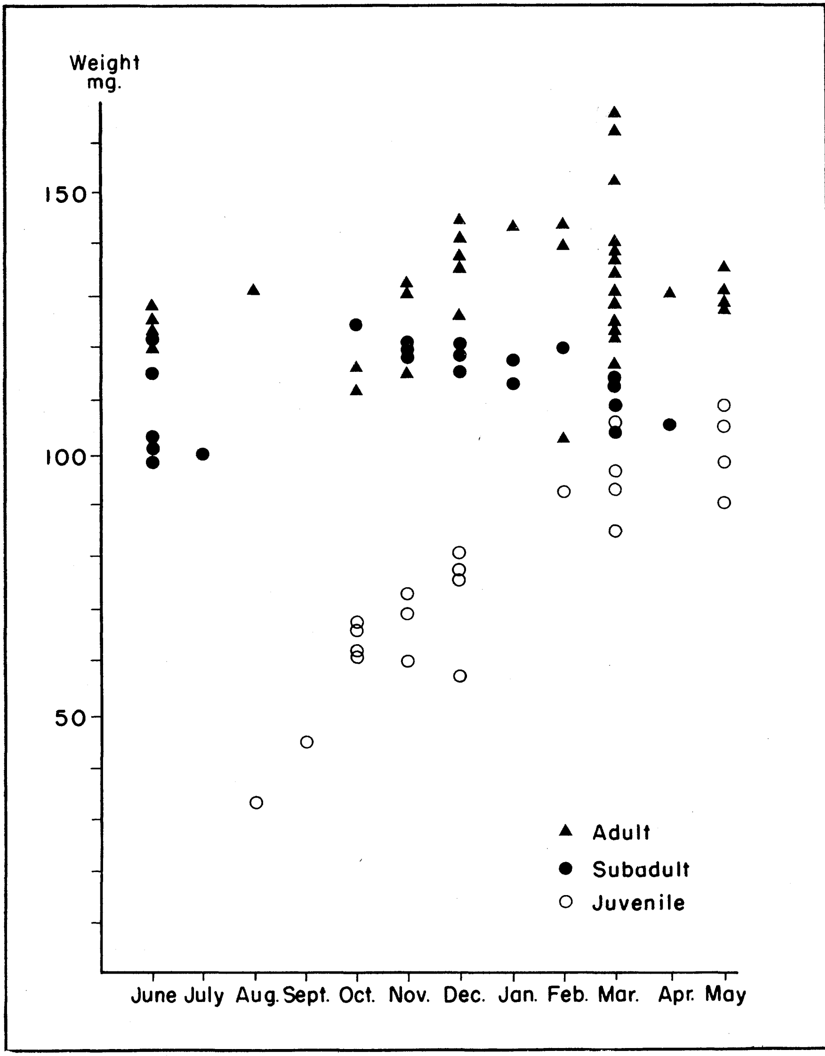


FIG. 10. Monthly distribution of weights of individual eye lenses from 80 raccoons from Alabama.

overlap, and the range of 105 to 120 milligrams included 3 of 22 juveniles and 6 of 38 adults.

From the data available it is concluded that juvenile raccoons can be segregated from older raccoons by lens weight, the lens growth curve of Sanderson *(167)* is generally applicable to juvenile raccoons in Alabama, and lens weight is helpful in distinguishing subadults, although there is much overlap.

DENTAL CHARACTERS

Annulations in the Cementum

Annular layers in the dental cementum have been reported for various mammals from the colder latitudes *(170)*. These layers apparently correspond to seasonal changes in physiology. Cemental layering has not been reported for mammals from the warmer latitudes, where seasonal changes are less pronounced. Cemental layering in raccoons has not been reported previously.

In the present study teeth were removed from raccoons, sectioned, and treated in various ways in an effort to detect layering in the cementum. Preliminary observations revealed that layering was most conspicuous in areas with thickest deposition of cementum. The areas between the roots on the fourth premolar and on the first molar were selected as the most promising sites for study. Longitudinal sections through this portion of the tooth generally displayed layering better than did cross sections of the roots.

Molars and premolars of 12 raccoons were cut longitudinally through the area of thickest deposition of cementum between the roots, Figure 11. The teeth were cut with a hobby saw equipped with a circular carborundum blade. The cut surfaces were then polished with the face of the blade, wiped with alcohol or glycerine, and examined under a binocular dissecting scope.

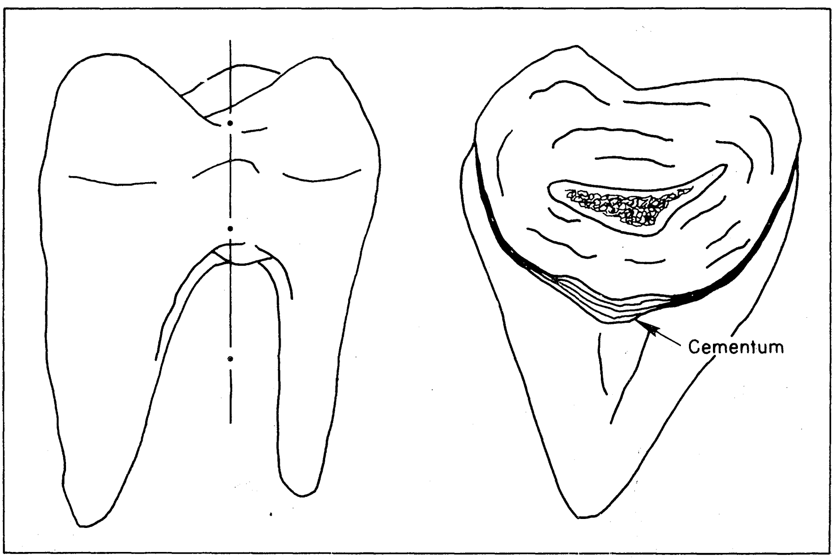


FIG. 11. Raccoon premolar showing point of sectioning.

Using the Sauer, *et al.* *(170)* method of histological preparation, sections of teeth from the same animals were then examined, and prominence of layers in the cementum was compared with the cut and polished teeth. Because no consistent advantage was noted from the histological preparation of the teeth, all remaining teeth were simply cut and polished and examined as first described.

The number of layers in the cementum was then compared to data relating to age of the animals from which the teeth came. Although exact ages of animals were not known, minimum ages were sometimes known from multiple sets of placental scars (sites of placental attachment) and from marked animals, which were recaptured at intervals up to 7 years after initial marking. Where such information was not available, other characters including those described by Stuewer *(188)* and Sanderson *(166,167)* provided some basis for comparison.

As reported for certain other mammals *(e.g. 110)*, it is apparently necessary to add "1" to the number of layers counted to obtain an accurate estimate of age in years. No layers were evident in animals having lived through only 1 winter.

Layering was quite distinct in the cementum of some animals, but in many it was indistinct, Figure 12. Interpretation was often difficult and required intensive examination of several teeth. False annuli were common, and their interpretation depended to a large extent upon subjective judgment. The error involved in this technique was variable from one animal to another, and the precision of the estimates of age could not be determined. However, ages estimated from dental cementum were in general agreement with other information on age, and a combination of cemental characters and other characters affording information on age should permit a reasonably accurate judgment as to age of raccoons.

Size of the Pulp Cavity

The size of the pulp cavity provided supporting evidence of age. Raccoons less than 1 year old generally had fragile teeth with very large pulp cavities. In 2-year-old raccoons, the pulp cavity was partly closed, and in 3-year-old and older animals the pulp cavity was almost entirely closed.

Tooth Attrition

Several investigators have used dental wear as a means of differentiating between age classes in raccoons *(e.g. 188)*. Animals in this study were grouped with a fair degree of objectivity into

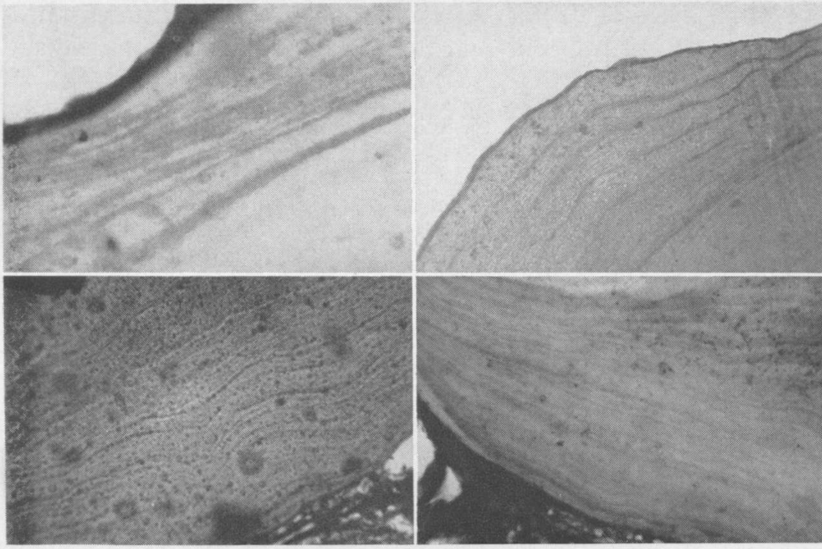


FIG. 12. Sections showing layering in the cementum of molars and premolars from raccoons. The sections at the top show fairly well defined layers. Animals from which these sections were taken were estimatd to be 11 and 7 years of age. Sections at the bottom show poorly defined layers.

three categories based on tooth attrition. One- and 2-year-old animals typically had very sharp canines and showed little evidence of attrition on the molars. Three- and 4-year-old raccoons showed wear on molars, but crests were still very evident and canines were still sharp. Older animals usually had crests of molars worn completely away.

Tooth Eruption

Montgomery *(137)* described the sequence of tooth eruption in young raccoons. Tooth eruption was sometimes used in the present study in ascertaining age of young raccoons when eye lenses could not be used.

EPIPHYSEAL DEVELOPMENT

Widths of epiphyseal cartilages of ulni and radii of many of the animals examined were recorded as described by Sanderson *(166)*. Sanderson found that in raccoons from Illinois epiphyseal cartilages were usually broad in animals under 15 months of age and disappeared at 15 to 30 months of age. This character seems to be quite variable, and its greatest value in the present study was as an aid in recognizing nearly mature animals in the fall of their second year.

SEXUAL CHARACTERS

Weight, length, conformation, and ossification of the penis bone or baculum, Figure 13, and whether the penis could be extruded through the preputial orifice *(162,166)* were very useful characters for separating immature and mature males. Raccoons in Alabama usually develop mature bacula at about 15 months. None of five subadults examined in June and August had extrusible penes or mature bacula. No subadults were examined in September, but all of three subadults examined in October, six in November, and six in December had mature bacula.

The preputial orifice was found to generally enlarge simultaneously with the maturation of the baculum. Although the baculum attains an adult conformation and length and becomes fully ossified in the fall of the second year, it continues to increase in weight to about 3 years of age. Thus, 56 of 58 juveniles had bacula weighing less than 1.2 grams (air dry weight); 33 of 35 subadults had bacula weighing 1.5 to 3.0 grams; and 40 adults had bacula weighing 2.5 to 5.4 grams. Therefore, raccoons with fully ossified bacula weighing less than 2.5 grams can be classified as subadults with a high degree of accuracy, although some subadults will have bacula weighing in excess of 2.5 grams.

The size and pigmentation of the teats *(162,163,188)* provided a useful means of distinguishing females that had been pregnant or pseudopregnant from those that had not, especially where live animals were involved.

Reproductive tracts of females examined at necropsy quickly revealed whether the animal had borne young, and when placental scars representing two or three reproductive seasons were present, a minimum age was known. For example, an animal with three distinct sets of placental scars, even if she bore young her first year, would have to be at least 3 years old.

DISTINGUISHING IMMATURE ANIMALS BY WEIGHT

When used in combination, the age criteria previously discussed provide fairly reliable estimates of the ages of most raccoons examined by necropsy, and immature animals can be distinguished with a high degree of accuracy. It is necessary in population studies, however, to have some reliable means, equally applicable to males and females, of distinguishing mature and immature animals without destroying or harming them.

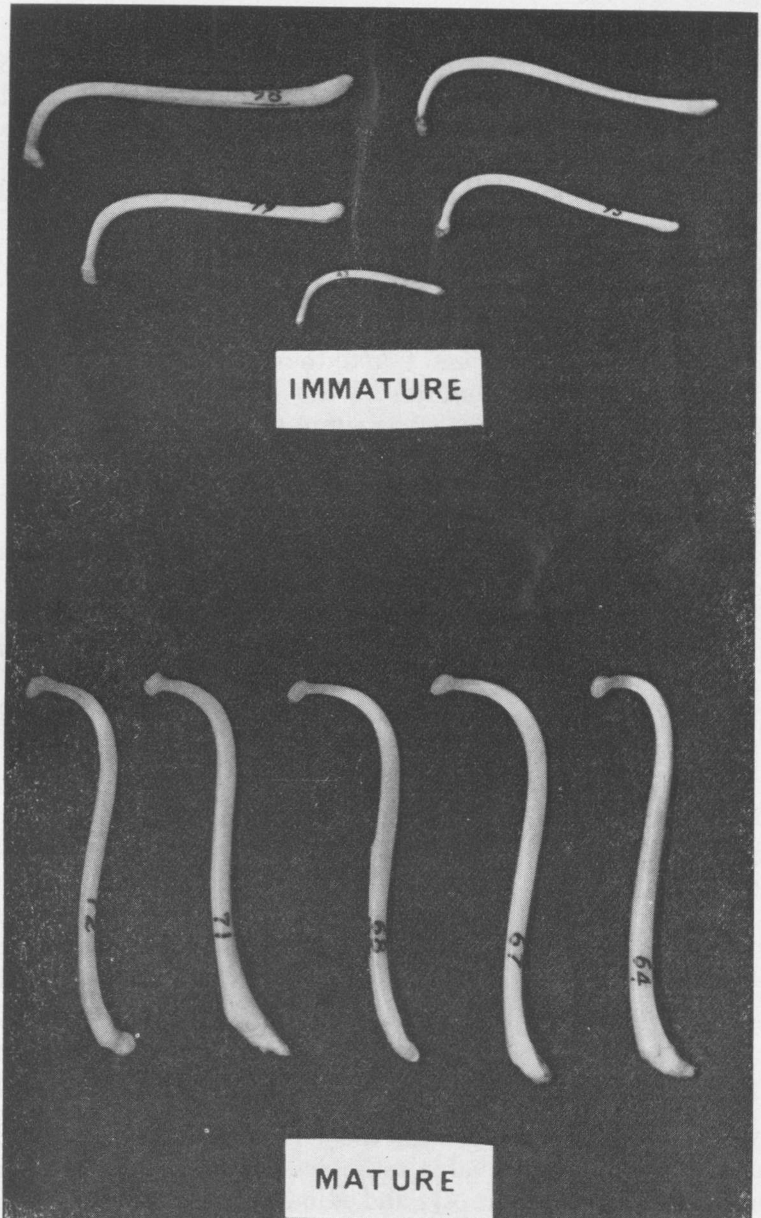


FIG. 13. Bacula from raccoons of various ages.

Because of this, and because some necropsy data provided by others did not include reliable age estimates, the relationship of total animal weight to age was investigated. Total weights of raccoons that were examined post-mortem were used to construct weight frequency histograms. Animals were classified either immature or mature by the criteria previously discussed. Animals in each age category were then grouped into ½-pound weight classes, and weight frequency histograms were drawn. This procedure was repeated for each of several areas because of obvious differences in weights of animals on different areas.

Necropsy data were obtained from 103 raccoons from the Fred T. Stimpson Game Sanctuary. Figure 14 illustrates the weight distribution within each of the two age categories. Data are pooled without regard to sex or season. Six pounds was determined to be the best weight for separating mature and immature animals. If those animals weighing 6 pounds or less are considered to be immature and those weighing over 6 pounds are classified as mature, four of them (4 per cent) are misclassified. Similar histograms were plotted with the data segregated by sex and time of year. But, regardless of sex or time of year, fewest animals were misclassified if all animals weighing 6 pounds or less were considered to be immature.

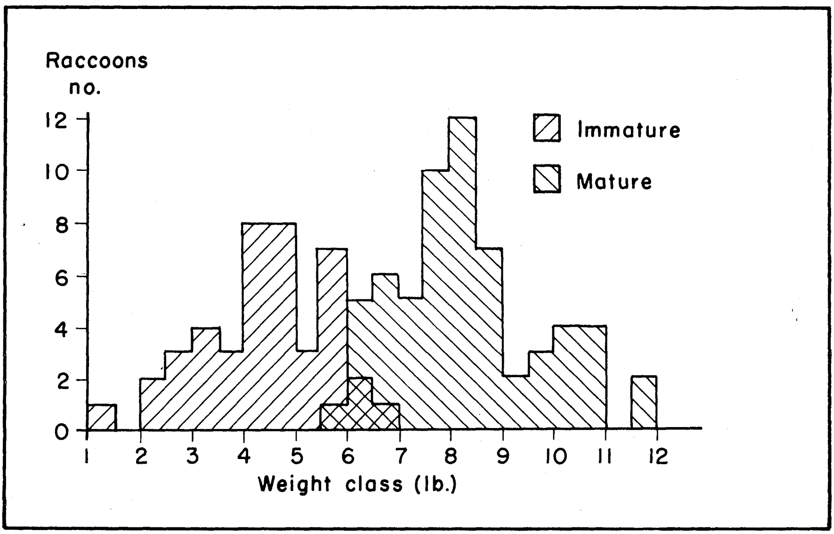


FIG. 14. Distribution of weights of 103 raccoons of both sexes collected from the Fred T. Stimpson Sanctuary and examined post-mortem.

Similar histograms were constructed using data on 110 raccoons collected from various other areas in southwestern Alabama, Figure 15. Results were similar to those obtained with the Stimpson Sanctuary data. With the age classes divided at 6 pounds, only 3 of 110 raccoons were misclassified. Because data from raccoons collected on the sanctuary were not appreciably different from those collected in various other areas in southwestern Alabama, the two groups of data were then pooled, Figure 16. Pooling of the data reveals that some accuracy would be gained if, in fall and winter, males were segregated at 7 pounds. With this modification, only 5 of 213 raccoons were misclassified. The lower weight limits of the mature male group are higher in fall and early winter, but a substantial number of females still weigh less than 7 pounds, probably because of nursing late-borne young.

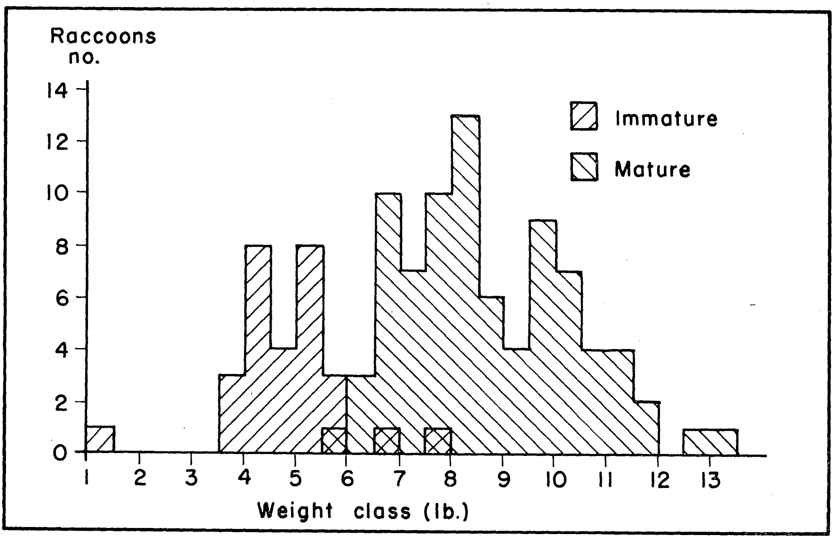


FIG. 15. Distribution of weights of 110 raccoons of both sexes collected from various areas of southwestern Alabama, excluding the Fred T. Stimpson Sanctuary, and examined post-mortem.

Weights of raccoons from east-central Alabama were less reliable as indicators of age, Figure 17a. Weights were much more variable. Even animals of the same sex taken from the same area varied greatly, and no advantage was gained when data were segregated according to the specific area from which the animals were taken. Figure 17b shows the weight distribution of 82 male

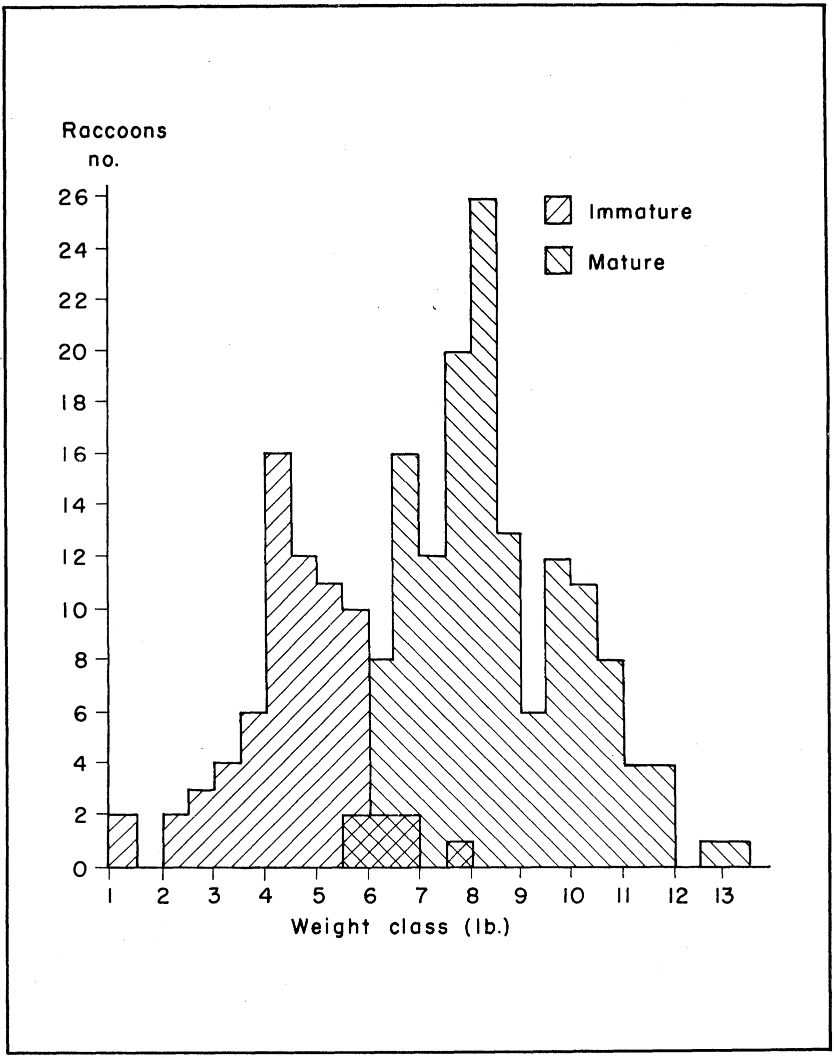


FIG. 16. Distribution of weights of 213 raccoons of both sexes collected from various areas of southwestern Alabama, including the Fred T. Stimpson Sanctuary, and examined post-mortem.

raccoons from east-central Alabama. Mature and immature animals were most efficiently separated at 7.5 pounds. But the range of overlap extended from 5.5 to 9 pounds, and eight animals (10 per cent) were misclassified. Sixty-four females could be separated at 6, 6.5, or 7 pounds with equal efficiency – 5 animals (9

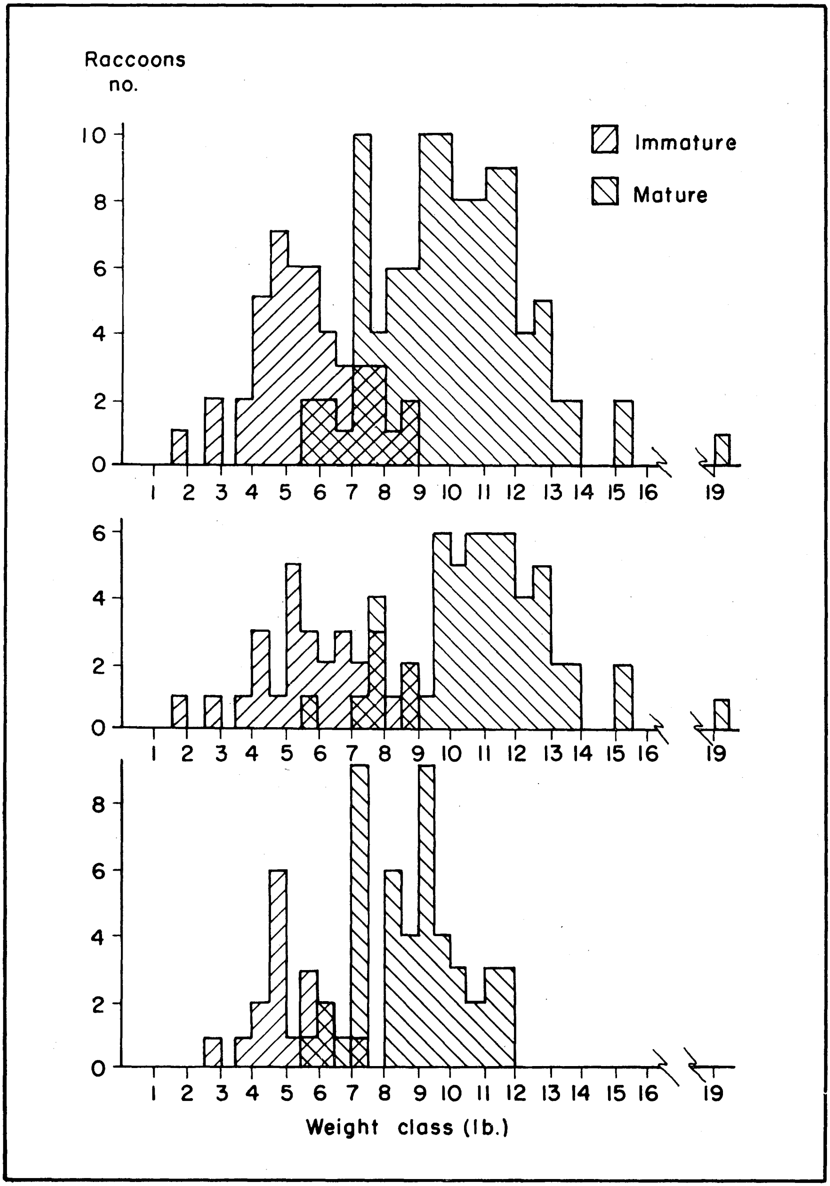


FIG. 17. Distribution of weights of raccoons collected in east-central Alabama and examined post-mortem. Top-to-bottom distributions are for: (a) 146 animals of both sexes; (b) 82 males; and (c) 64 females.

per cent) being misclassified in each case, Figure 17c. Thus 13 of 146 raccoons (9 per cent) from east-central Alabama were misclassified.

When used in conjunction with other information, weights provided age estimates with an acceptable amount of error. Caution must be taken, however, in applying weight frequencies to populations other than those for which they were developed. Whereas, 6 pounds was found as a breaking point between mature and immature animals in southwestern Alabama, for example, Sanderson *(162)* used 15 pounds to segregate the two age classes in Missouri.

It cannot presently be explained why weights of raccoons from east-central Alabama were so much more variable than those from southwestern Alabama. Possibly it is because of greater diversity in habitat and thus more diverse feeding opportunities in east-central Alabama. But, since raccoons from the same area often varied greatly in weight, it seems that some individuals must be excluded from favored food sources, perhaps by dominant individuals. It may be significant that many of the histograms showed peaks at two distinct weight classes even when data were from animals of the same sex.

Others *(e.g. 166)* have used weights to estimate ages of juvenile raccoons to the nearest month. As will be explained later, it was found in this study that weights of juvenile raccoons in Alabama were too variable to be of value in ascertaining age in winter. Prior to November, the age of juvenile raccoons in central and southern Alabama can probably be reliably estimated from Figure 30 (page 52).

GENERAL SUMMARY OF AGE CRITERIA

Male raccoons less than 1 year old (juveniles) have small bacula generally weighing less than 1.2 grams; the penis is not extrusible through the preputial orifice, and the testes contain no mature sperm. Juvenile females have small, non-pigmented nipples and an undistended uterus without placental scars. Juveniles of both sexes have open epiphyses. Teeth show little wear, open pulp cavities, and no annulations in the cementum. Oven-dry weight of the eye lens is less than 100 milligrams.

Male raccoons in Alabama attain sexual maturity at about 15 months. At this age the preputial orifice enlarges permitting extrusion of the penis, the baculum becomes full ossified, and mature sperm can be found in the epididymis. Bacula of subadults generally range in weight from 1.5 to 2.5 grams air dry weight. Both sexes usually attain adult weights at about 15 months. In southwestern Alabama this is about 6 pounds for both sexes. In east-central Alabama adult weights are generally above 7.5 pounds for males and above 6.5 pounds for females. Epiphyses close generally at 15 to 18 months, but there is much variation. Lenses of subadults generally weigh 105 to 120 milligrams.

Raccoons over 2 years old (adults) generally have eye lenses weighing 120 milligrams or more and closed epiphyses. Bacula weigh 2.5 grams or more. Nipples of females are generally somewhat enlarged and pigmented, and uteri usually display one or more sets of placental scars. Teeth of adults show definite signs of wear that provide general impressions of relative age. The pulp cavity is closed, and the cementum may show layering corresponding to annulations. Counts of these layers provide estimates of age to the nearest year.

PHYSICAL CHARACTERISTICS

Raccoons in Alabama are considered as representing only one subspecies. Howell *(91)* examined specimens from six localities in Alabama and pronounced them all typical *Procyon lotor lotor* (Linnaeus) (the eastern raccoon), showing no approach to the characteristics of *P. l. elucus* Bangs (the Florida raccoon). Skins, however, were said to be more ochraceous above than Maryland and Virginia specimens. Nelson and Goldman *(143)* re-examined these and other specimens and assigned them to a new subspecies, *P. l. varius* (the Alabama raccoon), the range of which extends from northwestern Florida and Georgia west to the Mississippi River and north to extreme southwestern Kentucky *(72)*.

The general characteristics of the Alabama raccoon were given as follows: "A small subspecies closely resembling *Procyon lotor lotor* but smaller, usually paler, pelage much shorter and skull differing in detail. Differing from *P. l. elucus* in paler color, rather decidedly smaller size and in cranial features" *(143)*.

MEASUREMENTS AND WEIGHTS

External Measurements

Standard measurements were generally obtained from animals examined post-mortem. Measurements for adults by region are presented in Table 2. All measurements were taken in the usual manner (38) except that the claw was not included when measuring the length of the hind foot. Averages of external measurements, except tail length in southwestern Alabama, were greater for males than for females. Measurements of total length and hind foot length were significantly different ($P < 0.05$) between the sexes within each region. External measurements of raccoons from southwestern Alabama were usually smaller than those of raccoons from east-central Alabama, but the differences were not statistically significant.

TABLE 2. EXTERNAL MEASUREMENTS OF ADULT RACCOONS FROM ALABAMA

Measurement	Males			Females		
		Mean ± 2SE	Range		Mean ± 2SE	Range
	No.	*Mm.*	*Mm.*	*No.*	*Mm.*	*Mm.*
East-central Alabama						
Total length	46	748.6 ± 12.8	643-813	33	724.4 ± 9.0	688-775
Tail length	22	234.0 ± 7.8	203-279	18	217.7 ± 9.9	196-249
Hind foot length (excluding claw)	23	103.7 ± 3.0	93-114	17	97.1 ± 3.2	84-109
Ear length (from notch)	20	56.2 ± 2.6	45-65	18	57.6 ± 2.2	46-65
Southwestern Alabama						
Total length	79	733.7 ± 6.4	673-813	51	717.9 ± 7.1	660-762
Tail length	65	233.0 ± 6.9	185-279	42	236.0 ± 5.0	198-274
Hind foot length (excluding claw)	60	99.8 ± 1.2	92-110	41	95.2 ± 1.6	82-105
Ear length (from notch)	58	56.1 ± 1.0	50-67	40	54.9 ± 1.4	40-66

Skull Measurements

Figure 18 shows the skull of an adult male from Washington County. Some measurements from the skulls of 18 adult raccoons from southwestern and east-central Alabama are presented in Table 3. All average measurements, except least interorbital constriction, were greater for males than for females.

Weights

Weights of 451 adult and 249 juvenile raccoons were recorded. The overall average for 277 adult males was 9.5 pounds; for 174 adult females, 8.1 pounds. Only four adult males weighed over 15 pounds; the largest weighed 19.4 pounds, the second largest 15.3 pounds. The largest female weighed 13.0 pounds. Average weights are compared by season, sex, and region in Figure 19.

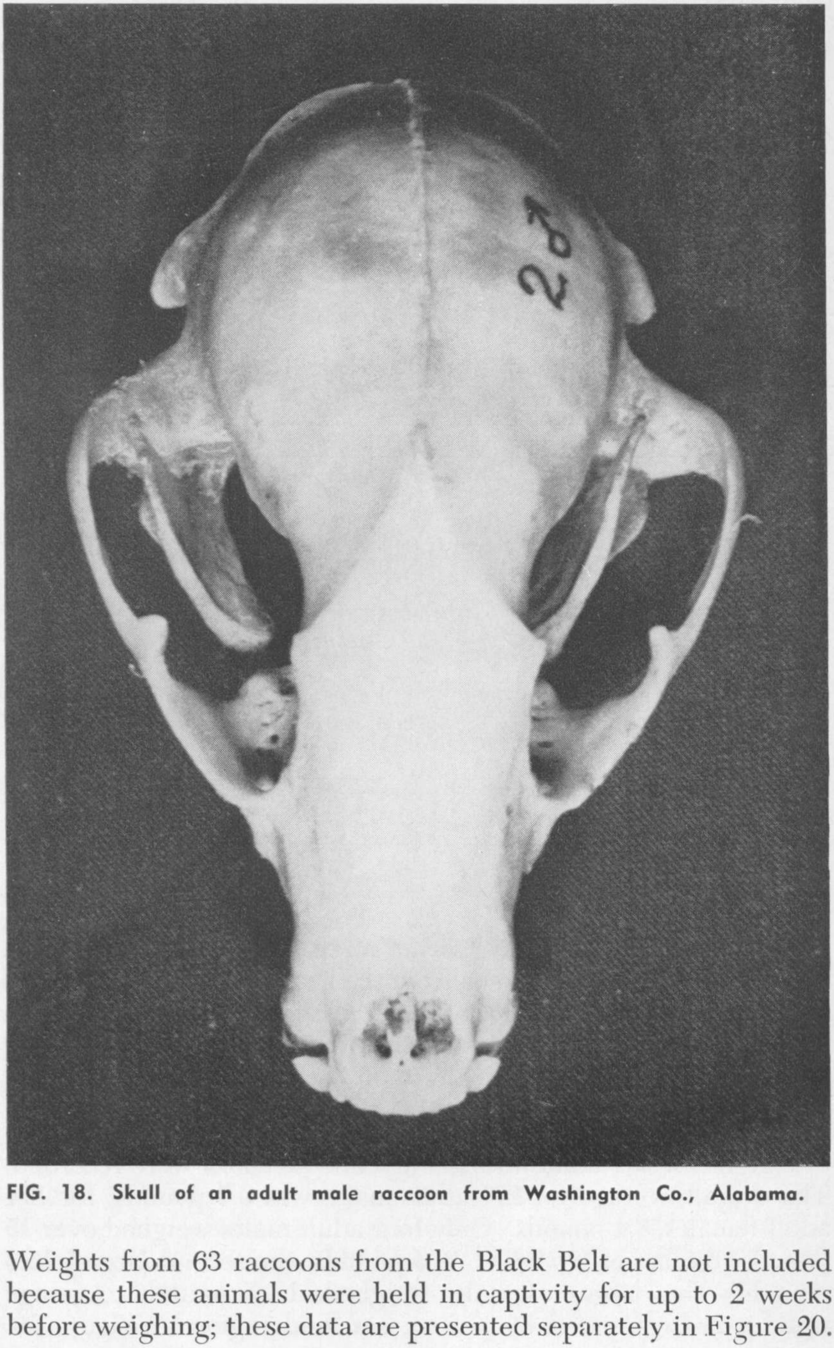


FIG. 18. Skull of an adult male raccoon from Washington Co., Alabama.

Weights from 63 raccoons from the Black Belt are not included because these animals were held in captivity for up to 2 weeks before weighing; these data are presented separately in Figure 20.

TABLE 3. SOME MEASUREMENTS[1] FROM THE SKULLS OF 18 ADULT RACCOONS FROM SOUTHWESTERN AND EAST-CENTRAL ALABAMA

Measurement	Males			Females		
		Mean ± 2SE	Range		Mean ± 2SE	Range
	No.	*Mm.*	*Mm.*	*No.*	*Mm.*	*Mm.*
Condylobasalar length	9	109.8 ± 5.8	100-123	8	103.1 ± 5.7	94-115
Basilar length	9	96.3 ± 2.2	93-103	8	92.6 ± 2.8	86-97
Zygomatic breadth	9	72.6 ± 4.9	67-81	9	66.4 ± 1.0	62-68
Mastoid breadth	9	58.2 ± 1.3	54-68	8	53.6 ± 1.2	48-57
Palatilar length	9	62.3 ± 2.5	58-69	8	58.6 ± 1.5	40-68
Least interorbital constriction	9	22.5 ± 1.1	20-25	9	23.6 ± 0.8	22-27
Length of maxillary tooth row	9	48.5 ± 0.9	46-51	9	47.1 ± 0.9	41-50

[1] Using the method described by Cockrum *(38).*

Average weights of adult males were generally greater than average weights of adult females. Both sexes were at minimum weight in the spring, and differences in weight were not pronounced at this time. But the differences between the average weights of males and females increased progressively in the summer and fall and were greatest in winter.

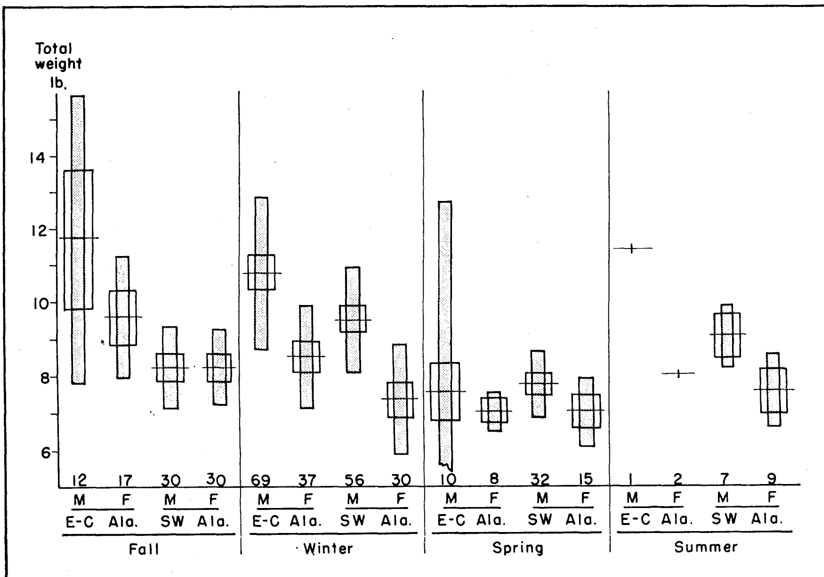


FIG. 19. Weights of adult raccoons in Alabama according to season, region of State, and sex. Horizontal lines represent the mean. The ranges of two standard errors and one standard deviation on either side of the mean are indicated by the shaded and unshaded bars, respectively. Numbers below bars show number of animals in sample.

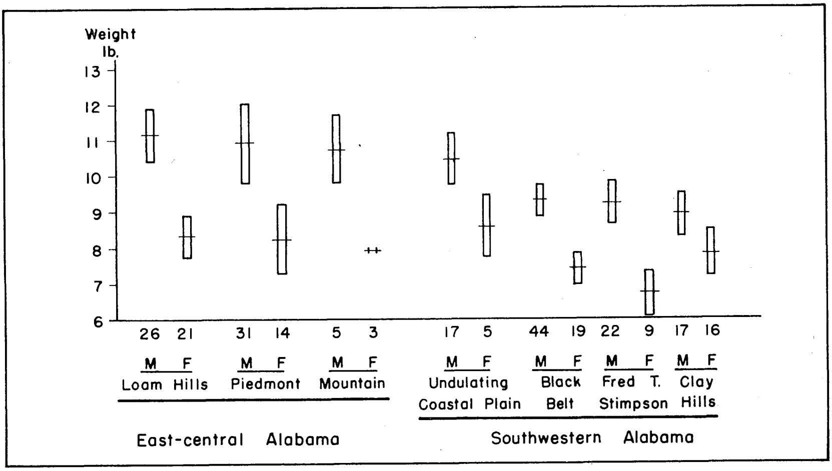


FIG. 20. Winter weights of raccoons in the various habitat regions of Alabama and on the Fred T. Stimpson Sanctuary. Horizontal lines represent the mean, and vertical bars represent the range of two standard errors on either side of the mean. Numbers below the bars show number of observations. Animals from the Black Belt were held in captivity for periods of up to 2 weeks before weighing and data are therefore unreliable.

Weights of adults typically declined drastically from late December to early May, then increased to the maximum level by mid-December. Spring weights were typically about 20 per cent less than fall weights.

Considerable geographic variation was evident. Data were analyzed by habitat types and soil types, and although substantial differences in average weights of adults were apparent, the difference was primarily between populations of east-central Alabama and those of southwestern Alabama, seemingly without regard to soil or habitat region, Figure 20. With one exception, average weights of raccoons in different soil or habitat regions in the same part of the State were not substantially different. The exception involved raccoons from the loamy soils subdivision of the Undulating Coastal Plain in Covington, Baldwin, and Mobile counties. These animals were substantially heavier than those from other areas of southwestern Alabama.

Raccoons of both sexes were significantly ($P < 0.05$) heavier in east-central Alabama than in southwestern Alabama. Average weights of males in east-central Alabama were over 40 per cent greater in fall and winter than average weights of males in southwestern Alabama. The difference between females was only 15 to 20 per cent. Average weights of males in the two areas were about the same in spring. The largest of 125 adult males from southwestern Alabama weighed 12.6 pounds. This was the only raccoon from this region weighing over 12 pounds, whereas 23 of 92 adult males (25 per cent) from east-central Alabama weighed over 12 pounds, and the largest weighed 19.4 pounds.

One adult male from northwestern Alabama weighed 9.8 pounds. Twelve raccoons from Cleburne County in the Mountain Province had average weights similar to those of raccoons from elsewhere in eastern Alabama. Average weights of raccoons obtained from Cleburne County in winter are presented in Figure 20.

The greater average size and weight of raccoons in east-central Alabama was probably a result of lower population density, less parasitism, more summer food, and less competition from other game animals. However, the possibility of genetic differences in body size cannot yet be discounted.

A striking relationship between soil fertility and body weight was reported for large samples of raccoons from Missouri *(42,141, 142)*. Stains *(182)* reported raccoons from soils of high fertility weighed on the average 3.6 pounds more than those from soils of low fertility in Kansas, but the difference was not statistically significant. The differences in body weights of raccoons in Alabama were not related to soil fertility in any obvious way.

Weights of raccoons of the same sex taken from the same area at the same time in east-central Alabama often varied greatly. There was much less variation in weights of raccoons from southwestern Alabama. More variable weights in east-central Alabama were probably because of more diverse feeding opportunities.

There was some variation from year to year, but data were insufficient for statistical comparison.

It is difficult to make meaningful comparisons of weights of raccoons. Because of individual variation, seasonal variation, and differences between sexes, large samples of the same sex, taken at the same time of the year, are required and reliable data on age are necessary. Few samples such as this are reported in the literature. Even when such data are available, local and temporary food supply may result in misleading variation.

Nevertheless, it is now clear that there is a general tendency for average weights of adult raccoons to increase with increasing latitude in the northern hemisphere. The raccoon has frequently been erroneously cited in biology books as an exception to the general rule that, within a species, warm-blooded animals tend to be larger in colder regions *(e.g. 24)*.

Marshall *(121)* reported that 27 adult males from Minnesota had an average weight of 17.5 pounds in August. Stuewer *(188)* reported an average weight of 13.6 pounds for 47 adult males in Michigan. Sanderson *(165)* reported that adult males among 426 raccoons examined in fur houses in Illinois had an average weight of 16.7 pounds. Nagel *(141)* reported that 5,371 males in Missouri had an average weight of 14.9 pounds.

These weights (of *P. l. lotor* and *P. l. hirtus* Nelson and Goldman) are considerably greater than those obtained in this study or others in the South. Cunningham *(43)* reported the average weight of adult males from the Savannah River area in western South Carolina to be 10.7 pounds. Cagle *(28)* reported that 11 adult males (*P. l. megalodus* Lowery) from the Mississippi Delta ranged in weight from 8.4 to 11.5 pounds. Joseph A. Caldwell provided data on 23 adult males collected in winter in north-central Florida. The average weight was 12.4 pounds. Goldman *(72)* described the Alabama raccoon as "decidedly smaller" than this Florida subspecies (*P. l. elucus*). Goldman also reported the average weight of five adult males from Key Vaca (*P. l. auspicatus* Nelson) to be only 5.3 pounds. But other subspecies from the Florida Keys are larger.

PELAGE

Although fur characteristics were not studied, considerable variation in color was noted. Individuals varied in color from light gray with much red to medium gray, Figure 21, to almost black. Raccoons from southwestern Alabama gave the impression of being generally lighter in color and redder than those from east-central Alabama. Two raccoons from the Fred T. Stimpson Sanctuary had white nose and foot pads.

More than a dozen reports of albinos, Figure 22, were received. Two of these were from northwestern Alabama; all others were from a specific locality in the lower Tombigbee River swamp. Albinism in raccoons is apparently inherited as a simple recessive allele *(2)*.

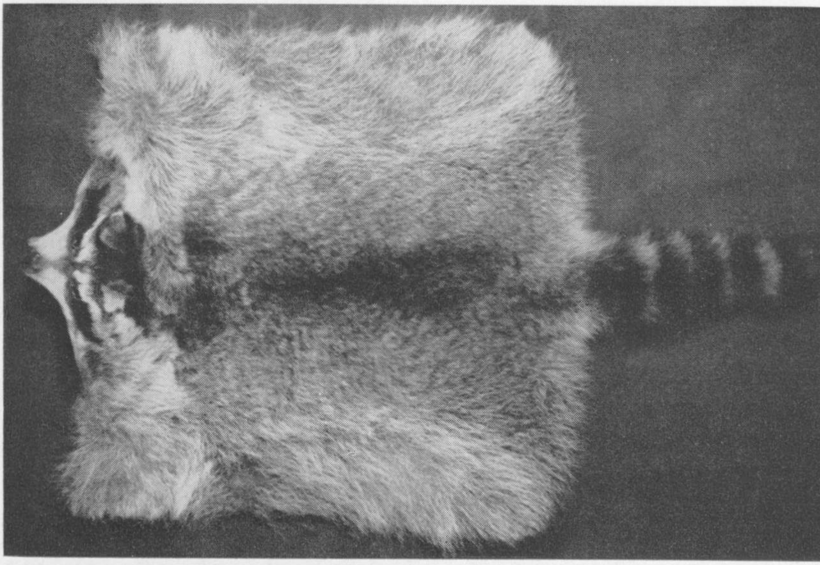


FIG. 21. Pelt of a typical "gray" raccoon from east-central Alabama.

FIG. 22. A young, albino male raccoon killed in the Tombigbee River swamp near McIntosh, Alabama.

BREEDING AND REPRODUCTION

AGE AT SEXUAL MATURITY

Methods

All males were examined for physiological capacity to breed as indicated by weight of testes, the presence or absence of sperm in the epididymes, and the size of the preputial orifice. Females were considered sexually mature if they were in estrus, showed stimulated nipples, were pregnant, or showed evidence of having borne young. Age data were collected on all animals, and an attempt was made to determine age at sexual maturity by relating age data to reproductive data.

Results

MALES. Pairs of testes of 49 juveniles all weighed 3.0 grams or less. Smears from the epididymes of 15 juveniles were all negative for sperm. Testes of four subadults collected in late June at about 13 months of age all weighed 2.4 grams or less and had no sperm in the epididymes. Testes of subadults reached the adult weight range and contained sperm in the epididymes by December or earlier, Figure 23. Smears from the epididymes of five subadults collected in December were all positive for sperm, as were smears from five other subadults collected in January and May, Figure 24.

FEMALES. Raccoons on which necropsies were performed included 35 females that were judged to be between the ages of 10 and 22 months. These animals, therefore, had passed through only one season corresponding to the reproductive season of adults. Two of these animals had placental scars. One pregnant female was estimated to be no more than 14 months old as indicated by a juvenile lens weight and dental characters. The estimated conception date for this pregnancy was June 26 – more than 2 months past the peak of the breeding season.

A juvenile female equipped with a radio transmitter-collar may have mated with an old male that was also equipped with a radio. The male occupied a home range adjacent to that of the female, and he shifted his activities into the vicinity of the female during the period from April 19 to April 27, 1968, and again rested near her on April 29. On one or more days they rested in the same tree. The male had not previously entered the range of the fe-

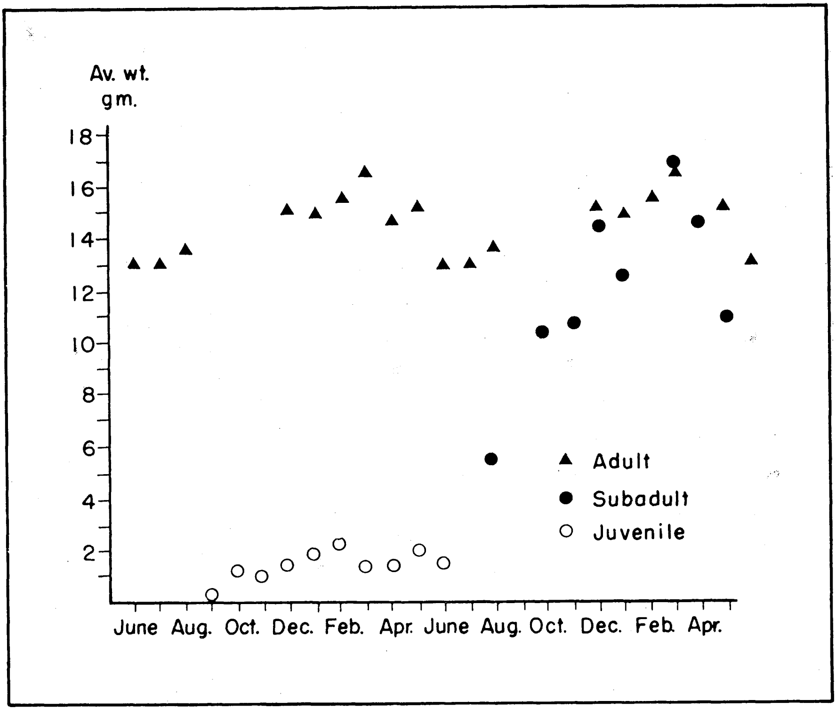


FIG. 23. Weights of pairs of testes of young raccoons in Alabama with average weights of pairs of testes of adults shown for comparison.

male during the period of monitoring, nor did he do so again. However, it is not known if the female produced young.

Discussion

There is much confusion in the literature concerning the age at which raccoons reach sexual maturity. Whitney and Underwood *(203)* stated that males do not become fertile until their second season. Bissonette and Csech *(22)* reported that females on a raccoon farm sometimes produced offspring in the first winter, but usually they did not.

Stuewer *(187)* cites a fur farmer as reporting that females are capable of breeding their first year, but males are not. Stuewer noted that in Michigan the testes did not attain adult size until autumn, after the breeding season. He noted that females denning with yearling males did not produce young. Of 28 yearling females he examined, 15 (53.6 per cent) produced young. The ages of nine were known, as they had been marked the previous year as juveniles.

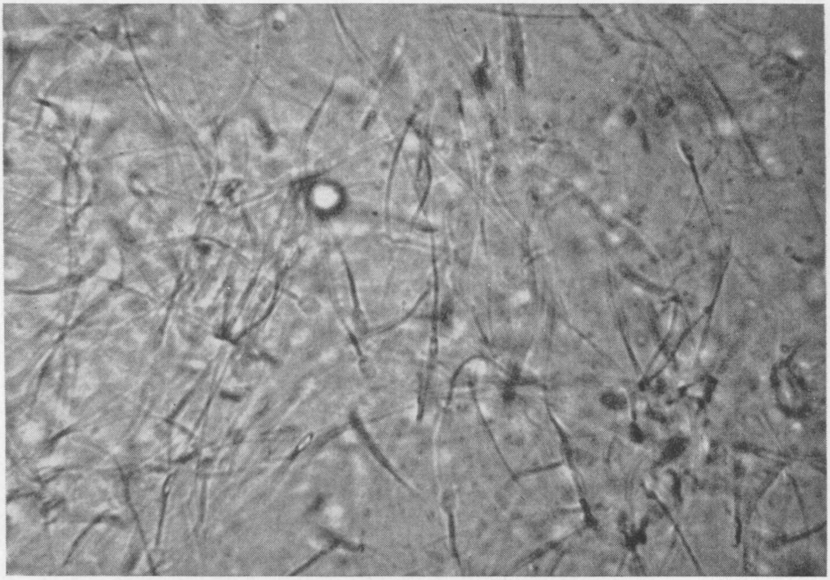


FIG. 24. Mature sperm from the epididymis of an adult raccoon.

Pope *(151)* reported two captive male raccoons breeding before they were 1 year old. Scheffer *(173)*, working in southwestern Washington, concluded that most females there did not become pregnant during their first winter. Sanderson *(163)* stated that probably all males are sexually active as yearlings in Missouri but not as early in the season as adult males. Llewellyn *(111)* concluded that the number of subadults breeding on the Patuxent Research Station in Maryland was insignificant. Wood *(208)* reported that in the Post Oak Region of Texas 20 per cent of the 1-year-old males possessed sperm, and 40 per cent of the 1-year-old females had placental scars. Sanderson *(168)* stated that in Illinois one-half to two-thirds of the males reach sexual maturity as yearlings, but juveniles become sexually active 3 to 4 months later than adults. Some females were pregnant at 1 year.

It seems from the present study and the works of Stuewer *(187)* and Sanderson *(163,168)*, that juvenile males are not generally sexually mature at the time of the regular breeding season but mature later in the summer or fall. The percentage of females bearing young as yearlings seems to vary from one area to another and may be related to diet or population density or both. The limited evidence obtained indicates that less than 10 per cent of the yearling females in Alabama produce young. At this rate, the contribution of subadult females to the total productivity of the population would be insignificant. This may not be true in all areas of the State.

BREEDING AND REPRODUCTIVE SEASON

Methods

Information on breeding and reproductive seasons was obtained primarily from necropsies. Reproductive tracts were examined for thickened, stimulated uteri and for ovarian characters (follicles) indicative of an active breeding status. Fetuses were aged according to the criteria developed by Llewellyn *(112)* and Sanderson *(168)* to estimate dates of conception.

Testes of adult males were weighed, grouped, and examined for seasonal variation. Smears from the tails of the epididymes were examined microscopically for the presence of mature sperm.

Ages of 25 juveniles were estimated by relating lens weights to the curve developed by Sanderson *(167)*. The animals were then grouped by month of birth to form a frequency histogram.

Dates of birth of two litters born to wild parents in captivity and approximate dates of birth of two litters born in the wild were also obtained.

Results

MALES. Seasonal variation in weights of gonads of sexually mature males was apparent, Figure 25. The average weight of testes in March was significantly greater than the average for May or June. The great variation within months was a result of combining data from southwestern Alabama and from east-central Alabama. Substantial differences existed in weights of testes of animals from the two areas, but they are directly proportional to differences in total animal weight.

Testes of 36 mature males that were collected in the months of January through June all contained sperm in the epididymes. Epididymal smears from two adults collected in July and August also contained sperm. A wild male that was held captive with a wild female and successfully bred to her in April was sacrificed in August. Smears from the epididymis were negative for sperm, and the testes were the smallest of any mature male examined. Their combined weight was 4.8 grams, as compared with an average weight of 13.5 grams for two males collected from the wild in August. It is suspected that this sexual regression was not

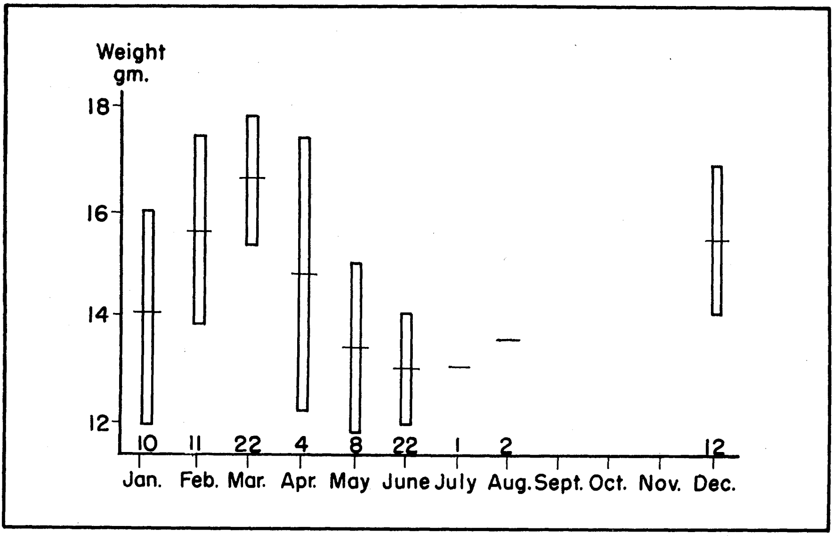


FIG. 25. Monthly variation in weights of pairs of testes of sexually mature raccoons in Alabama. Horizontal lines represent means, and vertical bars represent the range of two standard errors on either side of the mean. Numbers below the bars show sample size. Cause of great variation within months is explained in the text.

typical and that it possibly resulted from his continued confinement in a small pen with the female and his suppression by her aggressiveness during pregnancy and rearing of three young. Weights of gonads from this animal are not included in Figure 25. Data from two males collected in November are also omitted. One of these was the largest male observed during the study (19 pounds, 1 ounce) with testes weighing 26 grams – almost twice the average. The other male was abnormal in that only one testis was in the scrotum. It contained no sperm in the epididymis. Fluid from the epididymes of 10 of 11 mature males collected in December contained sperm.

Thus the epididymes of 45 of 46 mature males collected in the months of December through June contained mature sperm. It could not be determined if the sperm were motile, because most of the animals were not examined immediately after death. Inadequate data for the months of July through November prevent the drawing of any conclusions concerning the ability of adult males to breed during these months.

FEMALES. Conception dates of 18 litters were calculated, Figure 26. The earliest conception date was March 8; the latest was

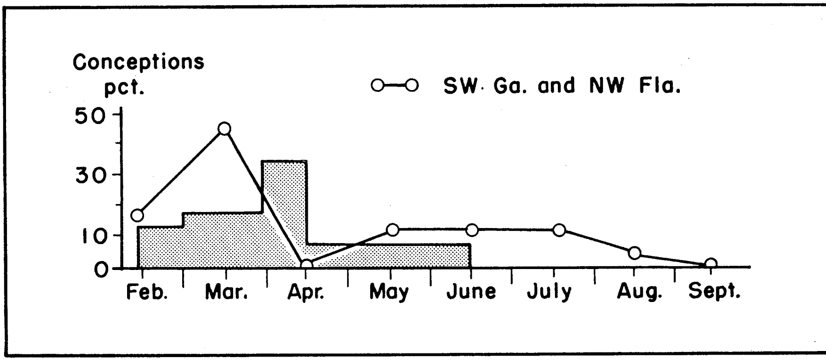


FIG. 26. Conception dates for 18 Alabama raccoon litters. Conception dates of 16 groups of fetuses were calculated from the fetal growth curves developed by Llewellyn (112) and Sanderson (168). Conception dates of two litters with known birth dates were calculated assuming a gestation period of 63 days. Data from southwestern Georgia and northwestern Florida (123) are included for comparison.

June 26. The greatest number of conceptions was in the last 2 weeks of April. The mean date of conception was April 17.

Average weights of testes of adult males reached a maximum somewhat in advance of the peak in conceptions, Figures 25 and 26. Sanderson *(168)* noted a similar relationship in Illinois.

Data on follicle development were recorded, but they were not presented because of lack of confidence in them. Ovary weights showed too much individual variation to be useful.

Mean date of birth for the 18 litters was June 18. Included are potential birth dates of 16 sets of fetuses as estimated from fetal growth curves and actual birth dates of one litter conceived in the wild and born in captivity and one litter conceived and born in captivity to wild parents. The earliest parturition date calculated was May 4 and the latest was August 27. Nine of the 18 birth dates were in June. Data are presented in Table 4 and Figure 27. Pregnancy rates among 38 necropsies performed by others are also given in Table 4. Birth dates of these animals are not included in Figure 27 because measurements of fetuses were not taken.

The limited data do not indicate variation in reproductive season between the areas studied.

Discussion

Stuewer *(187)* concluded that males are capable of breeding at all times of the year. Sanderson *(163)* found no sperm in the epididymes of raccoons in Missouri in July. Sperm were present

TABLE 4. MONTHLY PREVALENCE OF PREGNANCY AMONG 104 ADULT FEMALE RACCOONS FROM ALABAMA

Month	Adult females necropsied during the study			Adult females examined by others[1]	
		Pregnant	Post-partum, lactating		Pregnant
	No.	*No.*	*No.*	*No.*	*No.*
January	7	--	--	0	--
February	7	--	--	8	--
March	13	--	--	0	--
April	3	3	--	3	2
May	10	8	--	1	1
June	6	4	2	1	--
July	1	1	--	0	--
August	2	--	2	2	--
September	0	--	--	0	--
October	2	--	--	3	1
November	7	--	--	2	--
December	8	--	--	18	--

[1] Data provided by Dr. Kirby L. Hays and Alabama Cooperative Wildlife Research Unit.

in December but were not motile. In Illinois Sanderson *(168)* observed seasonal changes in weights of testes, with lowest weights occurring in the summer. He again noted that a majority of the adult males did not have sperm in the epididymes during the summer.

Although male raccoons in Alabama seem to show a definite seasonal cycle, it does not appear to be as pronounced as Sanderson reported for raccoons in Illinois. For example, Sanderson reported that average weights of testes just prior to the breeding season were nearly three times as great as in the summer *(168)*. In Alabama these differences were statistically significant, but the maximum average was only about one-fourth greater than the minimum average. However, the late summer and early fall samples were too small to be meaningful.

The number of young born after September seems to be very small. Of 19 adult females collected in the months of May through August, 18 had borne young by the end of August. The one remaining was neither pregnant nor in breeding condition when collected in May. Only about 4 per cent of the juveniles whose ages were estimated by lens weights had estimated birth dates after September 1, and none of the 17 adult females collected in October, November, and December were lactating. Although very small raccoons are commonly taken in late winter, it was found that these animals were not necessarily as young as

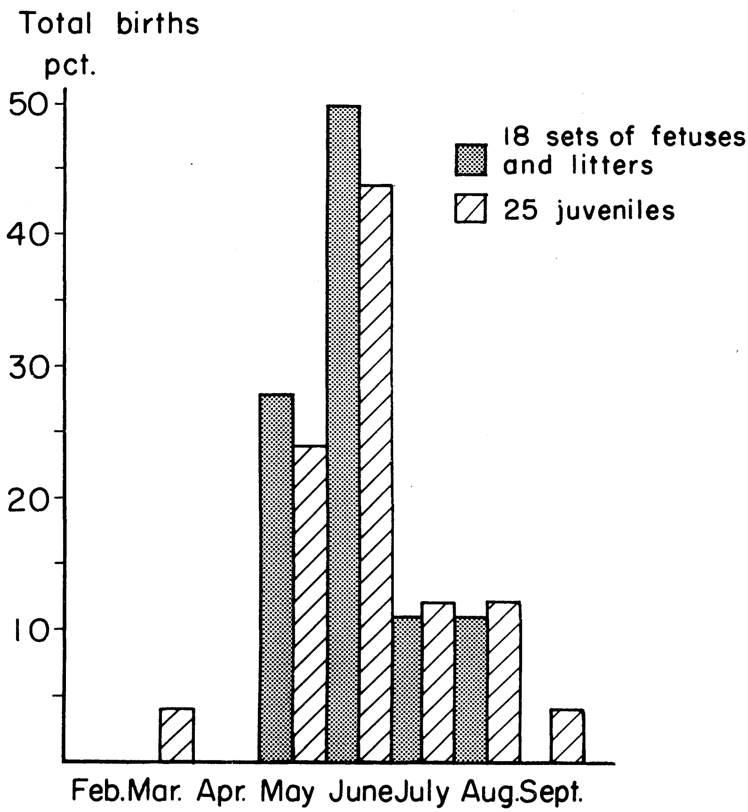


FIG. 27. Distribution of 43 actual and calculated birth dates of Alabama raccoons. Data on fetuses and litters came from 16 pregnant raccoons examined post-mortem, one litter conceived in the wild and born in captivity, and one litter conceived and born in captivity to wild parents. Potential birth dates of fetuses were calculated from the fetal growth curves developed by Llewellyn (112) and Sanderson (168). Birth dates of 25 juveniles were estimated from eye lens weights and the lens growth curve of Sanderson (167).

they appeared. The October pregnancy record is regarded as an extreme. The contribution to the total productivity of a population by such late pregnancies is probably insignificant, and juveniles born so late have reduced chances of survival during the critical winter period.

In the northern states raccoons generally breed from January to March *(80,163,168,188)*. The peak of the breeding season occurs in February *(80,168,187)*. The average gestation period is 63 days *(80,187,203)*, and most births occur in late April *(168)*. There is some variation, however, and several investigators have reported unusually early or unusually late births *(19,49,64,108)*.

In the more southern latitudes breeding and reproduction generally occur later. Cunningham *(43)* concluded that on the Savannah River in South Carolina the peak of the breeding season was in March, but that some breeding probably occurred throughout the year. In southwestern Georgia McKeever *(123)* examined 241 female raccoons and concluded that breeding occurred from February to August with a peak in March. Young were born from April to October with an early peak in pregnancies in March and April and a second peak in August. About half of the young had potential birth dates in May *(123)*. Data from the present study indicate that the breeding season in Alabama is somewhat later. McKeever's data are included for comparison in Figure 26. Caldwell *(29)* stated that in north-central Florida breeding extended at least from early December to early August and probably occurred throughout the year. Ivey *(92)* reported finding in the saltmarshes of northeastern Florida a litter with eyes still closed on March 10.

In Louisiana Arthur *(7)* reported February, March, and April as the months of birth. He reported that a female from Saint Charles Parish was pregnant with four advanced fetuses on February 9. But on the Delta Wildlife Refuge, less than 100 miles south of Saint Charles Parish, Cagle *(28)* found 6 of 7 females collected on May 3 to be pregnant and 10 of 11 females collected on May 25 to be post-partum.

It has been demonstrated that the onset of breeding is in part a response to a lengthening photoperiod *(20-23)*. Others *(49,168)* have suggested that the onset of breeding may be modified by temperature immediately preceding the breeding season. Movement of males may be so restricted by cold weather as to interfere with breeding *(182)*. Severe weather during February may cause a number of females to miss the first estrum and produce young from a second estrum 4 months later, resulting in a significant number of late-born young. Southern raccoons evidently respond to different thresholds of photoperiod and temperature. Otherwise, they would have an earlier breeding season rather than a later one.

The early reproductive season in colder climates is probably an adaptation to the cold winters, late-born young not being large enough to store sufficient fat to enable them to survive the following winter. In the South more moderate winter temperatures exert less selection pressure for early births and allow some late-born young to survive, thus maintaining greater genetic variability for time of breeding. Locally, especially in coastal areas, selection pressure from floods, hurricanes, seasonal availability of shellfish, or other factors may modify the more typical reproductive patterns.

Females not bred during the first estrum have a second cycle 4 to 5 months later *(168,187,203)*. Thus there is usually an early peak in births and a second, smaller peak 4 to 5 months later *(123)*. However, the above works state that yearlings that fail to breed during the regular season do not breed until the following winter. In the present study, however, one of two pregnant subadults collected would have borne young in late August. There is, of course, the possibility that this animal was misclassified as to age.

LITTER SIZE

Methods

Information on litter size was obtained primarily from counts of fetuses and sites of placental attachment, which have been demonstrated to be reliable indicators of the number of young produced *(168)*. Pregnant or actively breeding females were not examined for placental scars because pregnancy and estrus tend to obscure the scars. In cases of pre-implanted pregnancies number of corpora lutea, Figure 28, in the ovaries was used as an indicator of the potential number of offspring. Data obtained from necropsy were supplemented by observations on two litters examined in their dens in the wild and on two litters born in captivity.

Results

Twenty-one pregnant raccoons were among those on which necropsies were performed. Eight of these contained two fetuses

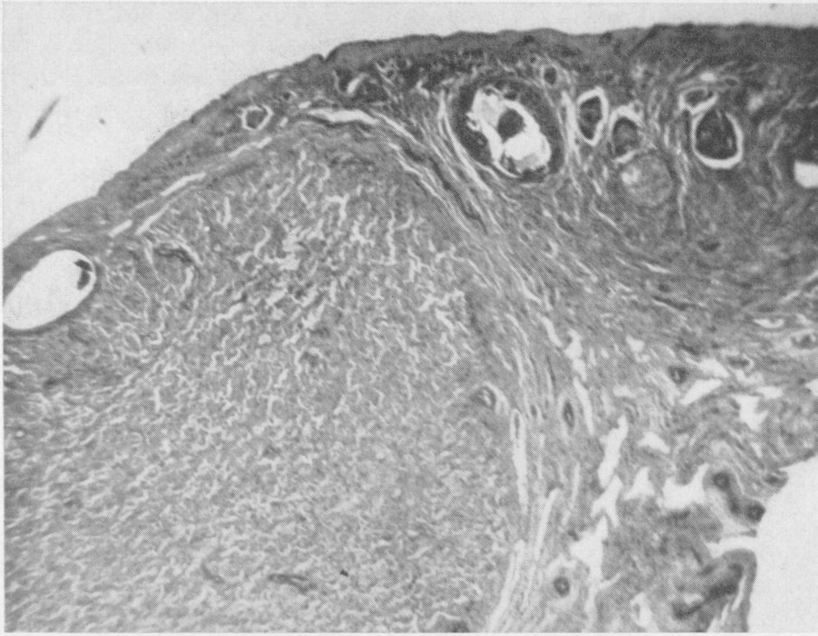


FIG. 28. Section of raccoon ovary showing corpus luteum.

each; 11 contained three fetuses each; and 2 involving pre-implanted pregnancies showed three corpora lutea in the ovaries. The mean was 2.62 (S.E. = 0.11) fetuses per pregnant female.

Uteri of 50 females displayed distinct placental scars. Twenty-two of these displayed 25 sets of old placental scars apparently from two or three previous seasons of reproduction. In most cases these were quite distinct, Figure 29. Sanderson *(168)* has reported that placental scars may persist for 30 months or more. Sanderson also observed that placental scars disappear sooner in captive animals than in wild animals and suggested that this might be a result of the better diet of captive animals. In this study it was noted that placental scars were more prominent and seemed to persist longer in raccoons from southwestern Alabama than in raccoons from east-central Alabama. Twenty-seven reproductive tracts contained two placental scars each from the most recent reproductive season, and 23 contained three scars. The mean number of most recent placental scars per female was 2.46. The mean number of old scars from the 22 tracts containing scars from more than one season was 2.38. The overall mean of 76 sets of placental scars was 2.43 scars per set.

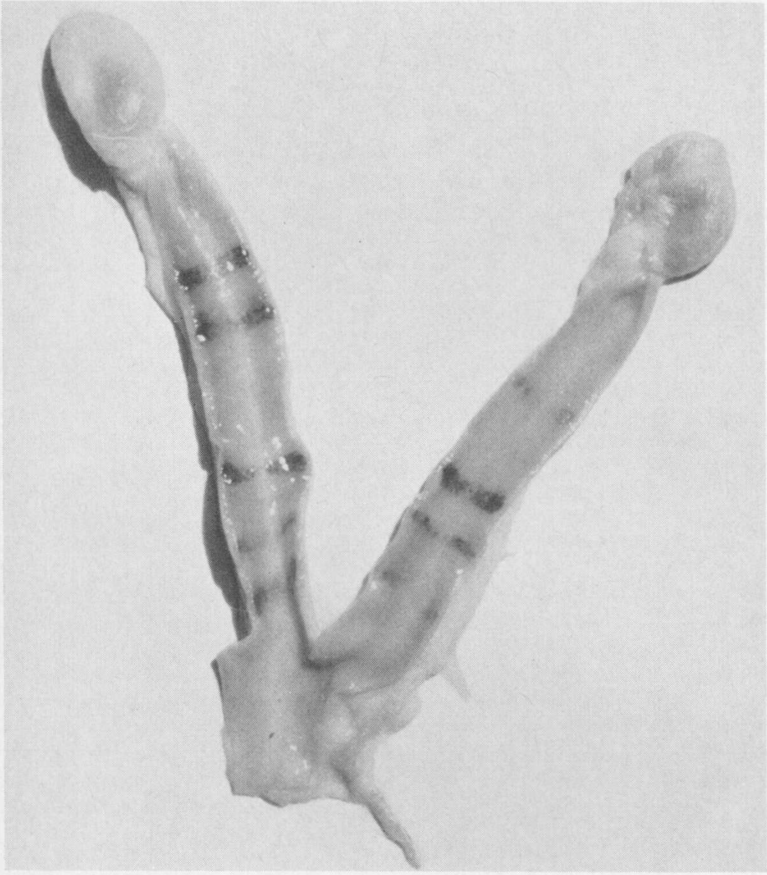


FIG. 29. Raccoon uterus split to show placental scars. The scars evident here are thought to represent three distinct reproductive seasons.

Data were obtained from two litters taken from their dens in the wild (Lee and Washington counties), one litter conceived in the wild and born in captivity to a Lee County female, and one litter conceived and born in captivity to wild parents from the Upper State Sanctuary in Clarke County.

Combined data from all sources resulted in a total of 101 observations on litter size. In every case the data indicated a litter size of either two or three, with 51.5 per cent of the observations being two. The overall mean was 2.48 young per female with a standard error of 0.05.

There was no significant difference in average litter size between east-central Alabama and southwestern Alabama, nor was there an obvious difference in average litter size between age classes.

Geographic Variation

There is much geographic variation in average litter size of raccoons, Table 5 *(111)*. Latitudinal gradients in clutch and litter sizes have been noted within many species, and various explanations have been offered *(e.g. 104,116,181)*.

TABLE 5. VARIATION IN LITTER SIZE OF RACCOONS IN THE UNITED STATES

Locality and reference	Litter size	
	Sample	Mean
	No.	*No.*
Alabama (this study)	101	2.5
Florida (northeastern coast) *(92)*	1	(5.0)
Florida (northwestern) and Georgia (southwestern) *(123)*	17	3.2
Illinois *(165)*	?	3.5
Kansas *(182)*	8	4.6
Louisiana (coast) *(28)*	6	3.8
Maryland *(111)*	12	2.3
Michigan (southern) *(187)*	11	4.0
Missouri *(162)*	22	3.8
New York *(111)*	4	5.0
North Carolina (coast) *(111)*	10	1.9
South Carolina (western) *(43)*	13	2.8
Texas (eastern) *(208)*	26	3.4
Virginia (southwestern) *(97)*	5	4.4
Washington *(173)*	7	2.0

Although there is a general trend among raccoons toward larger litter sizes in the more northern latitudes, there are many exceptions. No doubt winter mortality is a factor in most areas. Winter temperatures and length of winter seem to be important mortality factors *(133)*, but a clear correlation cannot be established. Lord *(116)* has suggested that, within certain species, higher winter mortality in the northern latitudes would result in a smaller breeding population in late winter, and, as a physiological response to low density, more young would be produced. An inverse relationship between breeding density and number of offspring produced has been well established for many species *(e.g. 53,58)*. Both natural mortality and mortality to hunting and trapping are, in general, proportionately greater in northern states than in southern states. Although high mortality may cause compensating reproductive responses, high reproduction may itself be the cause of much density-dependent winter mortality.

A more likely explanation also considered by Lord *(116)* is that of geographic difference within a species in genetic potential to produce offspring. Local environmental conditions and mortality rates are assumed to result in natural selection for an optimum litter size. Bissonnette and Csech *(21)* noted that although there was considerable variation between females in number of young produced, the number produced by individual females of known breeding history was fairly constant. All animals were provided the same diet, and this suggests genetic variability in reproductive capacity.

Another possible physiological explanation is that litter size is related to qualitative nutrition through soil fertility. Highest average litter sizes of raccoons have generally been reported from the fertile prairie soils. Lowest litter sizes seem to occur generally on the relatively infertile, leached soils of the Southeast. Larger litter sizes reported from the South have generally been on limestone soils or soils of recent alluvial origin. Relationships between litter size and soil fertility have been suggested for other species *(184,204)*, and body weights of raccoons have been related to soil fertility *(42,142)*. Bissonnette and Csech *(22)* have shown that reproduction is affected by protein intake.

Geographic variation in reproduction of raccoons cannot be explained from data presently available. Further work is needed. Raccoons of different geographic strains should be reared under standardized conditions to determine the extent to which this variation is genetic.

JUVENILE DEVELOPMENT

METHODS

Juvenile development was studied by estimating age of juveniles from weights of eye lenses at post-mortem examination. Weight changes of marked and recaptured juveniles were recorded, and young raccoons held in captivity were observed and studied.

RESULTS AND DISCUSSION

Three raccoons born in captivity to wild parents from Clarke and Lee counties were weighed periodically to obtain data on early rates of growth. A growth curve to 111 days was established, Figure 30. The early growth of young raccoons in Alabama seems to be much slower than has been reported in other areas *(80,168,*

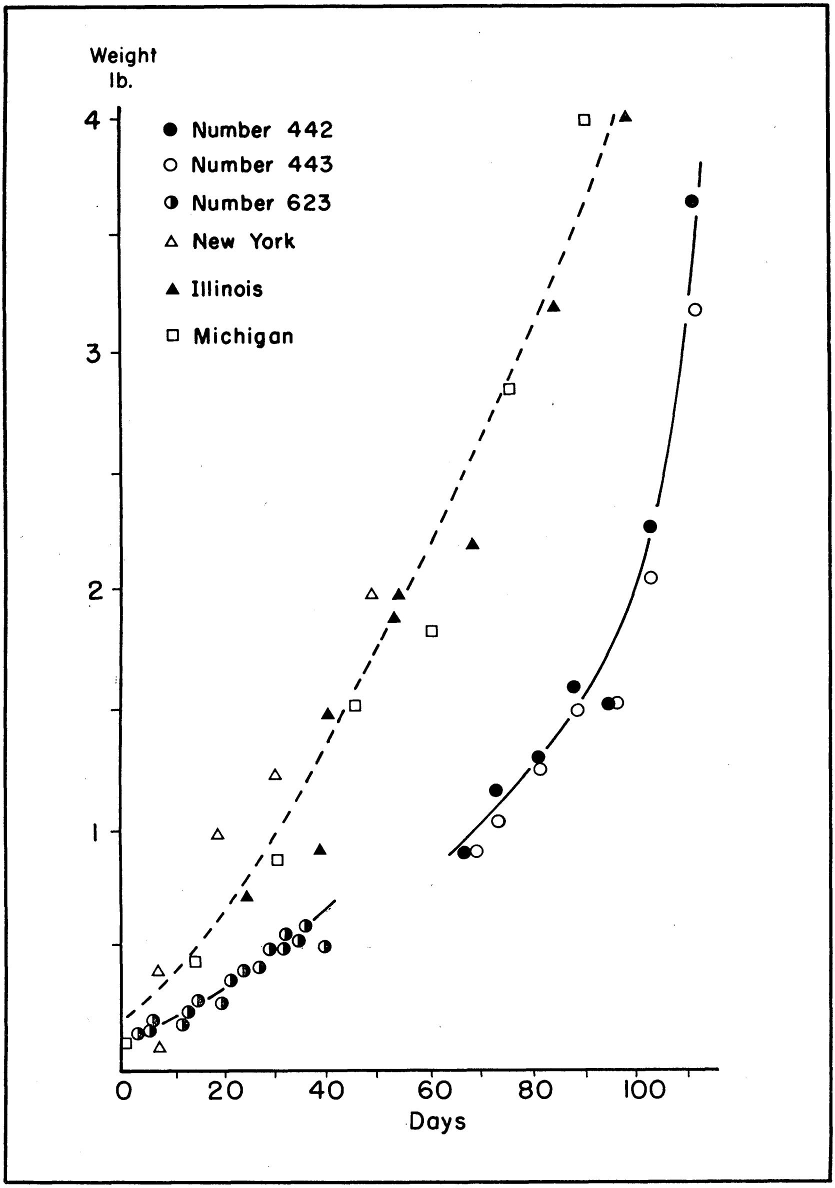


FIG. 30. Growth rates of three Alabama raccoons. Animals 442 and 443 were conceived and born in captivity to wild parents from southwestern Alabama. Animal 623 was conceived in the wild and born in captivity to a mother from east-central Alabama. Growth curves of raccoons from Illinois (166), Michigan (188), and New York (80) are shown for comparison.

188). Growth rates from other areas are shown in Figure 30 for comparison.

Figure 31 shows weight changes in juveniles recaptured in Clarke and Lee counties, indicating that young raccoons generally gained little weight during winter. Figure 32 reveals that average weights of juveniles reached a peak early in the winter and then declined. Adult weights were not attained until fall of the second year, Figure 33. Weights again declined in the second winter.

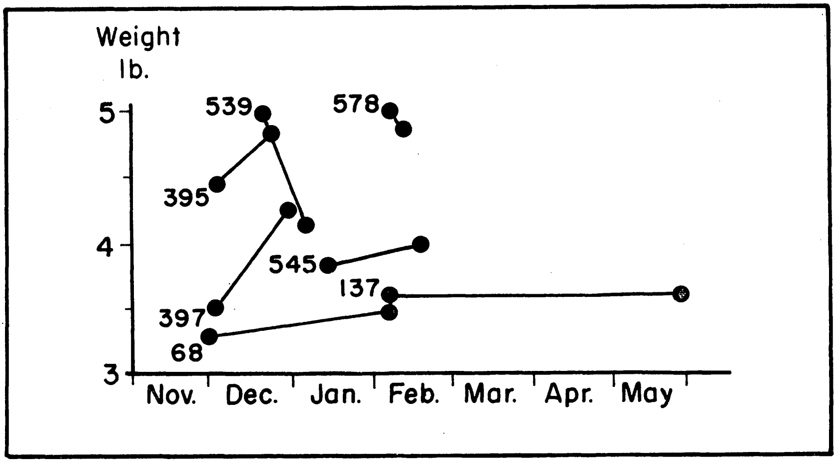


FIG. 31. Weight changes of seven juvenile raccoons tagged and recaptured in Clarke and Lee counties, Alabama.

Many small raccoons were examined in winter and spring. Because of the relatively late birth dates of raccoons in Alabama, young born late in the summer often do not attain weights of more than 3 pounds before winter and thereafter gain little or no weight until summer. One could erroneously conclude that these small raccoons encountered late in the winter were born in the fall or winter.

Figures 30 and 32 suggest that juvenile raccoons in east-central Alabama have faster growth rates than those in southwestern Alabama.

Eyes of a captive raccoon (Number 623) opened at 19 and 20 days. Montgomery *(137,138)* has described pelage and dental development of young raccoons.

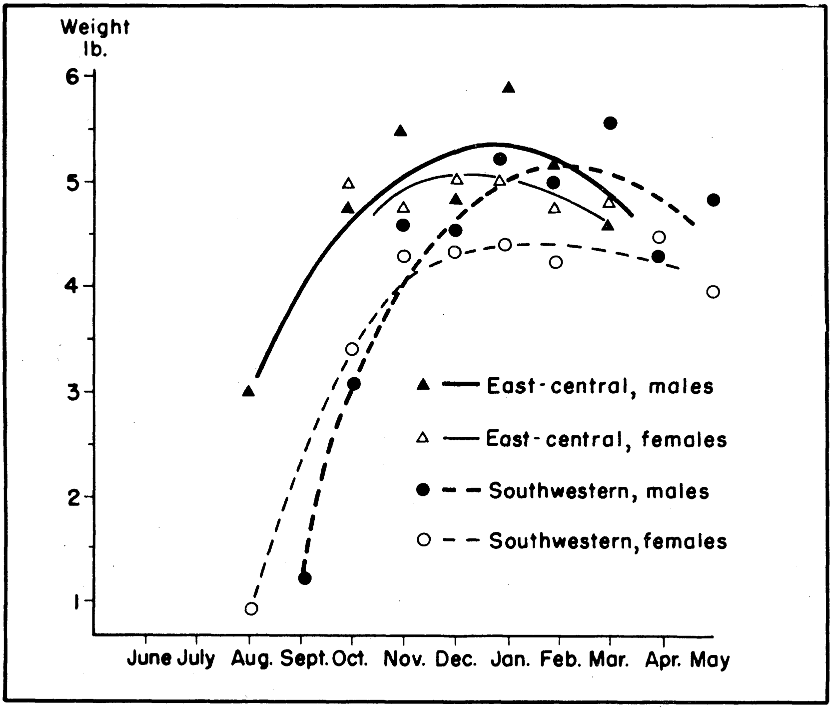


FIG. 32. Monthly trends in average weights of 222 juvenile raccoons in Alabama by region and sex.

FOOD HABITS

METHODS

Information on the diet of raccoons was obtained from examination of the contents of 79 stomachs and 70 large intestines, representing 112 different animals, and from the contents of 365 scats (fecal samples). Contents of small intestines were not used. Gastrointestinal tracts of 258 additional animals were not used because they were either empty or contained only debris or bait eaten while in traps. It was most practical to consider gastrointestinal contents as a single sample, even though stomach and colon contents often represented two separate meals. (Of 36 digestive tracts containing usable quantities of food, 39 per cent had completely different food items in the stomach and colon and 36 per cent had some of the same and some different food items in the two compartments. Only 25 per cent contained the same items in the stomach and colon.)

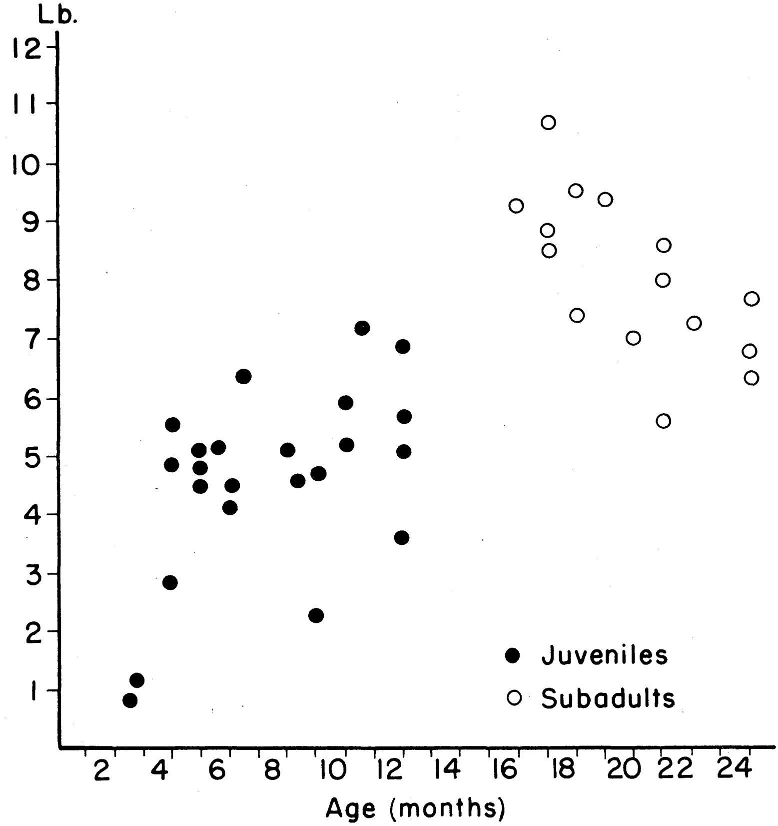


FIG. 33. Relationship of weight to age among 23 juvenile and 15 subadult Alabama raccoons. Ages of juveniles were estimated from weights of eye lenses according to Sanderson (167). Ages of subadults were estimated assuming a June birth date. Note decline in weights of subadults from 17 months (Nov.) to 23 months (May).

Contents were spread on a piece of white paper, segregated, and identified. Volume of each food item was then measured by water displacement in a graduated cylinder. The results were recorded as volume in milliliters. Any occurrence of less than 0.5 milliliter was recorded as a "trace." Sometimes, scats were examined in the field and only a listing of foods present (occurrence) was recorded. Also, volumes were not measured in a few cases involving stomachs and intestines because separation of materials would have been difficult. These cases usually involved mostly animal material and may therefore produce a slight under-estimate of volume of animal material. All data were grouped by month and tabulated as per cent occurrence and per cent of total volume for each food species.

Data obtained by these methods were supplemented by information gained from direct observation of feeding and interpretation of feeding sign. Hunting with dogs also provided some insight into feeding activities. Although caution is required in interpreting field observations, such observations often provide a better understanding of feeding habits than does analysis of stomach and scat contents. The latter approach can also be misleading because of sampling bias and differences in digestibility of different foods.

RESULTS

Statewide

Results of analyses of contents of scats and gastrointestinal tracts are presented in Tables 6 through 19. Fruits of naturally occurring plants were generally the most important food at all seasons. Acorns were important in fall, and planted crops assumed importance locally when natural foods were not readily available.

Invertebrates were taken consistently throughout the year but were most important late in the winter and in spring, Figure 34. Vertebrates were taken in significant quantities only late in the winter.

Fred T. Stimpson Game Sanctuary

Food habits of raccoons on this area are summarized in Table 7. Wild grapes were usually the first fruits to be used in great quantity each summer. Muscadines were very abundant on the area and were heavily used in August. Small grapes (especially *Vitis vulpina, V. riparia,* and *V. aestivalis*), although lower in preference than muscadines, were more important because they were available for a longer period of time. Pepper-vine and *Ampelopsis cordata,* also members of the grape family, each occurred only once in the specimens examined although pepper-vine was very abundant on the area. Wild grapes continued to provide most of the food for raccoons until late in October. In November and December fruits of sugar hackberry, one of the dominant species along the levees, were used almost exclusively. Raccoons apparently thrived on these foods, as those examined in November and December were very fat. Following the depletion of

TABLE 6. GENERAL FOOD HABITS OF RACCOONS IN ALABAMA

Food item	Spring (82)[1]		Summer (41)[1]		Fall (260)[1]		Winter (93)[1]	
	Vol.	Occ.	Vol.	Occ.	Vol.	Occ.	Vol.	Occ.
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Plant material	**79**	**90**	**90**	**90**	**82**	**90**	**74**	**53**
Fruits	44	72	72	80	69	78	33	26
Acorns, pecans	1	1	----	----	8	8	19	18
Corn	tr.	1	13	12	1	3	10	10
Tubers (chufa, groundnut)	34	15	5	2	4	5	12	5
Animal material	**19**	**39**	**6**	**34**	**9**	**25**	**16**	**44**
Insects	17	33	6	32	8	22	4	23
Crayfish	1	6	tr.	2	1	5	3	20
Earthworms	----	----	----	----	tr.	tr.	tr.	5
Mollusks	----	----	----	----	----	----	1	6
Fish	----	----	----	----	tr.	1	1	1
Frogs	----	----	----	----	tr.	1	----	----
Reptiles	tr.	2	----	----	tr.	tr.	----	----
Birds	tr.	2	tr.	2	tr.	tr.	4	6
Mammals	1	2	----	----	----	----	3	4
Unidentified material	**1**	**5**	**2**	**12**	**8**	**8**	**10**	**13**

[1] Numbers in parentheses indicate number of samples.

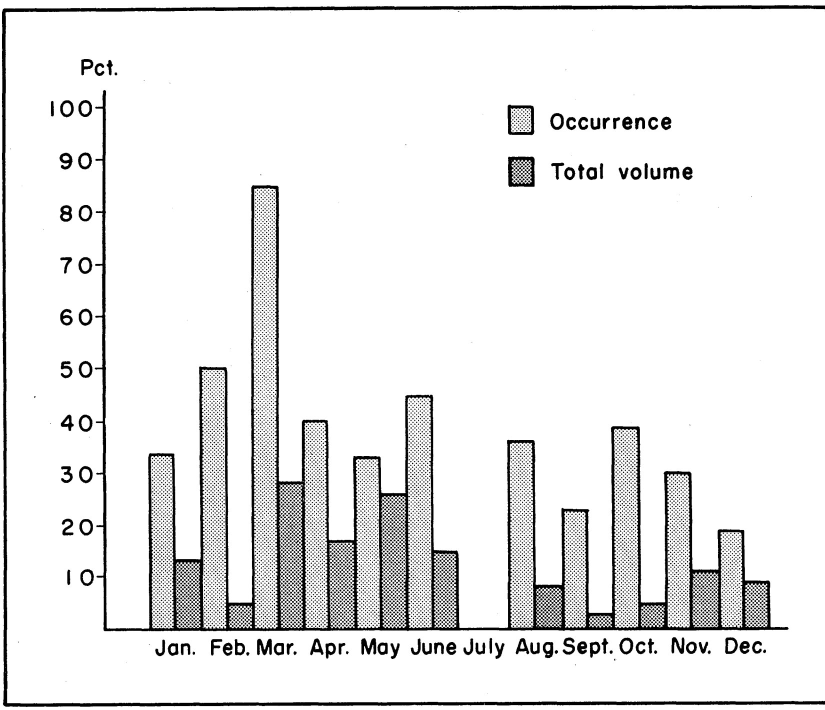


FIG. 34. Seasonal variation in consumption of animal foods by Alabama raccoons. Data from Tables 9-19.

TABLE 7. FOODS OF RACCOONS ON THE FRED T. STIMPSON GAME SANCTUARY AS INDICATED BY THE CONTENTS OF 74 SCATS AND 22 DIGESTIVE TRACTS

Food item	Spring (17)[1]		Summer (11)[1]		Fall (67)[1]	
	Vol.	Occ.	Vol.	Occ.	Vol.	Occ.
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Plant material	61	59	71	82	87	87
Sugar hackberry	----	----	----	----	48	52
Chufa (tubers)	57	47	12	9	6	10
Frost grapes	----	----	17	46	12	8
Rattan-vine	----	----	----	----	7	9
Corn	tr.	6	10	9	2	4
Muscadine	----	----	15	27	----	----
Persimmon	----	----	tr.	9	1	3
Eastern red-cedar	----	----	----	----	7	4
Acorns	----	----	----	----	3	3
Ampelopsis cordata	----	----	15	9	----	----
Pepper-vine	----	----	1	9	----	----
Possum-haw	----	----	----	----	2	1
Blackberries	4	6	----	----	----	----
Animal material	38	71	7	36	1	12
Beetles	20	53	1	9	1	6
Grasshoppers	16	37	4	18	tr.	1
Wasps	1	24	2	9	tr.	1
Insects, unid.	----	----	tr.	9	tr.	4
Crayfish	1	6	tr.	9	----	----
Unidentified material	1	6	22	46	11	15

[1] Numbers in parentheses indicate number of samples.

sugar hackberries, acorns and the fruit of rattan-vine assumed greatest importance. However, game on the area generally depleted the acorn crop relatively early, and raccoons became increasingly dependent upon animal foods (primarily insects and crayfish) as the winter progressed. Late in the winter is generally a time of hunger and food scarcity for raccoons. Evidence of this is presented elsewhere in this report. Stomachs of raccoons collected at this time of year were often empty or filled with decayed wood, moss, or unidentifiable debris. Commonly, insects were the only foods present and they were present only in small quantity. During spring, insects became more abundant and provided practically the only natural food available until summer fruits appeared. Grasshoppers, various beetles, and wasps, especially yellow jackets, made up most of the insect material consumed. On several occasions just before dark, raccoons were observed in open pastures, nearly 100 yards from cover, apparently searching for grasshoppers.

Chufa is intensively cultivated on the area to provide food for wild turkeys, and the tubers provided the bulk of the food volume in the samples collected in spring. However, animals and scats were more easily collected at food plots, and data on chufa and corn should be considered as biased to an unknown extent.

Freshwater clams were apparently used rather heavily by a few individual animals as indicated by feeding sign. However, they did not appear in samples examined.

Pine—Scrub Oak—Gallberry Habitat of Southwestern Alabama

This represents a habitat type sufficiently different from the remainder of the State to warrant separate consideration. Fifty-five samples were obtained from Baldwin, Mobile, and Washington counties. In late spring and early summer, foods consisted of blackberries, plums, and various other fruits. Later, muscadines and other wild grapes became important. Gallberries began to appear in scats early in August, when most were still unripe. They occurred in 38 per cent of the samples taken in summer, and comprised 23 per cent of the total volume of food. During fall, gallberries formed a less important part of the diet, and acorns contributed 54 per cent to the total volume of the samples. By January the acorn crop was usually depleted, and gallberry again became important along with fruits of greenbrier. Gallberry occurred in 74 per cent and greenbrier occurred in 42 per cent of the winter samples. Greenbrier comprised 37 per cent of the total volume of winter foods and gallberry made up 27 per cent. No data were collected from late in February to early in May.

East-Central Alabama

The Piedmont and Upper Coastal Plain of east-central Alabama have more land in early successional stages and more land recently in agriculture than the areas previously discussed. Such conditions favor plums, dewberries and blackberries, black cherries, persimmons, privet, and eastern red-cedar, all of which were regularly used by raccoons.

Early in the summer plums were obviously preferred above all else. Although blackberries were taken in large quantities, their use was inversely proportional to the availability of plums. Black cherries were heavily eaten only when plums and blackberries were not abundant. Persimmons began to appear in scats early in August, when they were still unripe. Raccoons showed a strong preference for persimmons and ate them almost to the exclusion of everything else when they were available. Muscadines were also heavily used in late summer and early fall.

The more important foods in late fall and early winter were persimmons, acorns, privet, and rattan-vine. Of lesser importance were possum-haw and eastern red-cedar. Persimmons continued to be represented out of proportion to their availability as late as January. Privet, which has escaped and become widely established along stream banks and low places in east-central Alabama, was heavily used by raccoons in November, December, and January. Winter foods were studied intensively in a beaver swamp in Lee County, Table 8, and privet contributed over 60 per cent to the total volume in the samples from this area in November and December.

Greenbrier fruit assumed importance late in the winter. These fruits were low in preference and were heavily utilized only after other more desirable fruits were gone. In the beaver swamp study area mayfly nymphs and a species of black maggot were very important foods in the winter of 1965-66 but did not occur in samples collected in December 1964, and winter 1967-68. Spring foods were mostly animal matter.

Small frogs were extremely common about the Auburn University experimental fish ponds, and, although raccoons spent much time about these ponds, frog remains were seldom encountered in food samples. Similar failure to utilize frogs has been reported by others *(50,81)*.

DISCUSSION

Limitations of the Data

Obvious problems are involved in extensively sampling the diet of a species that has as diverse behavior and food habits as does the raccoon. No claim is made that the data presented here are unbiased. It is doubtful if an unbiased evaluation of this type is possible. Nevertheless, the data should present a reasonably accurate representation of the diet of raccoons in the more extensive habitat types of the State.

Some of the more likely sources of error deserve comment. Much of the data were obtained from the contents of scats and colons. Soft-bodied animals and easily digestible material may leave an unrecognizable residue or none at all. Hamilton *(82)* noted this shortcoming of fecal samples and suggested that "a more nearly exact study of foods" could be made by examination of stomach contents. However, Wood *(207)* noted that, with similar volumetric readings, scats contained 31 different items not

TABLE 8. FALL AND WINTER FOODS OF RACCOONS, FROM FECAL SAMPLES, BEAVER SWAMP, ALABAMA PIEDMONT

Food item	November		December		January		February		March		Total	
	Vol. (13)[1]	Occ. (13)[1]	Vol. (59)[1]	Occ. (109)[1]	Vol. (8)[1]	Occ. (15)[1]	Vol. (5)[1]	Occ. (5)[1]	Vol. (2)[1]	Occ. (5)[1]	Vol. (87)[1]	Occ. (147)[1]
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Plant material	**92**	**100**	**83**	**94**	**81**	**53**	**6**	**40**	----	----	**79**	**85**
Privet	68	69	61	61	47	33	6	20	----	----	57	56
Persimmon	9	23	10	20	2	13	tr.	20	----	----	9	19
Greenbriers	13	23	5	14	5	20	----	----	----	----	6	14
Rattan-vine	2	23	3	13	19	27	----	----	----	----	4	14
Possum-haw	----	----	3	4	----	----	----	----	----	----	2	3
Frost grapes	----	----	----	----	9	7	----	----	----	----	1	1
Acorns	----	----	tr.	2	----	----	----	----	----	----	tr.	1
Moonseed	----	----	tr.	1	----	----	----	----	----	----	tr.	1
Sedge	----	----	----	----	tr.	7	----	----	----	----	tr.	1
Grass	----	----	tr.	1	tr.	7	----	----	----	----	tr.	1
Moss	----	----	tr.	1	----	----	tr.	20	----	----	tr.	1
Wood	----	----	----	----	----	----	tr.	40	----	----	tr.	1
Unidentified	----	----	----	----	----	----	tr.	20	----	----	tr.	1
Animal material	**8**	**31**	**12**	**17**	**7**	**27**	**19**	**60**	**86**	**100**	**13**	**24**
Crayfish	----	----	tr.	6	4	20	tr.	20	31	100	1	11
Mayfly nymphs	3	8	5	10	----	----	----	----	----	20	4	10
Grasshoppers	5	15	3	5	----	----	----	----	----	----	3	5
Mollusks	----	----	----	----	tr.	7	19	40	tr.	40	1	3
Beetles	tr.	8	----	1	----	----	tr.	20	tr.	40	tr.	3
Maggots	----	----	tr.	2	tr.	7	----	----	----	20	tr.	3
Insects, unid.	----	----	tr.	2	4	13	----	----	----	----	tr.	3
Fish (minnow)	----	----	----	----	----	----	----	----	53	20	1	1
Wireworms	----	----	----	----	tr.	7	----	----	----	----	tr.	1
Caterpillars	----	----	tr.	1	----	----	----	----	----	----	tr.	1
Earthworms	----	----	tr.	1	tr.	7	----	----	----	----	tr.	1
Bird, unid.	----	----	tr.	1	----	----	tr.	20	----	----	tr.	1
Unidentified	----	----	3	3	----	----	----	----	----	----	2	2
Unidentified material	----	----	**5**	**1**	**11**	**7**	**75**	**80**	**14**	**80**	**8**	**15**

[1] Numbers in parentheses indicate number of samples.

TABLE 9. JANUARY FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[2]
	Pct.	*Pct.*
Plant material	**50**	**83**
Gallberry	43	19
Greenbriers	34	17
Acorns	25	32
Privet	11	11
Corn	9	----
Rattan-vine	8	1
Persimmon	6	tr.
Frost grapes	2	2
Possum-haw	2	----
Sedge	2	tr.
Grass	2	tr.
Animal material	**34**	**13**
Crayfish	21	2
Insects, unid.	19	1
Songbirds	6	8
Wireworms	6	tr.
Grasshoppers	4	1
Mollusks	4	tr.
Millipedes	2	1
Beetles	2	tr.
Maggot	2	tr.
Spider egg case	2	tr.
Caddisfly larva	2	----
Earthworms	2	tr.
Rabbit	2	tr.
Unidentified material	**4**	**3**

[1] Fifty-three scats and eight gastrointestinal tracts.
[2] Sixteen scats and eight gastrointestinal tracts.

present in digestive tracts. Colon contents contained at least 10 food items not found in the stomach. Wood concluded that, for raccoons, analysis based on scats was at least as reliable as analysis based on contents of digestive tracts, and that colon contents provided a more reliable basis than stomach contents. In the present study earthworms and immature insects were encountered in scats, and it is doubtful if many food items were overlooked. However, volumetric data are probably distorted in favor of bulky fruits. The use of both scats and digestive tracts should provide more useful data than either used alone.

The combining of data obtained from scats and digestive tracts was considered to provide the most efficient use of the data by maximizing sample size. The possible bias involved is recognized.

Animals and fecal samples were easiest to obtain where foods were concentrated, such as in planted crops. This discriminated against dispersed foods to an unknown degree. Collecting in various wooded areas by using dogs at night probably provided the most representative data.

TABLE 10. FEBRUARY FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[2]
	Pct.	*Pct.*
Plant material	**67**	**76**
Acorns	28	3
Chufa (tubers)	17	24
Privet	17	11
Wood	17	tr.
Greenbriers	11	11
Corn	11	9
Blackgum	6	17
Pecan	6	1
Persimmon	6	tr.
Unidentified seed	6	tr.
Grass	6	tr.
Moss	6	tr.
Pine (straw)	6	tr.
Animal material	**50**	**5**
Insects, undi.	17	1
Mollusks	11	3
Crayfish	11	tr.
Songbirds	11	tr.
Squirrel	6	1
Beetles	6	tr.
Grasshoppers	6	tr.
Centipedes	6	tr.
Earthworms	6	tr.
Mammal, unid.	6	----
Unidentified material	**33**	**19**

[1] Five scats and 13 gastrointestinal tracts.
[2] Five scats and 12 gastrointestinal tracts.

TABLE 11. MARCH FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[1]
	Pct.	*Pct.*
Plant material	**46**	**61**
Chufa (tubers)	15	14
Corn	8	27
Pecan	8	10
Acorns	8	10
Grass	8	tr.
Leaves	8	tr.
Animal material	**85**	**29**
Crayfish	54	7
Beetles	23	1
Earthworms	23	1
Maggot	15	5
Mayfly nymphs	15	1
Mollusk	15	tr.
Rabbit	8	8
Fish (minnow)	8	4
Redwing blackbird	8	2
Insect larva, unid.	8	tr.
Unidentified material	**31**	**10**

[1] Five scats and eight gastrointestinal tracts.

TABLE 12. APRIL FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[1]
	Pct.	*Pct.*
Plant material	**60**	**77**
Groundnut (tubers)	20	56
Chufa (tubers)	20	15
Pecan	20	6
Animal material	**40**	**17**
Beetles	40	17
Unidentified material	**20**	**6**

[1] One scat and four gastrointestinal tracts.

TABLE 13. MAY FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[2]
	Pct.	*Pct.*
Plant material	**90**	**72**
Wild plum	64	34
Blackberries	26	33
Chufa (tubers)	10	1
Vaccinium	3	4
Greenbriers	3	----
Unidentified seed	3	tr.
Animal material	**33**	**26**
Beetles	23	16
Grasshoppers	10	5
Wasps	10	tr.
Crayfish	8	2
Insects, unid.	5	tr.
Rabbit	3	3
Turkey egg	3	tr.
Lizard, unid.	3	tr.
Wireworms	3	tr.
Unidentified material	**10**	**2**

[1] Twenty-seven scats and 12 gastrointestinal tracts.
[2] Eleven scats and 12 gastrointestinal tracts.

Factors Affecting Food Habits of Raccoons

Food habits of raccoons seem to depend upon availability, preference, and learning. Most papers on food habits of raccoons have stressed that availability determines what raccoons eat. In a broad sense this is true, but raccoons also have definite food preferences. To some extent these preferences vary from one area to another. Foods that are intensively used in some areas may be ignored in other areas even though abundant. Pokeberry, which is a major food in some areas, was not encountered in the present study despite its abundance on the study areas. Blackberry ranked high in preference in Alabama, but Tyson *(198)* reported that raccoons in Washington fed entirely on tidewater animals despite the abundance of blackberries. During times of abundance, rac-

TABLE 14. JUNE FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[2]
	Pct.	*Pct.*
Plant material	**95**	**85**
Wild plum	50	26
Blackberries	38	2
Chufa (tubers)	20	50
Corn	5	7
Wild cherry	5	----
Greenbriers	3	tr.
Grass	3	tr.
Animal material	**45**	**15**
Beetles	30	7
Grasshoppers	12	7
Wasps	8	tr.
Crayfish	5	1
Snake, unid.	3	tr.
Mammal, unid.	3	----
Quail eggs	3	----

[1] Twenty-eight scats and 12 gastrointestinal tracts.
[2] Eleven scats and 11 gastrointestinal tracts.

TABLE 15. AUGUST FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[2]
	Pct.	*Pct.*
Plant material	**84**	**87**
Persimmon	61	51
Corn	13	12
Muscadine	13	2
Gallberry	9	11
Ampelopsis cordata	4	6
Blackberries	4	2
Unidentified fruit	4	2
Frost grapes	4	1
Pepper-vine	4	tr.
Animal material	**36**	**8**
Beetles	30	1
Wasps	9	4
Grasshoppers	9	2
Songbird, unid.	4	1
Crickets	4	tr.
Insects, unid.	4	----
Unidentified material	**26**	3

[1] Eighteen scats and five gastrointestinal tracts.
[2] Eighteen scats and four gastrointestinal tracts.

coons are selective; during periods of scarcity, they eat whatever is available.

Food preference seems to be related in part to sugar content. Natural foods for which evidence of definite preference was obtained are all high in sugar content. Raccoons in captivity showed a strong preference for sweet foods.

TABLE 16. SEPTEMBER FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[1]
	Pct.	*Pct.*
Plant material	**100**	**96**
Persimmon	69	57
Frost grapes	31	31
Corn	8	8
Animal material	**23**	**3**
Insects, unid.	15	tr.
Grasshoppers	8	3
Crayfish	8	tr.
Unidentified material	**8**	**1**

[1] Twelve scats and one gastrointestinal tract.

TABLE 17. OCTOBER FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[2]
	Pct.	*Pct.*
Plant material	**100**	**93**
Persimmon	52	51
Muscadine	13	9
Frost grapes	6	17
Acorns	6	6
Rattan-vine	3	10
Corn	3	tr.
Animal material	**39**	**5**
Insects, unid.	23	1
Beetles	23	tr.
Crayfish	6	1
Wasps	6	tr.
Wireworms	3	1
Fish (minnow)	3	1
Rabbit	3	1
Grasshoppers	3	tr.
Grubs	3	tr.
Frog, unid.	3	tr.
Unidentified material	**10**	**1**

[1] Twenty-four scats and seven gastrointestinal tracts.
[2] Eight scats and five gastrointestinal tracts.

Preference seems to vary among individuals as well as among populations. For example, a pair of yearling raccoons collected while feeding together and judged to be litter mates contained entirely different food items. Where food supplies are concentrated or limited, apparent differences in preference may actually be a result of differences in feeding opportunity because of the individual's position in the social heirarchy.

Although many feeding habits seem to be instinctive, learning appears to be a very important factor in determining raccoon food habits, especially where predation is concerned. Learning may account for local differences in degree of use of certain foods. An

TABLE 18. NOVEMBER FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[2]
	Pct.	*Pct.*
Plant material	**96**	**84**
Sugar hackberry	38	25
Persimmon	14	12
Rattan-vine	13	7
Chufa (tubers)	13	7
Acorns	12	14
Privet	12	10
Greenbriers	5	2
Eastern red-cedar	4	4
Frost grapes	3	2
Possum-haw	1	1
Vaccinium	1	tr.
Muscadine	1	tr.
Dogwood	1	tr.
Animal material	**31**	**11**
Grasshoppers	12	2
Beetles	12	1
Wasps	9	5
Crayfish	5	1
Wireworms	5	tr.
Insects, unid.	3	1
Tent caterpillar	3	tr.
Flathead woodborer	1	1
Green anole	1	tr.
Frog, unid.	1	tr.
Maggot	1	tr.
Unidentified material	**8**	**5**

[1] Fifty-nine scats and 19 gastrointestinal tracts.
[2] Fifty-nine scats and 18 gastrointestinal tracts.

unusual example of a locally acquired predatory habit was reported by Bankston and Stilwell *(14)*. Thirty mature sheep and 200 lambs were said to have been killed by raccoons. The damage was reported to have been terminated when one large male raccoon was killed, even though other raccoons were involved. Apparently, only one individual had mastered the technique of killing the sheep. In some cases man is responsible for teaching raccoons to utilize a particular food. Several farmers told the author they experienced no damage to melon patches by raccoons until they left a broken melon in the field. Afterwards, raccoons destroyed the entire patch. Many other examples could be given. Members of populations learn to take advantage of new feeding opportunities or, when changing habitat conditions eliminate a traditional food source, to utilize foods not previously utilized. Acquired feeding skills are then taught to succeeding generations. The ability of raccoons to learn and their amazing memory *(101,122)* are largely responsible for their adaptiveness.

TABLE 19. DECEMBER FOODS OF RACCOONS IN ALABAMA

Food item	Occurrence[1]	Total volume[2]
	Pct.	*Pct.*
Plant material	**85**	**78**
Privet	46	41
Persimmon	18	8
Rattan-vine	12	5
Greenbriers	11	4
Sugar hackberry	5	7
Acorns	5	4
Corn	5	3
Possum-haw	3	2
Eastern red-cedar	1	2
Chufa (tubers)	1	2
Moonseed	1	tr.
Moss	1	tr.
Dry leaf	1	tr.
Fungi	1	tr.
Grass	1	----
Gallberry	1	----
Animal material	**19**	**9**
Mayfly nymphs	7	3
Crayfish	5	1
Grasshoppers	4	3
Tent caterpillar	3	2
Beetles	3	tr.
Insects, unid.	3	tr.
Maggots	1	tr.
Wasps	1	tr.
Centipedes	1	tr.
Earthworms	1	tr.
Fish, unid.	1	tr.
Lizard, unid.	1	tr.
Bird, unid.	1	tr.
Unidentified material	**9**	**14**

[1] One-hundred and thirty-three scats and 17 gastrointestinal tracts.
[2] Eighty-three scats and 16 gastrointestinal tracts.

Comparison with Previous Studies

Numerous studies of raccoon food habits have been conducted, Appendix Table 3. However, few studies have been conducted in the southeastern states. Results and general conclusions of the present study are similar to those of studies in Maryand *(113)* and South Carolina *(100)*. Food habits studies of raccoons from forested areas are in general agreement. Plant foods, mostly naturally occurring fruits, consistently comprise 50 to 80 per cent of the volume of food consumed from April to November. Acorns have been most frequently listed as the most important food. Corn is the primary food in some areas, especially the Mid-West *(e.g. 66)*. It is of much less importance in the areas that have been studied in the South. The most important animal foods are crayfish and insects such as grasshoppers, beetles, and wasps. In some areas these have been the most important food items.

Predation on Vertebrates

Data from the present study indicate that predation on vertebrates is infrequent. This is in accord with the results of most other studies. However, raccoons are adaptable, and in certain situations where vertebrates are abundant and easily obtained, they may be heavily utilized. In some areas raccoons prey rather heavily on young muskrats, and some writers have considered raccoons to be serious limiting factors on muskrat populations *(114,205,206)*. Errington *(54)*, after many years work with muskrat populations, concluded that predation did not seriously reduce populations but was one of a number of factors preventing excessive buildup by removal of surplus individuals occupying insecure niches. He noted that predation by raccoons was heaviest in areas of recurring muskrat disease, but stated that the role of the raccoon as a muskrat predator was not well understood.

Atkeson and Hulse *(10)* suspected that raccoons preyed heavily on young rabbits in northern Alabama. In general, however, raccoons are inefficient predators of mature birds and mammals.

The significance of predation by raccoons on eggs of ground-nesting birds and reptiles is not so well understood. Erickson and Scudder *(52)* and others have shown that raccoons in some localities destroy many turtle nests. It is well known that raccoons are very destructive to the nests of sea turtles. Predation on nesting waterfowl and marsh birds has also received much discussion *(17,102,114,149)*.

In Alabama many hunters and game managers suspect that raccoons are important predators on the eggs of wild turkeys. There is some evidence in support of this viewpoint. Davis *(46)* established 107 "dummy" nests in natural cover on areas well populated with turkeys. The nests contained turkey eggs poisoned with strychnine. Raccoons destroyed 29 per cent of the dummy nests. In the present study, it was observed that some raccoons from the Fred T. Stimpson Area, which supports a very dense turkey population, when held in captivity and offered chicken eggs, were able to open them quickly and deftly to feed upon the contents. Raccoons from other areas were unable to open the eggs. This suggests that egg-eating is a learned trait characteristic of some populations and not others.

Forty-seven food habits samples were collected from April through August on game management areas in southwestern Alabama. Wild turkeys are abundant on these areas, but only one of the samples contained egg fragments. However, when raccoons in captivity opened chicken eggs and ate them, they generally licked the contents, swallowing little of the shell in the process. Thus, if no shell is consumed, eggs might not be identifiable in samples.

The Fred T. Stimpson Sanctuary supports maximum wild turkey densities in spite of an abundance of raccoons. Wheeler *(202)* intensively studied the wild turkey population on the Fred T. Stimpson Sanctuary, and did not consider nest predation important. Raccoons were not even listed among nest predators. Raccoons are numerous throughout most of the best turkey range in southern Alabama, Florida, and the Lower Coastal Plain of other southern states, yet turkeys have thrived especially well in these areas. Stoddard *(186)* does not consider nesting losses of turkeys to predators to be as serious as in the case of bobwhite quail.

In the present study 123 samples of raccoon food habits were collected during the spring and summer months. Except for the fragments of turkey egg referred to previously, there was only one occurrence of bird eggs. One scat contained entire crushed shells of seven quail eggs, indicating that at least some individuals consume the shells of small eggs rather than opening them and lapping the contents as captives did with chicken eggs.

The infrequent occurrence of bird eggs is in agreement with the results of most other studies. Dorney *(50)* found duck eggs in 7 per cent and unknown eggs in 6 per cent of 95 raccoon scats collected in May and June from a Wisconsin marsh. Kinard *(100)* found bird eggs in 2 of 261 scats and stomachs collected from April to August in South Carolina. Bird eggs were not listed as foods of raccoons in other studies, Appendix Table 3.

PARASITISM AND DISEASE

Several surveys of helminth parasites of raccoons have been conducted in the southern United States, but no studies have been reported from Alabama. Harkema and Miller *(84)* examined 320 raccoons from North Carolina, South Carolina, Georgia, Florida, and Virginia and encountered 39 species of helminths. Chandler *(31)* examined 16 raccoons from eastern Texas and found 12 species of helminths. Babero and Shepperson *(11)* examined six raccoons from central Georgia and found 16 species of helminths. Jordan and Hayes *(95)* encountered only seven species of helminths in 100 raccoons from Ossabaw Island, Georgia. Similar surveys in other areas include those of McNeil and Krogsdale *(130)* in Washington and of Schultz *(176)* in Michigan. Stains *(182)* listed all parasites that had been reported from raccoons as of 1956.

METHODS

During post-mortem examinations various organs were inspected for helminth parasites. The organs were dissected and inspected under the dissecting scope. Some entire animals, but usually only certain organs, were thoroughly examined. Protozoan parasites were not studied. Casual observations were made on ectoparasites.

All animals necropsied were examined for gross lesions suggestive of a pathological condition. Pathological examinations were conducted only on raccoons that were obviously sick when taken or those found dead in areas where disease was suspected. These were referred for diagnosis to the State Veterinary Diagnostic Laboratory or to the Southeastern Cooperative Wildlife Disease Study Association.

Records of all confirmed cases of rabies in Alabama, by county, from January 1959 to June 1967 were obtained from the Alabama Department of Public Health, and surveillance reports of the United States Public Health Service Communicable Disease Center were examined.

Data on arthropod parasites, trypanosomes, and tularemia were available from studies conducted by others in Alabama. These data are presented as are pertinent data from states nearby.

RESULTS AND DISCUSSION

Helminth Parasites

Nineteen species of helminth parasites were encountered during this study, Tables 20 and 21. No doubt others were overlooked. Animals from southwestern Alabama were generally more heavily parasitized than those from other areas of the State, and more species were found there. Most of the species encountered were common raccoon parasites that have been reported from

TABLE 20. HELMINTH PARASITES FOUND IN RACCOONS FROM ALABAMA

Class Nematoda
Strongyloidea
Syngamidae
Syngamus (?) sp.
Ancylostomidae
Arthrocephalus lotoris (Schwartz, 1925)
Trichostrongylidae
Molineus barbatus Chandler, 1942
Crenosomatidae
Crenosoma goblei Dougherty, 1945
Metastrongylidae
Aelurostrongylus (?) sp.
Spiruroidea
Gnathostomidae
Gnathostoma procyonis Chandler, 1942
Physalopteridae
Physaloptera sp.
Dracunculoidea
Dracunculidae
Dracunculus insignis (Leidy, 1858)
Trichuroidea
Trichuridae
Capillaria plica (Rudolphi, 1819)
Capillaria sp.
Capillaria sp.
Class Trematoda—Order Digenea
Dicrocoeliidae
Eurytrema procyonis Denton, 1942
Diplostomatidae
Pharyngostomoides procyonis Harkema, 1942
(Unidentified: 3 species)
Class Cestoda—Order Cyclophyllidea
Mesocestoididae
Mesocestoides variabilis Mueller, 1927
Anaplocephalidae
Atriotaenia procyonis (Chandler, 1942)
Phylum Acanthocephala—Order Archiacanthocephala
Macracanthorhynchus ingens (von Linstow, 1879)

widely scattered areas. However, several uncommon species were encountered in southwestern Alabama.

NEMATODA. Two species of nematodes were encountered in the stomach of raccoons. *Gnathostoma procyonis* Chandler, 1942 was represented in raccoons from 12 of 15 counties from which raccoon stomachs were examined. Only one raccoon was examined from each of the three counties in which it was not recorded. This is a widely distributed parasite, and likely it occurs throughout the State. It was present in 59 of 153 stomachs examined (38 per cent). Although this parasite generally occurred in small numbers, several raccoons contained 50 to 100.

Larval gnathostomes produce extensive lesions when migrating through the tissues *(9)*. Adults produce large nodules in the

Table 21. Frequency of Occurrence of Helminth Parasites in Alabama Raccoons by County

Habitat and Parasite	Clarke	Choctaw	Marengo	Washington	Limestone	Macon	Butler	Covington	Cleburne	Lee	Chambers	Pickens	Elmore	Autauga	Baldwin	Barbour	Henry	Sumter	Total Statewide
Esophagus	(34)[1]	----	----	(5)	----	----	(7)	(1)	(4)	(1)	----	(1)	----	(1)	(4)	(1)	(1)	(1)	(61)
Capillaria sp.	2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2
Stomach	(84)	----	----	(11)	(1)	(11)	(7)	(1)	(8)	(19)	----	(1)	(1)	(1)	(4)	(2)	(2)	(1)	(153)
Gnathostoma procyonis	20	----	----	6	----	9	3	1	2	9	----	----	1	1	3	2	2	----	59
Physaloptera sp.	47	----	----	9	1	----	1	----	4	2	----	----	----	----	----	1	2	----	67
Intestine	(32)	----	----	(10	(1)	(1)	(7)	(1)	(4)	(2)	----	(1)	----	(1)	(4)	(1)	(2)	(1)	(68)
Physaloptera sp.	17	----	----	4	----	----	5	1	2	----	----	----	----	----	----	----	1	----	30
Capillaria sp.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	1
Arthrocephalus lotoris	----	----	----	----	----	----	----	----	----	----	----	----	----	1	2	----	----	1	4
Molineus barbatus	7	----	----	----	----	----	----	----	----	----	----	----	----	1	3	----	----	----	11
Pharyngostomoides procyonis	----	----	----	----	----	----	----	----	----	----	----	----	----	----	3	----	1	----	4
Mesocestoides variabilis	1	----	----	----	----	----	----	----	----	----	----	----	----	----	2	----	----	----	3
Atriotaenia procyonis	1	----	----	----	1	----	----	----	----	----	----	----	----	----	2	----	----	----	4
Macracanthorhynchus ingens	18	----	----	8	----	----	3	1	2	----	----	----	----	----	3	1	2	1	39
Unidentified trematode	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Unidentified trematode	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Unidentified trematode	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	1
Pancreatic ducts	(106)	----	(1)	(13)	(1)	(9)	(20)	(14)	(15)	(46)	(3)	(1)	(1)	(1)	(4)	(2)	(2)	(1)	(240)
Eurytrema procyonis	63	----	1	----	1	----	12	----	9	----	1	----	----	----	----	----	----	----	87
Urinary bladder	(26)	----	----	(2)	(1)	----	(7)	----	(3)	----	----	(1)	----	(1)	(4)	----	(1)	(1)	(47)
Capillaria plica	4	----	----	----	----	----	----	----	----	----	----	----	----	----	1	----	----	----	5
Subcutaneous (feet)	(41)	(1)	----	----	(1)	(4)	(2)	----	(4)	(9)	----	(1)	(1)	(1)	(4)	(1)	(2)	----	(72)
Dracunculus insignis	3	1	----	----	----	2	----	----	1	4	----	1	----	1	----	----	----	----	13
Lungs	(26)	----	----	(3)	----	----	(2)	----	(4)	(1)	----	(1)	----	(1)	(4)	----	(1)	(1)	(44)
Crenosoma goblei	4	----	----	----	----	----	----	----	----	----	----	----	----	----	3	----	----	1	8
Aelurostrongylus (?) sp.	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1
Syngamus (?) sp.	1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1

[1] Numbers in parentheses represent numbers of specific organs examined. Numbers below represent number of occurrences of each helminth species.

stomach wall, Figures 35 and 36, and tissue changes tending toward neoplasia have been noted *(9,95)*. Chandler *(31)* expressed the opinion that, when present in large numbers, this is probably the most harmful parasite of raccoons. In the present study raccoons were sometimes observed with empty nodules, seemingly regressing and healing. Ash *(9)* noted empty nodules indicative of a spontaneous loss of infestation in Louisiana raccoons.

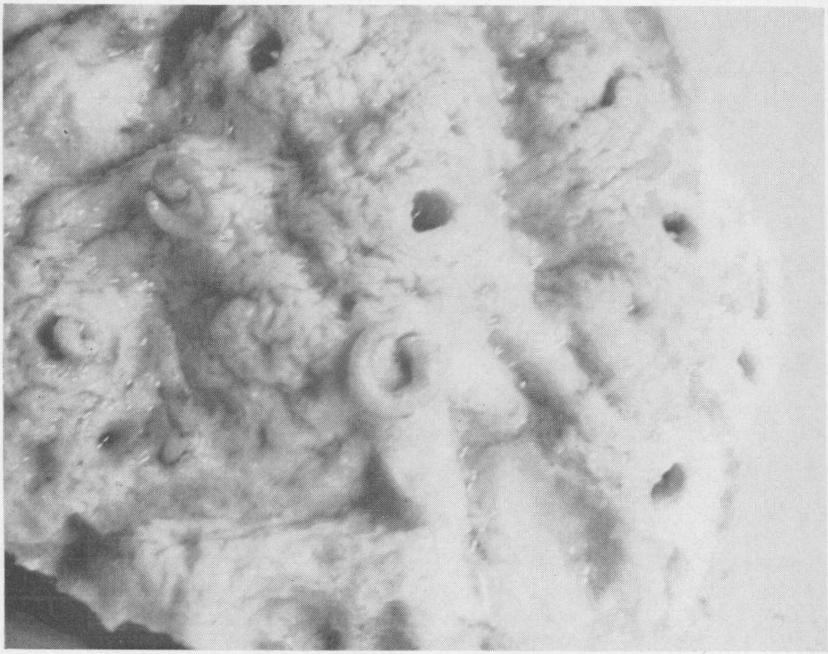


FIG. 35. Stomach of a raccoon parasitized by Gnathostoma procyonis. **Note large nodules in which worms reside.**

Chandler *(31)* stated that a marked seasonal occurrence of *Gnathostoma* was evident in 30 raccoons from eastern Texas. He reported that nine animals collected in December were heavily infested, whereas three raccoons collected in September were uninfested, and a raccoon collected in May contained only one individual. Ash *(9)* reported finding no evidence of seasonal variation in the gnathostome burden of 31 raccoons from Louisiana. In the present study there seemed to be a definite seasonal cycle with a very low rate of incidence in summer and a peak in early winter, Figures 37 and 38. Chi-square tests indicated highly significant ($P < 0.01$) differences in percentage of raccoons infested when

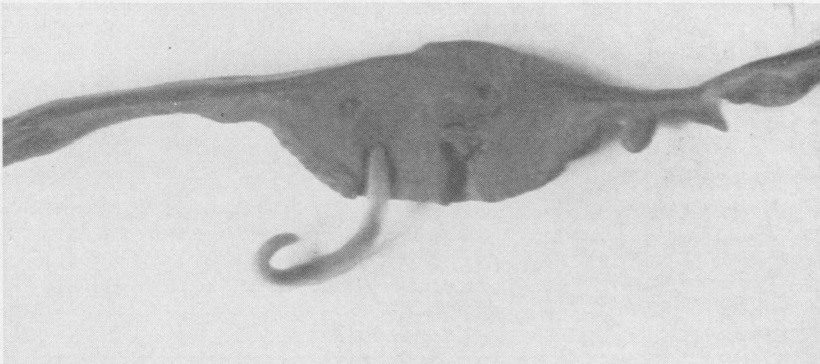


FIG. 36. Cross-section of stomach wall of a raccoon through nodule containing a gnathostome.

fall or winter samples or both were compared with spring or summer samples or both. Differences in the average number of worms per host were also highly significant ($P < 0.01$) in the same seasonal comparisons according to the t-test. Differences between rates of infestation in spring and summer were not significant; neither were differences between fall and winter samples. Although some differences between areas are included, seasonal variations were evident within the individual areas.

The life cycle of *Gnathostoma* involves copepods as first intermediate hosts and various cold-blooded vertebrates as second intermediate hosts *(8)*. The larvae have an obligatory stage in the

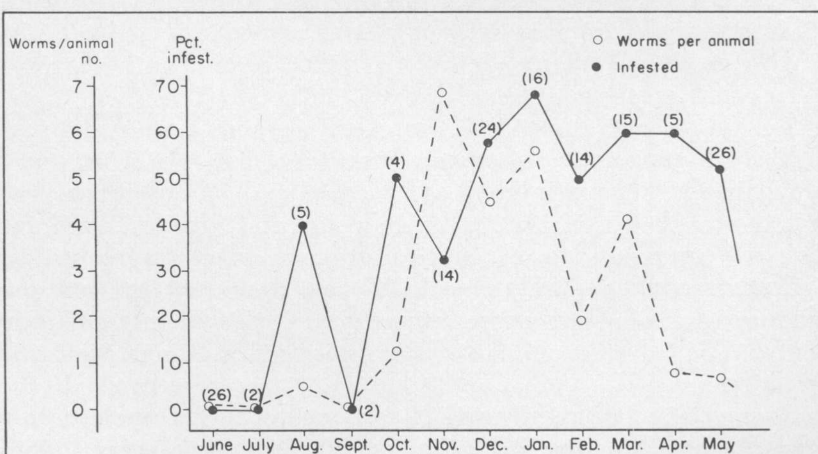


FIG. 37. Monthly variation in infestation rates of Gnathostoma procyonis **in 152 raccoons from Alabama. Numbers in parentheses indicate number of samples.**

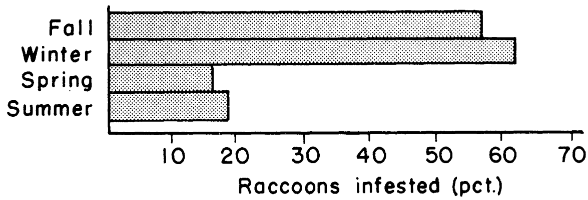


FIG. 38. Seasonal variation in incidence of gnathostome infestation in 152 Alabama raccoons.

tissues requiring 2 to 4 months before returning to the stomach *(9)*. Thus, animals apparently become infested during the summer, and the worms appear in the stomach in the fall.

Physaloptera sp. (probably *P. rara* Hall and Wigdor, 1918) is a widely distributed parasite found in the stomach and small intestine of raccoons. It was encountered in 67 of 153 stomachs (43 per cent) and in 30 of 68 intestinal tracts (44 per cent) representing eight counties. It was not found in small samples from six counties. Monthly variation in occurrence of *Physaloptera* in Alabama raccoons is shown in Figure 39. Incidence of infestation tends to be greatest in spring and least in the fall, but seasonal variation is not as pronounced as for *Gnathostoma*. This parasite utilizes an insect intermediate host *(83)*.

Arthrocephalus lotoris (Schwartz, 1925), a common hookworm of raccoons, was encountered in 4 of 68 raccoons (6 per cent). Infested animals were from Baldwin, Autauga, and Sumter counties.

A small nematode, *Molineus barbatus* Chandler, 1942, was found in the intestines of 11 of 68 raccoons (16 per cent). Infested animals were from Clarke, Baldwin, and Autauga counties. This is a common raccoon parasite. It has a direct life cycle *(78)*.

Capillaria plica (Rudolphi, 1819) was found in the urinary bladder of 5 of 47 raccoons examined for this parasite (9 per cent). The infested animals were all from Clarke and Baldwin counties.

Capillaria sp. was recovered from the intestine of one raccoon from Baldwin County. No other occurrences were noted. This may be *Capillaria mustelorum* Cameron and Parnell, 1932 which Harkema and Miller *(84)* found in the intestines of 4 of 320 rac-

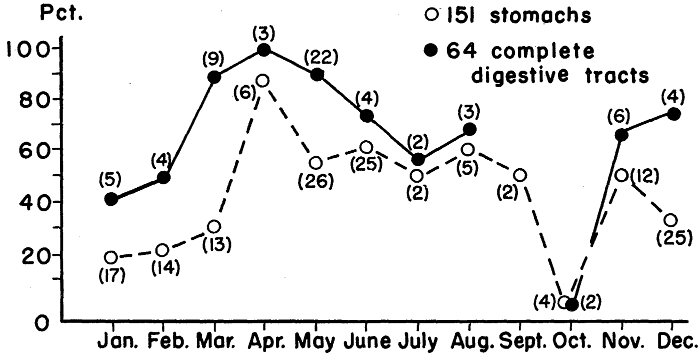


FIG. 39. Monthly trends in incidence of Physaloptera **sp. in raccoons from Alabama. Numbers in parentheses indicate sample size.**

coons from the southeastern United States. The infested individuals were from Georgia and North Carolina. It had not been previously reported from raccoons but is common in mink and weasels *(135)*.

Specimens of *Capillaria* sp. were found firmly attached to the esophagus of two raccoons from the Fred T. Stimpson Sanctuary. No reference was found in the literature to a *Capillaria* in the esophagus of raccoons, although various members of this genus inhabit the esophagus of other hosts, and these are not very host specific *(156)*.

Crenosoma goblei Dougherty, 1945 was encountered in the tracheae and bronchi of 4 of 26 raccoons from Clarke County, 3 of 4 raccoons from Baldwin County, and 1 raccoon from Sumter County. It was not encountered in 13 raccoons from seven other counties in various parts of the State. This is the most common lungworm of raccoons. It is often associated with verminous pneumonia and may be of significance in mortality from pulmonary infections.

Four of the eight infested animals had lungs tightly adhered to the thoracic walls, a condition often associated with pulmonary infections *(165)*. These were all heavily infested individuals.

The lungs of one raccoon from the Fred T. Stimpson Sanctuary contained thread-like strongyloid nematodes firmly embedded in cysts. Harkema and Miller *(84)* reported *Aelurostrongylus* sp. from the lungs of raccoons from North Carolina, South Carolina, and Georgia. It seems likely that this is the same species.

A bronchus of another raccoon from the same area contained a copulating pair of syngamid nematodes. Harkema and Miller *(85)* reported finding a syngamid probably of the same speices in 1 of about 400 raccoons from North Carolina. Otherwise syngamids have not been reported from mammals in North America.

Dracunculus insignis (Leidy, 1858), were found in the subcutaneous connective tissues of the feet, Figure 40. The intermediate hosts of this parasite are probably copepods of the genus *Cyclops*. The guinea worm (*D. insignis*) has been reported from various carnivores in widely separated localities in the United States *(55)*. Its distribution in Alabama, however, seems to be discontinuous. It was found in only 3 of 45 raccoons from Clarke and Baldwin counties, the infested individuals coming from the Upper State Game Sanctuary in Clarke County. Six of 13 raccoons from Lee and Macon counties in east-central Alabama were infested. Guinea worms have been reported from Florida and coastal areas elsewhere *(84,106)*.

FIG. 40. Guinea worm (Dracunculus insignis) **in subcutaneous tissue of the foot of a raccoon.**

ACANTHOCEPHALA. The large thorny-headed worm *Macracanthorhynchus ingens* (von Linstow, 1879) was of wide occurrence, being found in nine counties in 39 of 68 raccoons (57 per cent). It was generally found in the small intestine, although occasionally the large intestine was also infested. The rate of infestation varied from 1 to 70 worms per raccoon. This parasite has been widely reported from the Southeast and elsewhere in the United States. The intermediate hosts are the larvae of coleopterous beetles *(139)*. It does not seem to be very injurious to the host.

CESTODA. Two species of tapeworms commonly reported from raccoons were found, sometimes in large numbers. *Atriotaenia procyonis* (Chandler, 1942) was present in animals examined from Baldwin, Clarke, and Limestone counties. The intermediate host is probably a coprophagous beetle *(59)*. *Mesocestoides variabilis* Mueller, 1927, also was found in Clarke and Baldwin counties. Its life cycle is unknown *(32)*, but it infests a variety of hosts. Tapeworms examined early in the study were not specifically identified. They were from Barbour, Washington, and Sumter counties.

TREMATODA. *Eurytrema procyonis* Denton, 1942 occurred in the pancreatic ducts of 87 of 240 raccoons. It occurred with a high rate of incidence in raccoons from some areas but was absent from raccoons from other areas. This species is common in most of the Southeast but is apparently absent from Florida and at least the coastal areas of Georgia and South Carolina *(84,95)*. Its distribution in Alabama raccoons is shown in Figure 41. The distribution of this parasite is seemingly not related to the gross ecology of the area. The flukes were found in a wide variety of ecological types, some quite different, whereas some areas in which the parasite was not found were ecologically similar to nearby areas in which it was found. Although a snail serves as first intermediate host, the means by which the definitive host is infested is not known *(31,48)*.

On the Fred T. Stimpson Sanctuary 47 of 67 raccoons harbored *Eurytrema* (70 per cent). Although the incidence of parasitism was higher in older animals, juveniles apparently became infested quite early, as juveniles collected in November at 4 to 5 months of age were already heavily infested. There was no apparent correlation of incidence of infestation with season, probably because infestations are of long duration. One raccoon from Clarke County held in captivity for 9 months with no opportunity for re-

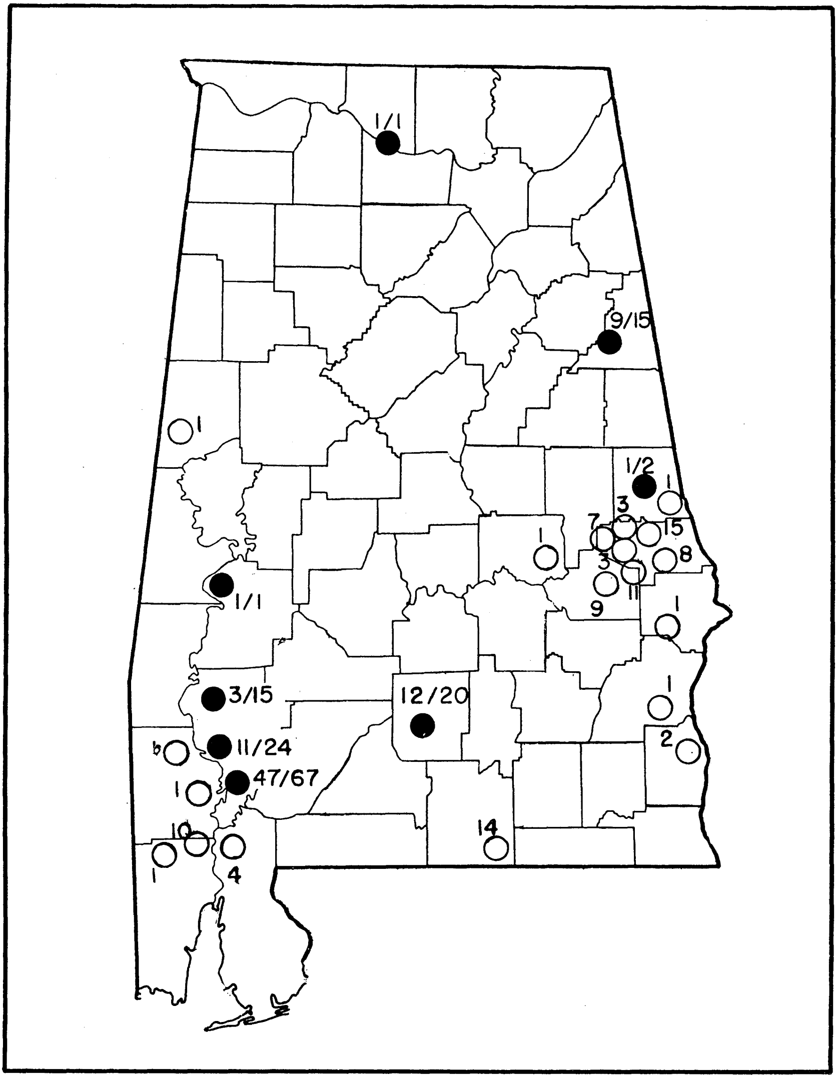


FIG. 41. Distribution of Eurytrema procyonis **in Alabama raccoons as determined by examination of the pancreatic ducts of 240 animals. Clear circles show locations where animals were examined and** Eurytrema **not found, and accompanying numbers show sample size. Filled areas show locations where animals positive for** Eurytrema **were examined, with first number indicating number of positive animals and second number indicating sample size.**

infestation still retained a moderate infestation when examined. There was no indication that they were harmful to the hosts. Apparently healthy animals sometimes harbored thousands of these flukes.

Pharyngostomoides procyonis Harkema, 1942 was found in great numbers in animals from Baldwin and Henry counties. It probably occurs throughout the State. It has been widely reported elsewhere.

Three other intestinal trematodes were encountered but were not identified. They each occurred in only one animal.

Ectoparasites

Raccoons were commonly observed to harbor fleas and ticks, but no instance of severe infestation was noted.

The ectoparasites of raccoons and other host species in Alabama have been surveyed by Royal *(161)*, Sanford *(169)*, Baker *(13)*, and Cooney *(41)*. Only one raccoon was included among the hosts examined by Royal, and it harbored no insect ectoparasites. Data pertaining to ectoparasites as they occur on raccoons are summarized from the other studies in Table 22. Percentages of hosts infested were not reported in these studies, although Cooney recorded average number per host. Cooney's data indicate that the ticks that occur most commonly on raccoons in Alabama are *Ixodes texanus* and *Dermacentor variabilis*. *I. texanus* was found only on raccoons.

TABLE 22. ECTOPARASITES OF RACCOONS IN ALABAMA

Ectoparasites and reference	Raccoons examined
	No.
Sucking lice (Anoplura) *(13)*	50
(none)	
Ticks (Ixodidae) *(41)*	59
Ixodes texanus Banks	
I. cookei Packard	
I. scapularis Say	
I. dentatus Marx	
Amblyomma americanum (Linnaeus)	
Dermacentor variabilis (Say)	
Fleas (Siphonaptera) *(169)*	52
Odontopsyllus multispinosus (Baker)	
Orchopeas howardii (Baker)	
Cediopsylla simplex (Baker)	
Ctenocephalides felis (Bouché)	
Echidnophaga gallinacea (Westwood)	

Morlan *(140)* examined 100 raccoons in a survey of the ectoparasites of mammals in southwestern Georgia. He found *D. variabilis* on 43 per cent of the raccoons examined and *I. texanus* on 14 per cent. These were the most prevalent ticks infesting raccoons. The flea recorded by Morlan as occurring most frequently on raccoons was *Orchopeas howardii.* Stains *(182)* listed 31 species of ectoparasites as having been reported from raccoons by 1956.

Mortality Resulting from Respiratory Disease and Canine Distemper

Reports of disease-induced mortality began to reach the investigator soon after the study was initiated. The most persistent reports came from areas along the Alabama and Tombigbee rivers from Autauga and Sumter counties southward to northern Mobile and Baldwin counties, Figure 42.

All mortality was reported in the colder months (November through April). Dead animals were found by hunters and foresters and were commonly brought in by dogs. Sick animals were seen during daylight hours, usually appearing tame and indifferent and offering no resistance when captured.

Six raccoons suspected of being diseased were examined by pathologists. All were suffering from variously diagnosed respiratory infections. Diagnoses included canine distemper, pneumonia associated with distemper, chronic pleurisy of unknown origin, and verminous pneumonia in conjunction with debilitation by intestinal parasites, Table 23.

Lungs were tightly adhered to the walls of the thoracic cavity in many of the raccoons from the Alabama-Tombigbee River System. Some also had nodules on the lungs. Twenty-nine per cent of those examined for lungworms were infested, and lungs were stuck to the thoracic wall in 50 per cent of those infested with *Crenosoma goblei.* Several of the raccoons with these conditions were taken during the day or were found dead on the road, which might indicate abnormal behavior. Most of the raccoons with the conditions described were apparently healthy, and several led dogs on long chases before being treed. Two captive raccoons that were held for several months with no symptoms of illness were found, when sacrificed for other studies, to have pleural adhesions. Sanderson *(165)* noted pneumonia in sick and dead raccoons in Illinois but also observed severe pneumonia in apparently healthy raccoons. Pneumonia did not cause visible symp-

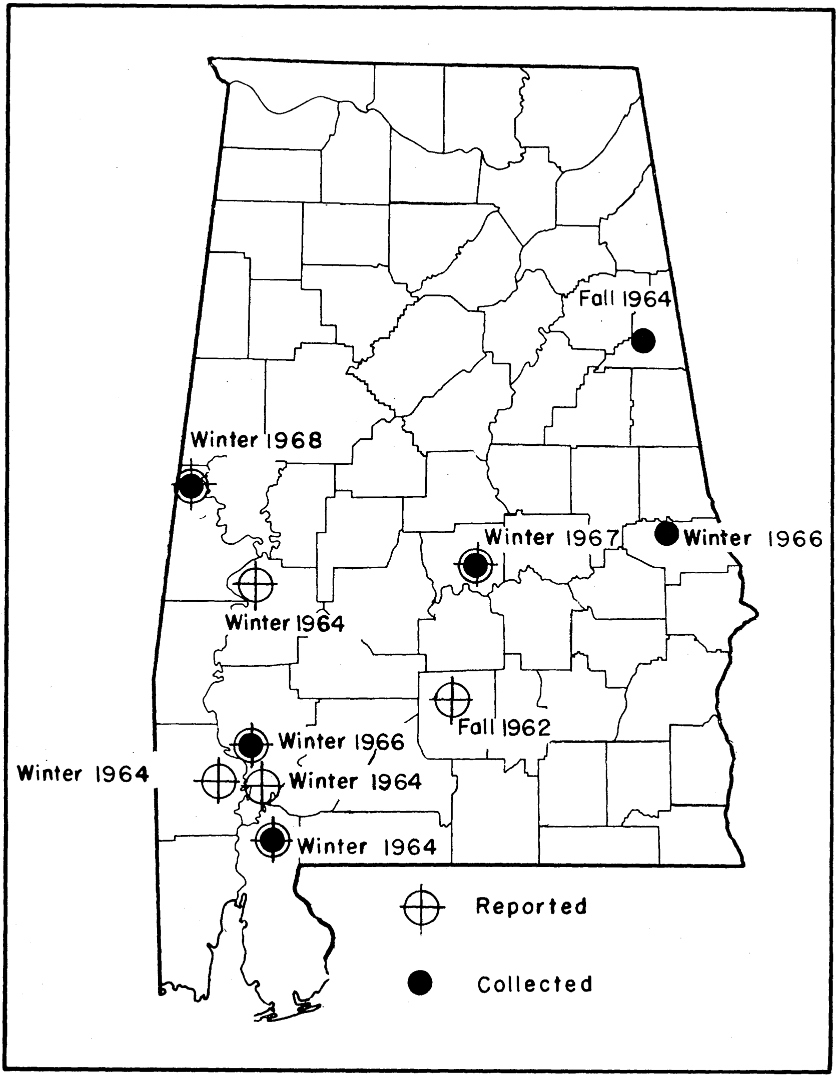


FIG. 42. Areas of extensive raccoon mortality resulting from disease and/or areas from which diseased animals were collected and subjected to examination by pathologists.

toms of illness, and Sanderson stated that pneumonia was not necessarily the cause of the illness and death with which it was sometimes associated.

Similar occurrences of mortality and abnormal behavior due to disease have been reported from raccoon populations in Iowa,

TABLE 23. REPORTS OF MORTALITY AND SICK RACCOONS IN ALABAMA, 1962-68

Date	Locality	Examined	Diagnosis
		No.	
Fall, 1962	Butler County	0	----------
Fall-Winter, 1963-64	Tombigbee River swamp from Sumter County south to Baldwin County	1	canine distemper
November, 1964	Tombigbee River swamp, Washington County	0	----------
November, 1964	Cleburne County	1	canine distemper
December, 1965	Clark County, Upper State Game Sanctuary	1	pneumonia associated with distemper
February, 1966	Lee County, North Auburn	1	pneumonia associated with distemper
April, 1967	Autauga County, Prattville vicinity	1[1]	chronic pleurisy of unknown origin, suggestive of verminous pneumonia associated with *Crenosoma goblei*
February, 1968	Northern Sumter County	1	pneumonia (possibly of verminous origin)

[1] Examined by Southeastern Cooperative Wildlife Disease Study Association; all others examined by Alabama State Veterinary Diagnostic Laboratory.

Kansas, Indiana, Maryland, Illinois, Kentucky, and Minnesota *(79,96,120,133,134,159,165)*. Canine distemper was the usual diagnosis.

Chronic respiratory infections endemic to the dense raccoon populations of western Alabama are probably a result of an interaction of canine distemper, lungworms, pneumonia, and general debilitation resulting from malnutrition and gross parasitism. These conditions were encountered infrequently in raccoons from east-central Alabama.

Infectious Diseases of Raccoons and Their Relation to Human Health

Numerous infectious diseases have been reported from raccoons, Appendix Table 4. Except for canine distemper, these diseases seem not to play an important role in the population ecology of the species. However, the occurrence of some of these diseases in raccoons is of potential public health significance. Public health workers are showing increasing interest in wild animals as reservoirs of diseases infective to man and domestic animals *(1,33, 194)*. The American dog tick (*Dermacentor variabilis*), which commonly occurs on raccoons, has been implicated in Saint Louis encephalitis, spotted fever, and tularemia. Most interest in raccoons as reservoirs of human diseases has focused on leptospirosis, rabies, Chagas' disease, and tularemia. These diseases will be discussed briefly.

It is necessary to have a knowledge of the role of all possible reservoirs and vectors before the epidemiology of a disease can be fully understood. However, it should be emphasized that there is no clear evidence that raccoons have ever been involved in any outbreaks of disease in man or domestic animals, with the possible exception of dog rabies, despite much contact by trappers, hunters, and hunting dogs.

RABIES. There is no evidence that rabies has ever been of significance in raccoon populations in Alabama. Records of the Alabama Department of Public Health reveal only one confirmed case of rabies in raccoons in Alabama from January 1959 to June 1967.

Little is known concerning the role of the raccoon in the maintenance and spread of rabies. Prior to the late 1950's the raccoon was considered an unimportant host, accounting only for a small number of sporadic cases of rabies. But in the late 1950's the disease emerged in a near epizootic form in central Florida.

Scatterday, *et al.* *(171)* reported that, in Florida, rabies in raccoons appeared to spread slowly along the major waterways, which provide best raccoon habitat. It slowly spread northward from central Florida into southern Georgia, seemingly confined on the west by the Chattahoochee River and the large reservoirs along it and on the east by the Altamaha River. Counties to the east of the Chattahoochee River in southern Georgia reported a high incidence of rabies in raccoons, while neighboring Alabama counties across the river reported only one confirmed case of rabies in raccoons, this in Houston County in 1961.

Surveys have generally indicated low rates of rabies infection among raccoons. In areas of raccoon rabies in Florida, the disease was usually restricted to raccoons, except that tame-appearing infected animals were often attacked by dogs when they ventured into areas of human settlement. Raccoons are somewhat resistant to the disease and secrete a relatively small amount of virus in the saliva *(180)*. Also, in contrast to other species, they are often, but not always, benign and unaggressive when rabid unless cornered or attacked. These factors in combination would account for the fact that raccoon populations rarely exhibit explosive epizootics of the type common in fox populations.

Rabies does not appear to spread readily from raccoons to other species, and geographic centers of fox rabies and raccoon rabies in Georgia and Florida have been generally distinct. Raccoon rabies has, however, spread into areas where fox rabies was already present, and there is currently some overlap.

Recent investigations have provided evidence that subclinical immunizing infection occurs in wild animals in nature. Sikes *(179)* reported that several wild animals experimentally innoculated with rabies virus developed serum rabies-neutralizing antibodies sufficient to provide protection against challenge doses of up to 16,000 MLD 50. Controls died from the challenge. Tierkel *(196)* reported the presence of an antiviral substance from the serum of wild mammals including raccoons. Sikes, in a letter cited by Barr *(16)*, reported serum rabies-neutralizing antibodies from 3.1 per cent of 128 raccoons examined in Alabama. All positive sera were from animals from areas with a history of recent fox rabies; serum neutralization tests of animals from "rabies free" areas were all negative *(16)*. Sikes *(179)* stated that such immunity is probably insignificant in preventing epizootics.

LEPTOSPIROSIS. Numerous serotypes of the pathogenic spirochaete *Leptospira* are recognized. As many as 10 serotypes have been identified in raccoons *(37,157,160)*. Leptospires of six serogroups were isolated from 60 of 856 raccoons (8.4 per cent) in southwestern Georgia *(75)*, and leptospires were isolated from 5 of 22 raccoons (22.7 per cent) in North Carolina *(62)*. Blood samples from 16 of 70 raccoons (23 per cent) in Ohio were positive for leptospires *(73)*. Leptospires have also been reported from raccoons in New York and Pennsylvania *(36,157)*. Investigators reported that none of the infected raccoons exhibited gross pathology or displayed symptoms *(75,125)*.

All of the serotypes of *Leptospira* found in raccoons are infective to both man and domestic animals. Human cases of leptospirosis are increasing, and public health workers have stressed the role of wild mammals as reservoirs of the disease *(36,60,61, 183)*. Human infection may be acquired from wildlife by direct contact, by swimming or wading in water or mud contaminated by urine, or indirectly through domestic animals. Raccoons seem to be the most commonly infected wild animals in the Southeast *(60)*. Raccoons accounted for 23.5 per cent of the total infections in wild mammals in southwestern Georgia *(75)*.

Several outbreaks of *Leptospira pomona* infections among humans in Alabama and Georgia have been attributed to contaminated water *(60)*. *Leptospira autumnalis* has been incriminated as the causative agent of an outbreak of pre-tibial fever ("Fort Bragg Fever") at Fort Bragg, North Carolina, in 1942. Involvement of wild animal reservoirs, including raccoons, has been suggested *(62,71,126)*. Infected raccoons were found in the area of the outbreak *(62)*.

TULAREMIA. Tularemia (caused by the bacterium *Pastuerella tularense*) may be transmitted by direct contact, by contaminated water, or by the tick *Dermacentor variabilis*, which commonly parasitizes raccoons *(87)*. Hays and Foster *(87)* found that 5 of 23 suspected serums from raccoons from Alabama gave positive reactions. McKeever, *et al.* *(128)* reported that 24.9 per cent of 618 serums obtained from raccoons in southwestern Georgia and northwestern Florida had significant titers. The raccoon was listed among the chief mammalian reservoirs in the Southeast *(128)*. Incidence was highest in animals from swamps and bottomland hardwoods and lowest in animals from agricultural lands *(128)*.

CHAGAS' DISEASE. *Trypanosoma cruzi* (Chagas), the causative agent of Chagas' disease, was isolated by Olsen, *et al.* *(148)* from 5 of 35 raccoons (14.3 per cent) from east-central Alabama. Eight of 608 raccoons (1.5 per cent) in southwestern Georgia and northwestern Florida were reported infected by McKeever, *et al.* *(127)* and Norman, *et al.* *(146)*. *T. cruzi* was found in 10 of about 472 raccoons in Maryland *(89)*. Eleven per cent of 80 raccoons examined in November were infected *(89)*. Raccoons and opossums are considered to be the primary reservoirs of *T. cruzi* *(89,148)*.

Human cases have been reported in the United States *(210)*, but such cases are rare. Farrar, *et al.* *(56)* found *T. cruzi* antibodies in 6 of 941 serum samples from Georgia residents, two of which were suffering from heart disease similar to chronic Chagas' disease. They suggested that the organism may be responsible for some unexplained heart disease.

MOVEMENTS AND RELATED BEHAVIOR

METHODS

Data on movements and related behavior of raccoons were obtained from recaptures of tagged animals and from telemetric studies. Observation of sign and hunting with dogs provided valuable supplementary information.

RACCOONS IN THEIR NATURAL RANGE

Results

SUMMER RANGE OF A RACCOON ON THE FRED T. STIMPSON SANCTUARY. A 1-year-old male on the Fred T. Stimpson Game Sanctuary was trapped and equipped with a radio transmitter-collar on June 29, 1967. This animal was released at its capture site 36 hours after capture and was located periodically by triangulation through September 19, 1967. The animal was located by triangulation 43 times on 17 different days over a period of 83 days. The approximate location of the animal was determined on numerous other occasions when triangulation was not possible because of the rapid movement of the animal and other reasons.

Well established locations of this animal are illustrated in Figure 43. These locations encompass a minimum home range of 122 acres. The distances between extreme points were 0.99 mile along the linear axis and 0.31 mile along the minor axis. Approximate locations obtained when triangulation was not possible were always within the limits of the estimated home range.

An apparent shift in activity pattern occurred during the second week in July. Prior to this time the typical daily routine of the subject involved resting during the daytime in large hardwoods on the natural levee along the Tombigbee River and feeding in the large open field to the east at night. During this time, he and other raccoons appeared to be feeding mainly on grasshoppers and corn obtained from the field. When the investigator returned to the study area on July 15 after an absence of a week, the subject was resting in the hardwood swamp to the east of the field. Throughout the remainder of the summer he was always found in this area in the daytime. Although he continued to visit the corn field at night, the time spent in the area seemed shorter

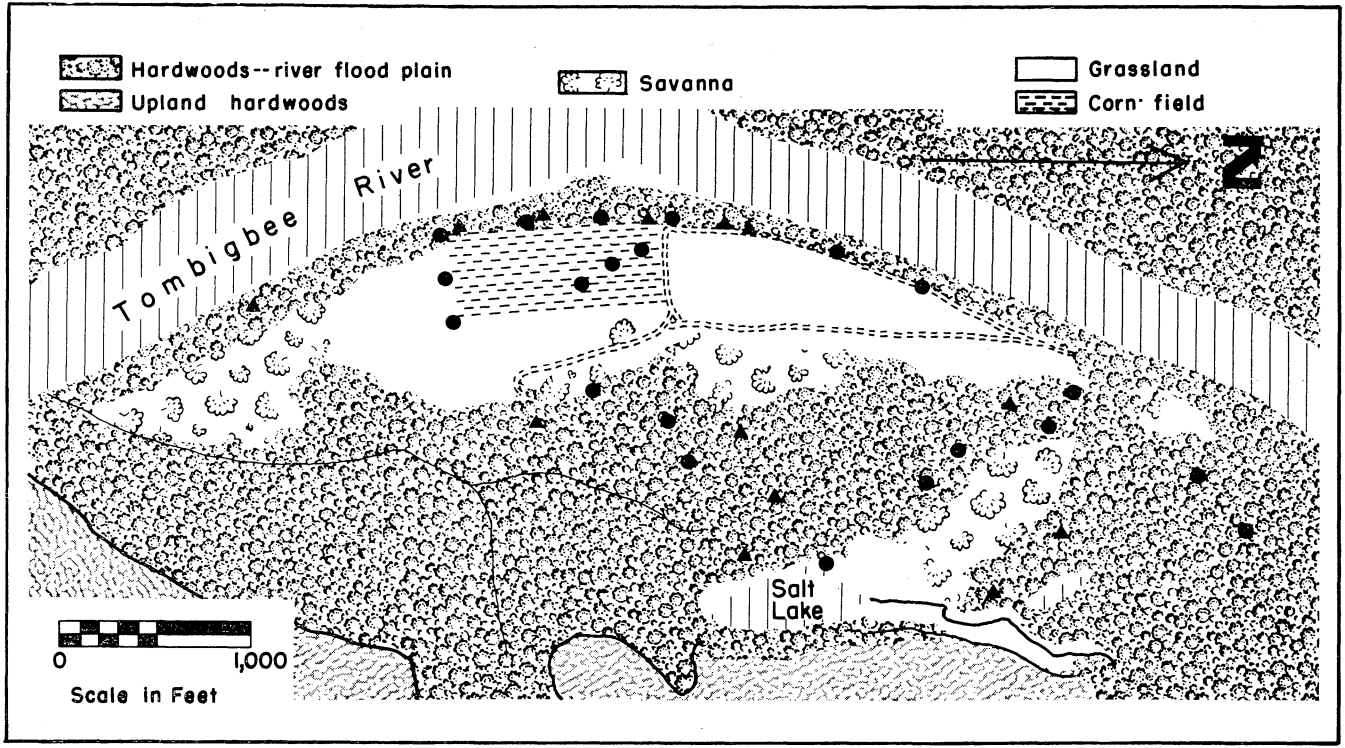


FIG. 43. Home range of a subadult male raccoon on the Fred T. Stimpson Game Sanctuary, as indicated by 43 telemetrically established locations between June 29 and Sept. 19, 1967. The animal was located at some points more than once, hence there are less than 43 points. Triangles show daytime resting sites; dots show locations when active.

than previously. During this latter period, the main food item was muscadines and various other species of wild grapes. On two occasions fresh fecal material containing frost grapes was found at the base of the tree in which he had been determined to be resting.

Also, after July 15, the Tombigbee River was out of its banks periodically for the remainder of the summer, and the area east of his home range was flooded. This may have limited the eastward extent of the range during part of this time. Absence of tracks indicated that raccoons were not feeding about the receding flood waters.

The entire range of the subject was within the flood plain of the Tombigbee River and was inundated for much of the winter. Unfortunately, no data were obtained during this time.

The animal was recaptured in a box trap by the refuge manager on May 24, 1968. He was captured in the large field within the range established in the summer of 1967.

WINTER AND SPRING RANGES OF TWO RACCOONS IN LEE COUNTY. A young female and an adult male on an area about 4 miles north of Auburn were equipped with radio transmitter-collars and were monitored telemetrically during the winter and spring of 1968. Receiver failure prevented tracking during February and early March, but the animals were located periodically from late March until May and June. Well established locations of both raccoons are shown in Figure 44. Most locations were daytime resting sites, but some were obtained at night when the animals were active. On most occasions it was possible to determine daytime locations precisely. This was accomplished by quietly walking into the area until the resting site was located. On several occasions the raccoons at rest were located visually. On two occasions the male made a major shift in the location of his activities following human activity in his vicinity, but it is doubted if the disturbance was responsble for this movement. Such shifts were frequent in the absence of any known disturbance.

The female, which was judged to be a yearling, was captured on January 22, 1968, along the small stream draining Farm Pond 9. This stream was used by several raccoons as a route to a corn field. She was equipped with a radio transmitter-collar and released at her capture site on January 23. She was tracked eastward along this stream until 10 p.m. Receiver failure prevented further monitoring until March 29. On this day she was found

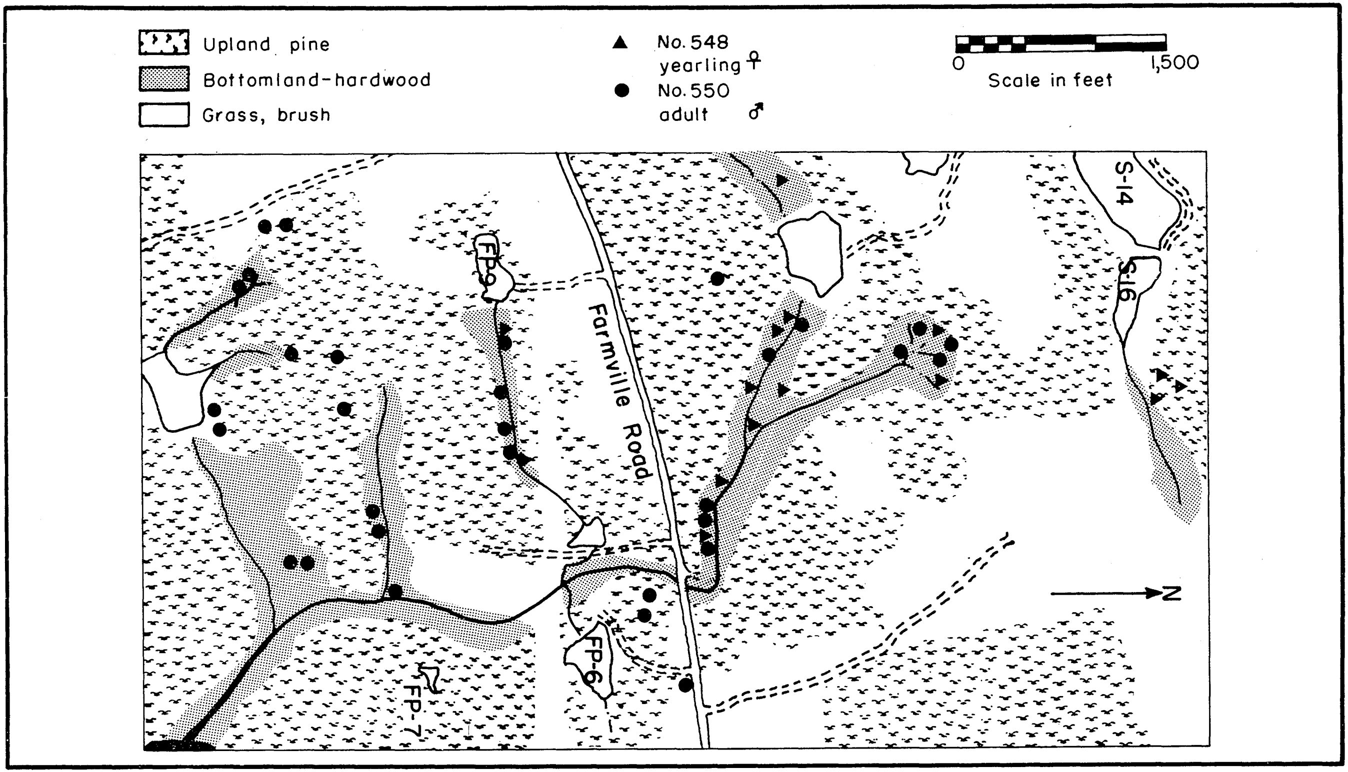


FIG. 44. Home ranges of an adult male and a yearling female raccoon in Lee Co., Alabama, as determined by telemetry, Jan.-June 1968.

resting in a hollow tree in a springhead across Farmville Road 0.86 mile north of the site of original capture. She was never located south of Farmville Road again. From March 29 through April 28 her activities were confined to the margins of several small creeks and branchheads. With one exception, all daytime (resting) locations were in one of three small branchhead areas. She generally shifted her center of activity between these areas, remaining in each area for about 1 week, then shifting her activities to one of the other areas. Transmission apparently ceased between April 29 and May 3. The most direct distance between extreme locations including the capture site, was 0.86 mile. When outermost points were connected, an area of 114 acres was encompassed.

The male, an adult, ranged over a much larger area, and during the entire period of monitoring he continued to enter areas he had not previously visited. He was trapped and equipped with a transmitter-collar on February 19, 1968, on the small branch draining Farm Pond 9, very near the site where the female was originally trapped. He was released at his capture site on February 20 and tracked along the stream until 10 p.m. From March 31 through April 4 he was using the eastern portion of the area, but definite locations could not be obtained. On April 5 he was found to be resting in a large, hollow water oak about 30 feet from Farmville Road, a well traveled paved road. That night he was tracked to a branchhead in the south-central portion of his range. He was never located in the area east of the larger stream again. He remained in this south-central area through April 16. On April 16 the eastern portion of the range was experimentally burned, and there was much human activity on this portion of the area. The subject was resting undisturbed in a stream bottom about 150 yards off the burned area. That night he shifted his center of activity northward across Farmville Road into the vicinity of the female. He remained in this vicinity for at least 10 days and was known to be denning with the female at least 1 day and was in trees very close to her on at least 2 other days. Between April 28 and May 22, the male moved back and forth, across Farmville Road, between the northern area and the southern area every few days. On May 29 he was found in a cove that he had not previously visited. He remained in this vicinity for 5 or more days, then shifted his daytime resting sites to the extreme southwestern portion of his range, which was adjacent to a plum thicket. He was located in the plum thicket on 2 nights and rested in the vicinity of it for at least 12 days. He was still in this area when tracking was terminated on June 20.

The most direct distance between extreme locations for the male was 1.0 mile. The area encompassed when outermost points were connected was 245 acres.

Contrary to reports from other areas *(68,132)*, trees were preferred for resting sites by the raccoons monitored in this study. Although hollow trees were commonly chosen as daytime resting sites, leaf nests built by squirrels were commonly used by the two subjects discussed here. On the warm, sunny days of early spring they obviously selected leaf nests for resting sites in preference to tree cavities.

Other raccoons were observed resting in large, open cavities on several occasions. These were all observed in a Lee County beaver swamp on clear, cold days. They apparently selected these sites to gain exposure to the sun.

MOVEMENT INFORMATION OBTAINED FROM TRAPPING AND HUNTING. Recaptures of tagged raccoons provided some information on movements, although movements beyond the limits of the area being trapped could not be determined. Distance between capture sites of individual raccoons on the Fred T. Stimpson Sanctuary extended up to 1 mile, Figure 54. Movements on this area were probably influenced by baited deer traps.

Trapping results indicated that, in winter, raccoons were most active on warm nights with light rain. Trapping was unsuccessful when temperatures fell below 25°F. Hunting success showed a similar relationship to temperature and rainfall.

Information obtained while hunting with dogs, although subject to some error because of the possibility of chases involving more than one raccoon, was of considerable value in ascertaining the ranging habits of raccoons and sites of activity. Raccoons whose trails were "struck" at feeding grounds often ran directly to secure refuge areas, giving the impression that the route of escape was familiar to the animal. Often these refuge areas were several miles from the feeding grounds. The idea of "planned" escape behavior by raccoons is common among hunters and those who have used dogs in studying them *(43,203)*. The learning ability and memory of raccoons should not be underestimated.

Refuge trees were generally the largest trees with the most foliage. Yellow-poplars were used by about 40 per cent of the raccoons treed. Other trees commonly used for refuge were laurel oak and water oak, pine, sweetgum, and sweetbay. Abandoned farm buildings were used for refuge on three occasions.

Lueth *(117)* reported 448 raccoons caught in steel traps set in permanent locations 0.1 mile apart on various game management areas in Alabama. The average distance between recaptures was 0.8 mile. The maximum distance was 5.1 miles. Unpublished data provided by Lueth include 11 incidences of recapture involving movements of 1 mile or more and 7 involving movements of 2 miles or more. The maximum distance between tagging and recovery was about 7 miles. Some of these animals were adults when first captured. Therefore, at least some of these extensive ranges were not a result of juvenile dispersal.

Discussion

Prior to the 1960's the most common method of studying movements of raccoons was by trapping and marking and recording sites of subsequent recaptures. Stuewer *(188)* reported the average longest diameter of known ranges of adult males in Michigan was 1 mile. Butterfield *(26)* reported the average distance traveled by 91 liberated raccoons was 0.25 mile, with the maximum 1 mile. Cunningham *(43)* reported a maximum of 0.88 mile between captures of adult males and an average of 0.27 mile.

The development of light-weight radio transmitters made possible the continuous monitoring of wildlife for the first time. Furthermore, it made possible locating an animal without disturbing it. Ellis *(51)* monitored seven raccoons in Illinois for periods of up to 18 days. The average estimated home ranges of his animals were 135 and 168 acres. Mech, *et al. (132)*, reporting on 173 daytime resting sites of seven raccoons in Minnesota, reported much variation in activity radii and, as in this study, unpredictable shifting of resting sites. Schneider, *et al. (175)* reported monitoring five adult females and eight young raccoons in Minnesota for 8 months. Adult movement areas ranged from 1.0 to 2.5 miles in diameter. Geis *(63)* monitored 9 raccoons and also tagged and recaptured 23 raccoons in South Dakota. He reported noticeable differences between sex and age groups and an influence of food availability on seasonal ranges. Sunquist *(190)* reported on the effects of a controlled fire on the movements of a family of raccoons.

It is the opinion of the author that conventional concepts of home range are not very useful when applied to raccoons in the areas studied in Alabama. Movements of raccoons seem to be directly related to food availability and preferences. In general, daily movements are much greater when food is scarce. Because of frequent shifts of centers of activity, linear and areal measurements are meaningful only when movements over a short period of time during a single season are considered. Raccoons in east-central Alabama seem to have small, shifting centers of activity within a much larger area of general familiarity. This area of general familiarity may include large areas that are visited infrequently, if at all. Most movement by the two monitored raccoons was along segments of a stream and the lesser tributaries entering this stream segment.

Raccoons in the areas studied were known to move far outside their usual home areas to establish temporary centers of activity about an especially attractive food source such as a corn field, a plum or privet thicket, or an abundant supply of persimmons. This has been noted by others *(77,203)*. While raccoons are utilizing such a food source, their daily movements may encompass no more than a few acres. How an individual becomes aware of a food source some distance from his home area remains a mystery.

Adult males probably expand their ranges during breeding season to establish temporary residence with sexually active females. The male monitored in Lee County was suspected of having moved into the vicinity of the monitored female for this reason, and he may have moved into the range of another neighboring female in early April.

There is obviously much individual variation in the movements of raccoons. This variation is probably related to sex and age, as suggested by Geis *(63)*, vigor of the individual, and perhaps population density as suggested by Ellis *(51)*.

RACCOONS RELEASED IN UNFAMILIAR TERRITORY

Only 3 of 178 raccoons transplanted into areas unfamiliar to them were ever reported recovered. Two of these were recovered within 30 days after release. No information is available on distances of recovery sites from release sites for these two individuals. The third raccoon was killed by a hunter 3 miles from where he was released 2 years previously. This raccoon was 1 of 37 from the Fred T. Stimpson Sanctuary released by the author in 1962 on private lands 8.1 miles north of the sanctuary. Both the release site and the sanctuary were on lands bordering the east banks of the Tombigbee River. The one raccoon that was recovered was killed 6 miles from the sanctuary. Apparently, none of these animals were able to find their way back to the sanctuary, despite the short distance and relatively simple route of travel available along the river banks.

All but 13 of the stocked raccoons were released in the first 2 years of the study, and all of the 178 transplanted raccoons were released on areas under the control of active raccoon hunters. The hunters had requested the release of the raccoons on these areas, and they had been requested to report any recoveries of tagged animals. It seems likely that the raccoons would have been recovered had they remained on the areas where released.

Workers in other states have found that stocked raccoons do not usually remain in the areas where released but may wander for many miles *(26,69,144)*. Stuewer *(188)* reported that raccoons stocked on a refuge in Michigan moved little more than native raccoons, but he stocked tame, pen-reared raccoons.

POPULATION DYNAMICS

An effort was made to determine natality and mortality among raccoons in Alabama and to identify the major factors regulating density of raccoons in Alabama. This objective was approached through analysis of sex and age structure of populations and collection of data on condition and weight changes, behavior and dispersal, adrenal weights, and response to exploitation. Data on reproduction, food habits, parasitism and disease, and movements were studied as they relate to each other. Specific techniques are discussed as appropriate.

POPULATION DENSITIES AND HABITAT PREFERENCES

Population Trends in Alabama

No reliable information is available on long term trends in raccoon populations in Alabama. Arant *(6)*, on the basis of a 1938 questionnaire survey, stated that raccoons were "abundant" in 16 counties, "common" in 42, and "scarce" in 9. Raccoons were reported as generally most abundant in southern Alabama. The areas of scarcity were in the Piedmont of east-central Alabama and in Fayette, Jefferson, and Tuscaloosa counties.

Results of another questionnaire survey *(15)* indicated that raccoons increased greatly during the period 1939 to 1942. Reduced trapping and hunting pressure was reported to be the cause of the increase.

Raccoon populations in Alabama are apparently still increasing. This is indicated by increases in highway mortality, Figure 45, pelts marketed, Figure 46, trapping success on game management areas, and reports by hunters, trappers, and managers.

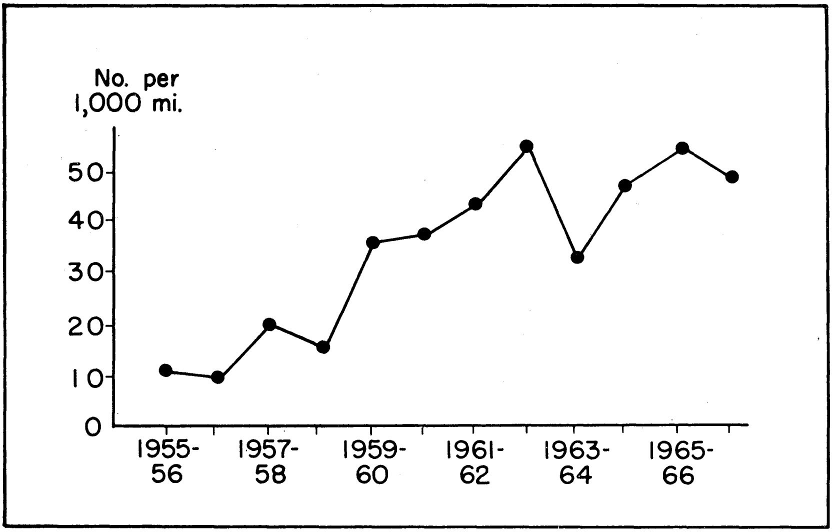


FIG. 45. Dead raccoons observed on Alabama highways by Alabama Department of Conservation personnel. Data reported by Lueth in Alabama Department of Conservation Federal Aid to Wildlife Restoration Annual Progress Reports.

Habitat Preferences and Populations on Specific Areas

Raccoons are obviously much more abundant in southern Alabama than in northern Alabama. In Annual Progress Reports, Department of Conservation personnel reported observing almost three times as many raccoons dead on highways per 1,000 miles driven in the southern part of the State as in the northern part and over twice as many as in the central part of the State.

Relative abundance in different types of habitat has been studied in several areas in the South. McKeever *(124)* reported trapping success using steel traps on a standardized trap line for 32,000 trap nights in various habitat types in southwestern Georgia and northwestern Florida. Catch of raccoons per trap night

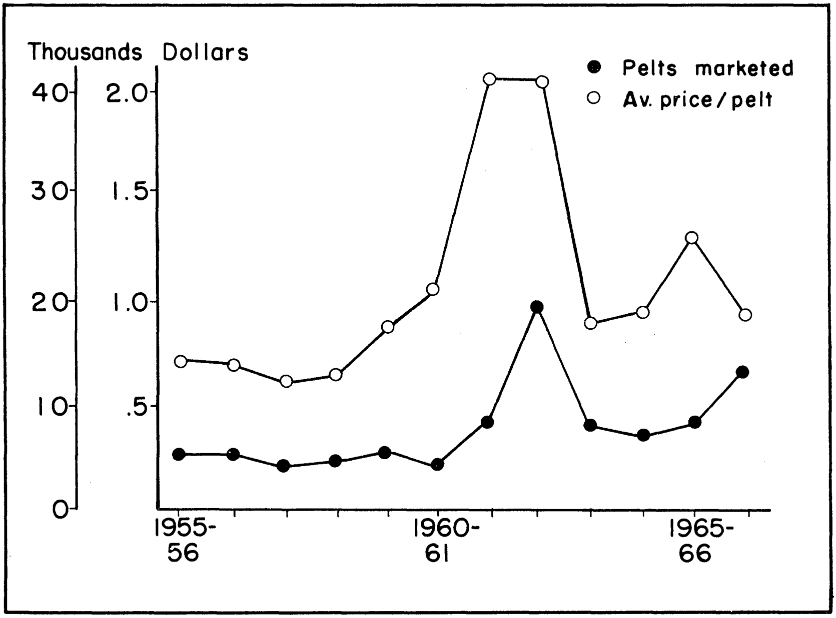


FIG. 46. Trends of sales of raccoon pelts in Alabama. Data from Alabama Department of Conservation Federal Aid to Wildlife Restoration Annual Progress Reports.

was greatest in bottomland hardwood; intermediate in cultivated lands, weeds and broomsedge, and upland hardwoods; slightly lower in mixed pine-hardwood; and lowest in pine forests. Caldwell *(29)* used number of trails struck while hunting with dogs under standardized conditions as an index to relative abundance of raccoons in north-central Florida. The index rating from best habitat to poorest was as follows: (1) swamps, (2) farmlands, (3) hammocks, (4) sandhills, and (5) flatwoods. These results are in general agreement with those of McKeever.

In the present study densities of raccoon populations were estimated on two areas. Trapping records were used to compute a population estimate for raccoons on the Fred T. Stimpson Sanctuary in the fall of 1962. Traps were set during three trapping periods from November 15, 1962, through May 24, 1963. About 20 per cent of the estimated population was marked. Four estimates of the number of raccoons responding to the traps were obtained from the Petersen and Schnabel methods of estimating populations. Trap coverage was estimated by assuming a trap response radius of 0.25 mile. The four estimates of the number of raccoons on the area were 105, 107, 109, and 121. The average density was about one raccoon per 20 acres if the figure of 107 raccoons is accepted.

Estimates were made in winter 1966, and winter 1968, of the number of raccoons using an 88-acre beaver swamp in Lee County. Eight raccoons were trapped and marked in 1966, and this was apparently the entire population using the area. Ten raccoons were marked in 1968 and the number of raccoons using the swamp was estimated at 17, or about 1 raccoon per 5 acres.

Few serious attempts at accurately estimating the density of raccoon populations have been reported. Stuewer *(188)*, Yeager and Rennels *(215)*, Dorney *(50)*, and Cunningham *(43)* reported population density data from different areas of the United States. Estimates ranged from 1 per 16 acres to 1 per 10 acres. The extreme reported was 100 raccoons taken from 102 acres in Missouri *(197)*.

LIMITING FACTORS

Nutrition

Whitney and Underwood *(203)* reported finding emaciated and starving raccoons late in the winter in a northern state. Starvation and extreme parasitism were reported to be the most important mortality factors on a study area in Minnesota *(133)*.

Acute food shortages do not seem to be as severe in Alabama as in the northern portion of the raccoon's range. Nevertheless, late in the winter food is a critical factor for raccoons in many areas in Alabama. Digestive tracts of raccoons collected late in the winter were often empty. Many contained only small quantities of decayed wood, moss, and various unidentifiable materials. Predation on birds and mammals was more frequent during this time.

Raccoons collected late in the winter and in spring were often emaciated and retained little reserve fat. General condition of raccoons was judged and expressed in two ways. A "condition factor" was calculated by dividing the weight of the animal (in pounds) by its total length (in inches). The condition factor was expressed as a decimal fraction. A "fat index" was used to rate animals on the basis of perirenal fat and subcutaneous fat on the rump. Animals with no fat reserves in these areas were assigned a value of "1." Animals having the kidneys buried in fat and having 3/8-inch or more fat on the rump were assigned a rating of "3," Figure 47. Animals with intermediate quantities of perirenal and subcutaneous fat were given a rating of "2." Averages of condition factors and fat indices were used to compare the condition of populations. Figure 48 shows monthly variation in the condition factor and the fat index among adult raccoons.

Several raccoons were recaptured and weighed, providing some information on weight losses of individual animals. Weight changes of individual adults in Clarke and Lee counties are shown in Figure 49. Weight changes of retrapped juveniles are presented in Figure 31. Loss of weight continued throughout the winter and early spring until May. One adult male was weighed and released on November 19, 1962, at which time he was probably at maximum weight. He was recaptured and weighed on June 2, 1963, and had lost 29 per cent of his November weight. The animal was thought to be at minimum weight for the year at the time of the second weighing. Intervals between first and last weighing in a given year were shorter for other raccoons. The maximum weight loss for any individual was 32 per cent. The average daily weight loss of adults during the critical months was 0.19 per cent. Stuewer *(188)* and Mech, *et al.* *(133)* reported that weight losses of over 50 per cent in winter were common in Michigan and Minnesota. Mech, *et al.* reported one female losing 62 per cent of her total weight and still producing a litter of young.

Figure 50 shows seasonal trends in weights of raccoons on the Fred T. Stimpson Sanctuary. The average weight of adult males on the sanctuary in the months of April through June was 7.7 pounds or 16 per cent less than the average weight of 9.2 pounds for adult males during the months of October through December. The average spring weight of adult females was 17 per cent below average fall weight. Average weight of juveniles in spring was only 9 per cent above the average fall weight, and this increase occurred entirely in May.

Food conditions obviously will vary from area to area and from year to year. In March 1963, a total of 31 adult raccoons were obtained from the Butler County and the Covington County Game Management Areas. They were trapped at approximately the same time by the managers of the two areas. Yet, those from the Covington County Area were very fat and had a condition factor of 0.35, whereas those from the Butler County Area had a condition factor of only 0.27. Ten adult males from the Covington

FIG. 47. Raccoon with thick deposit of subcutaneous fat: Fat index "3" (see text).

County Area had an average weight ⅓ greater than the average weight of seven adult males from the Butler County Area (10.8 pounds as compared to 8.3 pounds). Animals from both areas

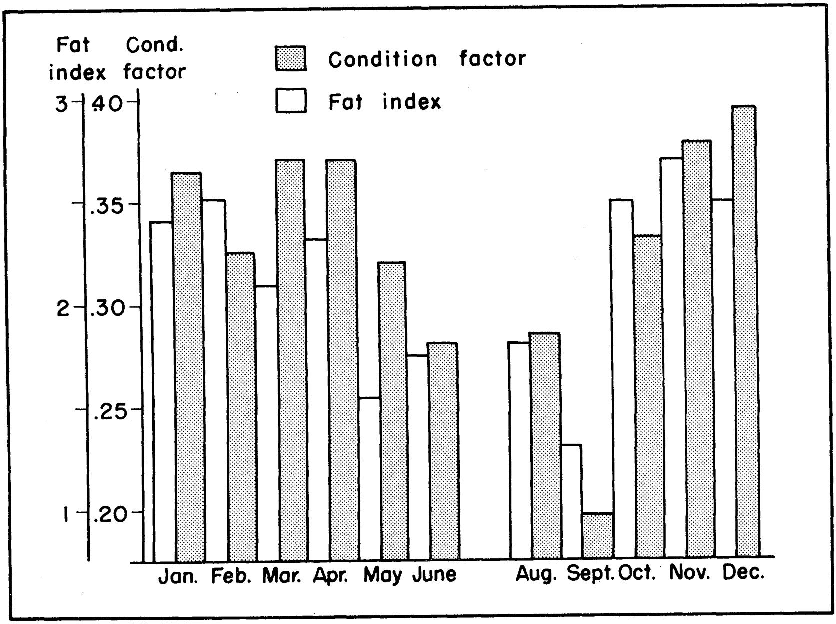


FIG. 48. Monthly variation in average condition of 205 adult Alabama raccoons. Values for condition factor are averages of the ratios of weight in pounds to length in inches for individual animals. Fat index values are averages of ratings of amount of perirenal and subcutaneous fat for individual animals.

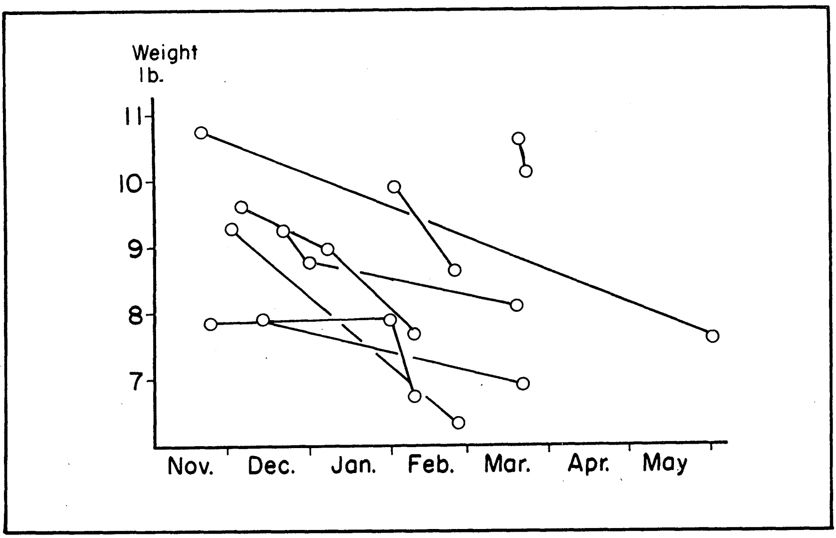


FIG. 49. Weights of eight individual adult raccoons at times of initial and subsequent captures.

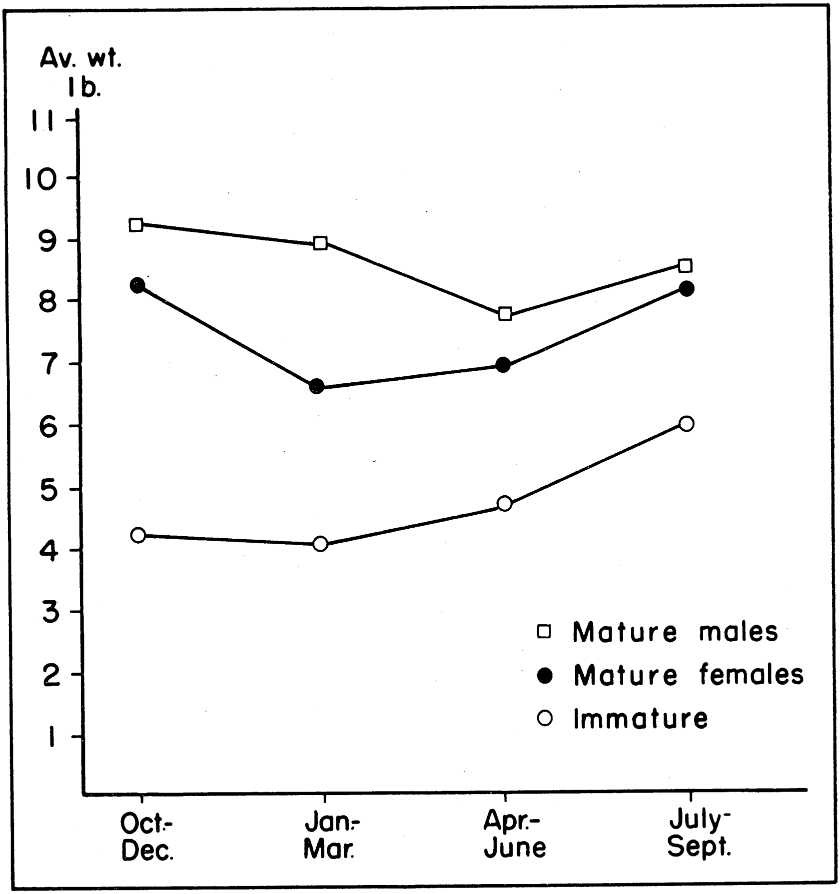


FIG. 50. Seasonal trends in weights of raccoons on the Fred T. Stimpson Game Sanctuary.

were in better condition than those from the Fred T. Stimpson Area. The cause of the differences was not ascertained.

Animals from east-central Alabama were generally in better condition than those from southwestern Alabama. Average condition factors for adults taken during the winter and spring months were as follows:

Fred T. Stimpson Sanctuary (38 animals)	0.27
Upper State Sanctuary (13 animals)	0.31
Choccolocco Wildlife Management Area, Cleburne County (13 animals)	0.30
Lee, Macon, and Chambers counties (65 animals)	0.35

A general failure of the acorn crop and a poor crop of persimmons in the fall of 1966 apparently affected the condition of raccoons taken the following winter and spring. Mast and fruit production were apparently affected over most of the State. Data are given in Table 24.

TABLE 24. RELATIONSHIP BETWEEN ACORN CROP AND CONDITION OF ADULT RACCOONS IN ALABAMA

Year	Acorn crop	Average condition factor[1]	Average fat index[2]
1963-64	very good	.35 (27)[3]	2.4 (19)
1964-65	good	.33 (20)	2.3 (6)
1965-66	very good	.34 (14)	2.2 (16)
1966-67	failure	.28 (25)	1.9 (25)
1967-68	very good	.34 (17)	2.3 (15)

[1] Ratio of weight in pounds to length in inches.
[2] Rating according to amount of perirenal and subcutaneous fat present (see text).
[3] Numbers in parentheses indicate numbers of animals on which figures are based.

No relationship between nutrition and prevalence of pregnancy or litter size was detected. Further inquiry into this subject is recommended. Bissonette and Csech *(20,22)* reported that raccoons fed on a high protein diet produced more litters than when fed on a low protein diet.

Despite the significant weight losses of adults and the obvious malnutrition in juveniles, no direct mortality because of malnutrition was encountered, and some individuals were found to be in very good condition when others were emaciated. Nutritional deficiencies are probably most important in weakening the animal and reducing its resistance to parasitism and disease.

Parasitism and Disease

Extensive mortality of raccoons from parasitism and disease has been reported from various areas within the range of the raccoon. Parasitism *per se* is rarely a direct mortality factor. In the present study seemingly healthy raccoons often carried heavy parasite loads with no indication of ill effects. The only parasites that showed evidence of any harmful effects were *Gnathostoma procyonis* and *Crenosoma goblei*. Parasitism in most cases seems to be a debilitating factor only in malnourished animals in dense populations, Figure 51.

The etiology of raccoon disease is not well understood, but the principal agents of disease-induced mortality seem to be canine

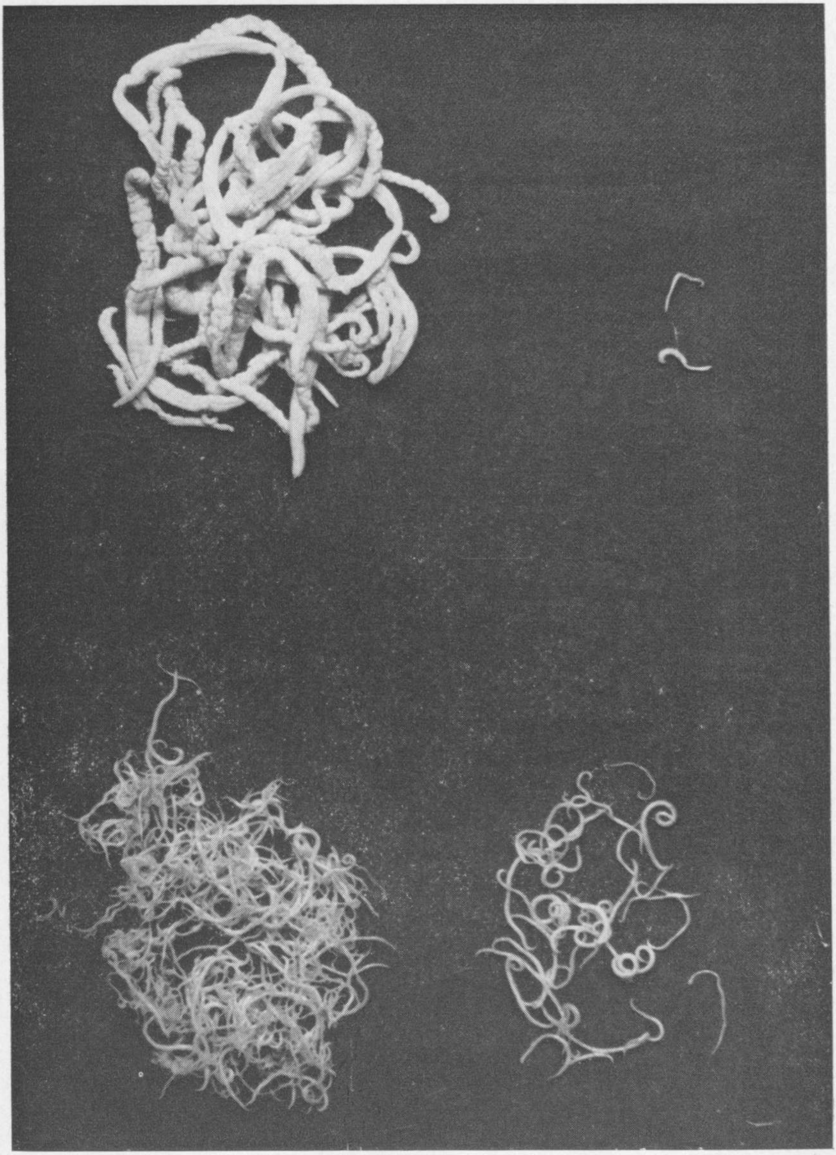


FIG. 51. A portion of the parasite load of a heavily parasitized female raccoon. Large worms at upper left are *Macracanthorhynchus ingens*. **Others are** *Gnathostoma procyonis* **at upper right and** *Physaloptera* **sp. at bottom.**

distemper and verminous pneumonia. These diseases probably have a significant role in controlling raccoon populations at high densities but play a relatively minor role at lower densities.

Because of the wide range of hosts affected and the vitality of the organism, it seems likely that canine distemper is widespread in nature. Gorham *(74)* suggested that this disease may be an important factor in regulating populations of carnivores. Juveniles are most susceptible, and recovery usually results in immunity for life. Therefore, greatest mortality should occur among juveniles. As populations increase to above normal densities, a greater proportion of the population will consist of susceptible young individuals, and the opportunities for spread of the disease will increase. Thus, periodic outbreaks of canine distemper can be expected.

Verminous pneumonia occurs commonly in raccoons but apparently does not cause extensive mortality. Lungworms were encountered in the present study only in dense populations of southwestern Alabama. Old, heavily parasitized individuals in poor condition were most commonly affected.

Predation

Predation on raccoons is probably negligible in Alabama. The only predators, other than man, of potential significance in this area are alligators, bobcats, and the larger owls.

Giles and Childs *(70)* reported that raccoons occurred in only 4 of 318 alligator stomachs collected in summer in Louisiana. Whitney and Underwood *(203)* stated that raccoons are not generally plentiful where bobcats are prevalent. They considered bobcats one of the foremost enemies of raccoons and stated that the "coonhunter's chief thought in raccoon preservation might well be the extermination of this one very real enemy. . . ." Davis *(45)* found raccoon remains in 6 of 239 bobcat stomachs (2.5 per cent) collected in Alabama. Raccoon remains were found in 2.1 per cent of 181 bobcat scats and digestive tracts from the Appalachians of North Carolina and Virginia *(155)* and in 0.4 per cent of 317 bobcat scats from South Carolina *(99)*. Raccoons occurred in these food samples as often late in the winter as in summer. Thus, predation by bobcats on raccoons was not restricted to young raccoons. Thrasher *(195)* found no raccoon remains in 213 stomachs from gray foxes collected in summer in Alabama, and Herbert *(88)* found raccoons in one of 321 stomachs of gray foxes from Alabama. He found no raccoons in 122 scats collected at red fox dens. Korschgen *(103)* reported 0.8 per cent occurrence of raccoons in 1,006 red fox stomachs from Missouri.

Whitney and Underwood *(203)* reported finding raccoon remains in the nests, pellets, and stomachs of owls (species not given). However, quantitative data from numerous food habits studies indicate that raccoons are not a common item in the diet of owls *(e.g. 105)*.

The infrequent occurrence of raccoons in the diet of alligators, bobcats, and the larger owls, and the relative scarcity of these predators, make it very unlikely that predators other than man are significant limiting factors on raccoon populations.

Exploitation by Man

Sport hunting, trapping for fur, and deliberate efforts at reducing populations by trapping or poisoning are important factors in the population ecology of raccoons. Outside the Coastal Plain, hunting and trapping are probably the major factors controlling raccoon populations. The total harvest of raccoons in Alabama during the 1966-67 season was estimated at 187,000 animals. Sport hunters accounted for 93 per cent of the harvest *(98,118)*.

Hunting seems to be a much more important factor than trapping, even when fur prices are high. Hunters generally take more raccoons statewide than do trappers, even though some hunters do not kill the animals after they are treed. An active, enthusiastic group of hunters, hunting 2 or more nights each week, can place heavy hunting pressure on areas of several hundred square miles. During the course of this study, the author became acquainted with several such groups.

Stuewer *(188)* noted a 17 per cent increase in raccoons on his study area after 2 years restriction of hunting. Cunningham *(43)* reported that his efforts at collecting with dogs were five times as successful on his study area, which was closed to public hunting, as on comparable adjacent areas that were hunted. Caldwell *(29)* noted that track counts and dog census indicated a decline in population of raccoons on heavily hunted areas in north-central Florida. Kansas hunters reported that the average mileage traveled to hunt increased as the season progressed, indicating that hunting became poorer locally *(182)*.

Atkeson and Hulse *(10)* reported that public hunting effectively reduced a dense raccoon population on the Wheeler National

Wildlife Refuge in northern Alabama, whereas trapping had not been effective in reducing the population. They reported that the harvest by hunting without guns was four to five times as great as the harvest by trapping and required only one-third the time. Figure 52 shows the continuous decline in harvest of raccoons on the Wheeler Refuge under regulated public hunting. Data were provided by Thomas Atkeson, Refuge Manager. Harvest of opossums responded similarly to the hunting pressure. After the season was closed for 6 years it was reopened, guns allowed, and the harvest indicated that the population had recovered.

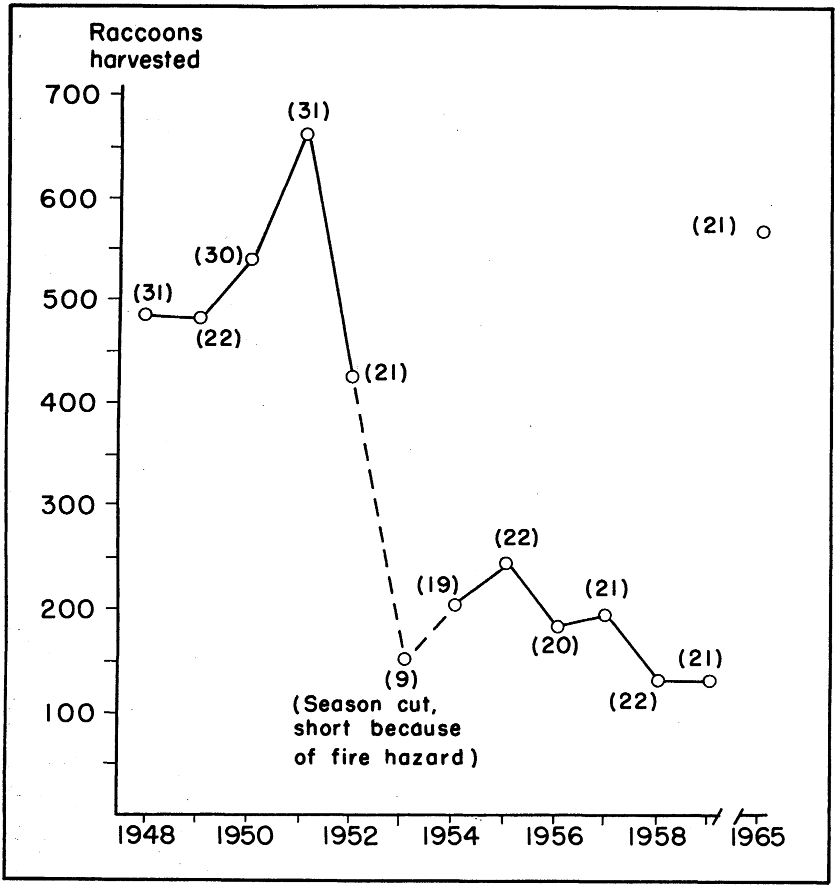


FIG. 52. Trends in raccoon harvest by hunters on the Wheeler National Wildlife Refuge, Decatur, Alabama, as reported by T. Z. Atkeson, Refuge Manager. Numbers in parentheses represent number of nights hunting was permitted. No hunting was permitted 1959-1964.

The Wheeler Refuge is an area of about 35,000 acres surrounded by habitat that has a dense human population and probably has relatively low raccoon populations. Data were also obtained on the effects of intensive removal of raccoons under a different set of circumstances. Each year large numbers of raccoons are removed from the intensively managed portion of the Fred T. Stimpson Sanctuary and transported to distant areas for supplemental stocking. The portion of the sanctuary involved is about 2,000 acres and is surrounded by excellent raccoon habitat that supports a high population. Figure 53 shows the number of raccoons removed from the sanctuary over a 21-year period. The data were provided by Huey L. Dykes, Area Manager. These data are not directly comparable to those from the Wheeler Refuge because the effort devoted to removing raccoons from the Fred T. Stimpson Area varied greatly from year to year. The data do show, however, that the sanctuary maintained a dense population of raccoons despite an average annual removal of about one raccoon per 30 acres for over 20 years. During the year of greatest removal (1949-50), an average of one raccoon per 18 acres was removed. The population on the trapped portion of the Stimpson Sanctuary was an estimated 107 raccoons in the winter of 1963. Thus, the removal during each of 4 years exceeded the number of raccoons estimated to be on the area in 1963. On the Wheeler Refuge marked decline in numbers of raccoons, as indicated by a declining harvest, occurred following removal of about one raccoon per 70 acres for 3 years and one raccoon per 53 acres in 1 year.

Game managers on certain private lands in the Southeast have expended considerable effort in controlling raccoons on small tracts of land by traps and poison with little success.

Immigration obviously occurs rapidly on small areas surrounded by habitat supporting many raccoons. Because of the social instability of intensively exploited raccoon populations, more raccoons may be present on such areas with control measures than without. This is especially likely where game food plantings make the area attractive to raccoons. To be effective, control measures must be extensive, and extensive control is best accomplished by hunting. This, of course, is dependent upon the popularity of raccoon hunting in the area.

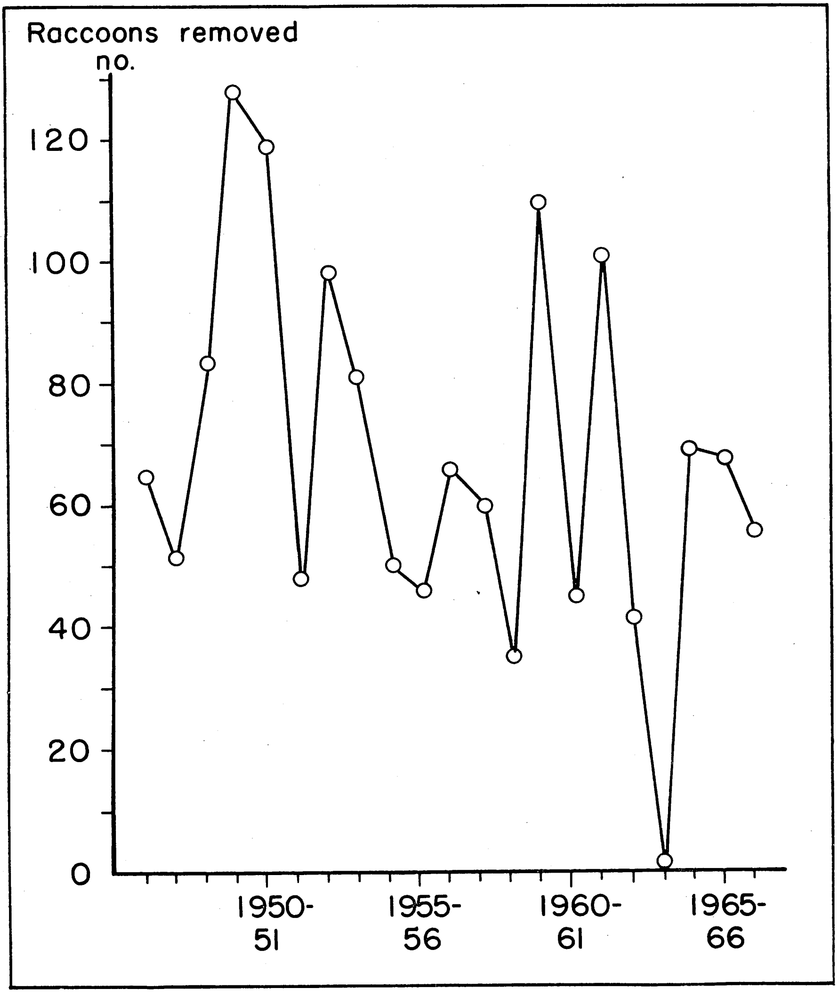


FIG. 53. Exploitation of the raccoon population on the Fred T. Stimpson Game Sanctuary over a 21-year period. Effort expended in trapping varied from year to year. Data provided by H. L. Dykes, Refuge Manager.

Social Stress

PERSPECTIVE: HOMEOSTATIC DENSITY REGULATION. Many population ecologists are now attaching greater importance to so called "internal" factors such as physiological, behavioral, and genetic factors regulating the density of mammal populations than to "external" factors such as predation, parasitism and disease, starvation, and weather, although all are interrelated. These ideas have been summarized by Errington *(53)*, Calhoun *(30)*, Wynne-Edwards *(211,212,213)*, Christian *(34)*, Christian and Davis *(35)*, Davis *(44)*, and others. Most experimental evidence is from studies of rodents, although some work has been done with carnivores, ungulates, and primates.

REVIEW OF SOCIAL TOLERANCE AMONG RACCOONS. Little is known about the social behavior and social tolerances of raccoons, and the present study shed little light on the subject. Raccoons are generally considered to be gregarious and socially tolerant *(131, 215)*, but dispersal of young, defense of feeding territories, and intolerance between breeding males probably play a role in limiting population density.

Tevis *(193)* observed much antagonism among raccoons frequenting a favored feeding area. Encounters between feeding individuals were accompanied by much growling and snarling, although family groups fed together peacefully. Tevis thought that this represented defense of feeding territories and functioned to keep the feeding individuals spaced so as to ensure efficient utilization of food supplies.

Sharp and Sharp *(177)* observed behavior of raccoons at a winter feeding station. They noted that each arrival was challenged by those already present before being permitted to use the station. Social dominance was evident. Females with young moved about the feeding area at will. They were not challenged by other adults. Juveniles unaccompanied by an adult female were usually driven from the feeding area. Seventy-five to 80 per cent of the raccoons arrived in packs of three to five or more. Groups were admitted by other groups already present after an exchange of threatening gestures. Lone adults were not admitted to the feeding area when groups were present. Increased aggressiveness and antagonistic behavior was noted as the breeding season approached, and use of the feeding station virtually ceased.

Whitney and Underwood *(203)* reported much intolerance among captive males in adjacent cages during the breeding season.

SOCIAL ORGANIZATION. The observations of Twichell and Dill *(197)*, Sharp and Sharp *(177)*, Mech and Turkowski *(131)*, and Geis *(63)* leave little doubt that there is some kind of social organization among raccoons, but the nature of this organization is very poorly understood.

Aggregations observed in the present study consisted of family groups composed of females and young, occasional pairs of yearlings evidently retaining the fraternal bond into the second year, and loose aggregations of several individuals at an attractive food source. Usually, however, raccoons other than females with young were observed alone.

Well-defined dominance behavior was observed among captive animals in the present study. Groups of raccoons held in captivity usually developed dominance strata within a few days.

Two male litter mates born in captivity to wild parents were held in the same cage for 2 years. They were similar in size and appearance, were friendly and playful toward each other, and were mutually concerned for each other. But dominance was established to the extent that the subordinate male was forced to remain at considerable distance from the feed and to obtain what he could by reaching into the feeder with his fingers. The dominant male spent much time on a swinging platform and vigorously defended his position on it.

The parent female was apparently very dominant over the parent male during the nursing period. Both animals were very wild and sought cover whenever possible, but the male was frequently found resting outside the den box after the young were born. He was apparently driven out by the female.

TERRITORIALITY. Evidence from other studies indicates that individual raccoons do not defend fixed territories *(188)*. Further evidence of the absence of fixed individual territories was acquired in the present study. Field observations, trapping results, and telemetric studies revealed much overlapping of ranges, Figure 54.

It seems clear that raccoons are not territorial in the conventional sense of an individual's defense of a fixed area of habitat against trespassers. But other forms of territorial defense, not so well understood, may exist.

Spacing of feeding individuals, as described by Tevis *(193)*, is accomplished by an individual's defense of an area of feeding ground about him, and this has been termed a "feeding territory." An apparent instance of defense of a feeding ground was observed in August 1962, on the Fred T. Stimpson Sanctuary. Fresh water clams were present in great abundance along a mud bar on the Tombigbee River, and there was much evidence of raccoons feeding on the clams. A lone male was observed one night feeding

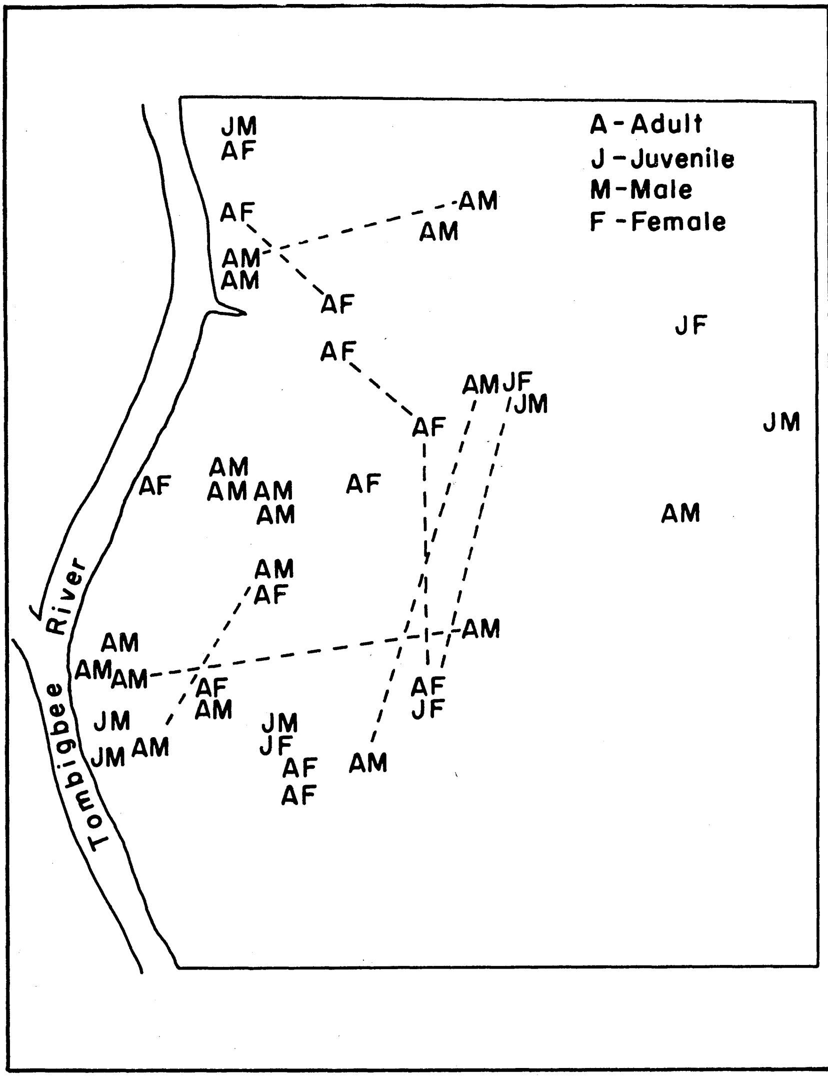


FIG. 54. Distribution of captures of 31 raccoons on the Fred T. Stimpson Game Sanctuary from Nov. 11, 1962 to Feb. 9, 1963, showing clumping of captures in best habitat and apparent lack of individually exclusive winter territories. Letters show sex and age. Broken lines connect different captures of the same animal. 1 in. = app. 2,350 ft.

on the clams. He was observed for some time and then was collected. After the removal, no raccoon sign was observed on the bar for over 1 week. Then new sign appeared.

A similar observation was made by Philip M. Wilkinson, biologist employed by the South Carolina Wildlife Resources Commission (personal communication, 1968). On South Island, South Carolina, Wilkinson made an effort to trap and remove raccoons to minimize predation on the eggs of sea turtles nesting on the beach. During the first night of trapping only large males were caught. Other raccoons were caught the next night. All sign then disappeared, and no more raccoons were caught for about a week; then more were caught. This was interpreted as indicating a defense of feeding territories. Raccoons caught the first night were thought to be dominant males that were doing most of the damage. Those caught the second night were subdominants. The lower-ranking, satellite population moved into the area when they found the dominants gone.

Mech, *et al.* *(132)* presented data that suggest that the raccoons in their study spaced their daily resting sites so as to maintain a certain minimum distance between them. However, Twichell and Dill *(197)* reported finding that only 32 of 101 raccoons taken from their resting sites were resting alone. Raccoons found resting together were thought not necessarily to be family groups.

ADRENAL STUDIES. Adrenals were taken from 286 raccoons and preserved in 10 per cent formaldehyde. Before weighing, adrenals were rolled on an absorbent paper towel. Pairs of adrenals were then weighed to the nearest .10 milligram. Average weights of adrenals of adult male raccoons (milligrams per kilogram of body weight) from nine areas were statistically compared.

Adrenals from the Covington County Game Management Area weighed significantly less ($P < .05$) than those from the Fred T. Stimpson and Rob Boykin areas (Washington and Mobile counties). There was considerable variation between other areas, but the differences were not significant. Other areas compared were Butler County Game Management Area, Macon and Henry counties, Lee and Chambers counties, Choccolocco Game Management Area (Cleburne County), Scotch Game Management Area (Clarke County), and Upper State Game Sanctuary (Clarke County).

Variation within populations was often greater than among populations. Preliminary analyses were made in an attempt to identify causes of variation. Among adult males from the Fred T. Stimpson Sanctuary there was no well-defined relationship between adrenal weight and any of the following variables: total animal weight, total length, month of the year, condition factor, fat index, and weight of testes. Weights of adrenals of adult males from various areas in the state showed no relationship to method of collection.

The cause of variation in weight among adrenals from raccoons in Alabama remains unknown.

DISPERSAL OF YOUNG. Stuewer *(188)* was apparently the first to report dispersal of young raccoons from the areas in which they were born. He reported that emigration usually occurred during the first fall. But, some juveniles remained over winter, emigrating in the spring, and some never dispersed at all.

The range of dispersal varies. Some juveniles disperse only a few miles *(188)* but there are records of young males apparently dispersing 165 miles or more *(119,154)*.

In the present study no tagged juveniles were recovered from outside the study areas, although some apparently left the areas.

Fate of individual marked animals was studied for evidence of losses of juveniles, but results were inconclusive. Between November 15, 1962, and February 9, 1963, 23 raccoons (about 22 per cent of the estimated population) were captured, tagged, and released on the Fred T. Stimpson Sanctuary. Between February 18 and June 2, 1963, 35 raccoons were captured and removed from the area. An additional seven adults and six juveniles were removed in December. The total of 48 raccoons removed constituted almost half of the estimated fall population. Among the 35 raccoons captured after February, there were six recaptures. These included 5 of 10 adult males marked in December and only 1 of 4 juvenile males marked in December.

Winter activities of raccoons in an 88-acre beaver swamp in Lee County were studied by trapping and marking in the fall and winter of 1965-66 and again in 1967-68. Three adult males and one adult female were known to be using the swamp throughout the trapping period in 1965-66. Three juvenile males were captured a total of six times in December 1965, but were never seen again after December. An adult male and an adult female initially tagged in December were recaptured several times in March 1966. This indicates that the juvenile males were not present on the area during the breeding season, possibly having been driven out by the adults. The presence of the three mature males during the breeding season indicates some degree of tolerance among familiar breeding males. There was no evidence of territoriality, as all individuals were recaptured throughout the swamp.

The area was again trapped in December 1967, and January and February 1968. Two of the four adults initially marked in 1965-66 were recaptured, but none of those marked as juveniles in 1965-66 were recaptured. An estimated 17 raccoons were using the swamp during the 1967-68 period, 10 of which were marked during trapping.

Two juveniles marked late in December and early in January were not recaptured in February. But, only one of four adults marked during December and early in January was recaptured in February, and trapping was terminated before the onset of breeding.

SEX RATIOS

The sex ratio among 1,742 raccoons from various areas in the state was 161 males per 100 females (62 per cent males). The sex ratio among 847 animals from the southern portion of the State was exactly the same as among 895 animals from the northern portion of the State.

Sample sex ratios for different methods of collection are presented in Table 25. Sex ratios among animals taken by various types of traps are similar, whereas sex ratios of the samples obtained with dogs and gun are more nearly balanced.

TABLE 25. SEX COMPOSITION OF RACCOON POPULATIONS IN ALABAMA

How taken	Locality	Year	Raccoons	Males per 100 females	Males
			No.	*No.*	*Pct.*
Night hunting/dogs	East-central Ala.	1963-67	138	128	56
Night hunting/dogs[1]	Sumter Co.	1938-39	41	128	56
Night hunting/dogs[2]	Wheeler National Wildlife Refuge	1950	520	149	60
Steel traps[3]	Statewide	1956-68	649	180	64
Box traps	Clarke, Lee, Washington co.	1962-68	226	166	62
Deer traps	Clarke, Marengo, Sumter co.	1962-65	156	188	65
All methods	Statewide	1938-39, 1956-68	1,742	161	62

[1] Data from files of Alabama Cooperative Wildlife Research Unit, collected by Robert J. Wheeler.

[2] Data provided by Thomas Z. Atkeson, Refuge Manager, Wheeler National Wildlife Refuge, Decatur, Alabama.

[3] Data on 464 raccoons provided by Francis X. Lueth, Alabama Department of Conservation. Other raccoons caught by the author and students at Auburn University.

Monthly variation in sample sex ratios, Figure 55, provides an indication of seasonal bias. The preponderance of males recorded in February and March is probably a reflection of greater activity and movement by males visiting females that are sexually active at this time. The excessively high percentage of males in May and June is probably because of the reduced activity of pregnant and lactating females.

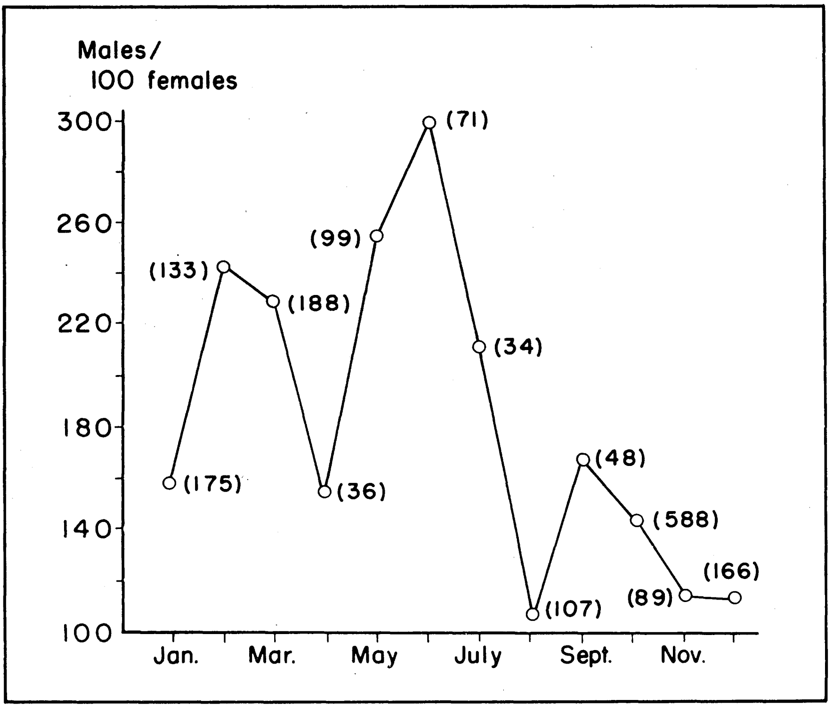


FIG. 55. Seasonal variation indicating bias in sample sex ratios based on 1,732 raccoons from various areas in Alabama. Numbers in parentheses indicate number of raccoons examined.

The sex ratio of 237 juveniles was 116 males per 100 females (54 per cent males). The sample sex ratio in uteri was approximately even, but the sample was too small to be meaningful. Six of 16 pregnant females contained fetuses sufficiently advanced in development to permit sex determination. Of 13 fetuses, 6 were females and 7 were males.

The adult sex ratios are considered to be biased to an unknown extent. Males are apparently more active than females and range over larger areas. This greater movement no doubt makes them more subject to capture.

Cunningham *(43)* found, as did the author, sex ratios much less in favor of males when dogs and gun were used for collecting instead of traps. He concluded that this method of collecting provides more representative samples of the sex composition of populations. Although sex ratios obtained by collecting with dogs and guns are more nearly balanced and seem to be more reasonable than those obtained from trapped animals, there are reasons to suspect that adult males are less vulnerable to hunting with dogs than are adult females. Although greater movement of males may result in more scent trails for dogs to find, males are no doubt better able to elude dogs than are females. Females traveling with their young in family groups no doubt leave more scent, increasing the likelihood of their trail being "struck" by dogs. When pursued, the female has less chance of eluding the dogs because of the presence of young and her concern for them.

One-sided sex ratios among raccoons have been reported in other states, Appendix Table 5. Careful study of the literature reveals no consistent relationship between sex ratio and collection method or type of area. It is difficult to explain the discrepancies in sample sex ratios.

It should be emphasized that trapping and hunting are major mortality factors themselves. If the chance of males being taken is greater relative to the proportion of males in the population as the data suggest, normal harvest by trappers and hunters would place much greater mortality on males than females. Thus, the true sex ratio of the population would be strongly in favor of females unless there was sex-selective natural mortality. If sample sex ratios in this study are representative of the true sex ratio in the population, then it is apparent that there is heavy natural mortality of females after they reach maturity.

AGE STRUCTURE, MORTALITY, AND TURNOVER

Age Structure

Of 770 raccoons that could be classified as to age, 243 (32 per cent) were immature. Percentages of immature raccoons in various samples from raccoon populations in Alabama are given in Table 26. Raccoons that were examined post-mortem were classified into 1-year age groups. From these data age structure pyramids were drawn, Figures 56 and 57.

TABLE 26. AGE COMPOSITION OF RACCOON POPULATIONS IN ALABAMA

How taken	Locality	Year	Raccoons No.	Juveniles Pct.
Night hunting/dogs	East-central Ala.	1963-67	138	47
Night hunting/dogs[1]	Sumter Co.	1938-39	41	41
Night hunting/dogs[2]	Wheeler National Wildlife Refuge	1951	666	34
Steel traps	Statewide	1962-68	185	32
Box traps	Clarke, Lee, Washington co.	1962-68	226	32
Deer traps	Clarke, Marengo, Sumter co.	1962-65	166	31
All methods	Statewide	1938-39 1962-68	1,436	37

[1] Data from files of Alabama Cooperative Wildlife Research Unit, collected by Robert J. Wheeler.

[2] Data provided by Thomas Z. Atkeson, Refuge Manager, Wheeler National Wildlife Refuge, Decatur, Alabama.

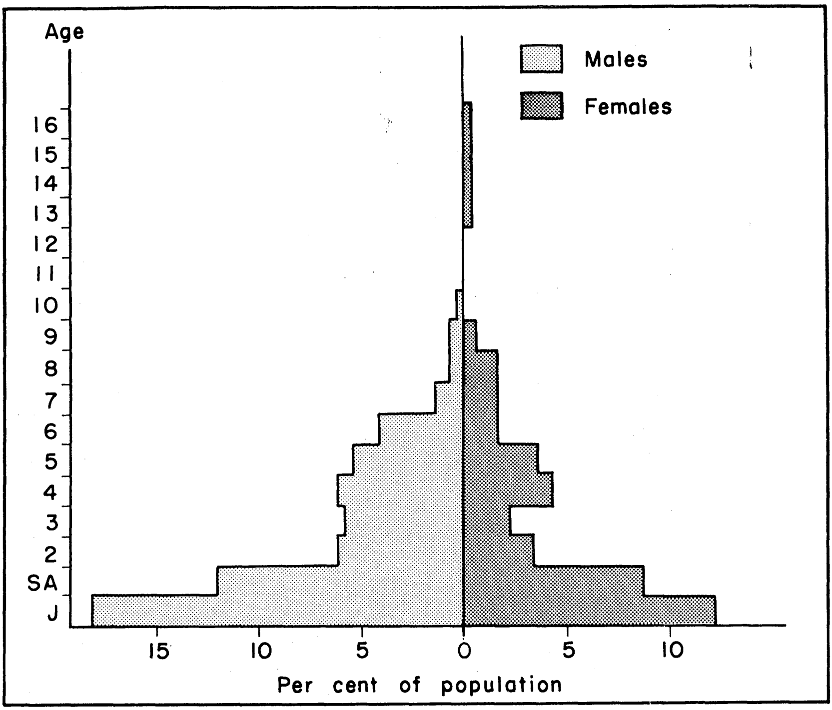
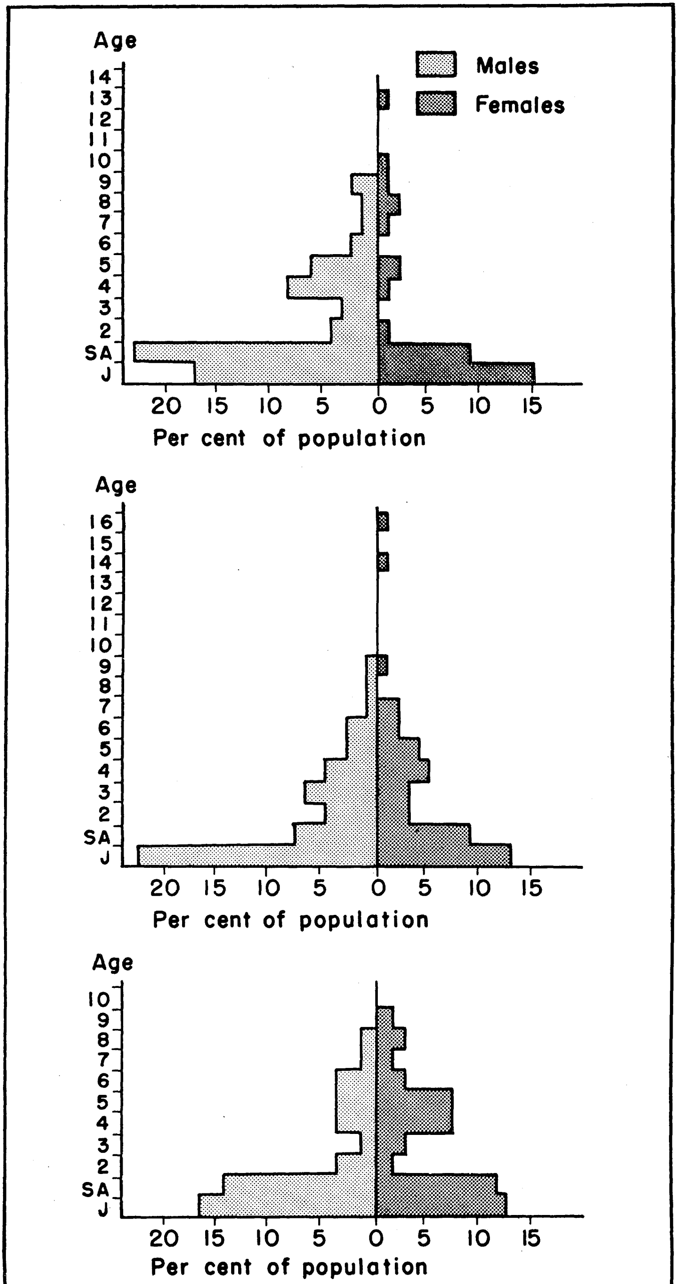


FIG. 56. Average age structure for raccoon populations in Alabama as indicated by 371 animals on which necropsies were performed.


Age
Males
Females
14
13
12
11
10
9
8
7
6
5
4
3
2
SA
J
20 15 10 5 0 5 10 15
Per cent of population
Age
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
SA
J
20 15 10 5 0 5 10 15
Per cent of population
Age
10
9
8
7
6
5
4
3
2
SA
J
20 15 10 5 0 5 10 15
Per cent of population

The data in Table 26 suggest that samples obtained by hunting with dogs are biased in favor of juveniles. Cunningham *(43)* also obtained proportionately more juveniles in samples taken with dogs than in samples taken with box traps. Because of the remarkable ability of raccoons to learn and to remember, old, experienced animals are probably less susceptible to capture than young, inexperienced ones. As Whitney and Underwood *(203)* pointed out, many old, experienced animals become so skilled at eluding hounds that they are virtually immune to capture.

In a study of behavior at a feeding station it was noted that old raccoons became active later at night and were much more alert and apprehensive than young animals *(177)*. Thus collection with dogs may be biased if hunting is restricted to the first part of the night.

Variation in behavior between individuals or groups of individuals within a population is a generally neglected consideration in population ecology *(201)*. This is especially true where the more intelligent species, such as raccoons, are involved. The individuality of raccoons has impressed almost everyone who has worked with them. Such variation makes representative sampling very difficult. These limitations must be recognized when considering the sex and age data.

Mortality

PRENATAL MORTALITY. Counts of fetuses, placental scars, and corpora lutea were compared. Significant differences would be suggestive of intra-uterine mortality. The mean of 50 sets of placental scars was 2.46. The mean number of fetuses in 19 pregnant females was 2.62. Corpora lutea counts in pregnant females agreed with fetal counts in all but one instance. In this case there were four corpora lutea in the ovaries, but only three fetuses were present. The limited data offer no real evidence of extensive prenatal mortality.

JUVENILE MORTALITY. There is apparently little mortality of juveniles during summer and fall. Six family groups were taken between October 27 and December 22. In four of the six groups the number of placental scars in the uteri of the females was equal

FIG. 57. Average age structures of raccoon populations in various areas of Alabama. Top: Fred T. Stimpson and Upper State game sanctuaries; heavily exploited, dense populations. Center: east-central Alabama; relatively sparse, moderately exploited populations. Bottom: southwestern Alabama, excluding Fred T. Stimpson and Upper State data; dense, mostly unexploited populations.

to the number of young with them. The remaining two females had a total of five placental scars in the uteri but only three young with them. The young may have been lost to mortality, or they may have been separated from the female during the chase or may have left her earlier.

The proportion of juveniles in the population, assuming no mortality, may be estimated by sex ratios and reproductive characteristics. It was assumed, from sample sex and age ratios, that a population consisted of 37 per cent females and that 25 per cent of the females were subadults. It was also assumed that 90 per cent of the subadult females were non-breeders (page 40). Thus, there were 29 per cent breeding females in the population. Assuming an average of 2.48 young per mature female (page 49), the fall population theoretically consisted of 42 per cent juveniles, if there were no mortality. The actual proportion of juveniles in the fall sample was 37 per cent. In the period from January to June, juveniles made up 35 per cent of the sample. If only females are considered, to eliminate bias resulting from greater activity of adult males during breeding season, juveniles made up 43 per cent of the sample. These figures do not indicate extensive mortality of juveniles.

MORTALITY OF MATURE ANIMALS. Age structure curves approximate survival curves. Figure 58 indicates that greatest mortality among raccoons in Alabama occurs during the second year of life. Animals in the 3- to 6-year age classes face few threats to survival other than hunting and trapping.

COMPARISON WITH OTHER STUDIES. Little is known of the factors regulating raccoon populations. Stuewer *(188)* reported no evidence of natural mortality and concluded that populations in Michigan were controlled primarily by hunting and trapping. Llewellyn *(111)* found unaccountable losses of juveniles from his study area in Maryland and concluded that mortality considerably reduced the raccoon population by fall. Stains *(182)* reported an average litter size of 4.6 in Kansas and an average of 4.3 young per female in family groups in November, declining to 2.5 in January. In South Carolina, Cunningham *(43)* collected 13 family groups and found 79 per cent of the placental scars in the uteri were accounted for by young with the females, indicating at least 79 per cent juvenile survival. Mech, *et al. (133)* concluded that only two of seven litters born on their Minnesota study area sur-

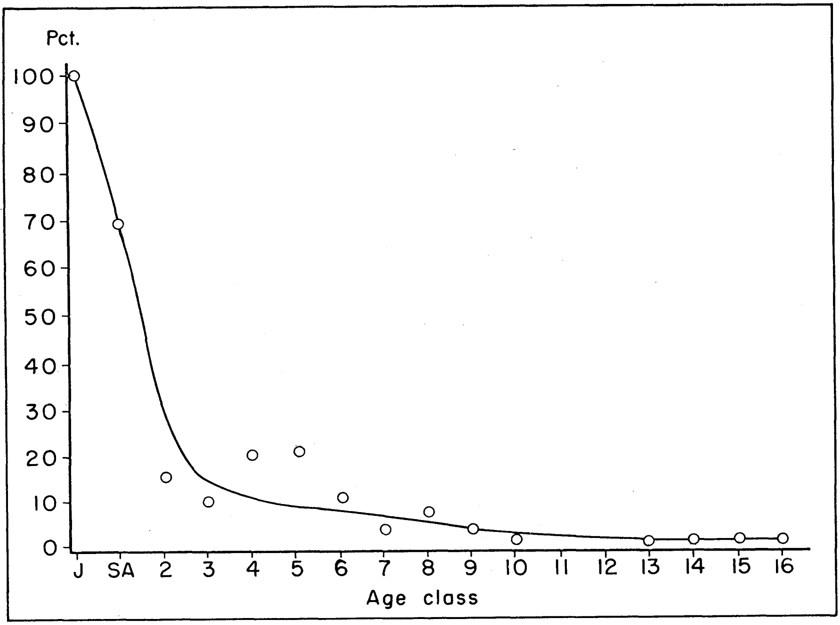


FIG. 58. Age structure curve for 371 Alabama raccoons showing approximate survival rates and turnover rate.

vived and remained on the area until winter. They observed mortality from starvation and extreme parasitism with the greatest losses of juveniles occurring in March.

Longevity and Turnover

Little information is available on the longevity of raccoons in nature. The potential longevity of raccoons is probably about 16 years *(57)*. Haugen *(86)* reported a female raccoon being shot 12 years and 1 month after initial capture and marking as a juvenile.

A few raccoons in the present study were estimated at ages up to 16 years from annulations in the dental cementum. The validity of the aging method is unknown, but estimated ages are thought to be fairly accurate, and there is no reason to doubt that a few individuals reach such an age. But the turnover period in Alabama was estimated at about 10 years.

Some information on longevity was obtained from predator studies by personnel of the Alabama Department of Conservation *(117)*. The following data were accumulated by Francis X. Lueth *(117 and unpublished)*. Over 500 raccoons were trapped with Number 2 steel traps, ear-tagged, and released over a period of 8 years. Doubtless, crippling injury reduced the average longevity of the animals. Nevertheless, over 10 per cent of the tagged raccoons were recaptured one or more times. Data are available on 19 raccoons recaptured 1 year or more after initial capture. The maximum interval between first and last capture of a raccoon was 7 years and 9 months. This was for a female, the age of which was not recorded at initial capture. Two other females, originally tagged as adults, were recaptured after 6 years and 4 months and 5 years and 7 months. A male of unknown age was recaptured after 5 years, and two adult males were recaptured after 4 years and 1 month and 4 years.

Sanderson *(163)* calculated the average longevity of raccoons in Missouri to be 1.8 years. When computed in the same way, the average longevity of raccoons in Alabama is estimated to be 3.1 years.

Raccoon populations in the northern states have proportionately more juveniles and a more rapid rate of turnover than those in the southern states. Other studies *(111,163,165,188)* show juveniles ranging from 41 to 70 per cent of the population in northern states.

Cunningham *(43)*, apparently the first to conduct population studies of raccoons in the Deep South, reported 25 per cent juveniles among raccoons taken by dogs and 20 per cent among those taken with box traps on an area unhunted for many years prior to his study. This was a much lower percentage than reported elsewhere in the literature, and Cunningham suspected that it was badly biased. But Caldwell *(29)* found 37 per cent juveniles among raccoons taken with dogs in north-central Florida.

The author's data on age structure are in general agreement with those of Cunningham and Caldwell and are probably representative of non-mountainous, inland areas of the southeastern United States. The latitudinal difference in age structure of raccoon populations is related to differences in productivity (page 50) and to the greater mortality from severe winters and intense hunting and trapping pressure in the northern states.

Summary of Mortality and Density Control

Heaviest mortality among raccoons in Alabama seems to occur in the first 2 years of life. In some areas in southwestern Alabama the combined effects of winter weather, malnutrition, and distemper probably result in much juvenile mortality. Age structure curves, however, suggest that mortality is greater in the subadult group than among juveniles. Much of this mortality is probably related to dispersal, although this was not proved. The extent of dispersal and when it occurs were not determined. It is known that some young animals did not disperse.

Natural mortality, other than that related to old age, seems to be negligible among well established adult animals, and most mortality in this group is a result of human exploitation. In southern Alabama a substantial percentage of those individuals reaching 3 years will live to die of old age. But, hunting is probably the greatest single factor limiting raccoon populations where there are significant numbers of raccoon hunters.

MANAGEMENT IMPLICATIONS

HABITAT IMPROVEMENT

Although the raccoon is a very adaptable species, habitat deficiencies are major limiting factors in many areas. Stuewer *(188)* concluded that raccoons in Michigan were limited by a deficiency of den trees. Kellner *(97)* reported that food was the major limiting factor in mountainous areas of Virginia. Habitat improvement would be the most effective measure that raccoon hunters interested in increasing raccoon populations could take. The most important habitat deficiencies in Alabama are late winter foods and refuge and den trees.

The raccoon is often thought of as a species found only in habitat in an advanced successional stage. This is not entirely true, although mature hardwood stands are important habitat components. As for many game species, variety in habitat is needed to provide diverse feeding opportunities during all seasons. In general, habitat improvement for wild turkeys, gray squirrels, and deer will also benefit raccoons, and no special measures are necessary. Most of the natural food plants utilized by raccoons are also favored foods of other forest game species.

Grassy openings are important for insect production. These may be maintained by fire or by other means. Spot-burning in winter stimulates early germination and sprouting of ground-story vegetation, especially grasses. This favors insect production, and raccoons were observed on several occasions feeding in the tall grasses in annually burned woodland.

The quantitative food habits data do not reflect the true importance of insects to a raccoon population. Insects provide needed protein throughout the year, as the majority of the plant foods in the diet are rich in fats and carbohydrates and low in proteins. More importantly, they seem to be the major buffer against starvation late in the winter and early in the spring. Grasshoppers are especially important in this regard.

Permanent openings and abandoned house sites should be maintained where it is practical to do so. Important fruit-producing species such as persimmon, wild plum, black cherry, blackberries, privet, greenbriers, and eastern red-cedar will generally be present about such sites. These species should receive protection and maintenance. Pecan trees and fruit trees about abandoned house sites should be cared for. Game food patches can be planted to provide emergency winter food. Chufa patches should be planned so as to produce enough food for both turkeys and raccoons.

A hardwood forest component with an abundance of mature oaks is essential. An abundance of acorns is good insurance against nuisance raccoon problems. Although acorns are not high in preference among natural foods, they are generally preferred to planted foods, when abundant. Acorns are essential for getting raccoons through the winter in good condition, unless planted foods are available. Sugar hackberry and blackgum should also be favored in bottomlands. Some desirable understory fruit-producing species are wild grapes, greenbriers, possum-haw, and rattan-vine. All den trees should be left for raccoons and other wildlife. Den trees are important in providing shelter during severe weather and providing homes for females and young. Stuewer *(189)* described the construction and use of artificial dens for raccoons, but natural dens are preferable.

An abundance of secure refuge sites is the best insurance against an excessive harvest. Large yellow-poplars and bottomland oaks, in particular, should be preserved for this purpose. These may also serve as den trees and produce mast.

Beaver activities are highly beneficial to raccoons and other wildlife. Beaver swamps produce aquatic foods that are heavily utilized by raccoons. Dead trees provide den and resting sites. Beaver swamps are, in effect, scattered, relatively inaccessible sanctuaries providing protection from hunters.

DAMAGE CONTROL

Damage by raccoons usually occurs only where they are too numerous. Raccoon hunting should be encouraged in such areas.

Local control of populations is effective only for short periods. Effective control must be extensive. Hunting is generally the only acceptable control method that is effective in areas where population density of raccoons is high. Furthermore, sport and recreation are provided as well as effective population control. The use of poison baits should be forbidden or rigidly controlled.

Most damage by raccoons is of a temporary and local nature. If damage is sufficiently great as to warrant control efforts, temporary relief may be obtained by trapping or by using a dog and gun. Often individual raccoons develop a preference for certain foods, and the removal of habitual offenders will prevent further damage, especially to domestic poultry.

An abundance of natural foods probably would serve as a buffer against predation and crop depredations by raccoons in Alabama. Observations on food preferences indicate that many naturally occurring fruits are preferred foods and are used first when available. Damage to crops (*e.g.* corn and chufa) and possibly to ground-nesting birds might be prevented by encouraging plums and blackberries, which produce fruit abundantly at the proper time.

REGULATION OF THE HARVEST

Ideally harvest should take place at a time when pelts are prime, females are not pregnant, and young have reached an age of self-sufficiency. Trapping interest has declined to the extent that primeness of raccoon pelts is not a major consideration in Alabama at present.

The most important harvest consideration in Alabama is preventing the destruction of entire family groups early in the season. Raccoons do not reach an age of self-sufficiency until they are at least 3 months of age. Orphaned young probably have greatly reduced chances of survival during the fall. Juvenile raccoons in the northern states may weigh 10 pounds early in the winter, whereas in Alabama young are born later, and even late in the winter juveniles often weigh only about 4 pounds; some weigh only 2 or 3 pounds. Family groups are still intact when hunting season opens. These family groups, which are most important to the population, are easily treed and exterminated. Where raccoons are valued, every effort should be made to discourage destruction of these groups.

For this reason, it is biologically desirable to delay opening of the hunting season in Alabama until about December 1. There is no biological objection to allowing the season to remain open as late as April 1. If, for other reasons, it is impractical to delay hunting, efforts should be made to discourage hunters from shooting family groups in fall.

Hunting is obviously a limiting factor on raccoon populations in some areas. In such areas hunters should be encouraged not to kill all raccoons they tree but to allow some to go unharmed after the chase has ended.

STOCKING

Transplanting raccoons from one area to another for the purpose of increasing the huntable population is a common practice among raccoon hunters. Stocking of this type is ineffective because raccoons usually leave, or are driven out of, the area in which they are released and may wander for many miles. Raccoons are greatly dependent upon learning rather than instinct to guide them in their feeding habits. If the habitat into which they are transplanted differs too greatly from that to which they are accustomed, they may not be able to find food.

From a biological viewpoint, stocking is a dangerous practice. Diseases and parasites may be introduced from endemic areas to areas in which they were previously absent. Raccoons are usually obtained for stocking from areas in the Coastal Plain, where they are most abundant. Such areas of high density are the most common focal points for canine distemper and other diseases, some of which are infective to man and dogs. Conceivably, the introduction of diseased animals from these areas into "disease-free" areas could depress populations rather than increase them. Raccoons from the central and northern portions of Alabama were not nearly so heavily parasitized as those from the southern portions of the State. Some of the parasites have local distributions. It would seem wise not to distribute them over uninfested areas until more is known of their ecology.

Florida is a common source of raccoons for stocking. It (with southern Georgia) is also the only area in the United States where rabies is a problem in raccoons. Rabies in raccoons has proved to be most persistent and resistant to control measures. Because of the fearless, often almost tame nature of rabid raccoons, the dangers are increased.

Because stocking of raccoons accomplishes nothing desirable and is potentially dangerous, it should be strongly discouraged. Hunters would more profitably direct their efforts at habitat improvement and regulating harvest.

SUMMARY

A study of the biology of the raccoon (*Procyon lotor varius* Nelson and Goldman) in Alabama was conducted from February 1962, to September 1968. Objectives were to obtain information on ecologically important aspects of life history and population structure and to evaluate the role of various factors in regulating population density.

Necropsies were performed on 371 raccoons to obtain information on weights and measurements, breeding and reproduction, parasitism and disease, age structure, condition, adrenal weights, and food habits. Two-hundred and fifty-two raccoons were marked and released for studies of movements, activity, longevity, population density, and seasonal changes in weights. Three raccoons were equipped with radio transmitter-collars for study of movements and related behavior. Raccoons were held in captivity for observations on behavior, reproduction, growth, and development. Field observations and hunting with dogs provided additional information. An attempt was made to bring together and synthesize published data from other studies, especially those from the Southeast.

A combination of methods was used to estimate the ages of raccoons. Ages of animals on which necropsies were performed were determined with a fair degree of accuracy from weights of eye lenses and layering in the dental cementum and other dental characters. Supporting data on age were obtained from sexual characters and widths of epiphyseal cartilages. Weight frequency histograms were constructed from weights of animals on which necropsy data permitted reliable estimation of age. These provided data that permitted the segregation of animals handled in the field into two age classes (immature and mature) on the basis of weight.

Weights were recorded for 700 raccoons. The average weight of 277 adult males was 9.5 pounds, and the average weight of 174 adult females was 8.1 pounds. Weights in fall were about 20 per cent greater than in spring. Raccoons from east-central Alabama were significantly heavier than those from southwestern

Alabama. External measurements and some skull measurements were also recorded.

Reproduction of raccoons occurred from May to August, and one record of an October pregnancy was obtained. The peak of the reproductive season was in June. Males reached sexual maturity early in the fall of their second year, when they were about 15 months of age. Females typically did not produce young until their second year, although about 10 per cent bore young during their first year. The mean litter size, from 101 observations, was 2.48 with a standard error of 0.05. The maximum number of young per litter was three. The average number of young per litter of raccoons in the northern states is reported to be much greater.

Juvenile raccoons from Alabama grew more slowly than those reported from northern states. They reached a weight of about 4 pounds at 4 months and typically gained little or no weight between January 1 and May 1. Juveniles weighing less than 4 pounds were commonly encountered late in the winter.

Food habits data were obtained from the contents of 79 stomachs, 70 large intestines, and 365 fecal samples. Plant materials occurred in 90 per cent of samples collected in spring, summer, and fall but occurred in only 53 per cent of the samples collected in winter. Major plant foods were persimmon, wild plum, blackberries, acorns, wild grapes, gallberry, sugar hackberry, privet, greenbriers, and rattan-vine. Stomachs were often empty or nearly empty in winter, and insects were probably a major buffer against starvation. Crayfish were also important in winter. No evidence was obtained that indicated raccoons were important predators on vertebrates in Alabama.

Nineteen species of helminth parasites were encountered. Most were common parasites of raccoons, but several unusual species were encountered. *Gnathostoma procyonis* Chandler, 1942, was present in 59 of 153 stomachs from 12 of 15 counties and was proved to be seasonal in occurrence. *Physaloptera* sp. was present in 67 of 153 stomachs from various regions of the State. *Dracunculus insignis* (Leidy, 1858) was present in 6 of 13 raccoons from east-central Alabama but was found in only 3 of 45 raccoons from southwestern Alabama. Other nematodes encountered were *Arthocephalus lotoris* (Schwartz, 1925); *Molineus barbatus* Chandler, 1942; *Crenosoma goblei* Dougherty, 1945; a syngamid lungworm; a strongyloid lungworm; *Capillaria plica* (Rudolphi, 1819); and two other capillarids. *Eurytrema procyonis* Denton, 1942, occurred in the pancreatic ducts of 87 of 240 raccoons. Data on the distribution of *Eurytrema* in Alabama are presented. *Pharyngostomoides procyonis* Harkema, 1942, and three unidentified trematodes were also encountered. Cestodes encountered were *Mesocestoides variabilis* Mueller, 1927, and *Atriotaenia procyonis* (Chandler, 1942). The thorny-headed worm *Macrocanthorhynchus ingens* (von Linstow, 1879) was common.

Data from other studies on protozoan parasites and ectoparasites of raccoons from Alabama are summarized.

Mortality of raccoons from disease was common in some areas and was attributed to an interaction of canine distemper, pneumonia, parasitism, and malnutrition. There were no confirmed cases of rabies in raccoons from Alabama during the study period. Data on leptospirosis and tularemia are cited from other studies.

Home ranges of two 1-year-old raccoons encompassed 114 and 122 acres. Distances between extreme locations were 0.86 mile and 0.99 mile. An adult male traversed an area encompassing 245 acres. Distance between extreme locations was 1.0 mile. Movements of raccoons in east-central Alabama were primarily along stream courses. Centers of activity shifted in an unpredictable manner. Trapping results and field observations indicated that raccoons often migrated some distance from their normal range to take advantage of temporarily attractive feeding opportunities.

Raccoon populations in Alabama typically contained about 62 per cent males and about 32 per cent juveniles. The turnover period (about 10 years) and average longevity (about 3 years) were much greater than has been reported in the northern states. Greatest mortality occurred in the second year and was probably related to dispersal. Adult mortality was low and was attributed primarily to exploitation by man.

A mature hardwood forest component interspersed with grassy openings for insect production and areas in early successional stages containing plum, blackberries, black cherry, persimmon, greenbriers, privet, and other fruit-producing species provide optimum habitat for raccoons. Large trees retaining foliage into the winter serve as refuge sites and help prevent over-harvest.

Control of raccoon populations is difficult on a local scale and is best accomplished by hunting. Data on food preferences suggest that damage by raccoons may be controlled by removing offending individuals and by encouraging favored natural foods during the time when damage occurs.

Delay of harvest until December 1 is recommended to minimize killing of very small young and destruction of entire family groups.

Transplanting raccoons from one area to another is ineffective as a means of increasing populations and is undesirable as it may help spread parasites and disease from endemic areas.

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APPENDIX

APPENDIX TABLE 1. COMMON AND SCIENTIFIC NAMES OF PLANTS REFERRED TO IN THIS REPORT

Common name	Scientific name
(None)	*Ampelopsis cordata* Michx.[1]
American holly	*Ilex opaca* Ait.
Ash	*Fraxinus* spp.
Black cherry	*Prunus serotina* Ehrh.
Blackgum	*Nyssa sylvatica* Marsh.
Blackberries	*Rubus* spp.
Black-jack oak	*Quercus marilandica* Muenchh.
Beech	*Fagus grandifolia* Ehrh.
Chestnut oak	*Quercus prinus* L.
Chufa	*Cyperus esculentus* L.
Corn	*Zea mays* L.
Cypress	*Taxodium distichum* (L.) Richard
Dewberries	*Rubus* spp.
Dogwood	*Cornus florida* L.
Eastern red-cedar	*Juniperus virginiana* L.
Florida anise	*Illicium floridanum* Ellis.[2]
Frost grapes	*Vitis vulpina* L., *V. aestivalis* Michx., *V. riparia* Michx., and related species
Gallberry	*Ilex glabra* (L.) Gray
Greenbriers	*Smilax* spp.
Groundnut	*Apios americana* Medic.
Laurel oak	*Quercus laurifolia* Michx.
Loblolly pine	*Pinus Taeda* L.
Longleaf pine	*Pinus australis* Michx. f.
Moonseed	*Menispermum canadense* L.
Muscadine	*Vitis rotundifolia* Michx.
Oakleaf hydrangea	*Hydrangea quercifolia* Bartr.
Overcup oak	*Quercus lyrata* Walt.
Pecan	*Carya illinoensis* (Wang.) K. Koch
Pepper-vine	*Ampelopsis arborea* (L.) Koehne
Persimmon	*Diospyros virginiana* L.
Plum	*Prunus angustifolia* Marsh.
Pokeberry	*Phytolacca americana* L.
Possum-haw	*Ilex decidua* Walt.
Post oak	*Quercus stellata* Wang.
Privet	*Ligustrum vulgare* L.
Rattan-vine	*Berchemia scandens* (Hill) K. Koch
River birch	*Betula nigra* L.
Sabal palmetto	*Sabal minor* (Jacq.) Pers.[2]
Shortleaf pine	*Pinus echinata* Mill.
Slash pine	*Pinus palustris* Mill.
Southern magnolia	*Magnolia grandiflora* L.[2]
Southern red oak	*Quercus falcata* Michx.
Spanish moss	*Tillandsia usneoides* L.
Sparkelberry	*Vaccinium arboreum* Marsh.
Spruce pine	*Pinus glabra* Walt.[2]
Sugar hackberry	*Celtis laevigata* Willd.
Swamp chestnut oak	*Quercus michauxii* Nutt.
Sweetbay	*Magnolia virginiana* L.
Sweetgum	*Liquidambar styraciflua* L.
Turkey oak	*Quercus laevis* Walt.

(Cont. next page)

APPENDIX TABLE 1. *(Cont.)*

Vacciniums	*Vaccinium* spp.
Virginia pine	*Pinus virginiana* Mill.
Water hickory	*Carya aquatica* (Michx. f.) Nutt.
Water oak	*Quercus nigra* L.
Yellow poplar	*Liriodendron tulipifera* L.

[1] Except where otherwise noted scientific names are from Fernald, Merritt Lyndon. 1950. Gray's manual of botany. 8th ed. American Book Co., New York.

[2] Scientific names from Small, John Kunkel. 1933. Manual of the southeastern flora. Univ. of North Carolina Press, Chapel Hill.

APPENDIX TABLE 2. SPECIES OF WILD VERTEBRATE ANIMALS REFERRED TO IN THIS REPORT

Common name	Scientific name[1]
Reptiles	
Alligator	*Alligator mississippiensis* (Daudin)
Green anole	*Anolis carolinensis* Voigt
Birds	
Bobwhite quail	*Colinus virginianus* (Linnaeus)
Redwing blackbird	*Agelaius phoenicius* (Linnaeus)
Wild turkey	*Meleagris gallopavo* Linnaeus
Mammals	
Beaver	*Castor canadensis* Kuhl.
Bobcat	*Lynx rufus* (Schreber)
Cottontail rabbit	*Sylvilagus floridanus* (Allen)
Gray fox	*Urocyon cinereoargenteus* (Schreber)
Gray squirrel	*Sciurus carolinensis* Gmelin
Mink	*Mustela vison* (Schreber)
Muskrat	*Ondatra zibethica* (Linnaeus)
Opossum	*Didelphis marsupialis* Linnaeus
Raccoon	*Procyon lotor* (Linnaeus)
Red fox	*Vulpes fulva* (Desmarest)
Weasel	*Mustela frenata* Lichtenstein
White-tailed deer	*Odocoileus virginianus* (Zimmermann)

[1] Scientific names are from Blair, W. Frank, Albert P. Blair, Pierce Brodkorb, Fred R. Cagle, and George A. Moore. 1957. Vertebrates of the United States. McGraw-Hill Book Co., New York.

APPENDIX TABLE 3. SOME PREVIOUS STUDIES OF RACCOON FOOD HABITS IN THE UNITED STATES

Locality and reference	Season	Samples
		No.
California *(77)*	----	178
Colorado *(192)*	F	100
Florida *(29)*	----	71
Illinois *(215)*	F	419
Illinois *(216)*	F, W	223
Iowa *(66)*	F	67
Iowa *(67)*	Sp, Su, F	365
Iowa *(27)*	Sp, Su, F	300
Kansas *(182)*	All	842
Louisiana *(28)*	Sp.	15
Maryland *(185)*	F, W	80
Maryland *(113)*	All	520
Michigan *(47)*	----	500
Michigan *(188)*	All	121
Minnesota *(174)*	Su	135
Mississippi *(39)*	W	50
New York *(80)*	F, W	130
New York *(81)*	Su	163
New York *(82)*	Sp, Su, F	94
Ohio *(152)*	F, W	17
Pennsylvania *(105)*	Sp, Su, F	52
South Carolina *(100)*	All	596
South Dakota *(63)*	All	367
Texas *(12)*	All	378
Texas *(207)*	All	217
Virginia *(97)*	All	119
Washington *(198)*	Su	29
Wisconsin *(50)*	All	402

APPENDIX TABLE 4. SOME INFECTIOUS DISEASES OF RACCOONS IN THE UNITED STATES

Disease and reference

Fungal diseases
- Histoplasmosis[1] *(134)*

Viral diseases
- Rabies[1] *(171)*
- Canine distemper[1] *(159)*
- Infectious enteritis[3] *(200)*
- Fox encephalitis[4] *(76)*
- Saint Louis encephalitis[2] *(40)*
- Eastern equine encephalitis[2] *(150)*

Bacterial diseases
- Leptospirosis[1] *(125,126)*
- Tularemia[2] *(128)*
- Listeriosis[1] *(65)*
- Tuberculosis[1] *(25)*

Protozoan diseases
- Trypanosomiasis[1] *(153)*
- Coccidiosis[1] *(158,214)*
- Toxoplasmosis[2] *(93)*

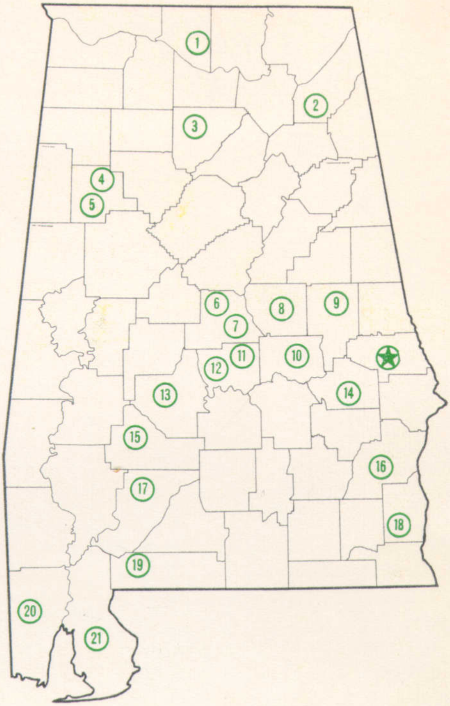
[1] Naturally occurring infections reported.
[2] Serological evidence of natural occurrence.
[3] Reported from raccoons in captivity.
[4] Experimental infections.

APPENDIX TABLE 5. SAMPLE SEX RATIOS FROM RACCOON POPULATIONS AS REPORTED FROM VARIOUS AREAS IN THE UNITED STATES

Locality and reference	Sex ratio (males per 100 females)	Sample	Year
Alabama (this study)	168	1,222	1956-68
Arkansas *(69)*	100	256	1941
Florida *(29)*	149	107	1961-63
Iowa *(27)*	108	79	1951
Kansas *(182)*	150	918	1952-54
Louisiana *(28)*	70	34	1946
Maryland *(111)*	80	492	1947-51
Michigan *(188)*	108	256	1939-41
Missouri *(18)*	127	306	1934-35
Missouri *(145)*	150	10,769	1940
Missouri *(197)*	67	100	1948
Missouri *(163)*	100	956	1948-49
Ohio *(152)*	126	132	1938-40
South Carolina *(43)*	140	223	1961
South Carolina *(209)*	170	49	1954-56
Texas *(208)*	93	71	1950-51
Washington *(173)*	98	127	1946-48

AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.