

A STUDY OF THE HABITS AND MANAGEMENT OF THE GRAY SQUIRREL
IN VIRGINIA (CONTINUED)

BY

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Major Thesis Submitted to the Faculty of
THE VIRGINIA POLYTECHNIC INSTITUTE
DEPARTMENT OF BIOLOGY

For the Degree of
MASTER OF SCIENCE
in
WILDLIFE CONSERVATION

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March 1942

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INTRODUCTION

Until the present time sufficient knowledge of the gray squirrel and its habits has been sadly lacking. Specifically, it might be stated that the object of this study is to secure definite information on the breeding habits of the gray squirrel in Virginia with reference to the hunting seasons, and to formulate a practical management plan to be used on representative areas.

The project was sponsored by the Virginia Cooperative Wildlife Unit* and set up by C. O. Handley, Leader of the Unit; the first year's work being performed by Donald D. Shipley, Graduate Student in Wildlife Research.

Although it was the original intention to finish the study in one year it was soon discovered that sufficient data on several phases of the subject could not be obtained during that time. Consequently, the author was appointed to carry the work through the second year and submit a final report including a complete summary of the results of the investigation.

Appreciation is extended to Donald D. Shipley for his valuable instructions and information concerning various techniques employed in the study. To C. O. Handley and A. B. Massey the author is indebted for helpful advice and suggestions during the

* The Fish and Wildlife Service (U. S. Department of the Interior) The Virginia Polytechnic Institute (College, Experiment Station and Extension Service), The Virginia Commission of Game and Inland Fisheries, and the American Wildlife Institute.

investigation and the preparation of the final report; to A. B. Culbertson for his able assistance during the period of trapping and tagging, and to Dr. J. W. Scales and Dr. T. A. S. Hays for numerous post-mortems and parasite identifications.

The author wishes to thank Warden W. E. Calohan, Warden L. A. Coleman, and the many sportsmen who contributed valuable assistance and information; also, the members of the Virginia Council of Wildlife Technicians for their interest and helpful advice, and Miss Martha Evans for the use of her farm as an experimental area during a part of the study.

Appreciation is also extended to F. C. Minter for photographs; to R. A. King for his help in the collection of specimens; and many others too numerous to mention.

REVIEW OF THE LITERATURE

Since this work is a continuation of the project started in 1940 all available literature on the gray squirrel up to that time has been reviewed by D. D. Shipley (12). A comparatively small number of publications has appeared during the period of this investigation and no previous new publications have been found.

Of special interest is the similar work performed by the North Carolina Game and Fish Division (4) in cooperation with the Federal Aid Division of the United States Fish and Wildlife Service. Although the two projects were carried out in an entirely different manner the resulting information is indeed gratifying. The two reports check remarkably close on the dates regarding the second or fall squirrel brood and for this reason we feel that our work has not been in vain. Furthermore, a similar check tends to reduce the source of error considerably.

A BRIEF REVIEW OF ACCOMPLISHMENTS DURING THE YEAR 1940-1941

Continuous trapping and tagging through the spring breeding period gave definite dates regarding the breeding season, gestation, and lactation periods of the gray squirrel at that time of the year. Data collected in the same manner in the late fall of the preceding year was sufficient to estimate the time of the fall breeding season. However, more information was needed before definite conclusions could be made regarding this period.

Trapping, tagging, and handling techniques, worked out in 1940-1941, were of much value. Until this time little was known of these specific practices as applied to the gray squirrel. Of equal importance were the experiments to determine the most desirable type of bait to be used in the traps, methods of observation, and systems for keeping notes and records.

Conclusive information pertaining to homing instinct, breeding age, irregular feeding periods, effects of inclement weather on activities, time of greatest daily activity, water requirements, reactions to being handled, and nesting habits was obtained.

The assembly and review of all available literature up to 1941 resulted in a volume containing a complete summary of previous accomplishments plus additional information acquired during the year's work.

METHOD OF PROCEDURE

Previous to the beginning of this project the author spent considerable time in the field with Shipley(12) and learned the various techniques employed by him in the study.

The first work was that of reviewing carefully the report of the investigation performed in 1940-1941 and determining those phases of the subject which lacked sufficient information. With this idea in view a plan of work was formulated for the investigation here reported.

Additional literature was reviewed and added to the bibliography already started.

Trapping and tagging was carried out in the woodlots previously selected at Blacksburg, Virginia. Special effort was made to perform this work with a system as similar as possible to that employed in the past in order that results might be compared and eventually combined into one complete report.

During September and November 1941, an attempt was made to trap squirrels in Campbell county in order that breeding season dates might be compared with those of Montgomery county. However, the number of animals trapped was too small to justify the amount of time required by the work. Operations were discontinued at the end of one week.

Numerous field observations were made on the college farm and campus at Blacksburg, Virginia, giving special attention to

feeding habits and the comparative use of dens and nests.

In September 1941, a field trip was made into Campbell and Amelia counties for the purpose of examining squirrels killed by hunters during the open season. A total of 54 squirrels were examined in Campbell county, September 1-7 and an additional 49 in Amelia county, September 8-15. Valuable assistance was rendered by W. E. Calohan and L. A. Coleman, Wardens of the respective counties.

Additional information was secured through the examination of squirrels killed during the annual hunting season on the Virginia State Forest, December 8-15, 1941. Graduate students* and Field Biologists**, operating check stations on the area, examined all squirrels killed and the records were assembled by the author.

Squirrels found dead in the traps at Blacksburg were autopsied in order to determine cause of death and the presence or absence of parasites.

* Graduate Students, Virginia Cooperative Wildlife Research Unit.
Biology Department, V. P. I.

** Field Biologists, of the Virginia Commission of Game and Inland Fisheries.

TRAPPING AND TAGGING

Brief Description of the Procedure

This project probably marks the first attempt to secure such information on the gray squirrel by means of trapping and tagging. Consequently, the various techniques employed were learned through careful experiments involving numerous ideas. By continuous trial and error the most desirable have been retained and undoubtedly there is room for further improvements.

Obviously, the primary object in this method of study is to trap the squirrel. Traps, as illustrated in Figures 8, 9, and 10, were set at the bases of mature oaks and hickories. Den trees proved most productive. After trapping in a woodlot for a period of two ~~week~~ weeks it was necessary to remove the traps in order that the squirrels might not become trap-shy. As a result, three specific woodlots were chosen and the traps simply transported from one to another at the end of each two weeks period. During those times when the average number of squirrels trapped was unusually low the traps were allowed to remain in the same woodlot for a longer time.

After trapping the squirrel it was then necessary to tag and examine the animal. By recording the condition of the external organs of all squirrels handled, information can be collected on various breeding habits. Therefore, an average will reveal the specific stage or season that might be applied to the entire population.

Although comparatively small, the gray squirrel becomes quite viscious when cornered. Consequently, it is necessary to handle them with considerable care. First, the squirrel is removed from the trap into a holding net, then tagged and examined. An illustration of this procedure is found in Figure 8. It was during this process that the greatest difficulty involving techniques was encountered.

Trapping and Handling Techniques

A bag made of stout netting of 1/4 inch mesh, such as that used for marketing oranges, onions and other produce, has proven to be quite practical for holding the squirrel while tagging. The 3/4 inch mesh fish net used in the past was unsatisfactory. The animal invariably became entangled in the large mesh of the latter net to such an extent that the marking tag was often pulled out of the ear. By the use of a bag of smaller mesh netting this trouble was eliminated entirely. The small mesh also reduced the chances of the handler being bitten by the squirrel during the tagging process. Figures 1 and 2 illustrate the two types of holding nets.

Advantages and Disadvantages of Various Types of Tags

The rabbit ear tag used during the first year's study had several faults. In the first place, this tag is too large to be used on an animal as small as the gray squirrel. The edges which protrude beyond the surface of the ear are easy to hang on various

objects and pull out. Another objection is the method of fastening, which is similar to that of a clinch rivet, as illustrated in Figure 5. If the tag is clamped tightly to the ear the skin immediately surrounding it begins to slough off and continues to do so until the hole becomes large enough to allow the tag to fall out. However, if it is fastened loosely it is soon pulled off. Numerous tags were lost because of the two prongs used to hold the tag by means of a celluloid washer on the opposite side of the ear. After the ends of the prongs were inserted through the washer and bent down they were easily caught by foreign objects and straightened out. A liquid solder was smeared over the washer and prongs in order to provide a smooth surface. While this remedy might have helped in a few cases it was not sufficient to warrant continued use. The author trapped 62 squirrels which had been previously tagged and found that 71 per cent of the tags were missing.

The monel tag, size I, as illustrated in Figure 6 was adopted in August, 1941. This type is smaller and far superior to the rabbit ear tag formerly used. The method of fastening greatly simplifies the tagging process and application requires less time. The chances of becoming entangled with other objects are reduced to a minimum. Since there is no pressure exerted upon the ear by the tag no trouble was encountered from sloughing off of the skin. Up to the present time no objections have developed from the use of the monel tag.

Advantages and Disadvantages of Various Types of Traps

The traps used in the study consisted of the wire trap and Baumgartner trap described by Shipley (12), and two types constructed by the author.

The wire trap constructed by Shipley is to be desired because its comparatively light weight makes handling much easier. The trap is also very easily cleaned or repaired. Offsetting these advantages is the fact that no protection is provided for the trapped squirrel. The animal is at the mercy of both weather and predators and frequently the traps were trampled flat by cattle attempting to get the grain used for bait. Squirrels often suffered serious injuries by rushing against the sides of the trap in an effort to force their way out. During prolonged rainy periods it was necessary to discontinue trapping operations because the bait became wet and consequently soured. This trap is shown in Figure 9.

The Baumgartner trap shown in Figure 8 proved superior to the wire type in that it afforded the trapped squirrels ample protection from predators and weather. It could also be used without interference in pastured woodlots. This type is rather heavy and hard to handle in large numbers and since it is practically airtight one squirrel was suffocated on a particularly warm day. The trap is also difficult to repair due to its compactness.

Another trap used in the study is shown in Figure 10. The main idea involved in the construction of this type was to eliminate the major defects possessed by the other traps and still have a trap

that would catch squirrels. Since it was believed that a squirrel would enter a trap more readily if the bait could be seen the half-wood and half-wire model seemed to be the answer. The wire part of the trap allowed the bait to be readily seen while the wood furnished protection after the squirrel was trapped. Although this type ~~also~~ afforded ample protection the average number of squirrels trapped did not exceed that of the all-wood trap built by Baumgartner. Therefore it was found that the greater amount of time required in their construction was unnecessary.

The ideal trap for taking gray squirrels, as visualized by the author, would be one of the Baumgartner type with a sheet metal treadle and a back constructed of 1/2 inch mesh hardware cloth. The wire back would permit sufficient air to enter the trap and prevent suffocation of the animals except under extreme conditions. A treadle cut from a piece of sheet metal is preferred since the squirrels gnaw and eventually destroy the wooden type treadle. The trigger mechanism is comparatively simple with a minimum number of parts and does not become broken or damaged easily.

Reactions of Squirrels Upon Release

Squirrels like human beings vary individually. Some animals become very nervous while being handled and others appear to be quite calm. However, it has been frequently noted that upon being released the squirrel usually does not stop before reaching its den or nest no matter whether his rate of travel be fast or slow.

Immediately after the squirrel is turned loose its first impulse is to get off the ground since safety is found in the tree tops. When released several individuals bounded upon the author before realizing that he was not a tree trunk. One particular animal jumped upon the hood of a truck parked nearby in his rush for freedom.

On at least three occasions squirrels were noted to fall from great heights while fleeing through the tree tops but none appeared to suffer injuries. Although several naturalists have described the accidental falling of a gray squirrel in much detail the author has never had the opportunity to witness such a spectacular landing. Those squirrels observed seemed to tumble through the air in a rather unorthodox fashion with legs outstretched presumably for the purpose of clinging to the nearest twig or branch. The tail was neither carried nor manipulated in any particular manner although it may serve as a parachute as some are inclined to describe it.

Causes of Trapping Mortality

During a period of seven months 368 squirrels were trapped and handled with a loss of six individuals. It is interesting to note that five of these deaths were caused by the unusually nervous temperament possessed by the gray squirrel.

Four of the six animals lost died from exhaustion when they became entangled in the loose treadles of the wire traps.

During an unusually warm day in October a young squirrel

suffocated in the Baumgartner trap. The squirrel remained in the trap for a period of three hours or less before succumbing to the heat.

One animal removed from a wire trap and examined by Dr. T. A. S. Hays* was found to have suffered a broken neck. This injury probably resulted from the squirrel's rushes against the sides of the trap in an effort to force its way out.

During unusually cold or wet weather it is entirely possible for squirrels to die from exposure when confined in the open type wire traps. However, due to the comparatively mild weather which prevailed throughout the trapping period no losses could be attributed to exposure.

Shipley (12) reported the loss of several squirrels due to shock. The writer has not lost animals from this trouble, however, two individuals were observed to suffer from mild forms of the disease. One animal regurgitated a considerable quantity of food in the trap and offered no resistance while being handled. Upon being released it appeared dazed and was unusually weak. Another squirrel, when released, seemed to have lost all muscular coordination and staggered as if drunk. After several minutes the animal recovered completely and showed no ill effects.

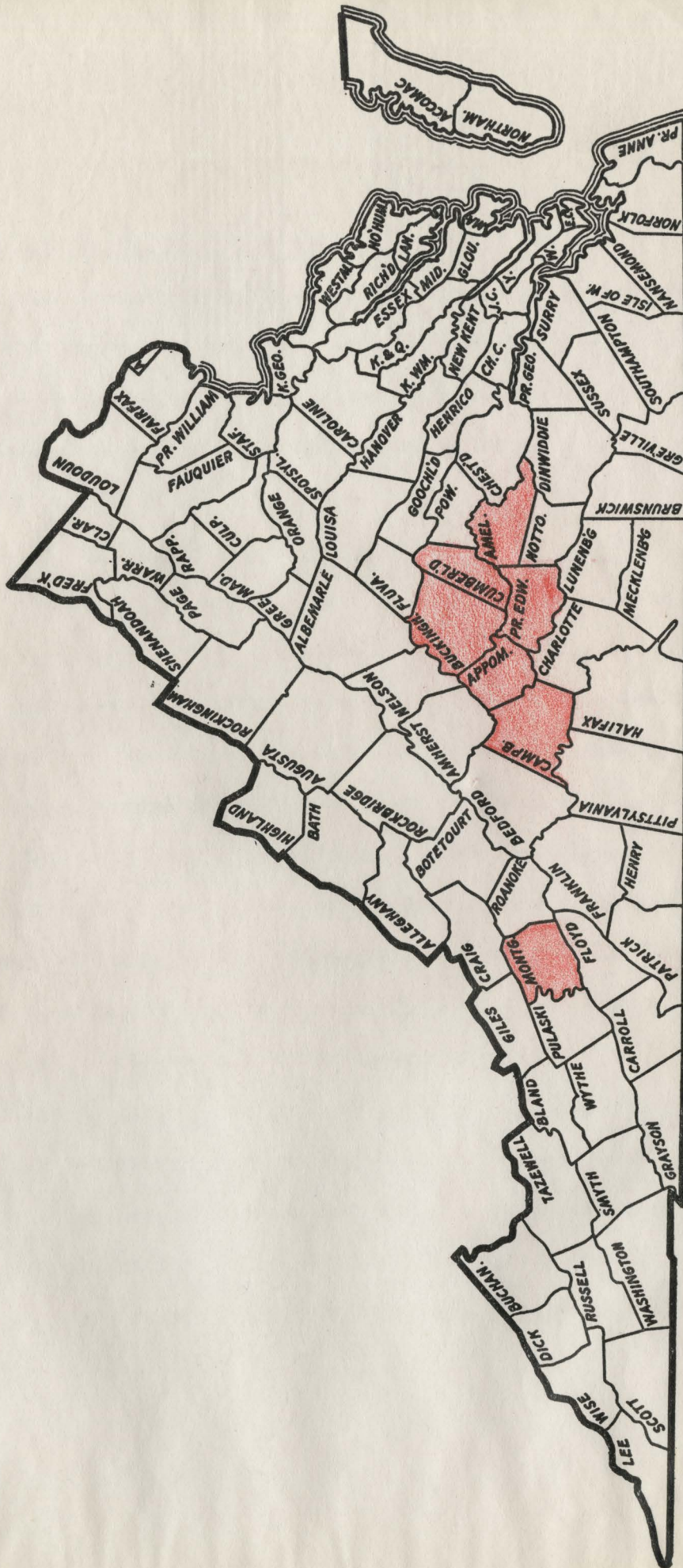
* Graduate Student in Parasitology, Virginia Polytechnic Institute.

Interference With Traps

The greatest problem encountered while trapping squirrels in pastured woodlots is that of cattle trampling the traps. Where the wire trap is used the bait is readily seen by livestock. In their effort to get the grain the trap is usually trampled flat and practically ruined. When covered or partially covered traps are used this trouble is almost entirely eliminated.

Where roving dogs are numerous the trapper can expect an occasional loss due to the squirrels being removed from the traps by the dogs. Again, this trouble is more common where open type traps are used.

While trapping in Campbell county, Virginia seven traps were stolen. This act might have been committed by a thief or by some well meaning sportsman who thought them to be operated by poachers. Although the traps were marked the identification tags were too small to attract immediate attention. Probably a greater percentage of traps would be lost in this manner if operations are carried out in open hunting territory.



Map of Virginia showing counties in which investigation was carried out. The majority of the work was performed in Montgomery County.

Chart 2. Showing Squirrels Trapped in June 1941

Woodlot :	Price's Fork Woods												
Date	18	19	20	21	22	23	24	25	26	27	28	29	30
Adult Males													
New	1		2	1	3			1	2	3	1		14
Repeats	2	1							1	2			6
Adult Females													
New	1	1		1	2			1			1		7
Repeats	1	1											2
Spring Brood													
New	4	8	6	2	7	2		1					31
Repeats			2	8	4	3	7	5	6	6	6	4	52
Total	8	11	11	11	15	7	7	8	9	11	8	4	112

Native Foods Available - Squirrel foods are comparatively scarce during the summer months. Main items at this time are mushrooms, flowers and fruits of various maples, flowers of American Elm, roots, tubers, etc. Domestic fruits such as cherry, apple, pear, are utilized when available.

Chart 3. Showing Squirrels Trapped in July 1941

Woodlot	V. P. I. Campus	Center Woods
Date	: 1: 2: 3: 4: 5: 6: 7: 8: 9: 10: 11: 12: 13: 14: 15: 16: 17: 18: 19: 20: 21: 22: 23: 24: 25: 26: 27: 28: 29: 30: 31: :	
Adult Males		
New	: 3: 1: : : x: x: x: : : : 2: 1: : : : : x: 1: : : : 1: : : : : : : : : : : : : : :	: : 10
Repeats	: 3: 3: 1: 1: x: x: x: 1: : 1: 1: 1: 3: 1: : : x: : 2: 1: 1: : : : : 1: 1: : : : : : : : :	: : 24
Adult Females		
New	: 4: 2: 2: : x: x: x: 1: 1: :	: : 13
Repeats	: 3: 1: 1: : x: x: x: 3: : : 2: 2: 1: : 1: : : x: : : x: : : 1: : : : : : : : : : : : : : :	: : 18
Spring Brood		
New	: 9: 6: 4: 1: x: x: x: : 1: : : : 1: 1: : : 1: 1: : : : : : : : : : : : : : : : : : : :	: : 31
Repeats	: 1: 4: 4: 1: x: x: x: 6: 6: 5: 1: 3: 2: 3: 3: 3: 3: x: : 1: : : 1: : : : 1: 1: : : : : : : : :	: : 50
Total	: 23: 17: 12: 3: x: x: x: 11: 11: 6: 2: 8: 7: 5: 6: 6: 3: : x: 3: 8: 3: 2: 1: 1: 1: 1: 1: : 2: : 146	

x Traps not in operation

Native Foods Available - Same as those listed for June.

Chart 5. Showing Squirrels Trapped in September 1941

Woodlot :		V. P. I. Campus																														
Date		1:	2:	3:	4:	5:	6:	7:	8:	9:	10:	11:	12:	13:	14:	15:	16:	17:	18:	19:	20:	21:	22:	23:	24:	25:	26:	27:	28:	29:	30:	
Adult Males																																
New																																
Repeats																																
Adult Females																																
New																																
Repeats																																
Spring Brood																																
New																																
Repeats																																
Fall Brood																																
New																																
Repeats																																
Total																																

Native Foods Available - Same as August. Additional foods might be Dogwood (fruit), White Pine (seeds), Black Haw (fruit).

Chart 7. Showing Squirrels Trapped in November 1941

Woodlot :	Price's Fork Woods																				
Date	1:	2:	3:	4:	5:	6:	7:	8:	9:	10:	11:	12:	13:	14:	15:	16:	17:	18:	19:	20:	
Adult Males																					
New	:	:	:	:	:	:	:	1:	:	:	:	:	:	:	:	:	:	:	:	:	1
Repeats	1:	:	:	1:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	1:	3
Adult Females																					
New	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Repeats	:	:	:	1:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	1:	:	3
Spring Brood																					
New	:	:	:	:	:	:	:	:	:	:	:	:	:	1:	:	:	:	1:	:	:	2
Repeats	:	:	:	:	:	:	:	1:	1:	:	:	:	1:	:	:	1:	1:	:	1:	:	6
Fall Brood																					
New	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	1
Repeats	:	1:	1:	:	:	:	:	1:	:	:	:	1:	1:	:	:	1:	:	2:	:	:	7
Total	1:	1:	1:	3:	1:	:	3:	1:	:	1:	4:	:	1:	4:	:	1:	5:	:	2:	23	

Native Foods Available - Foods present as previously listed but in less abundance.

LIFE HISTORY

Breeding Age

By the use of information collected while trapping and tagging it has been estimated that the gray squirrel reaches maturity at approximately the age of one year. Numerous males and females from the spring brood were noted to be entering the breeding stage in the winter of the same year. This means that the squirrels born during the spring (February) of one year would produce broods during the following spring.

Gestation Period

It is impossible to determine the actual number of days in the gestation period through trapping and tagging. However, those squirrels handled during the summer and fall of 1941 indicated that the duration of this period was between 40 and 45 days. Dr. Powers (11) and E. T. Seton (11) agree that the average length of the gestation period is 44 days.

Lactation Period

Results of examinations of trapped squirrels show that the length of the lactation period is from five to seven weeks. Seton (11) states that the young squirrels remain blind for a period of 37 days and it is concluded that the lactation period continues for a time after the eyes are open.

Length of Breeding Season

A few squirrels might be found in breeding condition during practically every month of the year, but this does not signify the actual breeding season. Some authorities believe that the oestrous period lasts about two weeks. The author has not secured sufficient data on the subject to justify a statement.

Number of Litters Per Year

The gray squirrel has two main breeding seasons each year. However, a few individuals may be found producing litters during practically every month. The Spring brood is born in mid-February and leaves the nest around the first of April while the Fall brood is born August 1-15 and leaves the nest during the latter part of September or the first of October. C. L. Bunn (4), in his studies in North Carolina, observed young squirrels in the nest on September 22, 1941. Since the squirrels' eyes were already open it is concluded that they were more than 37 days old and would soon be leaving the nest. A newspaper article featured in Virginia Wildlife (1) states that two young squirrels with eyes unopened were observed in a nest on September 1 or 2, 1941. This observation was made in Dickenson county, Virginia.

Average Number of Squirrels Per Litter

E. T. Seton (11) found an average of three to five squirrels per litter and in rare cases one, two, or six. C. L. Bunn (4)

examined nine nests and found that five nests contained three young, three contained two young and one nest contained only one squirrel. Therefore the average for these nine nests would be 2.4 individuals. Shipley (12) examined seven pregnant female squirrels and four young litters in the Spring of 1941 and discovered an average of 2.9 squirrels per litter.

Dens and Nests

It was hoped that a count of leaf nests might give some idea as to the total squirrel population on a specific area. However, the abundance of variable factors tends to make this method impractical. Observations indicate that the majority of the leaf nests are the result of the lack of dens. Consequently we might conclude that where nests are abundant, dens are scarce or vice versa. Possibly, a fairly accurate census might be made by counting nests on an area that is known to have practically no den trees.

Feeding Periods

On normal days the feeding activities of the gray squirrel are divided into two main periods, namely the early morning and late afternoon. If the day is cloudy and misty squirrels might be observed feeding during the entire day. Observations made in September indicated that the morning feeding at that season starts soon after daybreak and continues until about 9:00 A. M. while the afternoon

period begins around 4:00 P. M. and continues until dark or shortly thereafter. The actual times as stated above might tend to vary with the length of days of different seasons. Where squirrels are found living under park-like conditions special feeding periods are not so much in evidence. Here they usually feed all during the day unless severe weather is prevalent. This exception to the rule might be explained by the fact that the squirrels' tameness has caused them to ignore things that would ordinarily send them scampering to their dens for safety. Possibly the wild squirrels feed in the morning and afternoon because these are the two most quiet periods of the day. Also, on cloudy or rainy days there is not nearly so much activity in the forests as on bright and clear days. Another explanation might be the effects of different light intensities.

Manner of Feeding

Probably the best time to observe squirrels feeding is during August and September when the principal food is the hickory-nut. Soon after daybreak when the first songbirds begin calling, an occasional squirrel may be seen sneaking along through the tree tops on his way to the favorite hickory tree. In a short time there might be as many as six or eight squirrels in a single hickory and the patter of "cuttings" falling on the leaves is not unlike the sound of rain. At frequent intervals an animal will run out to the end of a limb, secure a hickory-nut, and scamper back to the tree trunk where

he then proceeds to remove the shell in order to get the fleshy meat inside.

Although there may be numerous hickories in a small area it is not uncommon to find the majority of the squirrels feeding in one or two trees. After the nut supply is exhausted in one place the group then move on to a new location. This manner of feeding is probably employed as a means of protection since a group is likely to detect the presence of an enemy more readily than a single individual.

The activities of gray squirrels on the ground are much easier to observe where the animals live under park-like conditions than in the wild. Even these semi-tame animals use the greatest precaution when feeding on the ground. While searching and digging for grubs, buried nuts or roots the squirrel is constantly jerking to attention and looking in all directions. At the slightest warning it immediately rushes to the nearest tree. After a snow has fallen, numerous holes, dug by squirrels in search of hickory-nuts and acorns, are a common sight on the forest floor.

Crop Damage

In normal years any crop damage caused by squirrels is indeed small. It is during squirrel emigration or mast shortage that this problem becomes serious. The author had the opportunity to observe serious damage inflicted by squirrels upon a corn crop in Campbell county, Virginia. However, this observation was made

approximately five years ago (1937). In this particular field, covering 20 acres, two hunters succeeded in shooting 60 squirrels during the first week in September.

Squirrel Foods

The diet of the gray squirrel is indeed varied throughout the year. The following foods are listed according to the seasons during which they are utilized at Blacksburg, Virginia.

Spring and Summer

Sugar Maple, Acer sacchrum (Buds)

Silver Maple, Acer saccharinum (Buds and samaras)

Red Maple, Acer rubrum (Flowers)

Elm, Ulmus americana (Flowers and buds)

Box Elder, Acer negundo (Samaras)

Domestic Fruits

Pears*, Pyrus communis (Fruit)

Apples**, Malus sp. (Fruit)

Cherry, Prunus sp. (Seed and fruit pulp)

Unidentified insect larvae*

Mushrooms, Russula sp. and Boletus sp.

5 Fall and Winter

Shagbark Hickory, Carya ovata (Nut)

Mockernut Hickory, Carya tomentosa (Nut)

* Observed by Shipley (12)

**Observed by Handley (8)

Fall and Winter (Continued)

- Pignut Hickory, Carya glabra (Nut)
Bitternut Hickory, Carya cordiformis (Nut)
Black Walnut, Juglans nigra (Nut)
False Pignut Hickory, Carya ovalis (Nut)
White Oak, Quercus alba (Acorn)
Hawthorn, Crataegus spp. (Fruit)
Honey Locust*, Gleditsia triacanthos (Pod)
Beechnut*, Fagus grandifolia (Seeds)
Basswood, Tilia americana (Nutlets)
Dogwood, Cornus florida (Fruit pulp)
Norway Spruce, Picea abies (Seeds)
White Pine, Pinus strobus (Seeds)

Other foods are various leaves, shoots, roots, tubers, insects*, mushrooms, domestic grains, and garbage*. One squirrel was observed gnawing on a chicken bone.

* Observed by Shipley (12)

Parasites

All of the squirrels found dead in the traps were autopsied by Dr. Hay. The only parasites in evidence were a few fleas, Orchopeas sp. Two live squirrels were found to be infested with wood ticks, Dermacentor variabilis, Say, but each squirrel possessed less than four of these parasites.

A young squirrel trapped on June 22, 1941 was practically hairless. Dr. Scales* determined the cause to be mange. However, no evidence of external parasites was noted. The squirrel had lost hair from the belly, legs, lower jaw and a few spots on the back. An ointment was applied to the infected parts after which the animal was released. Unfortunately the same squirrel has not been re-trapped.

While on a field trip in Campbell and Amelia counties, September 1-15, 1941, 103 squirrels killed by hunters were examined by the author. Of these, 29 (28.2%) were infested with warbles while 5 (4.9%) additional animals possessed scars from which warbles had only recently emerged. The number of warbles present on each infested squirrel varied from one to four with two being the average. As illustrated in Figures 11 and 12, these warbles are usually found burrowed under the skin around the shoulders and neck of the squirrel. Few are found under the front legs or on the upper back and sides.

* Dr. J. W. Scales, Veterinarian, Biology Department, Virginia Polytechnic Institute.



Figure 1. The squirrel is tagged and ready to be released. Note the original 3/4 inch mesh net and the rabbit ear tag used in the operation. (Photo by C. O. Handley)



Figure 2. Similar process as above. Note the new 1/4 inch mesh net and Monel tag, size I, used in the operation. (Photo by A. B. Massey)

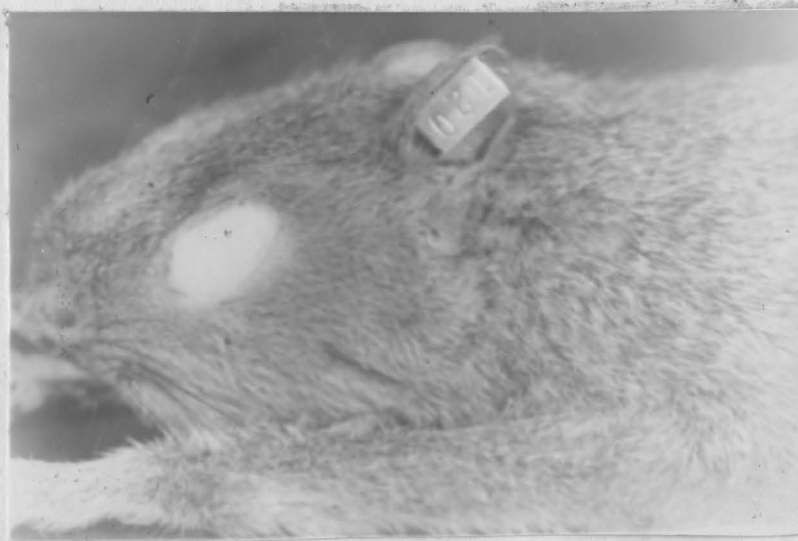


Figure 3. Rabbit ear tag on mounted squirrel. Note size of tag in comparison with squirrel's ear. (Photo by A. B. Massey)



Figure 4. Monel tag, size I, on mounted squirrel. Note size of tag in comparison with squirrel's ear. (Photo by A. B. Massey)

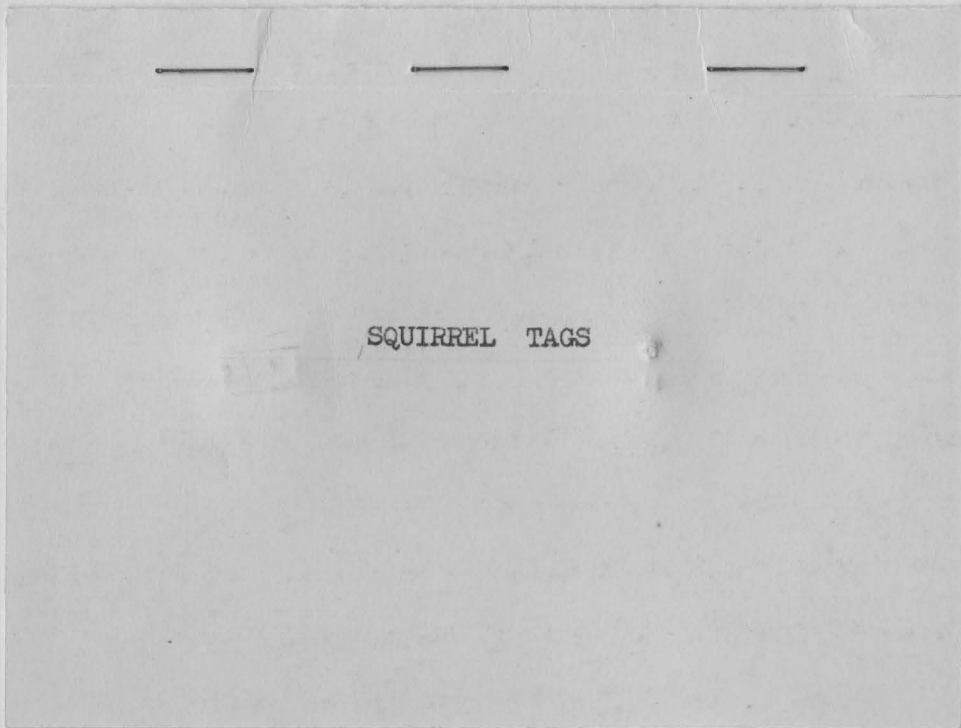


Figure 5. Rabbit ear tag (left) originally used in the investigation and the Monel tag, size 1, (right) that was adopted during the second year. Note difference in size and construction of the two tags.

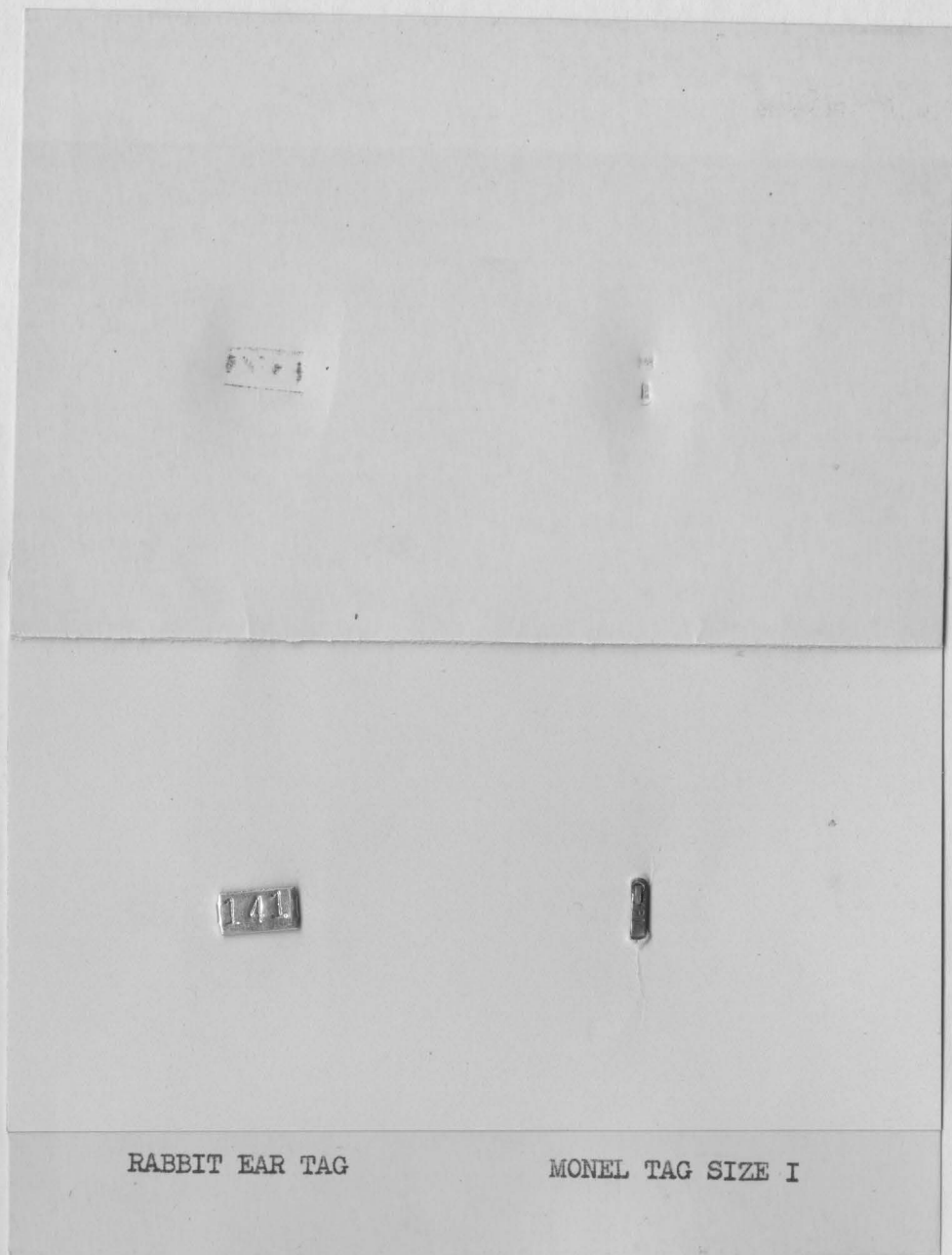


Figure 5. Rabbit ear tag (left) originally used in the investigation and the Monel tag, size I, (right) that was adopted during the second year. Note difference in size and construction of the two tags.



Figure 6. Original method of releasing squirrel after tagging. The animal often became entangled in the large mesh net and lost the identification tag. (Photo by C. O. Handley)



Figure 7. New method of releasing squirrel after tagging. Chances of the animal becoming entangled in the net are eliminated entirely. (Photo by C. O. Handley)



Figure 8. The wooden trap designed by Haugartner.



Figure 9. Trap made of galvanized wire cloth. The majority of the traps used in the investigation were of this type. (Photo by D. D. Shipley)



Figure 10. Combination of the wire and wooden traps. This type afforded excellent protection to the trapped squirrel but increased complexity of construction limited its possibilities as a type for extensive use.



Figure 11. Gray squirrel infested with warbles. Specimen collected by R. A. King in Campbell county, Virginia, September 15, 1941. (Photo by F. C. Minter)



Figure 12. Similar photograph as Figure 11. Note comparative size of warble. (Photo by F. C. Minter)

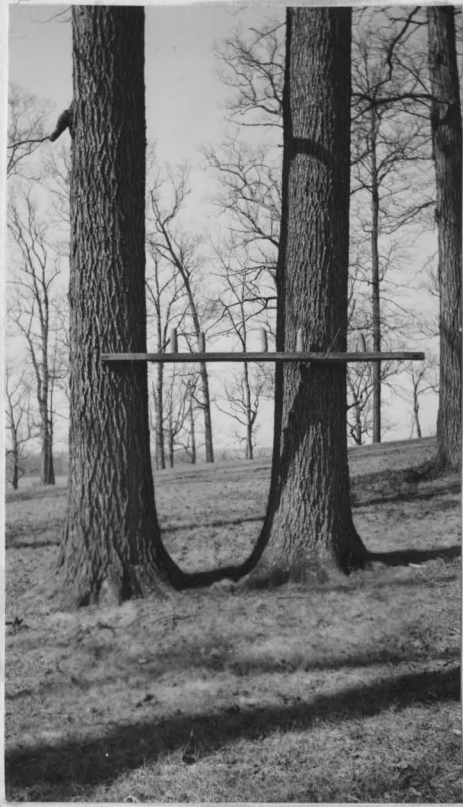


Figure 13. Spike-pole feeding station used by Chapman and Baumgartner.

this is not to be recommended during closed seasons. In Virginia, more is the way more susceptible to squirrel damage, and this is attacked only during acute shortages.

Hunting Methods in Virginia



Figure 14. Spike-board feeding station used by Chapman and Baumgartner.

Seasonal Open Feeding Season, Its Advantages and Disadvantages

The hunting season on gray squirrels varies considerably in the 100 counties that make up Virginia; in 81 of these counties there is a September season on squirrels while in the 19 remaining



Figure 15. Spike-stump feeding station.



Figure 16. Simple method of wiring corn to trees.



Figure 17. An excellent type of squirrel nesting box to be used where natural dens are scarce. (Photo by C. O. Handley)

Four specimens of this parasite were collected and identified as Cuterebra sp. Additional information concerning these parasites may be found in Chart 7 and 8.

Abnormal Pelage

A total of six squirrels possessing odd coloration were handled during the investigation. One of these, an adult female, was trapped by Shipley (12) in 1940 and mention was made of the unusual color. He also trapped two other animals with similar markings. All of the squirrels examined were marked according to Shipley's description. Each had five reddish brown stripes running lengthwise on the belly and sides. The limbs and underparts of the neck and jaw were of a rusty brown color and the back was of a darker and more reddish gray than usual. Except for these odd markings the squirrels were normal in all other respects.

Normal Variations in Pelage

The gray squirrel in Southwest Virginia undergoes two changes in color each year. During the summer the coat is a rather dark-reddish-brown while the winter coat is of a much lighter gray. The change from summer to winter pelage begins about the latter part of September and by the first of November the majority of the squirrels possess their full winter coats. The second change occurs in the spring but time did not permit the author to make observations regarding the actual dates.

Sex Ratio

A total of 242 squirrels trapped by Shipley (12) in 1940-1941 plus 152 animals trapped by the author in 1941 showed a ratio of 51.7 per cent females as compared to 48.3 per cent males.

Per Cent of Young and Adult Squirrels Killed During the Hunting Seasons

In September, 1941 a total of 103 squirrels killed by hunters indicated a ratio of 61.1 per cent adults and 38.9 per cent young animals from the spring brood. However, it should be mentioned that the adult females comprised 37.8 per cent of this number. Possibly the reason for this increase is due to the fact that 100 per cent of these females were lactating and required a comparatively larger amount of food. Therefore, they were forced to expose themselves more often to the hunter's gun. For further information on this subject please refer to Tables 7 and 8.

MANAGEMENT

Due to the abundance of gray squirrels, as compared to other game species, little or no management work has been done, nor has it been necessary until recent years. Slowly but surely, our squirrel population has been dwindling with the timber resources which are the source of its very existence. The addition of an annually increasing army of sportsmen plus unfavorable hunting seasons has greatly accelerated this downward trend. In order to perpetuate the present populations and increase them whenever possible, the following management practices have been listed.

Protection of Den Trees

The lack of suitable nesting cover is one of the most important factors limiting gray squirrel populations. This is readily seen if squirrel populations of immature woodlots are compared to those composed of mature trees. The older trees are more likely to possess the larger number of hollows which make ideal squirrel dens. Therefore it is a management practice of prime importance to save at least one den tree per acre if the numbers of the gray squirrel are to be increased.

Use of Artificial Nest Boxes

This practice has produced some excellent results. C. L. Bunn (4) erected 50 nest boxes in a 50 acre fairly open woodlot in North Carolina in the late summer of 1941. As many as 86 per cent

of the boxes were in use at one time during the fall nesting season. Although this method of management is indeed beneficial it is too expensive and time consuming to be put into effect on large areas. It could be used to the best advantage on demonstration areas to illustrate the great importance of leaving den trees for squirrels.

Winter Feeding

If there is a sufficient mast crop it is unnecessary to feed squirrels in winter except during periods of deep snow or heavy sleet. The animals are capable of finding sufficient food as long as it is possible for them to dig into the ground for buried nuts, roots, tubers, etc.

Handley (8) noted that squirrels utilize quail feeding shelters which are placed inside or on the edge of woodlots. When ear corn is used in the shelter the squirrels eat only the kernel from the grain and the remaining part is consumed by the quail.

Due to a comparatively mild winter there was not sufficient opportunity to experiment with the various types of feeding stations. The feeding stations illustrated in Figures 13, 14 and 15 were used by Chapman and Baumgartner (5) in Ohio.

Methods of Controlling Damage to Farm Crops

During the course of this investigation crop damage caused by squirrels was too insignificant to warrant any practice of control. The usual method employed in Virginia is shooting but

this is not to be recommended during closed seasons. In Virginia, corn is the crop most susceptible to squirrel damage, and this is attacked only during mast shortages.

Hunting Methods in Virginia

Many species of our wild game are pursued by means of stalking or "still hunting", as this method is commonly called. The principle upon which this manner of hunting is based is the fact that the quarry is sighted because of its own voluntary movements rather than by being jumped or flushed by the hunter.

The use of a dog for hunting squirrels is a common practice in Virginia when the trees are bare. The squirrel, upon being "treed", is more easily seen by the hunter if the trees have shed their leaves. The usual procedure, which is very similar to raccoon or opossum hunting, is to release the dog and simply wait until the familiar "tree bark" is heard. The hunter then closes in and bags his quarry provided the squirrel has not escaped to a den or nest. Where dens are numerous the sport becomes more difficult since a larger percentage of squirrels escape before the hunter arrives upon the scene.

Present Open Hunting Season, Its Advantages and Disadvantages

The hunting season on gray squirrels varies considerably in the 100 counties that make up Virginia. In 81 of these counties there is a September season on squirrels while in the 19 remaining

counties the season does not open until mid-November or the first of December. However, we are primarily concerned with the shooting that occurs September 1-15.

It is in the month of September that the "cutting season" usually reaches its peak. At no other time does the "still hunter" enjoy his sport more thoroughly. There is sufficient foliage for the sportsman to move through the forests virtually unseen by the wary squirrel and normally the weather is not warm enough to be unpleasant. Where squirrels might be damaging corn crops the problem is soon solved by hunters anxious to fill their bag limits. After several days of continuous shooting the animals seek the deep forests rather than the edges adjacent to fields.

Quite contrasting and far more important are the disadvantages of our September hunting season. First and foremost is the fact that one of the two main breeding seasons extends through this period. The gestation period, previously discussed under the section on "Life History", might be briefly summarized. The gray squirrel produces a fall brood about the first of August. This brood remains in the nest for approximately six weeks. Assuming that all broods are born between August 1-15, then these squirrels would leave the nest between September 15 and October 1. In the meantime, should the mother of the brood be shot, these young squirrels are lost because of starvation.

Some amazing yet perfectly logical conclusions concerning

this matter resulted from an investigation carried out in Campbell and Amelia counties September 1-15, 1941. The author examined 103 squirrels killed by hunters and found that 39 (37.8%) of that number were adult females. Exactly 100 per cent of these females were lactating, and would have continued so throughout the hunting season. Since the average gray squirrel litter is composed of 2.5 individuals it is estimated that by bagging 39 lactating females we have also killed 97.5 young squirrels by starvation. Furthermore, had the season been postponed until October 15 these young squirrels would have been out of the nest and the total number of animals to be hunted would have undergone a 95.3 per cent increase. By changing the hunting season to open October 15 we would save our fall brood of squirrels and also be assured of approximately twice as many squirrels to hunt. The only possible objection to this change might be heard from those who think it "unsportsmanlike" to shoot squirrels slightly more than half-grown. The author prefers to kill a half-grown squirrel outright, rather than be responsible for the deaths of two or more smaller animals through the slow process of starvation.

Each year numerous squirrels are killed by hunters, only to be discarded because of warble infestation. During the investigation, previously mentioned, it was found that 29(28.2%) of the 103 squirrels examined were infested with one to four warbles each, while 5(4.8%) possessed scars from which the parasites had only recently emerged. By mid-October a large number of these parasites have matured and

Chart 8. Shot Squirrels Examined in Campbell County, Virginia

September 1-7, 1941

Breeding Condition

Sex	: Adult Female	: Young Female	: Adult Male	: Young Male	: Total			
Dormant	:	9	:	2	:	11	:	22
Lactating	: 18	:	:	:	:	:	:	18
Breeding	:	:	:	8	:	1	:	9
Total	: 18	:	9	:	10	:	12	: 49

Degree of Warble Infestation

Warbles Present	:	2	:	1	:	7	:	5	:	15
Warble Scars	:	3	:	1	:	:	:	:	:	4
No infestation	:	13	:	7	:	3	:	7	:	30
Total	: 18	:	9	:	10	:	12	:	49	

Chart 9. Shot Squirrels Examined in Amelia County, Virginia

September 8-15, 1941

Breeding Condition

Sex	: Adult Female	: Young Female	: Adult Male	: Young Male	: Total			
Dormant	:	10	:	3	:	9	:	22
Lactating	21	:	:	:	:	:	:	21
Breeding	:	:	:	11	:	:	:	11
Total	21	:	10	:	14	:	9	54

Degree of Warble Infestation

Warbles Present	:	5	:	1	:	5	:	3	:	14
Warble Scars	:	1	:	:	:	:	:	:	:	1
No Infestation	:	15	:	9	:	9	:	6	:	39
Total	:	21	:	10	:	14	:	9	:	54

Chart 10. Shot Squirrels Examined On Cumberland State Forest

Cumberland County, Virginia

December 8-14, 1941

Sex	: Adult Female	: Adult Male	: Young Female	: Young Male
Lactating	: 1	:	:	:
Pregnant	:	:	:	:
Breeding	:	: 2	:	:
Dormant	: 1	: 2	: 8	: 10
Total	: 2	: 4	: 8	: 10

emerged from their hosts therefore this portion of the kill is not wasted. Additional information on warbles may be found in Tables 7 and 8.

A third objection is brought about by the variation of hunting season dates in different counties. In Amelia county in 1941 there was a September squirrel season while in every adjacent county the season was closed. The obvious result was a great influx of hunters from neighboring counties and the annual kill was far above that of normal years. Such conditions will seriously affect squirrel populations within a very short time.

Another objection to this is frequently heard from sportsmen and others. It is felt that other game is poached during this period; especially the wild turkey. No conclusive information has been found pertaining to this subject.

Recommendations for Hunting Season

1. Due to the conflict between the fall breeding period and the September (1-15) hunting season it is suggested that this season be changed to open October 15 and close October 31. An even better proposal would be to have a statewide closed season until November. However, the latter would prevent any satisfactory "still hunting" because the trees are usually bare by this time.

2. It would be desirable to maintain the same hunting dates over the entire state. This would eliminate dangerous concentrations of hunters in those counties that have early open seasons.

If entirely necessary the season dates may differ east and west of the Blue Ridge Mountains, but further exceptions would be decidedly detrimental. Many sportsmen west of the Blue Ridge prefer early seasons because of the inclement weather which usually prevails throughout the mid-winter.

3. Laws permitting landowners and tenants to hunt squirrels during closed seasons should be abolished. It has been the author's experience to find such people hunting regularly from early August until the general hunting season opens. Obviously, untold losses in gray squirrel populations result from this practice.

4. Where squirrels are believed to be damaging farm crops during closed seasons, control should be supervised by a county Game Warden. Permits allowing squirrels to be killed in the immediate vicinity of the damaged crops should be issued only after each complaint has been thoroughly investigated by the Warden. It has been found that many people use this excuse in order to secure a permit to hunt early.

Management of the Habitat

The purpose of a sound management plan is to provide a habitable range for the species to be managed. Leopold(9) describes this perfect environment as one which furnishes places for the given species to hide, sleep, rest, feed, play, and breed, all within the reach of its cruising radius. Thus, we find that a habitable range for the gray squirrel is indeed a simple one. A mature stand of oak-

hickory or other nut-bearing trees furnishes all of the requirements in order that this animal might thrive. Some desirable management practices are hereby listed.

Management of The Mature Woodlot

1. Protect den trees from being needlessly destroyed.
2. Guard against overgrazing. Forest reproduction is decreased by grazing and where this practice becomes excessive the woodlot is soon made less habitable for squirrels.
3. Unless otherwise advisable do not remove fallen logs or trees from the woodlot. Squirrels utilize these as runways and they often furnish excellent protection from predators.
4. Erect artificial feeding stations during mast shortages or whenever there is deep snow or heavy sleet.
5. Predator control is unnecessary except in rare cases.
6. The hunting season should be made to open not earlier than October 15 and close not later than December 15. The spring breeding season begins during the latter part of December.

Management of The Immature Woodlot

1. Erect nest boxes if den trees are scarce. This procedure might prove impractical on large areas due to excessive costs and labor. If possible there should be at least one den or nest per acre. Sanctuaries are indeed valuable where costs of managing the entire area are prohibitive. Here if food and cover can be increased to a

maximum the resulting populations will overflow and restock the surrounding open territory.

2. Guard against overgrazing.

3. Construct artificial feeding stations for use until the mast crop becomes sufficiently large to take care of the squirrel population. Feeding stations should by all means be utilized during periods of deep snow or heavy sleet.

4. Restocking is not recommended where breeding stock is already present. The rate of increase may be stimulated by declaring a closed season on the area until the desired population is acquired. Any type of restocking is to be discouraged where other methods can be put into effect. The practice is costly and satisfactory results are seldom obtained.

5. Plant mast bearing trees if necessary.

6. If the hunting season is opened the dates should correspond to those recommended for a mature woodlot.

7. Predator control is necessary only in rare cases.

Restocking

As already mentioned, this practice is not advisable except on areas where no breeding stock is present. If squirrels are taken from open hunting territory and used for restocking it will be necessary to transport them at least ten miles from the point of capture before releasing. The homing instinct is indeed strong in these animals, as proven by Shipley (12). Possibly the best results

would be obtained if young squirrels were used for this purpose.

It is suggested that squirrels from the spring brood be used for restocking depleted woodlots. The animals might be trapped when they are approximately four to five months of age. Therefore, the program should be carried out in June or July of the same year the squirrels are born. The animals will become accustomed to their new home before the critical winter season arrives and few losses will occur if suitable den sites or nests and food has been provided. These squirrels will produce their first brood during the following spring. A continuous closed season should be declared for at least one year after the squirrels have been restocked.

Breeding Potential of the Gray Squirrel in Virginia

1	2	3	4	5	6	7	8
Minimum	:	:	:	:	:	:	:
Age of	:Young	:Litters	:Young	:	:Females	:Ges-	:Maximum
Bearing	:Per	:Per	:Per	:Mating	:Served	:tation	:Longevity
Young	:Litter	:Year	:Year	:	:By 1 Male	:(days)	:(years)
1	:(2.5)	2	:(5)	Pr.	?	44	15

Authorities: 1, 3, Cross; 2, 4, Bunn; 1, 2, 4 Shipley; 5, 7, 8 Seton

Note: Figures in brackets are assumptions backed by authority.
 In the column "mating", Pr. - promiscuous.
 Chart form taken from Leopold (9).

SUMMARY AND CONCLUSIONS

1. The gray squirrel has decreased greatly in numbers during the past one hundred years.
2. There is very little scientific literature available on the gray squirrel at the present time.
3. Live-trapping and ear-tagging or toe-clipping are the most accurate means of taking a gray squirrel census, but a count of leaf nests or dens is a more practical means of censusing, depending upon the type of forests.
4. Mature forests of oak-hickory were the favorite habitat of gray squirrels on the areas considered in the present investigation.
5. Low temperatures and high winds are the most important climatic features controlling the activity of squirrels, as these factors will cause most squirrels to remain in their dens or nests during cold spells in the winter.
6. Abrupt temperature changes cause an increase in gray squirrel activities.
7. There is a tendency for squirrels to be more active on dull cloudy days than on bright sunny days, provided the weather is mild under both conditions.
8. Gray squirrels prefer to have a permanent supply of water in the woodlots they inhabit, but they are able to live under drought conditions for a part of the year.
9. There are five races or varieties of gray squirrels found in the Eastern United States.

10. In Virginia two races of squirrels are found, the Southern or Carolina Gray Squirrel - Sciurus carolinensis carolinensis and the Northern Gray Squirrel - Sciurus carolinensis leucotis. The ranges of the two races are imperfectly known in Virginia.
11. Two breeding seasons are found in the gray squirrel in Southwestern Virginia, one in midwinter and the other in midsummer.
12. The gray squirrel has two daily periods of activity, one in the early morning and the other in the late afternoon.
13. Definite feeding periods are not so pronounced where squirrels live under park-like conditions.
14. Native squirrel foods are comparatively scarce during midsummer.
15. Gray squirrels do not hibernate, except for a day or two at a time during cold spells in the winter.
16. No evidence was found to substantiate the belief that gray squirrels castrate their young or each other.
17. Squirrels are comparatively free from parasites. The only evidences were a few fleas and ticks. Squirrels in Campbell and Amelia counties were found to be infested with warbles.
18. The only disease observed in gray squirrels was mange.
19. The principal food of the gray squirrels on the areas studied were the nuts of the white oak, various species of hickories and the black walnut.
20. Gray squirrels are nervous and highly excitable.
21. Few of our native animals are able to move about in the trees with the ease that is possessed by gray squirrels.

22. There is little friction between gray squirrels and other native birds and mammals.
23. Family groups of gray squirrels often remain together in the same den through the winter.
24. Squirrels are diurnal animals, though one individual was trapped after nightfall.
25. The use of artificial dens and nestboxes is practicable only on certain areas such as small woodlots, parks or private grounds, and demonstration areas.
26. Shelled corn is the best bait to use when one desires to trap squirrels.
27. Wire traps are the easiest type of squirrel trap to build but a modification of the wooden trap designed by Baumgartner is the most satisfactory type.
28. The monel tag, size I, is superior to the rabbit ear tag as a means of identifying gray squirrels.
29. Squirrels exposed in open traps during inclement weather soon die from exposure.
30. Gray squirrels in Southwestern Virginia produce two litters per year.
31. Scattered breeding occurs at nearly all times of the year.
32. The majority of the trapped squirrels were caught in the morning.
33. Female squirrels which had young in the fall were found to have another litter the following midwinter or early spring.

34. The numbers of gray squirrels fluctuate in any region during a period of years.
35. No evidence of a population shift from one woodlot to another was revealed by the trapping operations.
36. Gray squirrels seem to have a very pronounced homing instinct as is evidenced by the return of some animals to the locality of the original trapping after they had been taken away and released at distant locations.
37. Squirrels generally do not cause any serious damage to crops in Southwest Virginia.
38. The limiting factors upon the gray squirrel are habitat changes and overhunting.
39. The gray squirrels have a very definite aesthetic appeal for most people.
40. The gray squirrel is one of the most important game animals in Virginia.
41. It seems advisable to recommend a hunting season on the gray squirrel in Virginia to open not earlier than October 15 and close not later than December 15.
42. The use of artificial nest boxes is an excellent means of studying the breeding habits of the gray squirrel.
43. Approximately 2.5 young squirrels (average litter) are lost for every adult female killed during the September hunting season in Virginia.

44. Since the fall brood increases the squirrel population by about 98.3 per cent, approximately twice as many animals are available for hunting by October 15.
45. Squirrels from the fall brood are about half-grown by October 15.
46. The variation of hunting season dates in different counties results in abnormally large concentrations of hunters. Such conditions are decidedly detrimental to gray squirrel populations.

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