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LEAF NESTS OF GRAY SQUIRREL IN CONNECTICUT

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In the fall of 1941, a study of leaf nests of the gray squirrel (*Sciurus carolinensis leucotis* Gapper) was conducted on the Litchfield-Morris Wildlife Sanctuary in west-central Connecticut. This sanctuary, about 4,000 acres, is located in the triangle formed by the villages of Bantam, Litchfield, and Morris. The area is about ninety-five percent forested with second-growth hardwoods, old field white pines, and coniferous plantations. Much of the land was originally in farms, so the few mature trees present are confined to old fence rows and isolated groves.

A census of gray squirrel populations, based on leaf nests (Goodrum, 1937), was attempted on the sanctuary and it was decided to parallel this work with a detailed study of the nests. The paucity of information on this subject seemed to warrant an investigation. Audubon and Bachman (1846–54) and Seton (1928) have written general accounts of the leaf nests of the gray squirrel. Middleton (1931) has done the same for the gray squirrel introduced into England. Chapman (1938) has made an intensive survey of gray squirrel leaf nests in southern Ohio, but his work is unpublished. Other authors have described the nests of the Western gray squirrel (Grinnell and Storer, 1924; Merriam, 1930), fox squirrel (Stoddard, 1919; Baumgartner, 1940), red squirrel (Hamilton, 1939; Hatt, 1929; Merriam, 1884), and the flying squirrel (Cowan, 1936). Studies of leaf nests of the gray squirrel in Connecticut are confined to the works of Goodwin (1935) and Goldstein (1940).

The investigation was confined to a tract one-half mile wide and one and a half miles long. Parallel lines running one eighth mile apart across the long axis were used to obtain a fair sample of the area. When a nest was located, the forest type, species of tree, and the diameter breast high were recorded, as were the distance of the nest from the ground, measured to the nearest tenth of a meter, and the total height of the tree (estimated). Position of the nest in the tree was described usually with the aid of a sketch. The exterior of the nest

was measured for length, width, and depth, as was the cavity within. Measuring the inner cavity proved to be difficult as the materials inside were usually soft and in the course of measuring the cavity would either be distorted or destroyed. The nest was taken from the tree, wrapped in an old sheet, and lowered to the ground. It was weighed and torn apart to determine the percentages of the various structural materials. The twigs were separated and weighed. The maximum and average diameters and the length of the average twig were measured. These data were recorded in a field notebook and later transferred to forms.

The gray squirrel uses two types of habitation: dens in tree cavities and outside leaf nests. The first provides permanent residences, but the leaf nests, which are the objective of this study, are transitory structures. Their construction is necessitated by several reasons; prominent among which is the lack of suitable shelter in the form of dens. During the winter months, the animals live and sometimes congregate in dens, but the advent of warmer weather and the mating season cause a reassertion of anti-social tendencies. The animals spread out from the communal den to find individual quarters. If these are not available in sufficient numbers to accommodate the population, leaf nests must supply this need.

A second reason that would seem to be important is sanitation. Like most arboreal species, the squirrels void their feces without regard to sanitary measures. Furthermore, the ectoparasites in occupied nests are legion, so it would seem that the desire for clean quarters was one of the prime considerations in seeking new summer lodgings. This need for sanitary quarters may initiate the maternal instinct that causes the mother to move her young from the den where they are usually born to a new leaf nest (Bailey, 1925). In some cases the young may even be born in a leaf nest as a week-old litter was found in a leaf nest by the writers on March 12, 1942.

Leaf nests have still another reason for their existence in that dens must be utilized where found, without regard to the squirrel's territory or food supply. In the case of leaf nests, location is primarily subject to the squirrel's whim. Thus the animal can choose a site more closely associated with its chief food supply than might be possible in the case of its den. In fact, the fox squirrel has been observed to build an outside nest where it stopped for only a day (Audubon and Bachman, 1851; Seton, 1928).

The number of nests built by a squirrel during the season is a controversial point. The writers found one nest to a tree, although there was evidence of new nests being built over the remains of previous ones. A census based on the supposition that the animals build only one nest gave reasonable results, hence, this conclusion is probably correct in most cases. One instance was recorded of three nests being found in mature white pines within a radius of fifty feet. While one was of recent origin, the others had been constructed earlier in the year, although still serviceable and containing fragments of green vegetation. It seems reasonable to suppose that one squirrel built all these nests, but, as Dr. F. B. Chapman has suggested, the older nests could have been the work of other

squirrels that moved out of the territory or were evicted by the owner of the recent nest.

It was necessary in the survey to determine whether a nest had been used the previous season. The chief factors in this determination were the condition of the materials and the appearance of the nest. When the majority of the nest material was green and the inner chamber dry, there was no doubt as to the proper category of the nest. Those built in the early part of the season presented a more difficult problem and the writers freely admit that there were several borderline cases. The vegetation had lost its greenness and the insects had usually worked it over thoroughly so that the remaining leaves offered little or no protection. Some types of vegetation, that is, mosses, retained their greenness over more than one season. Thus, it was necessary to use supplementary indications. Hair was found to be an excellent index to the species using the nest. Furthermore, it appeared to be present only in the more recent nests. As adult fleas that have fed will live about one hundred days (Metcalf and Flint, 1939) the presence of these parasites was taken as a good indication of the use of the nest. In the final analysis, 60 percent of the nests that were adjudged active, that is, in use, had fleas present.

NEST TREES

The 146 leaf nests examined were found in thirteen species of trees. White pine and hemlock were the only coniferous species containing nests, although red pine, white spruce, and Scotch pine were well-represented as pole plantations. Hickory, beech, alder, hop hornbeam, white birch, American hornbeam, and shadbush were available hardwood species that were not used.

Table 1 lists the tree species as regards the numbers and percentages of nests present and the numbers and percentages of active nests, both by species and by total number. Five species of trees contained 83.7 percent of the nests. The data showed quite conclusively that, on this area, white pine was the most important tree species as regards the location of squirrel leaf nests. The remainder contained few nests. White pine contained 54.1 percent of all the nests. This preference was not tempered by availability as 47 percent of the nests in white pines were in isolated trees in second-growth hardwood stands. The two coniferous species, white pine and hemlock, contained 59.6 percent of the nests, which was significant as the area was predominantely hardwoods. These figures seemed to be contrary to the popular belief that gray squirrels favor hardwood stands. As mentioned previously, many of the nests were in isolated pines and there were no nests found in red pine, Scotch pine, or white spruce plantations.

Sixty-six (45 percent) of the nests were considered active. White pine had the greatest number of these, 37 or 56.1 percent. Red maple was second with 9.1 percent and black birch third with 7.6 percent. Red maple doubtless owed its importance to the red maple-elm swamps, one of the major types on the area. These data assumed a different aspect on examination of the percent of active nests by species. Red oak, white oak, black birch, and yellow birch were the only species that had over 50 percent of their nests classified as active. The

nests in white pine were found to be 46.8 percent active, which was close to the 45.2 percent average for all species. Gray birch attained a high position in the number of nests present, but dropped sharply in the percentage of active nests. The trends in black birch and yellow birch were directly opposite. These may be explained partially by the fact that every nest seen on the lines was examined even if it contained no more than a bundle of twigs. Thus the gray birches with their lacy crowns offered the maximum of visibility as compared with the larger birches (see Table 2).

Discarding as incomplete samples the three species, elm, ash, and sugar maple, that were represented by a single tree each, Table 2 shows the relationship between the height of the nest and the height and diameter of the nest tree. The maximum, minimum, and average heights at which the nests were found are given. As there was apparently no maximum to the diameter or height of the nest tree used, only average and minimum diameters and heights are tabulated.

TABLE 1.—*Percent and number of total and active leaf nests by nest tree species*

SPECIES	NO. OF NESTS	% OF TOTAL	NO. OF NESTS IN USE	% TOTAL IN USE	% BY SP. IN USE
White pine (*Pinus strobus*)	79	54.1	37	56.1	46.8
Red maple (*Acer rubrum*)	15	10.4	6	9.1	40.0
Gray birch (*Betula populifolia*)	13	8.9	4	6.1	30.8
Hemlock (*Taxus canadensis*)	8	5.5	2	3.0	25.0
White oak (*Quercus alba*)	7	4.8	4	6.1	57.0
Black birch (*Betula lenta*)	5	3.4	5	7.6	100.0
Yellow birch (*Betula lutea*)	5	3.4	3	4.4	60.0
Apple (*Pyrus malus*)	4	2.7	0	—	—
Red oak (*Quercus* spp.)	4	2.7	4	6.1	100.0
Black cherry (*Prunus serotina*)	3	2.0	1	1.5	33.3
White ash (*Fraxinus americana*)	1	.7	0	—	—
White elm (*Ulmus americana*)	1	.7	0	—	—
Sugar maple (*Acer saccharum*)	1	.7	0	—	—

In examination of Table 2 it would be well to keep in mind the form of the various species of trees. For instance, apple had the largest average diameter, but the smallest average height, due to its growth habits. The minimum dimensions utilized were 15 centimeters d.b.h. and 8 meters in height. These measurements had added significance in that they were also the minimum for the tree species making up almost 70 percent of the nest trees: white pine, gray birch, and hemlock. The trees with the smallest average heights (hemlock, gray birch, and apple) were still above sapling size. The use of small hemlock and apple trees was understandable in that the first with its dense crown and evergreen foliage offered excellent cover and the second was a highly prized food. Gray birch was naturally a small-sized tree and was utilized in red maple swamps or hardwood stands where pine was not common. Furthermore, only 30.8 percent of its nests were active, the majority being remnants of previous seasons. The other species used for nest trees were all of medium size, showing that the squirrels chose good-sized trees.

The correlation between the height of nest and height of tree is demonstrated in Fig. 1. Here the average height of the tree was plotted over the average height of the nest above the ground in descending sequence.

TABLE 2.—*Heights of nests and diameters and heights of nest trees by species*

SPECIES	NO. OF NESTS	AVER. DIAM.	MIN. DIAM.	AVER. HT.	MIN. HT.	AVER. HT. NEST	MAX. HT. NEST	MIN. HT. NEST
		cm.	*cm.*	*m.*	*m.*	*m.*	*m.*	*m.*
White pine	79	40	15	17	8	11.8	22.0	3.5
Red maple	15	30	20	15	10	10.9	14.9	7.1
Gray birch	13	15	15	12	8	9.6	14.4	7.0
Hemlock	8	20	15	12	8	8.5	14.1	4.6
White oak	7	45	30	19	9	10.1	18.5	4.3
Black birch	5	30	20	18	17	13.8	15.0	11.1
Yellow birch	5	25	20	17	12	11.9	19.4	5.7
Apple	4	50	30	11	10	7.6	9.0	6.0
Red oak	4	35	20	17	15	11.2	13.3	7.6
Black cherry	3	30	25	16	15	10.9	12.3	8.3
Total	143	35	15	17	8	11.1	22.0	3.5

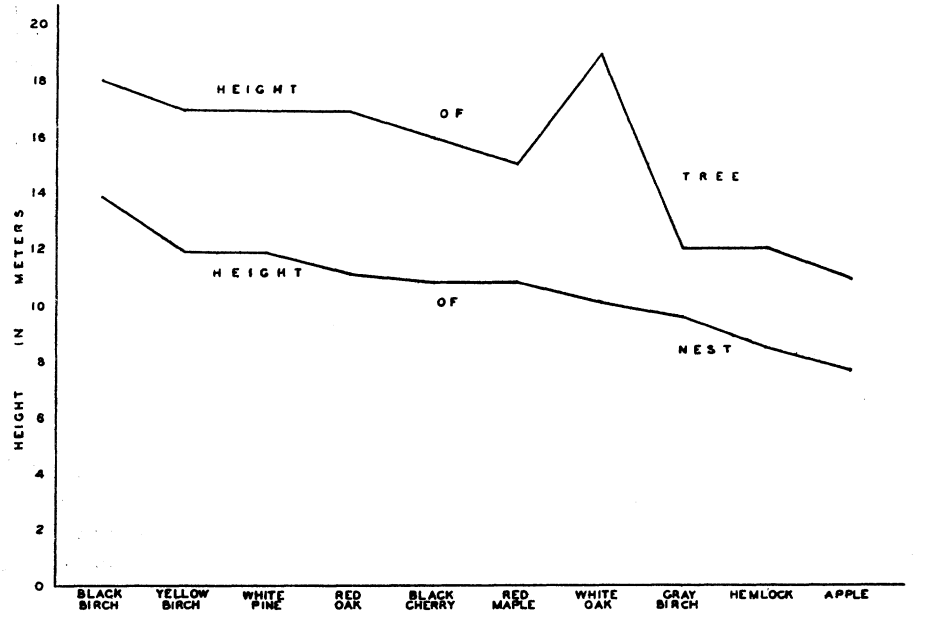

FIG. 1. Correlation of tree heights and nest heights

With the exception of white oak, a definite correlation can be found. The distance between the top of the tree and the height of the nest can be seen to be fairly constant with a progressive decrease in the smaller trees. Furthermore, this distance can be sharply divided between the small trees (gray birch, hemlock,

and apple) and the larger trees, red maple showing the transition. If more samples of white oak had been possible a smoother curve would probably have resulted. A possible explanation of this correlation is that the nests were usually found to be at the base of the crown in the larger trees and well up into the top of the smaller trees.

NEST

The construction of the nest varied so considerably that only a few generalizations could be made. It was built either in the top fork of the smaller hardwoods or close to the trunk on a main branch in the larger trees. Only 3.4 percent of the nests were built on lateral branches at any distance from the main stem. While the nests were generally globular, no true generalization could be made, as the shape was dependent upon the position and form of the supports utilized. The outside dimensions of the nests averaged 35 centimeters by 45 centimeters and 30 centimeters high, comprising a bulk of 47.25 litres. The largest found was 30 by 70 by 70 centimeters (147 litres) and the smallest was 30 by 30 by 20 centimeters (18 litres). There was usually only one well-concealed entrance to the nest. In most cases this faced the main trunk or the nearest limb that afforded a good runway, having no tendency to favor any particular point of the compass. The chamber lay a few centimeters below the opening giving the animal added protection. The dimensions of this inner cavity ranged from 17 by 18 by 16 centimeters (4.9 litres) to 9 by 10 by 6 centimeters (0.5 litres), the average being 12 by 15 by 9 centimeters (1.6 litres). The average weight of the nest was 1300 g. These weights varied between 450 and 4450 g. A comparison of these measurements with those taken of leaf nests in Ohio (Chapman, 1938) showed that the nests in Connecticut were consistently larger.

The nest consisted of three or four parts. A platform of twigs, generally of the nest-tree species, formed the base and support for the nest proper. Mixed with the twigs and forming a felted base for the floor of the inner chamber was a compacted mass of organic debris in varying stages of decomposition. Due to compression by the weight of the animal and the retention of moisture, decay was well-advanced in this region no matter how recent the nest. An outer shell of leaves and twigs protected the animal and made up the conspicious part of the nest. In over seventy-five percent of the nests there was a fourth part, an inner shell. This was either of shredded bark, grass, or the same material as in the outer shell, but it could be separated easily due to the interweaving of its components. This shell, when present, must have provided most of the warmth and protection.

The nests appeared to be built along three general plans: (1) freshly cut twigs with their leaves attached were packed in a support, usually a large crotch; (2) single leaves or short twigs with several leaves attached were woven together and held in place by a loose framework of dry twigs from the nest tree; or (3) simply a mound of grass, shredded bark, sphagnum moss, or similar material was placed on a platform and burrowed into. The first type was typical of that found in hardwood trees, particularly the birches. The second was prevalent

in the pines where oak leaves were used. The last type was the least common and did not appear to be restricted to any particular circumstances. These last two and sometimes the first type were built over a platform of twigs, usually taken from the nest tree. These platforms were elaborate or primitive, depending upon the supports. If the nest were located in the top of a small hardwood, the twigs were woven through several fine branches into a basket-like support that took up two-thirds the height of the nest. If the nest were in the main crotch or on a large branch, the platform was rudimentary.

NEST MATERIALS

Examination of the nest material was arbitarily divided into two classes: inside and outside. The inside of the nest was taken as that material forming the lining of the inner chamber. Usually this could be detached in the form of a hollow ball. The outside included the remainder of the material irrespective of whether it was exposed to the elements or lay under one or more protective coats of leaves. Table 3 lists the species of vegetation found in the nests, their total frequency, and their frequency in the outside and inside portions. It was based on 70 leaf nests, 58 of which were active and 12 inactive but in good condition.

Besides the above, the following species occurred once in the nests examined: beech (*Fagus grandifolia*), American elm (*Ulmus americana*), apple (*Pyrus malus*), chokecherry (*Prunus virginiana*), shadbush (*Amelanchier canadensis*), laurel (*Kalmia latifolia*), hop hornbeam (*Ostrya virginiana*), arrow-wood, (*Viburnum dentatum*), goldthread (*Coptis trifolia*), raspberry (*Rubus* spp.), blueberry (*Vaccinium* spp.), wild pea (*Lathyrus* sp.) and sedge (*Carex* spp.).

The oaks were the most important species in frequency and amount of materials utilized. Of the nests examined, 71 percent contained material from white oak and 70 percent from red oak. As white oak and red oak made up only 7.5 percent of the trees used as nest locations, it would indicate the chief value of these species was to provide nesting materials. White pine and red maple followed the oaks in both frequency and amount of materials used and doubtless owed their importance to their high rank as nest tree species. Shredded bark was used in some nests in great profusion and can be considered one of the most important of the inside materials. The mosses were not separated in determining frequency but the following species were determined: *Polytrichum commune*, *Calliergon cordifolium*, *Heterophyllium halanianum*, and *Sphagnum* spp. The main use of the mosses, as well as grasses and sedges, was in the lining of the inner chamber. These materials and shredded bark were also used in the construction of the third general plan of nest as previously mentioned. The presence of small forms, such as club moss, ferns, goldthread, pea, and raspberry, was difficult to explain as, with the exception of raspberry, it is doubtful that they were used for food. Furthermore, although some of these were found in a number of nests, they were represented by a single stem in most instances.

Audubon and Bachman (1846), describing the building of leaf nests by gray squirrels, said, "When constructing this summer-house it does not descend to

the earth in search of materials, finding them ready at hand on the tree it intends to make its temporary residence." The writers found their data at variance with this statement as only 8.6 percent of the nests showed that they were made up entirely of materials from the nest tree species, two being in white oak and one each in red oak, red maple, gray birch, and yellow birch. Sixty percent of the nests were made of a major percentage of materials from the nest tree. The maximum number of species found in a single nest was 14, the average, 6. The twigs used in the framework were generally taken from the nest tree. The

TABLE 3.—*Frequency of the various species of vegetation found in the outside and inside portions of the nest*

SPECIES	TOTAL (%)	OUTSIDE (%)	INSIDE (%)
White oak (*Quercus alba*)	71	57	50
Red oak (*Quercus* spp.)	70	64	50
White pine (*Pinus strobus*)	50	50	31
Shredded inner bark of various species	50	20	50
Red maple (*Acer rubrum*)	46	39	34
Mosses (*Bryophyta*)	27	13	21
Sugar maple (*Acer saccharum*)	24	19	16
Grasses (*Gramineae*)	24	1	24
Yellow birch (*Betula lutea*)	21	19	14
Black birch (*Betula lenta*)	20	17	13
Ground pine (*Lycopodium complanatum*)	17	1	17
Chestnut (*Castanea dentata*)	17	16	11
Gray birch (*Betula populifolia*)	16	13	10
Black cherry (*Prunus serotina*)	14	9	10
Aspen (*Populus tremuloides* & *P. grandidentata*)	12	7	5
Outer bark of various species	10	—	10
Grape (*Vitis* spp.)	9	3	7
Tree fern (*Lycopodium obscurum* var. *dendroideum*)	7	3	4
Hickory (*Carya* spp.)	7	4	4
White ash (*Fraxinus americana*)	7	5	4
Ferns (*Pteridophyta*)	6	—	6
Thorn apple (*Crataegus* spp.)	4	3	1
Hazelnut (*Corylus americana*)	5	1	5
Elm (*Ulmus americana*)	4	3	3
Hemlock (*Taxus canadensis*)	3	3	1
Dogwood (*Cornus* spp.)	3	3	—

proximity of the various species of vegetation to the nest tree did not necessarily determine their use.

The weight of the twigs used in the support of the nest averaged 300 g. or 23 percent of the total weight. The diameters of these twigs at the butt were found to average 4 millimeters, the spread being from 2 to 10 millimeters. The average length of the twigs was 40 centimeters.

In addition to vegetation, bird feathers, paper, and cloth were also found. The feathers of a ruffed grouse were found on the outside of one nest, but may have been left there by the bird itself rather than carried up by the squirrel.

The inside of another nest was well-lined with feathers that were believed to be those of a slate-colored junco. Paper and cloth from a "No Hunting" sign were torn in small strips.

Remnants of food (gnawed bones, cherry pits, red and white acorn husks, whole acorns, pine cones, and skunk cabbage seeds) were common, showing that the squirrels had been feeding in or around the nests. The importance of skunk cabbage as a food of gray squirrel was indicated by the fact that 20 percent of the nests contained one or more seeds of this species. White oak acorns or husks were present in 26 percent of the 70 nests.

Insects were very common in the nests. Several collections were made and the writers wish to express their appreciation of the work done by V. M. Carolin, Jr., of the Department of Entomology, New York State College of Forestry, Syracuse, New York, in identifying these collections. As mentioned above, fleas were found in 60 percent of the nests. These were all of the genus *Megabothris*. Larvae and pupae of the following insect families were represented by one or more species: *Noctuidae*—3 species; *Muscidae*—2 species; *Pyralididae*—1 species; *Tortricidae*—1 species; *Scarabaeidae*—1 species; *Tenthredinidae*—1 species; *Eucleidae*—1 species; *Elateridae*—1 species; *Braconidae*—1 species; *Syrphidae*—1 species; *Cerambycidae*—1 species. The *Noctuidae* and *Pyralididae* were the most abundant insects found. The presence of wood-boring insects as the *Scarabaeidae* and *Cerambycidae* in a structure composed mainly of leaves would be difficult to explain except that they were found in nests containing shredded bark. Thus they may have been carried to the nest with the nesting materials.

Several families were represented by adult forms: *Muscidae*—1 species; *Coccinellidae*—1 species; *Lampyridae*—1 species; *Carabidae*—1 species; *Staphylinidae*—1 species; *Chalcidiae*—1 species; *Miridae*—1 species; *Pselaphidae*—1 species. The occurrence of adult forms is probably accidental in most cases. The *Staphylinidae*, however, were probably scavenging through the organic debris while the *Carabidae* probably were preying on the caterpillars and other forms. Invertebrates, other than the Insecta, included a multitude of spiders, and several centipedes and free-living nematodes.

The commensal relationships between the insects and the squirrels would make an interesting study. The writers noted that skeletonization was heaviest on the inside of the nests and seemed to decrease progressively toward the outside. Insects were found active in the nests after the majority of invertebrates had disappeared. A number of nests had the outer shell so skeletonized by lepidopterous larvae that the inside was damp and uninhabitable although the nest had been built that season. Goodrum (1940) has said, "It is likely that animal food is essential to the gray squirrel in the wild, for over 3.5 percent of its total food consists of insects." If animal food is as essential in breeding as he seemed to think, these leaf nests offer a bounteous supply near at hand.

SUMMARY AND CONCLUSIONS

In the fall of 1941, an intensive study of 146 leaf nests of the gray squirrel was made on the Litchfield-Morris Wildlife Sanctuary in Connecticut. The con-

struction of leaf nests is important in the life history of the gray squirrel as it provides an adequate number of shelters and clean quarters located near a source of food. Nests were found in 13 species of trees; 5 species contained 83.7 percent of these nests. White pine was the most important, as it alone held 54.1 percent of all the nests. It was followed by red maple, gray birch, hemlock, and white oak, respectively. The smallest trees utilized were 15 centimeters in diameter and 8 meters in height. The average nest tree was 35 centimeters in diameter and 17 meters in height, showing that the squirrels preferred good-sized trees. The average height of the nest from the ground was 11.1 meters with extremes of 3.5 and 22.0 meters. Nests were built either in the top fork of the smaller hardwoods or close to the trunk on a main branch in the larger trees. Outside dimensions of the nest averaged 35 by 45 by 30 centimeters or 47.25 litres, while the dimensions of the inner cavity averaged 12 by 15 by 9 centimeters. The average weight of the nest was 1300 g.

The nest consisted of 3 or 4 parts: (1) supporting platform of twigs, (2) a compacted base of decaying organic matter, (3) an outer shell of leaves and twigs, and (4) usually an inner shell of closely woven material. They were constructed along three general plans: (1) loose pile of twigs and attached leaves, (2) single leaves woven into a framework of the twigs, or (3) simply a mound of grass, bark, or similar material. Thirty-nine species of vegetation were found in the nests. The most important species in the order of their frequency appeared to be the oaks, white pine, red maple, moss, sugar maple, grass, birches, ground pine, and chestnut. A fact at variance with former information showed that the nest materials are not necessarily confined to the nest tree species or the nearest species.

Remnants of food were common in the nests. Feather, paper, and cloth were also found. Insects and spiders were abundant. Fleas, *Megabothris* sp., were found in 60 percent of the nests adjudged active. Eighteen families of insects were found in the nests in addition to several centipedes and free-living nematodes.

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THE GIANT RAT-HEADED HAMSTER, *CRICETULUS TRITON NESTOR* THOMAS, OF MANCHURIA

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The giant rat-headed hamster appears to be the largest species of the genus *Cricetulus*, and it is the most injurious rodent to the agriculture of Manchuria. *Cricetulus triton* was described by De Winton and Styan in 1899 from Northern China. Since then a number of subspecies have been named from the northern and western provinces of China, Korea and Ussuriland of the Russian Far East. The giant rat-headed hamster inhabiting Manchuria and Korea was originally described by Thomas in 1907 as a full species under the name *Cricetulus nestor*. It is now considered a subspecies of *Cricetulus triton* and is the largest form of the species.

Prof. S. I. Ognev (1914) worked over a mammological collection from the southern part of the Ussuriland (or Maritime Province) of the Russian Far East and came to the conclusion that the giant rat-headed hamster should be placed in a special genus, as it has a number of peculiarities differentiating it from other members of the genus *Cricetulus*. As a result the generic name *Tscherskia* was proposed by him.

BRIEF DESCRIPTION

The giant rat-headed hamster is a peculiar rodent with wide blunt muzzle and flat massive body, comparatively short legs and tail, and with enormously