Proceedings of the Iowa Academy of Science

Volume 61 | Annual Issue Article 65

1954

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INTRODUCTION

For at least 30 years, during summer and fall months, the shade trees in residential areas of Ames, Iowa, have been a nightly rendezvous for thousands of bronzed grackles, *Quiscalus quiscula,* starlings, *Sturnus vulgaris,* cowbirds, *Molothrus ater,* and robins, *Turdus migratorius.* Each evening the birds have come from the surrounding countryside to roost in the city's trees, and each morning they have left to return to their feeding areas. Relatively few of the birds have remained in Ames during the day.

It was the writer's privilege to have studied this phenomenon from August, 1949, to November, 1952. Throughout this time it was observed that the birds resorted to certain trees night after night, and that they did not use others nearby. Because physical dimensions of the roost places were suspected to have a bearing, several features were measured. Tree size and tree grouping are reported in this paper.

METHODS

Mapping

To learn which trees served as roost places and which ones did not, maps were prepared of 47 city blocks used as roost sites during at least one of the years of the investigation. These maps showed the species and location of all trees, both along the streets and in back yards. Any tree was considered a back yard tree if it was 50 or more feet from the curbing. Hektographed copies of the maps were used to record the location of the roosting birds periodically, the accumulation of droppings beneath the trees serving as a guide. A complete account of the mapping and manner of keepig records is given in Bliese (1953a & b).

Tree Size

To secure information on possible relationships between tree size and degree of roosting use, all trees were measured on the 47 blocks mentioned above. Because the literature listed no single dimension as an ideal index of tree size, two were obtained for each tree: diameter of trunk at breast height in inches, and height of

the tree in feet. The former was measured with a Biltmore stick and the latter by the hypsometer technique. Experience soon revealed that neither of these measurements was clearly superior to the other, and all tabulations were finally made in terms of the more easily measured diameter at breast height (called DBH hereafter).

Tree Grouping

Rather early in the investigation the impression grew upon the writer that the birds tended to use trees that were more closely grouped. This seemed especially true in late June when the nuclei for the roost sites were established. Later, however, as the birds increased in numbers and overflowed to nearby trees, the tendency was less obvious. Data to study this phenomenon were obtained on the 47 blocks which were mapped in detail. Measurements taken included the distances from every roost tree to the nearest two trees, and from every non-roost tree to the nearest two trees, in each case from center of trunk to center of trunk. For this phase of the study only those trees that proved to be of roost size, 7 inches DBH or larger, were considered, and only those city blocks on which at least three roost trees were present were entered in the tabulations. If a roost tree was located between two non-roost trees, or if a non-roost tree was situated between two roost trees, then the pertinent distances were entered in both roost tree and non-roost tree tabulations.

Results and Discussions

Introductory Remarks

As was shown by Bliese (1953a & b), the birds used the trees at Ames selectively for species. Of the three most abundant species of trees present, they roosted in a greater number of American elms, *Ulmus americana,* but on a percentage basis used a larger proportion of black maples, *Acer nigrum,* and Norway maples, *Acer platanoides.* Although available in only small numbers, the following trees species were also used in rather high percentages: Cottonwood, *Populus deltoides;* green ash, *Fraxinus pennsylvanica lanceolata;* box-elder, *Acer negundo*; silver maple, *Acer saccharinum;* hackberry, *Celtis occidentalis,* and catalpa, *Catalpa bignonioides.* Over 40 species of trees in the roost area were never used as roost places.

Tree Size

Increasing DBH and Use by the Birds

Information on the roosting use of street trees, as related to size,

was secured for 1950, 1951, and 1952. Representative of the data obtained, Table 1 shows by size categories the number and percentage of American elms used by the birds on 33 of the 47 blocks in 1951. The table gives results according to the degree or extent of their use by the birds (N - none; L - lightly; M - moderately; and H - heavily), as well as simply "use" regardless of extent (L&M&H - lightly plus moderately plus heavily). Tables for other years and for other species of trees are given in Bliese (1953 a).

Table 1

Diameters at breast height of American elms along the streets and the extent of their use as roost trees on 33 city blocks, June 30 to October 25, 1951

DBH	No. of trees	Number & per cent according to degree of use									
		Number					Percent				
		N[1]	L[2]	M[3]	H[4]	LMH[5]	N	L	M	H	LMH
1- 2	8	8	0	0	0	0	100.0	0.0	0.0	0.0	0.0
3- 4	17	17	0	0	0	0	100.0	0.0	0.0	0.0	0.0
5- 6	9	9	0	0	0	0	100.0	0.0	0.0	0.0	0.0
7- 8	20	18	2	0	0	2	90.0	10.0	0.0	0.0	10.0
9-10	22	21	1	0	0	1	95.5	4.5	0.0	0.0	4.5
11-12	19	17	1	1	0	2	89.5	5.3	5.3	0.0	10.6
13-14	37	30	4	2	1	7	81.1	10.8	5.4	2.7	18.9
15-16	22	14	3	5	0	8	63.6	13.6	22.7	0.0	36.3
17-18	34	22	4	5	3	12	64.7	11.8	14.7	8.8	35.3
19-20	34	20	5	5	4	14	58.8	14.7	14.7	11.8	41.2
21-22	27	12	5	4	6	15	44.4	18.5	14.8	22.2	55.5
23-24	44	24	9	6	5	20	54.5	20.5	13.6	11.4	45.5
25-26	31	12	4	9	6	19	38.7	12.9	29.0	19.4	61.3
27-28	31	12	8	7	4	19	38.7	25.8	22.6	12.9	61.3
29-30	22	13	6	1	2	9	59.1	27.3	4.5	9.1	40.9
31-32	8	4	3	0	1	4	50.0	37.5	0.0	12.5	50.0
33-34	5	3	0	1	1	2	60.0	0.0	20.0	20.0	40.0
35-36	3	1	1	1	0	2	33.3	33.3	33.3	0.0	66.6
37-38	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0
39-40	2	0	1	1	0	2	0.0	50.0	50.0	0.0	100.0
41-42	2	0	2	0	0	2	0.0	100.0	0.0	0.0	100.0
43-44	1	0	0	0	1	1	0.0	0.0	0.0	100.0	100.0
45-46	1	0	1	0	0	1	0.0	100.0	0.0	0.0	100.0
Totals	399	257	60	48	34	142	64.4	15.0	12.0	8.5	35.5

[1]N—Trees not used; [2]L—Trees used lightly; [3]M—Trees used moderately; [4]H—Trees used heavily; [5]L&M&H—Trees used regardless of degree of use.

The L&M&H column in Table 1 indicates that a wide range of tree sizes was used by the birds in 1951, and that there was a tendency for an increase in tree size to be accompanied by a greater

proportion of use. As shown by the L, M, and H columns in the table, this trend appeared whether the birds used the trees lightly, moderately, or heavily; but it was somewhat irregular in these categories, doubtless because it was based on fewer trees in each case than were available for tabulation in the L&M&H column. The same tendency appeared for the American elms in 1950 and 1952, although it was erratic in 1952 when the bird population was lower and the number of trees used somewhat less.

In general the other species of trees used by the birds showed the same pattern indicated in Table 1. As was true for the American elms, the pattern was rather irregular whenever the total number of trees involved was quite small. Black maples, however, showed one striking departure from the general trend shown for American elms. In all three years the lightly used black maples showed a general decrease in the percentage of use with increase in size. The birds evidently tended to use the larger trees of this species either moderately or heavily if they used them at all. For no known reason roosting did not follow this trend in the very similar Norway maples, for the birds used them in a manner similar to American elms.

With only four exceptions, no trees smaller than 7 inches DBH were used for roosting purposes. Two of these were Norway maples (6 inches DBH); one was a hackberry (6 inches DBH); and one was a downy hawthorn *Crataegus mollis* (4 inches DBH). All of these trees were near larger trees that were being used by the birds, and apparently had overflow birds roosting in them.

Back yard trees were under observation for only two years, 1951 and 1952. In 1951, on the same 33 city blocks indicated by Table 1, only 9 back yard American elms were used as roost places, despite the fact that 111 of roost size were present; and only 11 such trees, out of 106 of roost size, on 27 blocks, served the birds in 1952. In 1951, no back yard black maples were used as roost trees, although 7 of roost size were present; and 4 out of a possible 7 were employed by the birds the following year. In 1951 only 1 Norway maple, of the 6 present, was a roost tree; and only 2 trees, of 7 that were available, were roost places in 1952. Yet all of the Norway maples in the back yards were 9 or more inches DBH. Too few of the above-mentioned species of trees were employed to draw any definite conclusions about pattern of use. If they are all put in one category, trees other than American elms and hard maples showed a definite pattern of increasing percentage of use with an increase in tree size in 1951. In that year 21 trees, out of a possible

188 of roost size, were in use by the birds. In 1952, on the other hand, only 8 of 158 were used, too few to expect a pattern to be discernable. Everything considered, therefore, it was quite clear that size was not the factor that prevented the birds from using more trees as roost places in back yards.

Mean DBH and Degree of Use by the Birds

As another approach to the problem, the data were examined for any relationship between the average sizes of the trees used by the birds, and the extent or degree to which they used them. To this end the mean DBH's and related data, for the various degrees of roosting for the several species of trees along the streets, were computed and are shown in Tables 2 to 5.

Tables 2 to 5 indicate that considerable differences existed between the mean diameters of those trees not used as roost places and those trees in which the birds did roost. As further evidence, when the differences between the means in the N column and the L&M&H column in each of the four tables were subjected to the t-test, all tested significant at the 1 per cent level except for the 1951 data in Table 3 which showed significance at 5 per cent.

Of the four groupings of trees in Tables 2 to 5, only the black maples (Table 3) showed a tendency all three years to have progressive increases in degree of roosting to occur with progressive increases in mean DBH. Norway maples (Table 4) and "all other species" (Table 5) showed the same tendency with some exceptions, but the means are based on fewer data. American elms (Table 2) showed an irregular pattern of use without any clear meaning.

The increased degree of roosting use with increased mean DBH, even for the black maples, was somewhat relative. As can be seen from Table 3, for instance, the 1951 mean DBH associated with moderate roosting was less than either the 1950 or 1952 DBH's for light roosting. Although there was a trend to use the larger trees to greater extent than smaller trees, the actual sizes were determined by the sizes of the trees present at whatever sites the birds roosted.

Interspecifically the story was a little different. The birds roosted in hard maples which had a much smaller average DBH than was noted for the American elms that they used. Clearly size was not the only criterion that caused the birds to roost in certain trees and to ignore others.

Too few back yard trees were used by the birds to draw any definite conclusions about degree of use versus mean DBH, and

no data are included in this paper. Such data as were gathered are available in Bliese (1953a).

Tree Grouping

Without exception, as shown by Tables 6 and 7, the average distance from roost trees to the nearest trees was less than the cor-

Table 2

Mean diameters at breast height of American elms near the streets and the extent of their use as roost trees for three consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
Aug. 2 to Oct. 6, 1950	34	Mean DBH	15.76	22.26	26.03	23.82	23.54
		Stan. dev.*	7.63	7.04	7.10	7.19	7.23
		Stan. error**	.52	.69	1.01	1.18	.53
		No. of trees	215	103	49	37	189
June 30 to Oct. 25, 1951	33	Mean DBH	16.15	23.67	22.67	24.15	23.44
		Stan. dev.	8.23	7.99	5.82	5.52	6.75
		Stan. error	.51	1.03	.84	.95	.57
		No. of trees	257	60	48	34	142
June 24 to Sept. 2, 1952	27	Mean DBH	17.15	26.95	23.12	27.50	25.74
		Stan. dev.	8.69	7.18	3.61	.....	5.94
		Stan. error	.54	1.08	.79	.....	.73
		No. of trees	260	44	21	1	66

*Standard deviation **Standard error

Table 3

Mean diameters at breast height of black maples near the streets and the extent of their use as roost trees for three consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting N	L	M	H	L&M&H
Aug. 2 to Oct. 6, 1950	34	Mean DBH	10.94	16.24	18.88	18.91	17.71
		Stan. dev.	5.97	3.78	3.39	3.41	3.76
		Stan. error	.92	.58	.64	.66	.38
		No. of trees	43	43	26	27	96
June 30 to Oct. 25, 1951	33	Mean DBH	13.57	15.20	15.82	18.64	15.98
		Stan. dev.	6.37	3.57	2.60	2.54	3.22
		Stan. error	.82	.79	.59	.96	.47
		No. of trees	61	20	19	7	46
June 24 to Sept. 2, 1952	27	Mean DBH	13.03	15.90	18.47	19.83	17.59
		Stan. dev.	6.18	4.32	2.74	2.66	3.68
		Stan. error	.83	.86	.48	1.08	.46
		No. of trees	55	25	33	6	64

Table 4

Mean diameters at breast height of Norway maples near the streets and the extent of their use as roost trees for three consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting				
			N	L	M	H	L&M&H
Aug. 2 to Oct. 6, 1950	34	Mean DBH	6.94	15.75	16.83	12.50	15.10
		Stan dev.	4.60	5.48	3.93	3.74	4.97
		Stan. error	.92	1.94	1.61	1.53	1.11
		No. of trees	25	8	6	6	20
June 30 to Oct. 25, 1951	33	Mean DBH	6.72	10.83.	14.83	15.10	14.37
		Stan. dev.	4.98	5.77	5.69	3.58	5.29
		Stan. error	1.17	3.33	1.46	1.60	1.10
		No. of trees	18	3	15	5	23
June 24 to Sept. 2, 1952	27	Mean DBH	6.80	14.67	15.50	.....	14.94
		Stan. dev.	4.41	5.15	2.19	.....	4.33
		Stan. error	.92	1.49	.89	.....	1.20
		No. of trees	23	12	6	0	18

Table 5

Mean diameters at breast height of all trees near the streets other than American elms and hard maples and the extent of their use as roost trees for three consecutive years.

Period of time	No. of blocks	Items	Data according to extent of roosting				
			N	L	M	H	L&M&H
Aug. 2 to Oct. 6, 1950	34	Mean DBH	11.24	23.50	25.50	33.50	24.50
		Stan. dev.	8.14	8.94	1.69	14.14	8.61
		Stan. error	.61	1.75	.59	10.00	1.44
		No. of trees	180	26	8	2	36
June 30 to Oct. 25, 1951	33	Mean DBH	10.50	21.50	24.70	27.50	23.45
		Stan. dev.	8.37	8.67	8.95	6.53	8.53
		Stan. error	.59	1.89	2.83	2.47	1.38
		No. of trees	203	21	10	7	38
June 24 to Sept. 2, 1952	27	Mean DBH	11.40	32.83	32.17	.....	32.61
		Stan. dev.	8.41	9.36	6.66	.....	10.49
		Stan. error	.61	3.82	3.84	.....	3.50
		No. of trees	189	6	3	0	9

responding average from non-roost trees to the nearest trees. This relationship was found for the roost as determined at various times during the season, and also when the data were combined for the annual summaries. The birds, on the average, used the more closely grouped trees throughout all three years.

The picture was not a simple one, however, for both street and back yard data showed that the mean distances varied from month

to month and from year to year. In similar locations several mean distances for roost trees were actually greater than were some mean distances for non-roost trees. Apparently the birds' use of the more closely grouped trees was a relative matter. At whatever sites they roosted, the birds used the more closely planted trees, but the closeness at one site was not always the same at another site.

There is little evidence from Tables 6 and 7 that the birds followed any seasonal trends in the use of groupings of trees, for the changing pattern from month to month was not the same for the three years. About the only common element was the narrowness of the range of the means, especially for the street trees. Further-

Table 6

Use of street trees as roost places as related to nearness of other trees.

Date	No. of blocks	Types of trees	No. of distances measured	Mean distance apart (ft.)	Stan. dev.	Stan. error
1950 Aug. 2	13	Roost	162	33.46	13.32	1.05
		Non-roost	153	35.68	13.96	1.12
Sept. 14	21	Roost	228	33.02	13.35	.88
		Non-roost	339	34.84	13.97	.76
Oct. 6	16	Roost	159	34.10	14.18	1.12
		Non-roost	246	36.72	13.25	.84
Summary	31	Roost	404	33.80	13.83	.69
		Non-roost	364	36.02	14.02	.73
1951 June 30	7	Roost	57	31.68	13.35	1.77
		Non-roost	140	35.21	16.32	1.38
July 16	10	Roost	100	34.50	15.43	1.54
		Non-roost	159	35.58	15.48	1.23
Aug. 11	14	Roost	151	36.05	15.45	1.26
		Non-roost	167	37.31	16.33	1.26
Aug. 30	12	Roost	134	33.93	14.43	1.25
		Non-roost	167	35.16	13.93	1.08
Oct. 5	11	Roost	95	32.53	12.86	1.32
		Non-roost	162	34.64	15.32	1.20
Oct. 25	10	Roost	84	33.18	12.47	1.36
		Non-roost	180	34.67	14.56	1.09
Summary	26	Roost	290	35.27	15.88	.93
		Non-roost	306	36.81	15.42	.88
1952 June 24	9	Roost	72	32.44	11.37	1.34
		Non-roost	123	33.77	13.12	1.18
July 11	6	Roost	59	28.08	11.65	1.52
		Non-roost	103	34.07	13.87	1.37
Aug. 6	7	Roost	70	30.57	12.59	1.50
		Non-roost	96	35.55	15.68	1.60
Sept. 2	9	Roost	86	33.99	12.78	1.38
		Non-roost	142	34.97	15.50	1.30
Summary	18	Roost	179	31.97	12.10	.95
		Non-roost	250	34.18	14.54	.92

Table 7

Use of back yard trees as roost places as related to nearness of other trees

Date	No. of blocks	Types of trees	No. of distances measured	Mean distance apart (ft.)	Stan. dev.	Stan. error
1951 June 30	7	Roost	5	26.80	22.43	10.03
		Non-roost	57	37.56	23.05	3.05
July 16	10	Roost	4	17.25	7.93	3.97
		Non-roost	87	36.45	23.06	2.47
Aug. 11	14	Roost	18	33.00	23.95	5.64
		Non-roost	101	40.57	22.53	2.24
Aug. 30	12	Roost	7	36.71	23.41	8.85
		Non-roost	71	40.56	23.74	2.82
Oct. 5	11	Roost	3	22.67	7.51	3.93
		Non-roost	63	42.76	23.13	2.91
Oct. 25	10	Roost	11	44.82	22.94	6.92
		Non-roost	86	46.66	22.91	2.47
Summary	26	Roost	30	39.83	21.23	3.88
		Non-roost	178	40.02	23.49	1.76
1952 June 24	9	Roost	0	.....	.....	.....
		Non-roost	49	39.22	22.63	3.23
July 11	6	Roost	14	30.86	14.64	3.91
		Non-roost	93	38.00	19.17	1.99
Aug. 6	7	Roost	20	33.25	16.82	3.76
		Non-roost	79	37.94	17.93	2.17
Sept. 2	9	Roost	15	26.67	14.32	3.70
		Non-roost	123	37.80	19.90	1.79
Summary	18	Roost	27	30.59	16.31	3.14
		Non-roost	170	39.03	20.60	1.58

more, except for the fact that roost tree mean distances were less than for non-roost trees, there was no particular correspondence between back yard and street data.

Several of the changes noted in Tables 6 and 7 have probable explanations. The increase in the mean dimensions for street trees from September 14 to October 6, 1950, and for both street trees and back yard trees from October 5 to October 25, 1951, were undoubtedly related to the changes in sites caused by the fall of leaves. The 1950 changes came earlier because high winds in late September had caused considerable loss of cover. When the birds moved to new sites they had to use trees that were farther apart. The small average distance for street roost trees for July 11 and August 6, 1952, were related to the use of the closely planted hard maples on Duff Avenue and Carroll Avenue. As the birds used other sites in addition by September 2, the mean distances between the trees increased.

The close parallel between mean distances for roost trees and non-roost trees, which is indicated in Tables 6 and 7, was probably

caused by the manner in which the data were handled. Numerous situations presented themselves where a roost tree was flanked by non-roost trees, or where a non-roost tree had roost trees on either side of it. Since by definition such distances had to be tabulated with both the roost tree and the non-roost tree data, there was a considerable tendency to equalize the two means. Despite this, the tendency of the birds to use the more closely grouped trees was strong enough to show consistently smaller means for the roost trees.

When the differences between the means for roost trees and non-roost trees for the annual summaries were compared statistically, t-tests showed the 1950 mean distances for street trees to differ significantly at the 5 per cent level, but those for 1951 and 1952 to be non-significant. For back yard trees similar t-tests indicated non-significance for the 1951 data, but significance at the 5 per cent level for the 1952 mean differences. In the light of the tendency to equalize the means because of the manner of computation, it is probably surprising to have two sets of the main differences test significant, but it does lend support to the conclusion that grouping of trees was important to the birds.

Of special interest were the greater distances that generally prevailed between trees in back yards than between street trees. As can be seen by comparing Tables 6 and 7 these greater distances resulted in greater average distances between non-roost trees. On the other hand, generally speaking, trees used as roost places in back yards were not farther apart than roost trees along the streets. As indicated by the tables, some were even closer together. Apparently there were not very many close groupings of roost size trees in back yards, and the relative absence of such may well have been a primary reason for the small proportion of back yard trees used for roosting.

That over 40 species of trees were not used as roost places seems at least partly explainable on the basis of size and grouping. Many such trees were small ornamentals or fruit trees, below the size limits used by the birds, whereas others, which were of roost size, were not closely grouped with other trees. No doubt other factors not measured were also important.

Summary

In general the percentage of trees used as roost places by bronzed grackles and their associates varied directly with the DBH of the trees. This was true whether the trees were used lightly, moderately, or heavily by the birds.

Lightly used black maples showed a decrease in percentage of trees used as the size of the trees increased.

With only 4 exceptions, trees smaller than 7 inches DBH were not used by the birds. No tree smaller than 4 inches DBH was observed in use.

Black maples showed a direct relationship between mean DBH and degree of use. Norway maples and "all other species" showed the same tendency with a few exceptions, but American elms had no pattern of use that had any meaning.

At whatever site the birds roosted they tended to use those trees that were more closely grouped.

The relative absence of closely grouped trees of roost size in back yards may have accounted for the small amount of roosting which occurred there. Roosting was primarily a phenomenon of street trees.

There was little evidence of any seasonal trends in the use of trees.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. George O. Hendrickson, Professor of Zoology at Iowa State College, for his guidance in the research, and to Mr. Paul G. Homeyer, Professor of Statistics, for his help on the statistical phases of the work.

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