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Parental Foraging in Chipping Sparrows (Spizella Passerina)

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PARENTAL FORAGING IN CHIPPING SPARROWS (*SPIZELLA PASSERINA*)

by

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PARENTAL FORAGING IN CHIPPING SPARROWS (SPIZELLA PASSERINA)

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During the breeding season of 1982, the population of Chipping Sparrows (Spizella passerina) that inhabits the Western Michigan University's campus was chosen to study the use of foliage and other foraging sites. Three pairs were selected to be observed intensively.

During the time the female is foraging and when the male is either foraging or in territorial advertisement activities both sexes choose needleleaf trees out of proportion to their availability.

It is also likely that in the later stages of caring for young, when food demands were highest, the birds become less selective and forage on needleleaf trees as well as broadleaf trees and on the grounds.

In general, the foraging behavior of Chipping Sparrows harmonizes well with the theory of optimal foraging. When the food demands are small, there is a tendency to forage on needleleaf but when the food demands increase the birds become less selective and forage on needleleaf trees as well as broadleaf trees and ground.

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CHAPTER 1

INTRODUCTION

The Chipping Sparrow (Spizella passerina) is a common bird of the Order Passeriformes and the family Fringillidae that has been comparatively little studied (Walkinshaw 1944).

Stull (1968) pointed out some of the habitats of the Chipping Sparrow: stands of jack pine, black spruce bogs, and stands of virgin red pine. He also indicated that it is likely to be found in aspen and conifer forest edges and tall shrubbery on margins of roads, streams, and lakes. He concluded that the original habitats of Chipping Sparrow were open woodlands or the borders of forest openings produced by rivers and lakes and that when man began to make clearings for his villages he created new open areas which were occupied by the Chipping Sparrow. Nowadays there is a close relationship between Chipping Sparrow habitats and those of man.

Even though this small bird is not important from an economical point of view, it possesses a series of characteristics that makes it a perfect subject of study. It exists in relatively high numbers, it is easy to find and observe because of the singing habits of the male, and its tameness permits it to be approached without interfering with its natural behavior.

During the breeding season of 1982, the population of Chipping Sparrows that inhabits the Western Michigan University campus was observed during its daily activities.

Welty (1982) divided reproductive behavior into these activities: territory establishment, mate selection or betrothal, pair bond establishment, copulation, nest building, laying of eggs, brooding of eggs and young, and the feeding and protection of the young.

Most of these activities are described and analyzed in the following chapters of this study; however, the main objective of this investigation was to study the use of foliage and other foraging sites. To fulfill this objective it was necessary to observe the birds and document any preference among the tree-shrub physiognomic type or ground which may reveal different methods of foraging associated with either different metabolic demands or with different food availability through the season.

Since one of the most important reasons for foraging during the breeding season is to obtain food for the young, and because foraging behavior depends on "peculiarities of the structure of the site selected for foraging areas" as indicated by Pokrovskaya (1968) it seems clear that both subjects of study--foraging sites and parental behavior--are close from an ecological point of view.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

This research was conducted on Western Michgian University's west campus, Kalamazoo, Michigan. The total campus area consists of 144 hectares. The exact location given by the Congressional Land Survey System is E 1/2 of Sec 20 and SW 1/4 of Sec 21, T 2 S, R 11 W.

The area has been artificially planted. There are ornamental trees and shrubs of many genera including conifers such as pine (Pinus) and spruce (Picea) and broadleaf plants such as apple (Malus), cottonwood (Populus), maple (Acer), hawthorn (Crataegus), yew (Taxus), honeysuckle (Lonicera), and oak (Quercus).

CHAPTER III

METHODS

The general approach employed was intensive observation during the breeding season of 1982 from the last days of April to September. Most observations were made between sunrise and noon or shortly before sunset, when the birds were most active. The investigator spent about 700 hours observing in the field. Observations were made with the aid of a 7x35 binocular.

Twenty-five territories were determined by mapping the different song perches of the males (Fig. 1).

After the territories were outlined, a considerable amount of time was spent keeping track of the pairs in order to know more about their behavior during courtship, mating, nest building, incubation period, and care and development of the young. This species is not sexually dimorphic, but male and female could be distinguished by behavior. Sometimes it was necessary to wait until the bird showed some behavior that could serve as a clue to indicate its sex (e.g: singing or sitting on the nest), since they were not banded.

Two young from nest 1 (Fig. 2) were banded when they were 6 days old, but it was impossible to keep track of them after they reached the fledgling period.

During the period between June 15th and September 20th, three pairs were chosen to be observed daily for recording foraging sites and care of the young by the parents.

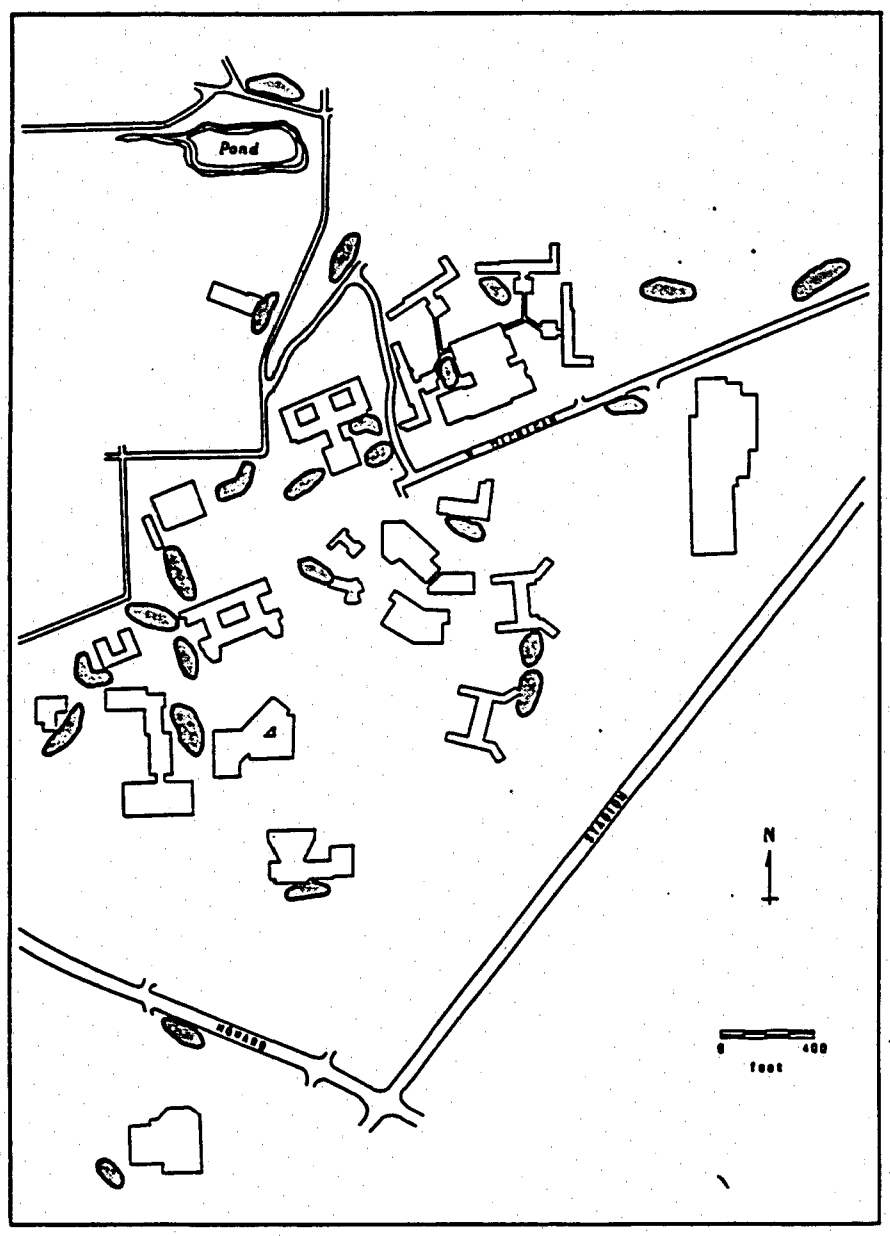

Fig. 1. Territories of males of Chipping Sparrow during the breeding season of 1982. Western Michigan University campus

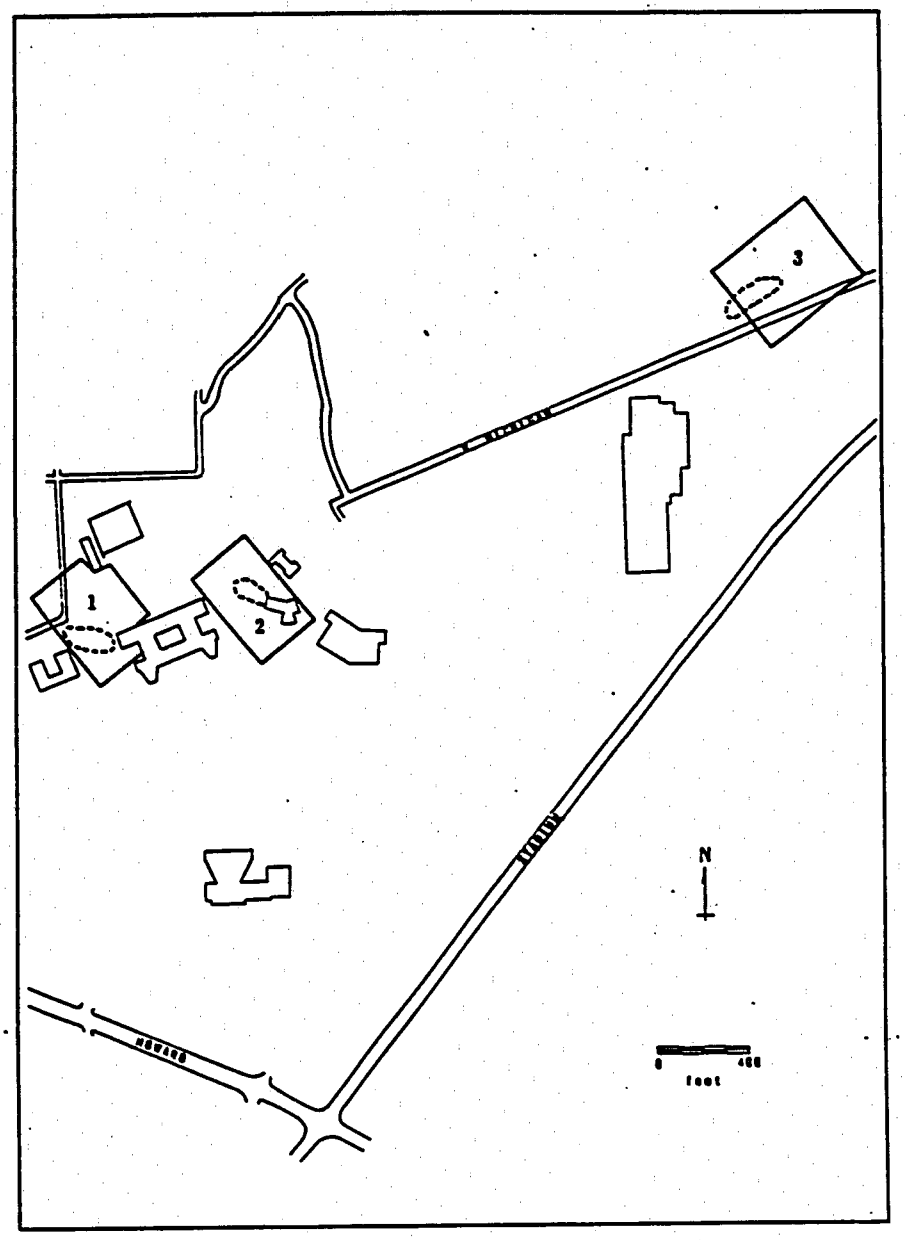

Fig. 2. Foraging areas of three pairs of Chipping Sparrow during the breeding season of 1982.

Daily visits of about 60 minutes for each pair were made. The daily data were compiled on individual maps summarizing the activities of the pairs.

Each day, both members of the three pairs were observed during their activities. The investigator stayed far enough away that her presence did not influence the birds' actions. The location of the bird (needleleaf tree, broadleaf tree, ground, or other) was noted at 60-second intervals on a field data sheet until 30 minutes were recorded for each bird. The time spent by the female on the nest was not considered. Most of the time the birds were either searching for food or foraging, on the ground or trees. Sometimes the bird was simply perching on a branch without showing any feeding behavior. This situation was also recorded on the data sheet.

Sizes of the foraging areas of the three pairs intensively studied were estimated graphically using simple geometry (Fig. 2).

Using the method of Balda (1969), the following data were recorded for all the trees and shrubs in the three foraging areas: total tree height (from ground to highest point), height from ground to lowest branches, and crown diameter. The shape of the crown for each tree or shrub was recorded as being perfectly conical, round, or cylindrical. A clinometer was used for height measurements.

Foliage volume for each tree was calculated using the formulas given by Balda (1969). Individual volumes were then summed for broadleaf and needleleaf trees in each of the three foraging areas.

To analyze foliage usage relative to available foliage, it was necessary to calculate an expected number of bird observations per category

of tree or shrub using percent of total volume of foliage for each category. This expected number of bird observations was then compared with the actual number of bird observations (male and female, separately) for each category of trees using the standard chi-square procedure (Zar 1974).

In addition, a two by three contingency table was used to analyze whether the time spent on the ground was independent of the different stages (incubation, nestling, and fledgling periods). The sexes were tested separately.

Another chi-square test was conducted to investigate any difference between male and female foliage choice during incubation, nestling, and fledgling periods. In this test the female observations were taken as the observed values, while the male observations were considered as the expected values. The values were compared for each category of trees again using the standard chi-square procedures.

CHAPTER IV

BREEDING BIOLOGY

Territory Establishment

The earliest part of this investigation was spent observing the males, which arrive first and establish territories (Stull 1968).

Males choose a conspicuous site to perch where they are noticeable to other males and possible mates. Most of the perching sites seem to be coniferous trees. As an exception, there was a male that regularly sang from a wire but when the pair selected the nest site they used one of the trees of a clump of conifers near the perching site.

Twenty-five territories of about one acre each in extent were mapped on the west campus area (Fig. 1). These 25 mapped territories represented about 75-80 percent of the total.

The size of each territory seemed to fluctuate during the breeding season, so the territories marked on the map are of the early breeding season. Skutch (1976) pointed out that bird territories tend to diminish during egg laying, incubation, and the nestling period and that after the young leave the nest, territorial boundaries may be disregarded and territorial defense neglected while the parents attend the brood.

Walkinshaw (1944) found that territories are not always completely surrounded by other territories of Chipping Sparrows, so that the limits were flexible. Nevertheless the investigator found two males singing to proclaim their territories and perching in two different trees that were only 10 meters apart.

Stull (1968) indicates that although it is the male that defends the territory, the female defends at least the area of the nest tree.

It was observed that preparation for second and third broods was accompanied by a resurgence of territorial zeal.

Morse (1968) found that in four congeneric species of wood warblers (Parulidae) males spend considerable time during the breeding season at or near the tops of trees singing. He also suggested that conspicuousness is an important part of maintaining territories successfully in these species. One reason for Chipping Sparrow use of conifers as singing posts may be that tops of conifer trees allow them to be more noticeable than on broadleaf trees because of their physiognomy.

It is possible to conclude from the observations made that most territories were settled within an area where there was at least one large conifer or preferrably a clump of conifers.

Courtship and Mating

Courtship occurs soon after the arrival of the females. Usually the female enters one of the territories defended by a male and starts feeding on the ground. During this time, the female makes a series of sounds, possibly to announce its sex to the male. The male starts singing more actively and then approaches the female, making a series of displays.

In general, copulation takes place on the ground and the female adopts a posture with head and tail slightly raised and wings rapidly vibrating. One or both birds utter a rapid call, "see-see-see-see-see" during this time. Similar behavior has been observed by Stull (1968) and Walkinshaw (1944).

They spend several hours feeding together and showing several ways of interaction which seem to help to establish the pair bond that lasts through the breeding season.

Even though they spent most of the time together, it was observed that the male searches for food at greater distances from the site where the nest will later be built.

Nest Building

As Stull (1968) has pointed out, the female does all the gathering of nesting materials. It appears that she also makes the nest site selection, while the male often accompanies her on her trips to select the site or gather nesting materials. The observations made by Nice (1964) indicate that the Song Sparrow (Melospiza melodia) pair goes about together searching for nest sites. She pointed out that the female tries out possible situations by nest molding and perhaps the male does likewise.

Morse (1968) pointed out that during this period males spend much of their time in territorial activities, while females are building the nest alone.

Some of the gathering of nesting material is made beyond the territorial boundaries, depending on the availability of raw materials used in the construction of the nest. Stull (1968) pointed out that the nest is constructed of dead grass, weed stalks, and rootlets and lined with fine grasses and hair.

He also pointed out that Chipping Sparrows nest predominantly in conifers, which appears to be true from the results obtained from this

investigation. From 32 nests found during the breeding season of 1982, 23 were located in conifers and 9 in broadleaf trees. Most of the earliest broods were located in conifers while some of the second and third broods were in broadleaf trees.

In general, the construction of the nest is done during the early morning hours, and the nest is built in three or four days (Walkinshaw 1944).

Incubation Period

Stull (1968) pointed out that the Chipping Sparrow usually lays four eggs, but sometimes only three or as many as five. In this investigation most of the nests found contained three eggs.

It was observed that incubation is entirely performed by the female. She "sits" beginning the night before the laying of the last egg (Walkinshaw 1944). The period of incubation is eleven days, on the average. Walkinshaw (1944) indicated that the nesting period is usually from May to August.

During the first days of incubation, and depending on the weather, the female takes several recesses each day but the frequency of coming and going to the nest decreases during the last days of incubation. It was observed that the female remains almost continuously on the nest during the later days of incubation period, being fed by the male. During this time, the female is so constant that often she can be approached quite closely.

Nestling Period

The scheme of the nestling period given by Kuhlmann (1909) fits in general with the development of the Chipping Sparrow. He divides it into three stages. The first four days the food reaction is the only coordinated movement present. The fifth and sixth day are "a stationary stage of development". From seven days on there is a rapid progress in motor coordination. Usually at 9-10 days of age the young are able to leave the nest.

Both parents cooperate in the care of the nestling,the female brooding and feeding them, the male feeding them. Walkinshaw (1944) indicated that as the young grow older, brooding decreases and that they are not usually brooded after the young are six or seven days old.

Fledgling Period

The fledgling period is the time after the young leave the nest. This occurs when the young are about 10 days old. Immediately after fledging, the young are characterized by a general immobility. They spend several hours hidden in shrubs or perching on the lower branches of the nest tree. The only time they make sounds is when calling for food. They began to use a "zip-ip-zip-ip-zip-ip" or "chip-chip-chip" call (Walkinshaw 1944). Skill in flying develops rapidly. By the age of 24 days they start the stage of independence when they can take care of themselves. They may still be accompanied by their parents for another few days.

Of the nests observed, 57 percent were successful in producing young through the fledgling period. This agrees well with the 60 percent found by Walkinshaw (1944).

It is likely that during the early as well as the late fledgling period the young acquire the necessary information to survive, such as alarm signals and territorial behavior (singing, perching). From the investigator's point of view, this period may be more important than the "imprinting period" mentioned by Lorenz (1981).

CHAPTER V

FOLIAGE USE AND FORAGING

This chapter will concentrate on the results obtained concerning the differential use of plant species by the two members of the pairs and other foraging behavior during nesting.

The data concerned with foliage choice were obtained beginning in June, so there is no statistical information on foraging behavior during the territory establishment and nest building.

Table 1 shows that the availability of broadleaf trees is much greater in all three foraging areas. The results of the chi-square tests (Tables 2 and 3) indicate that during the incubation period both parents spent significantly (indicated by asterisks on the tables) more time on conifer trees than would be expected on the basis of availability.

The observations made indicate that the male continued perching on evergreens within the territory and that the female remained most of the time on trees near the nest. This observation agrees with observations made by Nice (1968) on the Song Sparrow (Melospiza melodia); she found that during the incubation period, the male guards the territory, singing vigorously, while his mate is on the nest.

The general interpretation of the two by three contingency table (Tables 4 and 5) is that the time spent by the male on the ground is independent on the stage ($X^2_{0.05,2}$ is equal to 5.96).

The analysis of the data for the female showed different results since chi-square was equal to 40.59 and $X^2_{0.05,2}$ is equal to 5.99,

TABLE 1

Availability of broadleaf and needleleaf trees in three different foraging areas at Western Michigan University campus, 1982.

Foraging Areas	BROADLEAF			NEEDLELEAF		
	Foliage Volume (m^3)	Percent	No. of Trees	Foliage Volume (m^3)	Percent	No. of Trees
1	18,833	78.2%	83	5,254	21.8%	50
2	30,303	82.6%	44	6,376	17.4%	20
3	16,743	96.0%	43	634	4.0%	31

TABLE 2

Percent of time (actual numbers given in the Appendix) spent in needleleaf and broadleaf trees by female Chipping Sparrows of the three pairs intensively studied during nesting, and results of the Chi-square test.

	NEEDLELEAF		BROADLEAF		CHI-SQUARE
	observed	expected	observed	expected	
	Nest 1				
Incubation	68	22	12	78	391.55 **
Nestling	65	22	35	78	174.32 **
Early Fledgling	78	22	22	78	264.45 **
Late Fledgling	51	22	49	78	28.23 **
	Nest 2				
Incubation	84	17	16	83	636.08 **
Nestling	92	17	8	83	692.57 **
	Nest 3				
Nestling	77	4	23	96	1,051.24 **

TABLE 3

Percent of time (actual numbers given in the Appendix) spent in needleleaf and broadleaf trees by male Chipping Sparrows of the three pairs intensively studied during nesting, and results of the Chi-square test.

	NEEDLELEAF		BROADLEAF		CHI-SQUARE
	observed	expected	observed	expected	
	Nest 1				
Incubation	84	22	16	78	363.76 **
Nestling	73	22	27	78	230.30 **
Early Fledgling	80	22	20	78	244.81 **
Late Fledgling	40	22	52	78	21.96 **
	Nest 2				
Incubation	64	17	36	83	273.51 **
Nestling	69	17	31	83	432.13 **
	Nest 3				
Nestling	28	4	72	96	1,284.26 **

TABLE 4

Contingency table for males of Chipping Sparrows during the breeding season of 1982.

	Incubation	Nestling	Fledgling	
Ground	38 (25%)	70 (37%)	97 (34%)	205
Above Ground	112 (75%)	117 (63%)	183 (66%)	412
Total	150	187	283	617

Chi-Square is equal to 5.95695

TABLE 5

Contingency table for females of Chipping Sparrows during the breeding season of 1982.

	Incubation	Nestling	Fledgling	
Ground	15 (8%)	57 (32%)	72 (34%)	144
Above Ground	165 (92%)	121 (68%)	138 (66%)	424
Total	180	178	210	568

Chi-Square is equal to 40.58946 **

which means that for females, the time spent on ground depends on the stage of the brood.

Since these total values do not clearly express the situation itself, each stage of the brood was analyzed separately. During the incubation period, the female spent much less time on the ground than the male (8% and 25% respectively). In general, the female does not show much interest in foraging activities and during the last days of incubation she is frequently fed by the male. In general, the ground provides a ready supply of food but of low quality (that is, small items individually of low calorie content). The female does not need to resort to foraging on the ground during incubation, when she receives a substantial subsidy from the male.

The last way to analyze the data was to test for any differences between male and female foliage choice during the different periods.

During incubation at nest 1 chi-square is equal to 1.60, which means that the foliage choice made by both birds is very similar. The two members of the pair did not differ in the amount of time they spent on broadleaf or needleleaf trees.

Nest 2 reveals exactly the contrary, chi-square is equal to 31.64. The male spent less time on evergreens than the female, but more at deciduous trees (Table 6). Considering also the results from Tables 4 and 5 it is possible to notice that, in general, during the incubation period the male spent more time on the ground than the female.

To understand this great difference, it may be necessary to know that the data from nest 2 were taken while the parents were raising a second brood, and that the data for nest 1 were taken during the first brood.

TABLE 6

Comparison of foliage choice made by the members of the three pairs during nesting. The values are given in percent.

	NEEDLELEAF		BROADLEAF		CHI-SQUARE
Nest 1	Female	Male	Female	Male	
Incubation	88	84	12	16	1.60
Nestling	65	74	35	26	6.46 *
Early Fledgling	78	82	22	18	1.16
Late Fledgling	51	49	49	51	0.11
Nest 2					
Incubation	84	65	16	35	31.64 *
Nestling	92	82	8	18	13.04 *
Nest 3					
Nestling	77	77	23	23	0.04

It is very likely that during the first brood (nest 1) the female usually fed the young, but in the second brood (nest 2) the male fed the young from the first brood while the female was taking care of the eggs from the second brood. In other words, both parents feed fledglings but the female starts a second nest and may begin to incubate. During the later part of fledgling life the male, accordingly, may take the greater role in feeding the fledglings. That seems to be the reason for different results of the chi-square test.

Regarding the nestling period, Tables 2 and 3 show that there is an increase in time spent on broadleaf trees for both members of the pair during nest 1, but not at nest 2. The different results may in part be explained by the situation described for the incubation period, and also because "variations in the complex of behavior patterns of different individuals of the same species may be caused by peculiarities of the structure of the site selected for foraging areas" (Prokrovskaya 1968). Nest 2 was located in an area where more of the deciduous trees species were taller than the trees from the other areas. In any case, there is no clear trend in the use of broadleaf versus needleleaf trees with phase of the nesting cycle. One possible exception is the heavy use of broadleaves very late in the fledgling period at nest 2. Unfortunately, no comparable data from other nests are available.

A trend did exist, however, in time spent on the ground. It increased from the incubation period to the fledgling period. The reason could be that parents spend more time on the ground because the demand for food increases with the age of the young.

From Tables 4 and 5 the inference is that the time spent in the different foraging situations (broadleaf, needleleaf, ground) often differed. This suggests the parents were doing different "duties" during such periods. The observations indicate that even though the male cooperated in feeding the young, he usually foraged at a different rate than the female, and also could suggest resource partitioning in the use of foraging areas.

It is interesting to note that during the fledgling period, families of Chipping Sparrow enter the territories of other families to forage there, especially during the last brood.

Tables 2 and 3 show that although there is no dependence upon the type of vetetation chosen by the pair and the stage of development of the young, the male from nest 1 decreased the time spent on evergreens and the time spent on deciduous trees, which coincided with an increase in the time spent on the ground (Tables 4 and 5). The female shows a slight increase of the time spent on evergreens and a decrease on the time spent on broadleaves, but she also shows an increment on the time spent on the ground. This situation occurs when the young increase their demands for food. Both parents presumably spend more time on the ground for two main reasons: first, they have to collect more food for the young; and second, because they usually feed the young on the ground.

From Table 6, which is the chi-square to test whether the sample data came from a population having a 1:1 ratio of female-male foliage choice, it is possible to accept this hypotheses for the fledgling period. In other words, there is no statistical significance between the foliage choice made by the members of the pair.

CHAPTER VI

DISCUSSION

The preceding chapters have given a brief description of the foraging behavior and parental care of the young during the breeding season. Following Krebs (1978), this work is considered a descriptive and functional approach. This last chapter examines the problem from an evolutionary point of view, dealing with ultimate causes.

The following represent the most important conclusions obtained from the data analyzed and that may be interesting to explain in terms of ultimate causes:

(1) Most of the perching sites used by the males to establish their territories were coniferous trees.

(2) It is likely that the female does the nest site selection.

(3) Most of the nests are build in conifer trees, especially those coming from earliest broods.

(4) During the time the female is foraging, or when the male is either foraging or in territorial advertisement activities, both birds choose needleleaf trees disproportionately to their availability.

It is likely that in the later stages of caring for young, when food demands were highest (Tables 2 and 3, Nest 1, Late Fledgling Period), there was a greatest tendency to feed on broadleaf trees on the part of both male and female. Holmes (1981) indicated that tree species "might provide different foraging opportunities for birds" and Southwood (1961) found that oaks (Quercus) contained more number of insect species than conifer trees such as pine (Pinus) and spruce (Picea).

No comparable data for insect populations in different tree species is available for the study area.

Another possible reason for choosing broadleaf trees may be a reflection of taking items in relation to availability. MacArthur (1972) indicated that on locating an item, the consumer, the bird, has two alternatives: "to pursue, or to search again for a better item and pursue it instead." He also said that the animal will choose the act that promises to yield more per unit of time.

The fact that there is an increase in ground feeding by both male and female, may be also related to optimal foraging. Food items are presumably readily available but smaller on ground. With increasing food demand during those periods, foraging becomes less selective, with both ground and broadleaf foliage being increasingly added to the preferred needleleaf sites. This result accords well with the expectations of optimal foraging theory (MacArthur 1972).

Krebs (1978) indicated the importance of maximizing efficiency in harvesting food related to contributing to eventual reproductive success. Organisms have to forage efficiently because searching for food competes for time with activities such as defending a territory, mating, resting, and so on.

One point that may be considered as a possible bias factor when comparing foliage use and availability is that birds may not use the total foliage of trees. Balda (1969) found that in mixed forests, Chipping Sparrows utilize a particular height in the canopy and make use of all trees with foliage at that height. From this point of view, the total foliage volume perhaps should not be considered as the

availability for trees, since there were several trees, especially oaks, that measured more than 15 meters of height at the area studied.

In conclusion, it is possible to say that even though some of the observed trends may be the result of the great individual differences as well as pair differences in the way Chipping Sparrows forage, in general, the foraging behavior harmonizes well with the theory of optimal foraging. When the food demands are small, there is a tendency to forage on needleleaf foliage, but when the food demands increase, the birds become less selective and forage on needleleaf trees as well as broadleaf trees and on the ground.

APPENDIX A

ACTUAL NUMBERS OF TABLE 2

NEST: 1

SAMPLE #	NEEDLE Fo	NEEDLE Fe	NEEDLE Fo-Fe	BROADLEAF Fo	BROADLEAF Fe	BROADLEAF Fo-Fe	CHI-SQUARE x2
1	135.00	33.59	101.41	19.00	120.41	-101.41	391.55
2	103.00	34.46	68.54	55.00	123.54	-68.54	174.32
3	111.00	30.97	80.03	31.00	111.03	-80.03	264.45
4	29.00	12.43	16.57	28.00	44.57	-16.57	28.23
Total of CHI-SQUARE							858.55
CHI-SQUARE of total	378.00	111.46		133.00	399.54		815.19

NEST: 2

SAMPLE #	NEEDLE Fo	NEEDLE Fe	NEEDLE Fo-Fe	BROADLEAF Fo	BROADLEAF Fe	BROADLEAF Fo-Fe	CHI-SQUARE x2
1	174.00	36.16	137.84	34.00	171.84	-137.84	636.08
2	164.00	30.94	133.06	14.00	147.06	-133.06	692.57
Total of CHI-SQUARE							1328.65
CHI-SQUARE of total	338.00	67.10		48.00	318.90		1323.85

NEST: 3

SAMPLE #	NEEDLE Fo	NEEDLE Fe	NEEDLE Fo-Fe	BROADLEAF Fo	BROADLEAF Fe	BROADLEAF Fo-Fe	CHI-SQUARE x2
1	53.00	2.52	50.48	16.00	66.48	-50.48	1051.24
Total of CHI-SQUARE							1051.24
CHI-SQUARE of total	53.00	2.52		16.00	66.48	-50.48	1051.24

APPENDIX B

ACTUAL NUMBERS OF TABLE 3

NEST: 1

SAMPLE #	NEEDLE Fo	NEEDLE Fe	NEEDLE Fo-Fe	BROADLEAF Fo	BROADLEAF Fe	BROADLEAF Fo-Fe	CHI-SQUARE x2
1	134.00	34.68	99.32	25.00	124.32	-99.32	363.76
2	109.00	32.50	76.50	40.00	116.50	-76.50	230.30
3	99.00	27.05	71.95	25.00	96.95	-71.95	244.81
4	26.00	11.78	14.22	28.00	42.22	-14.22	21.96
Total of CHI-SQUARE							860.83
CHI-SQUARE of total	368.00	106.01		118.00	379.99		828.13

NEST: 2

SAMPLE #	NEEDLE Fo	NEEDLE Fe	NEEDLE Fo-Fe	BROADLEAF Fo	BROADLEAF Fe	BROADLEAF Fo-Fe	CHI-SQUARE x2
1	117.00	31.98	85.02	67.00	152.02	-85.02	273.51
2	126.00	27.29	98.71	31.00	129.71	-98.71	432.13
Total of CHI-SQUARE							705.64
CHI-SQUARE of total	243.00	59.28		98.00	281.72		689.25

NEST: 3

SAMPLE #	NEEDLE Fo	NEEDLE Fe	NEEDLE Fo-Fe	BROADLEAF Fo	BROADLEAF Fe	BROADLEAF Fo-Fe	CHI-SQUARE x2
1	63.00	2.92	60.08	17.00	77.08	-60.08	1284.26
Total of CHI-SQUARE							1284.26
CHI-SQUARE of total	63.00	2.92		17.00	77.08		1284.26

APPENDIX C

ACTUAL NUMBERS OF TABLE 6

NEST: 1

SAMPLE #	NEEDLE Fo	NEEDLE Fe	NEEDLE Fo-Fe	BROADLEAF Fo	BROADLEAF Fe	BROADLEAF Fo-Fe	CHI-SQUARE x2
1	135.00	129.79	5.21	19.00	24.87	-5.87	1.60
2	103.00	115.58	-12.58	55.00	40.62	14.38	6.46
3	111.00	113.37	-2.37	31.00	25.66	5.34	1.16
4	29.00	27.44	1.56	28.00	28.79	-0.79	0.11
Total of CHI-SQUARE							9.33
CHI-SQUARE of total	378.00	386.19		133.00	119.94		1.60

NEST: 2

SAMPLE #	NEEDLE Fo	NEEDLE Fe	NEEDLE Fo-Fe	BROADLEAF Fo	BROADLEAF Fe	BROADLEAF Fo-Fe	CHI-SQUARE x2
1	174.00	132.26	41.74	34.00	69.94	-35.94	31.64
2	164.00	142.85	21.15	14.00	31.74	-17.74	13.04
Total of CHI-SQUARE							44.68
CHI-SQUARE of total	338.00	275.11		48.00	101.68		42.71

NEST: 3

SAMPLE #	NEEDLE Fo	NEEDLE Fe	NEEDLE Fo-Fe	BROADLEAF Fo	BROADLEAF Fe	BROADLEAF Fo-Fe	CHI-SQUARE x2
1	53.00	54.34	-1.34	16.00	16.44	-0.44	0.04
Total of CHI-SQUARE							0.04
CHI-SQUARE of total	53.00	54.34		16.00	16.44		0.04

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