

SEASONAL VARIATIONS IN THE TREE SPARROW¹

BY A. MARGUERITE BAUMGARTNER

Plate 23

IN addition to the general characteristics of structure, size, and plumage of a given species, certain changes may be observed from season to season, as in the feather wear, weight, or gonads. In this study of the Tree Sparrow (*Spizella arborea arborea*), except for the description of molt which will be treated in full, only full-grown birds will be discussed. The growth of the nestling, development of feather tracts, etc., are a chapter in themselves and must be presented elsewhere. The following observations are based on specimens collected at Ithaca, New York, from October through April, and at Churchill, Manitoba, during June, July, and August.

MOLT

The most concise statement of molt in the Tree Sparrow is that given by Dwight (1900), and in the following discussion his summary, in quotation marks, will precede such additions as I have been able to make. Colors refer, as far as possible, to Ridgway's (1912) standard nomenclature.

The molts of the sexes of *Spizella arborea* are alike, as would be expected in birds of similar plumage. This species is classed by Dwight among those birds: 'I. which have an annual or single molt (Postnuptial); A. in which the postjuvénal molt is incomplete, not involving remiges nor rectrices; 1. in which young and adults are nearly alike in winter and nuptial plumages.' Plumage sequence is as follows:

(1) *Natal down*.—"No specimens seen" (Dwight). The Churchill nestlings, hatching in early July, were sparsely tufted with fuscous down. This plumage was of short duration, and at the time the young left the nest at the age of about nine days, only a loose fuzz remained, clinging to the tips of the superciliary feathers like elongated eyebrows.

(2) *Juvenal plumage*.—"Acquired by complete postnatal molt." This plumage I would subdivide into two phases on the basis of the dorsal feathers; for even before the birds are full grown and before any other region is affected, there is a gradual invasion of adult feathers in this area, with the result that full-grown birds still essentially juvenal have an altogether different appearance dorsally from young just out of the nest. This conclusion is based on observations at the nest and the preparation and study of thirty-eight specimens.

(a) *Fledgling*: from the time the bird is completely feathered (about eight days) until nearly full grown (about four weeks). Birds of known

¹ Submitted as part of a doctorate thesis at Cornell University, 1935.

age up to 23 or 24 days on July 26 were entirely juvenal; after August 1, only one unusually small individual can be considered as phase *a* (Plate 23, upper figure, two birds at left).

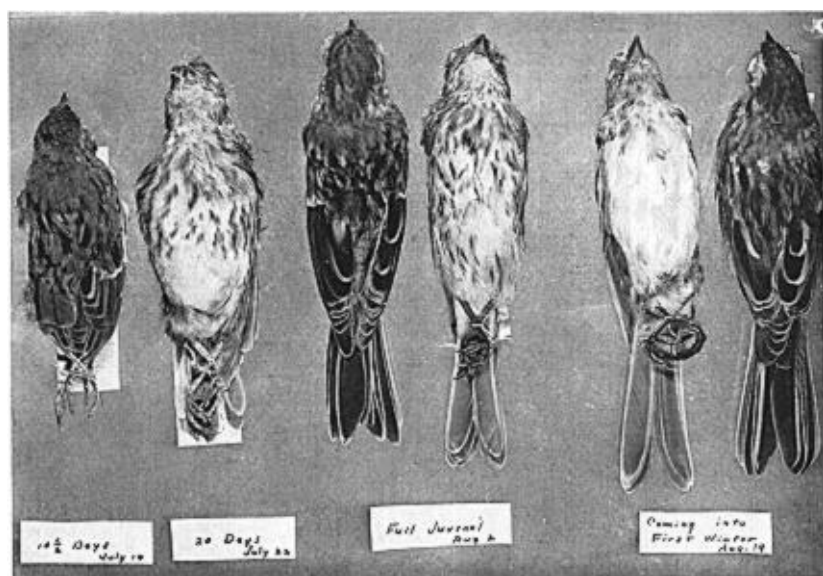
Description: Pileum dull cinnamon brown, streaked by the black shafts of individual feathers, and more or less edged with light buff; nape similar, the black shafts indistinct or lacking, becoming grayer or buffier on sides of neck; feathers of back and scapulars broadly centered with black, edged with light buff and occasional touches of chestnut, especially the latter; rump and upper tail-coverts light buff, indistinctly streaked or mottled with black; sides of head and whole under parts light buff (shading to light smoke gray on throat and becoming a rich buff on sides), heavily streaked with soft black, especially on the breast, but not on lower abdomen and under tail-coverts.

Except for the heavy streaking on the breast the color pattern is essentially like that of the adult plumage, with the distinct pileum color terminated by a grayer nape, the broadly streaked back and rich buff of the sides. The same facial expression is produced by a light superciliary stripe, an irregular dark line under the eye and a definite postocular streak. The dark pectoral spot, contrary to Beebe's assertion (1907), can be identified from among the heavy streakings of the breast. A small patch of dull chestnut at the bend of the wing is streaked with black in this phase of the juvenal plumage. The wings and tail are, of course, those of the first winter.

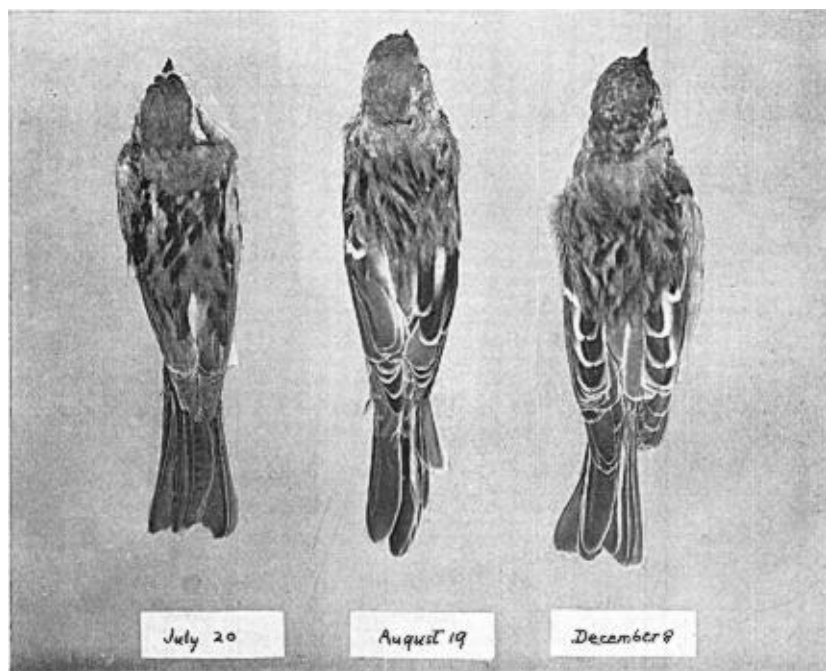
(b) *Full-grown juvenal*: transition stage from the time the first adult feathers appear until the more general molt (Plate 23, upper figure, two birds in center). At Churchill this phase was found during the first two weeks of August, when the young were practically full grown. Upon skinning, heavy rows of stubby sheaths were revealed in various parts of the body. The backs showed varying amounts of the rich chestnut-edged feathers of winter, and the streaked chestnut patch at the bend of the wing was early replaced by true adult feathers. After the middle of the month, the adult plumage rapidly replaced the juvenal and the birds passed into the next stage. Nelson (1887) states that in Alaska, full-fledged young were taken in mid-July or earlier, and that by the first of August, fall plumage had been assumed by nearly all, young and adults.

(3) *First winter plumage*.—"Acquired by a partial post-juvenal molt in August which involves body plumage but apparently not the wings or tail, young and old becoming indistinguishable." This molt, as just stated, has begun on the back and side patch before the young are full grown, about the first of August, but does not reach its culmination until after the middle of the month (Plate 23, upper figure, two birds at right).

The sequence of molt in the feather tracts is more or less irregular, with fresh quills appearing early in one individual which in another may not



PLUMAGE DEVELOPMENT IN YOUNG TREE SPARROWS



PLUMAGE DEVELOPMENT IN ADULT TREE SPARROWS

develop until near the end of the molt. One of the areas that regularly makes an early appearance is the wood brown of the sides, which at first has a decidedly pinkish cast and makes conspicuous blotches among the soft streaky feathers of the juvenal under parts. The first chestnut feathers of the pileum usually appear at the base of the bill or over the eye, developing in cephalocaudal sequence. Except in one specimen (August 2) none shows this development until after the middle of the month, when the back and sides are well feathered and other tracts are in heavy quills. The last juvenal feathers to disappear are those of the nape, the dark postocular stripe, and scattered streaky feathers of the throat and breast. None of the birds collected up to August 19 was in complete winter dress, and feet and bills were still somewhat pale.

When the species arrived in Ithaca in the fall, traces of the molt could still be discerned in ten per cent of those collected, of which three were young birds. An adult female, on October 31, showed pronounced sheaths on the inner row of the ventral tract. A few sheaths were found on the nape and throat in another on November 4, in a male on November 16. This and succeeding plumages have been fully described by numerous authors, so that repetition is unnecessary.

(4) *First nuptial plumage*.—"Acquired by wear, the buffy edgings of the back becoming grayish and the chestnut everywhere slightly paler" (this and ensuing paragraphs pertain, of course, to first-year and adult birds alike). A series of skins chronologically arranged, shows a gradual but definite change through the year, becoming more pronounced after the first of March. A certain amount of this is due to fading, as Dwight intimates, but the chief cause is actual wearing off of the feather edges.

In Table 1, on page 607, an attempt has been made to trace this development by describing representative stages at which the changes become conspicuous. Plate 23, lower figure, shows birds (from left to right) in late summer plumage, during postnuptial molt, and in early winter plumage.

During the spring there is in addition a restricted molt of which Dwight says: "New feathers regularly grow on the chin in March but apparently not in the other tracts and their appearance indicates, as in some other species, renewal rather than molt, for they are very few in number." This was first observed in three of twenty-three specimens on February 26, 1935, and became universal throughout March and April in both sexes. It was found, however, to be more extensive than is usually accredited this species, for of 130 specimens examined, fresh sheaths were evident regularly on *cheeks*, *chin*, later on the *throat*, and other tracts were affected in the following proportions (in this count scattered feathers were not considered, but only definite areas of new quills):

<i>Tract</i>	<i>No. of specimens showing molt</i>
Crown (sides and back only)	5
Superciliary stripe	6
Lores	3
Nape	10
Dorsal tract	19
Scapulars	4
Rump	2
Sides	5
Belly	6

(5) *Adult winter plumage*.—"Acquired by a complete postnuptial molt, indistinguishable from first winter dress." At Churchill, Manitoba, the first evidences of this plumage were detected on July 31, 1933, and on August 3, 1934. The sequence is again irregular, varying in different individuals, but in general it appears that the contour feathers somewhat precede the flight feathers, and progress more or less from the anal region cephalad. Thus the specimen on August 3 showed stubby quills in the lower ventral tract and the upper and under tail-coverts; but it also had one new sheath in the tail and several on the wing-coverts. An August 5 bird, still more contrary to rule, showed no molt except in the primaries. On August 19, however, seven specimens were in almost complete winter dress caudally, with the remnants of sheaths at the base only; heads were in every stage of molt, proceeding from the bill backward; napes were all excessively worn and bristling with new sheaths; while among the flight feathers the tails were incomplete, varying from only two feathers and short quills, to those in which the innermost were completely grown, the marginal ones half-grown; and wings showed only two or three central primaries and secondaries in sheaths.

During the early fall migration four specimens (five per cent of those collected) showed fresh sheaths. In one, the inner row of the ventral tract was in heavy molt; in the others it was restricted to small patches on cheeks, chin, crown and rump. Whether this should be considered the last of the postnuptial molt or simply feather renewal is uncertain.

(6) *Adult nuptial plumage*.—"Acquired by wear as in the young bird."

FEATHER RENEWAL

Besides the regular molt, the bird has the capacity to replace feathers that have been lost. Tail-feathers and even the whole tail are lost rather easily. Several cases were observed at the banding station and twice in the field. Miss Aslop (1926) notes that in a Tree Sparrow that had lost its tail at her station, new feathers came in irregularly, growing out and then being lost again. Miss Thorp (1929) gives a detailed record of the plumage re-

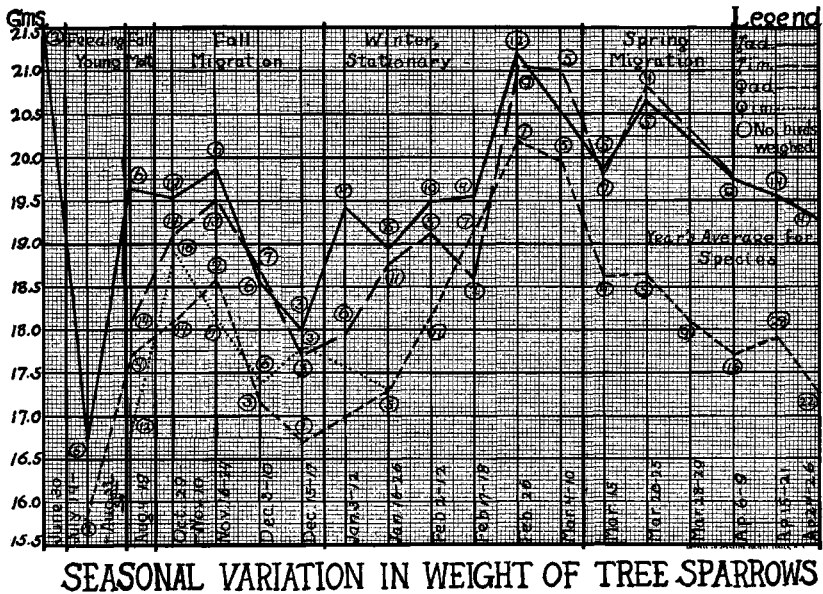
TABLE 1
Development of Feather Wear

	November 1 (Fresh winter plumage)	March 1 (End of winter)	May 1 (Last migrants)	June 1 (Pre-breeding)	August 1 (Pre-molting)
Crown	Chestnut; veiling more or less heavy	Beginning to wear	Veiling almost gone	Veil gone; feathers have frayed appearance	Faded to hazel; feathers badly worn and many lost
Nape	Rich chestnut wash		Wash slightly faded and worn	Wash almost gone	Wash completely gone, very worn and gray
Back and Scapulars					
a. Buffy edgings	Broad edgings	Slightly worn	Worn	Much worn, only narrow edging black, back dark	Almost gone, leaving back largely black and very frayed
b. Chestnut edgings	Broad edgings	More worn	Much worn	Almost gone on back, much worn on scapulars	Practically all gone except faded remnant on scapulars
Wings, outer web:					
a. Primaries	Blackish brown	Somewhat faded and worn	Edges slightly worn	?	Faded to clove brown and badly worn; edgings badly faded, coverts lost
b. Secondaries	Edged whitish		Faded to buffy or hazel		
c. Tertiaries	Edged chestnut (narrowly) Edged chestnut (broadly)				
Tail	Blackish brown; outer edge and tip broadly edged with whitish	Somewhat worn	Faded, more worn	Badly worn	Faded to clove brown, frayed and broken, outer webs worn com- pletely off, 3-10 mm. of length lost
Under parts	Pale buff, grayer on throat, sides pale wood brown	Slight and very gradual wear	Slight and very gradual wear	Slight and very gradual wear	Badly worn, very gray and ragged, sides faded to dirty buff

newal of a bird wounded in one of her traps. A gash from bill to crown, that laid bare the skull, required seventeen days before the skin was replaced and quills began to appear, and about a month before the bird was indistinguishable from the others.

WEIGHT

Correlation with life cycle.—Kendeigh (1934) states that passerine species are generally heavier in winter, presumably due to three factors: freedom from the cares of reproduction, freedom from the exhaustive process of molt,



TEXT-FIG. 1

and physiological changes accompanying changes in climatic environment. Weights of the Tree Sparrow at different seasons follow a curve that can be closely correlated with the bird's activities. The accompanying graph (Text-fig. 1) has been prepared from averages of 455 specimens collected from June 30 to August 19, at Churchill, Manitoba, and from October 29 to April 26, at Ithaca, New York. The figures in circles indicate the number of birds upon which each average weight is based. First-year birds have been given separate rank as long as they could be distinguished by skull or gonadal differences. All birds were weighed within a few hours of collection.

A study of these curves shows an abrupt loss of weight with the advent of young birds in early July, followed by an almost equal increase after the fledglings can take care of themselves and preparations for the fall migration have been initiated. No records were obtained from August 19 until the arrival of the species in Ithaca at the end of October; in this interval the young had attained practically adult proportions. Immature males average somewhat lighter than adult males, but young females seem slightly to exceed the adults of their sex. Whether the low averages from December 15 to 17 are due to an inaccuracy of the scales or to an influx of late migrants worn down by the vicissitudes of travel, is uncertain. A more or less uniform weight is maintained throughout the winter months, culminating in a sudden increase at about the end of February, after which there is a gradual decrease during the spring migration. L. E. Hicks (in litteris) collecting in Ohio during March, 1935, sends me figures very close to my own, but with a slight increase up to April 2, the last date of collecting. In both sexes the maximum figures for the year, both of averages and of individual high points, are attained in late February. Minima occur in July when both parents are feeding the young, although a few individuals approximate these low figures in late April.

Figures for the year are given in the following table (Table 2). In order to assure equal emphasis upon all periods of the year rather than upon days of heaviest collecting, these averages were compiled from the averages for each bi-weekly period. The average for the species is that of the four yearly averages.

TABLE 2
Yearly Average and Extreme Weights of Tree Sparrows

	Average	Maximum	Minimum
Male adult.....	19.47 grams	22.7 grams	15.9 grams
Male first year.....	19.28	22.6	15.3
Female adult.....	18.62	20.7	15.0
Female first year.....	18.85	20.0	15.3
<hr/>			
Species average.....	19.05 grams		

Comparison with birds at feeding stations.—Weights of forty-three birds at the feeding station during February and March of 1933, tended to range somewhat higher, doubtless due to full crops at the time of weighing, if not also to more sheltered conditions of the marsh near human aid. The average for the species here was 22.0 grams, with extremes of 24.4 and 19.0 grams.

Loss in weight of dead birds.—In order to check the value of second- and third-day weights on collected specimens, a few birds were weighed every evening over a week's time, with these results:

TABLE 3
Loss in Weight of Dead Specimens

	Loss first day	Loss in 7 days
Two specimens in cooler.....	0.4 gm.—01.90%	0.7 gm.—03.33%
	0.3 gm.—01.65%	0.6 gm.—03.29%
One specimen in room temperature.....	0.5 gm.—02.76%	

FAT CONTENT

Correlated with weight is the amount of fat encircling the body. While no pronounced change could be traced through the winter months due to the range of individual variation, there was a marked difference between winter and summer birds. Fat tracts were still well developed in specimens of the first week of June before breeding activities had begun, but the few birds collected during the nesting period were extremely lean. Fat was not observed again until August 8, when family cares were practically over. In juvenal birds it was first observed on August 1, in a fully fledged young.

On a well-padded specimen of March 20, 1935, the fat was scraped off as clean as possible and found to weigh approximately 1.5 grams, or 7.73 per cent of the total weight. The animal is not, as Beal (1925) extravagantly says, equipped with "a set of underflannels from $\frac{1}{8}$ to $\frac{1}{4}$ inch thick all over the bird's body" after the fashion of ducks and shorebirds. Rather fat is found in well-defined patches corresponding to the feather tracts, encircling the neck and upper breast, and especially on the lower belly and anal region.

SIZE OF STOMACH

Allen (1909) shows the change in width of stomach muscles of the Red-winged Blackbird with the change from granivorous to insectivorous diet in summer. A like development was noted between winter and summer Tree Sparrows, although no notes were taken on the subject. The width of the stomach muscle during winter is approximately 5-6 mm.

DEVELOPMENT OF SKULL

The juvenal birds of mid-August displayed uniformly unossified skulls. Upon the arrival of the species in Ithaca in late October, birds of the year could readily be identified by the large pellucid area of the parietal bones, although the floor and back of the brain case and all the occipital and mandibular regions were fully ossified. Gradually this area was invaded by the denser osseous tissue, working forward in a more or less regular pattern until in mid-December and early January, at the age of about six months, only a thin line remained, usually directly behind the occipital crest.

On January 16, six males still showed vestiges of the clear area, while two whose testes were distinctly immature, were indistinguishable from adults by skull characters. On the 26th two were incompletely, three completely ossified. The latest trace was found on February 2, 1935.

DEVELOPMENT OF GONADS

Three characters were traced in the seasonal changes of the gonads: size, color, and histological structure. With the generous advice and assistance of Dr. B. F. Kingsbury of the Cornell Histology Department, a series of over one hundred winter testes and ovaries was stained and sectioned, in the hope of detecting differences between adult and first-year birds in winter after other characters had failed. While results have not been entirely satisfactory in this connection, it was interesting to watch development with the approach of spring.

Juvenal birds.—Although young birds had attained their full size by the first of August, genital organs could not be detected with the unaided eye until August 17, at the age of about six weeks. Males evidently develop earlier than females, as indicated by the following table (sex based on measurements).

TABLE 4

Development of Sex Organs in Juvenal Tree Sparrows

(14 birds collected August 17-19, 1934, at Churchill, Manitoba)

Presence of:	In males	In females
Gland and duct.....	5 birds	1 bird
Duct only.....	1 bird	4 birds
Neither.....	0	3 (?)

Male.—The testes at first appearance were about half a millimeter in diameter and of a delicate translucent white. Fall testes of first-year birds (end of October) measured 0.8 mm. as compared with the buffy adult glands twice that size. No change could be detected through the winter until mid-February, when a few evinced a slight swelling; whiter testes measured the same as buffy ones so that age could no longer be declared with certainty. The smaller size still obtained for the majority, however, until March 15, and for one as late as March 28. The last spring testes ranged from 2.0 to 2.6 mm. in diameter.

By the first week in June at Churchill, Manitoba, testes were well developed and many of the birds were already breeding. In specimens collected on the 4th and 5th they ranged from 6 mm. to the full size of about 10 mm., buffy, more or less kidney-shaped organs on the surface of which could be discerned the fine reticulations of the tubules. Testes were still slightly enlarged on July 23.

Cross-sections of the testes of November birds which were known to be adult displayed a conspicuous shrinkage of the tubules from the basement membrane. While immature specimens studied were not shrunken, Dr. Kingsbury considers this a not wholly reliable characteristic of immaturity. In addition to this, the basement membrane and interstitial epithelium seemed to be less dense in first-year birds. By mid-February the swelling in size above noted was accompanied by the swelling of the tubules and rapid proliferation of new epithelium, so that it became increasingly more difficult to distinguish adults from birds in their first winter. By April, it was impossible even to hazard a guess at their age. Other characters that have escaped my attention may prove more permanent criteria, but considerably more study will be necessary before final conclusions can be drawn.

Female.—As just stated, the female organs developed later than those of the male, for only the beginning of an ovary was observed in one specimen on August 19, the last date of collecting at Churchill. By the end of October, however, the ovaries of young and old were indistinguishable in size, color, or shape. Whitish, flat, roughly triangular and finely granular in texture, they were about 3 mm. in length. After March 15, they began to appear more rounded and granular, attaining a maximum length of 4 or 5 mm. before the spring departure.

On June 4, a female collected in company with a fully developed male had ovaries only slightly developed, with individual ova only 1 or 2 mm. in diameter. The laying period followed from one to two and a quarter weeks later. On June 26, a bird taken on the nest contained in the oviduct a fully formed egg. The ovary held several other ova in which the yolk had begun to be deposited, ranging from 4 or 5 mm. to minute size. The reproductive organs in July were much reduced and by August had shrunk to winter dimensions.

Histological specimens showed little difference between adult and first-year birds. Follicle scars could sometimes be noted in the fall, indicating previous breeding, and it may be that further study of this material will reveal other characters.

LITERATURE CITED

- ALLEN, ARTHUR A.
1914. The Red-winged Blackbird: a study in the ecology of a cat-tail marsh. Abstract Proc. Linnean Soc. New York, nos. 24-25, pp. 43-128, pls. 1-22.
- ASLOP, E. B.
1926. Bird banding notes, no. 19, p. 5, May 29.
- BEAL, F. E. L.
1905. The Tree Sparrow. Educational Leaflet, Nat. Assn. Audubon Soes., no. 16, 4 pp.; also Portraits and Habits of our Birds, pp. 61-64.
- BEEBE, C. WILLIAM
1907. The bird, its form and function. 8vo, xii + 496 pp., illustr.
- DWIGHT, JONATHAN, JR.
1900. The sequence of plumages and moults of the passerine birds of New York. Ann. New York Acad. Sci., **13**: 73-360, pls. 1-7 (see pp. 133, 197).
- KENDEIGH, S. C.
1934. The rôle of environment in the life of birds. Ecological Monographs, **4**: 299-417.
- NELSON, E. W.
1887. Report upon natural history collections made in Alaska between the years 1877 and 1881. 8vo, Washington, 337 pp., 21 pls.
- RIDGWAY, ROBERT
1912. Color standards and color nomenclature. Washington, D. C.
- THORP, HILDEGARDE
1929. The case of Tree Sparrow No. A126302. Bull. Northeastern Birdbanding Assn., **5**: 120.

EXPLANATION OF PLATE 23

DEVELOPMENT OF PLUMAGE IN TREE SPARROWS

UPPER FIGURE: young Tree Sparrows. Two specimens at the left, fledglings; two in the center, full-grown juvenals; two at the right, molting into first winter plumage.

LOWER FIGURE: adult Tree Sparrows. At the left, worn breeding plumage; center, postnuptial molt; at the right, early winter plumage.

*629 East Grand River
East Lansing, Michigan*