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ECONOMIC STATUS OF THE ENGLISH SPARROW IN THE UNITED STATES

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UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

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NEED OF A CURRENT APPRAISAL

Fifty years have passed since the publication of the first extensive report by Barrows (*2*)[2] on the economic status of the English sparrow [3] in this country. That bulletin long has been looked upon as a classic among contributions to economic ornithology. Its pages chronicle a history and appraisal of the economic worth of the English sparrow that can be found nowhere else in the literature of American ornithology. Not only has the bulletin served as a basis for legislative action and as a guide to scientific and popular opinion, but it has stood as a fitting testimonial to the painstaking thoroughness of its author and his associates.

[1] Submitted for publication June 16, 1939.
[2] Italic numbers in parentheses refer to Literature Cited, p. 64.
[3] Popular and generally accepted usage in the United States, as well as the fact that most, if not all, of the sparrows successfully imported into this country came from England, prompts the use in this bulletin of the name "English sparrow" instead of "house sparrow," the term used extensively in Europe.

Since 1889, however, many changes have taken place. The range of the English sparrow in this country has more than doubled, and the bird has come to be of economic importance in every State. Changed agricultural practices, extension of crop areas, phenomenal growth of metropolitan sections, successive inroads of various new insect pests upon which the bird can prey—these and many other factors have added much to the history of this imported bird, and in the light of these altered conditions there has grown a need for another appraisal of its economic worth. To supply this has been the object of the present investigation.

RANGE AND ADAPTABILITY

NATIVE HOME

The English sparrow occurs in its typical form, *Passer domesticus domesticus* (Linnaeus) (pl. 1, *A*), throughout most of Europe, with the exception of Italy. Its range extends north beyond the Arctic Circle in the Scandinavian Peninsula; east as far as Irkutsk in Siberia; and south to Spain, Portugal, the Balearic Islands, and the Balkan Peninsula. Closely related subspecific forms are found in contiguous regions to the south and southeast. The combined ranges of these embrace portions of the northern coast of Africa, the Nile Valley to a point south of Khartoum, Syria, parts of Palestine, Persia, southern Arabia, Turkestan, India, and French Indo-China.

COUNTRIES INTO WHICH INTRODUCED

By reason of successful introductions into a number of countries, the range of the English sparrow has been extended far beyond the great area to which the bird is native. The countries include the United States, whence the bird has spread to Canada and Mexico; Bermuda; Cuba; temperate South America, where it is found in southern Brazil, Paraguay, Uruguay, south to southern Argentina; the Falkland Islands; New Zealand; Australia; Natal and Zululand in southeastern Africa;[4] the island of Mauritius in the Indian Ocean; and the Hawaiian and Philippine Islands.

INTRODUCTION AND SPREAD IN NORTH AMERICA

The English sparrow, along with other exotic species, was introduced into the United States partly because immigrants from Europe wished to have about them some of the familiar birds of their homeland and to further this objective maintained several active acclimatization societies for many years, but the specific reason often cited is that it was thought that the bird would control the dropworm, larva of the snow-white linden moth (*Ennomos subsignarius*), a very objectionable pest in cities at that time. Publications of the period credit the English sparrow with actually controlling this insect, but this may have been due to faulty observation, as the linden moth still occasionally develops extensive outbreaks.

[4] E. Warren, of the Natal Museum, reported in 1928 that "the sparrow has increased and spread in Natal very greatly during the last 15 years. The bird was quite uncommon in Pietermaritzburg in 1903 but since about 1915 it has become exceedingly common." Austin Roberts, of the Transvaal Museum, reported at the same time that the English sparrow had "progressed northward in Zululand as far as Hluhluwe Station on the new railway line."

B1038M; B14096

A, English sparrows, male and female, at a nesting box; *B*, straw-thatched cattle shed, a favorite nesting site for large numbers of English sparrows.

B54136; B54135

ENGLISH SPARROW NESTS.

A, Nest in a bird house, and *B*, bulky straw nest in a Bolleana poplar, both in Denver, Colo., November 22, 1939.

The initial importation occurred in the fall of 1850, when eight pairs were transported from England to the Brooklyn (N. Y.) Institute. They were kept in a cage during the winter and liberated early in the spring of 1851, but they did not thrive. In 1852 a second and successful attempt at introduction was made, of which Nicolas Pike, one of the directors of the Brooklyn Institute, who was instrumental in bringing in those early lots, has given the following account (*2, p. 17*):

> I went to England in 1852, on my way to the consul-generalship of Portugal. On my arrival in Liverpool I gave the order for a large lot of Sparrows and song birds to be purchased at once. They were shipped on board the steam-ship *Europa*, if I am not mistaken, in charge of an officer of the ship. Fifty Sparrows were let loose at the Narrows, according to instructions, and the rest on arrival were placed in the tower of Greenwood Cemetery chapel. They did not do well, so were removed to the house of Mr. John Hooper, one of the committee, who offered to take care of them during the winter.
>
> In the spring of 1853 they were all let loose in the grounds of Greenwood Cemetery, and a man hired to watch them. They did well and multiplied, and I have original notes taken from time to time of their increase and colonization over our great country.

Other importations followed, and in the 30 years subsequent to its introduction, at least 19 shipments, consisting of lots of a few birds up to consignments numbering several hundred, were received directly from Europe and liberated at various points from New England to Salt Lake City, Utah. Frequently sparrows were shipped from points of colonization to other spots in this country, and in that way the spread of the species was greatly expedited during the early period of its residence. Empty boxcars, especially those used in the transportation of grain, also aided in dispersing the birds along the lines of our various railway systems.

By the close of 1886 the English sparrow was generally distributed in North America from southern New Brunswick southward to southern Georgia, central Alabama, and Mississippi. Westward it had gone as far as eastern Arkansas, eastern Kansas and Nebraska, north-central Iowa, and southeastern Minnesota. To the north it had reached northern Wisconsin, upper Michigan, and similar latitudes in Ontario and Quebec. In addition, there were extensive and thriving colonies in and about New Orleans, the Salt Lake Valley, Utah, and the region about San Francisco Bay and the lower Sacramento and San Joaquin River Valleys in California. Many isolated small groups also were recorded in regions contiguous to those outlined.

At present the range of the English sparrow in North America covers the entire continental United States except Alaska, all thickly settled parts of the contiguous Canadian Provinces, and similar areas in Mexico south at least as far as San Luis Potosi and Guadalajara in Jalisco (*22*). The most northerly point of occurrence of which the writer has record is Two Islands Indian Village on the Mackenzie River, 30 miles below Fort Simpson, Mackenzie, latitude 62° N., reported by Williams (*42, p. 64*). The bird is known also at Athabaska Landing in northern Alberta and is present in most of the settlements in the coastal region of British Columbia.

Within the boundaries of this extensive range in North America there are heavily forested areas and desert regions in which the English sparrow still is scarce or absent. Cities in southwestern California were among the last to be populated by this bird, San Diego not having been occupied until 1913.

Along with the rapid extension of the range of the English sparrow during the latter part of the nineteenth century, the density of its population increased correspondingly in sections where it had been longest established. From the cities it overflowed into suburban and rural sections, especially in grain-raising areas. In the Salt Lake Valley, Utah, and other areas where grain, especially wheat, is plentiful in the country and where the sparrows are not confronted with a shortage of nesting sites, owing to their tree-nesting habits the species has become even more numerous in the rural sections than in the cities. Today the progressive extension of range and the increase of numbers are still in evidence at points in the West where the species has not yet reached its peak of abundance.

East of the Alleghenies, however, and even in some areas in the Middle West, it is evident that a reduction in the number of English sparrows has occurred within the last decade or two. Although there are few reliable and comparable figures based on actual counts to support this assertion, bird observers and farmers have quite generally noted and commented on this gradual change. Frequent reports from residents of New Jersey, Pennsylvania, and New York of a reduction in the sparrow population were received by the writer in the course of his field work in 1916. Since that time similar observations in Ohio, South Carolina, Kentucky, Illinois, Indiana, and elsewhere have come to his attention. In Washington, D. C., the flocks that customarily frequent downtown sections have decreased perceptibly in size in the past 20 years.

A HARDY, PROLIFIC SPECIES

Although in Northern States winter is a period of comparative food scarcity and hardship for many birds, English sparrows cope with such adversities remarkably well and at the first signs of spring begin nest building. As a matter of fact, in the latitude of Washington, D. C., they may be found gathering nest material in almost any month, although serious efforts toward providing shelter for forthcoming broods usually are not made before the first of March.

English sparrows are by no means fastidious in their choice of nesting sites. They are equally at home nesting in bird boxes (pl. 1, *A*; pl. 2, *A*), on beams in barns, in cattle sheds (pl. 1, *B*), in eaves spouts on dwellings, on fire escapes, windmills, or water tanks, and in almost any sort of cavity about a building. In some sections they construct their bulky nests of straw and feathers in exposed crotches of trees (pl. 2, *B*). Such a habit is prevalent in the Salt Lake Valley, Utah, where single Lombardy poplars, cottonwoods, or boxelders may contain as many as six or eight nests. About lumberyards or warehouses close to railroad tracks, these unsightly nests become fire hazards of considerable risk. Not only have industrial firms complained of the birds on this score, but at least one fire-insurance company has taken cognizance of this feature of fire risk and has made appraisals accordingly.

A report from Santa Fe, N. Mex., notes the finding of an English sparrow's nest containing five fresh eggs on December 12, 1927. Cottam (*9*, *p. 193*) recorded one found at Provo, Utah, in which the eggs were just hatching on January 1, 1929. At Ottawa, Ontario, a newly laid egg was found in 1890 as early as January 18, and in Middlesex, Ontario, a young bird was observed in the last week of

February. In the latitude of Washington, D. C., egg laying for the first brood is at its height about the middle of April, but individual birds may begin to lay much earlier. Young birds of the last broods of the year normally are out of the nest by the end of August, but misfortunes besetting earlier attempts may result in late broods that do not leave the nest before September or even October.

The number of eggs in a set varies from 3 to 7, with 5 or 6 most often found. The incubating period is 12 or 13 days. The number of young to the brood averages somewhat less than the number of eggs, owing to the infertility of some of the eggs and the uncertainties of incubation. In the Salt Lake Valley, Utah, the writer found (1911 and 1912) the average number of young based on 187 broods to be 3.67. This estimate should be increased slightly, however, to allow for the presence of a few unhatched eggs and the escape of young that may have left the nest before the inspection was made.

According to the writer's observations, young English sparrows remain in the nest about 10 days, but there appears to be variation in the length of the nestling period, governed perhaps by prevailing temperatures or other climatic conditions. Barrows (*2, pp. 27–28*) estimated it to be about a week in this country; Kirk (*29, p. 109*), 8 or 9 days in Australia; and Schleh (*36, p. 790*), 13 or 14 days in Germany. After leaving the nest the young birds are fed for several days by the adults until they become self-sustaining.

Three or four broods a year are not infrequent, and under favorable climatic and food conditions an even greater number may be brought forth. The broods may succeed each other rapidly, and occasionally eggs may be laid in a nest from which the young of the preceding brood have not departed. Usually, however, a short period of rest occurs between broods.

Soon after the young leave the nest they gather in small flocks that increase in size during July and August. As summer advances, these juveniles are joined by adults that have ceased their nesting activities. Such flocks, which often include several hundreds and at times more than a thousand birds, may be found feeding in ripening grainfields or about mills, warehouses, and market places in cities. At that time of the year English sparrows may be observed making daily trips from roosting places to feeding areas. Grain-raising sections near towns are always attractive to the urban birds, which may forsake their city homes entirely during the harvest season to live in adjacent fields, thus making limited seasonal migrations conforming with the shift in food supply.

With the coming of cool weather in fall, English sparrows often resort to nightly roosts, usually in protected spots, as on the vine-covered sides of buildings, in dense stands of evergreens, or even in the interior of buildings, as in barn lofts, cupolas, or church towers. Even deciduous trees in the center of cities, where sheltering buildings break wintry blasts, are used. A roost of this character on a principal thoroughfare in Washington, D. C., proved a nuisance for a number of years.

In regions where the winters are severe, English sparrows regularly construct feather-lined roosting cavities in bird boxes, crevices in buildings, or elsewhere, to which individual birds resort nightly. With such protection and with a substantial food supply at hand these hardy birds experience little difficulty in surviving winters in

northern latitudes or at high altitudes. At Leadville, Colo. (10,200-foot altitude), they commonly build such domiciles and pass the winter successfully.

This introduced species has encountered in North America a set of environmental conditions that in many respects differ radically from those experienced by the ancestral stock in its native home. Changes in the character of the food supply and in the climate, competition with new avian and mammalian associates, control by man, and, on the other hand, possibly a measure of freedom from certain parasites and diseases not introduced with the bird are a few of the new conditions. The spread of the species throughout this country has taken it into greatly diversified environments and brought it in contact with many additional factors affecting its welfare. Yet with all these complexities of life the English sparrow has displayed in this country an adaptability and a determination to survive equaled by few, if any, other birds.

In addition to the effects of the struggle for survival, which tends to develop vigor and perseverance, it would seem that reasons for the success of the English sparrow may be found also in its psychological reactions. Carefully conducted experiments to which Porter subjected the bird and in which "the general method used was the one common in comparative psychology of requiring the hungry animal to overcome some simple difficulty in order to obtain food", have revealed some of these secrets of its success (*34, pp. 317, 345–346*). When tested with food boxes, to which it had to discover access, and the experimental maze, the English sparrow revealed a rate and method of learning quite comparable with that of other higher vertebrates. It was found to profit readily by experience, and although its method of learning was one of trial and error, its persistency was most striking. Both in the laboratory and outside it displayed the wariness that is popularly attributed to it; and although it tested new and strange objects by various means, its caution was by no means senseless.

PREVIOUS STUDIES

The most comprehensive previously published report on the food habits of the English sparrow in this country is the one by Barrows (*2*) already mentioned. It presented a great mass of data on the various aspects of the sparrow's economic influence and had as a basis for an appraisal of food habits the results of the examination of 636 stomachs, 388 of which were collected on the Mall and other parkways in Washington, D. C. It reported also on evidence obtained, at least in part, from stomach examinations made by other early investigators, including S. A. Forbes, B. H. Warren, C. J. Maynard, John Dixwell, W. Brodie, and Charles Dury (*2, pp. 126–127, 133–146*). In the aggregate, these investigations—all conducted prior to 1890—involved the examination of more than 1,200 stomachs. An earlier and rather extensive report on the house sparrow by Gentry (*19*) has not been overlooked, but the writer does not consider it a source of accurate information on food habits.

During this same period much about the English sparrow was written also for the daily press and other periodicals. A bulletin by Coues (*10*), issued in 1879, consisted mainly of an annotated bibliography of 190 titles of writings about the species that appeared in the short period from 1867 to 1879.

The subject of the English sparrow's economic status in this country continued to be a fertile one for discussion in both scientific and popular literature, but no further intensive study of it was made until 1911. In that year and in 1912 the writer investigated the relation of birds to the alfalfa weevil in Utah, where the English sparrow's role as a weevil destroyer was determined through the examination of 1,143 stomachs, mostly those of nestlings. A report of the investigation was published in 1914 (*26*). Since then the species has continued to hold a prominent place in the ornithological literature of this country, but no further reports based on intensive study of its food habits have appeared.

In Europe the sparrow has been discussed from a much earlier time than in this country. In France, Germany, and Great Britain it has been the subject of controversy for several centuries, and governmental agencies, scientific organizations, and individual investigators have rendered reports of their findings. Noteworthy among these are the detailed and carefully tabulated accounts of the food of the sparrow prepared by Schleh, of Herford, Germany, and published in 1883 and 1884 (*36*). These were based on the examination of 261 stomachs of adult and nestling birds, and although the volumetric method of computing food proportions was not employed, the examinations compare favorably with those in modern treatises on bird food. In 1885 appeared the work of Gurney (*21*), in which were incorporated the summarized results of the examination of 694 stomachs. More recently Collinge (*7*) published the results of his studies of the food of some British wild birds, and among them the English sparrow is given full attention. His appraisal of this species in Great Britain was based on the examination of the stomach contents of 758 adults and 476 nestlings. Fortunately he employed the same volumetric method of determining food percentages that was used in the preparation of this bulletin, which permits comparisons of the food habits of British and American sparrows.

The closely related and economically similar *Passer domesticus indicus* has been the subject of interesting field and laboratory studies in Turkestan, in the course of which the contents of 2,221 stomachs, more than half of which were of nestlings, were critically examined by Kashkarov and assistants (*28*), Arinkina and Kolesnikov (*1*), and Rusinova (*35*) and carefully checked field observations yielded data valuable in determining the degree of damage inflicted on ripening grain crops.

The consensus of these European investigators, as well as of those who have contributed to the fund of information on the English sparrow in other countries, notably in Australia (*33*) and New Zealand, has been adverse to the bird. Those who have confined their studies to field observations have, in the main, been most outspoken in their condemnation, but even the research workers who have relied on stomach examination, including Schleh, Barrows, Collinge, and the investigators in Turkestan, have come to essentially the same conclusion, that, despite the insectivorous habits of nestling sparrows, the influence of the species as a whole is detrimental to agriculture. It is generally conceded by these investigators that excessive abundance of the birds is the critical factor that makes for an adverse decision.

MATERIAL USED IN PRESENT STUDY

A primary objective of the present study was to gather a large and representative series of stomachs of English sparrows from the examination of which conclusions reflecting present-day food preferences of this species could be drawn, inasmuch as much of the stomach material used in the preparation of the initial bulletin on the English sparrow in this country (*2*) reflected conditions that existed in the parkways of the city of Washington more than 50 years ago and was not representative of average conditions throughout the country even at that time.

As a result there has been assembled information gained from the examination of a series of stomachs more extensive and more nearly representative than that ever used for any other species of bird. This has yielded an abundance of definite data, the lack of which seriously handicapped earlier investigators. To supplement this information and to avoid certain inherent limitations of laboratory methods of approach, observations and experiences of reliable field observers have also been drawn upon. The writer has aimed to submit the evidence in an impartial manner devoid of the prejudice with which the English sparrow problem is so frequently beset. In all, 8,004 stomachs were examined—more than the aggregate number used in all previous important contributions to the literature on the food habits of *Passer domesticus*, both in this country and Europe, including the works of Schleh (*36*), Barrows (*2*), Collinge (*7*), Kalmbach (*26*), Kashkarov, and assistants (*28*), and Arinkina and Kolesnikov (*1*). The material included the 1,143 stomachs used by the writer in his study of the relation of the English sparrow to the alfalfa weevil (*26*), which gave data concerning the feeding activities of this species in the Salt Lake Valley, Utah, in 1911 and 1912 under conditions that to a large extent still exist. A few stomachs collected even earlier were included, but most of those used were obtained as a result of an effort that was made, beginning about 1913, to supplement the material then on hand by the accumulation of a series that not only could be considered representative of the country as a whole but that also would reflect modern conditions.

Information concerning the years in which the 8,004 stomachs were collected is presented below. The degree to which this material reflects relatively modern conditions is indicated by the fact that more than 86 percent of the stomachs were collected in the period 1911–25. The large number of stomachs taken in 1911–17 is the result of the intensive study of the relation of birds to the alfalfa weevil in Utah in 1911 and 1912 (*26*) followed by a general campaign soliciting sparrow stomachs throughout the country.

Years:	*Stomachs*	Years:	*Stomachs*
1879–80	33	1913	851
1881–90	607	1914	1,025
1891–1900	277	1915	676
1901–10	190	1916	648
1911	217	1917	918
1912	2,288	1918–25	274

Of the 8,004 stomachs examined, 337 were found to be too nearly empty or otherwise unfit for use in the computation of bulk percentages. They did, however, supply additional information concerning food items. This left 7,667 stomachs that were used in estimating the proportions of the various food items, 4,848 from adult sparrows and 2,819 from nestlings.[5] The former included some stomachs taken from juveniles—birds fully fledged and out of the nest and feeding largely by themselves, but not distinguishable from adults by many collectors. Had it been possible to segregate these juveniles, doubtless food habits intermediate in character between those of the adults and the nestlings would have been found.

The 4,848 birds were collected at periods well distributed throughout the year, with the maximum, 756, in June and the minimum, 196, in October. The gathering of the 2,819 nestling stomachs took place during spring and summer, April to August, inclusive.

As to locality, the material collected could have been bettered by a more even and general distribution of the sources of supply. Although 35 States, the District of Columbia, and Canada were represented, nearly 75 percent of the 7,667 stomachs were obtained from only 6 States—Alabama, Connecticut, Iowa, Kansas, Massachusetts, and Utah. More than 100 stomachs each were obtained from Alabama, Connecticut, Illinois, Iowa, Kansas, Massachusetts, Michigan, Mississippi, Pennsylvania, Utah, Virginia, Wisconsin, and the District of Columbia. The distribution of these stomachs, by localities and months for the adults and by localities for the nestlings, is presented in table 1.

The food-analysis data here presented are based on studies made and reported upon prior to 1929, and since then the writer has conducted no further fundamental research on the food of this bird. Though publication of the report has been delayed, it is of interest to note that both the first (*2*) and the last reports on food habits of birds made by the Biological Survey as a unit of the Department of Agriculture were on the English sparrow. (This Bureau was transferred to the Department of the Interior on July 1, 1939.)

[5] The writer wishes to acknowledge the valued assistance of two coworkers in the Biological Survey, L. L. Buchanan (now of the U. S. National Museum) and F. M. Uhler. Mr. Buchanan performed the painstaking and important task of indexing food items after examinations had been made, upon which is based much of the text on food habits, and identified many of the coleopterous remains not readily recognized. Mr. Uhler examined about 1,110 stomachs.

TABLE 1.—*Distribution, by localities and months (for adults), of the 7,667 English sparrow stomachs used in the computation of food percentages*

Locality	Adult stomachs													Nestling stomachs	Total stomachs
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total		
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Alabama	62	54	62	67	20	21	17	158	184	46	147	60	898	709	1,607
Arizona						1							1		1
Arkansas										2			2		2
California	2		2			2		4	1	5		1	17	11	28
Colorado				2				1					3		3
Connecticut	32	53	13	31	63	41	84	47	9	18	32	43	466	23	489
Florida		1			1								2		2
Georgia					1					1			2		2
Illinois	2	2	5	29	8	27	12	20	43	10	2	3	163	25	188
Indiana			5				5	32					42		42
Iowa	2	3		11	108	236	65				1		426	229	655
Kansas	82	61	52	28	27	41	35	45		20	63	85	539	399	938
Kentucky			15	6	1					6	8	3	39	3	42
Maryland	1	8		12	7	15	8	6	5	9			71	21	92
Massachusetts	29	80	7	23	139	101	118	109	56	50	66	40	818	73	891
Michigan	1	3	13	20	18	31	1		1		4	3	95	14	109
Mississippi					48	17	1	30	33	1			130	34	164
Montana			1										1		1
Nevada					2								2		2
New Jersey	5		4	3	2	2	10	8	5				39	22	61
New York	8	1	9	5	7	7	14	13	17	2	6		89	9	98
North Dakota					2	1							3		3
Ohio			1				6	1		3	1		12		12
Oklahoma														30	30
Oregon			1										1		1
Pennsylvania	3	1	5	20	16	13	9	9	1	6		8	91	77	168
Rhode Island						6							6		6
South Carolina						1							1		1
South Dakota				1			10						11		11
Texas				11	8			1			4		24		24
Utah				15	67	34	3		1	3			123	1,034	1,157
Vermont	1	1											2		2
Virginia			7	1	3	16	12	6	30	1			76	32	108
Wisconsin	3	16	10	6	2	23	15	229	10	7	2	2	325	15	340
Wyoming				2			2						4	2	6
District of Columbia				3	66	119	32	28	1	4		9	262	57	319
Canada			2	46	6	1	5			2			62		62
Total	233	284	214	342	622	756	464	747	397	196	336	257	4,848	2,819	7,667

FOOD HABITS

Before discussing the significance of the English sparrow's food habits as determined by analysis of stomach contents, it will be well to explain the nature of the various groupings and headings under which this information is presented. An initial segregation is made of the animal and vegetable parts of the food, and the various components of each are treated separately. Under animal food, in accordance with long practice, first consideration is given to the order Coleoptera. This is logical, both because insects of this extensive order are eagerly sought by many birds and because they constituted more than half the animal food of the adult English sparrows. Information is then presented on Orthoptera, Lepidoptera, Hemiptera, Diptera, Hymenoptera, and other insect orders less frequently represented in the food. Additional headings provide for the segregation of data on Arachnida and other miscellaneous animal food items. Under vegetable food, the headings used are feed (for poultry), oats, wheat, corn, other grain, grass and weed seeds, mast and wild fruit, cultivated fruit and vegetables, and other vegetable matter. The difficulties involved in assigning grains to the proper categories are discussed on page 22.

The headings were selected to convey an expression of the food preferences of the English sparrow in as concise and comprehensive a manner as possible. It will be noted that the categories are not, biologically speaking, of equal scope. For instance, percentages have been given for the coleopterous family Carabidae, the suborder Rhynchophora, the class Arachnida, the specific items corn, oats, and wheat, and of plants coming under the general designation of grass or weeds. By isolating or consolidating in this manner items that are respectively of greater or lesser importance in determining the economic status of the English sparrow and by grouping those that logically may be considered as having the same economic significance, it is believed that a clearer picture of the bird's status is obtained than if categories equivalent merely in a systematic biological sense were used.

An idea of the complexity of the economic considerations arising in an appraisal of the food of the English sparrow may be derived from the fact that 838 specifically different items of food were identified in the 8,004 stomachs examined, a greater number than has been recorded for any other bird in this country.

FOOD OF ADULTS

The examination of the 4,848 stomachs of mature birds has demonstrated that the adult English sparrow is primarily a vegetarian. The data obtained as to the volume of the various food items taken throughout the year are given in percentages in table 2 and are presented graphically in figure 1, with slight variations in groupings.

TABLE 2.—*Monthly and yearly food of 4,848 adult English sparrows, expressed by volume percentages*

[Under slightly different groupings, this information is presented graphically in fig. 1.]

Food items	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Animal food:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Weevils			0.68	1.63	2.74	2.26	0.41	0.20	0.24	0.04	0.05		0.69
Scarabaeid beetles	0.02	0.05	.09	1.63	5.91	3.69	.10	.04	.03	.10	.07		.98
Click beetles			.07	.02	.10	.43	.23	.01					.07
Ground beetles				.34	.10	.07	.01		.02				.05
Leaf beetles				.08	.08	.09	.02	.07	.03	.04			.03
Other beetles		.07	.64	.14	.85	.12	.40	.09	.01				.19
Grasshoppers, crickets, and other Orthoptera				.04	.54	.79	1.31	3.33	.89				.57
Caterpillars and moths			.04	.21	.57	1.14	.35	.20	.19	.01	.01		.23
Bugs				.32	.08	.12	.07	.03	.04				.06
Flies			.04	.49	.06	.28	.30	.05	.01				.10
Ants, wasps, bees, and other Hymenoptera	.03		.43	.19	.37	.35	.45	.59	.98	.07	.21		.31
Other insects		.02		.36		.07	.03						.04
Spiders and other Arachnida				.13	.07	.12				.01	.07		.03
Other animal matter		.25		.09	.11	.07							.04
Total	.05	.39	1.99	5.67	11.58	9.60	3.68	4.61	2.44	.27	.41		3.39
Vegetable food:													
Feed	70.97	84.16	77.64	67.00	50.97	52.36	50.36	41.63	31.51	47.77	64.01	76.49	59.57
Oats	11.87	3.17	4.90	13.80	21.64	25.89	26.09	33.77	14.23	10.06	4.60	2.37	14.37
Wheat			.43	.83	8.97	2.76	6.31	4.90	7.46	.20	.58		2.70
Corn	.41	.67		.29			.42	.65	2.39			.35	.43
Other grain	1.02				.10	.13		1.50	3.04		1.20		.58
Grass and weed seeds	15.10	11.32	14.41	9.65	5.16	2.40	7.19	10.71	38.31	41.05	28.63	19.60	16.97
Mast and wild fruit	.44	.05	.06	1.03	.65	5.55	5.63	1.19	.38	.63	.16	.92	1.39
Cultivated fruits and vegetables						.13			.13				.02
Other vegetable matter	.14	.24	.57	1.73	.93	1.18	.32	1.04	.11	.02	.41	.27	.58
Total	99.95	99.61	98.01	94.33	88.42	90.40	96.32	95.39	97.56	99.73	99.59	100.00	96.61

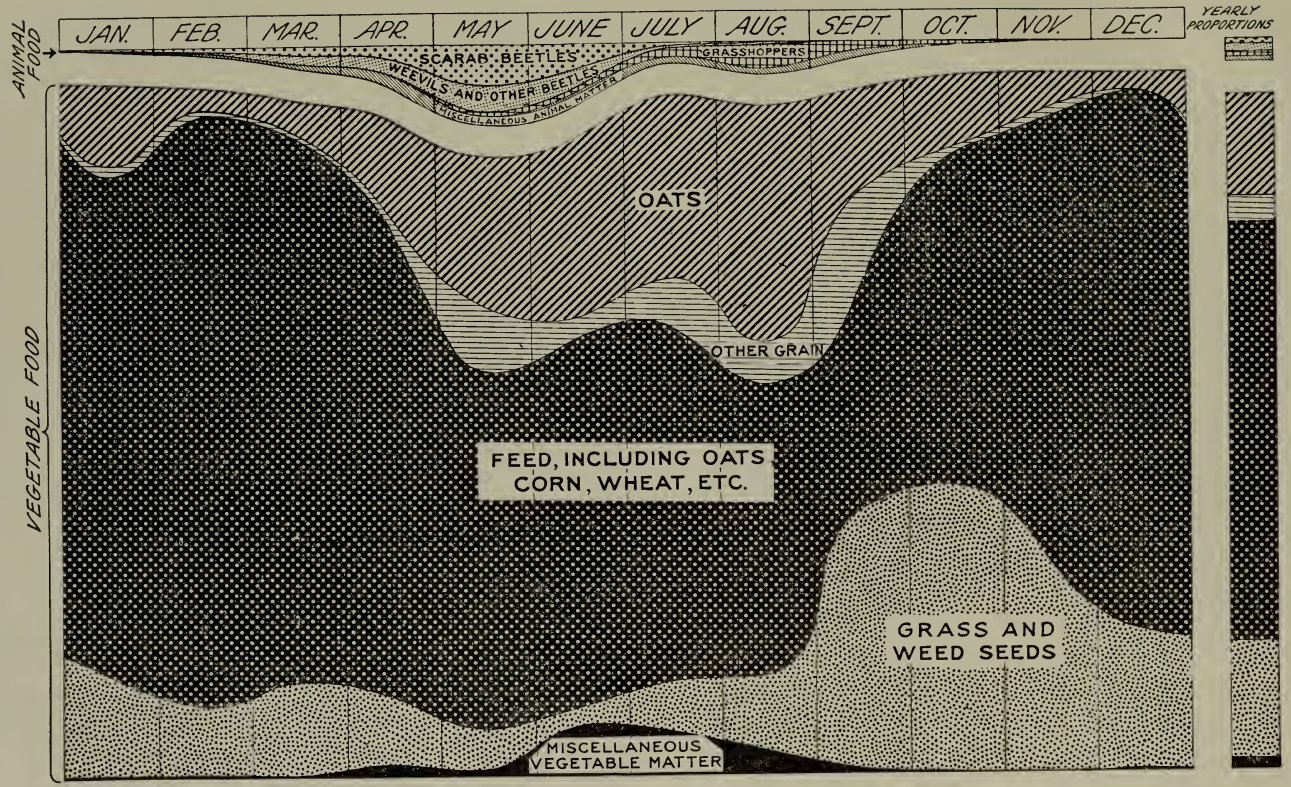


FIGURE 1.—Diagrammatic representation of the yearly food of 4,848 adult English sparrows. Under slightly different groupings this information is given in statistical form in table 2.

ANIMAL FOOD

Only 3.39 percent of the annual sustenance of the adult English sparrows was obtained from the animal kingdom. No animal food was taken by any of the 257 birds collected in December, and in 4 other months (January, February, October, and November) the animal items averaged less than 1 percent of the diet. May, the month in which the increase in insect life synchronizes with the annual peak in the nesting activity of the English sparrow, marked the seasonal point of greatest consumption of animal food. This was followed by a somewhat fluctuating decrease through summer and fall to the minimum in January.

Insects

The insect food of the adult English sparrow, in common with that of other species having a mixed animal and vegetable diet, is an important consideration in determining the bird's economic status, even though it forms only a small proportion (3.32 percent) of the annual diet. In this study insects comprised practically all of the animal food, the difference of 0.07 percent being accounted for by small quantities of arachnids, crustaceans, and a few other items. For this reason the sector in figure 1 denoting animal food may be construed also as representing, with a fair degree of accuracy, the insect proportion of the diet. The bulk of this, it will be noted, was taken during the spring and summer months, March to September, inclusive.

BEETLES (COLEOPTERA)

Weevils (*Rhynchophora*).—Weevils formed an important part of the small quantity of insect food consumed. They were eaten in the adult, pupal, or larval stages by 589 of the 4,848 adults studied. May and June were the months of greatest consumption.

Of particular interest is the relation of the English sparrow to the introduced alfalfa weevil (*Hypera postica*), the subject of the previously mentioned special study in the Salt Lake Valley, Utah, in 1911 and 1912 (*26*). Though the adults' most meritorious work in the destruction of this weevil was accomplished through their feeding of the nestlings (p. 36), they also proved highly effective weevil destroyers during May, June, and July in obtaining food for themselves. Field observations showed that they were regular visitors to infested alfalfa fields and that while engaged in seeking weevils for their young, they partook of much the same diet themselves. Fields nearest to barnyards and cattle sheds (pl. 1, *B*), where sparrows nested in great numbers, were benefited most, but numerous instances were noted in which the adult birds traveled considerably more than 100 yards to obtain this highly prized weevil food.

Examination of the 104 stomachs of adult English sparrows collected in the Utah study showed that weevil-destroying activities began as early as April, as weevils were found in 6 of the 14 April stomachs. In May, 46 of the 67 adults collected had fed on the insect, which composed 8.75 percent of the stomach contents. One bird had eaten 25 breeding weevils. In June, the 20 adult sparrows examined had destroyed 26 adult and 229 larval weevils, which aggregated nearly 30 percent of their food. One bird had eaten 49 larvae and 1 adult, and another, 27 larvae and 2 adults,

which composed 90 and 99 percent respectively of the stomach contents. That the adults continued their good work into July was evinced by the examination of the 3 July birds. All had fed on alfalfa weevils, which, with the exception of a single clover root curculio (*Sitona*), comprised the entire animal food.

Conclusions drawn from the above field and laboratory study were to the effect that the English sparrow is one of the most effective bird enemies of the alfalfa weevil. Though this decision was based largely on the diet of nestlings, it was evident that under the conditions of this insect outbreak the food preferences of adult birds also aided in the suppression of the pest.

Another instance that illustrates the readiness with which the English sparrow avails itself of a supply of weevil food was brought out by the examination of stomachs collected at Autaugaville, Ala., in 1913, 1914, and 1915, where a colony of sparrows that nested in the vicinity of a lumberyard relied to a great extent in raising their young on the abnormal number of bark beetles (Scolytidae) present in the stored lumber and logs. These insects formed the dominant insect food item of the young and also entered strongly into the diet of the old birds. Nearly half the insect food of the adults collected there was composed of weevils—a proportion more than twice that consumed by sparrows collected throughout the rest of the United States. In addition to the several genera of bark beetles, including *Platypus Ips*, *Dendroctonus*, and *Hylastes*, numerous specimens of the pine weevils (*Hylobius pales* and *Pachylobius picivorus*) were present.

On lawns and grassy areas of city parks, the adult English sparrow feeds on the clover leaf weevil (*Hypera punctata*) and the clover root curculio (*Sitona hispidula*) to a limited extent and also on the blue-grass billbug (*Sphenophorus parvulus*). Other species of *Sphenophorus*, as well as weevils of the genera *Hyperodes*, *Tanymecus*, *Lixus*, *Eudiagogus*, and members of the tribe Barini also enter into the diet. The cotton boll weevil (*Anthonomus grandis*) is eaten occasionally, but its presence in only 16 of 928 stomachs from boll-weevil-infested areas does not warrant placing the English sparrow high in the list of controlling agencies of that pest.

Dung beetles, May beetles, and other Scarabaeidae.—Scarabaeids constituted the favorite beetle food of the adult English sparrows, and the bulk of them were taken in April, May, and June. May represented the yearly peak of this activity, a fact that is borne out not only by the estimate of the bulk eaten but also by the frequency of consumption, nearly 33 percent of the 622 adults collected in May having fed on scarabaeid beetles. Most of the forms eaten belong to two genera—*Aphodius*, of the dung beetles, and *Phyllophaga*, the May beetle, the adult form of the white grub.

Dung beetles referable to several species of *Aphodius* were taken in every month except December, but the time of greatest consumption coincided with the emergence and flight of these beetles in April, when most of the scarabaeid food recorded consisted of beetles of that genus, together with a few other coprophagous species of the genera *Ataenius*, *Canthon*, and *Onthophagus*. Through its feeding on village street and in country barnyard, the English sparrow comes in close contact with an ample supply of dung beetles, as the principal propagating medium and food supply of these insects is manure. In this connection it is of interest to note that in Europe also the sparrow

manifests a similar partiality for these beetles. In the course of his examination of sparrow stomachs in Germany, Schleh (*36*) found some of the same species of *Aphodius* that were revealed in this study.

Of more interest from an economic standpoint are the May beetles, which comprised a greater bulk of the scarabaeid food. No less than 15 species were taken, mainly in May and June, the height of their seasonal abundance.

The extent to which the parent birds may partake of a food item used extensively in raising their young was brought out by the examination of 122 stomachs of adult English sparrows collected about gardens and on the streets of Bridgewater, Mass., in May 1925. May beetles had been eaten by 57 adults and formed more than 18 percent of their diet. Stomachs collected 50 years ago on the Department of Agriculture grounds in Washington, D. C., showed the same predilection for *Phyllophaga*, as 4 adult English sparrows taken there in June had fed on May beetles to the extent of 69 percent of their food. Again, of 235 stomachs collected in June 1917 at Independence, Iowa, 97 contained *Phyllophaga* and 50, *Aphodius*.

Analysis of the stomach material on hand shows that adult sparrows collected in and about cities feed to a greater extent on May beetles than do those collected in rural sections. This was demonstrated by the stomachs collected at Bridgewater, Mass., and Independence, Iowa, and is even more evident in the food habits of nestlings than in those of the adults discussed here. Field observations give a clew to this marked difference in habit and afford a basis for interpreting its significance.

The village or city street is the daily hunting ground of the urban sparrow. There it formerly obtained much of its ration of grain, and there, since the advent of brilliant lights, it has found a fruitful source of insect food also. A high percentage of the myriads of insects that are decoyed by bright lights soon perish in the immediate vicinity or seek shelter and protection from enemies nearby. Many of these insects are trampled underfoot by passers-by. Others find conditions there wholly unsuited to their existence. Most of them never live to reproduce. It is under such circumstances that the adult English sparrow finds an abundant and convenient supply of dead or disabled May beetles, which it eagerly seeks for itself or its hungry young. There is little doubt that most of the May beetles found in the stomachs reported on were obtained under such conditions. Their consumption by the English sparrow is therefore of little economic significance.

Among other scarabaeids eaten by the adult English sparrows were members of the genera *Cyclocephala*, *Anomala*, and *Euphoria*,which probably are devoured by the bird whenever found. The Japanese beetle (*Popillia japonica*), now spreading through eastern States, was found in two of the seven adult stomachs collected in areas infested by the insect.

Click beetles (*Elateridae*).—Click beetles, the adult forms of wireworms, formed but an insignificant proportion of the adult English sparrows' food. They were entirely absent from stomachs collected from September through February and in only June and July comprised more than one-tenth of the diet. In June, the month of greatest consumption, only 1 out of every 16 birds had fed on them.

Ground beetles (*Carabidae*).—The adult English sparrow cannot be considered an important enemy of ground beetles, which in only 1 month (April) formed as much as 0.34 percent of the food. May and June are the only other months in which they need be mentioned. The record for carabid destruction consisted of 20 specimens of the small phytophagous *Agonoderus comma* that formed 62 percent of the food of an adult male at Blue Rapids, Kans. Other carabids eaten were principally small forms, including species of *Amara*, *Anisodactylus*, *Cratacanthus*, and *Harpalus*.

Leaf beetles (*Chrysomelidae*).—There is little to be said of the relation of the adult English sparrow to leaf beetles, for in no month did these insects form so much as 0.1 percent of the food. Most prominent among them were *Chaetocnema denticulata* and *Colaspis brunnea*, eaten most frequently by birds collected in Southern States.

Other beetles.—Coleoptera other than those already mentioned were present in the food of the adult English sparrows in every month from February to September inclusive, but even in May, the month of greatest consumption, they formed less than 1 percent of the diet. Among those eaten were ladybirds (Coccinellidae), found in six stomachs; long-horned beetles (Cerambycidae), present mainly in stomachs of birds collected about a lumberyard in Alabama; tiger beetles (Cicindelidae), unusual victims for a sparrow; grain and bark-gnawing beetles (Ostomidae); darkling ground beetles (Tenebrionidae); hister beetles (Histeridae); and rove beetles (Staphylinidae). In no instance were any of these taken in numbers great enough to be considered of economic importance.

GRASSHOPPERS, CRICKETS, AND OTHER ORTHOPTERA

Orthoptera comprised 0.57 percent of the annual diet of the adult English sparrows, or about one-fourth of all beetles eaten. The extent to which the adults feed on these insects corresponds closely to the seasonal abundance of the latter. They were eaten from April to September, inclusive, and August marked the high point of this activity.

The earliest seasonal activity in feeding on Orthoptera manifested itself in April and May in Southern States and in those areas where species of acridids that hibernate as nymphs may be found early in the season. In June there was a slight increase in the grasshopper food taken and a few instances of unusually meritorious work were noted, percentages as high as 75 being recorded for several birds. By July the English sparrows of Northern States regularly partook of grasshoppers. Of 10 adults collected in 1919 on grass-covered hillsides near Pierre, S. Dak., during a period of grasshopper abundance, 7 had fed on these insects and 1 bird had made them 94 percent of its meal.

It is in August, however, that grasshopper destruction by the adult English sparrow is most noteworthy and consistent. This fact was well brought out by stomachs collected at Alden, Polk County, Wis., in that month during 1915–21, exclusive of 1919. Of the 190 stomachs examined, 97 contained grasshoppers, which comprised more than a tenth of the food. Material from other localities also contributed evidence of the adult sparrow's attack on grasshoppers during August and September. Percentages of 50 or higher were recorded for the

grasshopper content of individual stomachs collected in Mississippi, Alabama, Illinois, and Connecticut.

Dominant among the Orthoptera eaten by the adult English sparrows were the short-horned grasshoppers (Acrididae), including several of the highly destructive species of *Melanoplus*. The small grouse locusts (Acrydiinae) also were taken and, to a less extent, crickets (Gryllidae) and long-horned grasshoppers (Tettigoniidae). It is only occasionally that the restrictive effect of birds on insect life is plainly evident. For that reason the following observation by Hunter (*38, p. 40*), which so clearly illustrates the influence exerted by English sparrows on the abundance of grasshoppers in local areas, is well worth quoting.

* * * owing to a remarkably favorable season, a great many grasshoppers came in the fall of the year to the university campus to deposit their eggs, the campus being at that time well watered, while the surrounding gardens and lawns were not kept in such favorable condition. In consequence of this we had a terrible plague of grasshoppers the next year. About the time the first brood of Sparrows began to inspect things and feed out of the nest they discovered the insects and began devouring them. We soon noticed a great many of the birds on the campus, and as they are protected here, * * * it was not long before the work of extermination was carried on to such an extent that there [were] no grasshoppers left on the campus, which was the only place in this vicinity of which this was true.

CATERPILLARS AND MOTHS (LEPIDOPTERA)

Much has been written about the English sparrow's lepidopterous food. In fact, the introduction of the bird into this country was prompted largely by the expectation that it would prove an effective controlling factor for certain caterpillars. Frequently the bird has been observed pursuing and capturing moths about the streets and lawns in cities, and it has demonstrated its resourcefulness by searching the radiators of automobiles for impaled insects, principally moths, butterflies, and grasshoppers.

Stomach examination has verified assertions of the caterpillar- and moth-destroying proclivities of these birds and has shown that most of the adults' energy in this direction is expended in obtaining food for their young. The adults themselves eat comparatively few Lepidoptera. In this study insects of this order averaged only 0.23 percent of the annual food and in only 1 month (June) constituted more than 1 percent of the food. Only about 1 out of every 23 birds had fed on them. Cutworms (Noctuidae) and cankerworms, or spanworms (Geometridae), were the forms most frequently recognized in the stomachs. Identification could at best be carried only to the family, however, so that field observations have been drawn on to tell a more detailed story of the relation of the English sparrow to Lepidoptera. Although the notes that follow refer to the activities of the adult birds, it should be remembered that their search for caterpillar food is prompted largely by the needs of the young.

That outbreaks of the snow-white linden moth (*Ennomos subsignarius*) and its larva, one of the cankerworms, may be locally suppressed through the activities of English sparrows has been noted by reliable observers. In a report published in 1910 on this insect in New York, Herrick (*24, p. 61*) stated:

The testimony regarding the activity of the English sparrow in exterminating this pest in cities seems to show rather conclusively that this much-disliked bird did actually bring about the destruction of this insect. Nearly every writer on the snow-white linden moth makes acknowledgment to the sparrow and declares that the cities owe their freedom from this insect to that bird.

In a later report, published in 1923, Felt (*14, p. 84*) presented the following testimony:

> The snow-white moths of this species appeared on the streets of Albany July 21, being moderately abundant over a considerable area. They very probably had drifted from the infested areas northeast. The English sparrows fed greedily upon the moths and by noon little was to be seen except scattering wings.

Field observers have credited the English sparrow with commendable work also against the cabbageworm (*Pieris rapae*), an insect admirably suited in size and habitat to the needs of the sparrow when it has young to feed. Sherman (*37, p. 26*) stated that in North Carolina this bird was reported doing "really good work (especially in town and village gardens) in destroying cabbage lice, harlequin bugs, and cabbage worms."

In speaking of an outbreak of the fall armyworm in 1920 at Columbia, S. C., Luginbill (*30, pp. 61, 87*) stated that—

> birds, especially the English sparrow, visited infested areas and fed voraciously on the larvae. * * *.
>
> The English sparrow has been observed on several occasions to completely eradicate the fall army worm from lawns and other small patches of grass around dwellings. In this respect it benefits the city dweller more than the farmer. During a recent outbreak of Laphygma on the State capitol grounds and on the campus of the University of South Carolina at Columbia, the sparrows were observed to collect in flocks and devour the caterpillars in great numbers.

There are on record also observations noting the destruction by English sparrows of other lepidopterous pests, including the fruit-tree leaf-roller (*Cacoecia argyrospila*) (*20, p. 102*); the gipsy moth (*Porthetria dispar*) (*15*); the brown-tail moth (*Nygmia phaeorrhoea*) (*16, pp. 140–141*); and the forest tent-caterpillar (*Malacosoma disstria*) (*40, p. 26*).

It is evident throughout all these observations that, however limited may be the proportion of lepidopterous food eaten annually by the English sparrow, the bird is quick to detect any abnormal abundance of such insects and to turn its attention to their destruction. It is also true that urban communities are benefited more by such activities than rural ones.

BUGS (HEMIPTERA)

True bugs formed an insignificant portion of the adult English sparrows' food and were present in the diet only from April to September inclusive, with April the month of greatest consumption. The species eaten were small and included negro bugs (Cydnidae), stink-bugs (Pentatomidae), lace bugs (Tingitidae), treehoppers (Membracidae), leafhoppers (Cicadellidae), lantern flies (Fulgoridae), plant lice (Aphididae), and scale insects (Coccidae).

Had more stomachs been collected coincident with outbreaks of the periodical cicada (*Magicicada septendecim*), no doubt evidence bearing on the relation of the sparrow to this insect would have been obtained. Years ago Butler (*3, pp. 29–30*) observed that—

> Among birds, the English sparrow, * * * is perhaps its [the periodical cicada's] greatest enemy. Within one week from the date of the appearance of the Cicada in Brookville [Ind.], not one could be found, and I doubt if a single specimen was permitted to deposit its eggs owing to the persistent warfare waged by this garrulous sparrow.

In 1922 a correspondent in Illinois reported finding the English sparrows everywhere catching these cicadas, clipping off their wings, and eating the rest of the insect. Almost every sparrow observed was devouring a cicada, and frequently a dozen birds were in sight at the same time feeding on them.

Field observation in Ohio has established the English sparrow as an enemy also of *Macrosiphum solanifolii*, the pink and green aphid of the potato (*25, p. 80*).

FLIES (DIPTERA)

Flies appeared in the diet of the adult English sparrows in varying quantities from March through September and in April were eaten most freely. The kinds taken were mainly crane flies (Tipulidae) and muscid flies (Muscidae), including the housefly (*Musca domestica*). The latter and its larvae and pupae, which are fed extensively to nestling sparrows, are obtained largely from manure. The entire stomach contents of an adult sparrow from Massachusetts consisted of 15 housefly larvae that the bird had captured before 5 a. m., and an adult collected in 1887 on the grounds of the Department of Agriculture in Washington had eaten 5 adult houseflies.

The English sparrow, ever alert to possible new sources of food, is unusually adept in obtaining its necessary insect food from the rather barren hunting grounds of city streets. The following observation made by Chambers (*4*) in the Imperial Valley, Calif., depicts its resourcefulness in obtaining flies.

> I have noticed them [English sparrows] on several occasions congregated around store fronts early in the mornings while the air was still very cold. Close observation showed that the birds were industriously making hearty breakfasts of the flies which had settled on the store fronts the warm evening before, and were now benumbed with the cold. The supply of flies seemed inexhaustible but these imported fly traps must have eaten enormous quantities.

ANTS, WASPS, BEES, AND OTHER HYMENOPTERA

Hymenoptera, principally ants, parasitic wasps, and ichneumonids of several kinds, were eaten in small quantities by adult English sparrows in every month except February and December, with the peak of such activity in September. The yearly average was only 0.31 percent, about 1 out of every 14 birds having taken such food.

Prominent among the ants eaten was the cornfield ant (*Lasius niger americanus*), one of the most abundant insects. Two sparrows collected in Wisconsin in September had fed on it to an extent of 95 and 86 percent of their food, respectively, and a series of sparrows from Massachusetts, also obtained in September, had fed extensively on a closely related form. The large black carpenter ants (*Camponotus*) and ants of the genus *Formica* likewise entered into the diet, in a few instances forming as much as half the food. Conspicuous among the parasitic wasps eaten were those of the genera *Tiphia* and *Elis*, enemies of white grubs, both of which were found in numerous stomachs collected in Washington, D. C., at times forming half or more of the food. The slow-flying parasitic ichneumonids also fell prey to the sparrow, although the quantity eaten was not great. A few bees of the genera *Halictus* and *Andrena* complete the list of hymenopterous insects eaten that are worthy of mention.

OTHER INSECTS

The aggregate bulk of all other insects in the stomachs of the adult English sparrows was trivial. It included Isoptera (termites), Neuroptera (lacewings and others), Ephemeroptera (Mayflies), Odonata (dragonflies), and Plecoptera (stone flies).

The presence of termites in considerable numbers in two stomachs from Alabama corroborates field observations that the English sparrow is an energetic destroyer of these insects when opportunity presents itself. The birds were collected in the vicinity of farm buildings, where doubtless they had found a colony of termites among rotting timbers. W. L. McAtee, of the Biological Survey, has witnessed similar activities of sparrows that practically eliminated a colony of these insects.

The conditions under which Mayflies or other nocturnal insects may occasionally be captured by the ever-resourceful English sparrow are disclosed in the following interesting account by Malloch (*31*):

> On the evening of June 5, at 8:30 P. M., while passing the front of a brilliantly lit moving picture house on 9th Street Northwest, Washington, D. C., my attention was attracted by some object fluttering in the air over the middle of the street. * * * I discovered that it was * * * a House Sparrow, busily chasing a large Mayfly (Ephemeridae) which it eventually captured. It then flew back to the front of the theater * * * where its noisy reception indicated the presence of a nearly full grown brood of young. * * * I watched its operations for some time and was amused to see the facility with which it picked off the moths and May-flies as they appeared either in proximity to the lights on either side of the facade over the arch or within the radius of the lights below it.

SPIDERS AND OTHER ARACHNIDA

The spiders and other arachnids eaten by the adult English sparrows are of little economic significance. In this study they formed a mere trifle of the annual sustenance and were present in stomachs collected in only 5 of the 12 months.

OTHER ANIMAL MATTER

In the category of other animal matter eaten by the adult English sparrows are millepedes, earthworms and their cocoons, snails, and fat and meat fibers, material that must be classed simply as garbage. In the aggregate such items averaged only 0.04 percent of the food, and their destruction by the sparrow is of little economic importance.

Occasionally on city lawns a sparrow is seen closely following robins engaged in feeding on earthworms and availing itself of every opportunity to grasp some fragment or maimed individual dropped by the larger birds. On the west coast it has been observed feeding on the snail (*Helix pisana*), which has become destructive in San Diego Co., Calif.

Mention should also be made of the adult English sparrow's predilection for the shell of hens' eggs, on which 93 of the 4,848 adults had fed, nearly all of them in May and June. Although some of this hard material may have been taken merely to assist in the trituration of food, there is reason to believe that a physiological need for bone-building material lies back of the choice of such a food. The search by sparrows for particles of lime in the mortar of brick walls is apparently another manifestation of this same craving. Evidently the adults seek calcareous food for their young also, as an even more pronounced liking for it was exhibited by the nestlings (p. 44).

Strange though it may seem, the highly vegetarian adult sparrow has been convicted of cannibalism—under conditions, however, that were unnatural. According to Hempel (*23, p. 97*), a male sparrow pecked out the eyes and fed on the brains of a dead sparrow that was in the same bird trap with it.

VEGETABLE FOOD

In only 1 month, May, did vegetable food comprise less than 90 percent of the diet of the adult English sparrows, and in December it constituted the whole food. With a bird so strikingly vegetarian as this, it is evident that appraisal of its economic status rests largely on the interpretation placed on the constituents of its vegetable food.

Stomach examination is universally regarded as a fundamental procedure in determining the economic status of birds because, through it, accurate and detailed information is acquired that can be obtained in no other manner. In the present study, examination of the stomach material—greater in quantity than that ever before used for the study of a single species—has yielded a wealth of invaluable data. In dealing with the vegetable portion of the adult English sparrows' food, however, certain limitations inherent in the laboratory method of approach present themselves, and before discussing in detail the constituent vegetable items, it is advisable to point out these limitations and explain how the perplexing problem was handled.

Explanation of Categories

Difficulty arises in determining from the stomach contents the origin, nature, and economic significance of such items as wheat, corn, oats, milo, buckwheat, and other grains. From the known feeding habits of the English sparrow it is possible for such food to have been obtained from the ripening or newly harvested crop, from grain stored in warehouses, from waste grain about granaries or mills or scattered in hauling grain along roadways, from manure about stables and barnyards and on city streets, from feed for chickens or that placed by bird lovers to attract native species, and from other sources as well. Frequently the circumstances connected with the collecting of specimens give a clew to the source of such food, and at times the appearance of the grain itself, especially when obtained from ripening crop or from manure, indicates its origin. In many other instances, however, clews are either vaguely circumstantial or lacking. Whenever possible, information helpful to the proper appraisal of stomach contents was obtained at the time the bird was collected, but even with this at hand, in many instances it was impossible to determine positively the source of the grain contents.

The preponderance of various grains obtained manifestly from chickenyards or feed troughs about farms resulted in choosing a category entitled "feed," under which has been grouped all grain that would appear to have come from such sources. Here will be found wheat, oats, cracked corn, milo and other grain sorghums, buckwheat, and other grains. Segregation of grain items having a similar economic significance is more logical than an allocation of the grains under their several heads, especially as it is evident that the proportions of the various grains in the food are influenced strongly

by their respective proportions in the mixed feed encountered. The dominance of wheat in the chicken feed eaten by sparrows in Utah, of milo in that eaten by those in Oklahoma, and of rice in that eaten by those in Louisiana was occasioned largely by the preponderance of these respective grains in the mixed feed.

Headings in tables, text figures, and text entitled "oats," "wheat," "corn," and "other grain" refer to grain considered to have been obtained from the ripening or harvested crop, warehouses, mills, or any source other than "feed." Some of the grain under each of these categories no doubt was waste, but the appraisal was made largely in the light of the circumstances surrounding the collecting of the stomachs and the known feeding habits of the birds. Inasmuch as discussion of the various grain items has been handled in this manner, the percentages given for feed and the several grains should be regarded at best as fair estimates only.

Feed

Under the heading "feed" have been segregated all the grains picked up by adult English sparrows about poultry yards, corrals, and similar places. Though composite in character, this element of the bird's food is essentially a unit in its economic significance and, with the exception of an indeterminate portion that may have been waste when found by the birds, may be considered as representing a direct loss to the poultry raiser or farmer. It constituted by far the largest single item in the diet. Even in September, when the minimum quantity of such food was taken, the monthly percentage was 31.51, and in February, the month of maximum consumption, it reached 84.16. Practically half the birds collected in September and all but 14 of the 284 taken in February had fed on it.

When subsisting on feed, the adult English sparrow is a gross feeder and usually eats until satiated. Of the 3,367 adults that had partaken of feed, 980 (about 29 percent) had eaten nothing else and 2,147 (nearly 64 percent) had fed on it to the extent of 90 percent or more of their food.

The birds consuming the greatest quantities of feed were those collected in the vicinity of poultry runs, either on farms or in the suburban sections of towns or cities. Had a greater percentage of the specimens been obtained in other environments, the bulk of this food no doubt would have been materially reduced. The extent to which these birds may take feed during the winter under more or less rural conditions is shown by the fact that all but 1 of 55 adult sparrows collected near Onaga, Kans., in January had eaten such food, the volume of which was about 84 percent of the stomach contents. At Bridgewater, Mass., all but 3 of 31 sparrows collected in February had taken feed exclusively, and in the neighboring town of Brockton 27 birds had made it 97 percent of their nourishment. Even in Southern States during the spring, when other food was plentiful, feed furnished an important part of the diet of adult sparrows. All but 1 of 41 birds obtained in Mississippi in May had eaten it, and birds collected in Alabama revealed similar habits.

Cracked corn was the dominant grain in the feed taken by the adults. This may indicate a preference for this grain on the part of the bird, or it may be due to the preponderance of cracked corn in most mixed feeds. Next in bulk were oats, and then followed wheat,

the various sorghums (including milo, kafir, and sorgo), barley, buckwheat, and rice in the order named.

The English sparrow's habit of raiding the food supply of poultry is general throughout its range. Where the birds are numerous and little or no effort is made to combat them, losses resulting from these depredations may reach proportions that cut heavily into the margin of profit of poultry raising. This is particularly true under conditions prevalent on the farm or in suburban poultry yards where feed is scattered on the open ground or in uncovered runways. To reduce such losses, either the poultry must be fed within their houses or in runways covered with fine-meshed screen or control measures must be carried out against the sparrows. Even though the damage is preventable, however, the cost and labor involved in meeting such situations are definitely chargeable against the English sparrow in an appraisal of its economic worth.

Oats

Oats eaten by the English sparrow other than those taken in feed, are obtained from the standing, shocked, or stacked crop, from the stubble of harvested fields, from granaries, from horse manure, from grain scattered at warehouses, and from other sources where generally the grain is considered waste. In this study such grain formed 14.37 percent of the annual food of the adult sparrows, having been found in 1,076 stomachs, in many of which it formed the entire food. It was present in the diet in every month, the bulk having been taken in the period from May to August, inclusive. August and December were the months of maximum and minimum consumption. It is possible that some of the oats eaten in January that were classified under this heading should rightly have been considered feed and also that some of the oats considered feed in February, March, November, and December had in fact been obtained from other sources.

Oats obtained from the standing, shocked, or stacked grain and representing direct damage inflicted on farmers' crops were identified in only 15 stomachs, but there is reason for believing that some of the other oats eaten by the adult sparrows may also have been taken from the year's crop. It is likely that the preponderance of oats in the food during June, July, and August is due to the availability of the crop in one form or another.

It was evident that the village street and the barnyard were the sources of a large part of this food item, even though oats considered to have been taken from horse droppings could be definitely identified in only 179 stomachs. No doubt some of the oats found in other stomachs also came from this source, but the limitations of laboratory analysis precluded proof. The plausible contention that the decrease in the number of English sparrows in recent years is due to the scarcity of what was generally considered their principal winter food—oats gleaned from the roadway—has not been strongly substantiated by this study. Mixed grains (feed) rather than oats obtained from manure constituted the principal winter food, and, except in January, oats were not an important item of winter diet. There is the likelihood, however, that the material upon which this study is based reflects to a marked extent conditions obtaining since the sparrow has adjusted itself to a scarcity of what was formerly a favorite winter food.

From the locality standpoint there is little difference in the oat-eating habits of the English sparrow. From Wisconsin has come a series of 60 birds collected about a garden and willow thicket that shows well the extent to which sparrows may live on oats when necessity or opportunity presents itself. Of these birds, 43 had fed on oats to an extent of 63 percent of the food of the entire lot and 11 had eaten oats exclusively.

Depredations on the growing and ripened crops of oats are confined largely to parts of fields close to farm buildings and in areas adjacent to towns, from which the birds wander daily in search of food. Borders of fields flanked by trees to which the birds resort for shade and protection also are likely to show evidence of their work. Similarly located shocks of oats may have much of the exposed grain removed should a flock of 300 to 500 English sparrows feed on them for a few days.

Wheat

Wheat eaten by the adult English sparrows other than that obtained from mixed feed was taken largely during the period from May through September and was found in 202 of the 4,848 stomachs examined. Birds from Utah, Indiana, Pennsylvania, Maryland, and Virginia accounted for most of the wheat consumed during the summer. All but 13 of the 91 stomachs of adult sparrows containing wheat that were taken in May and June were obtained in the Salt Lake Valley, where that grain is the dominant cereal. The sparrows had picked it up about granaries, barnyards, and roadways, although it was evident that the grain in a few of the stomachs had been pilfered from the standing or shocked crop or gleaned as waste from the stubble.

Stomach examination has shown the English sparrow to be the same gross feeder on wheat that it is on other grains. When opportunity affords, the bird will feed on it exclusively and to repletion. This fact is of greater importance than the mere percentage the wheat forms of the stomach contents, as it indicates the possible damage that may result from the presence of large flocks of these birds in wheat-raising areas.

Corn

Despite the fact that cracked corn is frequently the principal constituent of the mixed chicken feed so eagerly sought by the adult English sparrow, unbroken corn does not form an appreciable part of the bird's diet. The kernels are too large for the sparrows to eat conveniently, a fact that doubtless has an important bearing on the comparative unattractiveness of the grain in this form. Whole corn may be obtained from the ripening grain on the stalk or about the barnyard and mill and along roadsides, where often it is merely waste grain. In this study it comprised a mere 0.43 percent of the annual food and the only month in which it was eaten in a quantity large enough to deserve comment was September, when it formed 2.39 percent of the food and was present in 24 of the 37 stomachs. At least a part of this, found in the stomachs of birds collected in New Jersey and Alabama, bore unmistakable evidence of having been taken from the ripening ear.

In feeding on corn the English sparrow inflicts less serious damage than the red-winged blackbird, grackle, or crow, although during

periods of wet weather its activities may result in considerable injury by allowing water to penetrate the ears. This harm is done principally when the grain is in the milk and dough stages. The sparrow, lacking the strength of any of the other corn eaters mentioned, limits itself to tearing apart the husks at the tip of the ears and feeding as far down as it can uncover the grain. Often sparrows, blackbirds, and even crows and squirrels work in the same field, and under such conditions the sparrows do not hesitate to follow the paths of their more vigorous companions and feed on what they may drop to the ground or expose by shredding the husks.

Other Grain

In addition to oats, wheat, and corn, English sparrows feed to a less extent on a few other grains, among which are the sorghums (including kafir, milo, feterita, and sorgo), rice, barley, and millet. All these are taken not only in mixed chicken feed but also from standing or shocked crops. Stomachs collected in August and September in Mississippi and Alabama gave conclusive evidence of the raids English sparrows may at times make on fields of standing or shocked kafir. Of 76 birds collected in September, 35 had fed on this grain, supplementing it with quantities of weed seeds.

Small plots of grain, particularly sorghums, grown at experiment stations are often severely damaged by English sparrows. Such plots, located not far from towns from which there is an annual drift of the sparrow population at harvesttime, are exposed to injury of a particularly serious character, because the loss of even a small portion of the grain may completely destroy the results of costly and painstaking experiments of an entire season. Complaints of such damage have come in recent years from 12 experiment stations in Kansas, Oklahoma, Texas, and New Mexico. It must be explained, however, that in some instances native species of birds joined the English sparrows in this destructive work.

Rice appeared in four stomachs collected in Texas, and from observations made by the writer this grain becomes the sparrows' staff of life in the rice section of southwestern Louisiana. Not only do the birds obtain great quantities about rice mills, but they even invade the rice fields. Barley, probably the most unattractive of all grains from the bird-food standpoint, was only occasionally taken. The presence of buckwheat and millet in the stomach contents was usually explained by the birds having fed on mixed feed containing these ingredients. There is the likelihood, however, of sparrows becoming troublesome to stands of millet when the birds are abundant. This charge has been convincingly proved against the bird in Turkestan (*1*, *28*).

Grass and Weed Seeds

Next to the miscellaneous assortment of grains classified as "feed," seeds of grasses or of those plants generally considered weeds formed the largest single group of food items in the dietary, nearly 17 percent of the food. Economically they represent the only vegetable food the consumption of which may be a credit to the bird, and, although the record of the English sparrow as a destroyer of weed seeds is not as favorable as that of several native sparrows, its good work in this direction deserves recognition. Grass and weed seeds furnished part

of the diet in every month, with the greatest consumption in October and the least in June. Slightly more than half the adults had fed on them, and in September and October they were found in all but 39 of the 593 stomachs. The sparrow's predilection for such food is confined to no particular area, though stomachs from Southern States as a rule revealed higher percentages.

Dominant among the grass and weed seeds eaten were those of ragweed (*Ambrosia elatior*). In size and suitability the achenes of this plant are admirably adapted to the needs of this bird, and during periods of heavy snowfall, when other foods are deeply covered, they often serve as a life-saving ration. They seldom comprised the bulk of the stomach contents, but the frequency with which they were taken marks their importance as a sparrow food. Stomachs collected in Alabama contained the greatest numbers, as many as 60 being found in a single stomach.

Taken in greater bulk and numbers but found in fewer stomachs, were the seeds of crabgrass (*Digitaria sanguinalis*, *D. ischaemum*, and others). As many as 1,274 were taken from the crop of a single English sparrow from Alabama; more than 900 each from 2 others; and 150 or more each from fully 40 others. Most of these seeds were found deftly hulled and often broken in two. The seeds are obtained from waste places and from lawns, where, during late summer and early fall, one often may see flocks of English sparrows, many of them young birds of the year, working in compact masses on areas infested with crabgrass. Under such conditions these seeds may serve as the sole food of entire flocks. On the grounds of the Department of Agriculture and in parks in the city of Washington, sparrows glean great quantities of crabgrass seed, working day after day for periods of weeks over comparatively limited areas. No doubt they prevent an appreciable quantity of crabgrass seed from reproducing, but despite this factor of control the grass persists and even spreads in areas suited to its growth. The seeds of yard grass (*Eleusine indica*) often were found in conjunction with those of crabgrass, and in stomachs from Alabama, seeds of the related *E. japonica* formed at all seasons of the year a substantial part of the grass seeds eaten.

Next in importance among the grass and weed seeds taken must be placed the achenes of smartweed, or knotgrass (*Polygonum*), of several species. Those of *P. aviculare*, a common dooryard weed, were most frequently found, but those of *P. convolvulus*, *P. hydropiper*, *P. lapathifolium*, *P. pensylvanicum*, *P. persicaria*, and others also were noted. Individual stomachs contained as many as 90.

Seeds of pigweed (*Chenopodium*) and amaranth (*Amaranthus*) of several species were also of importance in the diet, and those of the yellow and green bristle grasses (*Setaria lutescens* and *S. viridis*) and Italian millet (*S. italica*)—which, though cultivated, also appears in waste places—were regular items of diet. The seeds of witchgrass (*Panicum capillare*) and other related species, bull paspalum (*Paspalum boscianum*), wild millet (*Echinochloa crusgalli*), Egyptian grass (*Dactyloctenium aegyptium*), Johnson grass (*Sorghum halepensis*), annual bluegrass (*Poa annua*), and timothy (*Phleum pratense*) also entered into the food, particularly in Southern States, and the seeds of a sedge (*Cyperus compressus*) constituted a favorite food of birds collected in Alabama. Seeds of the common chickweed (*Stellaria media*), plantain (*Plantago*), sheep sorrel (*Rumex acetocella*), catnip

(*Nepeta cataria*) bedstraw (*Galium*), and other plants generally considered weeds were also eaten. The sparrow's feeding on seeds of the sunflower (*Helianthus*) has occasionally brought criticism from persons raising them for native species of birds. On city lawns one frequently finds sparrows taking the seeds of white clover (*Trifolium repens*).

Mast and Wild Fruit

Although mast and wild fruit were present in the food in every month, in only 4 did they aggregate more than 1 percent of the food. June and July, when 218 of the 1,220 adults examined had taken mast or wild fruit, marked the peak of the birds' activity in this direction. Aside from indicating the possibility of damage to closely related cultivated species, the English sparrow's consumption of wild fruits involves little of economic importance.

The seeds of elm (*Ulmus*) comprised the greatest single item and furnished the bulk of the percentages in the mast and wild-fruit category for June and July, when 165 birds fed on them, at times to the exclusion of all other food. Most of these birds were collected in towns and cities, where the elm seeds fall to the sidewalk or paved street. The birds hull the seeds, removing the circular membranous wing, and feed on the flat, disk-shaped embryos rich in vegetable oil. The habit is a common one with sparrows in the New England and North Central States, particularly in Massachusetts, Connecticut, Michigan, Illinois, Iowa, and Kansas.

Mulberries (*Morus*) and paper-mulberries (*Broussonetia papyrifera*) were eaten by the adult sparrows, but evidence points to their having been obtained largely from fallen fruit. Most of the records came from birds collected in the District of Columbia many years ago. Blackberries (*Rubus*), seeds of strawberries (*Fragaria*), fragments of rose hips, seeds of pine, and unidentified materials comprised the bulk of the remaining mast and wild fruit eaten.

Cultivated Fruits and Vegetables

Stomach examination gives little evidence of value concerning the food habits of the English sparrow in relation to cultivated fruits and vegetables. Inability to ascertain the character of such items when found in stomach contents, coupled with the fact that in order for food analysis to reveal such depredations the birds must be collected soon after they have committed them, makes this method of approach unsatisfactory. Field observations, which have disclosed many of the sparrows' activities as fruit and vegetable destroyers, must therefore be relied upon largely for evidence.

In the material studied in the laboratory, cultivated fruit and vegetables formed a mere trace of the annual food. Among those identified were domestic cherries, peas, beans, and cowpeas. Fruits injured by English sparrows as determined by field observations and reported to the Biological Survey include strawberries, raspberries, blackberries, gooseberries, currants, grapes, mulberries, cherries, plums, peaches, apples, pears, figs, and tomatoes. Damage of this kind is often sporadic and, as in the case of certain native fruit-eating birds, may be caused by a desire for fruit juices to supplement a scanty water supply.

The behavior of the English sparrow in fruit-raising sections of California shows the bird at its worst. Certain native birds, however, notably house finches, or linnets, mockingbirds, and quail, also participate in such depredations. In reporting the results of an investigation of the problem in Tulare County, in 1927, F. E. Garlough, of the Biological Survey, stated:

> At the time of my visit in August, English sparrows * * * (and certain native birds) * * * were working on the grapes which were just ready to be harvested * * *. The birds would peck and break the skin of several grapes in each bunch. These dry up and turn dark spoiling the appearance of the bunches for table use to such an extent that the packer has to employ a number of persons to remove the damaged grapes. Unless these are removed they soon moisten the adjoining grapes and packing material and mould will form before they reach the market. The superintendent of one ranch stated that his company lost about $15,000 in 1926 from bird damage and the manager of another has placed the loss of his company at about $30,000. To date this year the latter company has paid out $900 for ammunition. In addition to this it has had to employ four or five men to patrol the vineyard, shooting at flocks of birds to keep them from alighting.

Throughout the spring and summer the adult English sparrow feeds to a certain extent on green food—buds, sprouts, and foliage. Stomach examination has revealed this fact, but field observations must be drawn upon for a proper appraisal of its economic significance, especially when the birds feed in concentrated numbers on the swelling buds of fruit trees early in spring and on garden truck a little later in the season.

Here again California must be looked to for a striking example of damage. Destruction of fruit buds in that State has been a matter of increasing complaint during recent years, and the English sparrow, although not the only avian culprit involved, has played a conspicuous part. Joseph Keyes, field representative of the Biological Survey, reporting on a reconnaissance of the fruit-growing district of Tulare and Fresno Counties in 1928, called attention to the great damage inflicted by birds, principally English sparrows and house finches. The effect of their feeding was in marked evidence, fruit buds having been completely stripped from some branches. In one 10-acre almond orchard the housewife, relieved at times by the husband, had had to patrol the area daily for a period of 6 weeks, beginning the first of January and lasting until the trees were in full bloom. Moreover, horticultural commissioners of several California counties have in recent years called attention to this apparently increasing damage by birds, in which the English sparrow almost invariably takes part. Almonds, apricots, peaches, pears, and plums all suffer through the bud-stripping process.

In recent years, reports of such destructive work have come also from other and widely separated localities, among them being Idaho, Massachusetts, Iowa, Kentucky, and Alabama. With the exception of California, however, the damage, though severe at times, has been largely local in character.

The English sparrow's quest for green food brings upon it much criticism from the owners of small gardens. During spring and early summer it relishes the tender sprouting leaves of peas, beans, lettuce, peppers, cabbage, beets, asparagus, and other vegetables, as well as those of certain flowering plants, such as pansies and carnations. Though stomach examination sheds little light on the subject, field observations have left no doubt concerning the severity of such damage

when the birds are abundant. Typical of the complaints of the city gardener is one coming from a correspondent in Illinois, who stated that—

> it was impossible to raise lettuce on account of the English sparrows. I set out 300 plants of head lettuce, raised in a hot bed, but the sparrows took them all. I also had about 400 cabbage plants growing and these were reduced to 60. A 50-foot row of peas was kept picked close to the ground all the time.

Not only do English sparrows seek the earliest sprouts, but they also feed to an injurious extent on the flowers of such vegetables as peas and beans and even attack the newly formed crop itself. Complaints of the latter form of damage have been received from many gardeners and from officials of experiment stations where carefully kept records of yield are disrupted by the sparrow's inroads. Even in distant Hawaii, Chung (*5*) reports that—

> the bean crop, while still in its green stage, was shelled by these birds, and an accurate yield of the seed crop could not therefore be obtained. * * *
>
> The English sparrow is a very destructive pest to food crops in Hawaii, and unless its rapid reproduction is curbed the growing of beans and similar crops will be greatly handicapped.

Other Vegetable Matter

Other vegetable matter appeared in the adult English sparrows' food in every month, but only in April, June, and August did the quantity exceed 1 percent. By far the greatest part consisted of vegetable debris—bits of wood or grass fibers incidentally swallowed by the birds when feeding on other foods. The quantity taken at a time was never very great. During the winter months such other material as bread crumbs and bits of potato or fruit parings, evidently picked up from refuse, formed a minor part of the diet.

The stomachs examined did reveal, however, a peculiar feeding habit resorted to frequently from April to the end of August that, so far as the writer is aware, was not recorded by field observers. This was the feeding on foliage of white clover (*Trifolium repens*), obtained from lawns. A goodly number of stomachs collected in May and June contained such food, which in July and August was frequently mixed with quantities of crabgrass seed, also obtained from lawns. In a few stomachs there were also fragments of other foliage and bits of flower petals not further identified.

A few stomachs collected in July and August contained fragmentary remains of staminate flowers and pollen grains of corn, concrete evidence of a habit frequently indulged in when this crop is in bloom. In small gardens and in experimental plots of grain this food habit may result in a certain curtailment of the crop if the sparrow population is large, but in large fields the pollen supply is ample to withstand the drain.

Summary of Food Habits of Adults

In order to summarize the food habits of the adult English sparrow, a segregation has been made of the various food elements according to whether their consumption may be considered beneficial, neutral, or harmful to the interests of man (fig. 2 and table 3). This method of approach has the advantage of permitting the mathematical data

pertaining to food items to be presented in condensed and easily visualized form. It has certain shortcomings, however, to which attention should be called. Of the various groups of items, the destruction of which may be considered beneficial or harmful to man, no two are of equal economic importance, and within the groups themselves there are great differences in the economic significance of items. For instance, a weevil that feeds on cultivated plants would have a status directly opposite to one that feeds on weeds in the same garden; the small herbivorous carabids hold an economic position opposite to that of most of the family, and the feeding of the English sparrow on

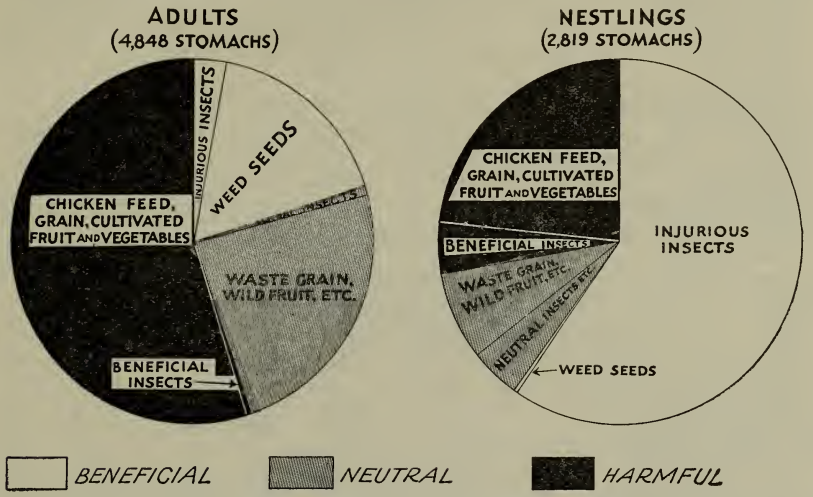


FIGURE 2.—Diagram showing beneficial, neutral, and harmful effects of the consumption of various food items by 4,848 adult and 2,819 nestling English sparrows. This information, in statistical form, is given in greater detail in table 3.

dead May beetles (*Phyllophaga*) picked up on city streets has no economic significance, although its capture of live ones is distinctly to its credit. Likewise, the impossibility of determining the exact economic significance of the consumption of some of the grain items, as previously mentioned (p. 22), has its uncertainty carried into the summarized appraisal here given. Nevertheless, in the absence of exact information in respect to all details, the general groupings used seem to afford the most tangible and workable method of approach.

In feeding on weevils, scarabaeids, click beetles, leaf beetles, grasshoppers, caterpillars, and flies, which totaled 2.67 percent of the annual food, the work of the adult English sparrows was in the main for the best interests of man; when consuming predaceous ground beetles and spiders, which aggregated 0.08 percent, it had the opposite influence; and in destroying other beetles, bugs, hymenopterans, other insects, and other animal matter, which totaled 0.64 percent, the birds fed on groups that are either largely neutral in their economic relation to man or comprised of both beneficial and harmful forms in approximately equal proportions.

TABLE 3.—*Percentages, by volume, of food items of 4,848 adult and 2,819 nestling English sparrows grouped to show whether the consumption is beneficial, neutral, or harmful to the interests of man*

Food items	Effect of consumption of food by—					
	Adults [1]			Nestlings		
	Beneficial	Neutral	Harmful	Beneficial	Neutral	Harmful
Animal food:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Weevils	0.69			15.17		
Scarabaeid beetles	.98			4.01		
Click beetles	.07			.46		
Ground beetles			0.05			2.65
Leaf beetles	.03			.29		
Other beetles		0.19			1.43	
Grasshoppers, crickets, and other Orthoptera	.57			25.24		
Caterpillars and moths	.23			11.16		
Bugs		.06			1.34	
Flies	.10			2.88		
Ants, wasps, bees, and other Hymenoptera		.31			1.34	
Other insects		.04			.16	
Spiders and other Arachnida			.03			1.79
Other animal matter		.04			.21	
Total animal food	2.67	.64	.08	59.21	4.48	4.44
Vegetable food:						
Feed [2]		9.57	50.00		6.76	23.00
Oats [2]		10.37	4.00		.19	
Wheat [2]		1.71	1.00		.25	.70
Corn [2]		.13	.30		.03	
Other grain [2]		.47	.10		.01	
Grass and weed seeds	16.97			.17		
Mast and wild fruit		1.39			.11	
Cultivated fruits and vegetables			.02			.11
Other vegetable matter [2]		.50	.08		.50	.04
Total vegetable food	16.97	24.14	55.50	.17	7.85	23.85
Total food	19.64	24.78	55.58	59.38	12.33	28.29

[1] Percentages for adults apply to entire year; for nestlings, to only spring and summer, periods of insect abundance. A comparison of the food of the nestlings with that of the adults during the breeding season is presented in fig. 4 and table 5 (p. 35).

[2] Explanation for dividing this item into the two categories neutral and harmful appears below.

Evaluating the effect of the consumption of vegetable food is more difficult, inasmuch as a part of each of the important categories—feed, corn, oats, wheat, other grain, and other vegetable matter—must be construed as waste material and hence its destruction is of neutral economic significance. The line of demarcation between grain that is of value to man and grain that is not is not definite, and the divisions made in this summary must be considered arbitrary, even though made on the basis of judgment gained from considerable experience with the bird both in the laboratory and in the field.

The entire consumption of grass and weed seeds has been placed to the credit of the bird, a practice generally followed in economic ornithology, even though some of the seeds are of plants not distinctly inimical to the interests of man. In the categories of feed, corn, oats, wheat, other grain, and other vegetable matter, however, consumption has been divided into that considered neutral and that thought to be harmful. These are at best merely estimates. The feeding on mast and wild fruit has been considered neutral in its effect and on the small quantity of cultivated fruit, harmful.

It will be seen that in the aggregate the adult English sparrows' consumption of animal foods, even though the volume taken was

small, stands to the birds' credit. On the other hand, the feeding on vegetable matter, which comprised 96.61 percent of the annual diet, reflects habits decidedly inimical to the interests of man, as the harmful effects of the birds' predilection for grain and other cultivated vegetable products were certainly not offset by the consumption of weed and grass seeds and harmful insects. That the adult English sparrow's potentialities for harm are greater than those for good is beyond question.

Such a conclusion does not mean that the adult English sparrow is a pest and a fit subject for control wherever found, but it does indicate that where environmental factors are favorable and the birds are abundant damage may be expected and control is warranted.

FOOD OF NESTLINGS

The food of the nestling English sparrows is here discussed first on the basis of the volume percentages obtained from the examination of all the juvenile material tabulated, 2,819 stomachs. These percentages are given in table 4. Then the progressive changes in the diet of the young birds from the time they are hatched until they leave the nest are taken up (p. 46). These changes are represented

TABLE 4.—*Food, by volume percentages, of 2,819 nestling English sparrows of various ages, showing progressive changes in diet*

[Some of these data are shown graphically in fig. 3.]

Food items	Food of nestlings—				
	1 to 3 days old	4 to 6 days old	7 or more days old	Of unknown age	Of all ages
Stomachs used	*Number* 864	*Number* 524	*Number* 743	*Number* 688	*Number* 2,819
Animal food:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Weevils	23.58	22.05	10.00	4.99	15.17
Scarabaeid beetles	2.62	3.68	1.62	8.59	4.01
Click beetles	.26	.28	.29	1.02	.46
Ground beetles	2.21	4.35	3.56	.93	2.65
Leaf beetles	.44	.18	.17	.31	.29
Other beetles	1.65	1.66	1.39	1.01	1.43
Grasshoppers, crickets, and other Orthoptera	28.24	19.81	24.17	26.81	25.24
Caterpillars and moths	18.06	6.75	4.98	12.53	11.16
Bugs	2.10	1.01	1.06	.93	1.34
Flies	4.95	2.63	.48	3.05	2.88
Ants, wasps, bees, and other Hymenoptera	1.61	1.31	.75	1.58	1.34
Other insects	.24	.04	.04	.29	.16
Spiders and other Arachnida	4.13	1.07	.33	.99	1.79
Other animal matter	.06	.35	.29	.23	.21
Total	90.15	65.17	49.13	63.26	68.13
Vegetable food:					
Feed	9.10	32.59	47.79	34.07	29.76
Oats	.02			.77	.19
Wheat	.03	1.60	2.35	.08	.95
Corn			.06	.05	.03
Other grain	.03				.01
Grass and weed seeds	.25	.08	.14	.20	.17
Mast and wild fruit	.01		.02	.43	.11
Cultivated fruits and vegetables	.13	.18	.09	.07	.11
Other vegetable matter	.28	.38	.42	1.07	.54
Total	9.85	34.83	50.87	36.74	31.87

graphically in figure 3. Then is discussed the influence of locality on food habits as revealed by analysis of part of the material (p. 48).

The stomachs examined include 864 that are representative of about the first third of nestling life, that is, of birds 1 to 3 days old; 524, of the second third, 4 to 6 days old; and 743, of the last third, 7 or more days old; and 688, of nestlings of unknown age, individuals in various stages of development, so that their inclusion in the general tabulation for nestlings probably does not disproportionately affect the results. Likewise the numbers of stomachs in the first three groups are not so greatly at variance with one another as to bias conclusions seriously when the whole lot is treated as a unit to show the food habits of what might be termed the "average" nestling.

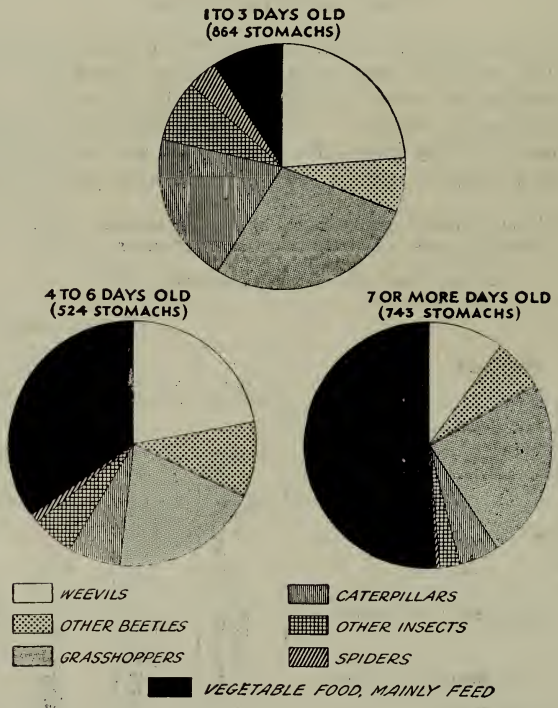


FIGURE 3.—Diagram showing the changing food habits of nestling English sparrows during their growth. This information, in statistical form, is given in greater detail in table 4.

ANIMAL FOOD

One need only compare the percentages, 3.39 and 68.13, representing the animal food of the adult and of the nestling English sparrows, respectively, to be convinced of the radically different food requirements of the two. On the one hand is a bird that even at the height of the breeding season (May) subsisted on vegetable matter to the extent of more than 88 percent of its diet, and on the other is one that during the first 3 days of life was fed animal food in the proportion of more than 90 percent of its diet. Of the 2,819 stomachs of nestlings

of all ages used in this study, only 25 contained no animal food and 504 held nothing else.

Insects

All but 2 percent of the animal food, or 66.13 percent of the entire diet of the nestlings, was composed of insects brought to them by parents that even in the nesting season are highly vegetarian. The pronounced insectivorous diet of nestlings (pl. 3) and the contrasting vegetarian character of the food of the adults during the same period are represented graphically in figure 4 and are presented in statistical detail in table 5.

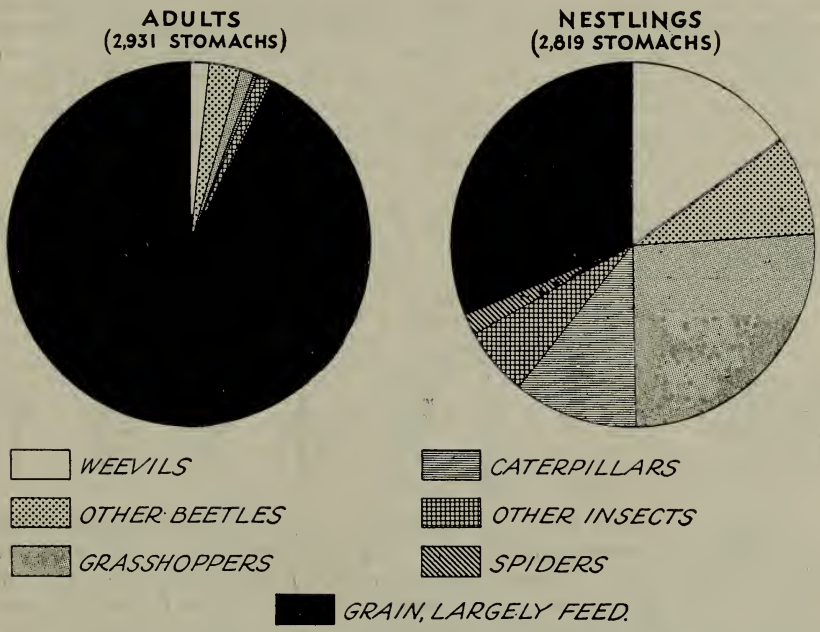


FIGURE 4.—Diagrammatic representation of the food of adult and nestling English sparrows collected during spring and summer (April to August, inclusive). This information is given in statistical form in table 5.

TABLE 5.—*Food items, expressed in volume percentages, of 2,931 adult and 2,819 nestling English sparrows, all collected from April to August inclusive*

English sparrows	Weevils	Other beetles	Grass-hoppers	Caterpillars	Other insects	Spiders, etc.	Grain, largely feed
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Adults	1.45	2.92	1.20	0.50	0.84	0.12	92.97
Nestlings	15.17	8.84	25.24	11.16	5.72	2.00	31.87

BEETLES (COLEOPTERA)

Weevils (Rhynchophora).—Weevils and their larvae formed, as a group, the largest single item of the beetle food of the nestlings. In economic importance the consumption of these insects is second only to that of grasshoppers and crickets in bespeaking commendable food habits of these young birds, and under certain conditions the English

sparrow's war against them compares favorably with more widely recognized activities of certain native birds. Throughout their 10 or more days of nestling life the young sparrows studied obtained 15.17 percent of their sustenance from weevils, and during the first 3 days of this period these insects comprised nearly a quarter of the food. Of the 2,819 nestlings examined, 1,863 had fed on weevils. About half of these records (966) were from the material collected in Utah in 1911 and 1912 during a period when the alfalfa weevil was exceedingly abundant (*26*).

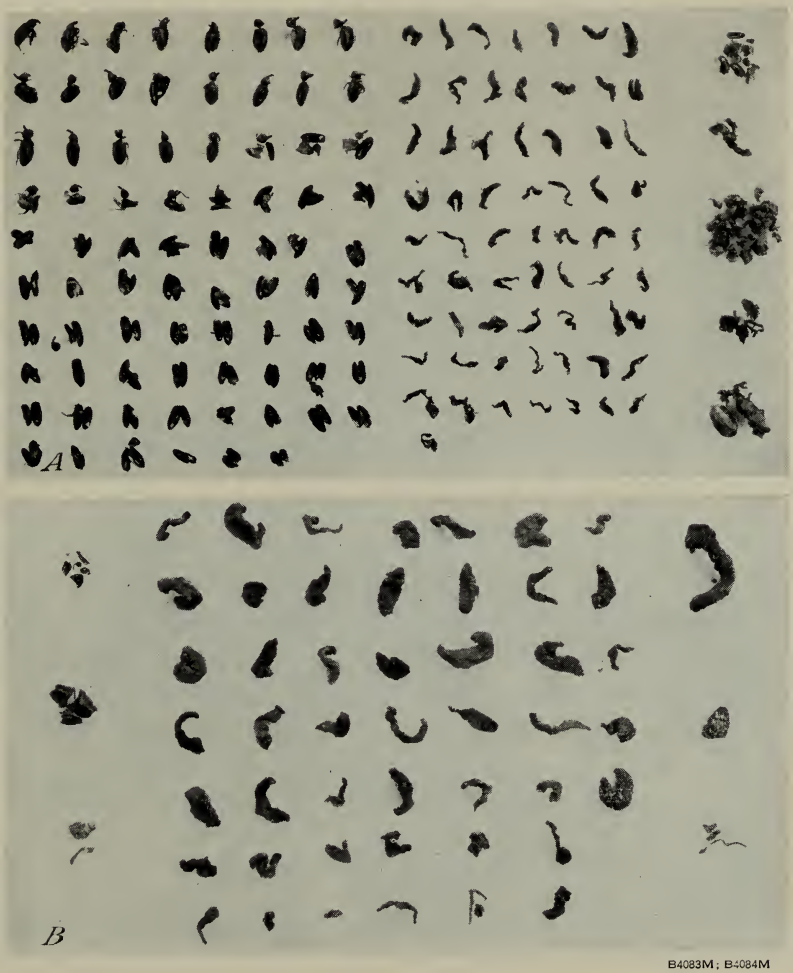
Despite the fact that the English sparrow doubtless has been too abundant in the Salt Lake Valley for the best interests of agriculture, the nestlings there must be ranked high in the scale of avian enemies of this introduced pest (pl. 3, *A*). Most of the stomachs collected in the study of the relation of these young birds to the alfalfa weevil (*26*) were obtained from the middle of May to the middle of June, which coincided with the period of greatest abundance of the larval form of the weevil. Seasonal fluctuations in the food of the Utah nestlings are shown in table 6 and figure 5.

TABLE 6.—*Food, by volume percentages, of nestling English sparrows collected in Salt Lake Valley, Utah, in 1911 and 1912, showing seasonal fluctuations in items eaten*

Semimonthly period	Alfalfa weevils	Grasshoppers	Caterpillars	Grain	Miscellaneous
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
May 1–15	14.00	0.94	4.19	65.62	15.25
May 16–31	36.12	.66	18.36	25.05	19.81
June 1–15	26.75	1.03	11.30	38.84	22.08
June 16–30	18.25	16.30	19.64	36.64	9.17
July 1–15	.77	35.23	8.82	51.83	3.35
July 16–31	9.20	24.71	1.86	58.20	6.03

It may be noted that the variations in the proportions of alfalfa weevils eaten correspond closely to the seasonal abundance of the larvae of this pest. Even during the first half of May parent birds in the Salt Lake Valley were already visiting alfalfa fields in search of the adult weevils as food for their young and were thus rendering good service in preventing numbers of those individuals that survived the winter from propagating. In the latter half of May the first brood of weevil larvae was available and furnished an ideal food for the nestlings. More than 36 percent of their food then was composed of alfalfa weevils, and only 19 of 530 stomachs did not contain the pests. During the first half of June, weevil larvae continued to supply an important part of the diet (26.75 percent), and of the 360 young birds collected in 1912 only 1 had not been given the larvae. During the latter half of June other insects became of more importance and a decrease in the proportion of weevils eaten was noted. By the first week in July weevil food became insignificant. In 1912, though, considerable numbers of adult weevils of the year's brood furnished part of the diet as late as the latter part of July.

Analyses of these stomachs furnished some of the most noteworthy records of insect destruction credited to the English sparrow. The 5 half-grown young of 1 brood had consumed, respectively, 55 larvae and 1 adult, 85 larvae and 4 adults, 95 larvae and 3 adults, 110 larvae and 2 adults, and 123 larvae and 1 adult, an average of 93.6 larvae



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FOOD OF INSECTIVOROUS NESTLING ENGLISH SPARROWS.

A, Stomach contents of a 5- to 6-day-old nestling collected in May 1912 in Utah: 78 adults and 64 larvae of the alfalfa weevil (80 percent of the food), 3 other weevils, a caterpillar, numerous hymenopterous cocoons, spider remains, and a little wheat.

B, Stomach contents of a 3-day-old nestling collected in June 1912 on a farm near Potts Grove, Pa.: 47 larvae of the clover leaf weevil (86 percent of the food), a dung beetle, a click beetle, 4 leaf beetles, a caterpillar, a scale insect, and a kernel of oats.

and 2.2 adult insects for each bird. Breeding weevils were still being fed to 4 young collected on June 1, 1912, as a total of 272 adults and 4 larvae were found in their stomachs. A single bird, 1 of a brood of 3, had eaten 170 larvae and 5 adults, the largest number found in a nestling's stomach.

Thus the study of the English sparrow's relation to the alfalfa weevil has clearly established the fact that the bird, largely through its choice of food for the young, must be classed as one of the leading avian enemies of the pest. Computations based on the quantity of food fed the young indicate that individual broods were daily destroy-

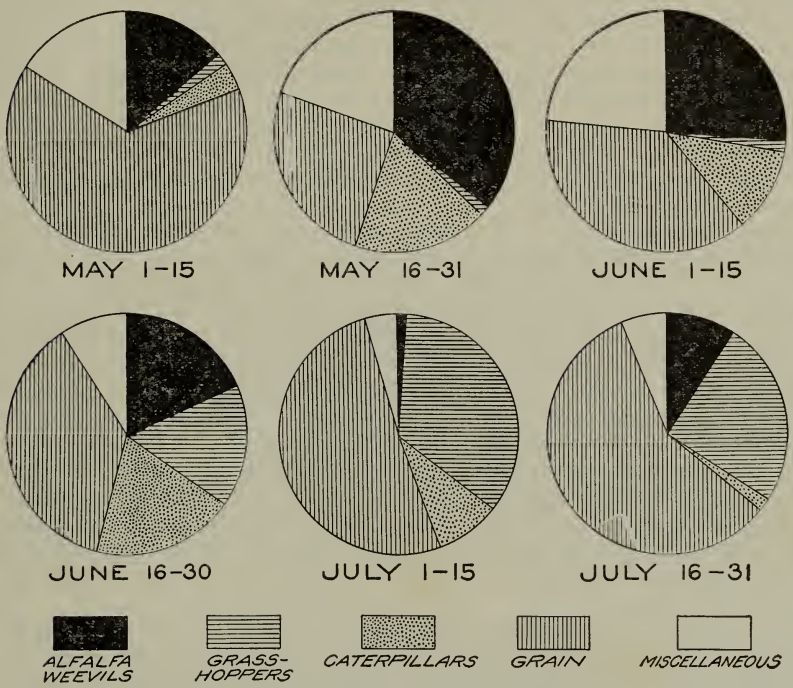


FIGURE 5.—Diagrammatic representation of the food of nestling English sparrows collected in the Salt Lake Valley, Utah, in 1911 and 1912, showing the seasonal fluctuations in food items. This information is given in statistical form in table 6.

ing nearly 2,000 larvae and that the aggregate number eaten by the birds on a single farm throughout the summer season might, under some conditions, reach half a million.

The destruction of bark beetles (Scolytidae) by English sparrows at Autaugaville, Ala., previously referred to (p. 15), was brought about largely through the activities of the parents in feeding the young. These birds, collected mainly in the immediate vicinity of lumber-yards, had availed themselves of the abundant supply of insect life there. Of 672 nestlings collected, 523 had been fed on weevils, principally bark beetles of several genera and the pine weevils *Hylobius pales* and *Pachylobius picivorus*. In bulk these beetles formed more than 10 percent of the food of the group (p. 49), and in many instances surprisingly large numbers were recorded in individual stomachs.

One nearly fledged nestling had eaten 103 bark beetles of 5 genera and 22 scolytid larvae; a half-grown bird, 105 adults of 4 genera; and a newly hatched young, 120 adults of 5 genera and 5 larvae. As many as 25 *P. picivorus* were found in a single stomach.

The larvae of the clover leaf weevil (*Hypera punctata*) furnished acceptable food to young sparrows throughout the Eastern States (pl. 3, *B*). Practically all the 105 records of their occurrence in the stomachs of the English sparrows examined are credited to the nestlings. No doubt most of these insects were obtained from city lawns or parkways.

Weevils of the genera *Sitona* (clover root borers), *Sphenophorus* (billbugs), *Baris* and related genera, *Tanymecus*, *Hyperodes*, *Brachyrhinus*, and *Calendra* also entered into the food of the nestling English sparrows. That individual birds at times obtained a great variety and number of weevils is illustrated by the following list of those taken from a nestling collected in Connecticut in July: 5 *Hypera punctata*, 1 *Phytonomus*, 1 *Brachyrhinus ovatus*, 1 barinid, 26 *Sitona hispidula*, 2 *S. flavescens*, 1 *Sphenophorus*, and 1 *Ceutorhynchus*, totaling in all 60 percent of the bird's food.

Dung beetles, May beetles, and other Scarabaeidae.—Scarabaeid beetles, mostly dung beetles of the genus *Aphodius* and May beetles (*Phyllophaga*), formed about one twenty-fifth of the food of the nestling English sparrows examined and were present in 1,011 of the 2,819 stomachs. The economic considerations involved in the destruction of such beetles have been discussed under the food of the adults (p. 15).

Although there is a fluctuation in the quantity of Scarabaeidae fed to English sparrows at different periods in their nestling life, the environment of the birds and the availability of the beetles, rather than the age of the bird, appear to determine the quantity and character of such food consumed. In rural sections of Utah the nestlings' scarabaeid food was restricted largely to dung beetles of the genera *Aphodius* and *Ataenius;* at Blue Rapids, Kans., May beetles predominated; and at Independence, Iowa, the young were raised largely on a mixture of the two.

Not infrequently 20 or more specimens of *Aphodius* or other beetle genera of similar size were found in a single stomach. One brood of 4 English sparrows, about 3 days old, collected in the Salt Lake Valley, had been fed 94 *Aphodius*, which comprised more than two-thirds of the diet. May beetles, because of their larger size, appeared in fewer numbers but often formed the bulk of the stomach contents. Eight individuals, found in the stomach of a bird collected at Independence, Iowa, constituted the record in point of numbers for a single nestling.

Mention also should be made of the nestling English sparrows' fondness for scarabaeids of the genus *Ochrosidia*, found frequently in stomachs from Alabama. As many as 20 were found in a single stomach, and in another instance these beetles comprised the entire food. Among the other scarabaeids eaten were representatives of the phytophagous genera *Euphoria* and *Strigoderma* and of the coprophagous genera *Canthon* and *Onthophagus*.

Click beetles (*Elateridae*).—That little assistance can be expected from the English sparrow in the control of click beetles, the adult form of wireworms, has been previously stated (p. 16). This fact can be reasserted after a study of the nestlings' food, only 0.46 percent of

which consisted of click beetles, the adult form having been taken in all but a few instances.

Ground beetles (*Carabidae*).—Contrasting somewhat with the adult sparrow's apparent aversion to ground beetles is their freer choice of them as food for their young. In this study, these hard-shelled beetles formed 2.65 percent of the nestlings' diet. They had been fed to more than a fourth of the 2,819 nestlings examined, and in the material from Utah the proportion was much greater. Members of the genus *Amara* predominated in these western stomachs. In Alabama the nestlings had been fed extensively not only on *Amara* but on other small carabids as well. Carabids of the genera *Platynus*, *Selenophorus*, *Agonoderus*, *Anisodactylus*, *Cratacanthus*, and *Harpalus* also entered into the diet of the nestlings collected elsewhere.

Leaf beetles (*Chrysomelidae*).—Though nestling English sparrows eat more leaf beetles than the adults they exert no appreciable controlling influence on these insects. In this study, Chrysomelidae contributed only 0.29 percent of the nestlings' food and only in rare instances comprised a substantial proportion of the stomach contents. The larvae of *Zygogramma* were eaten at times, 41 having been found in the stomach of a nestling from Massachusetts. In Southern States the toothed flea beetle (*Chaetocnema denticulata*) and the grape leaf beetle (*Colaspis brunnea*) were most often taken.

Other beetles.—The other beetles taken by the nestlings comprised 1.43 percent of their food. Prominent among them were beneficial ladybirds (Coccinellidae) and their larvae, the destruction of which has been held by some writers to contitute a serious indictment against the English sparrow, especially in areas where these beetles play an important part in the control of scale insects. In this study, material from California and Utah furnished most of the evidence against the sparrow on this point. Species of *Coccinella* and *Hippodamia* were frequently recognized. Most of the long-horned beetles (Cerambycidae) eaten by the nestlings were those obtained about lumberyards in Alabama. These included *Eupogonius tomentosus*, *Monochamus titillator*, *Acanthocinus obsoletus*, and others. Tiger beetles (Cicindelidae), present in fewer than 100 stomachs, had been eaten by nestlings taken at widely separated points. Hister beetles (Histeridae) had been taken sparingly by nestlings throughout the country, although material from Utah revealed them in greatest frequency. Metallic wood-boring beetles (Buprestidae), especially *Buprestis lineata* and species of *Chrysobothris*, had been eaten by numerous nestlings collected in lumbering sections of Alabama, as had also the brightly colored *Temnochila virescens*, a bark-gnawing beetle found on pine. A few scavenger water beetles (Hydrophilidae), fireflies (Lampyridae), dermestids (Dermestidae), darkling ground beetles (Tenebrionidae), and powder-post beetles (Bostrichidae) complete the list of other beetles, with the exception of those that must be looked upon as infrequent or accidental items of diet. Of more than passing interest are the records of two nearly fledged nestlings collected in April in Alabama that had been fed 54 and 25 individuals, respectively, of the powder-post beetle (*Stephanopachys densus*).

GRASSHOPPERS, CRICKETS, AND OTHER ORTHOPTERA

It is in the destruction of Orthoptera, particularly of the short-horned grasshoppers (Acrididae) that the nestling English sparrow is

entitled to greatest credit as an insectivorous bird. More than a fourth of the food of the young examined was obtained from this order of insects. This is nearly eight times the proportion taken by the adult birds in August (3.33 percent), the period of their greatest activity against grasshoppers. Orthoptera were present in slightly more than half (1,432) the nestling stomachs and often comprised the bulk of the contents. In 95 stomachs they composed the entire food; in 265 others, more than nine-tenths.

Availability appeared to be the primary factor affecting the quantity of grasshoppers fed to nestling sparrows. When abundant, these insects were taken almost to the exclusion of other insect food; when scarce, only occasional traces of them were found in the stomach contents. No marked changes in preference for these insects were indicated as the nestlings grew older, with the exception that nestlings in their younger stages were fed largely on the soft, less heavily chitinized nymphs, whereas the older ones were freely given the mature forms.

How an abundant orthopterous fauna may affect the food habits of young sparrows is well illustrated by material collected at Onaga, Kans., in 1912. Only 10 out of 380 nestlings of various ages had failed to feed on grasshoppers, which formed more than 84 percent of the food. From the viewpoint of numbers eaten, the records for nestling English sparrows cannot be expected to compare favorably with those for the larger avian enemies of grasshoppers, such as Franklin gulls, sparrow hawks, crows, and magpies, but the limited individual capacity of the nestling sparrow is somewhat offset by their excessive numbers. One nestling, three-fourths grown, collected in June, had eaten 47 acridids, and 3 others of the same brood had taken 40, 34, and 30, respectively. One group of 6 nestlings, possibly 2 broods, had made away with 149 acridids, which comprised 98 percent of their food; a brood of 5, about one-third grown, had consumed 68, which formed all but a fraction of 1 percent of their diet; and 2 broods of 4 each, about one-third grown, had been fed grasshoppers exclusively, 53 in one case and 42 in the other. Even the callow young, 2 days old, had been fed the soft-bodied nymphs, which comprised the entire stomach contents of 1 brood of 3. Many other instances were recorded in this material from Kansas of broods eating from 30 to 70 grasshoppers.

Among the acridids eaten by the nestlings in Kansas, species of the genus *Melanoplus* were dominant. The lesser migratory locust (*M. mexicanus*), considered one of the more destructive species of this genus, as well as the large *M. bivittatus* and *M. differentialis*, appeared at frequent intervals. There were also representatives of the genera *Hesperotettix* and *Hippiscus*, as well as of several species of long-horned grasshoppers (Tettigoniidae).

Stomachs of the nestling English sparrows collected at Autaugaville, Ala., showed a similar preponderance of grasshoppers, but an abundance of other insect food, particularly bark beetles (Scolytidae) and other Rhynchophora and long-horned beetles (Cerambycidae), tended to lower somewhat the bulk percentage of orthopterous food (p. 49). Nevertheless, 78 percent of the 672 nestlings collected there had eaten Orthoptera, including, in addition to the destructive forms of *Melanoplus*, numerous species of grouse locusts (Acrydiinae), meadow grasshoppers (*Conocephalus*), tree crickets (Oecanthinae), and field crickets (*Gryllus*).

A series of 30 nestlings showing a marked preference for orthopterous food (91.2 percent) was collected in May 1916 at Woodward, Okla., from which place, in recent years, have come many complaints of the English sparrow's damage to milo and other sorghums. Only 1 of these birds had obtained less than three-fourths of its food from grasshoppers, and 5 had fed on them exclusively. Species of *Melanoplus*, including the lesser migratory locust, comprised the bulk of this material.

Other instances of meritorious work on the part of the English sparrow against Orthoptera were revealed in the examination of stomachs from Massachusetts, Pennsylvania, Maryland, Mississippi, Wisconsin, Iowa, and Utah. Nestlings from Bridgewater, Mass., were fed usually on a mixture of grouse locusts, grasshoppers of the genus *Melanoplus*, and field crickets, whereas the orthopterous food of those from Utah consisted largely of field crickets.

CATERPILLARS AND MOTHS (LEPIDOPTERA)

Caterpillars and moths furnished about a ninth of the food of the 2,819 nestling English sparrows examined and had been eaten by 1,322 (almost 47 percent) of them. Caterpillars in particular were important in the growth of the very young birds, callow nestlings, 1 to 3 days old, having subsisted upon them to an extent of nearly a fifth of their diet. Among these insects were some of the most destructive pests of shade trees and garden products, and although the limitations of stomach examination permitted specific identification in only a few instances, the value of the nestling English sparrow as a destroyer of caterpillars can be appraised with a fair degree of accuracy.

At Independence, Iowa, nestlings as well as adults are entitled to honors in the destruction of caterpillars. Of the 229 nestlings collected there, caterpillars had been fed to 163 to the extent of more than a fourth of their food. All 17 nestlings taken on May 23, 1917, had eaten caterpillars, which, characterized by the prevalence of the cutworm *Polia legitima*, comprised more than 77 percent of the food. One stomach contained 24, and the average for the lot was more than 11.

Commendable also are records from other localities of the consumption of caterpillars by nestling English sparrows. At Autaugaville, Ala., 14 nearly fully feathered young taken on May 23 had obtained 75 percent of their food from caterpillars and a few moths. In 1 stomach 5 cutworms comprised the entire food, and in 17 stomachs the cotton bollworm (*Heliothis armigera*) was identified. Material from Utah gave added evidence of the young English sparrows' dependence on caterpillars. A brood of 5 newly hatched nestlings collected in May had eaten 25 caterpillar larvae, which furnished 95 percent of their food; and a family of 4, slightly older, had consumed 39, which comprised about five-eights of their stomach contents. From Onaga, Kans., came a record of a brood of five 1-day-old young that had eaten 41 caterpillars, and from Potts Grove, Pa., a record of 5 young that had obtained 89 percent of their sustenance from about 30 caterpillars.

Stomach examination has corroborated in part the testimony of field observers that English sparrows destroy cankerworms, or measuring worms, the larvae of Geometridae, as these were identified in

30 stomachs. Among the stomachs from Alabama, 1 contained fully 21 cankerworms and others gave indications that the English sparrow's attack on these insects was a general one in the vicinity.

BUGS (HEMIPTERA)

True bugs do not form an important element of the food of nestling English sparrows, for although they appeared in 644 of the 2,819 stomachs they comprised only 1.34 percent of the total contents. Material collected in Alabama in April, May, and June contained Hemiptera in greatest numbers. Among these were many treehoppers of the genus *Stictocephala*, 28 specimens of *S. festina* having been found in a single stomach. Members of the genera *Campylenchia*, *Entylia*, and *Telamona* also were present. Leafhoppers (*Cicadellidae*) of several genera, particularly *Draeculacephala* and *Xerophloea*, and lantern flies (*Scolops*) were frequent articles of diet. Negro bugs (*Allocoris and Galgupha*) and stinkbugs (*Pentatomidae*) of various kinds were present in many stomachs from Alabama and elsewhere.

The nestling English sparrow's relation to plant lice in areas where these insects are abundant was indicated by material from widely separated points. Stomachs of birds from Massachusetts, Alabama, and Utah collected early in the summer revealed the remains of numbers of plant lice, often so crushed that a count could not be made. The presence of 20 to 35 of these bugs in single stomachs of callow young sparrows is suggestive of the beneficial work that may be expected of the nestlings during periods of plant lice outbreaks.

FLIES (DIPTERA)

Flies, in adult, pupal, larval, and egg stages, supplied 2.88 percent of the food of the nestling English sparrows and were present in 607 of the 2,819 stomachs. The very young birds, as a rule, contained them in larger proportions than those about to leave the nest.

Local environment apparently plays an important part in the nestlings' relation to Diptera. The crane flies (Tipulidae) found came largely from the stomachs of birds from rural sections of Utah. Late in May 1912, numerous broods were collected there that had obtained the bulk of their insect food from the soft bodies of these long-legged, slow-flying insects. The more sluggish female crane flies filled with eggs easily fall prey to the English sparrow, a fact often indicated by the presence of hundreds of shiny black eggs throughout the stomach contents with possibly only a trace of the fragile body of the female that originally contained them.

Records of the destruction of houseflies by nestling English sparrows came largely from the material collected in a rural locality in Alabama. One series of 12 young birds taken in April had obtained nearly half their food from flies, mostly houseflies in larval, pupal, and adult stages. In 1 stomach were the remains of 24 larvae; and in another, 18. These no doubt had been obtained by the parents from manure in the vicinity of the barnyard where the young had been collected.

Bluebottle flies, or blowflies (*Calliphora*), appeared most often in stomachs from an urban locality in Iowa. Of 32 nestlings collected there late in May, 26 had been fed on flies, chiefly the red-headed blowfly (*Calliphora erythrocephala*), presumably captured in the vicin-

ity of carrion. Somewhat similar feeding habits were revealed by the stomach contents of a brood of 4 collected in Mississippi in June. Nearly half their food consisted of flesh flies (Sarcophagidae) obtained, according to the notes of the collector, "in the vicinity of a village hotel." Syrphus flies (Syrphidae), the species of which vary greatly in feeding habits and economic status, were present in stomachs from widely scattered points from Massachusetts to California. Nestling English sparrows from Bridgewater, Mass., had eaten the larvae of these flies in considerable numbers, 50 individuals having been found in a single stomach. Among the other flies eaten by the nestlings may be mentioned Anthomyidae, Scatophagidae, and Ortalidae. No fewer than 65 ortalid larvae were found in the stomach of a nestling from Massachusetts.

ANTS, WASPS, BEES, AND OTHER HYMENOPTERA

Insects of the economically heterogeneous order Hymenoptera formed but 1.34 percent of the food of the nestling English sparrows. Ants of many kinds strongly characterized this part of the food. Carpenter ants (*Camponotus*) were frequently eaten, as were also numbers of cornfield ants (*Lasius niger americanus*) and species of *Solenopsis*, which investigations in Georgia have shown to be highly destructive to hatching quail. A nestling collected in Alabama in May had been fed 35 of these ants.

The young English sparrows' destruction of sawfly larvae deserves recognition, not so much by reason of the frequency of such activities recorded in stomach examination as because of the rather surprisingly large numbers taken by individual birds under favorable conditions. Two nestlings collected in Alabama in April had eaten 250 and 130, respectively.

Offsetting to a certain extent the nestling English sparrow's work on injurious Hymenoptera is its destruction of beneficial forms, including the parasitic braconids, ichneumonids, and tiphiids. Braconids of the genus *Protapanteles* occurred frequently in material from Utah. These were in the pupal form encased in small white silken cocoons and in almost every instance were associated with caterpillar remains, affording strong circumstantial evidence that the birds had swallowed parasitized caterpillars. In the stomach contents of 1 brood of 4 nestlings were found the remains of 226 braconid cocoons, which formed more than half the food, and in the stomachs of others collected at the same time, equally surprising numbers occurred. The remains of ichneumonids and tiphiids seldom formed a large proportion of the stomach contents, although they occurred in many of the stomachs collected in eastern States.

Small mining bees (*Halictus* and related genera) were found in a number of the nestling English sparrow stomachs from California, but their capture involves nothing of economic importance.

OTHER INSECTS

Forming but a mere trifle of the annual sustenance and in no case involving matters of great economic importance, the other insects eaten by the nestling English sparrow need only passing mention. In addition to termites, which were found in a number of stomachs from Alabama, they included a few Neuroptera, Mayflies (Ephemeroptera), and dragonflies (Odonata).

Spiders and Other Arachnida

Arachnida of various kinds were present in about 30 percent of the stomachs and, as is the case with most birds, had been eaten most extensively by the callow young. More than half the nestlings less than one-third grown had been fed spiders. The fragile character of spider remains precludes the possibility of specific identification in most cases, but the terrestrial jumping spiders (Salticidae) appear to have fallen prey to the nestlings more frequently than any other group. The few mites (Acarina) eaten involve no economic problems of importance.

Other Animal Matter

Other animal matter consumed by the nestling English sparrows included a few millepedes, earthworm cocoons, snails, and fragments of the shell of hens' eggs. The latter item, previously alluded to in the discussion of the adults' food (p. 21) was present in 117 of the 2,819 stomachs. No doubt such food satisfies the definite need of growing birds for bone-building material, and apparently it is regularly sought by the adults for their growing young, as from April to August inclusive, small quantities of it, as well as snail shells and other calcareous matter, were given to the young birds at frequent intervals. It appeared most frequently in stomachs collected in May and June and was doubtless all obtained from refuse.

VEGETABLE FOOD

The economic importance of the vegetable part of the adult English sparrows' food and the difficulties involved in properly interpreting it have already been stressed (p. 22). Similar considerations arise in an appraisal of the vegetable food of nestlings, but their importance is lessened somewhat by the smaller proportion of vegetable food taken.

Through the examination of 2,819 stomachs of nestlings of various ages, it has been determined that 31.87 percent of the nestlings' food was obtained from the vegetable kingdom. More than four-fifths (2,315) of the nestlings had partaken of vegetable food, and the final meal of 56 was entirely of that character. An increase in the quantity of vegetable food eaten as the nestlings became older was noted. This aspect of the subject is discussed on pages 46–47.

Feed

Feed, consisting of mixed or unmixed grain obtained about poultry yards, feed troughs, corrals, and elsewhere, formed the largest and most important part of the nestling sparrows' vegetable food. It averaged 29.76 percent of the yearly food, ranging from only 9.1 percent in the stomachs of the very young birds to 47.79 in those of the more mature ones. It was present in 2,134 of the 2,819 stomachs, and in 39 of the older nestlings it comprised the entire food.

Analysis of the component parts of the feed eaten by the nestlings reveals differences in the proportions of corn, oats, and wheat from those taken by the adult birds. In the feed eaten by the adults cracked corn was dominant, followed by oats, wheat, and other grains (p. 23); in that taken by the nestlings oats predominated, with wheat, corn, and other grain following in the order named. This cannot be considered, however, as reflecting variations so much in the

suitability of these grains for adult and nestling as in the character of the feed available. About a fourth of the nestlings but less than a fifth of the adults came from points in Alabama, where oats appeared as a common ingredient of feed; and more than a third of the nestlings but only about 1 out of every 39 adults came from Utah, where wheat is used almost to the total exclusion of other grains, a factor that tends to emphasize wheat in the feed ration of the whole group of nestlings.

The persistency with which feed was relied upon to develop broods of young sparrows in Utah is brought out by the fact that only 9 of the 272 nestlings two-thirds or more grown had not been given any. It had been fed to those about half grown even more frequently, as only 9 out of 320 had not partaken of it. Even those Utah birds less than 4 days old, helpless individuals still being fed largely on insect food, were given feed in 219 out of 459 instances.

Nestlings from a number of other regions, though less extensive grain feeders as a rule than the young birds from Utah, showed a comparable consumption of feed. All but 2 percent of the aggregate food of 19 nearly fledged young from Illinois was obtained from the poultry yard, and at one point in Alabama conditions for obtaining poultry food were so favorable that all but 2 of 249 well-grown young had been fed on a mixed diet of oats, corn, wheat, rice, and other grains found in scratch feed. Though the evidence gained from the stomachs of birds from other localities is less extensive, it is none the less convincing proof that, when opportunity presents itself, parent English sparrows provide their young with their own staff of life, chicken feed, as a suitable and nourishing article of diet.

Oats, Wheat, Corn, and Other Grain

The food habits of nestling English sparrows cannot be blamed for serious damage to ripening, shocked, or stacked grain. Damage of this kind by the species must be charged almost wholly against the adult birds.

Although oats other than those acquired from feed averaged 14.37 percent of the adults' food, they constituted a mere 0.19 percent of the nestlings' diet. They were gleaned largely from the manure on the city street and in the country barnyard, which involves nothing of economic importance.

Wheat other than that from feed furnished 0.95 percent of the nestlings' food and was obtained largely from the ripening crop. The stomachs of a few of the nearly mature broods from Utah and Pennsylvania contained new wheat in considerable quantities, but its presence in only 43 of the 2,819 stomachs gives an idea of the very limited effect these nestlings have on the growing or ripening crop.

Corn that was considered to have been taken from the standing grain or the newly harvested crop was found in only three stomachs of nestlings, and the remains of rice in but two. In each case the quantity taken was small, and its consumption by the sparrow was of no economic significance.

Other Vegetable Matter

Other vegetable items, including grass and weed seeds, mast and wild fruit, cultivated fruits and vegetables, buds, foliage of a varied character, and miscellaneous vegetable debris, constituted only 0.93

percent of the diet of the nestling English sparrows. In this material were many of the same kinds of common grass and weed seeds as those found in the stomachs of adults (p. 26) but in quantities too small to be of economic importance. The seeds of the elm appeared in several stomachs from Iowa, and the remains of acorns in a few from widely separated points. Rubbish, or vegetable material accidentally swallowed by ravenous young when being fed, formed the greatest part of the miscellaneous vegetable matter. It consisted of bits of wood, grass, and other fibers that possessed little or no food value but possibly assisted in maintaining a satisfying sensation of fullness.

PROGRESSIVE CHANGES IN DIET

It is a generally recognized fact that the food habits of most nestling passerine birds undergo a series of progressive changes from the time the birds are hatched until they are ready to leave the nest. These alterations in diet result in corresponding changes in the economic status of the growing birds. Food items that are nourishing and attractive to the bird as a callow nestling are found to decrease in the diet as the bird becomes more robust, and those that are wholly unsuited or even indigestible to the bird when very young enter more and more into its food as the physiological development of the bird permits their assimilation. In species not wholly insectivorous, this progression is manifested by a decrease in insect and other animal food and a corresponding increase in such vegetable items as grain and fruit. Generally this has the effect of lowering the economic value of the bird as it grows older.

Of the ample series of 2,819 stomachs available in this study, 2,131 have served well to illustrate these progressive changes in the diet and economic status of the nestling English sparrow. The 688 that lacked the data necessary to allocate them accurately as to age were not used in the computations on which this discussion is based. To aid in visualizing the progressive changes in food elements, the reader is referred to the first three columns of percentages in table 4 (p. 33) and to figure 3 (p. 34).

The decline in the percentage of the total animal food consumed during the three successive periods of nestling life and the complementary increase in the vegetable food show forcibly the marked changes that occur. In the brief period of 10 to 12 days these rapidly growing birds had their ration of animal food reduced from more than 90 percent to less than 50. This was brought about principally through a reduction in the quantity of 4 items taken—weevil larvae, caterpillars, fly larvae and pupae, and spiders—all soft-bodied, and easily assimilated organisms extensively fed to newly hatched birds. The large percentage of weevil food is due largely to the fact that nearly half the nestlings were collected in the Salt Lake Valley in 1911 and 1912 at a time when the larvae of the alfalfa weevil were extremely abundant and were fed to the nestlings in preference to grasshoppers and even caterpillars.

The steady decrease in the quantity of caterpillars eaten is a phenomenon common to nestling English sparrows throughout the country. A similar decrease was noted in the percentage of spiders consumed. They were especially attractive as food for birds a day or two old, but the rather temporary character of this attractiveness is shown by the sudden falling off in the quantity taken. The quan-

tity of soft and easily digested larvae of flies eaten, mainly by newly hatched young, revealed a similar decrease as the birds matured.

The more nearly equal percentages of grasshoppers eaten during the three successive periods of the nestling's life would seem to show that, in addition to being an acceptable food to the very young, these insects are a standard article of diet for the older birds as well. Stomach examination has shown, however, that there is a marked change in the character of the orthopterous food taken. Young birds during the first third of their nestling existence were fed largely on the less heavily chitinized nymphs, whereas the birds about to leave the nest were given many of the larger and more mature forms.

The more heavily chitinized ground beetles, scarabaeids, and other coleopterons are fed in greatest quantity at about the middle of the nestling's development. The less digestible character of these insects makes them unsuitable for very young birds, and the fewer numbers of them noted in the food during the last part of the nestling's life may be logically explained as a part of the transitional process changing a highly insectivorous nestling to a decidedly vegetarian juvenile.

The other less frequently eaten animal food items reveal little concerning the changing food habits of the nestlings but give added evidence of the more highly insectivorous nature of the younger birds.

With the decreasing proportion of animal food taken in the successive periods of the nestling's life there occurred a complementary increase in the vegetable food eaten. This was characterized by the quantity of feed consumed, the food item that later became the dominant one of the mature bird. Similar increases in the quantity of wheat and miscellaneous vegetable matter consumed are further evidences of the rapidity with which the English sparrow acquires its highly vegetarian regimen. Other items of vegetable food were taken too irregularly to permit drawing conclusions concerning their role in the dietary development of the nestling.

Had it been possible to segregate a series of stomachs of juveniles that had just left the nest and were still fed by their parents, there is little doubt that a further decrease in insect food items would have been noted and that vegetable items would have shown a corresponding increase. In all probability the juvenile English sparrow just out of the nest possesses food habits that are intermediate in character and economic significance between those of the older nestling and those of the mature bird.

SUMMARY OF FOOD HABITS OF NESTLINGS

A summarized appraisal of the food of nestling English sparrows similar to that compiled for the adults (p. 30) is desirable not only to comprehend better the economic influence of these young birds but also to furnish a basis of comparison between old and young (table 3, p. 32; fig. 2, p. 31).

In considering the animal food eaten by the nestlings the destruction of weevils, scarabeids, click beetles, leaf beetles, grasshoppers, caterpillars, and flies, which aggregated 59.21 percent of the food, has been placed in the category of beneficial activities. Although it is true that there are genera and species under each of these groups that cannot be considered distinctly harmful to the interests of man (p. 31), on the whole they have tendencies in that direction. Among the harmful activities of the nestlings may be listed their destruction of

ground beetles (not all of which are useful, however) and spiders, which together totaled 4.44 percent of the food. Neutral in character, or about equally divided between beneficial and harmful in effect, is the nestlings' feeding on miscellaneous beetles, bugs, hymenopterans, miscellaneous insects, and other animal matter, which in the aggregate comprised 4.48 percent of the diet.

Consideration of the vegetable food of the nestlings again brings up the perplexing attempt to separate those parts of feed and various grains whose consumption indicates a direct loss to man from those whose consumption implies simply the use of waste material. In the case of oats, corn, and certain other grain the quantity eaten was so small that feeding on these grains has been classified among the neutral activities. With feed, wheat, and other vegetable matter, a division has been made into neutral and harmful consumption in proportions essentially the same as those adopted for the adults. In its feeding on a few weed seeds the nestling has been given credit for good work; its consumption of mast and wild fruit has been considered neutral in effect; and the toll it takes of cultivated fruit and vegetables has been charged against the bird. In estimating, therefore, the effects of the nestlings' vegetable-feeding activities, the consumption of 0.17 percent of their food must be considered creditable; of 7.85 percent, neutral; and of 23.85 percent, harmful.

A summary of both the animal and the vegetable parts of the diet reveals that consumption of 59.38 percent of the nestlings' food is beneficial to man; of 12.33 percent, neutral in effect; and of 28.29 percent, harmful. Although such abstract percentages, because of the varying degrees of value held by the component parts, cannot be weighed one against the other to determine the status of a species, there can be no question that the nestling English sparrow does more good than harm. During its 10 or more days in the nest, it has good habits that compare favorably with some of the beneficial native species. The diet includes many of the outstanding insect pests with which the farmer has to contend, and the toll the young bird exacts through its feeding on poultry food and other grain is a reasonable charge for good services rendered. Although this period of usefulness in the life history of the sparrow is brought about by the normal food requirements of the young, it must not be overlooked that the adults select the nestlings' food and perform all the labor of assembling it and feeding it to the young.

EFFECT OF LOCAL CONDITIONS

Studies of the food habits of birds aim to determine the economic status of species by appraising the merits and shortcomings of a great number of individuals. Naturally, the larger the series of stomachs examined, the more extensive the field notes taken, and the more carefully conducted the investigation, the more trustworthy will be the results. The greater the quantity of material available for study, the less will be that element of distortion produced by unusual local circumstances or conditions and the more nearly will the conclusions reached approach what might be termed an "average" for the species.

Admission of the need for extensive material implies that the conclusions as to food habits obtained from the study of a small group of birds are largely dependent on the circumstances connected with

their collection. The influence of local conditions is a dominant one despite the basic food preferences possessed by a species. One may determine the general economic tendency of a species by averaging the activities of many individuals, but the individual bird whose food habits actually conform to the standards of its race is indeed a rarity. As for the "average" English sparrow, it, like the mythical "average" man, is in reality nonexistent.

To demonstrate the influence of locality or transitory conditions on the food taken by the English sparrow a segregation has been made of 2,327 stomachs of nestlings collected at four points: Autaugaville, Ala.; Independence, Iowa; Onaga, Kans.; and the Salt Lake Valley, Utah. Nestlings rather than adults were used because their diet is wider in range and is susceptible to change by surrounding conditions. The number of stomachs used—672, 229, 375, and 1,051, respectively, having been collected in the four localities—is ample to give a true index to food preferences. The birds ranged in age from newly hatched young to those about to leave the nest and may be considered representative of the entire nestling period. At Autaugaville, rural conditions prevailed, though some of the birds were collected in the vicinity of lumberyards, where the parents had access to many bark and wood-boring beetles not otherwise easily obtained. At Independence, the nestlings were obtained in the urban environment of a small town, many of them from nests in trees along the streets. At Onaga, collections were made largely in rural sections, at a time when grasshoppers were abundant. In the Salt Lake Valley, also, the birds were taken in the country, during a period (1911 and 1912) when the alfalfa weevil was inflicting serious damage on the principal forage crop.

The information gained from this segregation of material is given in condensed form in table 7 and presented graphically in figure 6. The food items have been classified under seven headings—weevils, other beetles, grasshoppers, caterpillars, other insects, spiders and miscellaneous animal matter, and vegetable food (mainly feed), but comments on the food are restricted to the economically more important items.

TABLE 7.—*Food items, by volume percentages, of 2,327 nestling English sparrows collected in 4 localities, showing influence of local conditions*

Food items	Autaugaville, Ala.	Independence, Iowa	Onaga, Kans.	Salt Lake Valley, Utah
Stomachs used	*Number* 672	*Number* 229	*Number* 375	*Number* 1,051
Animal food:	*Percent*	*Percent*	*Percent*	*Percent*
Weevils	[1] 10.66	5.78	0.34	[2] 29.67
Other beetles [3]	10.02	15.87	1.05	8.19
Grasshoppers [4]	30.81	3.68	84.09	3.48
Caterpillars [5]	6.91	25.55	5.29	14.49
Other insects [6]	6.19	5.78	1.31	6.76
Spiders and miscellaneous animal matter [7]	1.87	.32	1.02	2.73
Total	66.46	56.98	93.10	65.32
Vegetable food (mainly feed)	33.54	43.02	6.90	34.68

[1] Largely adult Scolytidae and the pine weevils *Pachylobius picivorous* and *Hylobius pales*.
[2] Almost entirely alfalfa weevil (*Hypera postica*) larvae.
[3] Scarabaeidae, Carabidae, Chrysomelidae, Elateridae, and others.
[4] Acrididae mainly, with small quantities of Gryllidae and Tettigoniidae.
[5] A few adult Lepidoptera also.
[6] Hemiptera, Diptera, Hymenoptera, and others.
[7] Annulata, Mollusca, and animal garbage.

At Autaugaville, grasshoppers and crickets formed the dominant insect food of the nestlings. They were supplemented with scolytid and other weevils, other beetles (including many wood-boring forms), and caterpillars. The vegetable food was largely feed mixed with a few weed seeds. The diversified character and quantity of food that entered the diet of some of these Alabama nestlings is shown in figure 7 (p. 52), a facsimile of a stomach-examination card prepared in this study. The stomach, which was well filled, contained at least 39 specifically different items.

The material from Independence revealed the highest degree of caterpillar destruction recorded for any of the localities. More than

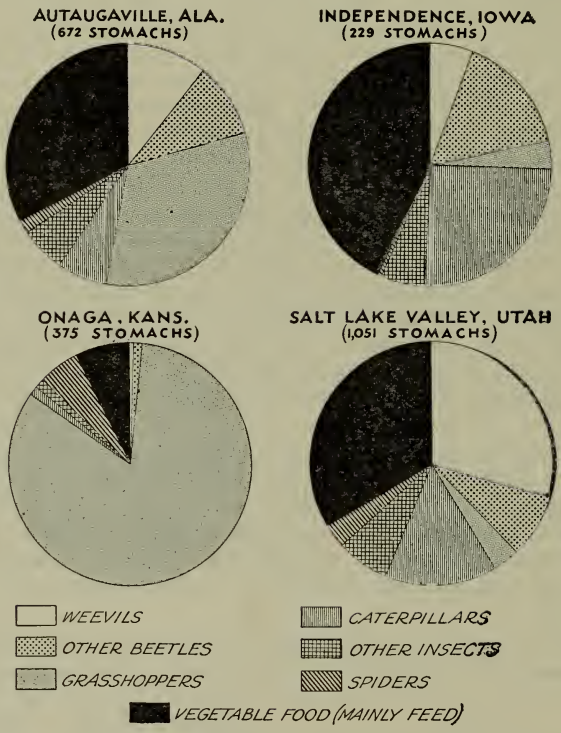


FIGURE 6.—Diagram showing the effect of locality on the food of the nestling English sparrow. This information is presented in statistical form in table 7.

a fourth of the young birds' food was obtained from lepidopterous larvae that were captured by the adults, probably about shade trees or garden crops. May beetles (*Phyllophaga*), picked up on lawns and city streets where many of them perish after being attracted to lights, helped swell the total of other beetles. The small quantity of grasshoppers taken also reflects the urban character of the environment in which these birds were collected. An increase in the vegetable food over that recorded for the other points gave evidence of frequent visits by foraging parents to poultry yards, feed bins, or city streets. As a whole the food of this group of nestlings was the most distinctly urban in character of any of the four discussed.

Grasshopper-infested farm fields were the main source of food of the nestling sparrows collected at Onaga. So dominant and accept-

able was this supply of insect food that grasshoppers not only formed the largest insect item in the diet of this group of birds but also comprised a greater proportion of the entire food than did the insects of all kinds eaten by the nestlings in any of the other three groups. No other single item so dominated the food of any of the other nestling groups. To say that the nestlings collected at Onaga were practically raised on grasshoppers is not far from the truth, the only other insects of importance eaten being caterpillars. The vegetable part of the diet was very much less than that of the nestlings in any of the other three groups, owing no doubt to the prevalence of grasshoppers.

In the material from the Salt Lake Valley is reflected the abundance of the alfalfa weevil, as practically all of the weevil food recorded consisted of this insect in one or another of its stages. The quantity of weevil food taken was nearly treble that eaten by the nestlings from Autaugaville, where unusual opportunity was presented for capturing timber-infesting forms (Scolytidae), and it represents the extreme in weevil consumption by any of the four groups. Caterpillars, many of which were found in the same fields with weevil larvae, were the next most important insect item. Other beetles and other insects were taken in quantities indicating a normal abundance of such forms. The vegetable food compared favorably in bulk with that eaten by the nestlings from Autaugaville and Independence but was characterized by a preponderance of wheat, the most extensively raised cereal in the Salt Lake Valley.

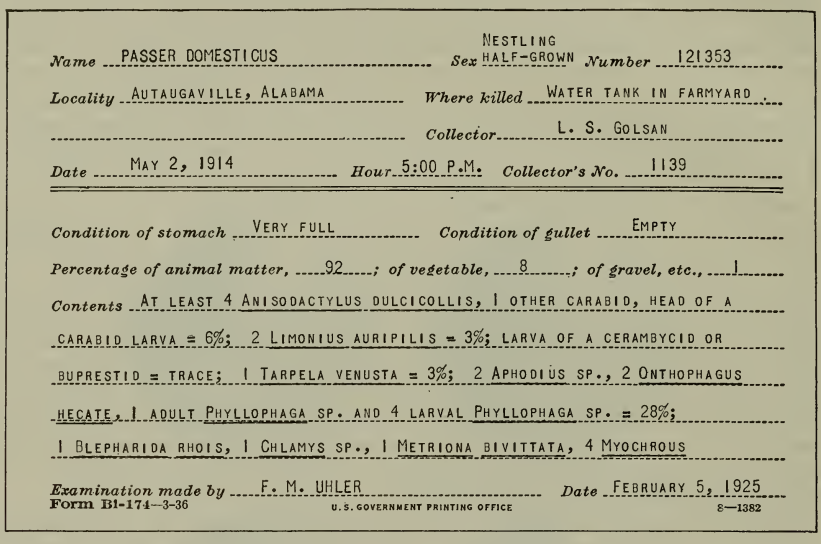
Other groups of stomachs could be analyzed to show the influence of local or transitory conditions on the food habits and economic status of the English sparrow. To show striking differences they need not be from localities hundreds of miles apart. Variations in the ecological complex on neighboring farms may be enough to cause great variation in the status of the bird locally and call for different treatment at the hands of man. On one farm ample nesting sites and an abundance of food in the shape of grain or mixed feed scattered carelessly about the barnyard may attract these birds in numbers great enough to make them a distinct economic liability. On another, new and well-built buildings, screened feeding runways for chickens, and careful and neat handling of feed may be decidedly unattractive to the bird. In areas infested with insects acceptable to it, the English sparrow has shown ability to render commendable control service; but in areas where such insects are absent, it is apt to take field and garden products and poultry feed instead. Where English sparrows obtain their ration of grain largely from city streets or waste material about mills, their harmful traits may not be apparent; where they take it from standing or shocked crops or from poultry feed, the opposite is true.

Collinge has ably shown that in England the economic status of the bird in agricultural and suburban sections differs from that in fruit-growing areas (*7, pp. 99–100*). He concluded that the English sparrow still requires very drastic reduction in the former and that—

> to a less extent, perhaps, it requires reducing in number in fruit-growing districts, and were this carefully carried out annually, after the nesting period, the good done during that season might probably compensate for the harm occasioned during the remainder of the year.

It follows, therefore, that even with species whose potentialities for harm may be greater than those for good, the matter of local influence

deserves consideration. Unless the species has an effect that is regularly and seriously injurious, to advocate indiscriminate destruction is as fallacious from an economic standpoint as to urge absolute protection for forms that may locally or periodically become destructive.



Name PASSER DOMESTICUS *Sex* NESTLING HALF-GROWN *Number* 121353

Locality AUTAUGAVILLE, ALABAMA *Where killed* WATER TANK IN FARMYARD

Collector L. S. GOLSAN

Date MAY 2, 1914 *Hour* 5:00 P.M. *Collector's No.* 1139

Condition of stomach VERY FULL *Condition of gullet* EMPTY

Percentage of animal matter, 92 *; of vegetable,* 8 *; of gravel, etc.,* 1

Contents AT LEAST 4 ANISODACTYLUS DULCICOLLIS, 1 OTHER CARABID, HEAD OF A CARABID LARVA = 6%; 2 LIMONIUS AURIPILIS = 3%; LARVA OF A CERAMBYCID OR BUPRESTID = TRACE; 1 TARPELA VENUSTA = 3%; 2 APHODIUS SP., 2 ONTHOPHAGUS HECATE, 1 ADULT PHYLLOPHAGA SP. AND 4 LARVAL PHYLLOPHAGA SP. = 28%; 1 BLEPHARIDA RHOIS, 1 CHLAMYS SP., 1 METRIONA BIVITTATA, 4 MYOCHROUS DENTICOLLIS, 3 PSYLLIODES CONVEXIOR, 2 SYSTENA TAENIATA = 5%; AT LEAST 5 TANYMECUS CONFERTUS, 1 SITONA FLAVESCENS, 1 HYPERODES SP., 12 SPHENOPHORUS DESTRUCTOR, 1 PACHYLOBIUS PICIVORUS, 1 HYLOBIUS PALES, 3 SITOPHILUS ORYZAE, 1 CEUTORHYNCHUS NEGLECTUS, 14 BARIS SP., 1 SCOLYTID = 29%; FRAGMENT OF UNKNOWN BEETLE = TRACE; 3 GRYLLUS SP., 2 ACRIDIDAE = 10%; 1 HYMENARCYS SP., 1 HOMAEMUS SP., AT LEAST 2 THYREOCORIS SP., 1 DRAECULACEPHALA RETICULATA, 1 STICTOCEPHALA SP. = 2%; 1 CATERPILLAR = 1%; HYMENOPTERON = TRACE; 1 LYCOSID SPIDER AND 1 OTHER SPIDER (? PHIDIPPUS) = 5%; CRACKED CORN AND 8 KERNELS OF OATS (CHICKEN FEED) = 7%; VEGETABLE FIBERS (DEBRIS) = 1%.

Examination made by F. M. UHLER *Date* FEBRUARY 5, 1925

Form B1-174—3-36 U.S. GOVERNMENT PRINTING OFFICE 8—1382

#121353

FIGURE 7.—Facsimile, front and back, of a stomach-examination card, showing the extensive and varied diet of a half-grown nestling English sparrow collected in Alabama in May. The percentage at the end of each group of items indicates its proportion by bulk of the total stomach contents.

QUANTITY OF FOOD EATEN

From the very beginning of economic ornithology investigators have interested themselves in the quantity of food eaten by birds. It is natural that the sequel to learning what a bird eats should be the

computation of how much it eats. As early as 1883–84 Schleh's pioneer works on the food of *Passer domesticus* in Germany (*36*) contained tables showing, among other things, the weight of many stomach contents of both old and young birds. Not only did Schleh compile data on the weight of the birds' food, but by comparing the weight of the food of nestlings with the weight of growing birds he revealed interesting facts concerning the relative quantity of food taken by nestlings at successive periods in their development (*36, p. 800*). Whereas the weight of the fresh stomach contents of day-old young was only 3.24 percent of the weight of the bird, that of young 2 to 3 days old was nearly 11 percent. From this age on the ratio of the weight of the fresh stomach contents to the weight of the bird decreased rather uniformly until the bird left the nest, when the stomach contents formed only 1.7 percent of the bird's weight. It must be remembered, however, that during this period the nestlings had gained rapidly in weight, so that the acutal decrease in the weight of the food as the bird grew older was not so pronounced as the ratio indicated.

In the course of the examination of material for the present bulletin, weights of what appeared to be representative stomach contents of both adult and nestling birds were recorded from time to time; also weights of a limited number of abnormally small or large stomach contents in order that an idea of the extremes in weight might be had. The weight was of the food found in the gizzardlike stomach after all sand and other grinding material had been removed by siphoning. It included none of the food in the upper esophagus or gullet (commonly called crop). Separate weighings of food found in the gullet revealed in some instances quantities several times greater than those found in the stomach proper. This food, in the case of adults, consisted mainly of freshly swallowed grain, which in one specimen weighed 2,370 mg., about a twelfth of the weight of the bird itself. It is apparent, therefore, that although considerable grain may be taken at a single meal, the stomach proper, owing to its small size, must assimilate this little by little from the supply in the gullet.

The average weight of the damp stomach contents of 23 adult English sparrows was about 306 mg., with the least weight 175 and the greatest 550 mg. Schleh (*36*) computed the weight of the stomach contents of the adult sparrow to be about 10 mg. greater than this, but his records included the weight of sand and other grinding material.

The average weight of the damp food contained in the stomachs of 69 nestlings of various ages was 873.8 mg., or more than 2.8 times that recorded for the adults. These weights ranged from 145 mg., for the food of a day-old nestling, to 2,375 mg. for the remains of 18 grasshoppers eaten by a bird one-third grown.

These weights of stomach contents may be presented in more understandable form by expressing them in terms of kernels of wheat for the adult birds and of grasshoppers for the more insectivorous nestlings. The average weight of 73 kernels of wheat freshly removed from the stomachs of English sparrows was 48.4 mg., which would make the average weight of the stomach contents of the 23 adult sparrows—306 mg.—equivalent to the weight of 6.3 kernels of wheat. This estimate has been substantiated by the records of actual stomach analyses, which show that the number of wheat kernels present in a single adult English sparrow stomach usually ranged between 5 and 15, with 30 the largest number found, although in that instance

some of the kernels were in an advanced stage of digestion. The weight of the average adult grasshopper of moderate size (*Melanoplus mexicanus* or *M. femur-rubrum*) is about 325 mg., so that the average weight of the stomach contents of the 69 nestlings—873.8 mg.—would be equivalent to the weight of about 2.7 such grasshoppers.

All the foregoing applies simply to the quantity of food contained in the stomach at any one time, and, although the given data aid in visualizing the momentary capacity of the birds, they do not tell the entire story. Were it possible to compute the frequency with which the English sparrow's stomach is emptied and replenished—a process that is in fact continuous—the daily food consumption could be determined. Unfortunately, this unseen process does not readily lend itself to observation, so that other methods must be used to complete the picture.

Forbush (*16*), Weed and Dearborn (*41*), and others have contributed much valuable information concerning the quantity of food required to develop nestlings and to maintain the physical fitness of adult passerine birds. These observations cover a wide range of species, including such common forms as crows, robins, cedar waxwings, song sparrows, goldfinches, and vireos. In some instances the daily rations of captive birds were carefully weighed; in others the daily food brought to wild nestlings by their parents was noted and the bulk or weight computed. Though the results obtained are presented in a variety of forms and usually consist of notes dealing with short periods of intensive observation, certain conservative and generalized deductions may be made that would appear applicable to the English sparrow. When such experimental work has shown that adult birds under the inactive conditions of confinement may daily take food equivalent to a quarter of their own weight and nestlings twice that relative quantity, it does not seem unreasonable to assume that the more active wild birds will take similar quantities as a minimum whenever available.

Schleh (*36, pp. 789–812*) found the average weight of 32 adult English sparrows to be 30.28 gm. A fourth of this, 7.57 gm, may easily be expressed in terms of kernels of wheat. The weight of 200 kernels of average grade wheat (air dried) is approximately 7.5 gm., which is nearly equivalent to the weight of the estimated daily ration. Extending this computation to cover the yearly cycle of the adult sparrow it is found that the annual food would approximate a weight of 6 pounds, or, if it were expressed in terms of wheat, about one-tenth of the standard bushel. It must be emphasized, however, that this somewhat hypothetical estimated weight of the annual food in reality applies to items that are beneficial, neutral, and harmful to the interests of man. *It is not an estimate of the annual consumption of wheat by an English sparrow.* Furthermore, it represents optimum conditions and so does not take into account any periods of food scarcity, to which all birds are at times subject.

According to Schleh the half-grown or average nestling weighs approximately 20 gm. Assuming that the nestling English sparrow daily consumed food weighing one-half its weight, or 10 gm., and that its nestling life lasted 10 days, a total of 100 gm. of food would be given to each nestling. This is equivalent to the weight of more than 300 medium-sized grasshoppers.

Inasmuch as the quantity of food eaten by a bird is dependent somewhat on the rapidity of the bird's digestive process, the following notes concerning the feeding of juvenile English sparrows on the wheat gall nematode (*Tylenchus tritici*) are pertinent. In the spring of 1921 the writer made a study with the particular object of learning to what extent the English sparrow may be instrumental in distributing the eggs or larvae of this nematode through its feces. Long a serious pest to wheat in Europe and in recent years a matter of concern in this country also, the nematode manifests itself most strikingly in the wheat heads, where small, dark-colored galls of the same general shape as wheat kernels but containing adults, eggs, and larvae of the nematode form in place of normal grains. In heavy infestations this results in a pronounced reduction in the wheat yield. The galls are easily mistaken for wheat kernels and may be eaten by English sparrows.

At the time the experiments were conducted the galls were well formed and contained usually one to several adult nematodes, several thousand eggs, and a few newly hatched larvae. The adults were dormant and doubtless had lived their span of life; the eggs were extremely small—one three-hundredths of an inch long; and the larvae were only about one-thirtieth of an inch long. The English sparrows used were all juveniles, trapped and kept in confinement so that careful note could be taken of their digestive processes as revealed from an examination of their feces and alimentary tracts.

In one series of experiments minute examination of the feces of a number of birds that had forcibly been fed nematode galls revealed that the eggs and larvae were voided during a period extending from 1 hour 30 minutes to 3 hours 50 minutes after feeding. Inasmuch as many of the larvae and eggs were partially assimilated in the process of digestion, it is likely that minute fragments were present in feces voided earlier than the period indicated.

Another series of experiments gave indication of this very thing and showed in a startling manner the rapidity with which some food elements may pass through the digestive tract. Each of 9 juvenile sparrows was given a meal of 10 nematode galls at intervals of 10 minutes, and 10 minutes after the last bird had been fed, all the birds were killed. There was thus obtained a series of 9 sparrows that had lived for graduated periods of 10 to 90 minutes after having fed on nematode galls. Subsequently the contents of the alimentary tract of each bird were carefully examined, the intestines being divided into 16 sections of equal length and each portion subjected to close scrutiny. It was found that the stomach of the last bird of the series, the one that had been fed galls 10 minutes before its death, contained crushed gall remains that showed little evidence of digestive action. The intestines, however, contained a few dead larvae at a point six-sixteenths of the distance from the stomach to the vent, numerous dead larvae at nine-sixteenths of the distance, others at thirteen-sixteenths of the distance, and several in the very last segment of the intestines. These were about to be voided. They had passed through the entire alimentary canal in a period of 10 minutes, although the bulk of the galls still remained in the stomach.

The possibility of these sparrows transmitting alive the eggs and larvae was definitely established in a limited number of cases, but in view of the ease with which infected seeds or chaff, or even desiccated

earth picked up on the feet of men and animals may distribute nematodes, or the wind scatter them, the English sparrow must be looked upon as one of the minor distributing agencies.

Experiments in Europe likewise have demonstrated the possibility of English sparrows, as well as certain other birds, scattering the living eggs and larvae of this nematode (*32*).

SUMMARY OF FOOD HABITS OF THE SPECIES

This investigation has shown that the adult English sparrow and the young that have left the nest do good through their destruction of a limited quantity of injurious insects and a greater quantity of weed seeds. The parent bird also has the ability to detect insect outbreaks and, impelled largely by the food demands of its young, to act as an agent in their suppression. On the other hand it has revealed that the adult takes a heavy annual toll from feed, various grains, and other cultivated crops. Thus it has shown that despite the adult English sparrow's commendable work under certain conditions its potentialities for harm are certainly greater than those for good.

The status of the nestling English sparrow is quite different. In this study nearly six-tenths of its food consisted of injurious insects, whereas less than three-tenths was composed of feed and other products of husbandry and beneficial insects. In its food are included many of the most destructive pests, and during insect outbreaks, through its food requirements, it contributes services as effective in pest suppression as those of many native birds. Were the food habits of the nestling retained throughout the bird's life, there is no question that the English sparrow would be acclaimed generally as one of the most valuable birds. Unfortunately, however, this highly commendable status lasts only for the short span of 10 or 12 days, after which the bird rapidly becomes highly granivorous.

An evaluation of the food habits of the species as a whole therefore resolves itself into a problem of balancing the beneficial traits of the nestlings over a short period of time against the objectionable ones of the adults covering most of their lives. A mathematical approach will assist in visualizing a comparison of the two during any one year and in making deductions therefrom.

The nestling period of the English sparrow lasts about 10 days. The number of young put on the wing, under favorable conditions, may average 4 to the brood; and 4 broods a season for each pair of adults is a generous estimate. In the aggregate this represents 160 nestling days a year for each family. Over a similar period the 2 parent birds account for 730 days of feeding. Ignoring the fact that the successive broods of fully fledged young exert an economic influence closely similar to that of their parents, it may be stated that the ratio of the generally beneficial work of the nestlings to the largely injurious tendencies of the adults, judged on the basis of the time element involved, is something in excess of 1 to 4.5 or, expressed differently, about 18 percent of the feeding activities of the species are the commendable ones of the nestlings, whereas more than 82 percent are those of the adults, which this study has shown are often detrimental to agriculture. Although there are other factors that may alter the situation somewhat, as, for instance, the fact that, bird for bird, the nestling eats more than the adult (p. 53), that fledged young possess food habits

closely similar to those of the adults, and that not all mature birds raise young, on the whole, the relative extent of the feeding activities of old and young as expressed may be considered as approximating the truth.

This being the case, decision rests in determining whether a species having feeding activities more than four-fifths of which must be construed as at least potentially injurious is to be considered an asset or a liability to man. It would seem that although the meritorious work of the nestlings has raised considerably the standard of the English sparrow's economic worth, it does not offset the weight of evidence against the species. This, be it remembered, is a conclusion applicable to that situation or set of conditions that may be considered "average." There are circumstances and environments in which the appraisal given is by no means so severe an indictment as demanded, and conversely there are others in which the criticism must be tempered or even changed to words of praise.

Expressed somewhat differently, it may be said that the English sparrow as a species must constantly be looked upon with suspicion. Its misdeeds frequently call for measures of control; but it must not be forgotten that nature in its complexity may locally present the exception rather than the rule. Indiscriminate and unlimited control of any creature having even a few redeeming qualities may easily r ustrate the basic object sought.

DISTRIBUTION OF DISEASES, PARASITES, AND INSECT PESTS

The abundance of the English sparrow and its close association with agriculture long have aroused suspicion regarding the bird's role in the transmission of livestock and poultry diseases and parasites, as well as certain insect pests of crops. Although the present study did not include investigative work on these aspects of the sparrow's relationship to man and has contributed nothing new on the subject, with the exception of the observations made on the transmission of the wheat gall nematode discussed on page 55, brief mention will be made of the more important and substantiated accusations of this character.

The intimate relation of the English sparrow to domestic poultry, both in feeding and nesting activities, makes it a likely vector of poultry diseases and parasites. Examinations by Smith and Smillie (*39*) have shown that—

> of 54 sparrows examined in or near Princeton, coccidia were found in 43, or 80 per cent. Most of the negative cases were encountered in November and December. In the summer and fall practically all were infected. These figures agree closely with Hadley's, who found 79 per cent infected from May to December.

The evidence regarding the sparrow's role as a vector of fowl typhoid and tuberculosis is less clear, although those who have investigated the transmission of these diseases have so strongly suspected the bird that they have directed their studies toward the determination of the facts. Even less certain is the evidence concerning the possible dissemination by the English sparrow of hog cholera and the foot-and-mouth disease of livestock. All that can be said is that, if these diseases are readily transferable through the agency of birds, the English sparrow, because of its close association with domestic animals, would be among the most likely carriers.

As a distributor of objectionable parasites, the English sparrow has attracted attention through its relation to the common poultry lice and mites. Ewing, who has definitely established that the bird frequently harbors and is the host of the poultry pest *Dermanyssus gallinae*, stated (*13, p. 340*):

> Sparrows become repeatedly inoculated with these mites from the chicken roosts because of their habit of lining their nests with poultry feathers, many of which have lice upon them, shaken off the infested chickens when wallowing in the dust, etc.
>
> Sparrow nests when built in the vicinity of chicken roosts, upon becoming deserted may leave hundreds or thousands of lice, to seek food and shelter elsewhere. These individuals being very active on their feet and able to sustain themselves for several days away from a host may travel considerable distances and infest new chicken-houses.
>
> On August 11 a rather large and recently deserted nest of the English sparrow was found in an old wagon shed entirely separated from any adjoining buildings. This nest was procured and upon examination was found to harbor hundreds, even thousands of the chicken mites. Every feather found in the interior of the nest had scores of mites upon it. A medium sized feather which appeared to be only moderately infested proved to have 72 individuals upon it. The number of feathers thus used in the construction of the nest was at least more than 200. I estimated them at 250. Multiplying this number by the number of individuals found on a single feather would give the total number of 18,000 individuals of the poultry mite found in only a single nest of the sparrow.

In common with all other birds that frequent orchards, the English sparrow has been accused, though not actually convicted, of transporting scale insects. The minute larval forms of the San José and some other scales are mobile creatures that can readily crawl onto the feet of a perching bird and thus be transported to uninfested areas, even at considerable distances, where they may be the source of new colonies. The practice of horticultural inspectors, acquired through long experience, of searching in the vicinity of birds' nests for possible new colonies of scale insects affords strong circumstantial evidence of this method of dispersal. The sedentary nature of the English sparrow, however, would tend to make the bird's capabilities in this direction less than those of the more mobile species. In like manner the sparrow must be appraised as a potential distributor of such maladies of plants as the pear and chestnut blights. Although birds of all kinds are possible disseminators of such diseases, a multitude of other living organisms also, ranging from man himself to innumerable insects, and even wind and rain, must be considered potential carriers. Until further study reveals reasons to the contrary, therefore, it appears unwise to attempt the curbing of such pests and maladies through the control of one of a host of possible carriers, even though that one be the generally unpopular English sparrow.

Of a somewhat different nature is the possible dispersal by the English sparrow (and unfortunately by other birds as well) of the insect eggs it has eaten. Such lepidopterous insect eggs as those of the gipsy, brown-tail, or tussock moths, which possess a hard shell resistant to digestive action, may occasionally be distributed in this manner. That such a method of dispersal is a possibility has been demonstrated in experiments in which 142 of 356 gypsy moth eggs fed to 3 English sparrows passed through the intestinal tract intact and 7 subsequently hatched (*8, p. 344*).

COMPETITION WITH NATIVE BIRDS

Wherever the English sparrow has been introduced, its relation to small native species has been a matter of concern. In the opinion of many of the earlier observers of the bird in this country, its competition with other species for food, shelter, and nesting sites constituted a more serious indictment than its destruction of products of husbandry. There were and still are many who lament the course of events since the middle of the last century, during which they have witnessed the disappearance of attractive native species from our rapidly growing metropolitan sections and have seen their places filled by the ubiquitous English sparrow. Even in rural sections, which are less affected than urban communities by the advance of civilization, this substitution has been noted and many instances of direct combat between the English sparrow and native birds have been recorded by trustworthy observers.

In the course of Barrows' study of the English sparrow (*2*), an idea of the bird's relation to native species was obtained from replies to letters of inquiry sent to persons who had had experience with it. From these early reports 70 species of native birds were listed as molested by the English sparrow. The sufferer most frequently mentioned was the bluebird; then followed, in order, the purple martin, the robin, wrens (probably all house wrens), and swallows of 6 species. Less frequently, the chipping sparrow, mockingbird, Baltimore oriole, and goldfinch were reported attacked. More than half the complaints concerned the aggressions of sparrows against martins, swallows, wrens, and bluebirds, whose nest or nest sites were sought by the sparrow. Barrows' deductions from these reports were summarized as follows: (*2*, *p. 95*):

> There seems, then, to be no possible escape from the conclusion that the Sparrow exercises an important and most harmful influence on our native birds. It is not claimed that in all cases where native birds have become less abundant, or have entirely disappeared from town or farm, the Sparrow is the cause. On the contrary, we know positively that there have been marked changes in the numbers and kinds of birds visiting certain districts, under such circumstances that it is impossible to attribute these changes to the influence of the Sparrow. The settlement of a country frequently causes great changes in its bird life. The rapid growth of towns and cities, without a corresponding increase in parks and gardens, has done much to diminish the number of birds. * * * But the fact that *all* disappearances of native birds from town or country can not be charged to the Sparrow in no way lessens its responsibility for such changes as it unquestionably has caused.

Thus are expressed not only the conclusions of an able economic ornithologist but also what might be considered the consensus of ornithological opinion of that time. True there were some who differed with Professor Barrows, but the differences of opinion often were of degree and not of fact and reflected to a great extent the varied effect of local environment rather than divergent ideas concerning the merits of the sparrow itself.

These conclusions were based on the conduct of the English sparrow for about the first 40 years of its existence in this country, during which period the few score imported birds had increased to an immense breeding population whose range comprised about half the area of this country. At the time the deductions were made the species was distinctly in the ascendancy and the crest of its peak of abundance had started to move westward. Where it had not already become

the most abundant urban or suburban bird east of the Mississippi River, it was rapidly becoming so. This new avian competitor, capable of thriving in close proximity to man, had been thrust with startling suddenness into a biologic complex already greatly disturbed. That it should prove to be a deciding factor in the case of certain other species of birds in that critical period seems indeed a logical result.

Since that time many changes have occurred. The English sparrow has extended its range practically to the limits of the continental portion of the United States (excepting Alaska). Over much of the eastern part of the country it has been a more or less stabilized biologic factor for more than a quarter of a century, and in some sections it has actually decreased in numbers. A status of abundance comparable with that which brought upon the bird such widespread condemnation earlier in its career still exists in parts of the Middle West, the Salt Lake Valley, and other western points. It is only in some parts of the far West and in areas less suited to it that the English sparrow is still a pioneer. The development of our great metropolitan sections has so altered conditions that habitation by certain of the former native avian residents is now impossible, regardless of the sparrow. On the other hand, the general movement for bird protection has brought such fruitful returns that in suburban and rural sections some of these species now enjoy advantages they did not possess 50 years ago.

In 1915 Forbush (*17, p. 6*), commenting on the sparrow in Massachusetts, said:

> I have seen it evict all species that nest in bird houses. Where it once gets a foothold in the bird houses it drives out all other bird tenants in the end. It destroys their nests, eggs and young, and it has been known to destroy wantonly the eggs, nests and young of many birds that do not nest in boxes. It appropriates the nests of swallows, robins, warblers, and other birds, and has driven out swallows, martins and wrens from large areas. The cliff swallows or eaves swallows and house wrens formerly common in many parts of Massachusetts are rare now in a large part of the State, and this can be attributed directly to persecution by the sparrow.

In 1918 that dean of American ornithologists, the late Robert Ridgway, wrote from Illinois to the Biological Survey that—

> the Cliff Swallow has been completely and the Barn Swallow practically extirpated in the "Middle West" (this portion at least) by the House Sparrow. I have not seen a Cliff Swallow for many years, and for the past three or four years have not seen a Barn Swallow's nest. The barns, both in the country as in towns, are now inhabited only by *Passer domesticus*, which infests all outbuildings in large numbers. I am very sure that it is no exaggeration to say that this imported pest outnumbers all native Passeres combined in this agricultural section of the Mississippi Valley.

Although the present study has produced nothing of a statistical nature to substantiate the contention that the English sparrow is at present by no means the aggressor against native species that it was pictured by early commentators, there is evidence that it is not, at least throughout the East. Current ornithological literature and the public press, though generally condemning the species, contain fewer notes depicting specific instances of vandalism. The same can be said of the correspondence coming to the Biological Survey during recent years. The writer's own observations and those of others with whom the matter has been discussed lend further credence to this belief. No doubt this has been brought about partly at least by

the departure from the scene of former competitors—the much-cherished native species—but even where the foreigner meets the native birds today on common ground, observers have noted on many occasions a certain docility or even timidity not evident in the sparrow's early career in this country.

However hopeful and refreshing such signs may be, they cannot, with the lack of more specific knowledge, serve to absolve the English sparrow completely of blame. Despite signs of improvement it still has much of its past to live down. One still finds instances of vandalism comparable with those of the early days, and when these occur the bird should be judged accordingly.

The relation between the English sparrow and native birds is a subject well worth intensive study over a period of years—a project that unfortunately was not possible in connection with the present study. Until such an investigation has been made, final decision on the subject will have to be withheld.

FACTORS CONTROLLING ABUNDANCE

NATURAL CONTROL

THE ELEMENTS

The indiscriminately destructive powers of the elements as manifested in storms accompanied by rain, hail, or heavy snowfall often claim English sparrows as victims. High mortality may occur when sudden storms arise at night, overtaking the birds roosting in exposed trees or even in the partial protection of vines on the sides of buildings. Death may be due to a thorough drenching and chilling as well as to sheer exhaustion. The following extract from an account by L. C. Whitehead, of the Biological Survey, describes the destructiveness of a hailstorm to the sparrow population of Marfa, Tex., in October 1923:

> The hail storm was accompanied by a severe wind and was followed by a marked drop in temperature. * * * It lasted about three-quarters of an hour and the sleet lay on the ground to the depth of about three inches. * * * The sparrows, driven from other perches, stayed their forced flight with the wind in the outer row of trees, there to be beaten out by the hail. Approximately 5 bushels of dead sparrows were gathered from the surface of the sleet covering the ground inside the park, an area 600 feet long and 100 feet wide. * * * With the melting of the sleet as many birds again were reported to have been found upon the ground.

Heavy snowfall over extensive areas may be even more destructive. In northern cities where English sparrows are dependent largely on the streets for their food, prolonged snowfall may practically wipe out local flocks through starvation.

PREDATORY BIRDS

Despite the fact that English sparrows obtain a certain degree of protection against predatory birds by reason of their close association with human activities, a number of birds feed upon them. Stomach examinations in the laboratory of the Biological Survey have revealed this trait on the part of Cooper's, sharp-shinned, red-shouldered, Swainson's, marsh, pigeon, and sparrow hawks, snowy and screech owls, and northern and white-rumped shrikes. Of these birds, Cooper's and sharp-shinned hawks, screech owls, and northern shrikes probably are the most effective controlling agents.

Field observations have disclosed a number of other avian enemies of the English sparrow. Both the purple and the bronzed grackles long have been recorded as being fond of the eggs and young, and the writer saw even a fully fledged sparrow fall victim to the vicious thrust of a grackle's bill when the two species were feeding side by side. In Washington, D. C., grackles formerly preyed on sparrow nests, and the larger fish crow in turn took toll from both grackles and sparrows. To one unaccustomed to the urban fish crows of Washington, the formerly common sight of these birds diligently searching for and pilfering sparrow nests beneath the eaves of buildings on the principal business streets was indeed unusual. The red-headed woodpecker also has been known to prey on English sparrows, especially when there is a controversy over nesting sites. The house wren, too, is a competitor for nesting sites and has been observed destroying English sparrow eggs. In recent years the European starling, now firmly established and generally distributed in the eastern United States, has proved itself an enemy of this sparrow, feeding both on the eggs and on the callow young. The close association of these two species with human habitation and the similarity of their nesting sites permit the aggressive starling to take full advantage of its opportunities, and in certain dooryards this avian immigrant has been known to take all the early eggs and young of the smaller and less aggressive English sparrow.

THE HOUSE CAT

Among mammals, the house cat, either feral or domesticated, is probably the most frequent destroyer of English sparrows. Young birds just learning to fly are common victims. Data compiled by Forbush (*18, pp. 74–75*) indicate that only the robin and bluebird are captured more frequently than the sparrow by the bird-killing cat. In the stomach of a feral house cat collected in Pennsylvania and examined in the Survey's laboratory the remains of an English sparrow formed a tenth of the food.

DISEASES AND PARASITES

Unseen or unnoticed agencies of control, possibly more potent than those plainly evident, exert a constant and powerful repressive influence on bird life. Among these are diseases and parasites, both internal and external, the effects of which are all too little understood. Who knows but that the real cause of the now generally recognized decrease in numbers of the English sparrow in the East may be one or more of these unseen factors rather than such evident ones as winter food shortage or adverse environmental changes?

A trematode parasite has been found prevalent among sparrows in this country and in Germany, and a study of it by Cole (*6*), who found that more than 31 percent of 64 young English sparrows examined at Madison, Wis., in June 1910 harbored this parasite, has given strong circumstantial evidence that it at times proves fatal to the birds. Other internal parasites, including nematodes and cestodes, infest the English sparrow, but little is known concerning their pathological significance. External parasites, particularly mites, infest the nests of sparrows and at times appear in such numbers as to lower materially the vitality of the birds or even kill them (*13*).

CONTROL BY MAN

Although man and the environmental changes that he has produced have been largely instrumental in the increase of the English sparrow population, man in turn has materially reduced the numbers of the bird locally through control campaigns. By the systematic destruction of nests and the elimination of nesting sites and by shooting, trapping, and poisoning, he has kept the sparrow within bounds in areas where it has become an economic liability. Ordinarily such campaigns of destruction are restricted to local communities, municipalities, or grain-raising rural sections in which the bird has thrived and become unduly numerous.[6]

CONCLUSIONS

This study was undertaken to determine the economic status of the English sparrow in this country. As a basis for this work 8,004 stomachs were examined, a larger number than ever before employed in the study of the food habits of a single species of bird. The information gained from that examination has been analyzed and deductions have been drawn. These are stated briefly in the following paragraphs.

Of the annual food of the adult English sparrow about one-fifth (19.64 percent) represents services beneficial to man; about one-fourth (24.78 percent), those neutral in effect; and the remainder, a little over half (55.58 percent), those injurious. The feeding on noxious insects (2.67 percent) and weed seeds (16.97 percent) represents the adult bird's meritorious work, whereas its harmful proclivities are centered largely in its consumption of chicken feed, grain of various kinds, and garden truck.

In marked contrast to the food of the adult is that of the nestling. Nearly three-fifths (59.38 percent) of its food reflects feeding habits beneficial to man; about an eighth (12.33 percent), those neutral in effect; and the remainder, well over a fourth (28.29 percent), those injurious. Practically all the nestling's beneficial work involves the destruction of injurious insects. Its harmful tendencies include its feeding on chicken feed, grain, and a few useful insects.

Despite the commendable food habits of the nestlings, however, and the fact that they outnumber the adults during the breeding season, their influence lasts individually for but a brief span of 10 or 12 days. In the final analysis the benefits accruing from the food habits of the nestlings do not appear to counterbalance the real and potential harm with which the adults must be charged.

This conclusion concerning food habits is applicable to those situations or conditions that may be considered average in character. There are circumstances and environments in which such an appraisal is too severe; and again there may be those in which the English sparrow, through excessive numbers, deserves even more emphatic condemnation and becomes a fit subject for control.

In addition to the unfavorable nature of its food habits, the adult English sparrow may be criticized on other grounds. It is known to be an agent in the transmission of certain poultry parasites and diseases. The charge that it has driven away beneficial native

[6] Methods of English sparrow control are given in U. S. Dept. Agr., Leaflet 61 (27) which may be had free on application to the Department.

species of birds, although not so frequently heard as in the early days of its spread, still persists where the bird is abundant or where it is encroaching on new areas. Less serious, but nevertheless real, objections are the unsightly appearance of the bulky straw nests, which are fire hazards as well, and the noisome chatter and dirt associated with the roosts.

It would have been better for the interests of American agriculture, as well as for the welfare of the native birds, had the English sparrow never been introduced; but now that it has long been established beyond the possibility of eradication, it must be dealt with accordingly. Control measures, though often called for, should always be limited to the needs of the occasion. The dictates of sound economy demand this; but it is well to restate one of the findings of this study, namely, that at times the English sparrow has been an aid in local insect suppression. There is likelihood that such conditions will again arise.

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