THE REGULATIVE ACTION OF BIRDS UPON INSECT OSCILLATIONS.

By S. A. FORBES.

Attention has already been repeatedly called in these studies to the fact (fundamental to this investigation) that the principal injuries due to insects are done by a few species, existing, for a time, in numbers far above the average, and soon to retire again to a much lower limit. As the number of a species which reach maturity is determined by the checks on its multiplication, it follows that these oscillating species are held in check by variable forces, and to the variations in these checks we must look for an explanation of their oscillations. On the other hand, we must expect to find that those insects whose numbers remain relatively constant from year to year are under the control of restraining influences of a much more uniform character than the preceding class.

Concerning the effects of birds upon insect life, and through this upon the interests of agriculture, there are therefore three questions to answer: —

1. Do birds originate any oscillations among the species of insects upon which they feed? That is, are their food habits ever so inconstant from year to year that species which are at one time principal elements of their food, are at other times neglected and allowed to multiply without restraint?

2. Do birds prevent or restrain any oscillations of insects now noxious, or capable of becoming so if permitted to increase more freely? That is, do they bring to bear upon any such species a constant pressure so great that those insects would increase unduly if this pressure were removed by the destruction of the birds?

3. Do they do anything to reduce existing oscillations of injurious insects? Do they sometimes vary their food habits so far as to neglect their more usual food and take extraordinary numbers

of those species which, for any reason, became superabundant for a time ?

For the purpose of answering these questions, two separate lines of investigation are necessary. For the first two we require a knowledge of the food habits of the various species of birds under ordinary circumstances, when the conditions of life are of average character, and especially when no species of insects are unusually and excessively abundant. On the other hand, for an answer to the third question we must look to the food habits of the birds under extraordinary circumstances, where the opposite condition of affairs prevails. We must learn to what extent birds depart from their usual practices when confronted by an uprising of some insect species. If they concentrate for its suppression, they must assist more or less effectively to reduce to order the disturbed balance of life; but if they remain indifferent to this condition of things, their influence is *nil.*

The present paper is a contribution to a discussion of the last of the above questions. As a striking and conclusive example of an extraordinary condition of insect life, and of the food of birds in the presence of a disturbed balance of nature, I selected an orchard which had been for some years badly infested by canker-worms, shot a considerable number of birds therein for two successive years, representing nearly all the kinds seen in the orchard, made full notes of the relative abundance of the species, examined carefully the contents of all the stomachs obtained, with reference not only to the presence of canker-worms but of all other insects as well, and tabulated the results as the basis of this paper. Besides preparing as full an account of the food of these birds as practicable, I have brought the summaries on these tables into comparison with those derived from birds of the same species shot in ordinary situations during the same month. These comparisons have been confined to a few of the kinds obtained in the orchard, for the reason that most were not found there in sufficient number to give a fair idea of the average food of the species. The collections were made in an orchard of forty-five acres of bearing apple-trees (belonging to Mr. J. W. Robison) in Tazewell County, Ill., which had been infested by canker-worms for about six years. As a result of their depredations, a considerable part of the orchard had the appearance, from a little distance,

of having been ruined by fire. Closer examination of the trees most affected showed that the branches, stripped of every vestige of green, were festooned with the webbing left by the worms. To the webs the withered remnants of the leaves adhered as they fell, the very petioles having been gnawed off at the twigs. Not one per cent. of the trees were uninjured, and these were invariably on the outer part of the orchard. Those which had been attacked several years in succession were killed; and there was a large area in the midst of the orchard from which such trees had been removed. One did not need to enter the enclosure to learn that the birds were present in extraordinary numbers and variety. From every part of it arose a chorus of song more varied than I had ever heard in any similar area at that season of the year. Most of the common summer residents were found there; and upon a second visit in 1882 many of the migrant species likewise occurred. The first collection was made on the 24th of May, 1881, and the second on the 20th of the same month im the following year. The season was less advanced at the time of the second collection than at the first, so that the actual difference between the two was probably not less than two weeks. At the first visit fifty-four birds were taken, representing twenty-four species, and seven other species were noted in the orchard of which no specimens were obtained. On the second visit ninety-two birds were shot, representing thirty-one species, and four other species were seen. In 1881 the worms were nearly all fully grown, and many of them had already entered the ground for their transformation, so that the larvæ were less abundant than they had been earlier. In 1882 most of them were about half-grown, only a few having reached adult size. They were distinguishable with difficulty upon the leaves of the trees; but when a large branch was shaken or jarred, from a dozen to twenty would expose themselves by spinning down and hanging at the end of a thread. The owner of the orchard informed me that they were about twice as abundant the preceding season.

TURDIDÆ. Thrushes.

Turdus migratorius, L. Robin.

This species was abundant and nesting in the orchard. Nine specimens were obtained in all, three in 1881 and six in the fol-

lowing year. The food was wholly animal, neither fruit nor any other kind of vegetation having been taken by any of the birds. Only three of the above number had eaten canker-worms, which composed, as nearly as could be estimated, about one-fifth of the food of the entire group. Insects made ninety-three per cent., the remainder consisting of a common species of myriapod (five per cent.), earth-worms, and gasteropod mollusks. Ants were eaten by these birds only in trivial numbers. Diptera, Orthoptera and spiders were conspicuous by their entire absence. Cut-worms were extraordinarily prominent in the food, making twenty-eight per cent. of the whole. Half of them consisted of a single large, injurious species (*Nephelodes violans*). Among the Coleoptera, which amounted to thirty-six per cent. of the whole, the Scarabæidæ and Elateridæ were the principal elements, the former represented by eighteen per cent., and the latter by eleven. Among the Scarabæidæ was a species known as a vine leaf-chafer (*Anomala binotata*), which made fourteen per cent. of the food. This insect was scarcely less abundant than the canker-worm, and appeared in extraordinary numbers in the food of nearly all the species of birds examined, although it had not attracted the attention of the owner of the grounds. I searched a small vineyard adjacent, but saw no signs of unusual injury to the leaves. Carabidæ, although common in the orchard, had scarcely been touched by the robins, only a single specimen of the family occurring. Hemiptera were found but in trivial numbers, representing about equally the families Coreidæ and Cydnidæ. Hymenoptera were still less abundant, composing only one per cent. of the food.

MIMUS CAROLINENSIS, L. CATBIRD.

This species was very common, and thoroughly at home among the trees, where it was doubtless nesting. Fourteen specimens were taken, three at the first visit and eleven at the second. With the exception of two per cent. of myriapods, their food consisted entirely of insects. Canker-worms had been eaten by eight of the birds, but not in any great number, as they composed but fifteen per cent. of the food of the species. A few cut-worms had been taken, and a larger number of other caterpillars, bringing the total for Lepidoptera up to about one-fourth of the food.

The catbird had shown its usual preference for ants, eating fourteen per cent. of these insects. These birds had taken an unusual number of Coleoptera, which made more than half the food, chiefly Scarabæidæ. About two-thirds of them belonged to the single species (*Anomala binotata*) mentioned above under the food of the robin. Three of these birds had likewise eaten large June bugs. Elateridæ and their larvæ occurred only in trivial quantities, while Carabidæ amounted to four per cent., chiefly Anisodactylus. As in the robin, Diptera, Orthoptera, and Arachnida, were not represented in the food.

HARPORHYNCHUS RUFUS, L. BROWN THRUSH.

This bird was not common in the orchard, and only four specimens were taken. The food of these was entirely animal, an unexpected circumstance, as the brown thrush usually feeds largely upon grain. Six per cent. of the food consisted of thousand-legs, and insects made the entire remainder. Lepidoptera were about one-fifth of the food, and half of these were canker-worms. Like the preceding species, this bird had eaten an enormous number of beetles, which amounted to two-thirds of its food. Twelve per cent. of the whole was Carabidæ, chiefly a species of Chlænius. Scarabæidæ stand at forty-four per cent., largely Diplotaxis, Melolontha, and Anomala. Six per cent. were Elateridæ, and three per cent. Rhynchophora. No specimens of the remaining orders had been eaten by these birds.

Summary of the Family.

Treating, now, of the twenty-seven thrushes mentioned as one group, we find that none of them had eaten any vegetation whatever; that ninety-six per cent. of their food consisted of insects (myriapods and earth-worms making up the remaining four per cent.); that sixteen per cent. was canker-worms; and only four per cent. predaceous beetles. The Anomala previously mentioned made just a fourth of their entire food, other Scarabæidæ bringing up the average of that family to thirty-eight per cent. Click beetles (Elateridæ) with their larvæ were five per cent. of the whole, and snout beetles (Rhynchophora) two per cent.

SAXICOLIDÆ. Bluebirds.

SIALIA SIALIS, L. BLUEBIRD.

This species was not at all abundant in the orchard in either year. Only one was taken in 1881, and four in 1882. All but two per cent. of the food of these five specimens consisted of insects, spiders making the remainder. Canker-worms were twelve per cent. of the food, and other Lepidoptera five per cent. additional. Two-thirds of the food consisted of Coleoptera. Carabidæ made more than one-third (twenty-three per cent.), belonging chiefly to a species (*Anisodactylus baltimorensis*) which depends largely upon vegetable food. Four of the birds had eaten *Anomala binotata*, which made thirty-six per cent. of the food of the whole. Five per cent. was Chrysomelidæ, and fifteen per cent. Hemiptera, all belonging to the family Cydnidæ.

PARIDÆ. Chickadees.

PARUS ATRICAPILLUS, L. BLACK-CAPPED CHICKADEE.

This little bird, unfortunately, was not at all common in the orchard; and only two specimens were taken, one in each year. Sixty-one per cent. of their food consisted of canker-worms, eaten by both the birds, and Coleoptera made the entire remainder. These were nearly all Cerambycidæ (*Psenocerus supernotatus*) and Rhynchophora of undetermined species, twenty-five per cent. of the former, and ten of the latter.

TROGLODYTIDÆ. Wrens.

TROGLODYTES DOMESTICUS, Bartr. HOUSE WREN.

Several specimens of this little species were observed, some of them evidently nesting. The food was chiefly insects,—all, in fact, but six per cent. of spiders and one of thousand-legs. Nearly half the food of these birds consisted of canker-worms, and other Lepidoptera and their larvæ brought the average of the order up to fifty-nine per cent. A few gnats and other Diptera (four per cent.) and five per cent. of ants were also noted. Coleoptera and Hemiptera were taken in nearly equal quantities, thirteen per cent. of the former and ten of the latter. Two of the

birds had eaten *Psenocerus supernotatus*, amounting to four per cent. of the food, and the other Coleoptera were scattered through the families Carabidæ, Nitidulidæ, Scarabæidæ, Elateridæ and Calandridæ. The Hemiptera were represented by trivial numbers of four families, including a few chinch bugs.

MNIOTILTIDÆ. Warblers.

HELMINTHOPHAGA PEREGRINA, Wils. TENNESSEE WARBLER.

A single specimen of this little warbler was taken in 1882. Four-fifths of its food consisted of canker-worms, and all the remainder of a single species of beetle (*Telephorus bilineatus*).

DENDRŒCA ÆSTIVA, Gmel. SUMMER YELLOW BIRD.

This bird, common every where at this season, was also abundant in the orchard. Five specimens were shot in all. The food was insects, excepting six per cent. of spiders. Two-thirds of the total amount eaten by all of the birds consisted of canker-worms. Coleoptera were twenty-three per cent. of the whole amount, six per cent. being Aphodius, and twelve per cent. *Psenocerus supernotatus*, already frequently mentioned. Carabidæ and Calandridæ were represented by insignificant ratios, and Lampyridæ by a single Telephorus eaten by one of the birds. One per cent. of Hemiptera, and two of Hymenoptera complete the record.

DENDRŒCA PENNSYLVANICA, L. CHESTNUT-SIDED WARBLER.

Two specimens of this abundant migrant were shot in the orchard in 1882. Like the preceding warbler, two-thirds of their food consisted of canker-worms, and an additional ten per cent. of other caterpillars. A few ants were eaten by both of the birds. Eleven per cent. of Coleoptera, likewise eaten by the two, was about equally divided between some undetermined Scarabæidæ and *Psenocerus supernotatus*. One of the birds had eaten plant-lice, which amounted to five per cent. of the food; and both had taken ants to the amount of six per cent.

DENDRŒCA STRIATA, Forst. BLACK-POLL WARBLER.

Four of these birds were shot in 1882. Some undetermined seeds found in the crop of one of them reduced the insect ratio

to ninety-five. Again two-thirds of the food consisted of canker-worms. The same little borer (*Psenocerus*) eaten by so many of the smaller birds in this orchard, made fifteen per cent. of the food; and an Aphodius and an undetermined carabid bring up the ratio of the Coleoptera to nineteen per cent. Four per cent. of ants, a few gnats (five per cent.), and traces of Hemiptera and mites were the only other elements detected.

DENDRŒCA VIRENS, Gm. BLACK-THROATED GREEN WARBLER.

A single specimen of this migrant was shot in 1882. Seventy per cent. of its food consisted of canker-worms, fifteen per cent. of Psenocerus, and five of undetermined Hemiptera. The remaining ten per cent. was made up of trivial numbers of Hymenoptera, gnats, coleopterous larvæ and mites.

GEOTHLYPIS TRICHAS, L. MARYLAND YELLOW-THROAT.

This resident warbler occurred but sparingly in the orchard. One specimen was seen in 1881, and two were obtained in 1882. Lepidoptera made four-fifths of their food, about equally canker-worms and undetermined caterpillars. A few Staphylinidæ and some specimens of Psenocerus composed the eight per cent. of Coleoptera. A small hemipter (*Piesma cinerea*) amounted to five per cent., and four per cent. was gnats.

Summary of the Family.

Of the warbler family as a whole, as represented by these fifteen specimens, I need only remark that fourteen of the birds had eaten canker-worms, which composed nearly or quite two-thirds of the food of the group; that ten per cent. consisted of *Psenocerus supernotatus;* and that the remaining averages, with the exception of six per cent. of undetermined caterpillars, were so much subdivided as to have little or no significance.

VIREONIDÆ. Vireos.

VIREO GILVUS, V. WARBLING VIREO.

Three specimens of this little bird were shot, of purely insectivrous habit. They had eaten canker-worms to the amount of forty-four per cent.; and other caterpillars made thirty-five per

cent. additional. A few Coleoptera (fifteen per cent.) of which one-third were carabid larvæ, and three per cent. of Cydnidæ (*Podisus*), were the only other important elements. *Anomala binotata* (eight per cent.), Telephorus, and an undetermined long-horn, were the other Coleoptera.

AMPELIDÆ. Wax-wings.

AMPELIS CEDRORUM, V. CEDAR WAX-WING.

A flock of about thirty of these birds was repeatedly started in the orchard during the first visit, but none were seen in 1882. Seven of the flock were shot, and the contents of their stomachs carefully studied. With the exception of a few Aphodii eaten by three of the birds in numbers too insignificant to figure in the ratios, the entire food of all these birds consisted of canker-worms, which therefore stand at an average of one hundred per cent. The number in each stomach, determined by actual count, ranged from seventy to one hundred and one, and was usually nearly a hundred. Assuming that these constituted a whole day's food, the thirty birds were destroying three thousand worms a day, or ninety thousand for the month during which the caterpillar is exposed.

HIRUNDINIDÆ. Swallows.

PETROCHELIDON LUNIFRONS, Say. CLIFF SWALLOW.

This species was nesting in great numbers under the eaves of a barn at the edge of the orchard, and many of the birds were continually circling through the air. A single specimen was shot, and found to contain nothing but the very abundant scavenger beetle (*Aphodius inquinatus*), with about two per cent. of undetermined Hemiptera.

FRINGILLIDÆ. Finches.

ASTRAGALINUS TRISTIS, L. AMERICAN GOLDFINCH.

A flock of these birds passed through the orchard, but only a single one was shot. No canker-worms had been eaten by it; but about seventy per cent. of its food consisted of undetermined seeds, and the remainder of a harpalid beetle.

COTURNICULUS PASSERINUS, Wils. YELLOW-WINGED SPARROW.

A single specimen of this bird, shot in 1881, contained spiders thirty per cent., seeds of pigeon grass (*Setaria*) fifteen per cent., an unrecognized beetle five per cent., and some undetermined caterpillars, certainly not canker-worms.

SPIZELLA DOMESTICA, Bart. CHIPPING SPARROW.

This species was not common in the orchard in 1881, and only a single specimen was obtained; but in the following year it was found much more abundant, and seven additional were taken. About one-third of the food consisted of caterpillars, half of which were recognizable as canker-worms. A large number of gnats (twenty-eight per cent.), nearly as many Coleoptera, (principally Scarabæidæ, including nine per cent. of Anomala), and six per cent. of Hemiptera, are all the other noteworthy items.

SPIZELLA AGRESTIS, Bart. FIELD SPARROW.

This species was less abundant than the preceding, and was represented by only three specimens. With the exception of five per cent. of gnats, and one of Hemiptera, the food of this bird was equally divided between Lepidoptera and Coleoptera. Nearly half the former consisted of canker-worms, while the Coleoptera were represented by Histeridæ, Scarabæidæ (chiefly the scavengers), Monocrepidius and Rhynchophora.

SPIZA AMERICANA, Gmel. BLACK-THROATED BUNTING.

This bird was the most abundant species in 1881, though but few were seen during the following May. Eleven were shot at the first visit and three at the second. With the exception of a little wheat eaten by two of the birds, and a trace of undetermined seeds, the food consisted almost entirely of insects and mollusks, eighty-eight per cent. of the former and six of the latter (Helix). Ten of these birds had eaten canker-worms, which made forty-three per cent. of the food of the entire group; Lepidoptera as a whole composing two-thirds of the food. Among the twenty-two per cent. of Coleoptera, we note Harpalus and Histeridæ, each four per cent., Aphodius and Anomala likewise each four per cent., and Sphenophorus and other Rhynchophora, two per cent.

ZAMELODIA LUDOVICIANA, L. ROSE-BREASTED GROSBEAK.

Only two were seen, and both were killed. A very few canker-worms were found (five per cent.) with fifty-eight per cent. of other caterpillars. About half the fifteen per cent. of Coleoptera were Rhynchophora, the remainder being *Anomala binotata*, one of the Lampyridæ, and undetermined specimens. One-fifth of the food consisted of seeds not recognized.

PASSERINA CYANEA, L. INDIGO BIRD.

This bird, noted as common in 1881, was by far the most abundant species in the orchard at the second visit. Eighteen specimens were shot, two in the first and the remainder in the second year. Although this bird is one of the typical finches, only three per cent. of its food consisted of seeds, chiefly Setaria and Compositæ. Canker-worms made fifty-nine per cent., eaten by all the birds but one, and other caterpillars an additional eight per cent. With the exception of a trace of Hymenoptera, the remainder of the food consisted entirely of beetles, about one-third of which were *Anomala binotata*.

Summary of the Family.

Only seven per cent. of the food of the forty-seven members of this family (commonly called seed-eaters) consisted in fact of seeds; and insects made up all but two per cent. of the remainder. The most interesting items on the general list are canker-worms forty per cent., predaceous beetles (Carabidæ) two per cent., and *Anomala binotata* six per cent.

ICTERIDÆ. Blackbirds.

MOLOTHRUS ATER, Bodd. COWBIRD.

A single wandering specimen of this bird contained only Scarabæidæ, including Aphodius, and a few other Coleoptera, with about sixty per cent. of corn and some seeds of Polygonum and other plants.

AGELÆUS PHŒNICEUS, L. RED-WINGED BLACKBIRD.

Two specimens of this bird, which were also accidentally in the orchard, had fed about equally upon insects and upon wheat and

other seeds. The Lepidoptera (twenty-seven per cent.) were nearly all the larvæ of *Nephelodes violans*. Of the Coleoptera (eleven per cent.), part were Anomala and Elateridæ, and the remainder consisted of specimens of *Tanymecus confertus*, eaten by one of the birds. A grasshopper had also been taken by one, making ten per cent. of the food; and traces of Hemiptera were recognized.

ICTERUS GALBULA, L. BALTIMORE ORIOLE.

Not common. Three were shot. These had fed only on insects,—Lepidoptera forty per cent. and Coleoptera sixty per cent., the former all canker-worms, and the latter chiefly *Anomala binotata* (fifty per cent.). Six per cent. of Cerambycidæ and two of Rhynchophora should also be mentioned.

ICTERUS SPURIUS. L. ORCHARD ORIOLE.

This bird was common in 1881, although but two were shot; but was not noticed the next year. More than three-fourths of the food of these consisted of canker-worms, and other caterpillars made an additional twenty per cent., leaving but three per cent. for ants.

QUISCALUS PURPUREUS ÆNEUS, Bartr. BRONZED GRACKLE.

Wandering specimens of the grackle were seen, and a few were apparently roosting in the trees at night. But three were shot, all of which had fed chiefly upon corn, which amounted to sixty-two per cent. of their food. Fragments of a crawfish were found in the stomach of one. Half the thirty per cent. of Coleoptera were Carabidæ, including a specimen of *Calosoma calidum*, and the remainder were nearly all Lucanidæ (Dorcus, eight per cent.) and undetermined Elateridæ.

Summary of the Family.

The five species of this family mentioned were represented by but eleven specimens, which, taken together, were found to have made two-thirds of their food of insects, the remaining third of corn and wheat with a few seeds of weeds. Canker-worms, eaten by the orioles, only amounted to one-fourth of the food of the whole,

and Coleoptera to a little more than another fourth. Of these, Carabidæ made four per cent., Cerambycidæ two, Rhynchophora one, and *Anomala binotata* fourteen.

TYRANNIDÆ. Flycatchers.

Tyrannus carolinensis, L. Kingbird.

This species was not uncommon, but only three were shot. Two of these, to my surprise, were found to have eaten canker-worms, which made more than a fourth of the food of the whole. Five per cent. of the remainder consisted of undetermined Hemiptera, and all the balance was Coleoptera. Seven per cent. was Elateridæ, two Lampyridæ, and more than fifty-eight Scarabæidæ, all Anomala except thirteen per cent. of *Aphodius inquinatus*, eaten by one of the birds.

Contopus virens, L. Wood Pewee.

Three of these were shot, none of which had taken canker-worms. Their food consisted chiefly of flies and gnats, which amounted to fifty-five per cent. Thirteen per cent. of Aphodius and ten per cent. of Ips, with a few ants and other Hymenoptera, are also worthy of mention.

Empidonax trailli, Aud. Traill's Flycatcher.

Two specimens, shot in 1882, had eaten only insects, one-fourth of which were canker-worms, and one-third Ichneumonidæ. Another fourth consisted of Coleoptera, nearly half of which were Anomala; and ten per cent. were ants and other Hymenoptera.

Empidonax flaviventris, Bd. Yellow-bellied Flycatcher.

A single specimen had eaten a number of Lepidoptera and their larvæ, but no canker-worms. Half the food was Coleoptera, nearly all Aphodius and *Anomala binotata*,—fifteen per cent. and twenty-five per cent. respectively. The little Psenocerus was likewise taken by this bird, and a specimen of Hymenarcys (Hemiptera).

Summary of the Family.

The nine flycatchers taken had eaten only insects, of which nearly half were Coleoptera, and the remainder were about equally distributed between the Hemiptera, Lepidoptera, and Diptera. Canker-worms make fifteen per cent. of the whole, and *Anomala binotata* seventeen per cent. The Scarabæidæ include all but ten per cent. of the Coleoptera.

CUCULIDÆ. Cuckoos.

COCCYZUS ERYTHROPHTHALMUS, Wils. BLACK-BILLED CUCKOO.

Three-fourths of the food of a single specimen shot consisted of canker-worms, other caterpillars making an additional twenty per cent. *Anomala binotata* was the only remaining element.

PICIDÆ. Woodpeckers.

MELANERPES ERYTHROCEPHALUS, L. RED-HEADED WOODPECKER.

This bird was abundant in the orchard, evidently nesting in the trees, although but four specimens were shot. Two of these had eaten corn, which amounted to twenty per cent. of the food. Fifteen per cent. was canker-worms, and twenty-four per cent. Carabidæ (eaten by two of the birds), including Calosoma, Scarites, and several Harpalids. Twenty-nine per cent. of Scarabæidæ embraced a Canthon and some specimens of *Anomala binotata*. Melanotus and other spring-beetles were also eaten by two of the birds.

COLAPTES AURATUS, L. FLICKER.

A single specimen, killed in 1881, had fed only on ants, the usual aliment of the bird.

COLUMBIDÆ. Doves and Pigeons.

ZENAIDURA CAROLINENSIS, L. MOURNING DOVE.

Several mourning doves were seen, and a single specimen was taken. Three-fourths of the food of this was corn, and the remainder the seeds of some leguminous plant.

PERDICIDÆ. Quails and Partridges.

ORTYX VIRGINIANA, L. QUAIL.

Two quails were shot, among half a dozen seen. All but four per cent. of their food consisted of corn and other seeds, chiefly those of Compositæ. A single chrysomelid, a rhynchophorous beetle, and a carabid, were the only insects found.

Besides the species of birds above mentioned, the following were noted rarely in the orchard, but no specimens were secured: and *Vireo olivaceus*, *Sturnella magna*, *Cyanurus cristatus*, and *Chætura pelasgica*. The blue jay was seen eating canker-worms in the trees. The total number of species observed in the orchard wa therefore forty, and the number of specimens obtained and studied was one hundred and forty-one, representing thirty-six of the species. Twenty-six of these species had been eating canker-worms, which were found in the stomachs of eighty-five specimens. That is to say, seventy-two per cent. of the species, and sixty per cent. of the specimens, had eaten the worms. Taking the entire assemblage of one hundred and forty-one birds as one group, we find that thirty-five per cent. of their food consisted of canker-worms; and if we exclude the species evidently merely accidental in the orchard, the average of canker-worms in the food of those properly belonging there rises to about forty per cent.

For a correct estimate of the probable effect of the birds in limiting the increase of the canker-worm, it is necessary to take into account some of the features of its natural history. The larval life of the insect lasts about one month, after which it enters the ground and pupates, where it remains until the following spring. The imagos, the females of which are wingless, emerge about the middle of April. They lay their eggs upon the bark of the trees, usually at night, remaining concealed upon the ground by day under fallen leaves and other rubbish. The eggs remain upon the trees about a month before the worms emerge, when the latter crawl up the trunk and commence their attacks upon the leaves. The pest is consequently exposed to destruction from the time it emerges until it disappears again, the adults falling an easy prey to birds which search the ground for

food, and the eggs to the small species which pry about the trunks of trees. The entire period during which the insect is doubtless fed upon by birds will usually amount to somewhat more than two months.

Besides the abundance of the canker-worms noted in the food of these birds, it is evident that two or three other species of insects occurred in this situation in extraordinary numbers, especially the vine leaf-chafer (*Anomala binotata*) and a small borer (*Psenocerus supernotatus*). The purple cut-worm (*Nephelodes violans*) was also somewhat commoner than usual. The Anomala was eaten by thirty-nine of the specimens, representing fifteen species, and amounted to eleven per cent. of the food of all the birds taken in the orchard. Many of these were too small to feed upon so large an insect, and a better illustration of the abundance of this beetle may be gathered from the food of the thrushes and blue-bird. Of thirty-two specimens of these families, nineteen had eaten the vine leaf-chafer, which amounted to twenty-seven per cent. of the food of all. Only fourteen of the same birds had eaten the canker-worm, which amounted to less than twenty per cent. of the food. It seems likely, therefore, that some of these birds were attracted to the orchard, not by the canker-worms, but by the superabundance of Anomala. The unusual frequency of *Psenocerus supernotatus*, a small long-horned beetle found upon the trees, is shown by the fact that of the twenty-five small arboreal birds (Paridæ, Troglodytidæ, and Mniotiltidæ), thirteen had eaten this beetle, which composed nearly one-tenth of their food.

We have next to make the comparison of the food taken in the orchard by the species most abundant there, with the food of the same species, taken elsewhere under ordinary circumstances. For the purpose of this comparison I have selected the robin, the catbird, the black-throated bunting (*Spiza americana*), and the indigo bird (*Passerina cyanea*). In the table of the ordinary food of the robin for May, published in Bulletin 3 of this series, as represented by fourteen specimens, caterpillars amounted to but twenty-three per cent., whereas in the orchard they rise to fifty-four per cent. This difference between the averages is almost exactly accounted for by the ratios of canker-worms and *Nephelodes violans* not appearing on the former table; these together amounting to thirty-five

per cent. Notwithstanding the number of Anomala eaten in the orchard, the ratios of the Scarabæidæ are substantially the same, as the ordinary food of the robin in May consists largely of June beetles. The surplus of Lepidoptera seems to be balanced by a deficiency in all the other orders, no one of which rises to the average of its ordinary food in May. The loss is greatest, however, in the Diptera, which drop from eleven per cent. to nothing.

Comparing the record of the fourteen catbirds shot in the orchard with that of twenty-two obtained in miscellaneous situations, we note, first, that the caterpillars on the first table are more than twice those of the second,—twenty-six in the one, and twelve in the other; and that this difference is evidently due to the fifteen per cent. of canker-worms taken by the birds of the first group. This shows that the catbird, like the robin, had simply added the canker-worms eaten to its usual ratio of caterpillars. A more striking difference is shown in the totals of Coleoptera, which stand at fifty-six per cent. in the orchard birds, and twenty-three in the others. This, again, is evidently due to the abundance of *Anomala binotata;* for when the ratio of this insect is subtracted from the total of Coleoptera, the remainder is twenty per cent. as against twenty-three of the ordinary food. These excessive ratios of Lepidoptera and Coleoptera are compensated by deficiencies in the Diptera, Arachnida, Myriapoda and Orthoptera, especially in the three first named groups. The decided preference of this bird for ants is shown by the fact that the usual ratio of these insects is scarcely diminished, fourteen per cent. having been taken in the orchard and eighteen elsewhere.

Fourteen of the black-throated bunting (*Spiza americana*), killed in the orchard, are to be contrasted with twelve shot in May from various situations. A striking difference is seen at once in the insect ratios, which amount respectively to eighty-eight and forty-seven per cent. This surplus of insects eaten by the orchard birds is readily traced to the orders Lepidoptera and Coleoptera. Of the former these birds had eaten more than three times their ordinary average, and of the latter nearly four times the usual amount. The excess of Lepidoptera is clearly due, as usual, to the presence of the canker-worms, since the balance left

after subtracting the canker-worm ratio from the average of that order taken by the first group, differs by only three per cent. from the average taken by the second group. The discrepancy in the ratios of Coleoptera is not so easily explained, but is distributed among several genera of Scarabæidæ and the small scavenger beetles. The excess of these two orders is compensated principally by diminished ratios of vegetation, which amount to only six per cent. in the birds shot in the orchard, and fifty-two per cent. among those taken through the country at large. Diptera and all the lower orders of insects as well as Arachnida and Myriapoda, are also omitted from the food of the orchard birds.

Insects composed ninety-seven per cent. of the food of eighteen indigo birds (*Passerina cyanea*) shot in the orchard, and but fifty-seven per cent. of the food of fifteen individuals taken elsewhere, the balance in both cases being seeds, chiefly Setaria, Polygonum and wheat. The excess of insects in the orchard specimens appears under Lepidoptera and Coleoptera, the former sixty-seven per cent., the latter twenty-nine, as compared with twenty-eight and nineteen per cent. respectively, in the other group. The Lepidoptera of the orchard birds are nearly all canker-worms, as are likewise ten per cent. of those taken by the specimens from various situations. The difference in the ratio of Coleoptera taken by the two groups was exactly compensated by the ten per cent. of *Anomala binotata* eaten in the orchard. The excess of caterpillars and beetles taken by the former group, is partly compensated also by the almost total disappearance of all other insects from the food.

What, now, may we conclude, from the above data, respecting the influence of birds upon such entomological insurrections as are illustrated by the uprising of the canker-worms in Mr. Robison's orchard?

Three facts stand out very clearly as results of these investigations: 1. Birds of the most varied character and habits, migrant and resident, of all sizes, from the tiny wren to the bluejay, birds of the forest, garden and meadow, those of arboreal and those of terrestrial habit, were certainly either attracted or detained here by the bountiful supply of insect food, and were feeding freely upon the species most abundant. That thirty-five

per cent. of the food of all the birds congregated in this orchard should have consisted of a single species of insect, is a fact so extraordinary that its meaning can not be mistaken. Whatever power the birds of this vicinity possessed as checks upon destructive irruptions of insect life, was being largely exerted here to restore the broken balance of organic nature. And while looking for their influence over one insect outbreak we stumbled upon at least two others, less marked, perhaps incipient, but evident enough to express themselves clearly in the changed food ratios of the birds.

2. The comparisons made show plainly that the reflex effect of this concentration on two or three unusually numerous insects was so widely distributed over the ordinary elements of their food that no especial chance was given for the rise of new fluctuations among the species commonly eaten. That is to say, the abnormal pressure put upon the canker-worm and vine chafer was compensated by a general diminution of the ratios of all the other elements, and not by a neglect of one or two alone. If the latter had been the case, the criticism might easily have been made that the birds, in helping to reduce one oscillation, were setting others on foot.

3. The fact that, with the exception of the indigo bird, the species whose records in the orchard were compared with those made elsewhere, had eaten in the former situation as many caterpillars other than canker-worms as usual, simply adding their canker-worm ratios to those of other caterpillars, goes to show that these insects are favorites with a majority of birds.

TABLES OF THE FOOD.

	Turdidæ.				Sialidæ.	Paridæ.	Troglodytidæ.	Mniotiltidæ.						
	Robin.	Catbird.	Brown Thrush.	Total.	Bluebird.	Black-capped Chickadee.	House Wren.	Tennessee Warbler.	Summer Yellow Bird.	Chestnut-sided Warbler.	Black-poll Warbler.	Black-throated Green Warbler.	Maryland Yellow-throat.	Total.
Number of Birds	9	14	4	27	5	2	5	1	5	2	4	1	2	15
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
	9	14	4	27	5	2	5	1	5	2	4	1	2	15
Animal Food	1.00	1.00	1.00	1.00	1.00	1.00	1 00	1.00	1.00	1.00	.95	1 00	1.00	.99
	3			3										
I. MOLLUSCA	.01	....	....	+	....	....	....	....	....	....	....	....	....	....
	9	14	4	27	5	2	5	1	5	2	4	1	2	15
II. INSECTA	.93	.98	.94	.96	.98	1.00	.91	1.00	.94	1.00	.95	1.00	1.00	.97
	4	11	2	17			2		2	2	3	1		8
1. *Hymenoptera*	.01	.14	.03	.08	....	....	.05	...	.02	07	.04	.02	...	.03
	4	11	2	17			2			2	3			5
Formicidæ	.01	.14	.03	.08	....	....	.05	....	....	.06	.04	....	....	.02
	9	12	4	25	3	2	5	1	5	2	4	1	2	15
2. *Lepidoptera*	.54	.26	.22	.34	.17	.61	.39	.80	.67	.75	.66	.70	.82	.71
	6	5	1	12										
Noctuidæ (larvæ)	.28	.04	.05	.12	....	....	....	....	....	....	....	....	....	....
Nephelodes violans (larvæ)	3 .14	1 .01	....	4 .05	....	....	....	....	....	....	....	....	....	....
	3	8	2	13	1	2	3	1	5	2	4	1	1	14
Anisopteryx vernata	.21	.15	.12	.16	.12	.61	.46	.80	.67	.65	.66	.70	.37	.64
							3		1	2	4	1	2	10
3. *Diptera*	....	....	....	....	....	....	.04	....	.01	.02	.05	.05	.04	.03
							2			1	4	1	2	8
Gnats	....	....	....	....	....	....	.03	....	....	.02	.05	.05	.04	.03
	9	14	4	27	5	2	5	1	5	2	4	1	1	14
4. *Coleoptera*	.36	.56	.67	.51	.66	.39	.13	.20	.23	.11	.19	.08	.08	.18
	4	5	3	12	3		1		1		1			2
Carabidæ	.01	.04	.12	.04	.23	....	.01	....	.01	....	.01	....	....	.01
	1			1									1	1
Staphylinidæ	.04	....	....	.01	....	....	....	....	....	....	....	....	.05	.01
							1							
Phalacridæ	....	....	....	....	....	....	+	....	....	....	....	....	....	....
	5	2	1	8										
Histeridæ	.01	+	.02	.01	....	....	....	....	....	....	....	....	....	....
	6	12	3	21	5		1		1	1	1			3
Scarabæidæ	.18	.49	.44	.38	.36	....	.01	....	.06	.05	.02	....	....	.03
	3	10	2	15	4									
Anomala binotata	.14	.36	.14	.25	.36	....	....	....	....	....	....	....	....	....
	6	1	3	10			1							
Elateridæ	.11	.01	.06	.05	....	....	.01	....	....	....	....	....	....	....
								1	1					2
Lampyridæ	....	....	....	....	....	....	....	.20	.04	....	....	....	....	.03
						1	2		3	2	3	1	1	10
Cerambycidæ	....	....	....	....	....	.25	.04	....	.12	.06	.15	.15	.03	.10
Psenocerus supernotatus	....	....	....	....	....	....	....	....	3 .12	2 .06	3 .15	1 .15	1 .03	10 .10
					1									
Chrysomelidæ	....	....	....	....	.05	....	....	....	....	....	....	....	....	....
	3	3	1	7		1	1		1					1
Rhynchophora	.01	.01	.03	.02	....	.10	.01	....	+	....	....	....	....	+
	3	6		9	3		4		2	1	1	1	2	7
5. *Hemiptera*	.02	.02	....	.02	.15	....	.10	....	.01	.05	.01	.05	.06	.02

TABLES OF THE FOOD—Continued.

	Robin.	Catbird.	Brown Thrush.	Total.	Bluebird.	Black-capped Chickadee.	House Wren.	Tennessee Warbler.	Summer Yellow Bird.	Chestnut-sided Warbler.	Black-poll Warbler.	Black-throated Green Warbler.	Maryland Yellow-throat.	Total.
Number of Birds	9	14	4	27	5	2	5	1	5	2	4	1	2	15
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Homoptera							1 .02			1 .05				
Aphides										1 .05				
Tettigonidæ							1 .02							
Heteroptera	3 .02	4 .02		6 .02	3 .15		1 .06						1 .05	1 †
Aradidæ							1 .02							
Lygæidæ							1 .02						1 .05	1 †
Chinchbugs							1 .02							
Coreidæ	1 .01			1 .01										
Cydnidæ	2 .01	3 .02		5 .01	3 .15									
III. ARACHNIDA					2 .02		3 .06		3 .06		1 †	1 †	5 .02	
IV. MYRIAPODA	2 .05	2 .02	1 .06	5 .03			1 .01							
VI. VERMES (Lumbricus)	1 .01			1 .01										
Vegetable Food (seeds)											1 .05		1 .01	

TABLES OF THE FOOD—Continued.

	Vireonidæ.	Ampelidæ.	Hirundinidæ	Fringillidæ.								Icteridæ.		
	Warbling Vireo.	Cedar Wax-wing.	Cliff Swallow.	American Gold-finch.	Yellow-winged Sparrow.	Chipping Sparrow	Field Sparrow.	Black-throated Bunting.	Rose-breasted Grosbeak.	Indigo Bird.	Total.	Cowbird.	Red-winged Blackbird.	Baltimore Oriole.
Number of Birds.....	3	7	1	1	1	8	3	14	2	18	47	1	2	3
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Animal Food.....	3 1.00	7 1.00	1 1.00	1 .30	1 .65	8 .96	3 1.00	14 .94	2 .80	18 .97	47 .93	1 .30	2 .50	3 1.00
I. MOLLUSCA.....	....	....	....	....	....	....	....	1 .06	....	....	1 .01	....	....	....
II. INSECTA.....	3 1.00	7 1.00	1 1.00	1 .30	1 .35	8 .95	3 1.00	14 .88	2 .80	18 .97	47 .91	1 .30	2 .50	3 1.00
1. *Hymenoptera*.....	....	1 †	1 .02	....	....	3 .03	....	3 .01	1 .02	2 .01	8 .01	....	....	....
Formicidæ.....	....	....	....	....	....	1 .01	....	1 †	....	....	2 †	....	....	....
Tenthredinidæ....	....	....	....	....	....	1 .02	....	....	....	....	1 .01	....	....	....
2. *Lepidoptera*.....	3 .79	7 1.00	....	....	1 .30	7 .32	3 .47	13 .65	2 .63	17 .67	43 .57	....	2 .29	3 .40
Noctuidæ.....	....	....	....	....	....	....	....	2 .14	....	....	2 .04	....	1 .25	....
Nephelodes violans (larvæ)...	....	....	....	....	....	....	....	....	....	....	....	....	1 .25	....
Phalænidæ (larvæ)	3 .44	7 1.00	....	....	....	2 .16	1 .20	10 .46	1 .05	17 .60	31 .41	....	1 .01	3 .40
Anisopteryx vernata.....	3 .44	7 1.00	....	....	....	2 .16	1 .20	10 .43	1 .05	17 .59	31 .40	....	1 .01	3 .40
3. *Diptera*.....	1 .03	....	....	....	....	7 .28	1 .05	....	....	....	8 .05	....	....	....
Gnats.....	....	....	....	....	....	7 .28	1 .05	....	....	....	8 .05	....	....	....
Muscidæ.....	1 03	....	....	....	....	....	....	....	....	....	....	....	....	....
4. *Coleoptera*.....	2 .15	3 †	1 .98	1 .30	1 .05	7 .25	3 .47	11 .22	2 .15	18 .29	43 .26	1 .30	2 .11	2 .60
Carabidæ.....	2 .05	....	....	1 .30	....	....	....	3 .04	....	....	4 .02	....	....	....
Nitidulidæ.....	....	....	....	....	....	....	....	1 .01	....	....	1 †	....	....	....
Histeridæ.....	....	....	....	....	....	....	1 .03	3 .04	....	1 .01	5 .01	....	....	....
Trogositidæ.....	....	....	....	....	....	....	....	....	....	....	....	....	....	1 .01
Scarabæidæ.....	1 .08	3 †	1 .98	....	....	3 .14	3 .08	7 .11	1 .02	9 .15	23 .12	1 .25	1 .03	3 .50
Anomala binotata	1 .08	....	....	....	....	2 .09	....	2 .04	1 .02	4 .10	9 .06	....	1 .03	3 .50
Elateridæ.....	....	....	....	..	....	...	1 .01	....	....	2 .01	3 .01	....	1 .04	1 .01
Lampyridæ.....	....	....	....	....	....	....	....	....	1 †	....	1 †	....	....	....
Cerambycidæ.....	1 .02	....	....	....	....	....	....	....	....	....	....	....	....	3 .06
Psenocerus supernotatus.....	....	....	....	....	....	....	....	....	....	....	....	....	....	1 .02
Chrysomelidæ.....	....	....	....	....	....	2 .01	....	....	....	....	2 †	1 .02	....	....

TABLES OF THE FOOD — Continued.

	Warbling Vireo.	Cedar Wax-wing.	Cliff Swallow.	American Goldfinch.	Yellow-winged Sparrow.	Chipping Sparrow	Field Sparrow.	Black-throated Bunting.	Rose-breasted Grosbeak.	Indigo Bird.	Total.	Cowbird.	Red-winged Blackbird.	Baltimore Oriole.
Number of Birds	3	7	1	1	1	8	3	14	2	18	47	1	2	3
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Rhynchophora	....	....	....	....	....	1 .01	3 .08	6 .02	2 .08	6 .03	18 .03	....	1 .04	1 .02
5. *Hemiptera*	1 .03	....	....	....	....	5 .06	1 .01	....	....	1 †	7 .01	....	1 †	....
Homoptera	....	....	....	....	....	....	....	....	....	1 †	1 †	....	1 †	....
Heteroptera	....	....	....	....	....	1 .03	....	....	....	....	1 †	....	....	....
Lygæidæ	....	....	....	....	....	1 .03	....	....	....	....	1 .01	....	....	....
Cydnidæ	1 .03	....	....	....	....	....	....	....	....	....	....	....	....	....
6. *Orthoptera* (Acrididæ)	....	....	....	....	....	....	....	....	....	....	....	....	1 .10	....
III. ARACHNIDA	....	....	....	....	1 .30	6 .01	2 †	....	....	....	9 .01	....	....	....
Vegetable Food (seeds)	....	....	....	1 70	1 .35	4 .04	....	3 .06	2 .20	6 .03	17 .07	1 .70	2 .50	....
Compositæ	....	....	....	....	....	....	....	....	....	2 .01	2 .01	....	....	....
Polygonum	....	....	....	....	....	....	....	....	....	....	....	1 .05	1 05	....
Wheat	....	....	....	....	....	....	....	1 .05	....	....	1 .02	....	1 .45	....
Setaria	....	....	....	....	1 .15	2 .01	....	2 †	....	2 .01	7 .01	....	....	....
Corn	....	....	....	....	....	....	....	....	....	....	....	1 .60	....	....
Panicum	....	....	....	....	....	1 .01	....	....	....	....	1 †	....	....	....

TABLES OF THE FOOD — Continued.

	Icteridæ			Tyrannidæ.					Cuculidæ.	Picidæ.			Columbidæ.	Perdicidæ.
	Orchard Oriole.	Bronzed Grackle.	Total.	King Bird.	Wood Pewee.	Traill's Flycatcher	Yellow-bellied Flycatcher.	Total.	Black-billed Cuckoo.	Red-headed Woodpecker.	Flicker.	Total.	Mourning Dove.	Quail.
Number of Birds	2	3	11	3	3	2	1	9	1	4	1	5	1	2
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
	2	3	11	3	3	2	1	9	1	4	1	5		2
Animal Food	1 00	.38	.68	1.00	1.00	1 00	1.00	1.00	1 00	.80	1.00	.84	....	.04
	2	3	11	3	3	2	1	9	1	4	1	5		2
II. INSECTA	1.00	.30	.66	1 00	1.00	1.00	1.00	1.00	1.00	.80	1.00	.84	....	.04
	1		1	1	2	2	1	6		1	1	2		
1. *Hymenoptera*	.03	....	.01	.05	.12	.48	.02	.16	....	.01	1.00	.21	....	....
	1		1		1	1		2		1	1	2		
Formicidæ	.03	....	.01	....	.04	.05	....	.02	....	.01	1.00	.21	....	....
						1		1						
Ichneumonidæ	....	....	....	....	....	.33	....	.07	....	....	....	....	....	....
	2		7	2	1	1	1	5	1	1		1		
2. *Lepidoptera*	.97	....	.34	.28	.05	.25	.30	.20	.95	.15	....	.12	....	....
			1											
Noctuidæ (larvæ)	....	....	.05	....	....	....	....	....	....	....	....	....	....	....
Nephelodes violans (larvæ)	....	....	1 .05	....	....	....	....	....	....	....	....	....	....	....
	2		6	2		1		3	1	1		1		
Phalænidæ (larvæ)	.77	....	.25	.28	....	.25	....	.15	.75	.15	....	.12	....	....
	2		6	2		1		3	1	1		1		
Anisopteryx vernata	.77	....	.25	.28	....	.25	....	.15	.75	.15	....	.12	....	....
					3		1	4						
3. *Diptera*	....	....	....	....	.55	....	.08	.19	....	....	....	....	....	....
							1	1						
Tipulidæ	....	....	....	....	....	....	.08	.01	....	....	....	....	....	....
					1			1						
Gnats	....	....	....	....	.23	....	....	.08	....	....	....	....	....	....
					2			2						
Muscidæ	....	....	....	....	.32	....	....	.10	....	....	....	....	....	....
		3	8	3	2	2	1	8	1	4		4		2
4. *Coleoptera*	....	.30	.29	.67	.28	.25	.50	.43	.05	.64	....	.51	....	.04
		3	3							2		2		1
Carabidæ	....	.16	.04	....	....	....	....	....	....	.24	....	.19	....	.01
					1			1						
Nitidulidæ	....	....	....	....	.10	....	....	.03	....	....	....	....	....	....
			1											
Trogositidæ	....	....	†	....	....	....	....	....	....	....	....	....	....	....
		1	1											
Lucanidæ	....	.08	.02	....	....	....	....	....	....	....	....	....	....	....
		1	6	3	2	2	1	8	1	3		3		
Scarabæidæ	....	.01	.17	.58	.18	.10	.40	.33	.05	.29	....	.23	....	....
			4	2			1	3		2		2		
Anomala binotata	....	....	.14	.43	....	....	.25	.17	....	.04	....	.03	....	....
		1	3	1				1		2		2		
Elateridæ	....	.05	.03	.07	....	....	....	.02	....	.09	....	.07	....	....
				1				1						
Lampyridæ	....	....	....	.02	....	....	....	.01	....	....	....	....	....	....
			3				1	1						
Cerambycidæ	....	....	.02	....	....	....	.10	.01	....	....	....	....	....	....
Psenocerus supernotatus	....	....	1 .01	....	....	....	1 .10	1 .01	....	....	....	....	....	....
			1											1
Chrysomelidæ	....	....	†	....	....	....	....	....	....	....	....	....	....	.02

TABLES OF THE FOOD — Concluded.

	Orchard Oriole.	Bronzed Grackle.	Total.	King Bird.	Wood Pewee.	Traill's Flycatcher.	Yellow-bellied Flycatcher.	Total.	Black-billed Cuckoo.	Red-headed Woodpecker.	Flicker.	Total.	Mourning Dove.	Quail.
Number of Birds.....	2	3	11	3	3	2	1	9	1	4	1	5	1	2
KINDS OF FOOD.	NUMBER OF SPECIMENS AND RATIOS IN WHICH EACH ELEMENT OF FOOD WAS FOUND.													
Rhynchophora	....	1 †	3 .01	....	....	....	....	....	....	....	....	....	...	1 .01
5. *Hemiptera*.....	....	....	1 †	...	....	....	1 .10	1 .01	....	....	....	....	...	....
Homoptera.....	....	....	1 †	....	....	....	....	....	....	....	....	....	....	....
Cydnidæ.....	....	....	....	....	....	....	1 .10	1 .01	....	....	....	....	....	....
6. *Orthoptera* (Acrididæ).....	....	....	1 .02	....	....	....	....	....	....	....	....	....	....	....
V. CRUSTACEA (Crawfish).....	....	1 .08	1 .02	....	....	....	....	....	....	....	....	....	....	....
Vegetable Food (Seeds)	....	3 .62	6 .32	....	....	....	....	....	....	2 .20	2 .16	....	1 1.00	2 .96
Leguminosæ.....	....	....	....	....	....	....	....	....	....	....	....	....	1 .25	1 .02
Compositæ.....	....	....	....	....	....	....	....	....	....	....	....	....	....	1 .32
Polygonum.....	....	....	2 .01	....	....	....	....	....	....	....	....	....	....	2 .03
Wheat.....	....	....	1 .08	....	....	....	....	....	....	....	....	....	....	....
Setaria.....	....	....	....	....	....	....	....	....	....	....	....	....	....	1 .02
Corn.....	....	3 .62	4 22	....	....	....	....	....	....	2 .20	2 .16	....	1 .75	2 .57

GENERA AND SPECIES RECOGNIZED IN THE FOOD.

The following lists are intended to supplement the preceding tables and, taken together with them, to present all the details concerning the food of the birds observed in the orchard, upon which the foregoing discussion is based. In the first list the genera and species recognized in the food of each kind of bird are given separately ; in the second the food elements are systematically arranged, and against the name of each element the names of all the species of birds are placed in whose food that element was recognized. The figures preceding the names of the birds in the second list indicate the number of individuals in which the given element was found :

TURDIDÆ.

Turdus migratorius · Helix, Hyalina, Limnea humilis, Formica, Nephelodes violans, Anisopteryx vernata, Elaphrus ruscarius, Staphylinus badipes, Aphodius, A. inquinatus, Phyllo-

phaga, Anomala lucicola, A. binotata, Melanotus, Monocrepidius, Graphorhinus vadosus, Alydus eurinus, Cœnus delius, Hymenarcys, Polydesmus serratus, Lumbricus.

Mimus carolinensis: Formica, F. fusca, Lasius, L. niger, Nephelodes violans, Anisopteryx vernata, Clivina striatopunctata, Anisodactylus, Hister americanus, H. perplexus, Onthophagus, Aphodius, A. inquinatus, Phyllophaga, Anomala binotata, Melanotus, Graphorhinus vadosus, Tanymecus confertus, Baris, Sphenophorus, Cœnus delius, Podisus spinosus, Iulus.

Harporhynchus rufus: Anisopteryx vernata, Chlænius, Stenolophus conjunctus, Hister americanus, H. perplexus, Aphodius, Diplotaxis georgiæ, Anomala binotata, Melanotus, Monocrepidius, Baris confinis, Iulus.

SAXICOLIDÆ.

Sialia sialis: Anisopteryx vernata, Anisodactylus baltimorensis, Aphodius, Anomala binotata, Chrysomela suturalis, Diabrotica vittata, Cœnus delius, Hymenarcys æqualis, Euschistus.

PARIDÆ.

Parus atricapillus: Anisopteryx vernata, Psenocerus supernotatus.

TROGLODYTIDÆ.

Troglodytes domesticus: Anisopteryx vernata, Olibrus, Aphodius, Monocrepidius auritus, Psenocerus supernotatus, Blissus leucopterus, Iulus.

MNIOTILTIDÆ.

Helminthophaga peregrina: Anisopteryx vernata, Telephorus bilineatus.

Dendrœca æstiva: Anisopteryx vernata, Aphodius, Telephorus bilineatus, Psenocerus supernotatus.

Dendrœca pennsylvanica: Anisopteryx vernata, Psenocerus supernotatus.

Dendrœca striata: Anisopteryx vernata, Aphodius, Psenocerus supernotatus.

Dendrœca virens: Anisopteryx vernata, Psenocerus supernotatus.

Geothlypis trichas: Anisopteryx vernata, Psenocerus supernotatus, Piesma cinerea.

VIREONIDÆ.

Vireo gilvus: Anisopteryx vernata, Anomala binotata, Telephorus bilineatus, Euschistus.

AMPELIDÆ.

Ampelis cedrorum: Anisopteryx vernata, Aphodius inquinatus, A. femoralis.

HIRUNDINIDÆ.

Petrochelidon lunifrons: Aphodius inquinatus.

FRINGILLIDÆ.

Coturniculus passerinus: Setaria.

Spizella domestica: Anisopteryx vernata, Anomala binotata, Baris, Setaria, Panicum.

Spizella agrestis: Anisopteryx vernata, Onthophagus, Aphodius A. inquinatus, Monocrepidius, Baris, Sphenophorus.

Spiza americana: Helix, Agapestemon, Anisopteryx vernata, Anisodactylus, Ips fasciatus, Aphodius, A. inquinatus, Anomala binotata, Sphenophorus, Wheat, Setaria.

Zamelodia ludoviciana: Anisopteryx vernata, Anomala binotata.

Passerina cyanea: Aphidius, Anisopteryx vernata, Onthophagus, Aphodius, Anomala binotata, Monocrepidius, Baris, Setaria.

ICTERIDÆ.

Molothrus ater: Aphodius, Dibolia aërea, Polygonum, Corn.

Agelæus phœniceus: Nephelodes violans, Anisopteryx vernata, Anomala binotata, Tanymecus confertus, Polygonum, Wheat.

Icterus galbula: Anisopteryx vernata, Anomala binotata, Phymatodes variabilis, Psenocerus supernotatus.

Icterus spurius: Camponotus, Anisopteryx vernata.

Quiscalus purpureus æneus: Calosoma calidum, Dorcus parallelus, Crawfish, Corn.

TYRANNIDÆ.

Tyrannus carolinensis: Anisopteryx vernata, Aphodius inquinatus, Anomala, A. binotata, Melanotus.

Contopus virens: Ips fasciatus, Aphodius, A. inquinatus.

Empidonax trailli: Anisopteryx vernata, Anomala.

Empidonax flaviventris: Aphodius, Anomala binotata, Psenocerus supernotatus, Hymenarcys.

CUCULIDÆ.

Coccyzus erythrophthalmus: Anisopteryx vernata, Anomala.

PICIDÆ.

Melanerpes erythrocephalus: Camponotus, Anisopteryx vernata, Calosoma calidum, Scarites substriatus, Canthon hudsonias, Anomala binotata, Melanotus, Corn.

COLUMBIDÆ.

Zenaidura carolinensis: Corn.

PERDICIDÆ.

Ortyx virginiana: Chrysomela suturalis, Polygonum, Setaria, Corn.

Helix: 1 Turdus migratorius, 1 Spiza americana.

Hyalina: 1 Turdus migratorius.

Limnæa humilis: 1 Turdus migratorius.

Agapestemon: 1 Spiza americana.

Formica sp.: 1 Turdus migratorius, 1 Mimus carolinensis.

F. fusca: 1 Mimus carolinensis.

Lasius sp.: 1 Mimus carolinensis.

L. niger: 3 Mimus carolinensis.

Camponotus: 1 Icterus spurius, 1 Melanerpes erythrocephalus.

Aphidius: 1 Passerina cyanea.

Nephelodes violans: 3 Turdus migratorius, 1 Mimus carolinensis, 1 Agelæus phœniceus.

Anisopteryx vernata: 3 Turdus migratorius, 8 Mimus carolinensis, 2 Harporhynchus rufus, 1 Sialia sialis, 2 Parus atricapillus, 3 Troglodytes domesticus, 1 Helminthophaga peregrina, 5 Dendrœca æstiva, 2 Dendrœca pennsylvanica, 4 Dendrœca striata, 1 Dendrœca virens, 1 Geothlypis trichas, 3 Vireo gilvus, 7 Ampelis cedrorum, 2 Spizella domestica, 1 Spizella agrestis, 10 Spiza americana, 1 Zamelodia ludoviciana, 17 Passerina cyanea, 1 Agelæus phœniceus, 3 Icterus galbula, 2 Icterus spurius, 2 Tyrannus carolinensis, 1 Empidonax trailli, 1 Coccyzus erythrophthalmus, 1 Melanerpes erythrocephalus.

Elaphrus ruscarius: 1 Turdus migratorius.

Clivina striatopunctata: 1 Mimus carolinensis.

Calosoma calidum: 1 Quiscalus purpureus æneus, 1 Melanerpes erythrocephalus.

Scarites substriatus: 1 Melanerpes erythrocephalus.

Chlœnius: 1 Harporhynchus rufus.

Anisodactylus sp.: 1 Mimus carolinensis, 1 Spiza americana.

A. baltimorensis: 2 Sialia sialis.

Stenolophus conjunctus: 1 Harporhynchus rufus.

Staphylinus badipes: 1 Turdus migratorius.

Ips fasciatus: 1 Spiza americana, 1 Contopus virens.

Olibrus: 1 Troglodytes domesticus.

Hister americanus: 1 Mimus carolinensis, 1 Harporhynchus rufus.

H. perplexus: 1 Mimus carolinensis, 1 Harporhynchus rufus.

Dorcus parallelus: 1 Quiscalus purpureus æneus.

Canthon hudsonias: 1 Melanerpes erythrocephalus.

Onthophagus: 1 Mimus carolinensis, 1 Spizella agrestis, 1 Passerina cyanea.

Aphodius sp.: 1 Turdus migratorius, 1 Mimus carolinensis, 1 Harporhynchus rufus, 1 Sialia sialis, 1 Troglodytes domesticus, 1 Dendrœca æstiva, 1 Dendrœca striata, 1 Spizella agrestis, 3 Spiza americana, 1 Passerina cyanea, 1 Molothrus ater, 2 Contopus virens, 1 Empidonax flaviventris.

A. inquinatus: 1 Turdus migratorius, 1 Mimus carolinensis, 2 Ampelis cedrorum, 1 Petrochelidon lunifrons, 1 Spizella agrestis, 1 Spiza americana, 1 Tyrannus carolinensis, 1 Contopus virens.

A. femoralis: 1 Ampelis cedrorum.

Diplotaxis georgiæ: 1 Harporhynchus rufus.

Phyllophaga: 1 Turdus migratorius, 3 Mimus carolinensis.

Anomala sp.: 1 Tyrannus carolinensis, 2 Empidonax trailli, 1 Coccyzus erythrophthalmus.

A. lucicola: 1 Turdus migratorius.

A. binotata: 3 Turdus migratorius, 10 Mimus carolinensis, 2 Harporhynchus rufus, 4 Sialia sialis, 1 Vireo gilvus, 2 Spizella domestica, 2 Spiza americana, 1 Zamelodia ludoviciana, 4 Passerina cyanea, 1 Agelæus phœniceus, 3 Icterus galbula, 2 Tyrannus carolinensis, 1 Empidonax flaviventris, 2 Melanerpes erythrocephalus.

Melanotus: 1 Turdus migratorius, 1 Mimus carolinensis, 1 Harporhynchus rufus, 1 Tyrannus carolinensis, 1 Melanerpes erythrocephalus.

Monocrepidius: 1 Turdus migratorius, 1 Harporhynchus rufus, 1 Spizella agrestis, 1 Passerina cyanea.

M. auritus: 1 Troglodytes domesticus.

Telephorus bilineatus: 1 Helminthophaga peregrina, 1 Dendrœca æstiva, 1 Vireo gilvus.

Phymatodes variabilis: 1 Icterus galbula.

Psenocerus supernotatus: 1 Parus atricapillus, 2 Troglodytes domesticus, 3 Dendrœca æstiva, 2 Dendrœca pennsylvanica, 3 Dendrœca striata, 1 Dendrœca virens, 1 Geothlypis trichas, 1 Icterus galbula, 1 Empidonax flaviventris.

Chrysomela suturalis: 1 Sialia sialis, 1 Ortyx virginiana.

Diabrotica vittata: 1 Sialia sialis.

Dibolia aërea: 1 Molothrus ater.

Graphorhinus vadosus: 1 Turdus migratorius, 1 Mimus carolinensis.

Tanymecus confertus: 1 Mimus carolinensis, 1 Agelæus phœniceus.

Baris: 1 Mimus carolinensis, 1 Spizella domestica, 1 Spizella agrestis, 1 Passerina cyanea.

B. confinis : 1 Harporhynchus rufus.

Sphenophorus : 1 Mimus carolinensis, 1 Spizella agrestis, 1 Spiza americana.

Piesma cinerea : 1 Geothlypis trichas.

Blissus leucopterus : 1 Troglodytes domesticus.

Alydus eurinus : 1 Turdus migratorius.

Cœnus delius : 1 Turdus migratorius, 1 Mimus carolinensis, 1 Sialia sialis.

Hymenarcys : 1 Turdus migratorius, 1 Empidonax flaviventris.

H. æqualis : 2 Sialia sialis.

Euschistus : 1 Sialia sialis, 1 Vireo gilvus.

Podisus spinosus : 1 Mimus carolinensis.

Polydesmus serratus : 1 Turdus migratorius.

Iulus : 1 Mimus carolinensis, 1 Harporhynchus rufus, 1 Troglodytes domesticus.

Crawfish : 1 Quiscalus purpureus æneus.

Lumbricus : 1 Turdus migratorius.

Polygonum : 1 Molothrus ater, 1 Agelæus phœniceus, 2 Ortyx virginiana.

Wheat : 1 Spiza americana, 1 Agelæus phœniceus.

Setaria : 1 Coturniculus passerinus, 2 Spizella domestica, 1 Spiza americana, 1 Passerina cyanea, 1 Ortyx virginiana.

Corn : 1 Molothrus ater, 3 Quiscalus purpureus æneus, 2 Melanerpes erythrocephalus, 1 Zenaidura carolinensis, 2 Ortyx virginiana.

Panicum : 1 Spizella domestica.

ERRATA.

Page 6, line 12 from bottom; page 8, line 15; page 11, line 2; for *Cydnidæ*, read *Pentatomidæ*.

Page 17, line 9, before *Vireo*, omit *and*.

Page 23, above ARACHNIDA, for *Cydnidæ*, read *Pentatomidæ*.

Pages 25 and 27, above *Orthoptera*, for *Cydnidæ*, read *Pentatomidæ*.

Page 28, lines 2 and 8, for *Graphorhinus vadosus*, read *Epicærus imbricatus*.

Page 64, under *Hemiptera*, for *Siphonophora granariæ*, read *Aphis maidis*.

Page 69, line 5 from bottom, for *fresh-water*, read *local*.

Page 78, line 1, after *all*, insert *the*.

Page 82, line 7, for *character*, read *characters*.

Page 91, line 5, for *consisted*, read *consists*.

Page 92, line 2 from bottom, for *more*, read *most*.

Page 97, line 11, for *fory-six*, read *forty-six*.

Page 99, line 2, for *witn*, read *with*.

Page 101, lines 12 and 13 from bottom, for *structure*, read *structures*.

Page 105, line 23, for *aération*, read *aëration*.