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ART. I. ON THE COMMON SHREW-MOLE IN ILLINOIS

BY

FRANK ELMER WOOD, A.B.

ART. II. A STUDY OF THE FOOD OF MOLES IN ILLINOIS

BY

JAMES A. WEST, A.M.

ERRATA AND ADDENDA

Page 54, lines 3 and 2 from bottom, and elsewhere in Article III, for *Cassia chamaechrista* read *Cassia chamaecrista*.
Page 62, between lines 4 and 5 from bottom of table insert *Erigeron annuus*.
Page 101, table, after *Croton glandulosus* read var. *septentrionalis;* and for *Equisetum laevigatum* read *Equisetum hyemale* var. *intermedium*.
Page 131, line 3, for *coerulea* read *caerulea*.
Page 138, last line, for *Ziza* read *Zizia*.
Page 141, line 21 from bottom, dele *Diodia teres*.
Page 169, between lines 3 and 4, insert as follows:
Erigeron annuus (L.) Pers. An interstitial in the bunch-grass association in the Hanover area.
Page 177, line 5, for *eastward* read *westward*.
Page 209, line 3 from bottom, for *copalina* read *copallina*.
Page 210, line 13 from bottom, for *Diospyrus* read *Diaspyros*.
Page 211, line 5, for *Foresteria* read *Forestiera*.
Page 256, line 3 of table, for Dr. H. *M*. Pepoon read H. *S*. Pepoon.
Page 278, line 16, the fifth word should be in Roman type.
Page 286, line 6 (second column), page 295, list of secondary species (second column), and page 353, line 8 from bottom, for *hiemalis* or *hiemale* read *hyemale*.
Page 313, line 4 from bottom (first column), for *pedicularis* read *pedicularia*.
Page 315, line 10, second column, for *Apocynum* read *Apocynum*.
Page 323, line 3 from bottom, for *Cyperus* read *Scirpus*.
Page 330, line 14, for *virginianum* read *virginicum*.
Page 336, lines 3 and 2 from bottom, for *virginicum* read *virginianum*.
Page 337, line 2 from bottom, for *philadelphicum* read *philadelphicus*.
Page 339, in first list of invading species, for *Rhus hirta* read *Rhus typhina*.
Page 351, line 4 from bottom, for *xerophtic* read *xerophytic*.
Page 355, above line 6 from bottom, insert *Scirpus heterochaetus* Chase.
Page 356, line 14 from bottom, for *Symlocarpus* read *Symplocarpus*.
Page 360, line 14, for *Pirus* read *Pyrus*.
Page 362, after line 7, insert *Acer saccharinum* L.
Page 363, line 2 from bottom, for *quadiflorum* read *quadriflorum*.
Page 365, line 14, for *thapus* read *thopsus*.
Page 369, last line, for *Tanecetum* read *Tanacetum*.
Page 417, line 1, dele *the*.
Page 497, line 9 from bottom, for *neglible* read *negligible*, and in foot-note, for *Austalt* read *Anstalt*.
Page 498, line 4 from bottom, for *Lockport* read *Chillicothe*.
Page 500, line 13 from bottom, after *up* insert *in*.
Page 501, line 2 from bottom, for *dissolving* read *dissolved*.
Page 504, line 23, for *gryina* read *gyrina;* line 17, for *dentata* read *knickerbockeri*.
Page 506, line 11, for *vernata* read *ternata*.
Page 507, line 3 from bottom, for *Mazon* read *wagon*.
Page 513, line 19, for *Nepa* read *Zaitha;* line 18, and page 517, line 13 from bottom, page 520, line 12 from bottom, and page 532, line 4, read *naid* or *naids* for *naiid* or *naiids*.
Page 517, line 6 from bottom, for *pondweed* read *pickerel-weed*.

Page 519, for first sentence of last paragraph read as follows:

We have no exactly comparable chemical data for July; but analyses for August give percentages of saturation for Morris and Marseilles as follows: 20.4 per cent. at Morris on the 11th and 11 per cent. at Marseilles on the 12th; 16.35 per cent. at Morris on the 22d and 23d and 7.4 per cent. at Marseilles on the 24th and 25th.

Page 521, line 6 from bottom, and page 529, line 9, for *chrysoleucas* read *crysoleucas.*

Page 525, line 22, and page 536, lines 21 and 24, for *Ekmann* read *Ekman.*

Page 532, line 1, for *Ancyclus* read *Ancylus.*

Page 551, line 7, for *00* read *512.*

Page 615, second line above foot-note, for *106* read 94.

Page 616, line 1, for the second *Bündeln* read *Bündel;* line 2, for *Bündeln* read *Bündels;* line 3, for *aussern* read *ausseren;* line 6, for *zwcierlie* read *zweierlei.*

Page 629, line 12, for *kein* read *keinen.*

Page 634, line 9, for *unternommen* read *unternommenen;* and in line 14 from bottom, after *575* insert *13 fig.*

Plate III, Fig. 1, after the word *mixed* in legend insert *consocies of the.*

Plate IX, Fig. 2, dele the legend and read instead: Root-system of *Tephrosia virginiana,* exposed by blowing of the sand.

Plate X, Fig. 2, dele the legend and read instead: A blowout almost stabilized by bunch-grasses, especially *Leptoloma cognatum.*

Plate XXXIX, for *Calamogrostis* read *Calamagrostis.*

Plate LIV, exchange places of cuts, but not the legends.

Plate LXXXV, for *7* read *7c.*

ARTICLE II.—*A Study of the Food of Moles in Illinois.* BY JAMES A. WEST.

The moles which furnished the basis for this discussion were in part specimens collected in central Illinois at various times, whose stomachs had been preserved with the material of the State Laboratory of Natural History without definite data as to the special situation in which the moles were found, but chiefly specimens recently collected, nearly all trapped in 1907 and 1908 by Mr. F. E. Wood, assistant in the State Laboratory of Natural History.

In April, 1907, special interest in the subject of the feeding habits of the mole was stimulated by a letter from C. A. Rowe, of Jacksonville, Illinois, to Dr. S. A. Forbes, Director of the State Laboratory, under whose direction this investigation was undertaken. Mr. Rowe reported that moles had been very abundant in that locality for several seasons, and that they had been seriously destructive to seed-corn in recently planted fields. His letter was accompanied by the contents of a mole's stomach, which proved to be about 65 per cent. corn.

On account of the subterranean life of the mole its feeding habits are but little known. In captivity it is a voracious feeder, incapable of enduring any considerable period of starvation. The only accurate way, however, of determining the character of its natural food is to examine the material which it has actually eaten.

METHOD OF EXAMINATION

In studying the food of the mole we must examine and classify in detail the entire stomach contents of each specimen, and must estimate the amount of each of the food materials, taking account also of any undetermined residue. For this purpose sheets of filter-paper, twenty by twenty inches, were ruled into one-inch squares and placed on a sheet of glass. A stomach was then opened and the contents, put into a dish with alcohol, were broken up by agitation and thrown upon the filter-paper in a way to distribute the particles of food well over it. The material on each square was then examined and estimated separately. If the entire stomach content, or the greater part of it, was composed of one material—earthworms, for example—it was often possible to determine its character by simple inspection.

The contents of the stomachs examined were mainly earthworms, insects—either adults, larvæ, or pupæ—vegetation, and a miscellaneous remainder. The mole had commonly chewed its food so fine as to make it impossible to recognize the species of insects and their larvæ; nevertheless, the number specifically determined was sufficient to give a fair idea of the dominant character of the insect food.

GENERAL RESULTS OF THE EXAMINATION

The following table shows the per cent. of the various kinds of food in each stomach. There is no "miscellaneous" column, since stomach contents not otherwise assignable were rare, and may conveniently be mentioned later.

Accessions Number	Per cent.				Collection Data
	Earthworms	Adult Insects	Insect Larvæ	Vegetation	
1	10		90		
2	20	70	5	5	
3	60	20			
4	45	15	10	30	
5	25	5	70		
6		100			Urbana, Jan. 26, 1887. Well
7	60	10	30		Normal, April 17, 1883
8	75	10	10	5	Normal, April 19, 1883
9	45	20	35		Normal, 1887
10	30	10	30	30	Normal, 1877
11		20	10	70	Normal, July 29, 1884
12	55	15	30		Urbana, March 26, 1886
13			35	65	Jacksonville, April 20, 1907. Yard

Accessions Number	Per cent.				Collection Data
	Earthworms	Adult Insects	Insect Larvæ	Vegetation	
14	80	5	13	2	Jacksonville, May 21, 1907. Plowed field
15		95	5		Jacksonville, May 22, 1907. Woodland
16	5	10	55	30	Jacksonville, May 23, 1907. Garden
17	80		20		Jacksonville, May 23, 1907. Plowed field
18		40	60		Jacksonville, May 24, 1907. Garden
19	100				Jacksonville, May 24, 1907. Garden
20		80	15	5	Jacksonville, May 24, 1907. Plowed field
21	30	20	20	30	Jacksonville, May 24, 1907. Corn field
22			95	5	Jacksonville, May 24, 1907. Corn field
23	50	40		10	Jacksonville, May 25, 1907. Corn field
24	35	5	60		Jacksonville, May 26, 1907. Garden
25		5	75	20	Jacksonville, May 27, 1907. Garden
26	40		45	15	Jacksonville, May 27, 1907. Yard
27	10	85	5		Jacksonville, May 27, 1907. Woodland
28	15	5	70	10	Urbana, June 29, 1907. Woodland
29		50	25	25	White Heath, Oct. 17, 1907. Corn field; corn cut and shocked
30		5	5	90	White Heath, Oct. 17, 1907. Corn field; corn cut and shocked
31	75	5	20		Staley, Oct. 26, 1907. Sod
32		80	20		Topeka, October 30, 1907. Corn field
33		65	35		Urbana, April 4, 1908. Dooryard
34	100				Urbana, April 17, 1908. Woods

Accessions Number	Per cent.				Collection Data
	Earthworms	Adult Insects	Insect Larvæ	Vegetation	
35	30	25	40	5	Urbana, May, 15, 1908. Cemetery
36	20	20	25	35	Urbana, May 22, 1908. Cemetery
37	15	20	60		Urbana, May 28, 1908. Cemetery
38		15	65	20	Urbana, June 1, 1908. Corn field
39			80	20	Urbana, June 1, 1908. Cemetery
40		10	90		Urbana, June 2, 1908. Cemetery
41	30	25	40	5	Urbana, June 2, 1908. Cemetery
42		40		60	Urbana, June 3, 1908. Corn field
43			95	5	Urbana, June 4, 1908. Edge of corn near pasture
44			85	15	Urbana, June 4, 1908. Corn field
45	90		10		Urbana, June 9, 1908. Alfalfa
46			90	10	Urbana, June 10, 1908. Alfalfa
47		100			Urbana, June 10, 1908. Cemetery
48		100			Urbana, June 12, 1908. Cemetery
49	15	5	45	35	Urbana, June 12, 1908. Corn field
50	70	20	10		Urbana, June 13, 1908. Cemetery
51			100		Urbana, June 15, 1908. Alfalfa
52		60	40		Urbana, June 16, 1908. Clover
53		5	95		Urbana, June 17, 1908. Clover
54	30	40	30		Urbana, June 17, 1908. Clover
55	95			5	Urbana, June 18, 1908. Clover
56		80	20		Flora, Aug. 25, 1908. Orchard

The preceding table shows that 31 moles had eaten earthworms, which formed 26 per cent. of the total food of the 56 specimens; 53 had eaten insects, amounting to 62 per cent. of the total food, of which 36 per cent. was insect larvæ (contained in 47 stomachs), and 26 per cent. was adult insects (in 42 stomachs). The 3 moles which had eaten no insect food had taken earthworms, and one of them a little grass. Vegetable matter was present in 28, to the amount of 11 per cent. of the total food. About 1 per cent. of the stomach contents are classed as miscellaneous. This includes spiders, myriapods, needles from a spruce tree, mole hair, and feathers, these various items each occurring but once, except spiders, which were found twice.

Before entering into further details it seems desirable to add a table giving a summary exhibit of the situations where the fifty-six moles were taken, the number from each situation, and the number of occurrences of the different kinds of food, classified in relation to situation. The table, page 19, although very imperfect, may serve a useful purpose to those pursuing the subject later.

DETAILS OF THE FOOD.

Such kinds of their food as are quite generally distributed—earthworms, some insect larvæ, and adult insects, for example—are very frequently and freely eaten by moles. This is evident in the case of earthworms, white-grubs (larvæ of *Lachnosterna* and *Cyclocephala*), cutworms, wireworms, ground-beetles and their larvæ, and the common brown ant. Fragments of at least 9 white-grubs were present in one stomach; and the bronzed, the W-marked, the glassy, and the dingy cutworms were all identified. Among *Carabidæ*, the following genera were distinguished: *Pterostichus*, *Agonoderus*, *Bembidium*, *Harpalus*, *Platynus*, and *Geopinus*. *Geopinus incrassatus* had been eaten by a mole in the sand region near Havana, Illinois, where this insect is quite abundant. Other larvæ prominent in the food were sod web-worms and larvæ of the banded Ips, each occurring twice. One mole had eaten at least 18 sod web-worms, and another at least 85 larvæ of *Ips quadriguttatus*. May-beetles had been eaten only by moles living in sod in the months of May and June. Whenever present they formed a large part of the contents, and one stomach contained nothing else. The common corn-field ant, *Lasius niger americanus*, was present in several stomachs in large numbers. The single mole taken in winter (January) had eaten no less

Kinds of situations in which moles were taken	Number of moles from each situation	White-grubs	Cutworms	Wireworms	Carabid larvæ	Sod web-worm	Nitidulid larvæ	Carabid beetles	June-beetles	Elaterid beetles	*Lasius niger americanus*	*Camponotus*	*Solenopsis*	*Myrmica*	Corn	Vegetation	Earthworms
		Various items of food and number of stomachs in which each item was found															
Sod..........	14	4	4	3				5	5		1				2	4	7
Unknown......	12	5	1	1	4	1		6		2	4				1	4	10
Corn field......	11	5	2	2	2	1	2	4			1			1	7	2	3
Garden	5	2	3	1				1				1			1	1	3
Woodland ..	4							2				4				1	3
Clover..........	4		2					3		2	2					1	2
Alfalfa...... .	3	1	2	1												1	1
Plowed ground; not planted	3		2	1							1		2			1	2
Totals	56	17	16	9	6	2	2	21	5	4	9	5	2	1	11	15	31

than 150 specimens of this ant. The carpenter-ant, *Camponotus pennsylvanicus,* which usually nests in logs and stumps in shady woods, was found in the stomachs of all moles taken in woodlands and in one from a garden. Two more species of ants were recognized: *Solenopsis debilis,* present in two moles taken in plowed ground; and a *Myrmica,* probably *scabrinodis,* which was found in a single mole captured in a corn field. The click-beetles shown in the table formed but a small part of the total food, and but one buprestid was found. The abdomen of a wasp very much like that of *Tiphia* was found in a mole from a corn field, and a hymenopterous puparia had been eaten by one from an alfalfa field. Two noctuid pupæ occurred in the stomach of a mole from a corn field. It is unfortunate that an important part of the insect food must remain unclassified.

Corn was present in the stomachs of eleven moles, making 8 of the 11 per cent. of vegetable matter eaten by them. Five of these specimens were trapped in corn fields in spring, shortly after corn had been planted, and three of the five had burrowed along the planter track. Two were taken from fields in which the corn was cut and shocked, two were from lawns, and one was from a garden, corn being near at hand in each case. Indeed, corn had been carried into the run of one of the moles trapped in the lawn. Corn in some cases formed the principal part of the stomach content, in one instance 90 per cent. Six moles which probably had access to corn, had eaten none.

Some observations made in the spring of 1908 on the work of moles in corn fields illustrate the nature of the damage they may do. In one instance the writer saw a mole-run which followed the track made by a planter wheel for a distance of seventeen hills. Occasionally the mole had turned slightly out of its course; but it had immediately worked back into the packed soil. The corn had sprouted and was showing above ground. Fourteen hills in this strip were dead or dying, the kernel having been eaten away and the sprout left untouched. A similar instance is reported of eighteen hills, not all in the same row, destroyed, apparently by a single mole, after the corn had sprouted. In another case one or more moles, entering a corn field from a pasture adjoining, formed a network of burrows in an area ten hills wide by nineteen long. Eighty-nine corn hills were missing in this plot. Grass, grass-roots, seeds, etc., were frequently found in the mole stomachs, usually in small quantities, but

amounting in three cases to 30 per cent., and in one to 35 per cent. of the food.

The known dates of capture of the moles were as follows: January 1, March 1, April 5, May 17, June 19, July 1, August 1, and October 4. Seven of the fifty-six specimens were preserved without dates.

Twenty-eight of the stomachs were well filled with food, 21 were moderately filled, and in 7 there was but a small amount.

CONCLUSIONS OF OTHER WRITERS

In the Seventh Report of the Kentucky Agricultural Experiment Station (1894) H. Garman reports the examination of fourteen mole stomachs. He found some fragments of dead parts of grasses and other plants, taken, as he believes, by accident while animal food was being devoured, but no traces of fresh plant structures. He says: "I am disposed to acquit the mole of the charge of intentionally eating vegetation. I do not offer this as a final conclusion, however; more material should be studied."

Fifty stomachs containing food were examined by L. L. Dyche, as reported in Volume XVIII of the Transactions of the Kansas Academy of Science. He says that vegetable food, almost all of it corn, amounted to 3.7 per cent. of the whole. Corn was found in 4 stomachs, in the ratios of 10, 30, 60, and 65 per cent. of the food of these animals, respectively. The last two were taken in January and October. "It is evident," he says, "that the damage done to lawns, gardens, and fields by moles is due chiefly, not to the food the animals eat, but rather to their manner of securing it."

Another paper on this subject is published in Bulletin No. 31 of the Pennsylvania Department of Agriculture. Of 36 stomachs, examined by Harry Wilson, only one contained green tissue of grain, but this had been bitten off in pieces by the teeth of the mole. One mole, killed in the ground under a corn shock, contained corn about equivalent to a single kernel. Wilson believes that all the damage done by the eating of grains, seeds, and fibrous roots, and by the gnawing of tubers, which is attributed to moles is due to mice, for it is a fact, he says, that the runways of the mole are often occupied during the latter part of the summer by the common brown field- or meadow-mouse.

CONCLUSION

The contents of the stomachs here reported, have shown perhaps a greater amount of insect food and somewhat smaller ratios of earthworms than those examined by other writers, but there is a substantial agreement to the effect that half or more of the food of the mole consists of insects and their larvæ, most of them noxious. So far as its food is concerned, the mole is thus beneficial, on the whole. There is no direct evidence that it will eat potatoes or other tubers, but circumstantial evidence on this point is so strong that the mole must remain under suspicion, even admitting that mice of herbivorous habit may occupy mole-runs in fall. In this paper it is shown, for the first time, that corn may form an important item of the food of moles; that recently planted corn is sometimes destroyed by them; and that if numerous in corn fields in spring, they are capable of doing considerable damage there.

October, 1910.