in the enclosure, cover them with the coverglass, place a drop of solution containing paramecia at the opening in the enclosure, and then study the process of feeding under low or high power at the place where the two solutions meet. Didinia thus enclosed can be studied for hours without danger from drying and if put into a damp chamber when not in use they can often be kept for days. This is an excellent method for observation on all sorts of protozoa.

2. A few seconds after adding paramecia to a solution containing many didinia kill them suddenly by flooding the dish with a liberal supply of Worcester's fluid. If the animals are killed at just the right time specimens in all stages of the process of feeding will be found. These can be mounted and studied at leisure under any magnification desired. If the animals are treated with glycerine as described above the different structures stand out very distinctly. I used this method in demonstrating the protective function of the trichocysts. In order to do this it is, however, necessary to have relatively large paramecia and small didinia.

Another very interesting and instructive process that can be observed readily in *Didinium* is encystment. Although this is a protective process of the greatest importance in many organisms, it is rarely studied first hand. Didinia can be induced to encyst almost any time by cutting off the food supply and adding considerable decaying organic matter, and as previously stated they can be induced to develop and become active again by adding a strong culture of paramecia. Different stages in these processes can frequently be seen, as for example the disappearance of the cilia, mouth seizing-organ, macronucleus, etc.

Conjugation occurs abundantly at times in *Didinium,* but the environmental factors necessary to induce it have not as yet been ascertained with sufficient accuracy to make this form at all favorable for the study of this process. Fission, on the other hand, occurs more frequently than in *Paramecium* and many other protozoa and the essential features in the process are easily worked out.

It seems to me then that owing to the readiness with which *Didinium* can be procured at any time, the ease with which its structures can be worked out, and the possibility of observing the phenomena of fission and encystment and especially the marvelous process of feeding, this animal should become as familiar in biological laboratories as *Paramecium* now is. In fact, the study of *Paramecium* must be regarded as very superficial indeed without observations on *Didinium* and its method of protection against this deadly enemy.

LITERATURE

Balbiani, E. G. 1873. "Observations sur le *Didinium nasutum*," *Arch. d. Zool. Exp.*, Vol. 2, pp. 363–394.

Thon, Karel. 1905. "Ueber den feineren Bau von *Didinium nasutum* O. F. M.," *Protistenkunde*, Vols. 5–6, pp. 280–315.

Mast, S. O. 1909. "The Reactions of *Didinium nasutum* (Stein) with Special Reference to the Feeding Habits and the Function of Trichocysts," *Biol. Bull.*, Vol. 16, pp. 91–118.

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THE NUMBERS OF INSECTS DESTROYED BY WESTERN MEDDOWLARKS (STURNELLA NEGLECTA)

Little definite data as to the exact numbers of insects destroyed by birds in a given locality has as yet been available. In connection with an investigation into the food habits of certain California birds now being carried on by the California State Board of Fish and Game Commissioners, and the University of California, considerable evidence as to the toll of insects taken by certain species of birds is being made available. With the help of the deputies of the commission it has been possible to collect birds in sufficient quantities for stomach examination, in some twenty different parts of the state, and in every month of the year. A knowledge of the food habits of the birds throughout the year is therefore at hand.

The western meadowlark (*Sturnella neglecta*) has been the subject of considerable complaint from the ranchers of the state, owing to its habit of pulling sprouting grain. The investigation has shown that this bird is guilty of destroying sprouting grain; but the evidence as to its value as a destroyer of insects is of greater interest. Some idea of the remarkable change of food habits during the year can be obtained from the following table.

COMPARISON OF THE FOOD HABITS OF THE MEADOWLARK FOR DIFFERENT MONTHS OF THE YEAR, 1911

Birds Collected in Grain Fields in the Vicinity of Red Bluff, Tehama County, Cal. Average of Six Birds for Each Month

Month	Per Cent. Animal Food	Per Cent. Vegetable Food	Per Cent. Beetles	Per Cent. Cutworms	Per Cent. Grain	Per Cent. Grasshoppers
January....	1.0	99.0	1.0		94	
February...	38.5	61.5	3.6	31.0	41.6	
March.....	87.2	12.8	22.7	20.6	10.6	
April.....	73.6	26.4	5.2	51.0		
May.....	99.9	.1	6.2	69.0		4
June.....	96.5	3.5	3.0	15.0		57.5
July.....	91.3	8.7	4.7		6.3	85.5
August.....	75.2	24.8	2.1		15.6	72.6
September..	88.0	12.0	7.8	3.2		61.2
October....	37.5	62.5	.5		47.1	35.6
November..	28.4	71.6	14.0	14.1	38.1	
December..	57.6	42.4	18.6	15.8	13.0	
Avs. for year	64.6	35.4	7.6	18.3	22.2	26.4

Grain appears to be resorted to when insects are not available. Beetles are taken the year round. Cutworms in the food reach a maximum in May, whereas grasshoppers reach a maximum in July, in this particular locality. A table showing the numbers of cutworms actually counted in the stomachs of meadowlarks taken at Red Bluff in February, March, April, May and June, and their per cent. of volume demonstrates the quantities of these pests destroyed by this species of bird. It will be noted that the numbers of cutworms consumed is greater when the worms are still of small size. The percentages represent the comparative volume of the different kinds of food found in the stomach. A few larvæ not typical cutworms, taken by the birds, are nevertheless classified under this heading.

TABLE SHOWING NUMBERS AND PERCENTAGES OF CUTWORMS CONSUMED BY MEADOWLARKS TAKEN IN THE VICINITY OF RED BLUFF, CAL.

1911	No. of Birds	No. of Cutworms	Per Cent. of Cutworms
February....	12	360	36.8
March.....	12	16	22.5
April.....	12	68	41.9
May.....	12	90	44.7
June.....	6	6	9.1
Totals.....	54	540	Av. 31.0

The value of meadowlarks as checks on the increase of grasshoppers is also attested by the accompanying table.

TABLE SHOWING NUMBERS AND PERCENTAGES OF GRASSHOPPERS CONSUMED BY MEADOWLARKS TAKEN IN THE VICINITY OF EL TORO, CAL.

1911	Number of Birds	Number of Grasshoppers	Average Number of Grasshoppers	Average Per Cent. of Grasshoppers
June.....	13	53	4	43.2
July.....	7	59	8.4	77.5
August.....	19	314	16.5	93.89
September.....	6	75	12.5	96.3
October.....	13	122	9.3	61.9
November.....	8	115	14.3	66.6
Totals and avs...	66	738	10.1	73.23

The numbers of grasshoppers were estimated by counting paired mandibles. Mandibles pass through the alimentary tract without being digested, as can be shown by an examination of the feces. Experiments with young meadowlarks has shown the time of digestion of grasshoppers to be between three and four hours. The numbers found in stomach examination doubtless represent, therefore, those which have been eaten during the preceding three or four hours, before the birds were killed. In order to ascertain some idea of the numbers consumed in a day, the average number per bird needs to be multiplied by four. It seems safe to conclude that the particular meadowlarks examined were averaging almost fifty grasshoppers a day. As many as twenty-eight pairs of mandibles were found in a single stomach.

Of course not all of the grasshoppers destroyed can be considered injurious, for only certain species become abundant enough to destroy crops. The main point to be noted

is that birds, if they feed on insects to the extent shown in this instance, must play a much more important part as checks on the numbers of insects than many people have hitherto believed.

Stomach examination has shown that a considerable percentage of the food of the western meadowlark is made up of ground beetles, these insects being eaten every month of the year. The harm done in destroying beetles considered beneficial because of their predacious habits (*e. g., Calosoma*) is in a large measure counteracted by the destruction of certain injurious elaterid (*e. g., D. rasterius*) and chrysomelid (*e. g., Diabrotica soror*) beetles. The stomach of a meadowlark taken at Big Pine, Inyo County, California, November 20, 1911, contained over thirty-six chrysomelid beetles of the species *Diabrotica soror*. In that this species is very destructive in the state, and as insecticides are seldom used as a means of control, any natural means of check becomes of importance, and should be so recognized.

A knowledge of the part played by certain birds in the economy of nature is yearly becoming more important and demands attention, lest the information needed be forthcoming too late. As the fairest test of the value of a bird is dependent on a knowledge of its food habits, the investigation in hand will help to demonstrate the economic value of those birds now considered of doubtful value. The investigation will not stop with a knowledge of the food habits alone, for the life history of each bird and its relation to its environment constitute factors almost as important, which must be considered. The justification of the investigation does not only lie in the increased information as to the food of birds, but in the saner protection which must necessarily follow the knowledge of the use of birds.

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THE MOSAIC DISEASE OF TOBACCO

DURING the past winter an investigation of the Mosaic disease of tobacco was undertaken by the writer. Mosaic has been generally regarded as a so-called physiological disease and it was planned to carry out the investigation along physiological lines. However, certain observations soon brought to light new facts which would seem to throw considerable doubt on former views as to the nature of the malady. It was found that insects are involved in the dissemination of the disease and the Bureau of Entomology has undertaken to follow up this phase of the problem. It will doubtless require considerable time to work out satisfactorily the questions involved, but it is thought desirable to announce the more important facts which have been established regarding this obscure disease.

Susceptibility of other Solanaceous Plants to the Mosaic Disease

Heretofore, no investigator has shown definitely that the mosaic disease of tobacco is communicable to other plants. The writer, however, has readily transferred the disease from tobacco to a great variety of solanaceous plants. By inoculation the disease has been obtained in plants of the following genera: *Nicotiana, Lycopersicon, Petunia, Physalis, Datura, Hyoscyamus, Solanum* and *Capsicum*. A mosaic plant of the species (*Solanum carolinense*) brought to the writer's attention, indicates that the mosaic disease of tobacco sometimes occurs in strictly wild plants.

Efforts to inoculate the common potato (*Solanum tuberosum*), the eggplant (*Solanum melongena*) and belladonna (*Atropa belladonna*) were without success. Among the species of *Nicotiana*, it has not yet been possible to develop the disease in the species *N. glauca* and *N. viscosum*.

Appearance of the Blossoms of Mosaic Tobacco Plants

The development of mosaic in all varieties of *Nicotiana tabacum* usually affects the in-