thoroughness to protect nearby sugar beets. It seems to be more desirable to recognize and destroy its favorite food plants and resort to the use of poisoned bran mash as soon as the insects are detected either on cultivated crops or on weeds.

In the season of 1915 at the suggestion of Assistant Entomologist J. R. Parker, of this office, a test of poisoned bran mash as a means of killing these insects was made at the Huntley Substation by Mr. Dan Hansen, who is in charge of the Station for the Office of Western Irrigation Agriculture, Bureau of Plant Industry, United States Department of Agriculture. Poisoned bran mash, prepared by the usual formula, was scattered among the weeds near the beet field where the insects were present in great abundance. The insects ate the mash greedily and the next day the dead insects could be found on the ground in great abundance and no living ones were seen. Mr. James Scilly, formerly agriculturist of the Billings Sugar Company, reported that he had placed the poisoned bran mash under burlap bags in the beet fields and stated that the adult beetles were attracted by the covering afforded and were killed by eating the poison.

PRESIDENT C. GORDON HEWITT: If there is no discussion, the next paper will be given by Mr. C. H. Richardson.

THE RESPONSE OF THE HOUSE-FLY TO CERTAIN FOODS AND THEIR FERMENTATION PRODUCTS¹

By C. H. RICHARDSON, *College of Physicians and Surgeons, Columbia University,
New York City*

Any economic study of the house-fly must obviously take into consideration the subject of food, for it is usually during its search for food that this insect is most intimately associated with man. That the house-fly has decided food preferences has already found expression in the various baits now used in fly traps. Previous studies on baits have been made largely with complex food mixtures and while they form a valuable contribution, it is felt that a more intimate knowledge of the attractive constituents of these preferred foods is highly desirable.

The experiments that form the basis of this paper were therefore conducted largely with solutions of known chemical compounds found in certain foods or their fermentation products which are eagerly sought by house-flies. They were performed at New Brunswick, N. J.,

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¹ Published by permission of the Director of the New Jersey Agricultural Experiment Station.

during the summer of 1916 and form a part of a larger project on the responses of the house-fly to environmental factors undertaken by the Entomological Department of the New Jersey Agricultural Experiment Stations. (Richardson 1916.)

A study of the food preferences of this insect is beset with numerous difficulties. Temperature and light affect the abundance, but more puzzling is the great difference in numbers often noted on two consecutive days when conditions of temperature, moisture and light appear to be nearly uniform. Many explanations are offered such as the appearance of new broods, disposition to migrate and the desire to vary the diet. These conditions necessitate the repetition of all experiments as isolated tests may lead to erroneous conclusions. The data given here must be considered as a preliminary treatment of this subject, awaiting further verification and extension.

HISTORICAL

Morrill (1914) studied the response of the house-fly to a variety of foods, some of the results of which have a direct bearing on the present investigation. Sucrose was comparatively unattractive when used in aqueous solution with formaldehyde. The addition of ethyl alcohol (95 per cent), one part to twenty parts of water, increased its attractiveness. Vinegar in combination with sucrose was eagerly sought by house-flies. This may be due to the acetic acid contained in it. Ethyl alcohol when added to beer did not form an attractive mixture. This result can probably be explained by the fact that American beers have an alcohol content close to the optimum for the house-fly. The addition of alcohol would render it less attractive. Morrill's studies point out the irregularity of response to the same bait on different days.

Buck (1915) conducted a similar series of experiments. He found that not less than 3 per cent nor more than 8 per cent of 95 per cent ethyl alcohol in water was a good bait. Sucrose was also found to be a valuable addition to various baits, sometimes increasing their attractiveness from 10 to 20 per cent.

METHODS

The experiments which are described here were performed on a shelf along the south side of a barn in a well-lighted location where flies were always plentiful. Screen-wire fly traps, 9 $\frac{3}{4}$ inches high and 6 inches in diameter were used in all experiments. The screen was given a coat of spar varnish to prevent rusting. White glazed earthenware dishes, 122 mm. in diameter with a capacity of 125 cc. were used as containers for the solutions. The metal trap pans and dishes were

carefully washed at the conclusion of each experiment. All solutions were made with distilled water.

The traps were placed in a linear series along the shelf three feet apart. Special care was exercised that no trap contained the same material or occupied the same position in the series in two consecutive experiments. Unless otherwise stated only one portion of a substance was used in each test.

The results given apply only to the house-fly (*Musca domestica* L.) which made up more than 95 per cent of the catches during the summer.

EXPERIMENTS WITH CARBOHYDRATES

Because of the prevalence of carbohydrates in foods to which the house-fly is attracted, it was decided to test them rather thoroughly. Glucose (dextrose), fructose (levulose) and galactose were chosen from the monosaccharides; maltose, lactose and sucrose (cane sugar) from the disaccharides; and dextrin and starch from the polysaccharides. Solutions of 1 gram, 2 grams and 5 grams to 50 cc. of water were employed and 50 cc. were placed in each trap. The experiments with galactose were not completed owing to the difficulty of obtaining this compound. The results are expressed in the following table:

EXPERIMENTS ON CARBOHYDRATES

Material in 50 cc. dist. water	1 gm. 7/12 -15 75 hrs.	1 gm. 7/15 -18 67 hrs.	1 gm. 7/14 -18 89 hrs.	2 gm. 7/20 -21 28 hrs.	5 gm. 8/23 -25 22 hrs.	5 gm. 8/23 -25 41 hrs.	5 gm. 8/25 -28 76 hrs.	5 gm. 8/29 -30 20 hrs.	5 gm. 8/30 -31 24 hrs.	5 gm. 8/31 -9/2 45 hrs.	5 gm. 9/2-4 47 hrs.	Total last 4 expts.	Avg. last 4 expts.	Avg. last 6 expts.
Glucose (dextrose)			3	1				11	5	1	9	26	6.5	
Fructose (levulose)								3	1	5	76	85	21.2	
Galactose			0	63										
Maltose			1	14	2	21		5	2	1	8	16	4	6.5
Lactose			0	0		90	62	14	24	1	13	52	13	34
Sucrose			0	2		7	6	2	2	7	2	13	3.2	4.3
Dextrin					2	23		3	44	28	35	110	27.5	22.5
Starch	1	2						1	2	1	5	9	2.2	
Control (water)			0 ¹	4 ¹										

¹ Two traps used in experiment.

On the whole these carbohydrates in aqueous solution were not very attractive to house-flies. Considering all the experiments, lactose caught the largest number of flies (204), starch the least (12). Dextrin also caught a comparatively large number of flies (135). Sucrose was consistently a poor bait, catching but 26 flies in six experiments. From the foregoing tests, I believe it can be safely stated

that the common carbohydrates in freshly prepared aqueous solution are not eagerly sought by house-flies.

EXPERIMENTS WITH ALCOHOLS AND ACIDS

Foods containing large amounts of fermentable carbohydrates decompose with the formation of an extensive series of compounds, prominent of which are ethyl alcohol, carbon dioxide, acetic acid, lactic acid, a mixture of amyl and other higher alcohols called fusel oil and succinic acid. Of these ethyl alcohol, technical amylic alcohol (which contained a mixture of isoamyl and d-amyl alcohols, the former predominating) and acetic acid were used in six experiments and lactic and succinic acids in two experiments. Concentrations of 4 and 10 per cent were used for each compound except succinic acid. The results of these experiments follow:

EXPERIMENTS ON ALCOHOLS AND ACIDS

Material 50 cc.	8/28-29 22 hrs.	8/29-30 20 hrs.	8/30-31 24 hrs.	8/31-9/2 45 hrs.	9/4-7 66 hrs.	9/7-8 30 hrs.	Total	Av. per expt.	Av. per hr. (all experi- ments).
4% Ethyl Alcohol	146	67	37	82	14	545	891	148.5	4.3
10% Ethyl Alcohol	19	21	12	156	3	333	544	90.6	2.6
4% Amylic Alcohol (tech)	142	123	106	292	17	576	1,256	209.3	6.0
10% Amylic Alcohol (tech)	203	41	31	59	7	778	1,119	186.5	5.4
4% Acetic Acid	88	22	2	101	4	235	452	75.3	2.1
10% Acetic Acid	173	11	4	17	8	1,029	1,242	207	6.0
4% Lactic Acid	5	5					10	5	0.2
10% Lactic Acid	39	11					50	25	1.1
4% Succinic Acid	64	12					76	38	1.8

Four per cent ethyl alcohol caught 891 flies; 10 per cent 544 flies; 4 per cent amylic alcohol was considerably more attractive, catching 1,256 flies, while 10 per cent amylic alcohol caught 1,119 flies; 4 per cent acetic acid caught 452 flies, 10 per cent 1,242 flies, or nearly as many as the 4 per cent amylic alcohol. However, a comparison of the individual experiments shows that amylic alcohol gave more consistent results than acetic acid. Four per cent amylic alcohol was more than twice as attractive as 10 per cent acetic acid in four experiments while the acetic acid was more attractive, though not twice so, in two experiments. The results with lactic and succinic acids showed some attraction in two experiments.¹

¹ Experiments made by Barrows (1907) on *Drosophila ampelophila* Loew. (Journ. Expt. Zool., Vol. IV, No. 4, pp. 515-537) showed that this insect responded positively to amyl alcohol, ethyl alcohol, acetic acid and lactic acid, but that the most pronounced response was to a solution containing $2\frac{1}{2}$ per cent ethyl alcohol and $\frac{5}{8}$ per cent acetic acid.

EXPERIMENTS WITH CARBOHYDRATES IN SOLUTION WITH ACETIC ACID AND ALCOHOLS

Mixtures of maltose, lactose, sucrose and dextrin with ethyl alcohol, amylic alcohol and acetic acid were made, using five grams of the carbohydrate to fifty cubic centimeters of solution. The alcohols and acetic acid were made up in 4 per cent concentrations. The results are stated in the following table:

EXPERIMENTS ON CARBOHYDRATES WITH ALCOHOLS AND ACETIC ACID

Material 5 gm. in 50 cc.	8/22-23 22 hrs.	8/23-25 41 hrs.	8/25-28 76 hrs.	Total	Av. per Expt.	Av. per hour
Maltose and dist. water	2	21		23	11.5	0.3
Maltose and 4% ethyl alcohol	0	500		500	250	7.3
Maltose and 4 per acetic acid	5	100		105	52.5	1.6
Maltose and 4% amylic alcohol (tech)	638	440		1,078	539	17.1
Lactose and dist. water		90	62	152	76	1.2
Lactose and 4% ethyl alcohol		160	200	360	180	3.0
Lactose and 4% acetic acid		60	175	235	117.5	2.0
Lactose and 4% amylic alcohol (tech)		270	450	720	360.	6.1
Sucrose and dist. water		7	6	13	6.5	0.1
Sucrose and 4% ethyl alcohol		155	78	233	116.5	1.9
Sucrose and 4% acetic acid		75	28	103	51.5	0.8
Sucrose and 4% amylic alcohol (tech)		550	380	930	465.0	7.9
Dextrin and dist. water	2	23		25	12.5	0.3
Dextrin and 4% ethyl alcohol	11	400		411	205.5	6.5
Dextrin and 4% acetic acid	0	150		150	75	2.3
Dextrin and 4% amylic alcohol (tech)	2	944		946	473	15.0

In every case the attractiveness of the carbohydrates was increased by the addition of amylic alcohol, ethyl alcohol or acetic acid. Amylic alcohol was more effective when used with carbohydrate than when used alone; indeed, with maltose and dextrin it appeared to be remarkably attractive. Ethyl alcohol was more attractive with maltose and dextrin than when used in aqueous solution, but less so when used with lactose and sucrose. Acetic acid seemed to be about as attractive when used alone as when added to solutions of the carbohydrates employed in these experiments.

EXPERIMENTS WITH OTHER FOOD SUBSTANCES

WHEAT FLOUR:—The fact that bread has some value as a fly bait, especially when added to other mixtures, led to a study of the attractive constituents of wheat flour. Owing to a lack of time, it was not possible to carry this investigation very far.

Starch and two proteins, gliadin and glutenin make up the larger part of wheat flour. I have already spoken of the unattractiveness of starch. The present experiments concern the effectiveness of certain proteins and the water soluble portion of white flour.

By kneading white flour dough in water till practically all the starch granules are detached, it is possible to prepare a substance consisting largely of gliadin and glutenin known as crude gluten. The crude gluten cannot be entirely freed of water soluble substances by this method. Small amounts of crude gluten in water attracted only six flies, in two experiments, while equal amounts of white flour in water captured 332 flies. In view of the poor success of crude gluten it did not seem advisable to try gliadin and glutenin separately.

Solutions of the water soluble ingredients of white flour contained, besides the starch granules in suspension, a number of water soluble proteins, especially albumin and proteose, organic and inorganic salts and small amounts of many other compounds. Three traps containing solutions of 1 gram of total dissolved substance to 50 cc. of water caught 2,112 flies. In other experiments three traps containing 1.35 grams each of dissolved material attracted 225 flies and 2.5 grams in two traps, 855 flies.

Solutions containing the water soluble ingredients without starch in suspension gave with 0.1 gram concentrations in 50 cc. of water the following results: three traps a total of 4 flies; two traps a total of 2,400 flies.

The experiments indicate that there is something present in these aqueous solutions of white flour which strongly attracts house-flies. Experiments which extended over a period of 67 to 75 hours were on the whole more successful than those whose duration was shorter, 23 to 48 hours. These solutions improve on standing, apparently due to the formation of certain fermentation products.

MILK:—A few experiments were made on milk, prompted by the fact that it is a uniformly good fly bait. Fresh milk was acidified with dilute acetic acid till the caseinogen was precipitated. The liquid portion was separated from the caseinogen, which held much butter fat, by filtration. The caseinogen-fat mixture was unattractive to house-flies in two experiments. Fat-free caseinogen caught 77 flies in one experiment while butter fat (ether extract) caught only two flies.

These tests indicate that fat-free caseinogen is somewhat attractive to house-flies but are not conclusive. The experiments on carbohydrates, as already stated, show that flies are not attracted to milk sugar (lactose) in large numbers.

PRACTICAL APPLICATION

While it was not possible to subject any of the materials used in this investigation to rigorous field tests, a few experiments indicated that the water soluble part of wheat flour, technical amylic alcohol, and molasses solution containing amylic alcohol have considerable value as fly baits. The aqueous wheat flour solution was made up with 1 gram of sodium arsenite and 4 cc. of amylic alcohol to each 100 cc., the molasses was diluted with water 1 to 2 or 1 to 3 and the same amounts of sodium arsenite and amylic alcohol were added. The materials were exposed in shallow dishes. Many flies were poisoned, but without control over the breeding places it was impossible to effect a permanent reduction in their number. It should be added that amylic alcohol has certain drawbacks. It evaporates rather quickly and is only slightly soluble in water rendering an even mixture difficult.

CONCLUSIONS

The following conclusions are drawn from these experiments:

(1) Glucose, fructose, maltose, lactose, sucrose, starch and dextrin were not very attractive to house-flies. Lactose and dextrin caught the largest number of flies, starch the least. Sucrose was consistently a poor bait.

(2) Four per cent amylic alcohol gave better results than ethyl alcohol, or acetic acid in 4 or 10 per cent concentrations and better than 10 per cent amylic alcohol. Four per cent ethyl alcohol was better than 10 per cent, 10 per cent acetic acid gave better results than 4 per cent. Succinic and lactic acids showed some attractive qualities in two experiments.

(3) Maltose, lactose, sucrose and dextrin in 4 per cent solutions of amylic alcohol, ethyl alcohol and acetic acid were more frequently visited by house-flies than the corresponding aqueous solutions. Maltose and dextrin solutions were more effective than lactose or sucrose. The order of response to the alcohols and acetic acid containing carbohydrate was the same as that for the aqueous solutions of these compounds.

(4) Crude gluten from wheat flour was not attractive. The water soluble portion with or without starch in suspension was decidedly attractive.

(5) Several experiments with milk indicate that fat-free caseinogen is attractive while butter fat is not.

(6) Experiments indicate that aqueous solutions of wheat flour and molasses to which sodium arsenite and amylic alcohol are added have considerable value as poisoned baits for house-flies.

BIBLIOGRAPHY

BUCK, J. E. 1915. Fly Baits. Cir. 32. Alabama Agric. Experiment Station, Auburn, pp. 39.

MORRILL, A. W. 1914. Experiments with House-Fly Baits and Poisons. Journ. Econ. Ent., vol. VII, No. 3, pp. 268-274.

RICHARDSON, C. H. 1916. The Response of the House-Fly (*Musca domestica* L.) to Ammonia and other Substances. Bul. 292, New Jersey Agric. Experiment Stations, pp. 19, 1916. The Attraction of Diptera to Ammonia. Annals Ent. Soc. America, vol. 9, no. 4, pp. 408-413.

PRESIDENT C. GORDON HEWITT: This paper is now open for discussion.

MR. MAX KISLIUK, JR.: In the Bureau of Entomology during the summer of 1915, Mr. Hutchinson and I performed several baiting experiments similar to the ones reported by Mr. Richardson. Among some of the materials used was blood of pigs secured from a slaughterhouse. We tested sample traps and found that pig blood was very attractive—more so than any other material tried. Its odor, however, is very disagreeable to man, although it apparently attracts flies very strongly.

PRESIDENT C. GORDON HEWITT: The next paper will be read by Mr. W. E. Britton.

RECENT ANTI-MOSQUITO WORK IN CONNECTICUT

By W. E. BRITTON, *New Haven, Conn.*

At the Cleveland meeting of this Association, four years ago, the writer presented figures showing that in 1912 some 2,697 acres of salt marsh in Connecticut were ditched to prevent mosquito breeding (See JOURNAL OF ECONOMIC ENTOMOLOGY, vol. 6, p. 89).

In 1913 a contract was awarded for the elimination of all mosquito-breeding places in Greenwich from the shore inland for a distance of about two and one-half miles, at a cost of \$15,500. The major portion of the work related to inland breeding places such as fresh water swamps, the overflow from springs, and surface pools, but a small portion consisted of tide-water marsh which was ditched. The work was not finished until 1914.

Greenwich was formerly a malaria ridden community; it has been unofficially estimated on good authority that 900 cases of malaria occurred there in a single season. In 1914 up to September it was reported that there had been only 36 cases, of which only 15 were new ones. Since, according to several reports, there has been no malaria in Greenwich except a few hold-over cases. At any rate it seems to be