

THE RANGE OF FLIGHT OF *MUSCA*  
*DOMESTICA*<sup>1</sup>.

EXPERIMENTS CONDUCTED IN THE TOWN OF CAMBRIDGE.

*Introductory note.*

IT having been considered desirable that further experiments upon the range of flight of flies should be carried out, the investigation of the subject was entrusted to Dr E. Hindle and Mr G. Merriman, who are engaged in research in my laboratory. Although the experiments here recorded were carried out under somewhat adverse climatic conditions, they appear of sufficient interest to warrant publication, since the results with regard to the influence of wind seem to run counter to those recorded by previous workers, and also, apart from Hewitt's work referred to below, data have hitherto been wanting in respect of the range of flight of flies (*Musca domestica* Linn.) in towns. The simple graphic method of recording the results of the flight experiments, which occurred to me during the course of the work, may commend itself to others who may carry out similar investigations in the future.

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## REPORT UPON EXPERIMENTS.

BY EDWARD HINDLE, PH.D., AND GORDON MERRIMAN

*(From the Quick Laboratory, Cambridge.)*

(With 13 Charts.)

*Previous Investigations.*

THE first attempt to investigate this subject experimentally was that made by Dr Arnold, at Monsall Hospital, Manchester, in 1906 (recorded by Niven, 1906). Three hundred flies, each marked by a spot of enamel on the thorax, were liberated from the hospital and five were recovered at distances varying from 30 to 190 yards.

In 1910, Copeman, Howlett and Merriman (1911) made a number of experiments for the Local Government Board on the range of flight in open country. The investigations were carried out at Postwick (a small village about five miles east of Norwich), where the inhabitants suffered from a plague of flies, resulting from the breeding facilities afforded by a large refuse tip about half a mile away. Several thousands of chalk-powdered flies were liberated from the tip, which was situated in open country, the nearest cottages being about half a mile distant, and under these conditions invariably a number of the flies travelled distances exceeding 300 yards. In one case a fly travelled 1,700 yards, this distance being covered within 48 hours from the time of liberation. This constitutes the longest flight that has yet been recorded, although many of the flies in this series of observations were found to travel between 800 and 1,000 yards.

In these experiments, owing to the nature of the country, long distances had to be travelled before the flies could enter any houses. Therefore, the results, although important as showing the powers of flight, are no indication of the behaviour of flies in a locality where houses are many, and in consequence, food plentiful.

The same year J. S. Hine (1910), in the United States, also made an effort to determine the distance travelled by flies in open country. Three hundred and fifty flies were captured, coloured by means of spots of gold enamel, and liberated from a barn. The greatest distance at

which they were recovered was 240 yards from the point of liberation, but Hine remarks (cited by Howard, 1911, p. 55): "It appears most likely that the distance flies may travel to reach dwellings is controlled by circumstances. Almost any reasonable distance may be covered by a fly under compulsion to reach food or shelter. Where these are close at hand the insect is not compelled to go far, and consequently does not do so."

Howard (1911, p. 56) also mentions some experiments made under the direction of S. A. Forbes in Cook County, Illinois, U. S. America. Flies were trapped and, after being sprayed with a chemical solution, were then liberated from a hospital in that district. They were recovered at distances ranging up to a quarter of a mile from the point of liberation.

In the summer of 1911, Dr C. G. Hewitt (1912) carried out for the Board some experiments on this subject in Ottawa, Canada. The flies were coloured by spraying them with a solution of rosolic acid in 10 per cent. alcohol. The presence of a marked fly on a sticky fly-paper was indicated by its producing a ruddy colouration when the paper was dipped into slightly alkaline water. The flies were liberated from an island in the middle of the town and individual examples were recovered at distances of 520, 600, and 700 yards respectively. They were usually recovered in those areas of the town towards which the wind had been blowing.

As far as we are aware no other experiments upon this subject have been recorded, and it seemed desirable to obtain further information regarding the range of flight of flies in towns. The present investigation, therefore, was undertaken for the Local Government Board, in continuance of the work arranged for in 1910 (see p. 46, 3rd report on Flies as Carriers of Infection).

#### *Experiments conducted in Cambridge during 1912.*

During the months of July, August, and the first week in September, 1912, we conducted a series of experiments on the range of flight of *Musca domestica* Linn. in Cambridge. In the course of these experiments upwards of 25,000 flies have been liberated under very variable meteorological conditions, and 191 were recovered at one or other of about 50 observation stations employed for their recovery.

In all cases the flies for liberation were either caught in balloon traps or directly netted. The method of obtaining flies by breeding

was abandoned, as it was almost impossible to obtain them without numerous other species of insects, and also on account of the possible objections to such artificially-bred flies.

Prior to being liberated, the flies were kept for about 24 hours in cages made of mosquito netting and were fed on brown sugar, the moisture being supplied by a layer of damp sand. By this method it was assured that the insects had emerged sufficiently long to allow the full development of their chitinous exoskeleton, presumably necessary to obtain the full power of flight.

Preparatory to colouration, the flies were transferred from the mosquito cages into wire balloon traps. This transference was effected as follows:—the mosquito-netting cage was tied round the bottom of the balloon trap. The latter was then held towards the light and the whole of the cage surrounded with a black cloth. Owing to the strong attraction of the light, the insects all made their way towards the brightly-illuminated trap, and in passing through the small hole in the bottom of the latter, it was possible to make accurate counts of them, as not more than two or three were able to pass through at the same time. When about 1,500 flies had entered the balloon trap it was closed, then removed, and another trap fixed in its place.

The most satisfactory mode of marking the flies was found to be that devised by Nuttall (*vide* Jepson, 1909), and this was employed in all our experiments. The balloon trap containing the flies was placed in a large brown-paper bag, in which was a handful of powdered black-board chalk, coloured either red, orange, or yellow. The mouth of the bag was then closed, and the whole gently shaken for one or two minutes so that the flies were thoroughly dusted with the chalk. The balloon was then removed and after being taken to the point selected for the liberation, the trap was opened and the flies allowed to escape in any direction they chose. The flies were recovered either by means of fly-papers or balloon traps, several of which were exposed at the various observation stations. The traps and papers were examined for several successive days after the liberation of a number of coloured flies, and as the observation stations extended as far as 900 yards from the point of liberation, comprising both thickly and sparsely populated localities, an accurate idea of their distribution was thus obtained. Full meteorological data were kindly supplied by Messrs W. E. Pain, chemists, Sidney Street, Cambridge. Their observations were made in the centre of the town and in consequence indicated the exact meteorological conditions under which the flies travelled. In all, thirteen

experiments were completed, after which the investigations had to be concluded as a result of the bad weather.

When the flies were liberated in the morning, the traps and fly-papers were examined on the afternoon of the same day. Subsequently, however, the observation stations were visited every morning and, therefore, any flies then recovered would have been exposed mostly to the winds of the preceding days. This point should be remembered in examining the following results, for in some cases the flies seem to have travelled with the wind owing to its change of direction on the day of recovery.

Owing to the variable meteorological conditions, we consider it advisable to describe each of these experiments separately.

*Experiment 1.—16th–21st July, 1912.*

About 1,000 orange-coloured flies were liberated from the roof of the Medical Schools<sup>1</sup> at 11 a.m. on July 16th. The weather was warm and a light wind was blowing from the east, the conditions thus being favourable for the distribution of the flies. In spite of this, as will be seen from the following chart, only five examples were recovered, and these at comparatively short distances. However, since all the fly-papers and traps were set in buildings, the fine and warm weather prevailing at the time of the experiment would explain the few recoveries of marked flies, as cold and damp appear to be the main factors which cause these insects to seek shelter in houses. (See Chart 1.)

It will be noticed that of the five flies caught, all took a direction either across the wind, or somewhat against it. For example, on July 17th flies were recovered from three stations situated respectively E.N.E., N.W. by N., and W.S.W. These were recovered subsequent to the first day, none of them at a greater distance than 160 yards.

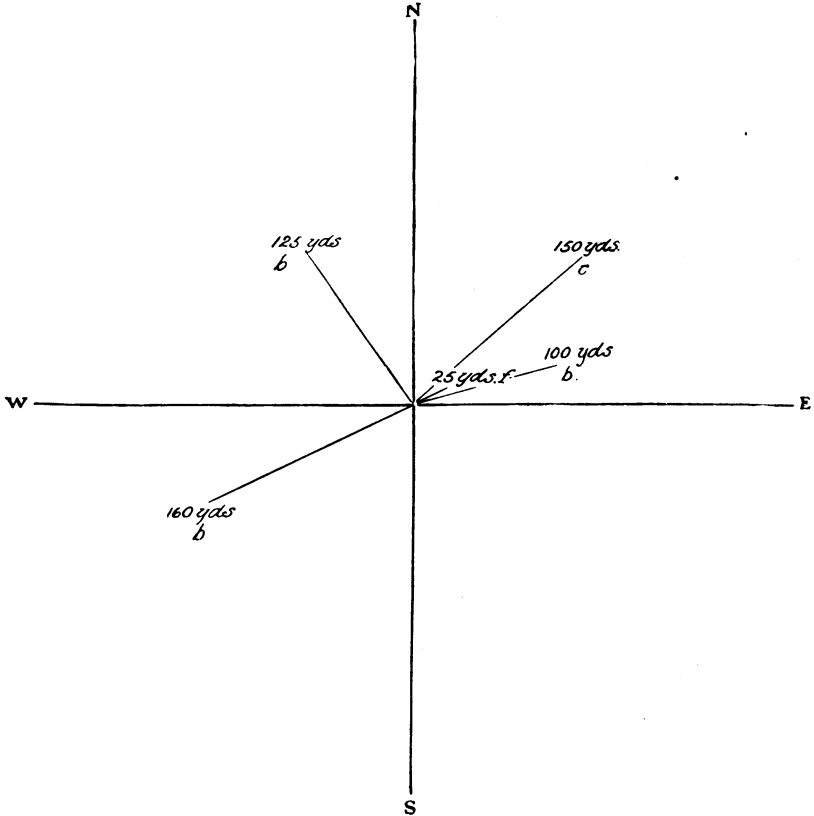
*Experiment 2.—20th–23rd July, 1912.*

1,650 red-coloured flies were liberated from the roof of the Medical Schools on July 20th. 1,050 were set loose at 10.30 a.m., and the remaining 600 at 1.15 p.m. The weather was warm, but later in the day was inclined to be showery, and probably owing to the latter fact a large number of flies were recovered at distances ranging up to as much as 650 yards. As will be seen from the accompanying chart (2), the

<sup>1</sup> A height of 45 feet.

*Musca domestica*

conditions prevailing throughout this experiment seem to be very favourable for the distribution of the flies, as 21 were re-caught. Here again, in all the longer flights the flies tended either to fly across or

Chart 1<sup>1</sup>.

100 yds. = 0.75 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
<i>a</i>	July 16	E.	6	89	59	0.0
<i>b</i>	„ 17	N.	8	89	58	0.0
<i>c</i>	„ 18	NNW.	7	78	57	0.0
<i>d</i>	„ 19	NW.	8	68	48	0.0
<i>e</i>	„ 20	N.	6	59	50	0.26
<i>f</i>	„ 21	SE.	3	68	56	0.02

<sup>1</sup> The letters at the points at which the marked flies were captured represent the day on which they were caught, *e.g.*, *a*=1st day; *b*=2nd day, and so on; *aa* would thus signify that two marked flies were caught on that day. The figures represent the distance from the point of liberation.

against the wind. For example, the individual that flew 440 yards was recovered from a station W.S.W. from the point of liberation, and that at 650 yards from a point S.E. by S., whilst in both cases the wind on the day of recovery and preceding day was S.W. and S.E. respectively. It should, however, be mentioned that three flies recovered at a distance of 275 yards had apparently flown directly down the wind, which was from the S.E. on the previous day.

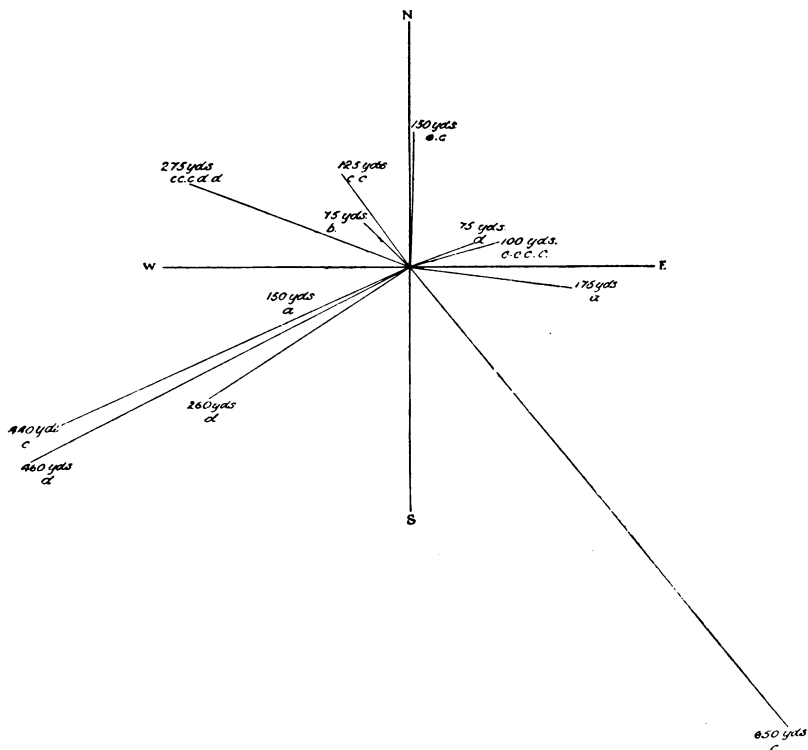


Chart 2.

100 yds. = 0.48 ineh.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	July 20	N.	6	59	50	0.26
b	„ 21	SE.	3	68	56	0.02
c	„ 22	SW.	2	75	56	0.0
d	„ 23	SE.	3	70	59	0.02

*Experiment 3.—23rd–27th July, 1912.*

1,350 yellow-coloured flies were liberated from the roof of the Medical Schools at 9.30 a.m. on July 23rd. The weather was warm and showery, with a slight S.E. wind blowing. Although the sun was shining at the time of liberation, a slight shower coming shortly afterwards drove a number of the flies (20–30) into the Quick Laboratory, which is situated on the ground floor of the Medical Schools. Possibly on account of this shower, a comparatively small number of flies were recovered at any of the stations, as they were mostly driven into buildings close at hand, for large numbers of the flies were observed to take shelter in the sheds below the point of liberation. One fly was recovered at a distance of 440 yards, to reach which, if it flew in a straight line, it had to pass over three high buildings. Yet again, the tendency of flies to travel *across* the wind was noticeable, as in this case the above-mentioned fly travelled in a S.S.E. direction, whilst the wind on the preceding day was W.S.W.

*Experiment 4.—26th–29th July, 1912.*

1,500 red-coloured flies were liberated from the roof of the Medical Schools at 9.30 a.m. on July 26th. The weather was warm and fine, and a moderate breeze was blowing. The fly which travelled the longest distance (400 yards) would appear, from the chart, to have travelled *with* the wind, and so constitute an exception to our rule, but as the fly was caught early on the morning of the 27th it had, therefore, mainly been subjected to the wind of the previous day. In this case it travelled in a N. by W. direction, whilst the wind of the previous day was W.S.W. We would also call attention to the fact that this entailed passing through the most thickly-housed part of Cambridge. One of our most striking instances of flies travelling deliberately *against* the wind is that afforded by an individual which was found in a trap 325 yards distant in a W. by S. direction, only 1½ hours after the time of liberation, although the wind was blowing steadily the whole time five miles an hour in a W.S.W. direction. (See Chart 4.)



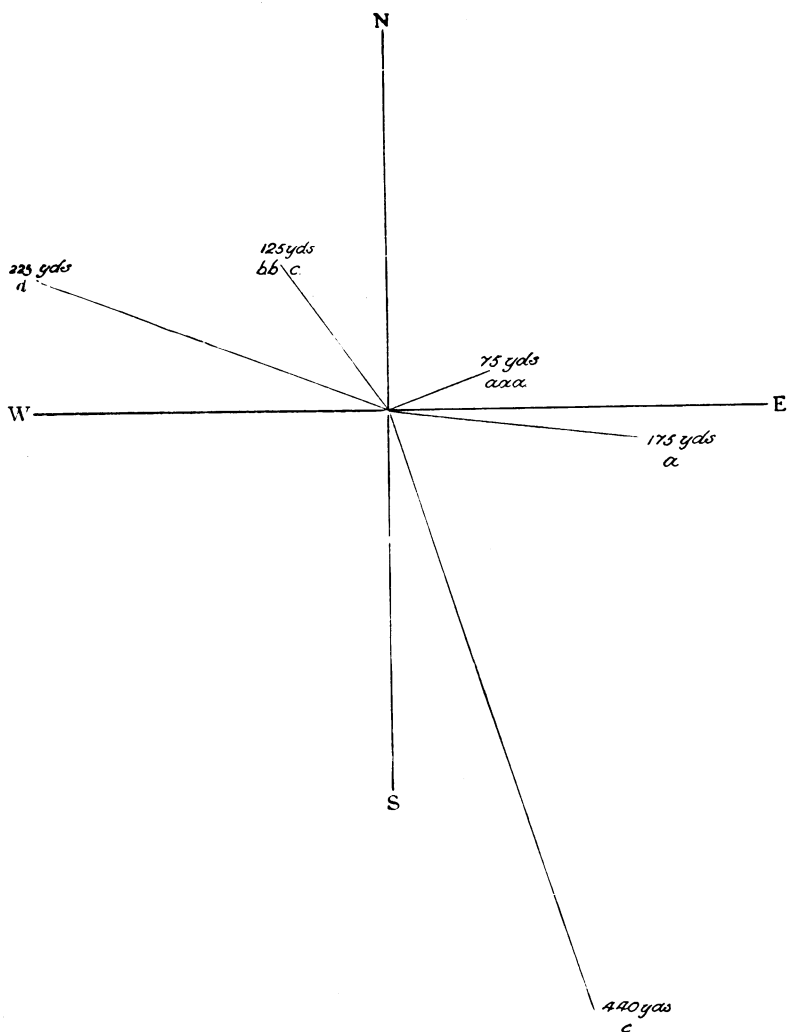


Chart 3.

100 yds. = 0.75 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	July 23	SE.	3	70	59	0.02
b	„ 24	SSE.	5	75	60	0.01
c	„ 25	S.	3	79	63	0.07
d	„ 26	WSW.	5	79	55	0.0
e	„ 27	SE.	4	76	62	0.13

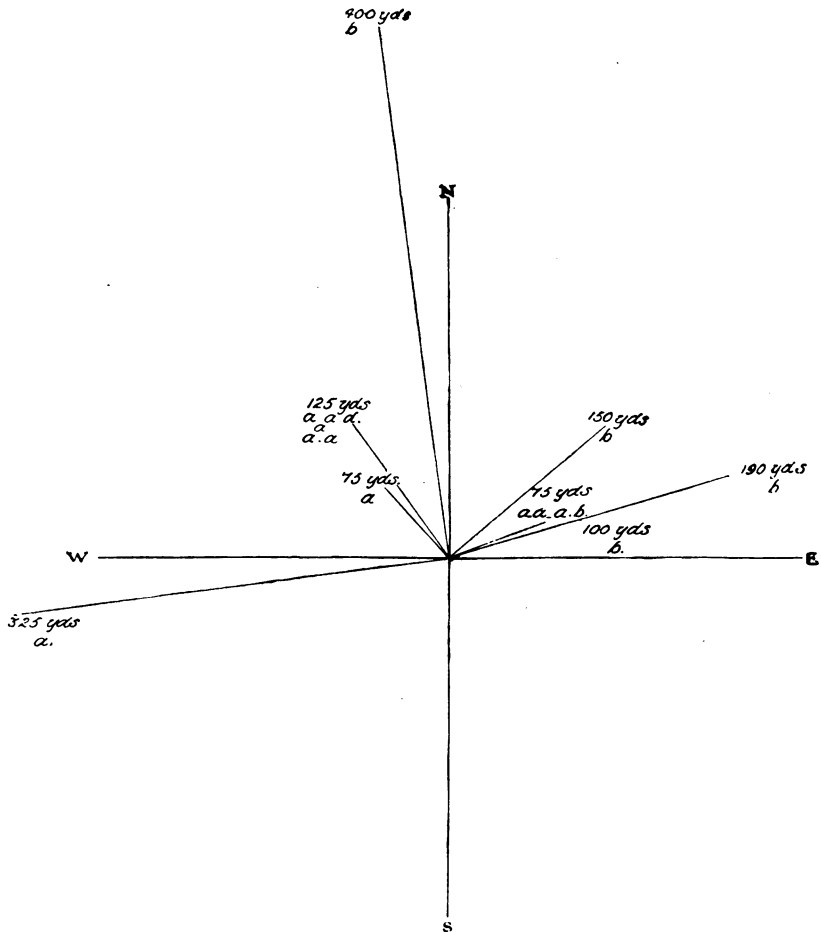
*Musca domestica*

Chart 4.

100 yds. = 0.7 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	July 26	WSW.	5	79	55	0.0
b	„ 27	SE.	4	76	62	0.13
c	„ 28	SW.	8	77	61	0.01
d	„ 29	SSW.	12	71	56	0.06

*Experiment 5.*—29th July—1st August, 1912.

1,500 orange-coloured flies were liberated at 11.15 a.m. on July 29th. In all our previous experiments the flies were liberated at an altitude of 45 feet, but in this case they were set free on the ground. The temperature was somewhat lower than on the previous occasions, and it

was raining slightly at the time of liberation, so that it is not surprising that only six flies were recovered. In spite of the strong wind (12 miles per hour) that was blowing throughout the whole period of the experiment, the two flies that travelled the longest distance were both recovered at a point S.W. by W., whilst the wind was from S.S.W. to W. (See Chart 5.)

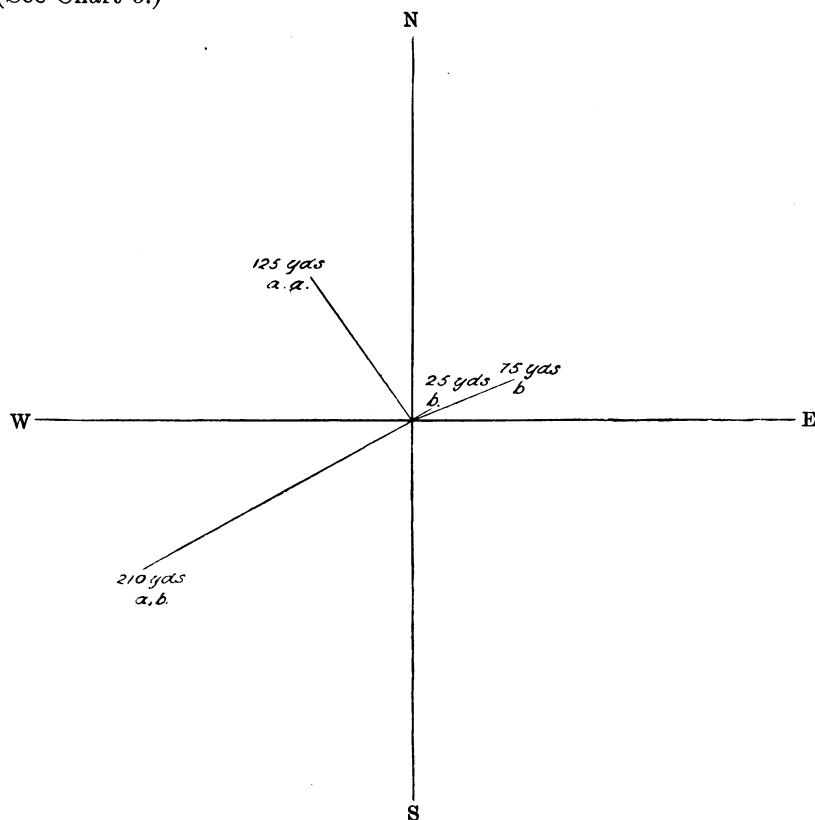


Chart 5.

100 yds. = 0.75 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	July 29	SSW.	12	71	56	0.06
b	„ 30	W.	12	65	53	0.08
c	„ 31	S.	8	69	52	0.0

*Experiment 6.*—6th–12th August, 1912.

2,400 red-coloured flies were liberated from the ground at 11.30 a.m. on August 6th. A strong wind (11 miles per hour) was blowing at the time of liberation, and several showers fell during the day, but,

*Musca domestica*

nevertheless, no less than 34 flies were recovered at distances ranging up to 325 yards from the point of liberation. It will be noticed that most of the 15 flies which travelled a distance of more than 150 yards had flown either across, or in the teeth of, the wind prevailing on the day previous to their recovery. In this case, a number of flies were recovered from rooms at an altitude of 30 feet, and in many cases the insects must have flown over buildings at least 50 feet high.

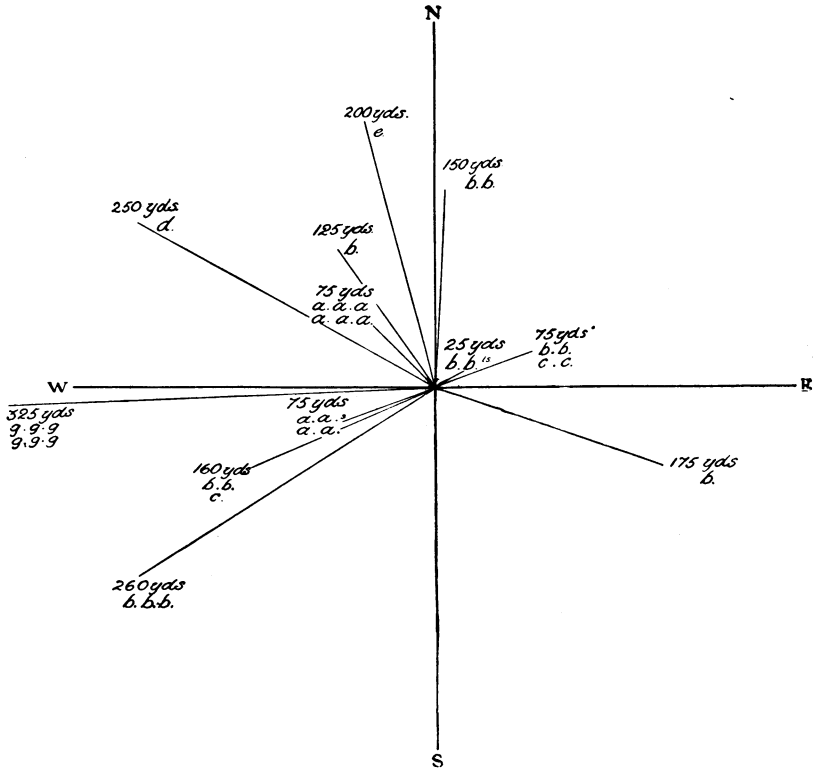


Chart 6.

100 yds. = 0.7 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	Aug. 6	SE.	11	68	56	0.1
b	„ 7	WSW.	10	65	53	0.2
c	„ 8	W.	8	66	52	0.16
d	„ 9	W.	6	67	54	0.04
e	„ 10	S.	5	67	52	0.0
f	„ 11	W.	6	66	49	0.08
g	„ 12	E.	4	64	49	0.03

Experiment 7.—9th–12th August, 1912.

3,000 yellow-coloured flies were liberated from the ground on the 9th of August at 11 a.m. The weather from now onwards was cold and

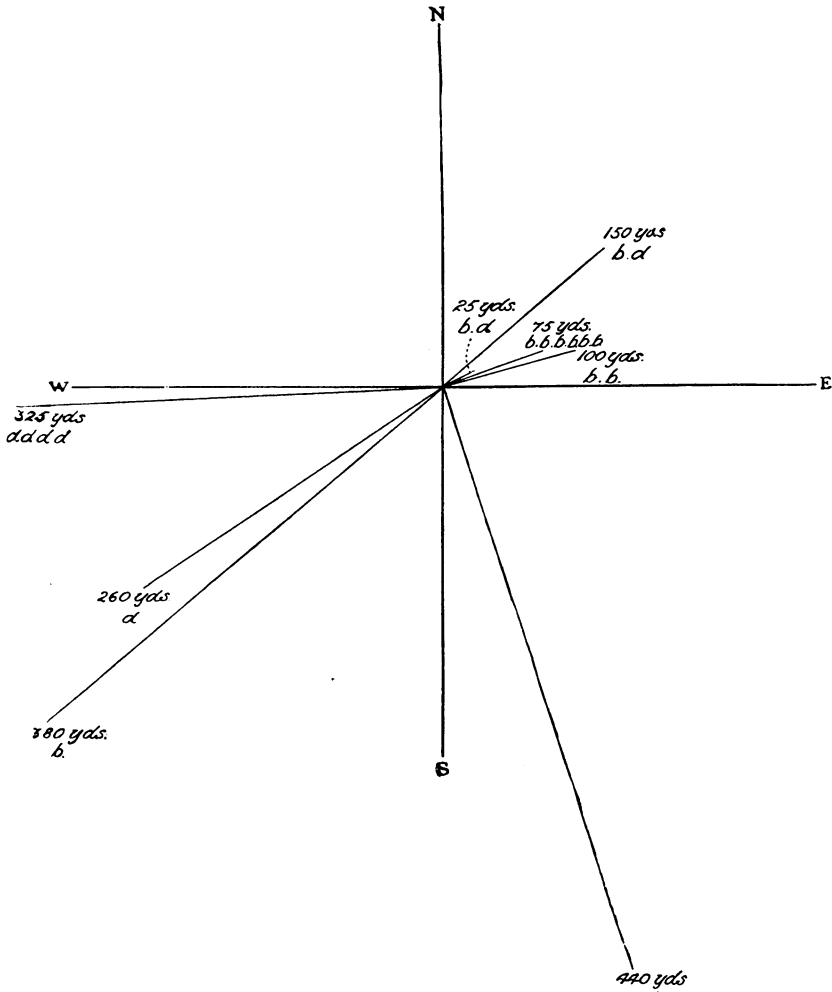


Chart 7.

100 yds. = 0.73 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	Aug. 9	W.	6	67	54	0.04
b	" 10	S.	5	67	52	0.0
c	" 11	W.	6	66	49	0.08
d	" 12	E.	4	64	49	0.08

rainy, so that the conditions were somewhat unfavourable for the distribution of the flies. In this experiment, however, 19 flies were recovered at stations up to a quarter of a mile distant in directions either across or against the wind.

*Experiment 8.*—12th–17th August, 1912.

1,500 red-coloured flies were liberated from the ground on August 12th at 4 p.m., since we were desirous of finding out whether the hour

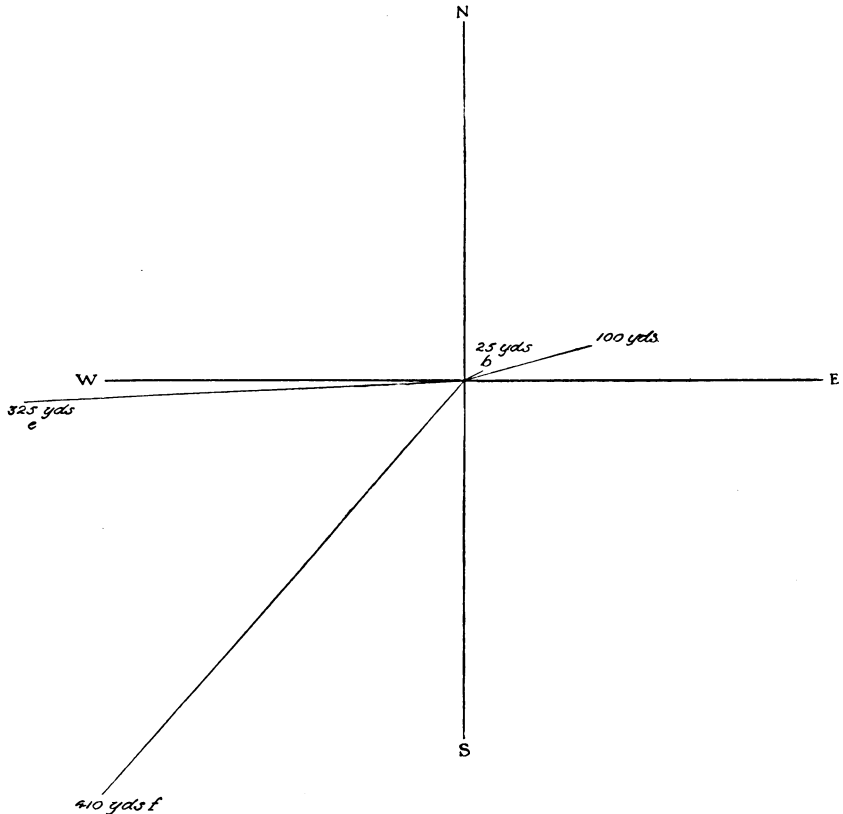


Chart 8.

100 yds. = 0·7 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
<i>a</i>	Aug. 12	E.	4	64	49	0·03
<i>b</i>	„ 13	N.	7	67	45	0·05
<i>c</i>	„ 14	W.	7	61	46	0·0
<i>d</i>	„ 15	W.	8	61	51	0·03
<i>e</i>	„ 16	W.	7	61	51	0·05
<i>f</i>	„ 17	WSW.	9	67	56	0·05

of liberation had any effect on the distribution of the flies. Considering that in this experiment only four flies were recovered, it is probable that flies liberated in the afternoon do not disperse so readily as those set free during the morning. During the night following the day of liberation the thermometer fell to 45° F., and the succeeding days being cold, the flies having taken shelter probably remained under cover. This view is supported by the fact that the two flies which travelled any distance were not recovered till the 4th and 5th days respectively. These two flies had both travelled against the wind, which was blowing from seven to nine miles per hour.

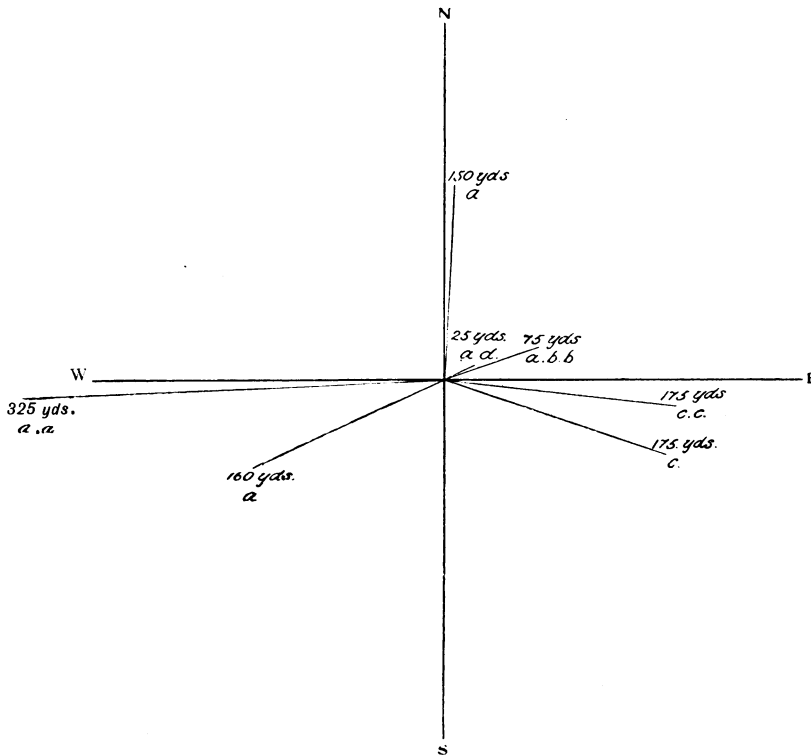


Chart 9.

100 yds. = 0.7 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	Aug. 16	W.	7	61	51	0.05
b	„ 17	WSW.	9	67	56	0.05
c	„ 18	W.	8	68	57	0.06
d	„ 19	S.	7	68	53	0.35

*Experiment 9.*—16th–19th August, 1912.

1,500 orange-coloured flies were liberated from the ground on August 16th at 10 a.m. The weather was cold and wet, but, nevertheless, on the same day two flies were recovered at a distance of 325 yards, five hours after they were liberated. During this period a west wind of seven miles per hour had been blowing, and the point at which the flies were recaptured (a butcher's shop) was W. by S. It seems possible that they were attracted in this direction by the smell of meat coming down the wind. (See Chart 9.)

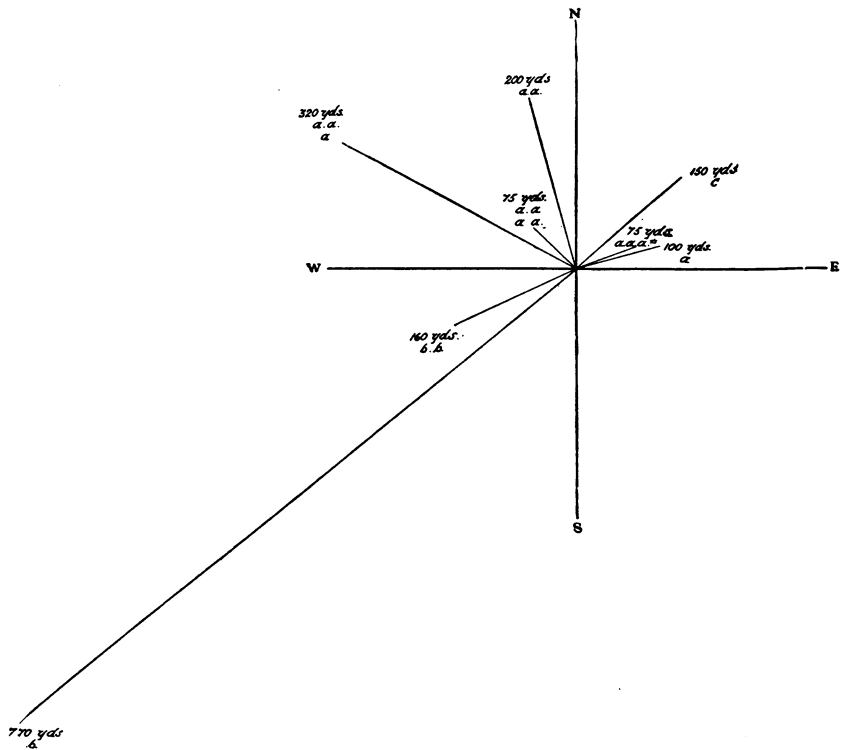


Chart 10 (A).

100 yds. = 0.5 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	Aug. 31	NW.	8	68	49	0.01
b	Sept. 1	W.	6	65	52	0.22
c	,, 2	NW.	6	66	53	0.15



*Experiment 10 (A and B).—31st August–2nd September, 1912.*

In this case 4,000 flies were liberated at 10 a.m. on August 31st: 2,000 yellow-coloured flies were liberated from the ground, and at the same time 2,000 red-coloured flies were set free from the roof, the object being to determine whether the altitude at which the flies were set free had any effect on their dispersal.

The difference between the two cases was not very marked, but the flies liberated on the roof tended to become more widely diffused than

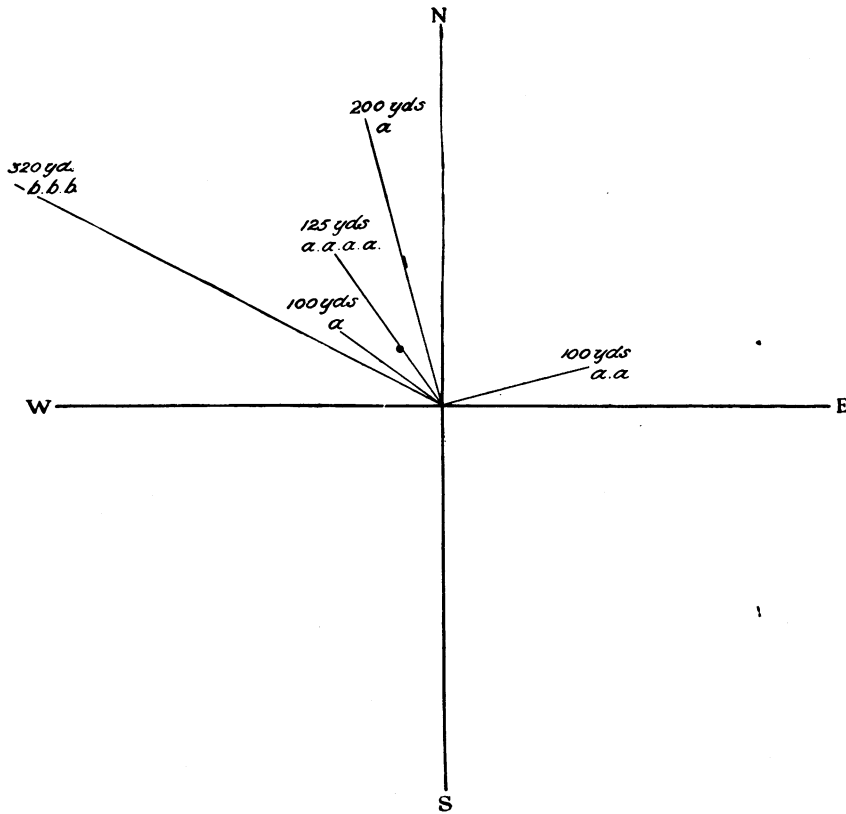


Chart 10 (B).

100 yds. = 0.8 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
<i>a</i>	Aug. 31	NW.	8	68	49	0.01
<i>b</i>	Sept. 1	W.	6	65	52	0.22
<i>c</i>	„ 2	NW.	6	66	53	0.15

those set free at ground level. Of those set free from the roof, 17 were recovered at distances ranging up to 770 yards, and of those liberated on the ground 11 at distances up to 320 yards.

*A.* 2,000 red-coloured flies liberated from roof, August 31.—In spite of the unfavourable weather, which was both cold and wet, one of these flies was recovered at a distance of 770 yards, which constitutes the longest flight which we have observed throughout this investigation. It should be noted, however, that of this 770 yards, 250 were across open fen-land. This was the first occasion on which we had a predominating north-westerly wind during an experiment, and also the first time flies were recovered from any considerable distance at stations N.W. of the point of liberation. Three flies were recovered at a restaurant situated N.W. by W. and 320 yards distant, and as the wind had been blowing from this direction, it is possible that they were attracted by smell. To reach this point it would be necessary for the flies to traverse a very thickly-housed locality comprising many high buildings.

*B.* 2,000 yellow-coloured flies liberated from ground, August 31.—As mentioned above, these flies did not travel quite as far as those liberated from the roof, but three were recovered from the same restaurant—a distance of 320 yards. In every case, the flies recovered took a northerly or north-westerly direction, the prevailing wind being N.W.

*Experiment 11 (A and B).—5th–7th September, 1912.*

6,000 flies were liberated at 11 a.m. on September 5th. A strong wind (11 to 12 miles per hour) was blowing, and the weather was very cold. As in the previous experiment (10) half the flies were liberated from the ground and half from the roof. This experiment was very unsatisfactory, as the cold wind rendered the flies very torpid; but, as before, a larger number of those liberated from the roof were recovered.

*A.* 3,000 orange-coloured flies liberated from roof, September 5.—In this case, 23 flies were recovered at distances up to 190 yards, and no less than 17 from one station 125 yards distant. The short distances traversed clearly demonstrate the effect of cold in rendering these insects torpid.

*B.* 3,000 red-coloured flies liberated from the ground, September 5.—In this experiment only 14 flies were recovered, as against 23 in (*A*); but it is rather curious that two of these flies covered greater distances

than any of those liberated from the roof. This, however, is insignificant, as the maximum distance travelled was only 210 yards.

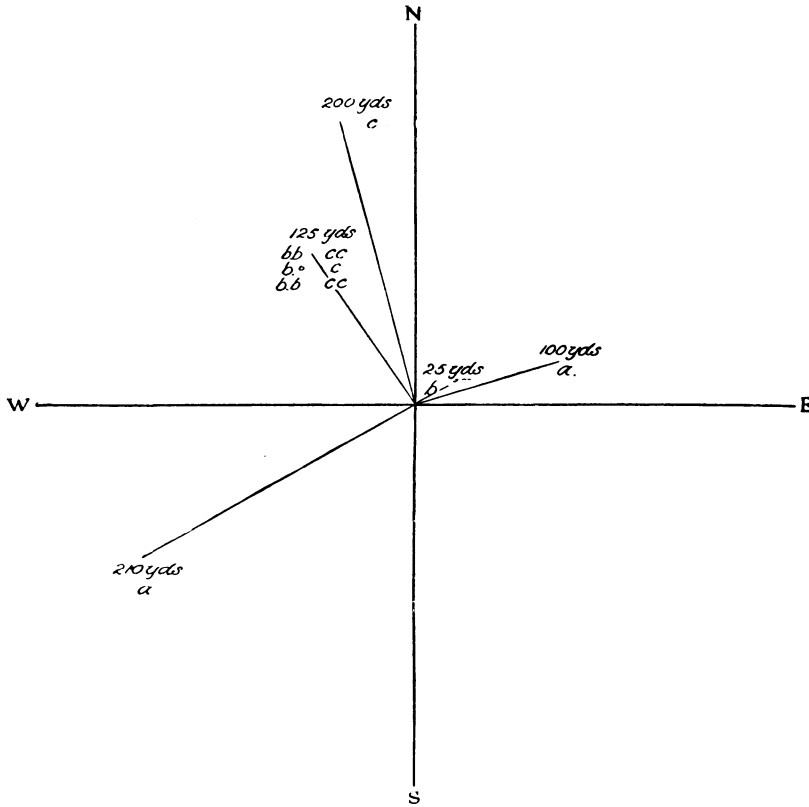


Chart 11 (A). 100 yds. = 0.75 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	Sept. 5	W.	11	66	49	0.0
b	„ 6	W.	12	61	45	0.02
c	„ 7	NNW.	11	59	45	0.0

*Discussion of the above-described Experiments.*

Unfortunately, nearly all our experiments in Cambridge were seriously handicapped by the great difficulty of obtaining flies in sufficient numbers and also by the adverse meteorological conditions. Throughout August the weather was so bad that from the 19th to the

*Musca domestica*

31st of this month not a single fly could be liberated. During the early part of September nearly all the flies became infected with *Empusa muscae*, and this, in conjunction with the cold weather, brought the investigation to a sudden end. In the earlier experiments we should have preferred to have liberated at least double the number of flies, but owing to the difficulty of procuring them this was impossible. Our results, therefore, are not as complete as we could have wished.

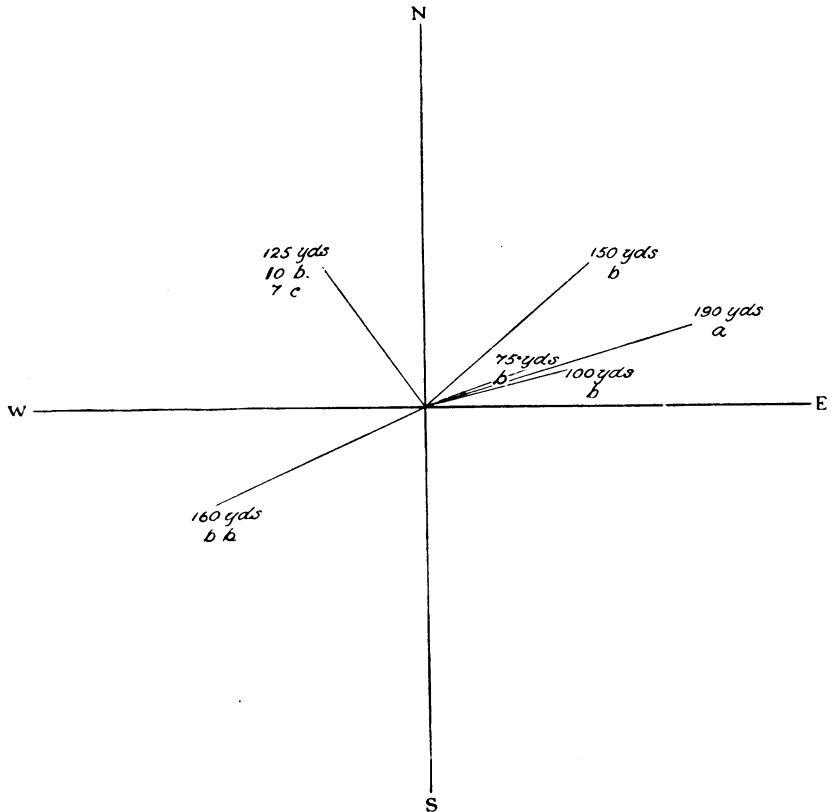


Chart 11 (B).

100 yds. = 0.77 inch.

	Date	Direction of wind	Velocity of wind in miles per hour	Thermometer		Rainfall in inches
				Maximum	Minimum	
a	Sept. 5	W.	11	66	49	0.0
b	„ 6	W.	12	61	45	0.02
c	„ 7	NNW.	11	59	45	0.0

Nevertheless, owing chiefly to the large number of stations employed for the recovery of the flies and their being situated in various directions, we have been able to obtain certain definite results.

The most striking feature brought out by our experiments is the marked effect of the direction of the wind on the courses taken by the flies. After a careful examination of all our results, it appears to us that the flies tended to travel either directly *against* or *across* the wind. The main exceptions to this rule were those recovered within a radius of about 150 to 200 yards from the point of liberation, and probably these flies were individuals that had merely selected the first shelter they could find. These results differ somewhat from those of Copeman, Howlett, and Merriman (1911), who found that for the most part the flies tended to travel *with* the wind. But it should be remembered that not only were these investigators working in open country, but also their traps were necessarily set at stations to the east of the point of liberation, and consequently none of the flies that flew in a westerly direction would be recovered.

Owing to lack of opportunities we have been unable to decide why, in our experiments, the flies tended to travel either against or across the wind. Two explanations are possible:—

(1) The flies may tend to fly against any current of air to which they are subjected. This property is known as positive anemotropism, and is possessed by some other insects and birds. In view, however, of the results obtained by Copeman, Howlett, and Merriman (1911), we cannot come to definite conclusions on this point, and further experiments are required to determine if other factors than wind-direction influence the direction of flight.

(2) The flies may travel against the wind, being attracted by any odours it may convey from a source of food. A point in favour of this supposition is the nature of the stations at which flies were recovered after they had travelled any distance. These comprised a butcher's shop, public houses, and a restaurant, all of which gave off odours that are notoriously attractive to flies.

The maximum distance travelled by any of the flies we liberated in Cambridge was 770 yards, which is considerably less than that covered by those liberated in the open country at Postwick—in one case as much as 1,700 yards. This difference may be attributed to the absence of shelter in the case of the Postwick flies, whereas in Cambridge food and shelter were always plentiful. On the whole, we do not think it likely that, as a rule, flies travel more than a quarter of a mile in thickly-

housed areas. Throughout our experiments only two flies exceeded this distance and in the case of the individual that had travelled 770 yards, a large part of its journey was across open fen-land.

The chief factors influencing the dispersal of the flies are probably the temperature, weather, and the time of day when the insects are liberated. The effect of temperature is very marked, as when it is low the flies become torpid and seek the first available shelter. This is shown in Exps. 11 (*A*) and 11 (*B*), respectively. Fine weather is also a necessary condition for long flights, as rain at once drives the flies into shelter. The ideal experimental conditions for a flight experiment are two or three days of fine warm weather, during which the flies can make their flight, succeeded by a wet or showery day, when they are driven indoors, and thus can be recorded at the various stations.

With regard to the altitude of the point of liberation, flies set free from the roof tended to disperse slightly better than those liberated from the ground, but the differences are not very considerable.

With regard to the vertical flight of the house-fly, although we have found no means of estimating the maximum, nevertheless, during our experiments, when liberating them from the ground, we have frequently observed the flies at once mount almost vertically upwards to a known height of 45 feet.

#### SUMMARY.

Under the conditions of our experiments, indication was afforded that—

(1) House-flies tend to travel either *against* or *across* the wind. The actual direction followed may be determined either directly by the action of the wind, or indirectly owing to the flies being attracted by any odours it may convey from a source of food.

(2) It is likely that the chief conditions favouring the dispersal of flies are fine weather and a warm temperature. The nature of the locality is another considerable factor, as in towns flies do not travel as far as in open country, this being probably due to the food and shelter afforded by the houses.

(3) Under experimental conditions, the height at which the flies are liberated, and also the time of day, appear to influence the dispersal of the insects. As judged by one experiment, when flies are set free in the afternoon they do not scatter so well as when liberated in the morning.

(4) The maximum flight in thickly-housed localities in our experiments was about a quarter of a mile; but in one case a single fly was recovered at a distance of 770 yards. It should be noted, however, that part of this distance was across open fen-land.

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