Flight Rhythms of Aphids at Suwon

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It may be of use to know the flying rhythm of aphids for the study of aphid biology and establishment of effective control measures of aphid vectors.

To investigate this, hourly counts of aphid catcheswere made using "Yellow Traps", which were set on the lawn south of the main building on the campus at Suwon.

Two traps were operated for 5 successive days in June and 3 days in October in 1967. Since the results were somewhat different from those of Johnson and Taylor (1957), another trial was carried out in 1968 for 15 days in September.

A bimodal curve of numbers departing during the day with no flight at night is a common feature of such population [see Johnson (1954) and Johnson and Taylor(1957)] ※ Fig. 1. However, at Suwon, such bimodal form is not clear (see Table 1). ※※ The distributions of numbers of aphid flight in Table 1 look like unimodal forms except that on 17 June, 1967. The frequency of numbers of flights on 17 June may be due to sudden change of environmental factor, in this case, a shower followed by strong sunshine ※※※ (Fig. 2). During the poriods, predominant aphids were Cervaphis quercus, Aphis spiraecola and Tetraneura akinire, respectively.

There are three elements contributing to the periodicity of flight in aphid populations. These are: the rate of moulting into the winged adults; the length of the teneral period from moulting to flight; the environmental factors inhibiting flight.

All these elements vary in a complex way especially with temperature, and in nature they are integrated to produce a flight curve. Johnson and Taylor (1957) considered a simplified example (case 1 in their paper) to bring out the basic interactions between the above three elements in relation to temperature.

The temperature curve at Suwon has smaller fluc-

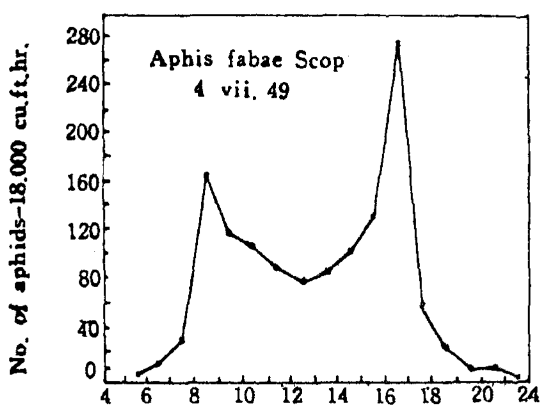
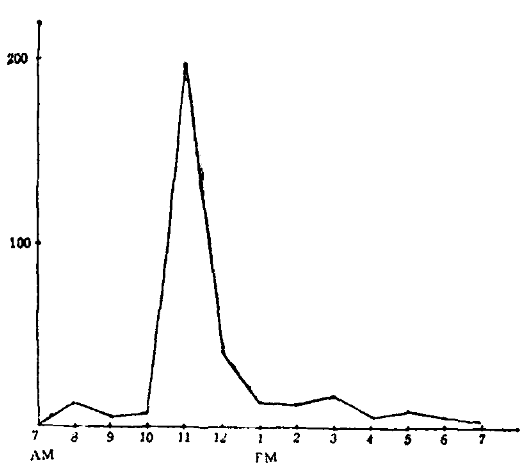


Fig. I. Typical curve of aerial density change for alienc*lae of A. fabae flying above a bean crop on which they were produced. (After Johnson and Tylor, 1957)

Fig. 2
Hourly Catches of Flying Aphids
19 June 1967



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tuation between day and night higher mean temperature than that at Rothamsted. The mean hourly temperature during 24 hours in mid-June at Suwon somewhat resembles the folllowing curve (Fig. 3).

※※ Table 1. Hourly Catches of Flying Aphids at Suwon

1 9 6 7

		Total	A.M 7	8	9	10	11	12	P.M. 1	2	3	4	5	6	7
June	15	199	11	10	7	18	28	33	43	17	4	8	4	9	7
	16	226	10	10	10	11	21	40	31	20	19	12	30	6	6
	17	471	7	19	6	19	108	39	62	43雨	8快晴	35快晴	95	24	6
	18	157	2	15	15	23	17	16	9	18	10	12	7	9	4
	19	335	—	12	5	6	199	41	15	13	18	7	9	6	4
	Total	1,388	30	66	43	77	373	169	160	111	59	74	145	54	27
								24% (12–P.M.1)							
							59% (11–2)								
雨 Oct.	12	9	—	1	—	—	—	—	8	—	—	—	—	—	—
晴	13	1,025	—	20	12	15	28	54	188	334	201	72	45	46	10
晴・强風	14	25	4	2	1	—	5	1	3	9	—	—	—	—	—
	Total	1,059	4	23	13	15	33	55	199	343	201	72	45	46	10
								24% (12–P.M.1)							
							59% (11–2)								

1 9 6 8

		Total	A.M 7	8	9	10	11	12	P.M. 1	2	3	4	5	6	7
Sept.	10	262	—	1	8	3	16	34	24	34	30	26	43	26	17
	11	254	—	4	1	14	31	85	53	32	17	7	3	5	2
흐림,濕	12	197	—	12	8	9	9	25	35	41	18	15	12	10	3
	13	131	—	—	1	14	24	27	19	29	10	4	2	—	1
	14	154	—	3	3	12	26	40	31	23	5	6	—	5	—
快晴	16	90	—	15	5	9	14	14	16	10	3	—	1	3	—
〃	17	167	—	7	18	14	12	34	22	18	28	4	4	6	—
〃	18	208	3	10	3	9	60	81	14	21	3	4	—	—	—
흐림	19	147	7	10	23	28	20	30	17	8	1	—	—	3	—
快晴,强風	20	10	—	—	3	6	—	—	—	—	—	1	—	—	—
晴風	23	20	—	—	—	1	7	2	2	4	4	—	—	—	—
快晴	24	24	—	—	—	1	1	1	8	4	—	3	—	—	6
〃	25	10	—	2	1	—	—	—	1	2	3	1	—	—	—
〃	26	11	—	—	—	—	—	2	3	3	2	—	1	—	—
흐림,晴	27	41	—	4	5	—	4	7	2	3	4	5	2	5	—
	Total	1,726	10	68	79	120	224	382	247	232	128	76	68	63	29
								36% (12–P.M.1)							
							63% (11–2)								

1. 無降水日 12日間繼續
2. 16～17 最高氣溫이 30°以上 氣溫較差 14° (19日以前은 最高27～28°)

In case 1 of Johnson and Taylor, it is supposed that the moulting rate is constant at 1°C per hr., the velocity of development during the teneral period is linearly related to temperature, and flight occurs immediately after maturation.

In Fig. 3 an organism moulted at time t_1 and temperature θ_1 maturse and flies at time t_2 and temperature θ_2. The amount of heat necessary to complete development is represented by the sum of all the temperature for the period of development; that is, by the area under the sine curve between moulting and flight. This is the thermal constant:

$$\text{The teneral period} \int_{\theta_1}^{\theta_2} \theta dt = \sum_{t_1}^{t_2} \theta = \text{Constant}$$

$$(t_2 - t_1) = \sum_{t_1}^{t_2} \theta \Big/ \bar{\theta}$$

But beceuse $\bar{\theta}$, the mean temperature, varies with time of moulting, and therefore with θ_1, so $\sum_{t_1}^{t_2} \theta \Big/ \bar{\theta}$, the teneral period, will also vary with the time of moulting.

As each successive batch of ten insects moult at mean intervals of 1 hr., so they mature at longer of shorter intervals according to the mean temperature. The moulting rate, with the accumulated number of moults along curve k_1 l_1 is thus translated to a curve k_2 l_2 for accumulated mature insects. If the insect flies off immediately on maturation then the numbers departing each hour will be the successive hourly differences along the accumulated maturation curve k_2 l_2 this is represented by a single-peaked curve, xy. in Fig. 3, the curve $k_2 l_2$ for accumlated mature insects, particularly after 10 a. m., is not so steep as that at Rothamsted. The aphids that develop comletely during the night will wait until dawn, when they will depart, not all at once, but distributed over a certain periode. The final result is a double peaked curve, the heavy line uv in Fig. 3, but the second peak does not appear clearly in our case. This is the theoretical basis for the curve of bimodal flight in aphid populations. Obviously, this theory involves the case in which a single-peaked curve might appear.

For complete explanation of the shape of the light curve at Suwon, further investigation may be needed, including the length of teneral period.

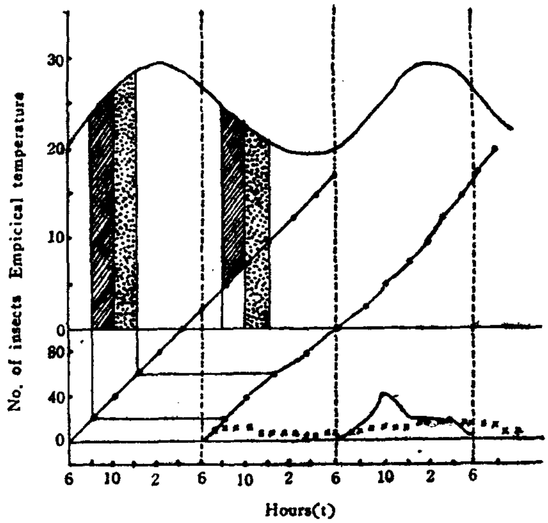

Fig. 3. Theoretical reconstruction of bimodal flight curve. θ1θ6, temperature curve; t1 t2 t3 t4 t5 t6 teneral periods of differerent length; k1 l1, accumulative moulting rate, constant at 10 per hr.; k2 l2, accumulative maturation curve; xy, hourly differences along k2 l2 showing number of insects maturing each hour; uv, flight curve showing number of insects departing each hour

the moulting rate, and the special evironmental factors inhibiting flight.

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摘 要

진딧물 有翅虫의 日周活動

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진딧물의 日周活動에 關한 硏究는 Johnson (1954), Johnson and Taylor (1957) 에 依해 詳細히 報告되었을뿐 亞熱帶, 熱帶地方에서의 實態는 아직 報告된바 없다. 이들은 英國의 Rothamsted에서 調査硏究하여 飛翔虫數의 分布가 大体로 雙峰曲線(Bimodal Curve) 을 이루는것이 特徵이라고 하였다 (그림 1). 그런데 筆者들이 水原에서 1967~8年에 調査한 바에 依하면 表 1 에서 보는바와 같이 1967年 6月 17日것을 除外하고는 어느것이나 大槪 單峰頻度曲線으로 나타났다. 이 代表的인것이 그림 2에 表示되었다. ※※※ 1967年 6月17日것은 例外的인데 午后에 소낙비가 온후 强한 日照가 繼續된 特別한 氣象條件때문이라고 生覺된다.

진딧물의 飛翔周期에 關與하는 要因으로는 羽化率 (Moulting rate), 飛翔前期 (Teneral Period) 飛翔阻止 環境因子等을 들 수 있다. 이들 要因은 서로 複雜하게 作用하여 變異를 나타낼것이며 特히 氣溫에 依해 큰 影響을 받을것이다.

水原에 있어서의 晝夜間의 氣溫差異는 6月 中旬에 있어 그림3에 表示된바와 같은 曲線이 될것이 豫想되는데 이것을 Rothamsted에 있어서의 그것과 比較하면 晝夜間의 隔差가 작고 平均氣溫이 높은 것을 알 수 있다. [Johnson and Taylor(1957), Fig2參照] . 이 溫度曲線을 基準으로 하고 Johnson and Taylor의 모든 假定을 살리고 그들의 理論에 依하여 水原에서의 飛翔曲線을 作成하면 그림 3의 曲線 uv 와같이 나타난다. 이 曲線 uv 에서 두째번 봉오리가 大端히 낮고 境遇에 따라서는 別로 눈에 뜨이지 않을 程度로 될 수 있을것이 豫想된다. Johnson and Taylor의 理論을 빌어서 水原에 있어서의 飛翔曲線의 特徵이 說明될수 있을것이나 이것을 完全히 밝히자면 Johnson and Taylor 理論의 基礎가 되어 있는 羽化率, 飛翔前期, 飛翔阻止要因等을 밝힌 다음 再檢討해야할 問題이므로 爲先 여기서는 英國에 있어서의 飛翔型과 水原에 있어서의 그것사이에 顯著한 差異를 發見하였기에 報告하는 바이며 詳細한것은 后日을 期하겠다.

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