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REGULATION OF BODY WEIGHT AND FECUNDITY IN *Megoura viciae* (BUCKTON)[1]

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ABSTRACT

The weight of pre - reproductive adult bean - vetch aphids (*Megoura viciae*) was correlated with their subsequent reproductive rate when the aphids were reared in isolation but no correlation was found when the aphids were crowded.

Nymphal weight during the first 12 hours after birth was related to the weight of isolated parents, but in crowded aphids, this relationship only persists for the first 2 hours. The weight of parent aphids was shown to influence 32 p uptake when aphids were isolated, but not under conditions of crowding.

INTRODUCTION

In many aphid species the individual adults vary considerably in size and weight. Dixon (1970) found a fourfold difference in weight in *Drepanosiphum platanoides* (Schr.) collected at different times of the year. Murdie (1969a) showed a twofold variation in weight in relation to crowding in *Acyrthosiphon pisum* Harris, and Way and Banks (1967) found that changes in population den -

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sity could produce a sixfold variation in the weight of apterous *Aphis fabae* Scop. Under crowded conditions or on mature plants small aphids appear, whereas large aphids develop on young or senescent plants, or in isolation. Smaller adults deposit fewer nymphs and those deposited at the beginning of the reproductive phase are smaller than average (Murdie, 1969b;Dixen 1970). The number and size of first born *A. pisum* is correlated with parental weight (Murdie 1969 a) and a relationship between parental weight and nymphal weight has been demonstrated for *D. platanoides* (Dixon 1970) and *A. fabae* (Dixon and Wraten 1971). A similar relationship between adult weight and fecundity in *Megoura viciae* was discussed by Bonner and Ford (1972). Way and Banks (1967) suggest that production of a range of sizes by aphids may result in the survival of many individuals under crowded conditions or on poor quality host plants which otherwise might have failed to survive. The effect on fecundity of a reduction in the reproductive period, caused by crowding, in clonal cultures of *Myzus persicae* (Sulz). has recently been discussed by Hodjat and Bishop (1978). Crowding nymphs affects the size of the subsequent adult aphids, and the size of adults affects their fecundity (Peters and Barbosa, 1977). However, crowiding adults also affects their fecundity even though the adults are of average size (Dixon 1975). Hence, crowding may regulate the population density by producing small adults of lowered fecundity and by direct effects on adults. The measurements of fecundity reviewed above have usually been made by isolating aduits of different weights and counting the offspring produced. This report is concerned with the possible direct effects of crowding on adult aphids.

MATERIALS AND METHODS

The culture of *Megoura viciae* was maintained as described previously (Bonner and Ford, 1972). Uptake of sap was measured by feeding the aphids for 24 hours on bean leaves into which 32p (lmCi/ml of water) had been incorporated, using the reservoir shown in figure l. Radioactivity was measured with an I. C. N. Tracerlab gasflow counter.

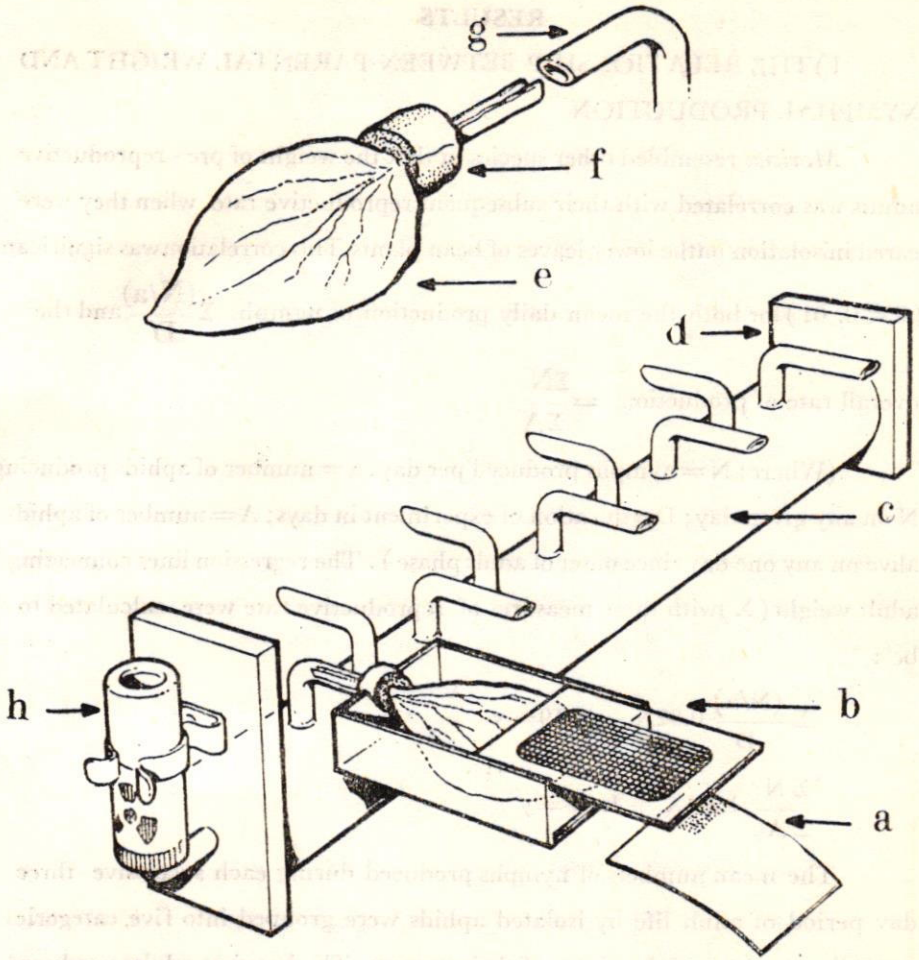

Fig. 1- Apparatus used to feed aphids on exised bean leaves, irrigated with 32p, and to collect their honeydew; a. Bromocresol green paper; b. perspex cage with sliding lid; c. reservoir; d. vertical support; e. bean leaf; f. foam rubber; g. neoprene tubing; h. filler tube.

The honeydew was collected on paper strips stained with bromo - cresol green, and its activity was determined using a Packard 7201 radiochromatogram scanner. Aphids were weighed on a Cahn G - 2 electrobalance.

RESULTS

1) THE RELATIONSHIP BETWEEN PARENTAL WEIGHT AND NYMPHAL PRODUCTION

M. viciae resembled other species in that the weight of pre - reproductive adults was correlated with their subsequent reproductive rate when they were reared inisolation onthe lower leaves of bean plants. This correlationwas significant ($P < 0.01$) for both the mean daily production of ngmphs, $\Sigma\frac{(N/a)}{D}$ and the overall rate of production $=\frac{\Sigma N}{\Sigma A}$

(Where; N = nymphs produced per day; a = number of aphids producing N on any given day; D = duration of experiment in days; A = number of aphids alive on any one day since onset of adult phase). The regression lines connecting adult weight (X) with these measures of reproductive rate were calculated to be :

$$\Sigma\frac{(N/a)}{D}\ 0.92X + 2.19 = y$$

$$\frac{\Sigma N}{\Sigma A}\ ;1.04X + 1.31 = y$$

The mean numbers of nymphs produced during each successive three day period of adult life by isolated aphids were grouped into five categories according to the initial weights of their parents. The heaviest adults produced the most nymphs (table 1). This relationship between initial adult weight and subsequent rate of reproduction suggests that the aphids which are heaviest or lightest at the beginning of the final instar remain in the same weight relation - ship to one another throughout the reproductive life.

This was confirmed by weighing isolated aphids each day; the weights remained in substantially the same relationship to one another and were highly correlated with the numbers of nymphs deposited in the first 24 hours following birth.

Thus, the pre - reproductive weight of isolated aphids can be used for predicting relative weights during the remainder of the adult stage.

	ISOLATED APHIDS (n=40)				CROWDED APHIDS (n=63)				
Days	4. 88 - 3. 67mg	3. 6 - 3.03mg	3. 01 - 2. 88mg	2. 56- 2. 22mg	2. 28 - 1. 38mg	2. 82 - 2. 47mg	2. 39 - 2. 10mg	2. 14 - 1. 99mg	1. 78 - 1. 43mg
2 - 4	7. 8	7. 3	7. 2	4. 7	5. 3	5. 01	3.93	3.63	3. 44
5 - 7	5. 5	6. 4	3. 7	4. 2	2. 8	4. 40	2. 79	3. 82	3. 71
8 -10	5. 6	5. 7	5. 9	4. 3	3. 9	5. 25	3. 36	3. 37	3. 60
11-1	4.9	4.8	3. 2	4. 3	3.7	3.92	3. 58	3. 34	2. 78
14 -16	3. 0	2. 3	4. 5	1. 9	3. 4	2. 00	3. 19	3. 00	2. 34
17 -19						1. 75	2. 00	1. 83	2. 50

Table 1. The mean number of nymphs produced by isolated and crowded aphids during successive 3 day periods. The data have been pooled according to the intiail weight of the parents.

By contrast, there was no significant difference in the fecundity of aphids of different initial weights when they were maintained under crowded conditions. Aphids were reared in 13 crowded groups, each of 1. 8 aphids per cm^2, and there was no correlation between the mean parental pre - reproductive weight and the mean rate of nymphal production based on the entire life span (figure 2B). The mean numbers of nymphs produced by the crowded aphids were pooled into four categories based on the initial weights of the parents (table 1.).

Analysis of variance of the data from both isolated and crowded aphids (table 1) showed significant differences in nymphal production with time, but only in isolated aphids was there a significant difference ($p < 0.01$) between the weight groups.

2. THE INFLUENCE OF ADULT WEIGHT ON NYMPHAL WEIGHT

Dixon and Wratten (1971) have shown that large adults produce heavy nymphs and light adults produce lighter nymphs, but their adults were all reared under isolated conditions.

Pre - reproductive parental weight was significantly correlated with the weight of the offspring produced by *M. viciae* during the first 12 hours of reproductive life when the adults were isolated ($r = 0.66$, $P < 0.001$).

Under crowded conditions, however, the weight of the pre - reproductive aphids and the weights of the offspring produced within 12 hour periods were not correlated (table 2) except in the first generation.

However, in a subsequent experiment in which aphids had been reared under crowded conditions for several generations, nymphs were weighed within 2 hours of birth. In this case parental weight (Y) was correlated ($p < 0.01$) with nymphal weight (X);

$$Y = 0.016X + 0.043$$

Thus, the weight of 12 hour old nymphs produced by isolated parents is directly related to the weight of their parents, whereas, in the crowded nymphs,

Generation F_1	Parents	1. 89±0. 08	2. 56±0. 11
	Offspring	0. 09±0. 01	0. 17±0. 03
Generation F_2	Parents	–	—
	Offspring	0. 15±0. 02	0. 14±0. 07
Generation F_3	Parents	1. 92±0. 09	2. 53±0. 14
	Offspring	0. 09±0. 01	0. 09±01
Generation F_4	Parents	1. 90±0. 09	2. 53±0. 14
	Offspring	0. 09±0. 01	0. 12±0. 02

Table 2. The mean weight (mg) and confidence limits of four genera - tions of prereproductive adults and nymphs. The parents were separated into two weight groups during the first three days of reproductive life.

there is no correlation with parental weight if nymphal weighing is delayed beyond two hours. This difference might be explained by differences in the uptake of the nymphs, since we found that the uptake of 32p from leaves by crowded nymphs was appreciably higher than by isolated ones. In isolation the small uptake of food has little effect on the weight of the nymph during the first 12 hours after birth, whereas crowded nymphs show a greater variation in uptake, and a corresponding variation in the weight of the 12 hour nymph.

3. THE UPTAKE OF 32PBY APHIDS OF DIFFERENT WEIGHTS

The correlation between nymphal production and adult weight in isolated aphids could be explained if larger adults take in more food and hence have more material available for nymphal production. The question arises as to whether this is a relationship between parental weight of crowded aphids and uptake. This relationship was investigated, using 32p.

The radioactivity of the aphids, their nymphs, and their excretions (collected on the bromocresol green paper strips)were each compared with the mean weight of the aphids (table 3).

The results (table 3) indicate that the weight of the isolated parent aphids influences their uptake of 32p. The total activity removed by the aphids (i. e. the sum of activity of the adults, activity of the nymphs and activity excre -

	Isolated Adhids (adult weight)	Crowded Ahids(adult weight)
	n=30	n=60
a) Adult counts	r= 0. 39	r= 0. 33
b) Nymph counts	0. 40	0. 57
c) Honeydew counts	0. 59**	— 0. 31
d) Total a+b+c	0. 69***	0. 17
e) No. of nymphs	0. 63	— 0. 16

Table 3. Correlation matrix showing r values between 32p counts and weight of adult aphids (***, $p < 0.001$; **$p < 0.01$).

ted) was highly correlated ($p < 0.001$) with the weight of the aphids.

Furthermore, the results substantiated the conclusion that parental weight is correlated with the number of nymphs produced ($P < 0.01$). In crowded aphids there is a narrower adult weight range (see table 1) and there is no correlation between parental weight and the radioactivity in the aphids or their excreta. Parental weight was not correlated with the number of nymphs produced by crowded aphids ($r = -0.16$) nor was the latter correlated with the radioactivity in the aphids or excretions.

CONCLUSIONS

In isolated aphids there seems no reason to doubt a simple relationship between the size of a parent, its food uptake and the nymphal production. when the aphids are crowded as adults, feeding is reduced and one might expect therefore a corresponding reduction in nymphal production. This indeed occurs but the fact that the number of nymphs produced is no longer correlated with uptake, suggests that crowding affects both feeding and fecundity

Feeding determines the amount of material available for embryo formation. A direct effect of crowding on fecundity, presumably mediated via the neuroendocrine system, could effct the amount of food assimilated and used in embryo production, but the nature of this neuroendocrine activity remains to be elucidated. Nevertheless, the work described here demonstrates the «self

regulatory» mechanism which operates in aggregations of aphids (Way and Banks, 1967).

Summary

when maintained in isolation under constant conditions, the main influence on the reproduction of individual apterae of the aphid *Megoura viciae* is the size of the adult. Heavy aphids produce significantly heavier nymphs at a more rapid rate than light aphids. By contrast,the rate of reproduction of crowded adults is reduced and it is not correlated with the weight of the parent. The relationship between the size of the parent and the weight of its offspring also disappears under crowded conditions.

The results of radiotracer studies suggest that the reproductionof iosolated aphids reflects a direct relationship between the size of the adult and its uptake of food.Under crowded conditions feeding is suppressed and is no longer related to the number of nymphs produced.It is therefore postulated that in addition to the influence of feeding, there must also be a more direct effect on reproductive ability as a result of crowding individuals of this species.

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