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Behaviour of larvae of two Pierid butterflies when switching hostplant species

by

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A number of studies of butterfly populations have shown occasional depletion of a hostplant by larvae (DETHIER, 1959; WHITE, 1974). The gregarious larvae of *Pieris brassicae* are regular defoliatiors of their hosts in many Palaearctic populations. In high altitude populations at Oikaimedon, Morocco, larvae frequently completely strip individuals of *Isatis tinctoria*, whilst at lower levels in the same area, near Asni, larvae are frequently found to have largely eaten out their initial host and moved onto others.

Such larvae may, for instance begin feeding on *Crambe hispanica*, but thereafter transfer to other crucifers such as *Brassica* spp., *Sisymbrium* spp. or even to the caper bush, *Capparis spinosa*. In moving to a new host, larvae experience a distinct chemical profile in their food with, in particular, a new array of glucosinolates (the primary defence chemicals of Brassicaceae/Cruciferae) quite unlike that of the original host. The present study was undertaken to investigate this potentially traumatic effect of food transfer, by changing the foodplants presented to developing *P. brassicae* larvae. The results obtained are compared to those from the congener *P. napi*, which usually lives solitarily as a larvae. However, occasional overloading of plants with eggs of this species does occasionally occur (COURTNEY & COURTNEY 1982), such that larvae are forced to seek out new hosts when the original foodplant has been eaten. In some Nearctic populations of *P. napi* associated with small cruciferous hosts, such migration of larvae may be frequent (F.S. CHEW, pers. comm.).

Larvae of *P. brassicae* and *P. napi* were reared at 10° and 15°C respectively, and were allowed to become established on their normal hostplants (for Northern England): *Brassica oleracea* and *Alliaria petiolata*. During the second instar they were transferred to other hosts, and their performance compared with control populations which were transferred to different individuals of the original host species. The mean weights of larvae during the course of the experiments are shown in Figures 1 and 2. It is seen that after transfer to alternative hostplants, some cohorts of larvae (particularly those put onto *Barbarea vulgaris*) either lost weight or suffered a marked reduction in growth rate in the period immediately subsequent to transfer. However once this period had passed, larvae on all foodplants grew at the same rates. This point is made particularly clear by the linear regression lines (also shown in Figures 1 and 2) over the period of growth of later instars, which do not differ significantly from one another. Thus switching hostplants results in an immediate retardation

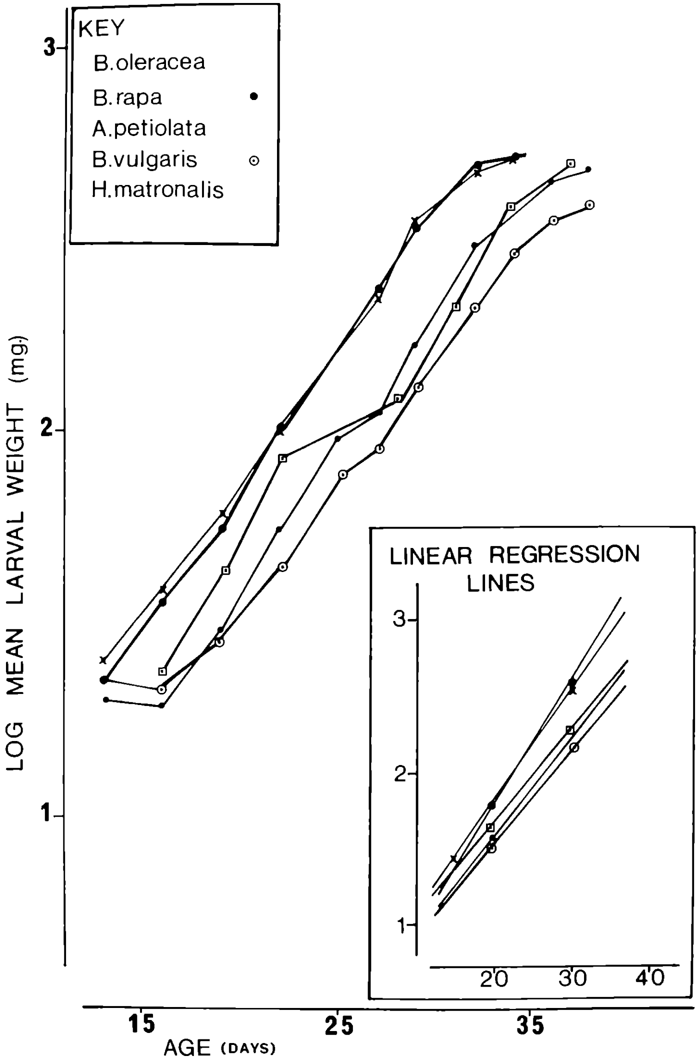

Figure 1: Weights of *P. brassicae* larvae transferred at the second instar to five foodplant cultures. Inset are linear regression lines for growth from the period at which larvae begin gaining weight again. These do not differ significantly from one another.

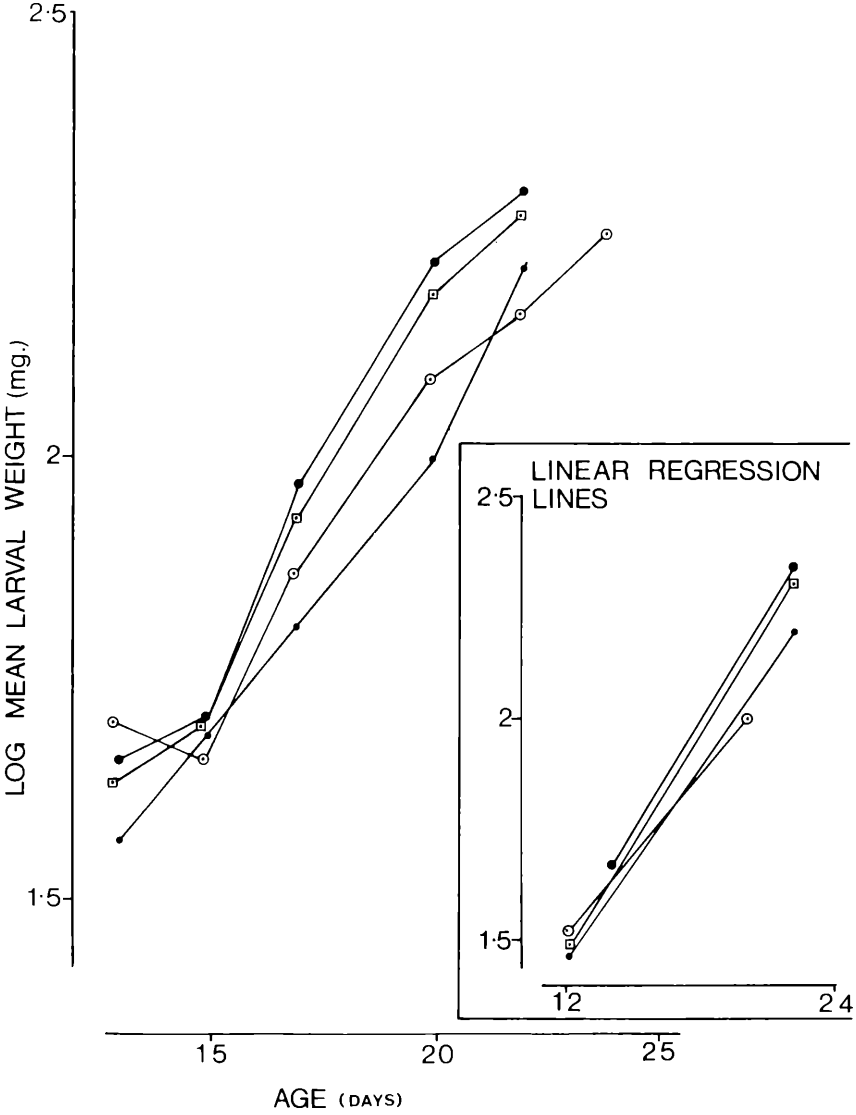

Figure 2: As Figure 1, but *P. napi*. Foodplants as in key of Fig. 1. Linear regression lines of growth over time are again not significantly different from one another.

of growth which is subsequently overcome; only the period of larval development is altered. Note that this effect does not occur on control transfers to the same host species, nor in *P. brassicae* transfered from *Brassica oleracea* to the congener *B. rapa*. For both butterfly species *B. vulgaris* appears to be the hostplant with the most pronounced inhibition of growth rate. At day 30 significant heterogeneity exists in the weights of *P. brassicae* larvae on the different hostplants, but this effect vanishes when the later pupal weights are compared. Only *B. vulgaris* is seen to produce markedly smaller pupae. Note that since pupal size is related to adult wingspan (BAKER, 1968) larvae fed upon such unfavourable hosts in the wild may have reduced migratory capability as adults.

The observed period of reduced growth rate may arise from a number of mechanisms such as a lack of inducible enzymes, necessary for the detoxification of plant poisons, or the effective use of substrates. However it was observed that larvae on transfer to new hosts were not feeding with typical voracity, and that they were frequently observed off the hostplant in the surrounding container. This prompted the suggestion that larvae were in some way conditioned to the host on which they had been previously feeding, and were not feeding on novel hosts because these failed to stimulate feeding behaviour. Choice experiments were then set up with both species, where larvae were placed in a container with specimens of five plant species; the food specimens were of known and approximately equal wet weight. The amount of wet weight of each plant consumed over 24 hours (corrected by a control) was then calculated, and tables of ranked preferences of larvae of both butterflies were obtained (Tables 1 and 2). It is seen that larvae were largely in agreement over their preferences. *P. brassicae* larvae always fed upon *B. oleracea*, and in half of the experiments this hostplant was the first choice. Conversely *B. vulgaris* was consistently ignored by larvae and was never the preferred host. *P. napi* similarly showed strong perferences for *S. ifficinale*, and against *B. vulgaris*, which was rarely even sampled. Note that *A. petiolata*, the plant upon which the *A. napi* larvae had been previously reared, was surprisingly not a highly favoured host.

Several deductions may be made from these results. *B. vulgaris*, for instance, is seen to give low development rates, with small resultant pupae and is the least favoured host of larvae of both species. This crucifer is suspected of having unique deterrent compounds (F.S. CHEW; A.M. SHAPIRO pers. comm.) which may be responsible for the observed inhibition of feeding. The results also show clear larval preferences for certain hostplants, indicating that animals in their early instars are able to distinguish amongst foodplants, probably on the basis of glucosinolate profile.

It is particularly interesting that *P. brassicae*, having fed upon *B. oleracea*, do not lose weight on *B. rapa*, and rank this species highly in the choice tests. Similarly, the preferred foodplant of *P. napi* was *S. officinale*, which is taxonomically (and chemically) closely related to *A. petiolata*, on which the larvae had been previously reared. It is not possible to deduce from these results whether such preferences are induced (by a form of conditioning) or innate; nevertheless choice of food similar to that previously eaten does indicate a surprising sophistication in larval sensory discrimination. Such abilities are perhaps unexpected, in that a larvae which has depleted its original host can rarely be free to choose amongst alternative replacement foodplants. The behaviour described here may however provide a mechanism whereby acceptance of less suitable hosts, such as *B. vulgaris*, may be inhibited in the initial phases of foodplant search. Such non-preferred hosts would then only become acceptable to larvae as hunger increases, as appeared to be the case in the initial rearing experiments. The behaviour of both species thus appears to be well-suited to the occasional search for new hostplants, as a results of destruction of the original host. Switching of hostplant species in both these oligophagous butterflies appears to entail only minor problems in feeding behaviour.

	Mean Rank	Ranked First	Not Eaten
Brassica oleracea	1.75	9	0
Alliaria petiolata	2.58	4	4
Brassica rapa	2.96	4	3
Hesperis matronalis	3.04	3	3
Barbarea vulgaris	4.42	0	11

Table 1: The preference of *Pieris brassicae* larvae for different hostplants. The mean ranked preference in choice tests is given, together with the number of occasions the foodplant was ranked first or equal first, and the number of trials in which a host was not eaten atall. N = 18. *B. oleracea* is preferred and *B. vulgaris* discriminated against, with the other three foodplants being roughly equally acceptable.

	Mean Rank	Ranked First	Not Eaten
Sisymbrium officinale	2.24	12	5
Hesperis matronalis	2.72	6	9
Alliaria petiolata	3.12	6	11
Brassica rapa	3.38	2	18
Barbarea vulgaris	4.10	1	22

Table 2: As Tab. 2 but *P. napi* larvae. N = 25. Larvae discriminate against *B. vulgaris* and possibly *B. rapa*, and prefer *S. officinale* over alternative hosts.

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The ecology of movement in Pierid butterflies
(Lep., Pieridae)

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Introduction

BAKER (1968, 1969) examined many Palaearctic butterflies and established that most displacement in these species was voluntary. He sought an evolutionary explanation for observed differences between species and obtained a correlation between adult mobilities and the growth form and successional status of the larval foodplants. His classifications of foodplants and adult mobility were necessarily subjective and may be challenged by intensive study of any one species, e.g. *Maniola jurtina* (BRAKEFIELD, 1982); moreover his results were obtained with both sexes, despite his predictions mainly being concerned with females searching for oviposition sites. It is my purpose to record here more detailed studies and observations on a number of Pierid butterflies in Britain (1977–80) and Morocco (1978–82) which more directly address the association between larval hostplants and movement patterns.

Anthocharis cardamines (LINNÉ, 1758)

The movement patterns of *A. cardamines* were studies in northern England over the period 1977–1980, as part of a larger investigation of population biology (COURTNEY, 1981; COURTNEY & DUGGAN, 1983). *A. cardamines* in this

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