Notes for Guidance
Death to Aphids

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Syllabus links

This unit is intended for specialist Biology and for Environmental Science courses. The unit includes both practical work on the predation of aphids by hoverfly larvae and a data handling activity using results from a research project. The practical work lends itself to internal assessment.

Science, technology and society

Topics
The unit provides an example of
- the need for careful screening and monitoring of any manipulation of the environment such as using biological control

Skills
This unit gives students the opportunity to
- use real data as a basis of judging the suitability of a particular method of controlling aphid pests

Biology and environmental science

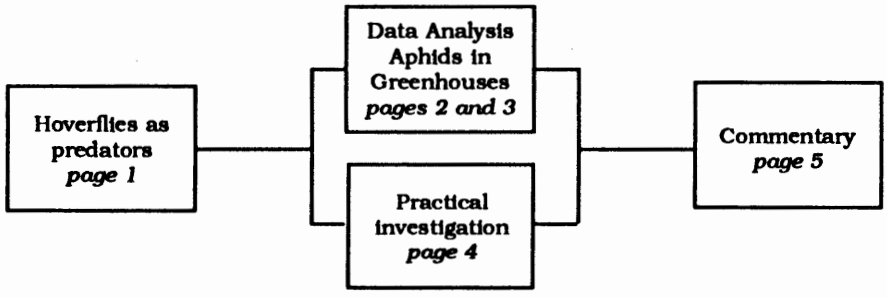
Topics
This unit provides an opportunity for students to extend their knowledge and understanding of
- a predator-prey relationship
- biological control
- classification of insects including aspects of life history

Skills
During the unit students will have the opportunity to
- carry out a practical exercise investigating the relationships between the populations of predator and prey
- interpret and evaluate research data
- communicate their interpretation and evaluation in the form of a formal report

Links with other SATIS 16 - 19 units

SATIS 16 - 19 trial unit T27 *Birds of a Feather* includes a decision-making exercise related to pest control.

The structure of the unit



Using the unit

Timing
A full treatment calls for preliminary private study followed by a 2 hour practical session and then more time for analysis of the results and discussion.

A suggested approach
The data analysis or the practical investigation can be undertaken independently.

The practical work will have to be carried out between May and October. Just over 24 hours before the practical session it will be necessary for someone (teacher, technician or students) to collect the hoverfly larvae and aphids and place them in appropriate conditions (see page 4).

The data in the unit might be studied by students during the practical and can be discussed while waiting for results. The practical report and data analysis can be completed for homework.

Other Sources of Information

Gilbert, F.S. *Hoverflies* Naturalists Handbook 5 (Cambridge University Press.)

Rotheray, G.E. *Aphid Predators* Naturalists Handbook (Cambridge University Press).

De Bach, P. (Ed.) *Biological control of insect pests and weeds* (Chapman and Hall).

Acknowledgements

Dr. Francis Gilbert, Department of Zoology, Nottingham University and Dr. Graham E. Rotheray, Royal Museum of Scotland helped with the preparation of this unit.

Death to Aphids

Biological control of pests is an increasingly important alternative to the chemicals which have been used so freely in recent decades. In many ways it seems a perfect solution to use one organism to control or destroy another. However, there is great potential for any system of biological control to go wrong, and the controlling organism may become a greater threat than its prey. Therefore rigorous and systematic testing is essential before any system of biological control can be introduced and a complex series of experiments must be carried out to ensure that an effective balance is likely to be reached.

This unit takes a look at the possibility of using hoverfly larvae to control aphids. You can investigate the way in which hoverfly larvae prey upon aphids, evaluate research data on this biological system, and consider the possibility of using hoverfly for biological control of greenfly.

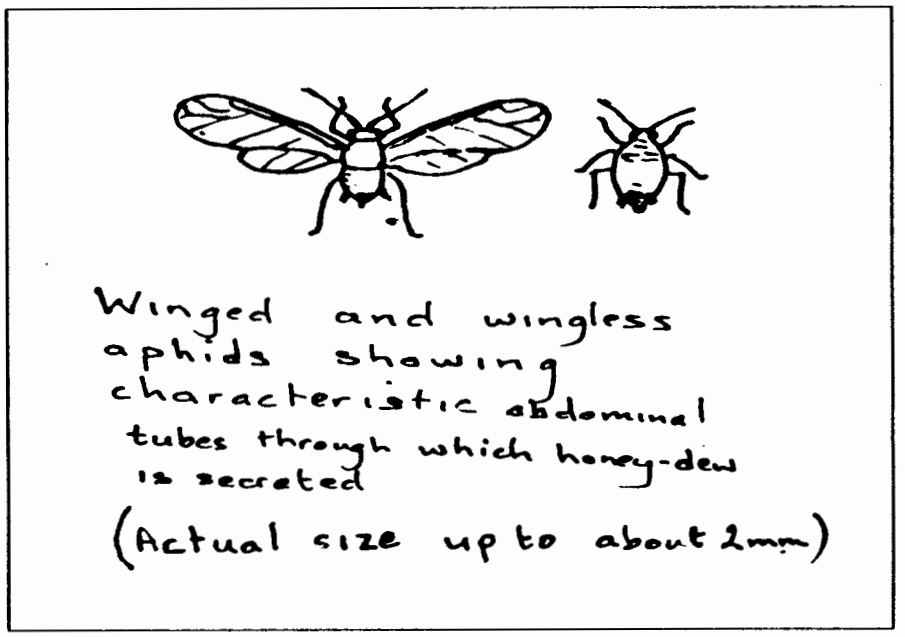


Figure 2 Aphids

Hoverflies as Predators

Talk to gardeners and you will soon discover that they regard greenfly and blackfly as pests. These aphids multiply rapidly, mainly by asexual reproduction; they quickly colonise plants and feed by tapping their sap. Unchecked, aphid colonies can stunt or even kill the host plants. Many garden plants including roses, dahlias, raspberries and beans can be ruined by these extraordinarily successful parasites. However, they do have many natural predators and among the more voracious are the larvae of hoverflies.

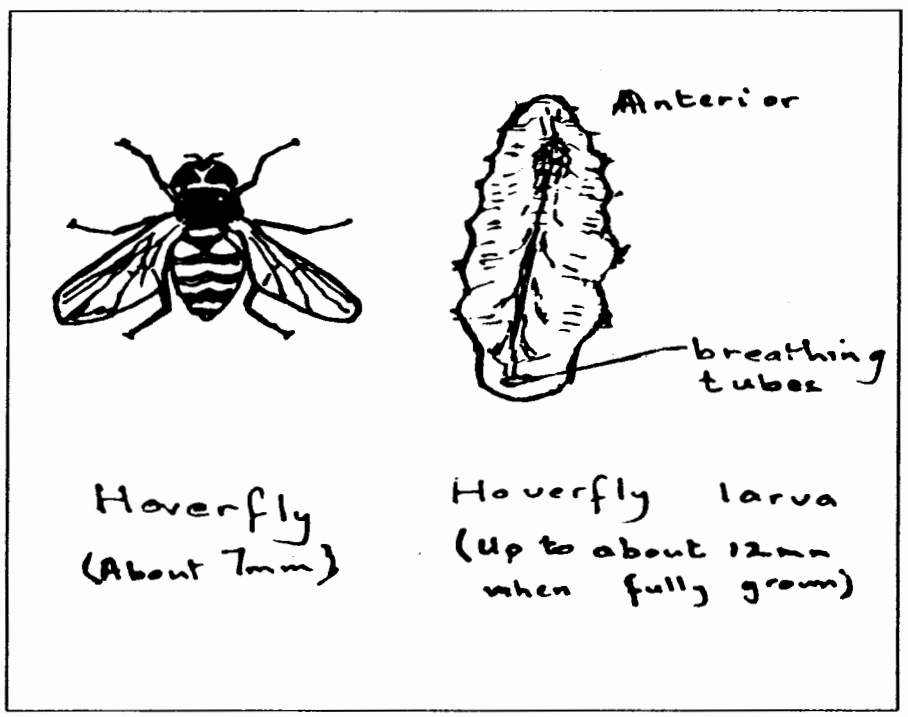


Figure 1 Hoverfly and larva

Hoverflies are mimics of bees and wasps but they have no sting. One of the common predaceous hoverflies is *Syrphus ribesii*, which can be found between May and October on a variety of trees, shrubs and low herbage. The female hoverfly is sensitive to the smell of aphids and homes in on colonies to lay a small number of oval, white eggs on them. After three days the larvae emerge and move forward, rather like caterpillars, until they can fasten their sharp, piercing mouthparts onto an aphid and begin to suck out the body fluids. At this stage it takes the tiny larvae several hours to suck one greenfly dry, but in the second and third larvae stages they are formidable predators, taking only minutes to eat each aphid and feeding all night.

Successful predators are able to find suitable prey, capture it, and gain nourishment by eating it. Hoverfly larvae are well suited as predators of aphids: their random lashing movements and touch sensors help them to detect their prey; they have tooth like structures for digging into and holding aphids; their sticky saliva holds the prey in position while piercing mouthparts extract the body juices.

Do hoverfly larvae have the potential to control aphids? A wide range of experiments has to be carried out to determine whether a predator is a suitable candidate for use in the biological control of pests. Studies are designed to assess the efficiency of the predator by measuring the overall time taken to kill a prey animal. Another criterion is capture efficiency which can be determined by counting the total number of capture attempts and the number of successful attempts in a certain time.

Many factors can affect the capture efficiency including the size of the predator and of its prey, the previous feeding state, the density of prey and the density of predators (where density is measured by the average numbers in unit area). When biological control of aphids is considered, the response of predators to the density of the prey is very important; a high density of aphids causes maximum damage to the crop plants and so the way in which the predators respond to this situation is critical.

The suggested investigation gives a procedure for studying the response of hoverfly larvae to the density of the aphid prey.

Aphids in glasshouses

The use of hoverfly larvae to give complete control of aphid populations in gardens or on outdoor field crops is not in fact practicable because many other factors are involved, including other aphid predators, temperature and humidity. Despite these complications, studies are now being carried out to investigate the potential of hoverflies for the control of aphids in glass houses in the Soviet Union and in this country.

R.J. Chambers of the Department of Entomology and Insect Pathology at the Glasshouse Crops Research Institute has been studying the ability of *Metasyrphus corollae* to control *Aphis gossypii*, an aphid which can cause great damage to commercial cucumber and chrysanthemum crops grown under glass. A method of biological control is needed as the aphid clone is resistant to systemic carbamate and organophosphate insecticides.

Experiments were designed to find answers to these questions:

- Can *M. corrollae* stop the population of *A. gossypii* increasing and even initiate a decline in numbers?
- What is the most effective ratio of predators to prey?
- How long does control last?

The study used cucumber plants infested with aphids. Once female hoverflies had laid eggs on the aphid colonies the plants were enclosed in perspex cages. The plants were kept at a constant daily temperature of 21±2°C with a long photoperiod of 16 hours light followed by 8 hours in darkness.

In a further study one gravid (egg-laying) hoverfly female was placed in each of 5 cages containing a single aphid-infested cucumber plant and left there throughout the experiment.

For the results see figures 4, 5 and 6. on page 3

Figure 3 Syrphus ribesii lifting an aphid clear of a rose leaf before piercing and devouring it

Data analysis

Examine the data carefully and produce a report on the results. Comment on the apparent suitability or otherwise of *M.corollae* as a predator to control aphids.

Points to consider might include:

1 Under what conditions is control achieved?
2 How long does control last?
3 Is control better if females remain to lay further eggs?
4 What practical problems could you foresee if females need to be continuously present? How might these problems be overcome?
5 What ratios of aphids to larvae seem appropriate?
6 How best might *M.corollae* be used?
7 What further investigations might usefully be initiated?

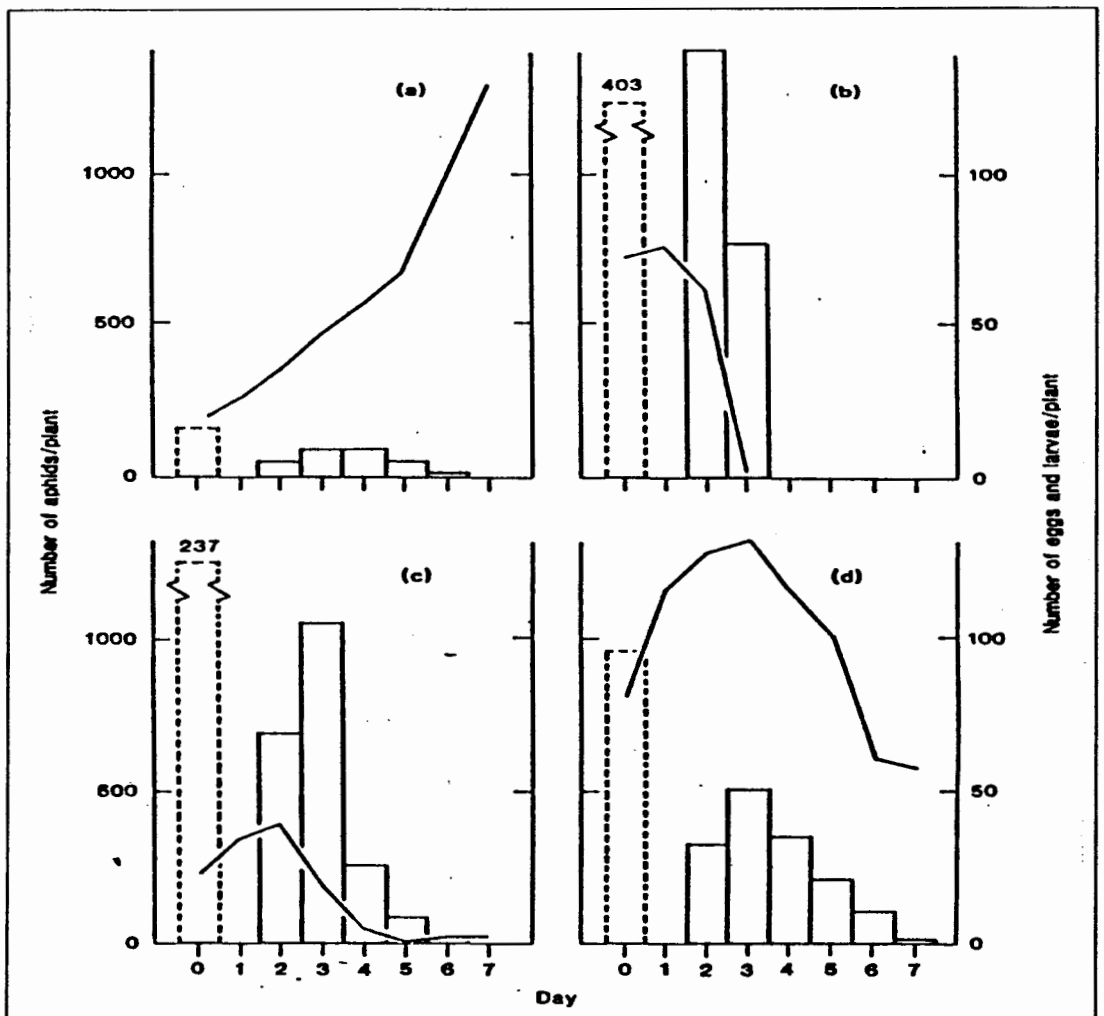


Figure 4 The number of aphids (—), hoverfly eggs (dashed histograms) and larvae (solid histograms) on days 0 to 7 in four cases with different initial ratios of aphids to eggs.

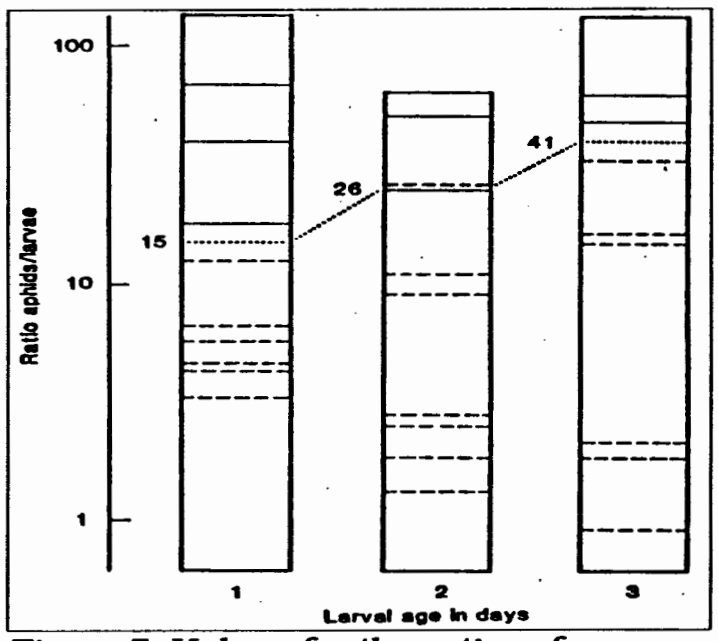


Figure 5 Values for the ratios of aphids:hoverfly larvae which resulted in aphid increase (—) or decrease (— —) over the following 24 hour period for 1, 2 and 3 day old hoverfly larvae, with inferred threshhold ratios for control (·····)

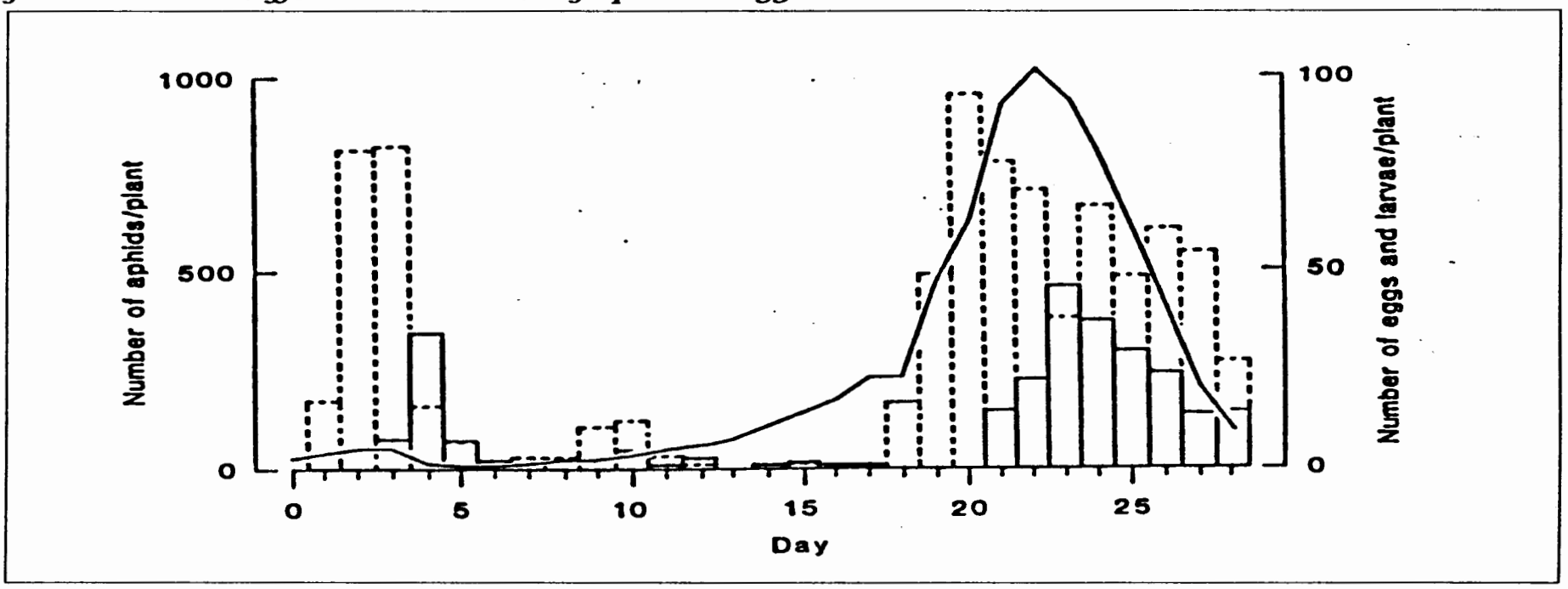


Figure 6 Number of aphids (—), hoverfly eggs (dashed histograms) and larvae (solid histograms) on a plant kept with 1 gravid female M.corollae.

Practical investigation

Collecting hoverfly larvae

Requirements
petri dishes
paint brushes
sealed containers with foliage and greenfly
filter papers or sycamore leaves
large numbers of greenfly
hoverfly larvae

Larvae must be collected at least 24 hours before the investigation because they have to be starved for 24 hours to ensure they will feed in daylight. If they are collected before this, keep them in a cool dark place in a sealed container with plenty of greenfly and foliage. Starve for 24 hours on damp filter paper in petri dishes in the dark.

The best places to find hoverfly larvae vary with the time of year. The larvae respond strongly to touch and seek all round contact and so are usually found during daylight at the bottom of the curled bases of leaves. The larvae are delicate and should be lifted carefully with a paintbrush.

From May to June: Search among roses, cabbages and other garden plants with greenfly infestations. Collect plant material with lots of greenfly colonies and place in plastic bags (sealed) in the dark for 24 hours - the larvae will be visible on the plastic looking like translucent, whitish, very small maggots.

In June, July and August: Giant hogweed and similar unbellificae - many larvae can be found in base of sheath like leaf and stalk bases.

From September to October: Under surface of fallen sycamore leaves - a bag of leaf litter may yield very large numbers of larvae. [NB Many will be mature larvae which are no use for the experiment. They can be recognised by the black waste substances (meconium) clearly visible in the gut.]

The investigation

Starve the larvae for 24 hours. This ensures that they will feed in daylight, rather than at night only as in their natural habitat. The larvae should not be starved for any longer or they will feed much more slowly. This seems surprising but when the larvae are very hungry they extract all the body tissue rather than just the readily available fluids.

Prepare several petri dishes by placing damp filter paper or similar sized sycamore leaves in the bottom. Establish a range of densities of aphids by placing different numbers of aphids in each dish (try: 4, 8, 16, 32 and 64 aphids).

Introduce 5 predators to each dish and leave them for a fixed time (in the range 40 - 60 minutes). Count the numbers of aphids killed.

Interpreting the results

Display the results graphically, to get a functional response curve.

Plot
- the number of aphids killed against density
- the percentage of aphids killed against density

What are the implications of the two curves?

What factors do you consider might affect the functional response curve of a particular predator/prey relationship?

Death to Aphids

Commentary

Data analysis

Here is a summary of the main points which might emerge from an analysis of the data.

For the use of *M. corollae* as an aphid-controlling predator:

1 Control of the aphid is achieved rapidly'

2 Predation pressure is sustained for only a few days

3 Continuous control is possible if females remain but any lull in egg-laying leads to an increase in aphids. Probably, there would be a more stable situation in a greenhouse with its many plants where larvae could redistribute themselves and thus, perhaps, help to compensate for any shortage of egg laying females.

4 As pollen is needed for gametogenesis, females tend to disperse through greenhouse vents unless suitably netted. *M. corollae* is probably not very suitable as a greenhouse dwelling predator.

6 It is best suited for regular releases to combat sporadic outbreaks of aphids or to supplement control by other means. Inundating plants with eggs or larvae is very time consuming but gravid females are easy to release and actively seek out aphid colonies.

7 Further work could be undertaken to determine:
- the effectiveness of adult hoverflies and their larvae in searching for small colonies of aphids in both chrysanthemums and cucumbers;
- the stability of control in a stand of plants;
- the number of gravid females needed for the protection of a given acreage of crops;
- methods of improving the efficiency and lowering the cost of hoverfly rearing methods.

Behavioural Scheme?