SATIS 2.0

Death to aphids

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INTRODUCTION AND SYLLABUS

This unit is intended for specialist biology and for environmental science courses. The unit includes a data handling activity using results from a research project and an opportunity for practical work on the predation of aphids by hoverfly larvae.

SCIENCE, TECHNOLOGY AND SOCIETY

This unit illustrates:

» the need for careful screening and monitoring of any manipulation of the environment such as the use of biological control.

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

This unit provides an opportunity for students to extend their knowledge and understanding of:

» a predator-prey relationship,

» biological control,

» the biology and life histories of insects.

During the unit students will have the opportunity to:

» interpret and evaluate research data,

» communicate their interpretation and evaluation in the form of a formal report,

» carry out a practical exercise investigating the relationship between the populations of predator and prey.

USING THE UNIT

TIMING

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

The data in the unit might be studied by students during the practical investigation and discussed while they are waiting for results. The report and data analysis can then be completed in private study.

Less time is needed if students just tackle the data analysis exercise.

A SUGGESTED APPROACH

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

The practical work has to be carried out between May and October. Just over 24 hours before the practical session someone (teacher, technician or student) has to collect the hoverfly larvae and aphids (see page 5). Giant hogweed should be avoided as a source of larvae because some people find it irritates the skin.

Immature larvae with black waste substance visible in their guts are required for the investigation. Mature larvae lose the black waste substance (meconium) from their guts just they before they pupate.

The Association for Science Education

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Study Guide

Figure 2: Syrphus ribesii hoverfly larva feeding on aphids

INTRODUCTION

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.

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.

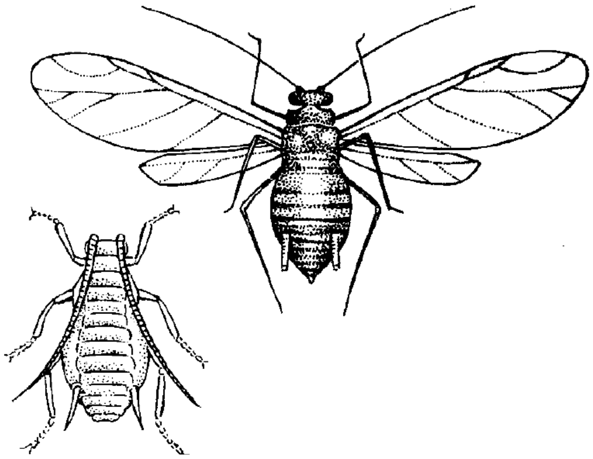


Figure 1: Winged and wingless aphids showing the characteristic abdominal tubes through which they secrete honey-dew - actual size up to about 2 mm

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 a couple of 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.

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.

R. J. Chambers of the Department of Entomology and Insect Pathology at the Glasshouse Crops Research Institute has been studying the ability of the hoverfly M etasyrphus 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:

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

The study used cucumber plants infested with aphids. Once female hoverflies had laid eggs on the aphid colonies they were removed and the plants were enclosed in perspex cages. The plants were kept at a constant daily temperature of 2132 °C with a long photoperiod of 16 hours light followed by 8 hours in darkness (see figures 4 and 5).

In a further study one gravid (egg-laying) hoverfly female was placed in each of five cages containing a single aphid-infested cucumber plant and left there throughout the experiment (see figure 6).

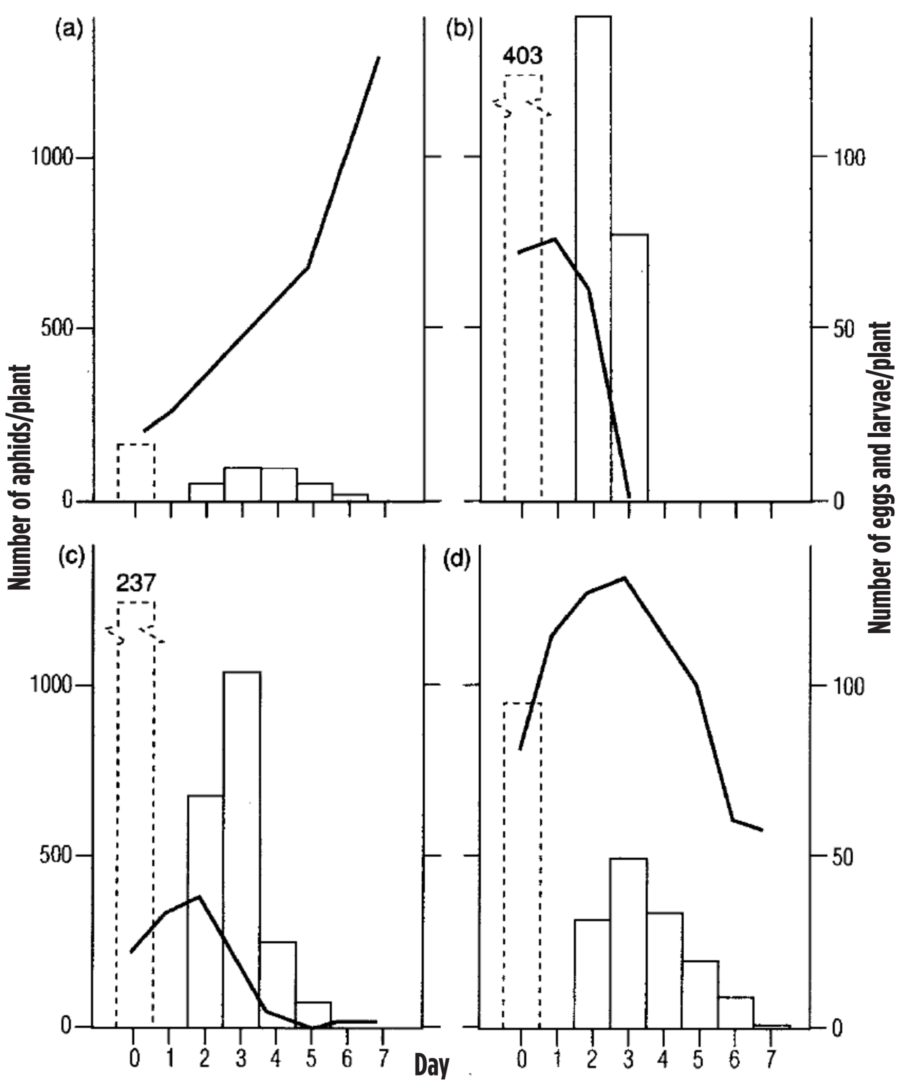


Figure 4: These graphs show the results on days 0 to 7 of experiments with different starting conditions. Note the initial numbers of aphids and eggs and the ratios of aphids to eggs. The number of aphids per plant (-) is shown on the left-hand scale. The numbers of hoverfly eggs (dashed histograms) and larvae (solid histograms) per plant are shown on the right-hand scale

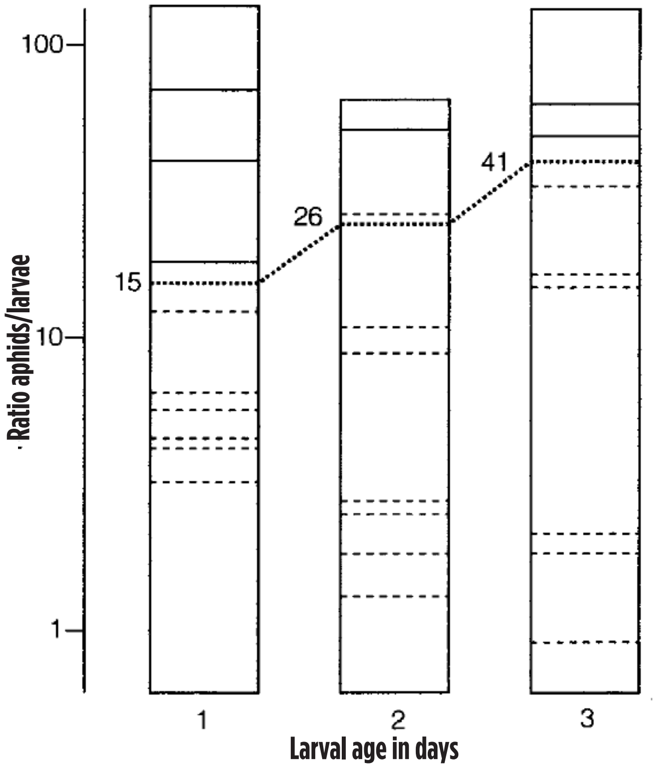
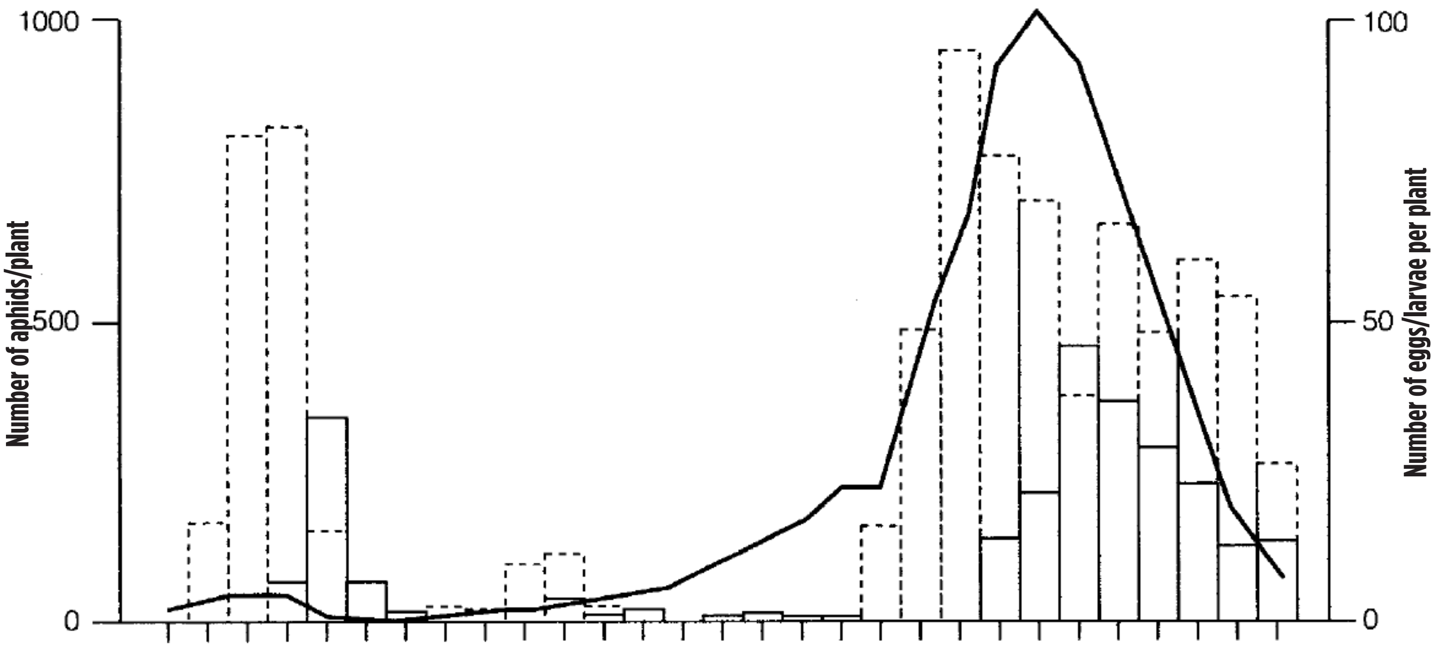


Figure 5: Values for the ratios of aphids: hoverfly larvae which resulted in aphid increase (——) or decrease (------) over the following 24 hour period for 1,2 and 3 day old hoverfly larvae. From these results, the investigators have inferred threshold ratios for control (..........)

Figure 6: In this experiment each plant was kept with one gravid female M. corollae. The number of aphids per plant (——) is shown on the left-hand scale. The numbers of hoverfly eggs (dashed histograms) and larvae (solid histograms) per plant are shown on the right-hand scale.



DATA ANALYSIS TASK

Examined the data carefully and produce a report on the results comment upon the apparent suitability or otherwise of M. corollae a predator to control aphids.

Points to consider might include:

1. How do you account for the conditions of temperature and light chosen for this investigation of the control of aphids on chrysanthemums and cucumbers?
2. Under what conditions is control achieved? How long does it 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 larva seem important?
6. How best might M. corollae be used?
7. What further investigations might usefully be initiated?

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Teacher notes

COLLECTING HOVERFLY LARVAE

REQUIREMENTS

- **Petri dishes**
- **paint brushes**
- **sealed containers with foliage and greenfly filter papers or syca-more 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 move onto the plastic. They look like translucent, whitish, very small maggots.

IN JUNE, JULY AND AUGUST

Many larvae can be found in base of sheath-like leaf and stalk bases of umbellifers. Look in the cups at the base of the leaves of ground elder, alexanders, cow parsnip, hogweed (Heracleum sphondylium) or angelica.

FROM SEPTEMBER TO OCTOBER

Look under the surface of fallen Sycamore Leeds- a bag of leaf litter may yield very large numbers of larvae (note that many will be mature larvae which are no use for the experiment they can be recognised by their lack of black waste substances clearly visible in the guts of immature instars.)

THE INVESTIGATION

Starve the larva for 24 hours. This ensures that they will feed in daylight, rather than at night only as is 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 five predators to each dish and leave them for a fixed time (in the range of 40 to 60 minutes). Count the number of aphids killed.

Display the results graphically, 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 might affect the response curve of a particular predator/prey relationship?

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. The chosen conditions are those in which the plants flourish.
2. Control of the aphid is achieved rapidly.
3. Predation pressure is sustained for only a few days.
4. 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.
5. 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.**

DISCUSSION QUESTIONS

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. It is vital, for example, that predators are relatively specific and do not begin to eat helpful insects such as pollinators. 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.

The size and density of free-living populations is governed by a large number of physical and biological environmental factors. All over the world the natural balance of ecosystems has been disturbed by agriculture and industry. In many instances human activity has opened the. way for the outrageously successful growth of pest organisms which damage or destroy the crops. External control has then had to be introduced.

Chemicals are often applied in a variety of ways to destroy the pests; however, not all organisms are easily attacked by chemicals, due to their habit or mode of life. Increasing concern about the toxicity of pesticides has encouraged a search for effective biological control systems.

Biological control has a long history going back to the ancient Chinese who bought predaceous ants nests to place in mandarin orange trees to reduce the numbers of foliage feeding insects. In 1762 mynah birds were introduced into Mauritius from India to control red locusts. Many organisms including nematodes, snails, fish, amphibians, birds and mammals now play a part in biological control systems but 700000 out of the approximately 900 000 species involved are insects. So it is that most successful examples of biological control have been initiated and developed by entomologists.