Ladybirds as teaching aids: 2 Potential for practical and project work

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Introduction

Ladybirds are one of the most attractive and popular groups of insects. They attract attention and mention wherever they occur. Because they find favour with children they are potentially useful as teaching material. In this paper we suggest ways in which they may be used as illustrative material in a range of biological fields. We also point out areas where there is scope for original project work which may be of scientific merit, for despite their popularity and potential use in controlling aphids, ladybirds have received relatively little attention.

There appear to be two main reasons why ladybirds have not been widely used in schools and colleges in the past. The first is that they have generally been regarded as difficult to culture in the laboratory. Over the last nine years we have developed techniques which overcome most of the culturing problems for most of the British ladybirds. Our techniques for culturing ladybirds have been described elsewhere (Majerus *et al.*, 1989) together with notes on when, where, and how ladybirds may be collected in the wild (see also, Majerus and Kearns, 1989).

Secondly, the lack of literature on the basic biology and ecology of British ladybirds has almost certainly contributed to them being little used in teaching. We hope that publication of our ideas on the ways in which ladybirds might be used as teaching tools, coupled with the recent publication of a book on British ladybirds (Majerus and Kearns, 1989), will encourage the use of ladybirds in teaching, and perhaps stimulate original research.

Abstract

Ladybirds are popular insects with children. As a result, they have considerable potential as teaching aids for a range of biological subjects. They are particularly amenable for studying topics such as insect life cycles, genetics, population biology, and behaviour, but the list of potential projects is almost endless. We give here details of the more obvious potential projects. In many cases, it is likely that novel information will result and we have indicated when we think this is most likely.

Ladybirds belong to the beetle family Coccinellidae. There are 42 British coccinellids, but a number of these are relatively small and not strongly patterned, so they would not normally be recognized as ladybirds. Consequently, there are 24 species of ladybird in Britain. Although many exhibit considerable colour pattern variation, most species are easy to identify. For the few which are more problematic, a field key to the 24 species is available (Majerus and Kearns, 1989). (Full keys to the British Coccinellidae which may be consulted are Pope, 1953, or Majerus and Kearns, 1989.)

Several species of ladybird are very common and widely distributed, and may be obtained easily almost anywhere in Britain. As ladybirds show a complete metamorphosis, they can be used to demonstrate all the normal stages of the insect life cycle. In most species, the whole cycle can be completed in four or five weeks. This means that a generation is completed well within a teaching term. In fact, some species will brood continuously in the laboratory, and two or three generations can be obtained in term.

Twenty of the British species are predatory (one is herbivorous and three feed on mildews), so they can be used to illustrate predator–prey relationships. In addition, the principal foods of all these species are insects, such as aphids, coccids, and adelgids. Many of these are pests which suck the sap of plants, so ladybirds may also be used to illustrate the operation and potential of biological pest control systems.

Different species of ladybird occupy different habitats and, because in their preferred habitat they are often very abundant, they are ideal for use in ecological and population studies.

Many ladybirds show great variation in their colour patterns, and, in both the 2-spot ladybird (*Adalia 2-punctata*) and the 10-spot ladybird (*Adalia 10-punctata*), it is known that the inheritance of many of

the forms follows a simple Mendelian pattern. The differences between forms are obvious and easy to score, so these species provide a most attractive alternative to *Drosophila* for demonstrating basic genetic laws of segregation. The frequencies of the different forms of several species vary across the country. Consequently, there is also scope for studies of these frequency variations and of the causes of, and maintenance of, genetic variation by observations in the field, and by experimentation in the laboratory.

Because our knowledge of the biology, ecology, behaviour, and genetics of British ladybirds is limited in many areas, studies of them have the added attraction that they may produce original and publishable findings.

Ideas for using ladybirds

The limits of our knowledge of ladybirds will make any list of the potential uses of ladybirds as teaching material incomplete and inadequate. However, below we have outlined subject areas for which we think ladybirds would provide suitable demonstration material, with notes on which ladybirds can be used, how they can be used, and limitations of use (time of year, location, etc.). Some topics are suitable for formal practicals; other subjects will involve outside field work which may be undertaken by a whole class or by one or a small group of students doing project work. In this section an asterisk indicates that the results of work on the subject suggested are likely to be original and publishable.

All the suggested projects require ladybirds to be obtained from the wild, and for many of the projects ladybirds will then have to be kept or bred in the laboratory. For descriptions of techniques that may be used in collecting and culturing ladybirds see Majerus and Kearns (1989) and Majerus *et al.* (1989).

Insect life history

During the summer, virtually any species may be used when gravid females or immature stages can be found in the wild, and aphids are easy to obtain. In winter, only continuously brooding species will be suitable (see Majerus *et al.*, 1989). Stocks will need attention each day. Substantial changes in life cycle form will be seen each week. Children tend to be extremely enthusiastic about caring for ladybird families and watching them grow and develop. Two-spot (*Adalia 2-punctata*), 7-spot (*Coccinella 7-punctata*), 14-spot (*Propylea 14-punctata*), Cream-spot (*Calvia 14-guttata*), Cream-streaked (*Harmonia 4-punctata*), and Eyed ladybirds (*Anatis ocellata*) (figure 1) are ideal.

Intra-specific variation

The 2-spot ladybird (figure 2) and the 10-spot ladybird (figure 3) are the most variable British species. (For descriptions of the variations in these species see Majerus and Kearns, 1989.) Both species are common in most areas. The Hieroglyphic ladybird (*Coccinella hieroglyphica*) and the Cream-streaked ladybird also have easily scored discrete variations. Continuous variation can be shown using the 14-spot ladybird which varies with respect to the extent of the black markings (figure 4), or Adonis' ladybird (*Adonia variegata*) in which spot number varies from 3 to 15.

Taxonomy and inter-specific variation

Any species may be used. Apart from showing the range of sizes, shapes, and colour patterns—ladybirds are not all red with black spots—a useful exercise is to get students to make their own keys. Select half a dozen species, and ask students to produce a key so that each may be identified. Then provide a second sample and ask the students to identify each. Some species should be new, and the students should be able to adapt the key to cater for these additional

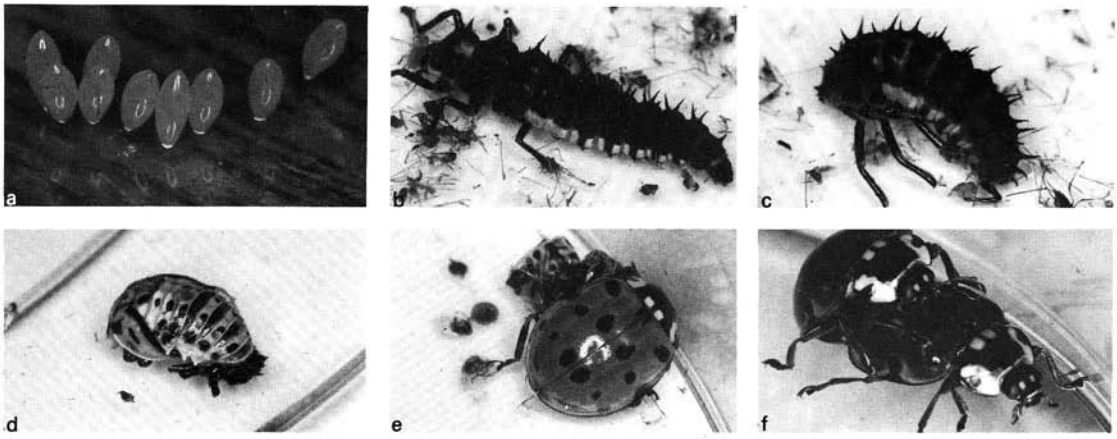

Figure 1 Stages of the life cycle of the eyed ladybird (*Anatis ocellata*): (a) eggs; (b) larva; (c) prepupa; (d) pupa; (e) newly emerged adult; (f) mating adults.

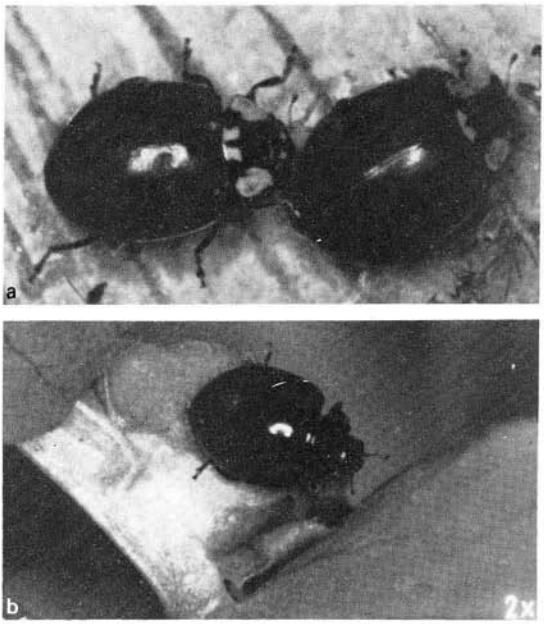

Figure 2 Variation in the 2-spot ladybird (*Adalia 2-punctata*): (a) typical form; (b) form *quadrimaculata*, the commonest of the melanic forms.

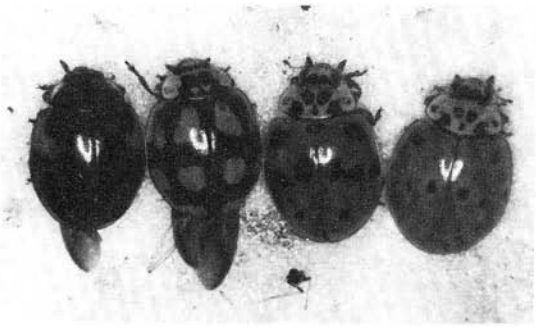

Figure 3 Variation in the 10-spot ladybird (*Adalia 10-punctata*) showing (left to right): melanic (f. *bimaculata*); chequered (f. *decempustulatus*), T_{12} (f. *duodecempunctata*); and typical (f. *decempunctata*).

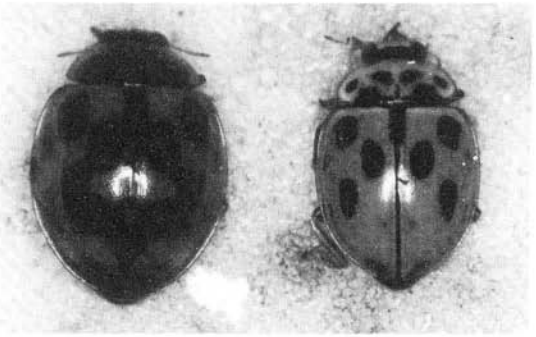

Figure 4 Variation in the 14-spot ladybird in which the variation is continuous from almost completely black to almost completely yellow.

species. If a different form of one of the polymorphic species is used in the key, some of the problems of dealing with variable species can be illustrated. A possible pair of samples using common ladybirds could include:

Sample A
Pine ladybird (*Exochomus 4-pustulatus*)
2-spot (typical form)
7-spot ladybird
14-spot ladybird
10-spot (melanic form)
Cream-spot ladybird

Sample B
2-spot (melanic form)
10-spot (typical form)
7-spot ladybird
22-spot ladybird (*Psyllobora 22-punctata*)
Cream-spot ladybird
11-spot ladybird (*Coccinella 11-punctata*)

The complexity of the exercise can be varied according to the target class.

Genetic studies

Many Mendelian mechanisms of inheritance may be illustrated using the enormous variation in the 2-spot and 10-spot ladybirds. Single- and two-gene systems, bi-allelic or multiple allelic series, full dominance, incomplete dominance, co-dominance, epistasis, and other gene for gene interactions can all be illustrated. (See Majerus and Kearns (1989) for details of the systems of inheritance in these species.) Polygenic inheritance can be illustrated by a simple two-line experiment using the 14-spot ladybird. Simply take and score a wild sample of 14-spots. Then split off the 25 per cent with most extensive black markings and set up a breeding culture with them. Repeat for the 25 per cent of the original sample with least black markings. When these cultures produce progeny, score them, noting the difference in the range of black markings produced compared with the original sample and with each other*.

Behavioural studies

A wide range of behavioural studies may be undertaken. The way in which larval or adult ladybirds search for prey may be studied by introducing them on to a new plant with a small number of aphid colonies. The reactions of ladybirds to encounters with other ladybirds may shed light on courtship, mating preferences, and species recognition. The reactions of ladybirds to disturbance by predators or parasites can also be studied by using real or pseudo predators. For example, the pupae of many ladybirds 'alarm flick' when disturbed (figure 5); they flick up and down rapidly several times. This behaviour can be induced by touching the pupa with a brush or twig. Which species flick, the frequency and number of flicks, and the reaction to continued disturbance

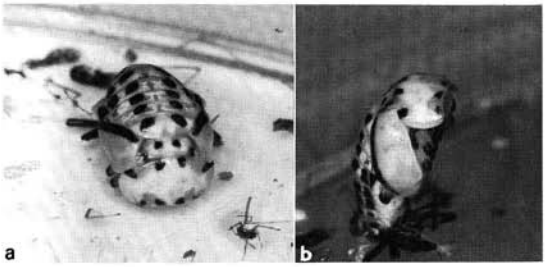

Figure 5 Pupa of the striped ladybird (*Myzia oblongoguttata*) alarm flicking: (a) in resting position; (b) raised.

could all be studied*. Similarly, many adult, and some larval and pupal ladybirds, 'reflex-bleed' when disturbed. This involves releasing small droplets of a pungent yellow fluid from pores in their legs (figure 6). Studies on reflex-bleeding could include which species and which stages reflex-bleed, under what circumstances and how often they reflex-bleed, and whether repeated bleeding is possible*.

Food studies

A great many studies on the interactions between ladybirds and aphids could be conceived, and the results of such studies could have important applications in terms of biological control of plant pests (see also Dixon, 1958, 1959; Evans, 1976a,b; Rotheray, 1989). Studies which would be easy to carry out include: which aphids are acceptable as prey to which ladybirds; whether ladybirds show preferences between two different acceptable aphids; which aphids are toxic; whether rates of development of larvae vary with different prey species; number of prey eaten per day; and many more. Such studies will illustrate some of the complexity of predator–prey relationships. However, they may also be undertaken on a very small scale if required, and still produce interesting and valuable results*.

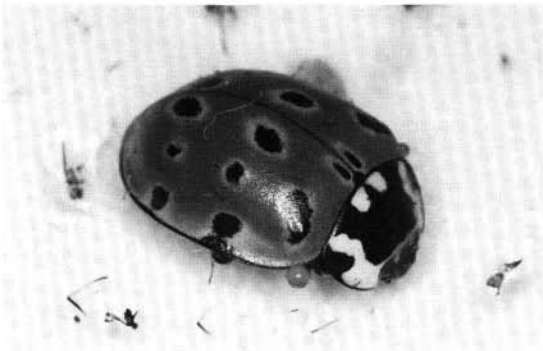

Figure 6 Eyed ladybird (*Anatis ocellata*) reflex-bleeding. A pungently scented yellow fluid is secreted from pores in the legs and forms as droplets on the edge of the elytra.

Habitat surveys

This type of work is best carried out in May and June, and is particularly appropriate for whole classes. If the different techniques (searching, sweeping, and beating) are carried out carefully, a particular site can be covered fairly rigorously. The information gained from such a survey will depend to some extent on the ability of the class (and the teacher). At the most basic level a simple species list may be the product of such a survey. More elaborate information could include numbers of each species, host plants, behaviour (feeding, mating, egg-laying, resting, flying), the forms of variable species, and how the ladybirds were found.

Any information from habitat surveys should be put on record, even if it is just a species list for a particular site. Data should be sent to Dr M. E. N. Majerus, The Cambridge Ladybird Survey, Department of Genetics, 219d Huntingdon Road, Cambridge CB3 0DJ, or to Dr J. Muggleton, Ministry of Agriculture, Fisheries and Foods, Slough Laboratories, London Road, Slough, Berks.

Population biology

Any species may be used, but common species may be most appropriate. The 2-spot, 7-spot, 10-spot, and 14-spot ladybirds are recommended. However, the Larch ladybird (*Aphidecta obliterata*) and the Pine ladybird are often abundant on conifers, and the colonial Kidney-spot ladybird (*Chilocorus renipustulatus*) is very amenable to population studies if a colony lives near. The basic studies which may be carried out in the field are population size estimation, changes in population size, population structure including sex ratio, life history timing, number of generations produced during the summer, movement and migration, changes in host plants, level of parasitism. Many of these studies require ladybirds to be marked. Marking can be done using small spots of Tippex or some types of paint placed on the elytra of the ladybirds. (For details of mark–release–recapture techniques see Majerus and Kearns, 1989; Chalmers and Parker, 1989; Blower, Cook, and Bishop, 1981; or Begon, 1979.)

Overwintering biology

All British ladybirds overwinter as adults. Different species overwinter in different types of situation. For example, 10-spot ladybirds usually overwinter in leaf litter or low amongst growing vegetation close to the ground, while 2-spots choose a site on tree trunks, around window frames or in houses well above the ground. Table 1 gives a list of preferred overwintering sites. However, the list is undoubtedly incomplete. So, for example, the overwintering sites of the Eyed ladybird and the Striped ladybird (*Myzia oblongoguttata*) are unknown. Overwintering ladybirds often form aggregations which are sometimes of a single species, but often consist of several species. Studies to investigate when ladybirds migrate to and from over-

Table 1 Preferred overwintering sites of British ladybirds

24-spot ladybird	Low herbage
13-spot ladybird	Unknown
Adonis' ladybird	Plant litter, low on shrubs
Water ladybird	In reed mace or reed stems
Larch ladybird	Pine bark crevices
16-spot ladybird	Low herbage, grass tussocks, any low dry situations
2-spot ladybird	In or on bark, around window frames, in buildings
10-spot ladybird	Leaf litter
7-spot ladybird	Diverse, usually close to the ground
5-spot ladybird	Under stones, in litter
11-spot ladybird	Plant litter
Scarce 7-spot ladybird	On shrubs
Hieroglyphic ladybird	On heather, in litter under heather
Cream-streaked ladybird	Under bark or in bark crevices of pines
Orange ladybird	Leaf litter
18-spot ladybird	On pine trees, usually high up in foliage or in bark crevices
22-spot ladybird	Low herbage
Cream-spot ladybird	Leaf and plant litter
14-spot ladybird	Diverse, usually close to the ground
Striped ladybird	Unknown
Eyed ladybird	Unknown
Kidney-spot ladybird	Bark crevices of host trees
Heather ladybird	On heather, in litter under heather, on adjacent vegetation
Pine ladybird	On or under pines

wintering sites, the type of site chosen, the amount of mortality during the winter, causes of mortality during this period, the level of activity during the winter, and the size and composition of winter aggregations of ladybirds are all plausible and could produce publishable results*.

Summary

A great many other studies could be undertaken, particularly as project work. Food tests could be extended to consider the range of mildews accepted by the 16-spot (*Micraspis 16-punctata*), the 22-spot, and the Orange ladybird (*Halyzia 16-guttata*). The variation in the 2-spot, 10-spot, and Hieroglyphic ladybirds could lead to studies on form frequencies and population genetic studies, including correlations between form frequencies and environmental factors, mating preferences, differential reproductive rates, differential winter mortality, and so on. The causes of ladybird death could be investigated. In particular levels of parasitism and disease in wild populations are needed. The distastefulness of different ladybirds to birds could be tested, and many, many more.

This list is not exhaustive. Other suggestions may be found in Hodek (1973); and Majerus and Kearns (1989). We are sure that many teachers will have other ideas about the ways in which ladybirds may be used in or out of the classroom or laboratory.

The widespread use of ladybirds as a commercial motif bears witness to their popularity. Children are particularly fond of them, because of their bright colours. Their usefulness to plant growers as pest control agents and their associations with good luck add to their charisma. We hope that we have shown in this and our previous paper (Majerus *et al.*, 1989) that ladybirds can also be interesting and convenient teaching tools, and we commend to you their use for this purpose.

Acknowledgements

We wish to acknowledge with thanks those who have helped us in our work on ladybirds during the past nine years.

We have received a great deal of advice on ladybirds from Mr R. D. Pope and Dr J. Muggleton. A great many people have sent us information on ladybirds since we began the Cambridge Ladybird Survey in 1984. Much of the information on overwintering sites in table 1 has been due to their efforts. We are grateful to them all, whether they have been involved as our own survey recorders, or through the WATCH Ladybird Spots carried out in 1986 and 1987.

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