ASPECTS OF THE OVERWINTERING BIOLOGY OF LADYBIRDS IN BRITAIN

M.E.N. MAJERUS

Department of Genetics, Downing Street, Cambridge CB2 3EH.

Part 1: Introduction

DESPITE considerable amounts of work on the overwintering behaviour of Coccinellidae in continental Europe (see Hodek, 1967, 1973, 1986) and North America (Hagen, 1962), there is a general dearth of information in the literature on the overwintering sites and overwintering ecology of coccinellids in Britain (Benham and Muggleton, 1979).

In 1984, the Cambridge Ladybird Survey was instigated to collect data on the ecology, behaviour and geographic distributions of ladybirds in Britain. The data collected between 1984 and 1989 in respect of geographic distributions, and habitat and host plant preferences, are being published elsewhere (Majerus, Forge and Walker, 1990; Majerus, 1991). I herein present some of the information drawn from the Cambridge Ladybird Survey data in respect of the overwintering biology of ladybirds in Britain.

The Cambridge Ladybird Survey

The Cambridge Ladybird Survey relies on a formidable team of ladybird enthusiasts spread across Britain for collection of preliminary data. The recorders range from young children to nonagenarians. Some are experienced entomologists or professional biologists, but many have no formal biological training or other qualifications as recorders except an interest in ladybirds. Recorders send their notes and observations to the survey headquarters in Cambridge. Over five million records, from over seven thousand sources, had been received by the end of 1989. Records are checked in a number of ways, including cross-checking of grid references with descriptive locations, checking of any uncertain identifications, and following up any unusual observations, usually by a personal visit from one of the Cambridge scientists. (For further details of the procedures used to ensure data accuracy and integrity, see Majerus *et al,* 1990.)

The preliminary data are used as an indicator of areas of specific interest which then become the subject of detailed investigation by members of the Cambridge team. When specific types of data or notes on particular species are required from recorders, these are requested via the survey newsletters which are produced twice a year for this purpose and to keep recorders informed of the progress of the survey.

The survey does not cover all the British Coccinellidae. A number of the 42 coccinellids on the British list are small (less than 3mm in length), are black or brown, and are not strongly patterned. These species would not normally be recognised as ladybirds. Some, such as the species belonging to

the genera *Nephus* and *Scymnus* are difficult to distinguish without the use of a microscope and some taxonomic experience. Because it was considered undesirable to exclude from the survey people who lacked specialist knowledge and equipment, it was decided that the survey would concentrate on the larger and more strongly patterned species. Recorders were provided with notes on the identifications of 24 species. These notes, which have been updated and improved as the survey has progressed, have proved to be useful aids, and there have been very few cases of misidentification. It has been the policy of the Cambridge team to request recorders to send live specimens to Cambridge when identity is in doubt. It should be stressed that in any instance where there has been doubt about the identity of a ladybird, or the situation in which it was overwintering, the records have not been used.

Ladybirds in winter

All ladybirds pass the winter as adults. In Britain, all the species live for approximately a year and so pass just one winter as adults. However, occasionally females of the 2 spot (*Adalia 2-punctata*), 14 spot (*Propylea 14-punctata*), Cream-spot ladybird (*Calvia 14-guttata*), and Eyed ladybird (*Anatis ocellata*) may survive for two winters (Majerus, pers. obs.). The winter is an unfavourable period for ladybirds. Food is scarce or absent, and low temperatures lead to a reduced metabolic rate and reduced activity. Consequently, most ladybirds remain more or less inactive throughout the winter. This diapause or quiescence is primarily a response to the ephemeral occurrence of the prey of predatory species (Hodek, 1986). The exceptions are the four non-predatory species. The herbivorous 24 spot (*Subcoccinella 24-punctata*) and the three mycophilous species, the 16 spot (*Micraspis 16-punctata*), the 22 spot (*Psyllobora 22-punctata*) and the Orange ladybird (*Halyzia 16-guttata*) become active in mild periods throughout the winter, presumably because their food, low growing plants such as campions, clovers, trefoils, plantains and chickweeds, in the former case, and powdery mildews of the family Erysiphaceae, in the latter, are available for much of the winter. Predatory species do not have suitable food available except in abnormally mild winters and so they seek out sheltered situations during the autumn. In their refuges, they remain until food is available again. Sites chosen vary between species. Some, such as the 7 spot (*Coccinella 7-punctata*), 14 spot and Cream-spot are relatively non-specific about their choice of site, so that any position which affords some protection from wind and rain may be used. Typical sites for these species are in curled dead leaves, leaf litter, hollow plant stems, bark crevices, grass tussocks, or amongst thick foliage on evergreen shrubs, coniferous trees or tight leaf rosettes of herbaceous plants. Other species are more specific. The Water ladybird (*Anisosticta 19-punctata*) usually overwinters between the dead leaf blades of reed-mace (*Typha* spp.) or

common reeds (*Phragmites australis*). The 18 spot (*Myrrha 18-guttata*) chooses sites in the crowns of mature Scots pine. In both these species, the sites chosen are sheltered situations in their normal habitats. However, some species move away from their normal summer haunts to overwinter. The 2 spot ladybird usually passes the winter in buildings, particularly around window frames, in double glazing units, or tucked into corners of unheated rooms or outhouses. It is probable that the two largest species of British ladybird, the Eyed and the Striped ladybird (*Myzia oblongoguttata*) also disperse from their summer habitats to pass the winter. Both are conifer specialists, favouring Scots pine. Exhaustive searches of Scots pine during the winter have produced less than a dozen records between November and February, even in locations where both species are common or abundant on the pines in the autumn and spring. It is hard to believe that these large species could have been missed during these searches if they do remain on the pines during the winter. It may be noted that two other conifer specialists, the Pine ladybird (*Exochomus 4-pustulatus*) and the Cream-streaked ladybird (*Harmonia 4-punctata*) are commonly found on Scots pine during the winter, usually in numbers that correspond well to their abundance in the months running up to and following their quiescent periods.

Not all winters are the same. The survey has spanned two particularly mild winters to date (1988/89 and 1989/90). The records for those two winters, when compared with those from 1984/85 to 1987/88, suggest that some species may show climate related variations in overwintering behaviour. For example, the Kidney-spot ladybird (*Chilocorus renipustulatus*) was rarely found in exposed positions on the trunks of its host trees during the winters between 1984/85 and 1987/88, nor was it recorded feeding from October to February in these years. However, in 1988/89 and 1989/90, the species was recorded many times in exposed positions on the trunks of sallow, ash, poplar and birch during the winter. In these years, records of adults feeding on coccids have been received for all winter months, and in 1990, the ladybirds were becoming active and mating by early March. Similarly, prior to 1989/90, the Orange ladybird had been recorded mainly from leaf litter beneath sycamores, and had never been observed in exposed situations except when active on particularly mild days. However, between October 1989 and February 1990 over 80 observations of this species, apparently inactive on the trunks or under lateral branches of deciduous trees, were made. These individuals were left undisturbed and their positions were checked repeatedly until they disappeared. The ladybirds, which were all first seen in January 1990, remained at the sites where they were first observed for between six and 124 days. Similar observations were recorded in Dyfed by Fowles (1990). He studied the overwintering sites of this species in a small oak/hazel dingle woodland at Coed Nant Llolwyn, Dyfed. Thirty-eight ladybirds were monitored on 51 visits to the site from December 1989 to March 1991. The

majority of the ladybirds were found on the north-eastern sides of trees, away from the prevailing south-westerly winds. Most were on relatively thin vertical stems (less than 3.5cm diameter), directly beneath an overhanging knot, twig or branch. Fowles suggests that, in such situation, the ladybirds are protected from the worst of the chilling and desiccating effects of the wind, and avoided frequent wetting in rain. Indeed, Fowles noted that ladybirds did occasionally move to avoid water trickling down the trees. Finally, Fowles noted that the ladybirds favoured young trees with smooth bark, such as hazel, hawthorn, beech and sycamore, avoiding trees with roughened bark which would prevent the ladybirds clamping down tightly if attacked by arboreal predators such as ground-beetles.

The winter sites of 7 spot ladybirds were also somewhat abnormal in 1989/90. Many reports of clumps of 7 spots residing in exposed positions particularly in deciduous woodland, have been received. These observations may be explained by the mildness of the winter, or, because 7 spots were particularly abundant during the winter of 1989/90, it is possible that these clumps were the result of a limited number of suitable more sheltered sites all being occupied. During the winter of 1989/90, several recorders reported finding large numbers of 7 spots just below the soil surface. Such a situation has only been reported once previously for the 7 spot in Britain, in 1985 in West Lothian (Pattle, pers. comm.). Whether 7 spots commonly overwinter in such situations or whether this behaviour is a consequence of the unusual weather, and in particular the abnormally high soil temperatures during the winter of 1989/90 is not known.

Many ladybirds congregate into small, or occasionally large groups during the winter. In Britain the species which regularly produces the largest groups is the 16 spot. Aggregates of several thousand individuals are not uncommon and one gorse bush, near Lakenheath in Suffolk was host to a population estimated in excess of 30,000 in January 1990. Aggregates in excess of a thousand have also been recorded in the 2 spot and 22 spot. Indeed the largest reported aggregation of British ladybirds that I can find is one of more than 50,000 2 spot ladybirds between an old wooden trellis and a garden wall in Sevenoaks, Kent, in February 1950 (Williams, 1960). Three other species have been found in groups in excess of a hundred, namely the 24 spot, the 7 spot and the Pine ladybird. Table 1 gives details of the approximate proportions of records of overwintering ladybirds which involved groups, and the maximum and average number of the ladybirds recorded in groups.

The mechanisms by which ladybirds are attracted to one another for the winter is not known for certain. Hodek (1973) states that behavioural responses which lead to the production of aggregates may be indirect or direct. Responses to factors such as light, gravity, temperature and humidity may lead many individuals to accumulate at the same place. In such cases the production of aggregations is determined by factors extrinsic to other ladybirds. Alternatively, there may be a pheromonal attraction

Table 1. Notes on the grouping of overwintering ladybirds. Only Cambridge Ladybird Survey records from October 1984 to March 1990 are included.

	Percentage of records involving group	Maximum number in a group	Approx. mean number in group**	Number of records*
24 spot	31	>200	18	c
13 spot	—	—	—	—
Adonis'	24	7	2-3	a
Water	9	17	2-3	f
Larch	8	9	2-3	d
16 spot	95	>30,000	480	d
2 spot	61	>3,000	19	f
10 spot	11	12	3-4	e
7 spot	31	250	8	f
5 spot	14	3	2-3	a
11 spot	16	17	3-4	d
Scarce 7 spot	27	19	4	c
Hieroglyphic	3	2	2	b
Cream-streaked	21	14	4-5	d
Orange	12	8	2-3	c
18 spot	13	7	2-3	d
22 spot	21	>1,000	31	d
Cream-spot	9	4	2-3	d
14 spot	2	7	2-3	b
Striped	0	—	—	5
Eyed	17	2	2	6
Kidney-spot	16	37	5-6	e
Heather	3	4	2-3	a
Pine	16	>350	12	f

* For the purposes of number and percentage of records, an aggregation of ladybirds counts as a single record, so an aggregation of over thirteen thousand 16 spots is one record (a — 10-49; b — 50-99; c — 100-499; d — 500-999; e — 1,000-9,999; f — more than 10,000 records).

** The mean number of ladybirds in groups is calculated by dividing the total number of ladybirds in groups by the number of groups. Single ladybirds are not included.

between ladybirds which causes them to aggregate. If so, it seems probable that the scent is of long duration as the same sites are often used by ladybirds year after year. As ladybirds generally do not survive through two winters, there must be some method by which the new generation of ladybirds is attracted to these regularly used sites. A pheromone laid down at a site by the previous winter's tenants could acccomplish this. Alternatively, Hills (1969) has suggested that 2 spots are attracted to overwintering sites by the smell from the excreta of the previous year's population, or by the few adults that die at such sites each winter.

Little work has been carried out on the relative importance of physical and chemical stimuli to aggregate formation in different species. Pullianen (1963, 1964) studied the responses of 8 spot ladybirds which overwinter in

bark crevices of pine trees in Finland. He found that they showed a strong negative response to humidity, which was only reversed after prolonged desiccation. They were repelled by short-wave light, and by long-wave light following desiccation. However, the relevance of these results to British populations of 18-spots must be questioned for Pullianen reported that 93% of 18 spots overwinter in bark crevices in the lowest 10cm of the trunks of pines. This figure can be contrasted with that of Majerus (1988) who found the species to have a strong preference for overwintering in the crowns of Scots pines at two locations in England. Virtually no work has been carried out on the existence or function of pheromonal attractants. However, recent studies have provided circumstantial evidence of a chemical attractant. Repeated washing with water during the summer, of sites regularly used by 2 spot ladybirds in the winter reduces the probability of the site being used subsequently (Majerus, unpublished data).

If a pheromonal attractant is involved in aggregate formation, is seems unlikely that the pheromone is species-specific, for aggregations often involve ladybirds of two or more species. Table 2 gives a list of species which have been found together during the winter. However, this table does not indicate the occurrence or composition of aggregations comprising three or more species. Such groups do occur. Particularly common are aggregations in buildings in which 2 spots predominate but are accompanied by a small number of individuals, usually just one or two, of the 10 spot, 14 spot, 11 spot (*Coccinella 11-punctata*) and/or 7 spot. Indeed, one group in a house on the west edge of the New Forest contained all these species, the precise composition of the group being 23 2 spots, two 10 spots, two 14 spots, one 11 spot and one 7 spot. Three or four species groups are not uncommon on pines, the species involved usually being 7 spots with Pine ladybirds and one or others of the Cream-streaked ladybird, 10 spot, 11 spot, 14 spot, 2 spot, Hieroglyphic (*Coccinella hieroglyphica*) or Larch (*Aphidecta obliterata*) ladybirds. The most diverse such group was one comprising six species. It was situated amongst the needles at a base clump of pine cones on a young Scots pine near Dry Drayton, Cambridgeshire, on 21st October in 1989, and included seven pine ladybirds, six 7 spots, three 10 spots, two Cream-streaked ladybirds, two 2 spots and one 11 spot.

The abundance of 7 spots in the winter of 1989/90 led to the formation of abnormally large groups of this species, often in exposed situations, particularly in deciduous woodland. These groups are easily seen and may be scanned for other species without disturbing the insects. At Madingley Wood, Cambridgeshire, 150 such clumps, containing some 3,497 7 spots were checked between 17th January and 3rd February 1990. The aggregates of 7 spots varied in number from three to 137 individuals. Individuals of 11 other species were found in these clumps, the numbers of each being given in Table 3. In all clumps, 7 spots were the commonest species.

Table 2. Species of ladybird found together in overwintering aggregations. (Only Cambridge Ladybird Survey records from October 1984 to March 1990 are included.)

	24 spot	13 spot	Adonis'	Water	Larch	16 spot	2 spot	10 spot	7 spot	5 spot	11 spot	Scarce 7 spot	Hieroglyphic	Cream-streaked	Orange	18 spot	22 spot	Cream spot	14 spot	Striped	Eyed	Kidney-spot	Heather	Pine
24 spot	0																							
13 spot	•	0																						
Adonis'	•	•	5																					
Water	•	•	•	7																				
Larch	•	•	•	•	6																			
16 spot	•	•	•	•	•	11																		
2 spot	•	•	•	•	•	•	15																	
10 spot	•	•	•	•	•	•	•	11																
7 spot	•	•	•	•	•	•	•	•	19															
5 spot									•	1														
11 spot	•	•	•	•	•	•	•	•	•	•	12													
Scarce 7 spot									•		•	3												
Hieroglyphic	•						•		•				5											
Cream-streaked					•		•	•	•		•			9										
Orange							•	•	•						4									
18 spot									•					•		4								
22 spot	•			•		•	•		•								6							
Cream spot						•	•	•	•								•	7						
14 spot	•			•		•	•	•	•					•				•	8					
Striped																				0				
Eyed																					1			
Kidney-spot							•		•						•			•				6		
Heather	•					•			•				•	•		•						•	8	
Pine			•		•	•	•	•	•		•	•	•	•	•	•					•	•	•	14

• means aggregations including both species have been recorded. The numbers arranged diagonally show the number of other species with which each species has been found in the winter.

Furthermore, 7 spots comprised more than half the ladybirds present in all groups except one consisting of 11 7 spots, seven Kidney-spots and six Pine ladybirds.

Little work has been carried out on the cues involved in stimulating ladybirds finally to leave winter sites in Britain. Workers elsewhere, have shown that overwintering 7 spots from central Europe (latitude 50°N) and south-eastern France (latitude 41°N) show a pronounced photoperiodic response if transferred to high temperatures (23.5°C) in the laboratory. Reproductive activity was initiated under long day-length conditions (18 hours light, 6 hours dark), but inhibited by short day-length (12 hours light, 12 hours dark) (Hodek *et al,* 1977; Hodek and Ruzicka, 1979). However, samples from northern Greece (latitude 41°N) showed a neutral response to

2 spot	4
14 spot	11
10 spot	35
Kidney-spot	81
Pine	34
Eyed	1
Larch	3
Orange	3
22 spot	2
Cream-spot	17
11 spot	6

Table 3a. Numbers of ladybirds of 11 species present in 150 groups dominated by 7 spot ladybirds in Madingley Wood, Cambridgeshire, January/February 1990.

Just 7 spot	84
2 species	26
3 species	24
4 species	14
5 species	2

Table 3b. Numbers of species present in each of 150 ladybird groups in Madingley Wood, Cambridgeshire, January/February 1990.

photoperiod, both long and short day-length initiating oviposition in most females after a short period, and similar results have been reported from two samples from southern Spain (latitude 37°N) (Hodek *et al*, 1989). Other studies on 7 spots have endorsed this variability in response to environmental cues (see Hodek, 1973 and 1986 for reviews). Indeed, in Japan, the subspecies *Coccinella 7-punctata brucki* shows the opposite response to that seen in central European populations, with short day-length promoting oviposition (Hodek *et al*, 1984).

In Britain, final emergence from overwintering sites varies considerably from year to year, predatory species becoming active earlier following mild winters and later after harsh ones. For example, in Cambridge, the main emergence from winter sites for 7 spots in 1988, a relatively average winter in terms of temperature, was during the second week in April. In 1989, after a very mild winter, the main emergence was a month earlier, during the second week in March. Similarly, the earliest observed matings were on 21st April in 1988 and on 17th March in 1989. These observations suggest that cues other than day-length are important. It may be that during early forays from overwintering sites, ladybirds are able to assess levels of prey availability. Alternatively, they may have some ability which enables them to discern, from their previous experience during the winter, whether food is likely to be available.

(to be concluded)