

LIFE CYCLE STRATEGY OF ADALIA BIPUNCTATA (L.) (COL., COCCINELLIDAE) IN A TEMPERATE COUNTRY

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Introduction

Since 1968, the cereal aphids (*Sitobion avenae* /F./, *Metopolophium dirhodum* /Walk./ and *Rhopalosiphum padi* /L./) have been major pests of wheat in Europe. This may be a consequence of the recent intensification of agricultural methods (Carter et al., 1980). Preventive applications of pesticides is the commonest method of control employed in most of the European countries (Carter et al., 1980, Latteur, 1985). Surprisingly, integrated pest management (OILB 1977, Luckmann and Metcalf, 1982) has not been used against cereal aphids. Little attention has been given to management practices which avoid or reduce the development of aphid populations on wheat and/or increase the impact of their natural enemies. *Adalia bipunctata* is one of the cereal aphid predators regularly present in wheat fields in Belgium. In this paper we draw a parallel between its phenology throughout the year and its gonadal physiology. More particularly, hibernation sites, distribution between habitats and the state of maturation of its gonads are described. Study of the life cycle strategy of *A. bipunctata* contributes to our understanding of the agricultural ecosystem, a prerequisite for the implementation of integrated pest management.

Phenology of *A. bipunctata*

Hibernation

A. bipunctata overwinters in aggregations in window-frames, on the walls of houses or in crevices in the bark of trees. Observations made in 15 poplar plantations during three winters have shown that aggregations of a mean size of 2.56 ladyb./min=1, max=36, n=1627/ occur mainly on trees growing along the Southern edges. On the trunks, the ladybirds prefer crevices orientated from East to South-West ($F=27.11$, $P<0.001$). South facing windows and walls are also more attractive as hibernation sites. In these sites, however, architectural characteristics greatly influence the size of the aggregations. In our country, which lacks high mountains, we did not observe hypsotactic tendencies during hibernation.

Generally, *A. bipunctata* begin to seek out dormancy sites in mid September and leave these sites from March to early May (Hemptinne, 1985).

Distribution in habitats

From spring to summer, *A. bipunctata* occurs on herbaceous vegetation

and crops as well as on bushes and trees. At first sight, Figure 1 shows a continuous presence of *A. bipunctata* on crops, bushes and trees from the beginning of spring to the end of September. On the other hand, there is a period in summer when it is not present on herbaceous vegetation. Nevertheless, this ladybird does not simultaneously settle in all habitats. In addition to these general tendencies, there are three outstanding chronological events:

- i/ early in spring, sporadic ladybirds are seen on bushes (willows, hazel-trees, elder, hedges) close to the dormancy sites.
- ii/ from April, large populations of adult *A. bipunctata* occur on trees with a very highly significant preference for fruit trees in blossom ($u=5.9910$, $P<0.001$). We did not observe any aphids on these trees until mid June, which possibly accounts for the absence of eggs and larvae on these trees early in the year (see below: Histophysiology of the gonads). During this period, *A. bipunctata* eats pollen or micro-arthropods like *Psylla mali* Forst (Hom., Psyllidae).
- iii/ the ladybird abundance decreases in the orchards when the flowering comes to an end. At that time, large numbers of *A. bipunctata* were observed on herbaceous vegetation, amongst which nettle patches are very important because they form a network throughout the countryside and support large colonies of aphids (*Microlophium evansi* Theob.) early in the year. The ecological conditions prevailing in the nettle patches allow the development of the first generation of the season. Because of the abundance of *M. evansi*, nettles act as a very efficient insectary quickly producing a large number of ladybirds. Around mid July, nettle aphids become rare and *A. bipunctata* migrates to crops.

During the summer, there are a number of successive and overlapping generations of *A. bipunctata* in the different kinds of habitat. Figure 1 also indicates that *A. bipunctata* will return to herbaceous vegetation at the end of summer. At that time, *Heracleum sphondylium* L. and *Tanacetum vulgare* L. provide the most important habitats, independent of the presence of aphids, as the ladybird beetles eat the pollen of the flowers.

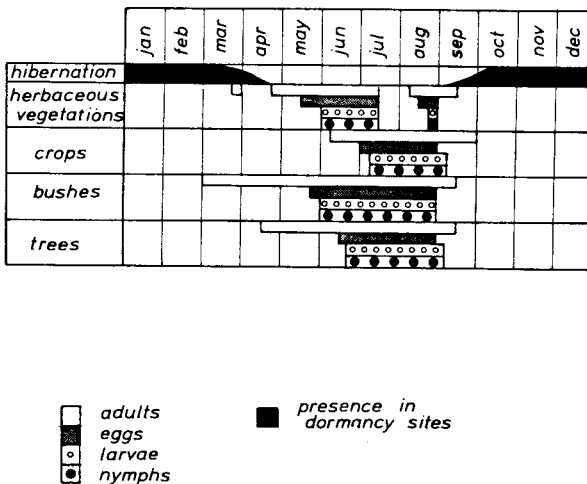


Fig. 1. Phenology of *A. bipunctata*. Distribution of the different stages in the main habitats.

The results of quantitative observations made in orchards, nettles, and wheat fields are given in Figure 2. *A. bipunctata* is the dominant species (83% of the ladybirds) in orchards as well as on nettles.

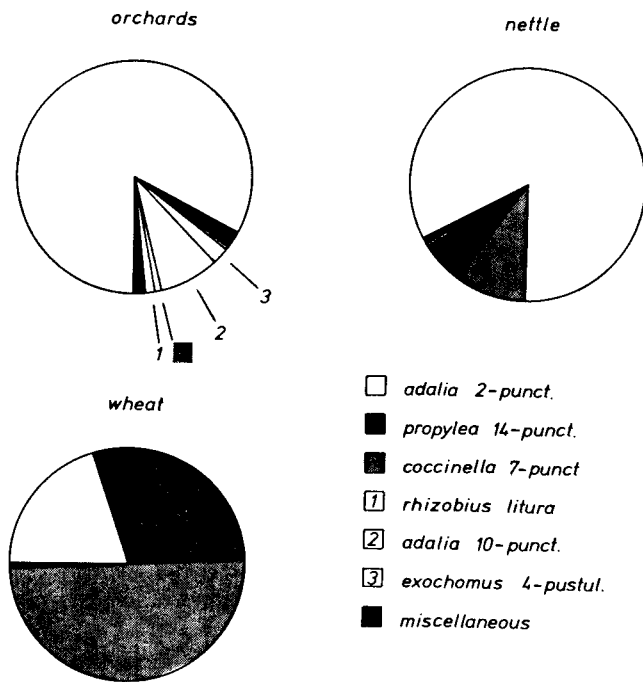


Fig. 2. Relative importance of the different species of ladybirds in three habitats.

However the ladybird community of orchards is especially diverse. In wheat fields, *A. bipunctata* made up 19.63% of the ladybirds encountered. Each year they are observed from the beginning of June until harvest in mid August. At the maximum, the mean adult density is rather low ($\bar{x}=0.20$ ladyb./m², $miq=0$, $max=0.44$, 6 fields) while that of the larvae reaches 2.60 ladyb./m² ($min=0.17$, $max=6.67$) (Fig. 3). In 1986 (Fig. 3), ladybird adults colonized wheat fields when aphid population was low. However, the aphid density was adequate for ladybird reproduction and survival of sufficient larvae to give a good aphid kill.

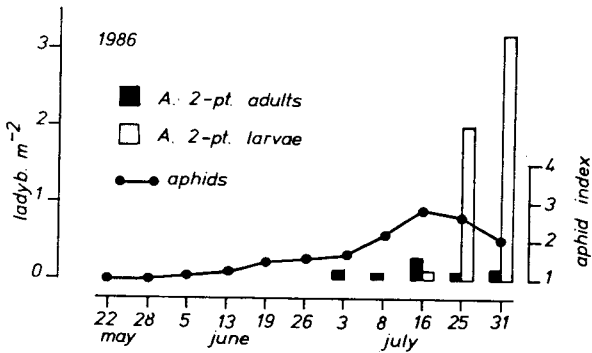


Fig. 3. Development of cereal aphids and *A. bipunctata* populations in wheat fields (mean of 6 fields).

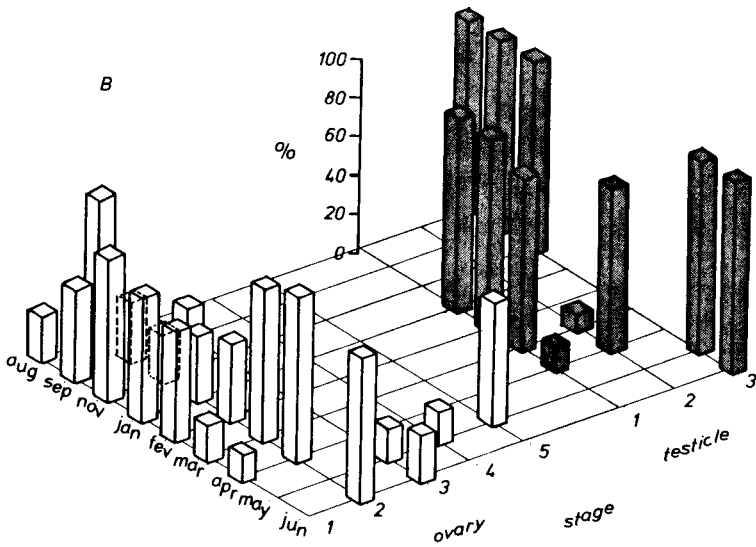
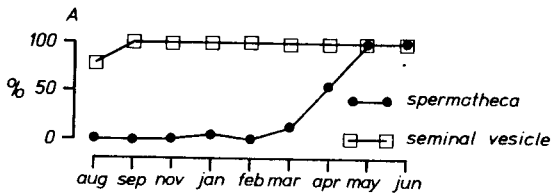
Legend:

- aphid index:
- 1: no aphids,
 - 2: very low density, aphids only recorded with a sweep-net,
 - 3: low density but aphids detected by visual observation,
 - 4: high density.

Histophysiology of the gonads

The histological method and characterization of the gonadal stages used in this chapter are described elsewhere (Hemptinne and Naisse, 1987). The condition of the reproductive system of *A. bipunctata* at three periods of the year:

- 1) autumn (from August to November),
 ladybird activity decreases from the end of August to late September when they aggregate both at night and during the day. Their ovaries are active but the oocytes are immediately resorbed (stage 1 and 2, Fig. 4B). Differentiated oocytes become more frequent relative to growing ones as the season progresses. The spermatheca of the females is empty (Fig. 4A). In the males, spermatogenesis is observed up until November. However, spermatogenesis begins to end in September when there is a progressive degeneration of all the differentiated spermatogonia and follicular invasion by testicular fluid (Fig. 4B). The spermatozoa produced in autumn is kept during the winter in the seminal vesicles, which are full and very bulky (Fig. 4A).



. State of maturation of the reproductive system of *A. bipunctata* from August to June,

A: Frequency of full spermathecas and seminal vesicles,

B: Frequency of the various gonadal stages.

Legend:

ovary stages: 1: differentiated oocyte,

2: growing oocyte,

3: full-grown oocyte,

4: vitellogenesis,

5: chorionated oocyte in the lateral oviduct.

testicle stages:

1: inactive pro-spermatogonia,

2: recovery of mitotic activity in spermatogonia,

3: active spermatogenesis.

2) winter (from January to March),
 at first sight, the histological sections made in winter look like those of autumn. Nevertheless the proportion of ovaries with growing oocytes (stage 2) increases progressively from January to March (Fig. 4B). The testicles are now completely inactive. It is only in March that the spermatogonial mitotic activity starts but development does not go beyond the spermatogonial stage (Fig. 4B). At this time the ladybirds begin to mate (Fig. 4A), but because of the males' physiological condition, females can only be fertilized by sperm produced before the onset of winter. We have demonstrated that this sperm is fertile (Hemptinne and Naisse, 1987).

3) spring (from April to June),
 vitellogenesis and spermatogenesis are fully resumed at the beginning of May when the ladybirds are present in the orchards. Histological preparations indicate that some females have already laid a few eggs but that in most beetles vitellogenesis is abnormal and abortive. This is probably because they are feeding on pollen and explains the scarcity of eggs in orchards (see above: Distribution in habitats).

In another way, pollen has a positive affect on testicle maturation as shown in figure 5. After 4 days, spermatozoa (n° 6 on vertical scale of Fig. 5) are produced by all the males (n=4) fed with pollen. When fed aphids (*Acyrtosiphum pisum*) they produced spermatocytes II (n° 4 on the scale) or spermatids (n° 5) in the same time under the same experimental conditions. Fasting males died after 3 days.

The cycle in gonadal activity and field observations, indicate that there are at least three generations of *A. bipunctata* produced per year.

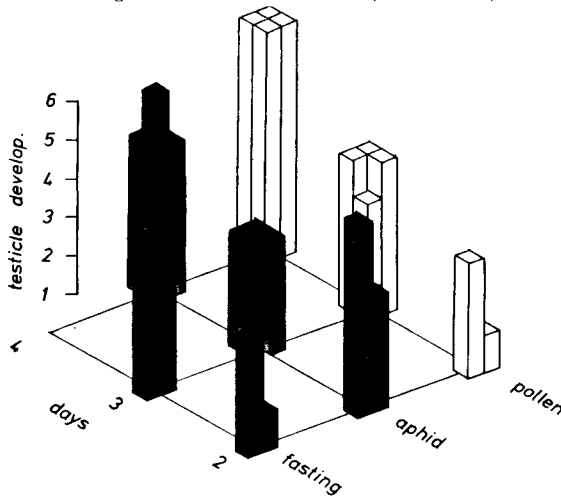


Fig. 5. Testicle development of males taken from hibernating sites and kept for 2,3 or 4 days in laboratory conditions (22°C,18 HL).The males were fed with three kinds of diet.

Legends: testicle development:

- 1: inactive
- 2: mitosis in spermatogonia
- 3: spermatocytes I,
- 4: spermatocytes II,
- 5: spermatids,
- 6: spermatozoa.

Conclusions

A. bipunctata is a precocious and multivoltine species. This is associated with the early dispersal from dormancy sites and early onset of gonadal activity. The development of the reproductive system from January to March indicate that intensity of diapause decreases at that time. These conclusions agree with those of Obrycki et al. (1983) and Quinet (1987, in preparation).

In Belgium *A. bipunctata* is recorded from a wide range of habitats. Nevertheless, orchards and nettle patches are of a great importance. The first furnish the ladybirds with large quantities of alternative food to aphids early in the year which allows them to come into reproduction early in the year. Large aphid colonies on nettles are necessary for the growth of ladybird populations. It is likely that the conditions prevailing in these two habitats greatly influence the impact of *A. bipunctata* on cereal aphids. The synchronization of *A. bipunctata* with these aphids has been regularly observed year after year.

Field observations coupled with histological studies are important sources of information for the understanding of insect life cycles. Generally, these methods are complementary. The eco-physiology of *A. bipunctata* indicates that it should be included in the integrated pest management of cereal aphids in wheat fields.

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