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PRELIMINARY SURVEY OF THE LACEWINGS (NEUROPTERA: CHRYSOPIDAE, HEMEROBIIDAE) IN AGROECOSYTEMS IN NORTHERN FRANCE, WITH PHENOLOGICAL NOTES

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A survey of lacewings was undertaken in an agricultural zone of northern France. Adults were investigated in four cultures: strawberry, potato, witloof and kidney bean, and in apple orchards. A fixed suction trap gave an overview of the lacewing assemblage present. Yellow trap together with portable suction-device collections showed the hemerobiids and chrysopids currently harboured. Stalked eggs, larvae and cocoons of chrysopids were sampled in strawberry, potato, cabbage and carrot, and in apple-tree orchards. Rearing in the laboratory of all preimaginal instars of the green lacewings collected bore witness to the actual establishment of any species in the field.

Seven green lacewings species were identified, but the lacewing diversity is low. In all cases, the eurytopic generalist predator *Chrysoperla kolthoffi* was the dominant species. Adults flied from May (wintering generation) to autumn, showing a peak in July. The occurrence of preimaginal instars suggests three generations. Four brown lacewing species were recorded, among them *Micromus variegatus* was the most abundant. They flew mainly in July and August.

Key words: chrysopid, *Chrysoperla kolthoffi*, hemerobiid, pest predator, biological control, agroecosystem

INTRODUCTION

Need of food of high quality for the west European market is increasing significantly so that Integrated Pest Management (IPM) or organic farming now becomes a concern for agronomists in charge of farmers' advice. Crops must be harvested free of chemicals and their protection against phytophagous pests must be managed more and more by alternative methods. In this way, naturally occurring generalist predators may play a key role. Among them, the green and brown lacewings show many favourable traits such as widespread prey range and high voracity (see review in MCEWEN *et al.* 2001).

The aim of the present report is to feature which lacewings occur in agricultural zones grown over with various low crops and orchards, which species are really established and when they are active.

MATERIALS AND METHODS

This study was carried out in northern France, "Région Nord, Pas-de-Calais", in the southern part of the Flanders plain. It is an agricultural zone of strong tradition of vegetable and fruit production. The target fields are of commercial type. They are all managed with soft cultural techniques: either in supervised management (lutte raisonnée), in integrated pest management (lutte intégrée) or in strict organic farming (agriculture biologique). Several crops and their nearby uncultivated biotopes were sampled (Table 2). Strawberry, potato, witloof, tobacco and kidney-bean were chosen for analysis of adult occurrence of both green and brown lacewings. They are regularly sampled during the growing season 1999, from May to October. The neighbourings of the experimental areas are constituted of other similar crops in which chemicals were used according to the usual advise programmes.

Adult lacewings were collected by several methods (Table 1). Besides, a fixed Taylor suction device operated approximately in the centre of the experimental zone. It gave an overview of the aerial neuropteran guild occurring in the district. It collected permanently at 12.2 m high. To estimate the actual neuropteran fauna possibly associated with plant stands, restricted samples were taken in each crop. Two standard yellow traps were set out in each plot, at 0.9 m high and 10 m intervals; specimens captured were taken out twice a week. A mobile individual vacuum device was used by day, during a time unit ranging from 30 secondes to five minutes. In addition, specimens were swept by hand net; other individuals were offered a feeding McPhail trap baited with 5% diammonium phosphate or they entered casually an INRA noctuid control pheromone trap working in the experimental area. All collected adults were stored in vials containing alcohol 70% + glycerol 5% and kept in the "Station d'Études sur les Luttes Biologique, Intégrée et Raisonnée, Service Régional de la Protection des Végétaux (FREDEC)", Loos-en-Gohelle, France.

As hemerobiid eggs are difficult to see on plants, only the stalked eggs of chrysopids were investigated in four low cultures: strawberry, potato, cabbage and carrot, and in apple orchards. The preimaginal instars of only green lacewings were also collected. Some eggs were regularly picked up, and some larvae and cocoons were collected. All were brought to the insectarium for further development allowing identification of adults.

Rearing cabinets were conditioned as following: the temperature was 20±1°C, relative humidity was 70±10%, the photoperiod used provided 16 hours of light per day to inhibit the possible induction of diapause. The larvae were kept in individual vials to avoid cannibalism. They were fed with sterilized eggs of *Ephestia kuehniella* (ZELLER) given every day *ad libitum*.

To state the brood phenology, the larvae collected are registered in Figure 3 with an earlier time displacement proportional to their estimated embryogenesis and larval development duration.

Four indices were calculated to quantify the biodiversity. Taxonomic species abundance [S], i.e. the number of species collected, provides a rough evaluation of habitat richness. The diversity is also characterized by the most widely used index, the Shannon's diversity index [H'] proposed by SHANNON and WEAVER (1963):

$$-\sum_i \left(\frac{q_i}{Q}\right) Log_2 \left(\frac{q_i}{Q}\right)$$

where qi = the number of individuals in theith taxa and Q = the total number of individuals.

We calculated two more indices measuring dominance which are independent on sample size:
– the McIntosh's diversity index [D(MI)] (MCINTOSH 1967):

$$\frac{Q - d(MI)}{Q - \sqrt{Q}}$$

where $d(MI) = \sqrt{\sum_i (q_i)^2}$ is the McIntosh's distance or Eucledian distance.

The McIntosh's index is sensitive for the dominant taxa (BEISEL *et al.* 1996) and by the way not subject to aggregative distribution;

– the Simpson's dominance index [λ] (SIMPSON 1949), modified by BERGER and PARKER (1970):

$$\frac{\sum_i q_i (q_i - 1)}{Q(Q-1)}$$

The Simpson's index is slightly more sensitive for samples showing low dominance and more efficient to characterize rare taxa distribution than the previous McIntosh index.

RESULTS AND DISCUSSION

The wandering lacewing species

Cumulating all collecting methods, six species of green lacewings were recorded as adults in the agricultural experiment area. They were in decreasing order of relative abundance: *Chrysoperla kolthoffi* (NAVÁS, 1927), *Chrysopa phyllochroma* WESMAEL, 1841, *Chrysoperla carnea* (STEPHENS, 1836), *Chrysopa perla* (LINNAEUS, 1758), *Dichochrysa flavifrons* (BRAUER, 1850), *Cunctochrysa albolineata* (KILLINGTON, 1935) (Fig. 1).

All these chysopids are common constituents of the European fauna. *Chrysopa phyllochroma* and *C. albolineata* also occur in Asia up to Korea and Mongolia, and *D. flavifrons* has a holomediterranean distribution range including Mediterranean islands and the Maghreb.

The number of specimens appear in Table 1 as a function of sampling techniques and in Table 2 as a function of crops sampled. One can note that the McPhail trap did not attract any lacewing, neither chrysopid nor hemerobiid, contrarily to other conditions in which it constitutes a satisfying method (*e.g.* NEUENSCHWAN-

Table 1. Number of individuals of adult lacewings (green/brown in the total column) captured in the agroecosystems according to different collection techniques. Abbreviations of species are *kolt*: *Chrysoperla kolthoffi*; *phyl*: *Chrysopa phyllochroma*; *carn*: *Chrysoperla carnea*; *perl*: *Chrysopa perla*; *flav*: *Dichochrysa flavifrons*; *albo*: *Cunctochrysa albolineata*; *vari*: *Micromus variegatus*; *angu*: *Micromus angulatus*; *hum*: *Hemerobius humulinus*; *lute*: *Hemerobius lutescens*

	kolt	phyl	carn	perl	flav	albo	vari	angu	hum	lute	Total
suction trap	86	1	7	–	3	2	–	–	–	–	99/0
vacuum	41	21	–	4	–	–	58	24	3	1	66/86
yellow traps	85	33	2	–	–	–	–	–	–	–	120/0
hand net	29	3	1	3	–	–	4	1	1	–	36/6
McPhail	–	–	–	–	–	–	–	–	–	–	0/0
(other)	2	1	–	–	–	–	–	–	–	–	3/0
Total	243	59	10	7	3	2	62	25	4	1	324/92

DER *et al.* 1981). Only the first two chrysopid species were of numerical importance. The common green lacewing *Ch. kolthoffi* occurred in each sample. It was the absolutely dominant species in each case and in each habitat, constituting 75% of the green lacewings and 58% of all Neuroptera. It showed here once more its dominance and its character of eurytopic generalist predator in extramediterranean

Table 2. Number of individuals adult lacewings (green/brown in the total column) captured in the surveyed crops. Abbreviations as in Table 1

	kolt	phyl	carn	perl	vari	angu	hum	lute	Total
Trees									
apple tree	10		1	1	7		1		12/8
Shrubs									
hop	1								1/0
hedges	1								1/0
Arable crops									
witloof	56	27							83/0
potato	31	27	2		4				60/4
strawberry	31			3	29	17	1	1	34/48
kidney-bean	12	1			22	8	2		13/32
tobacco	6	1							7/0
maize	5								5/0
lettuce	2	1							3/0
Weeds	4			2					6/0
Total	159	57	3	6	62	25	4	1	225/92

Table 3. Number of individuals of green lacewings established, i.e. issuing from eggs, larvae and cocoons, collected in the surveyed crops. Abbreviations as in Table 1

	kolt	carn	luca	phyl	perl	Total
Tree: apple tree	54	10			1	65
Arable crops: potato	14			23		37
strawberry	131		7	3		141
cabbage and carrot	13			7		20
Total	212	10	7	33	1	263

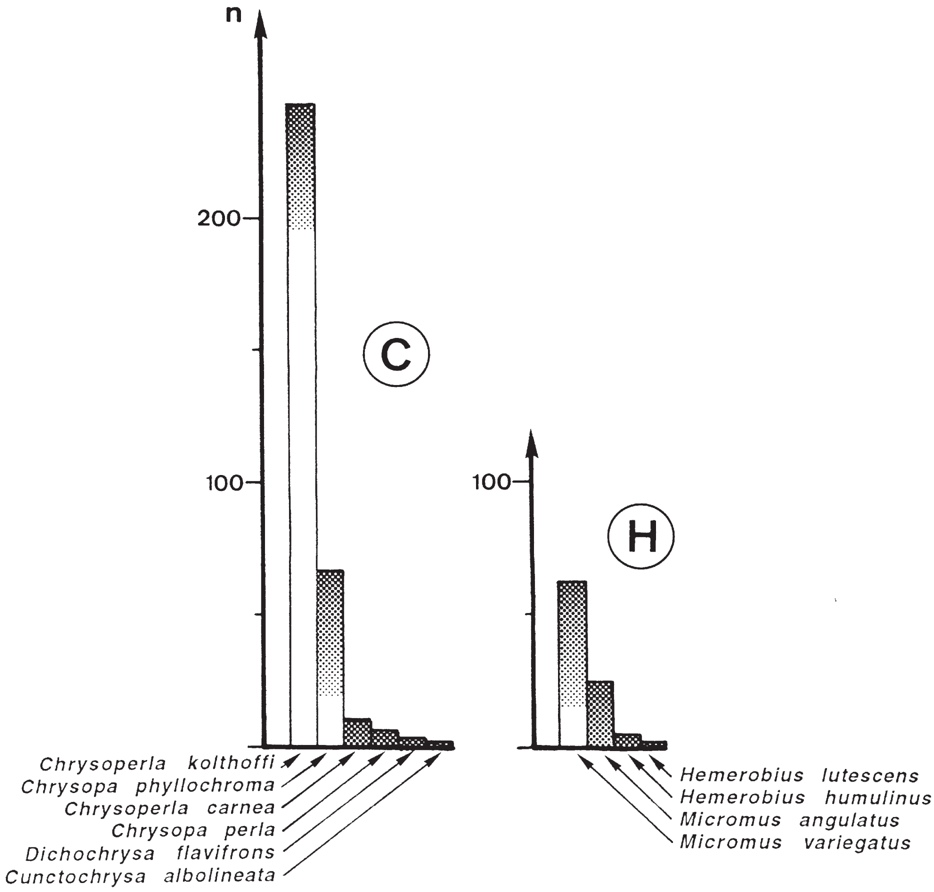

Fig. 1. Total number of individuals of adult chrysopids (C) and hemerobiids (H) collected in agroecosystems (data derived by cumulating all collecting methods)

Europe (THIERRY *et al.* 1996). On the contrary, *Ch. phyllochroma* (18% of the chrysopids and 14% of the Neuroptera) only occurred in yellow traps and in the vacuum collections, in the low and thick crops like witloof and potato. These captures agree with previous literature data reporting *Ch. phyllochroma* associated with intensively cultivated vegetation, root and fodder crops, and meadows (STELZL & DEVETAK 1999). It can be surprising that a closely related species, *Chrysopa commata* KIS et ÚJHELYI, 1965, has not been found in the chrysopid assemblage, though it has been recorded in France (LERAUT 1988) and it is more widespread and more common than *Ch. phyllochroma* in UK (PLANT 1994). However, surprisingly, a few individuals of *Ch. commata* were identified among the adult lacewings reareded from eggs and larvae collected in the crops (see below).

The brown lacewings represented only 22% of the total number of Neuroptera collected. They belonged to four species, in decreasing order of relative abundance: *Micromus variegatus* (FABRICIUS, 1793), *M. angulatus* (STEPHENS, 1836), *Hemerobius humulinus* LINNAEUS, 1758, *H. lutescens* FABRICIUS, 1793 (Fig. 1).

All of them are widespread eurytopic species. Only the two *Micromus* spp. are abundant, constituting 95% of the brown lacewings ; they are known as regular predators in crops, common in northwestern and Central Europe and considered associated with Euro-Siberian herbaceous vegetation (MONSERRAT & MARÍN 1996, SZENTKIRÁLYI 1997). The hemerobiids were collected only by vacuum and hand net, they did not enter either the yellow traps, the McPhail traps, or the (too high?) suction trap (Table 1). They were abundant on strawberry and kidney-bean fields where they superseded even green lacewings, but they were only sporadically present on the other crops.

Phenology of lacewings

The seasonal distribution of adult lacewing flight in the crops are shown in Fig. 2. One can see that some chrysopids and hemerobiids appeared in the beginning of May, representing the first spring generation (*Chrysopa perla, Micromus* spp.) and the remaining overwintering adults of *Chrysoperla.* The actual flight of the lacewings occurred mainly in July and lasted up to the middle (chrysopids) or the end (hemerobiids) of August. Later the brown lacewings totally disappeared, and the common green lacewings remained constantly present in low numbers as a consequence of their proper way to overwinter as adults in reproductive diapause. Concerning the voltinism of *Ch. phyllochroma*, the encountered population showed an heterogeneous life-history strategy: Among the eggs collected in June and the relative larvae weaving cocoons on mid-July, some individuals entered diapause directly until the next spring to resume their development and to emerge as adults. They must constitute a univoltine strain. Others manifest a multivoltine capability, giving rise to a summer brood, the adults of which were found in the field up to the autumn. Such a strategy is known in some Palaearctic *Chrysopa* (PRINCIPI 1992).

The established green lacewing species

A total of 357 Neuroptera were collected on the plants as preimaginal instars, in which there were four hemerobiid larvae. For estimating the actual consistency of chrysopid predatory activity, we tried to rear the specimens of green lacewings, namely 187 eggs, 47 larvae and 29 cocoons. The results are reported in Table 3 and

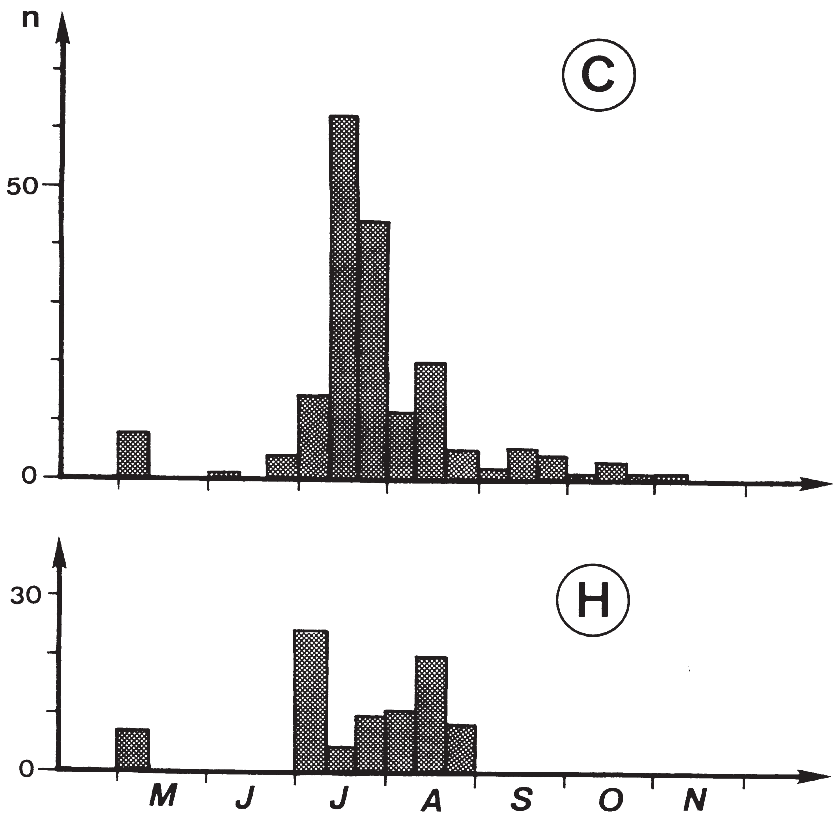

Fig. 2. Number of individuals of the collected adult chrysopids (C) and hemerobiids (H) in the sampled crops taken as a function of time

in Figure 3. A total of 263 specimens collected randomly gave rise in the insectarium to adults which have been identified as *Ch. kolhoffi*, *Ch. carnea*, *Ch. phyllochroma*, *Ch. commata*, *Ch. lucasina* and *Ch. perla.*

Twelve specimens did not develop directly to adults, but required several months to resume morphological development after winter (outside) diapause; all of them were *Ch. phyllochroma* emerging in oudoors rearing from the end of January to the middle of May.

Eggs and larvae of the common green lacewing are here also strongly dominant constituting 87% of the total chrysopid sample of established species. Within the *Chrysoperla carnea*-complex, *Chrysoperla kolthoffi* was the main species. Three peaks of occurrence appeared in mid May, at the beginning of June and at the end of July (Fig. 3) suggesting that three generations may develop. *Chrysoperla carnea* sensu stricto developed only on apple trees, in accordance with its

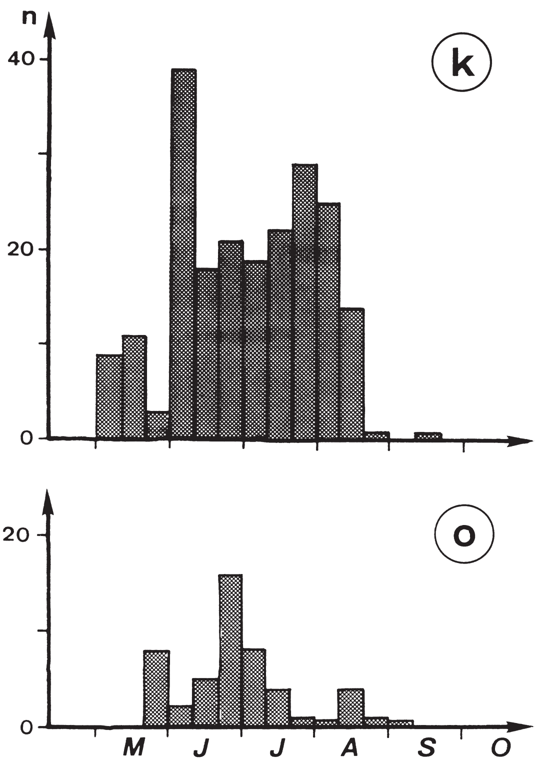

Fig. 3. Total number of individuals of chrysopid preimaginal instars recorded at actual or estimated date of egg deposition, collected in surveyed crops. K = *Chrysoperla kolthoffi*, O = other species

known ecological (arboreal) habits, whilst *Ch. lucasina* was found only on strawberry as expected with respect to its climatical and ecological (low stratum inhabiting) habits (THIERRY & CLOUPEAU, unpublished data). The possible occurrence of *Ch. commata* as an established species on potato opens a problem because all specimens of this group-species recorded as adults were identified as *Ch. phyllochroma*, despite fluctuating coloration characters of the head markings which are known in these allied species (SZIRÁKI 1994 and in lit.). We collected specimens showing either none or one (or more) of the following characters: post-ocular black spots, two or four post-occipital black spots, a light grey shade on the internal face of the scapes. However, some *Chrysopa* adults obtained after rearing in the insectarium and so coming from eggs collected on potato are undoubtedly referable to *commata* with respect to the gonocristae, but lacking of the typical black spot on internal face of the scapes.

Concerning mortality in the field, egg parasitization was commonly recorded in every crop, due to the embryonic parasitoid *Telenomus acrobates* Giard. For further parasitization, only two specimens of the pupal parasitoids *Dichrogaster* sp. emerged from the cocoons. However, the working method – sampling of eggs rather than older instars – is evidently unpropitious for the collection of pupal parasitoids which commonly infest either the second and/or third instar larvae or the prepupae and/or pupae within the cocoon (ALROUECHDI *et al.* 1984).

Biodiversity indices

Neuroptera are valuable indicators for assessing ecological statement of an habitat (STELZL & DEVETAK 1999). The taxonomic abundance of adult chrysopid recorded S = 6 was reduced and the related biodiversity was weak as attested by the Shannon's diversity index H' = 1.14. Many green lacewings, either rare or even common, have ecological requirements incompatible with modern farming systems. Consequently, (i) the lacewing assemblage appeared to be truncated (Fig. 1), (ii) the quantitative distribution of the remaining species seemed to be rather well-balanced, as attested by the Simpson's dominance $\lambda = 0.61$ and the McIntosh's diversity $D(MI) = 0.4$ indices. In comparison, an agropastoral system situated near Millau in southern France showed a much more diversified chrysopid assemblage. These biotopes slightly influenced by human activity, harboured 12 chrysopid species and gave evidence of a high biodiversity: H'=2.76; λ=0.17; $D(MI)$ = 0.62 (THIERRY *et al.* 2001).

CONCLUSION

In the investigated crops, the number of lacewing individuals were high enough, as to help in controlling arthropod pests such as aphids and caterpillars. However, the impoverished species diversity showed that the agricultural area has been perturbed by some cultural practices and intake of chemicals, and consequently, hazardous with respect to the auxiliary fauna. The modern mechanized farming often involving removal of hedges together with a long pesticide pressure is probably a cause for such a low biodiversity. Restoration of a bocage-type landscape, improved mastership of chemical pest control, use of biocontrol methods by farmers remain priority aims to promote safe agricultural production and to avoid aggressive interference with natural environment.

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