CHAPTER 24

Lacewing occurrence in the agricultural landscape of Pianura Padana

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24.1 INTRODUCTION

Techniques of manipulation of agroecosystems have an important role among the strategies of integrated pest management (IPM) (van den Bosch & Telford, 1964) and its successive developments, i.e. vegetational management (Altieri & Letourneau, 1982) or ecosystem management (Speight, 1983). This technique is a complex agronomic practice leading to diversification of the agroecosystem which creates a less suitable environment for the development of the phytophagous populations (Delucchi, 1997). In this context the natural enemies are augmented either by removing and mitigating adverse elements or by providing lacking requisites (DeBach, 1974).

It appears evident that to reach these aims more must be known about the ecology of the various guilds of useful, harmful, and innocuous insects or at least about the main species. Such knowledge must necessarily concern not only crops, but also all the surrounding territory in relation to it. Numerous species, in fact, spend only a part of their life in cultivated fields needing other habitats for activities such as nesting, reproduction, overwintering, or for simple refuge (Maini, 1995).

In relation to chrysopids and other lacewings, attention has been directed for years more towards the field release of artificially reared individuals (augmentation method) than towards the above aspects. Ridgway & Kinzer (1974) and Ridgway & Murphy (1984), reviewing the use of lacewings in biological control, only once mention environmental manipulations speaking almost exclusively about the food attractants. These techniques are now well developed but their results depend on the natural populations in neighbouring areas, and on which more information is also needed.

At the Istituto di Entomologia ‘Guido Grandi’, University of Bologna, under the direction of Maria Matilde Principi, a research group worked for a long time on the use of chrysopids in biological control. This topic was linked to the implementation of the regional IPM programme in Emilia Romagna. The group operated along two main lines. First it was dedicated to testing and improving artificial rearing systems and to studying environmental factors, in particular the photoperiod, that regulate the development of the preimaginal stages and adult egg-laying rhythms (for a review see Principi, 1992, 1993). This research helped towards the setting-up of an insectary (Biolab, Cesena) to trade chrysopids (Celli *et al.*, 1991). The second research line regarded the chrysopid occurrence in ecosystems and agroecosystems of the southeastern Pianura Padana. This information had to provide the basic knowledge for future development of environmental manipulation techniques for crop protection. A review of this research carried out between 1979 and 1990 and possible practical implications are discussed in this work.

24.2 THE LANDSCAPE

24.2.1 Geography

The Pianura Padana (northern Italy) is approximately 46 000 km^2 with a maximum length of 396 km and an average width of about 120 km. It is confined by the Alps and the Apennines and crossed in a west–east direction by the course of the River Po (the antique ‘Padus’, from which the plain’s name is derived) (Gribaudi, 1956). The research was carried out in the southeast quadrant, about 8500 km^2, south of the watershed of the river Adige and east of the Panaro, the last tributary to the south of the Po (Fig. 24.1). This concerned the provinces of Bologna, Rovigo, Ferrara, Ravenna and Forlì. Approximately 1 700 000 people live

	Locality	Vegetation		Locality	Vegetation		Locality	Vegetation
A	Lido delle Nazioni	gardens	N	Canaro	large hedge	Y	Bosco della Mesola	mixed wood
B	Lido delle Nazioni	herbaceous strip	O	Ro Ferrarese	willow and fruit tree row	Z	Comacchio	lucerna field
C	Pineta di Volano	pine wood	P	Frassinelle Polesine	willow and elm tree rows	1	Punta Alberete	ash–alder wood
D	Dune di San Giuseppe	oak scrub	Q	Vechiazzano	some crops	2	Pinete di Ravenna	stone pine grove
E	Lido delle Nazioni	tri-row of trees	R	S. Martino Villafranca	some orchards	3	Malborghetto	apple orchard
F	S. Martino di Gualdo	oak wood	S	Ravenna	apple orchards	4	Ferrara	peri-urban park
G	Civitella	xerophilous oak wood	T	Tamara	some orchards	5	Malalbergo	ash–alder wood
H	Corniolo	conifer grove	U	plain on left of Reno	pear orchards	6	Castel Maggiore	apple orchard
I	Campigna	beech forest	V	Cento	pear orchard	7	San Pietro in Vincoli	peach orchard
J	Passo Calla	beech forest	W	Poggetto	pear orchard	8	Faenza	peach orchard
K	Bologna	urban park	X	S. Matteo della Decima	pear orchard	9	Cesena	Biolab insectary
L	Montesanto	country park				α	Rovigo	
M	Bagnacavallo	abandoned farm				β	Forlì	

Fig. 24.1. Map of southeastern Pianura Padana, with location of cited places.

in this area (ISTAT, 1990). The region is characterised by average annual temperatures of between 12 °C and 14 °C, January averages between 1 °C and 4 °C, July averages from 22 °C to 24 °C. Annual rainfall is on average between 600 mm and 900 mm and presents an autumnal maximum and a summer or winter minimum (Mori, 1956).

24.2.2 **Potential vegetation**

The whole of the Pianura Padana falls in the Middle-European bioclimatic zone. The vegetation belts in the southeastern plain and in the neighbouring Apennine sector are described by Pignatti (1980).

The three main forest formations of the area are herein briefly described (Pignatti, 1998). The Illyrian holm-oak woodland, *Orno-Quercetum ilicis*, is a wood of holm oak (always prevalent) mixed with flowering ash. Of the holm-oak formations it is the one that develops in the coolest and dampest climatic situations forming the point of contact between the evergreen and deciduous wood in the Italian peninsula. In the southeastern Pianura Padana it is limited to the well-stabilised coastal dune ridges. The oak–hornbeam forest, *Ornithogalo-Carpinetum*, is a mixed wood of English–oak and hornbeam with the presence of elm, hedge maple, ash, and other tree species. It is the climax of the Pianura Padana, where it is found in areas rich in water, but with well-drained soil, and also extends over the surrounding hills. Today it is reduced in the inner plain to a few examples of relict fragments. The ash–alder wood, *Carici remotae-Fraxinetum oxycarpae*, is a mixed wood of ash, elm, and poplar which grows along the rivers or in the depressions that have high groundwater level in spring. Once certainly widespread, they have now almost disappeared due to land reclamation and drainage.

Along the coast, in well-conserved local situations such as in the Bosco della Mesola, it is possible to record the serial and chain relations between the different forest formations. The consolidated dune is occupied by Illyrian holm-oak woodland, which is then substituted by oak–hornbeam forest; in the damp lowlands the ash–alder wood becomes established (Piccoli *et al.*, 1983).

The age of oak woods and the other broad-leaved tree formations, in the present form, goes back to about 5000 BC or slightly further, when in the Pianura Padana the wild-pine palaeoclimax was definitively substituted by the actual climax (Bertolani Marchetti, 1966/7, 1969/70).

The confining hilly areas and lower mountain slopes of the Apennines present a more complex mosaic of vegetation in which mixed oak woods predominate but with important floristic differences in respect to areas in the plain. In fact, here are found north Italian *Quercus cerris* woods, north Italian *Quercus pubescens* woods, hop–hornbeam woods and others. In the mountainous areas, above 800–1000 metres, beech forests and silver-fir forests grow (Ferrari, 1987; Pignatti, 1998).

24.2.3 **Landscape evolution**

The native ancient forest probably began being reduced by human activity in the Bronze Age between 2000 and 1000 BC, but with the Roman conquest vast wooded areas were transformed into cultivated fields. This deforestation was not interrupted until the Middle Ages between the 4th and 10th centuries when the population abandoned the countryside. The consequences on the land were damage and floods, contraction of cultivated land and the return of woods, waste land, and damp areas (Tomaselli & Tomaselli, 1973). Palynologic and stratigraphic analysis confirm a wood crisis in Roman times and a recovery in the Middle Ages (Bertolani Marchetti & Cupisti, 1970).

With the disastrous flood of the 'rotta di Ficarolo' (AD 1152) the geography of the southeastern Pianura Padana underwent catastrophic evolution with the changes in course to the north of the main branch of the Po, the transformation to swamp of the southern delta branches and most of its Apennine tributaries. Hence an enormous increase of wet areas, named 'valli', occurred in all of the low plain (Corbetta *et al.*, 1981). This event made land reclamation necessary and this was begun by the monastic communities in mediaeval times and continued up to the 1970s (Bondesan, 1990). Contemporarily a type of agricultural system, named 'piantata', was adopted, to enable an efficient drainage in territories with a very superficial groundwater level.

The 'piantata' system, known since antique times, consists of planting lines of trees holding up vines along the main side of the fields, usually maples, elms, and poplars. Often, two small ditches flanked the row of trees. The dimensions of the fields and the distance between the 'piantate' have increased over the centuries in relation to the work capacity of the ploughing systems. It is thought that in the Middle Ages the

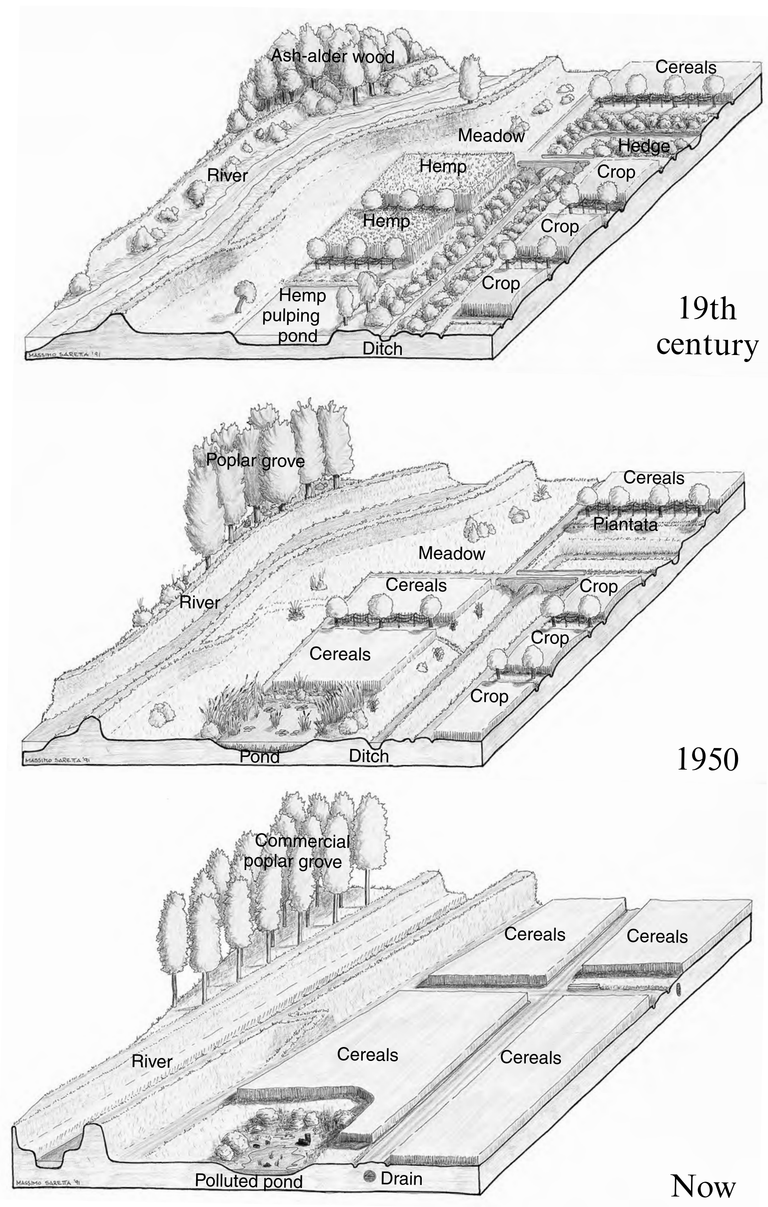

Fig. 24.2. Landscape evolution in the southeastern Pianura Padana. (Drawing by Massimo Saretta, slightly modified; from Agostini, 1993, by permission of '*Il divulgatore*' Bologna).

distance between rows was 6–7 m as against 38 m at the beginning of the 20th century. During this later period it reached its maximum extent and was present on more than 4500 km^2 (Agostini, 1993).

The advent of mechanisation almost completely eliminated the 'piantata'. Ditches, small fields, and rows of trees also represent obstacles for agricultural machinery (Giardini, 1977). This coincided with the rapid expansion of the maize monoculture or moreso with the cultivation of cereals, sugar beet, and, more recently, soya-bean (Paoletti, 1985; Paoletti & Lorenzoni, 1989) (Fig. 24.2).

The southeastern Pianura Padana is now intensely cultivated and hedges, woods, and even isolated trees are rare if not entirely absent. The only patches of uncultivated vegetation are those that surround cities and towns (parks, gardens, avenues with trees, etc.) or along streets and canals. In some areas fruit groves, more or less alternated with annual crops, are extremely widespread. The natural areas, woods and wet zones ('valli') are concentrated along the coast. This, intensely urbanised for the sake of tourism, appears in some tracts as an uninterrupted stretch of gardens tens of kilometres in length and some hundreds of metres deep (Pirola & Chiusoli, 1976).

The old naturalised plantations of stone pine, on dune ridges along the coast, should also be mentioned amongst the non-agricultural environments (Pignatti, 1998).

24.3 LACEWING OCCURRENCE IN LANDSCAPE UNITS

24.3.1 Coastal areas

The occurrence of the lacewings present in five coastal habitats near the Valli di Comacchio was studied in the period 1979–83 using insect net samples for periods varying from one to three years (Table 24.1) (Pantaleoni, 1982, 1984).

Site A was made up of a group of gardens bordered by many ornamental shrub hedges with numerous trees, among which occur conifers (*Pinus*, Cupressaceae), and a lot of flower beds. Only in this site a New Jersey light trap was used contemporaneous with sweeping. Site B was made up of a strip of uncultivated land some metres deep along an irrigation canal with exclusively herbaceous vegetation. Site C was represented by a tract of pine wood aged about 60 years partly of marine pine (*P. pinaster*) (strip neighbouring the sea) and partly of stone pine (*P. pineae*) (strip lying behind), planted on dune ridges and laid upon a pre-existing holm-oak woodland and perhaps, in some places, hornbeam–oak forest. Site D was a modest strip of holm oak and pubescent-oak scrub on internal dunes. Lastly, Site E was composed of a triple row of Lombardy poplar (*Populus nigra pyramidalis*) placed along the edge of a lucerne field.

Sites A, B and E are found within urbanised areas and could be considered unnatural. Throughout the research they were to constitute a useful comparison with physiognomically similar agricultural environments. At the time, however, ecological conditions of the whole area were quite good with the absence of pesticide use and with horticultural intervention being limited to mowing and pruning.

The most abundant species were chrysopids. *Chrysopa formosa* in particular predominately on grasses (site B) or shrubs (site A). *Dichochrysa prasina* was dominant, or at least very abundant, in the presence of sparse shrubs and trees (sites A, D, E). *Chrysoperla carnea* was confirmed to be a widely euryoecious species representing in each site about one-fifth of the total captures. *Chrysopa dorsalis* and *C. viridana* were, on the other hand, strongly influenced by the presence of their plant hosts: pine for the first, deciduous oak for the latter. *Chrysopa pallens* occurred rather irregularly. Various species of hemerobiids, *Wesmaelius subnebulosus*, *Hemerobius humulinus*, *Sympherobius pygmaeus*, were well spread but not very abundant anywhere. Among the coniopterygids *Coniopteryx esbenpeterseni* was the most abundant species in the gardens of site A, *Semidalis aleyrodiformis* on English oaks of site C and *C. borealis* on poplars of site E.

The seasonal trends of captures in general assumed a characteristic aspect, with a single spring maximum due mainly to the abundance of the species of the genus *Chrysopa*. *Chrysoperla carnea* showed a capture peak always later, sometimes, as in site A, even in autumn (Fig. 24.3).

Altogether in a territory of a few square kilometres 30 species were found belonging to the three preceding families: the 28 species listed in Table 24.1 plus *Conwentzia psociformis* and *Wesmaelius nervosus* found later (Pantaleoni, 1986).

Unfortunately, it has not been possible to study some coastal forest areas of great interest. Only fragmentary data are known from Bosco della Mesola: *Micromus angulatus*, *Chrysopa formosa*, *Chrysoperla carnea,* and *Dichochrysa* sp. by samples with Malaise trap in 1994/5 (Civico Museo di Storia naturale di Ferrara, unpublished data). In the Punta Alberete ash–alder wood *Chrysopa perla*, *C. pallens*, *Chrysoperla carnea,* and *D. prasina* were collected in a once-only net sample. The latter two species are present too in the Pinete di Ravenna and in the bordering areas (Pantaleoni, 1990*b*).

24.3.2 Hills and mountains

In order to obtain an overall picture, the Neuroptera taxocoenoses of the hilly and mountainous areas near to the southeastern Pianura Padana were also studied. After a year (1985) of preliminary faunistic research in just over 40 localities of the Apennines of Romagna, in 1986/7 five sites located along the altitudinal gradient

Table 24.1. *Relative abundance of species collected in coastal areas*

Relative abundance[a]	Site A[1] Gardens Lido delle Nazioni 1979–81 insect net	Site A[2] Gardens Lido delle Nazioni 1979–81 light trap	Site B Herbaceous grasses Lido delle Nazioni 1979–80 insect net	Site C Pine wood on scrub Pineta di Volano 1979–80 insect net	Site D Holm-oak formation Dune di S. Giuseppe 1982–3 insect net	Site E Poplar filare Lido delle Nazioni 1983 insect net
66%–100%			*Chrysopa formosa*			
33%–66%	*Chrysopa formosa*	*Chrysopa formosa*				*Dichochrysa prasina*
16%–33%	*Chrysoperla carnea* *Dichochrysa prasina*	*Chrysoperla carnea*	*Chrysoperla carnea*	*Chrysopa pallens* *Chrysopa formosa* *Chrysopa dorsalis* *Chrysoperla carnea*	*Chrysopa viridana* *Dichochrysa prasina*	*Chrysoperla carnea*
8%–16%		*Dichochrysa flavifrons*	*Chrysopa abbreviata*	*Dichochrysa flavifrons*	*Chrysopa formosa* *Chrysoperla carnea* *Chrysopa pallens*	
4%–8%	*Dichochrysa flavifrons* *Coniopteryx esbenpeterseni*	*Wesmaelius subnebulosus* *Dichochrysa prasina*		*Semidalis aleyrodiformis*	*Sympherobius pygmaeus*	*Coniopteryx borealis* *Sympherobius pygmaeus* *Dichochrysa flavifrons* *Chrysopa pallens*
1%–4%	*Sympherobius pygmaeus* *Chrysopa abbreviata* *Chrysopa dorsalis* *Wesmaelius subnebulosus* *Hemerobius micans* *Chrysopa pallens* *Coniopteryx haematica*	*Chrysopa abbreviata* *Chrysopa pallens* *Sympherobius pygmaeus* *Chrysopa dorsalis* *Micromus angulatus* *Hemerobius humulinus* *Hemerobius stigma*		*Hemerobius humulinus* *Hemerobius micans*	*Cunctochrysa baetica* *Dichochrysa flavifrons* *Chrysopa abbreviata* *Coniopteryx arcuata*	*Chrysopa abbreviata* *Chrysopa formosa* *Chrysopa viridana* *Hemerobius humulinus* *Chrysopa dorsalis*
max 1%	*Hemerobius humulinus* *Semidalis pseudouncinata* *Micromus angulatus* *Semidalis aleyrodiformis* *Chrysopa viridana* *Cunctochrysa baetica* *Chrysopa nigricostata* *Coniopteryx borealis* *Coniopteryx tineiformis* *Coniopteryx arcuata*	*Chrysopa nigricostata* *Semidalis pseudouncinata* *Hemerobius micans* *Conwentzia pineticola* *Micromus variegatus* *Cunctochrysa baetica* *Coniopteryx borealis*		*Chrysopa abbreviata* *Dichochrysa prasina* *Semidalis pseudouncinata* *Nineta flava*	*Hemerobius humulinus* *Hemerobius micans* *Hemerobius gilvus*	*Wesmaelius subnebulosus* *Hemerobius handschini*

Note:
[a] The species are in order of decreasing abundance.

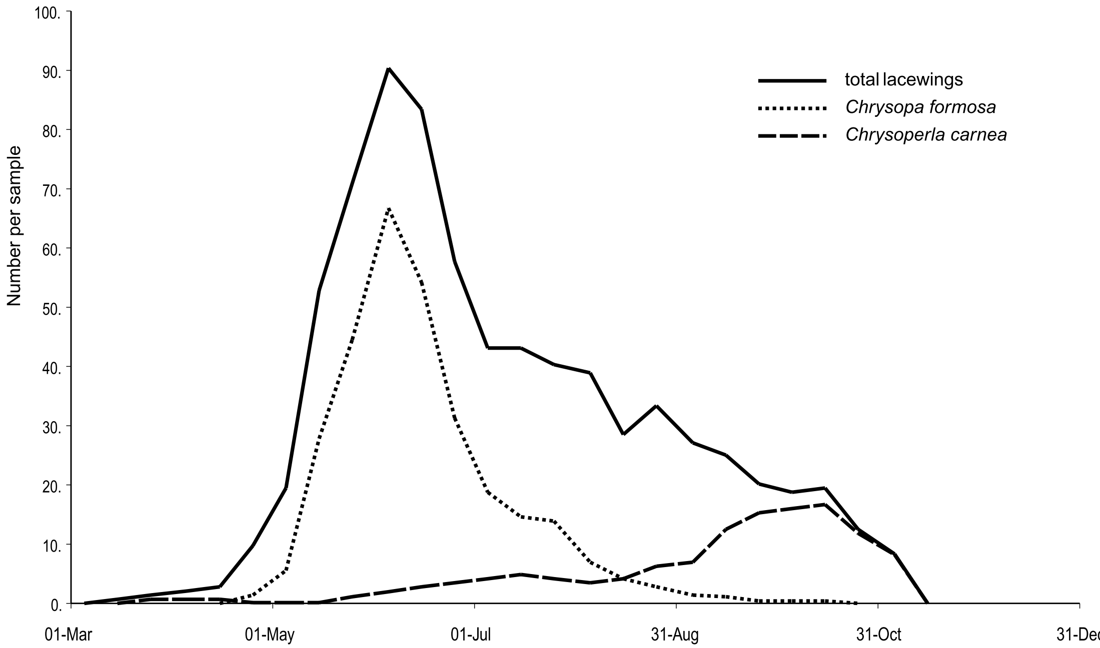

Fig. 24.3. Seasonal trends of captures by insect net in gardens of site A, 1979–80. (From Pantaleoni, 1986.)

of the Bidente–Ronco valley were studied using samples with insect net (Table 24.2) (Pantaleoni, 1988, 1990*a*).

Site F (135m a.s.l.) was one of the remaining strips of pre-Apennine oak wood with pubescent-oak predominance, but a few durmast oak. Site G (250–300 m a.s.l.) was a little valley with xerophilous pubescent–oak formations. Site H (500–550 m a.s.l.) was represented by a reforestation of conifers, mainly pine, but also fir and in lesser measure silver fir. Site I (1,000–1,075 m a.s.l.) was composed of a glade and of the surrounding beech forest. Lastly, site J (1,300–1,350 a.s.l.) was made up of the beech forest and glades of a brief tract of the Apennine ridge.

The data recorded can be summarised briefly as follows. The genus *Chrysopa* was always only rather uncommon. *Dichochrysa prasina* on the contrary reached high abundance in the oak woods at the lower altitudes (sites F, G) confirming its preference for sunny and breezy habitats with open vegetation of deciduous trees. *Chrysoperla carnea* was particularly common in the beech woods probably following seasonal phenomena of dispersion (see Pantaleoni, 1990*a*). Hemerobiids, in contrast to the coniopterygids, were rather abundant, in particular *Hemerobius gilvus* in the oak woods, *H. handschini* in the conifer groves, and *H. micans* in the beech forests.

Altogether in the Apennines of Romagna, 51 species were found belonging to the coniopterygids, hemerobiids, and chrysopids (Pantaleoni, 1988).

24.3.3 Parks and low plain woods

Within the low plain areas the only scraps of uncultivated vegetation that have a sufficiently complex structure and a two-dimensional development are represented by parks and the wood fragments that have survived by chance.

The lacewings present in three parks were studied in 1989 by means of insect nets. The three sites taken into consideration were: K, the experimental garden of the Istituto di Entomologia 'Guido Grandi' of Bologna with a surface of about 3000 m^2, in an urban area, with vegetation kept in a natural state; L, a country park of 3–4 ha with ancient trees and thick undergrowth; M, a farm of about 10 ha, not cultivated for roughly 30 years and still presenting the traditional agricultural system with hedges and 'piantate' (Table 24.3) (Pantaleoni, 1995).

Table 24.2. *Relative abundance of species collected by insect net in Apennine areas*

Relative abundance[a]	Site F Pre-Apennine oak wood S. Martino di Gualdo 1986/7	Site G Xerophilous oak wood Civitella 1986/7	Site H Conifer wood Corniolo 1986/7	Site I Beech forest Campigna 1986/7	Site J Beech forest Passo Calla 1986
33%–66%	*Dichochrysa prasina*			*Chrysoperla carnea*	*Hemerobius micans*
16%–33%	*Chrysoperla carnea*	*Dichochrysa prasina*	*Dichochrysa flavifrons* *Peyerimhoffina gracilis*	*Hemerobius micans*	*Chrysoperla carnea*
8%–16%	*Hemerobius gilvus*	*Hemerobius gilvus* *Chrysoperla carnea* *Dichochrysa zelleri*	*Hemerobius handschini*		
4%–8%	*Dichochrysa zelleri* *Semidalis aleyrodiformis*	*Chrysopa viridana* *Hemerobius micans* *Sympherobius pygmaeus*	*Hemerobius stigma* *Chrysoperla carnea* *Coniopteryx pygmaea* *Nineta pallida* *Semidalis aleyrodiformis*	*Hypochrysa elegans* *Hemerobius lutescens* *Coniopteryx pygmaea*	*Hemerobius lutescens*
1%–4%	*Chrysopa viridana* *Dichochrysa flavifrons* *Sympherobius pygmaeus* *Italochrysa italica* *Hemerobius micans* *Dichochrysa clathrata*	*Hemerobius humulinus* *Helicoconis pseudolutea* *Dichochrysa flavifrons* *Coniopteryx arcuata* *Hypochrysa elegans* *Semidalis aleyrodiformis*	*Conwentzia pineticola* *Helicoconis pseudolutea* *Dichochrysa prasina* *Chrysopa dorsalis* *Hemerobius micans*	*Hemerobius humulinus* *Dichochrysa prasina* *Hemerobius gilvus* *Chrysopa viridana*	*Chrysopa perla* *Hemerobius contumax* *Hemerobius humulinus* *Cunctochrysa albolineata* *Dichochrysa ventralis*
max 1%	*Chrysopa pallens* *Coniopteryx esbenpeterseni* *Hemerobius humulinus* *Chrysopa walkeri*	*Hemerobius handschini* *Coniopteryx borealis* *Cunctochrysa baetica* *Conwentzia pineticola* *Chrysopa dorsalis* *Chrysopa pallens* *Coniopteryx esbenpeterseni*	*Hemerobius humulinus*	*Dichochrysa flavifrons* *Dichochrysa ventralis* *Nineta pallida* *Wesmaelius subnebulosus* *Hemerobius contumax* *Cunctochrysa albolineata* *Coniopteryx tineiformis* *Sympherobius pellucidus* *Wesmaelius nervosus* *Micromus variegatus* *Chrysopa pallens* *Coniopteryx borealis*	*Wesmaelius subnebulosus* *Hemerobius gilvus* *Hemerobius stigma* *Sympherobius elegans* *Hypochrysa elegans* *Nineta flava* *Peyerimhoffina gracilis* *Dichochrysa prasina* *Coniopteryx pygmaea*

Note:

[a] The species are in order of decreasing abundance.

Table 24.3. *Relative abundance of species collected by insect net in parks s.lat.*

Relative abundance[a]	Site K Urban park Bologna 1989	Site L Country park Montesanto 1989	Site M Abandoned farm Bagnacavallo 1989
33%–66%	*Conwentzia psociformis*	*Chrysopa formosa*	
16%–33%	*Semidalis aleyrodiformis*	*Coniopteryx esbenpeterseni*	*Coniopteryx esbenpeterseni* *Dichochrysa prasina* *Dichochrysa flavifrons*
8%–16%	*Chrysopa viridana* *Chrysoperla carnea*	*Hemerobius humulinus*	*Semidalis aleyrodiformis*
4%–8%	*Dichochrysa prasina* *Dichochrysa flavifrons*	*Chrysopa pallens* *Dichochrysa prasina*	*Chrysopa pallens* *Coniopteryx borealis*
1%–4%	*Hemerobius humulinus*	*Coniopteryx borealis* *Dichochrysa flavifrons* *Micromus angulatus* *Chrysoperla carnea* *Hemerobius micans* *Chrysopa perla*	*Chrysoperla carnea* *Coniopteryx haematica* *Hemerobius humulinus* *Hemerobius micans* *Chrysopa formosa*
max 1%	*Sympherobius pygmaeus* *Chrysopa pallens* *Coniopteryx esbenpeterseni* *Coniopteryx lentiae* *Hemerobius micans* *Wesmaelius subnebulosus* *Sympherobius luqueti* *Cunctochrysa baetica* *Nineta guadarramensis*	*Micromus variegatus*	

Note:
[a] The species are in order of decreasing abundance.

In the urban park in Bologna (a city near to the Apennine range) the lacewing species were particularly numerous: the 16 listed in Table 24.3 plus *Chrysopa formosa* already recorded for the same site (Principi, 1958; Pantaleoni & Letardi, 1998). The most abundant species were those associated with the deciduous oaks, such as *Conwentzia psociformis, Semidalis aleyrodiformis*, and *Chrysopa viridana*.

In the two rural parks (true 'islands' immersed in very ample, intensely cultivated areas) the number of species falls to just over ten. In site L the most abundant species was *C. formosa*, followed by *Coniopteryx esbenpeterseni* and *Hemerobius humulinus*. Species typically attached to oaks were not found, even though these trees were very numerous. On the other hand *S. aleyrodiformis* was abundant on the English oaks of site M, but the dominant species was *C. esbenpeterseni* together with *Dichochrysa prasina* and *D. flavifrons*.

The constant finding of preimaginal stages proved that, except in a few cases, all the found species occurred permanently in each site.

The odd sporadic captures of lacewings in the large suburban parks of the city of Ferrara (R.A. Pantaleoni, unpublished data) provided, other than some of the more common species already named, the hemerobiid *H. perelegans*.

A series of samples on the riparian vegetation of the Po near Canaro (Rovigo) gave disappointing results with only two species found, *Chrysoperla carnea* and *D. flavifrons*, in very low numbers of individuals (Pantaleoni & Sproccati, 1987).

Unfortunately, for the few remaining plain woodlands, very little data is known. Results of research carried out in these environments by the Civico Museo di Storia naturale of Ferrara are still not completely available. In the 'Tenuta la Comune', near Malalbergo, *Wesmaelius subnebulosus*, *Micromus angulatus*, *H. humulinus,* and *Chrysopa perla* were found using a Malaise trap in 1993/4. Paoletti *et al.* (1989) studied an environment of this type in the northeastern Pianura Padana, the Lison wood, also giving data on lacewings, unfortunately identified only at genus level. On the marginal trees of the wood coniopterygids, *Hemerobius*, *Chrysopa*, *Chrysoperla,* and *Dichochrysa* were found.

24.3.4 Hedges and tree rows

The hedges or, in the territory studied, the rows of the 'piantata' practically develop linearly but their structure can be more or less complex in relation to the length, to the vegetation pattern, and to the management practices.

In 1982 in a belt of land on either side of the Po mainly growing maize, some hedges were studied using the usual samples by nets to find out the occurrence of lacewings (Pantaleoni & Sproccati, 1987). The sites studied were: N, large hedges about 100 m in length made up of willows, poplars, elms (some of large dimensions), and fruit trees grown wild again, flanking a small abandoned ditch overgrown with herbaceous vegetation; O, a row of willows along the access road and garden of a farm; P, rows of elms, willows, and fruit trees of two closely neighbouring farms.

The dimension and vegetation structure of the sites, as expected, strongly influenced the Neuroptera taxocoenoses. The number of species found in sites N, without doubt the most ample and varied, total altogether 12 belonging to three families, while those collected in site O and P are only 6 belonging to the chrysopids (Table 24.4). In all the sites *Chrysoperla carnea* was easily the most abundant species always followed by *Chrysopa formosa*. Another three chrysopids were always present: *C. pallens*, *Dichochrysa flavifrons,* and *D. prasina*.

Further samples in a very small garden of a farmhouse in the same zone (Canaro) gave only three species, *C. formosa*, *Chrysoperla carnea*, and *D. flavifrons*.

In 1983, research was concentrated to within site N to determine the seasonal variations of chrysopid abundance, by means of samples with net and by beating, and of the aphid colonies, by means of direct inspection (Fig. 24.4) (Pantaleoni & Sproccati, 1987).

The chrysopids showed a secondary peak between the end of May and the beginning of June in which *Chrysopa formosa* was prevalent and a main peak in August, due particularly to *Chrysoperla carnea*. The data of net and beating captures were very similar. With this second method however adults were collected belonging only to the genera *Chrysoperla* and *Dichochrysa*; this brought about the almost complete absence of spring captures mainly made up of *Chrysopa*. There was no quantitative correlation between aphids and adult chrysopids: their curves appear completely unconnected. There was a relation between aphid abundance and chrysopid larvae captures, belonging almost exclusively to *C. formosa*.

24.3.5 Orchards

Fruit production represents one of the principal economic activities of Emilia Romagna. The first Italian IPM programme carried out on orchards was developed in this region so that available data for these environments is relatively abundant.

Excluding some vague citations by Golfari (1937, 1946, 1947), the first published data were those by Principi (1958) for an apple orchard at Castel Maggiore (Bologna) and then by Principi *et al.* (1967) and Castellari *et al.* (1967) for apple orchards at Malborghetto (Ferrara). Only four lacewings, in very low numbers, were recorded by inspection on aphid colonies: *Hemerobius humulinus*, *Chrysopa formosa*, *C. pallens,* and *Chrysoperla carnea*. It should be remembered that in those years organophosphate insecticides and DDT were heavily used to control pests.

Again Castellari (1980), with five years of research (1975–9) in peach orchards of Romagna (San Pietro in

Table 24.4. *Relative abundance of species collected by insect net on hedges*

Relative abundance[a]	Site N great hedge Canaro 1982/3	Site O willow and fruit-tree row Ro Ferrarese 1982	Site P willow and elm rows Frassinelle Polesine 1982
66%–100%		*Chrysoperla carnea*	
33%–66%	*Chrysoperla carnea*		*Chrysoperla carnea*
16%–33%	*Chrysopa formosa*	*Chrysopa formosa*	*Chrysopa formosa* *Dichochrysa prasina*
8%–16%	*Dichochrysa prasina* *Dichochrysa flavifrons*		*Dichochrysa flavifrons*
4%–8%	*Chrysopa pallens*		
1%–4%	*Chrysopa perla* *Hemerobius humulinus* *Coniopteryx borealis*	*Chrysopa pallens* *Dichochrysa prasina*	*Chrysopa pallens*
max 1%	*Coniopteryx haematica* *Semidalis aleyrodiformis* *Micromus angulatus*	*Dichochrysa flavifrons*	

Note:
[a] The species are in order of decreasing abundance.

Vincoli and Faenza, Ravenna), published a fundamental contribution to ecological knowledge of *Coniopteryx esbenpeterseni* occurring in large numbers as an efficient mite predator.

In 1979/80 Monari studied in apple orchards (site S) the occurrence of chrysopids and other predators in relation to the aphid infestations (Table 24.6) (data published partially in Pasqualini *et al.*, 1982). Sampling started at the end of April and finished in mid-July in 1979 and mid-August in 1980. Inspection of the aphid colonies found only a few larvae of *Chrysopa pallens*. *Chrysopa formosa*, *C. pallens*, *D. prasina,* and *Chrysoperla carnea* were collected with insect net. The latter was present only in the July–August period of 1981.

In the same period 1979/80 in the province of Forlì the chrysopid taxocoenoses of vineyards, peach, and apple orchards were studied (Table 24.5) (Pantaleoni & Tisselli, 1985). The vineyard data (site Q[3]) are the only ones relating to the southeastern Pianura Padana. In September there are contemporaneously the highest number of individuals and the highest number of species. In this month practically all the *Chrysopa viridana* were captured. In the peach orchard (site R[1]) four species were found, the same as those found by Monari (see above), while in the apple orchard (site R[2]) there were only two: *C. pallens* and *Chrysoperla carnea*. The latter represented about 90% of the capture in both orchards.

In 1984 in site T chemical knockdown samples were used in three orchards, apple, pear and peach, and contemporaneously the presence of chrysopid egg-laying and aphid colonies were examined by visual surveys (Table 24.6) (Pantaleoni & Ticchiati, 1988). The total species collected were only four, two hemerobiids and two chrysopids. The overlap between the curves of aphid infestation and the lacewing presence was almost nil. The Neuroptera were however strongly influenced by the pesticide treatments, still based on organophosphates, carried out on the crops (Fig. 24.5).

The following year chemical knockdown samples were used in two plots (apple and peach) to determine the spatial pattern of *C. carnea* in orchards (Pantaleoni

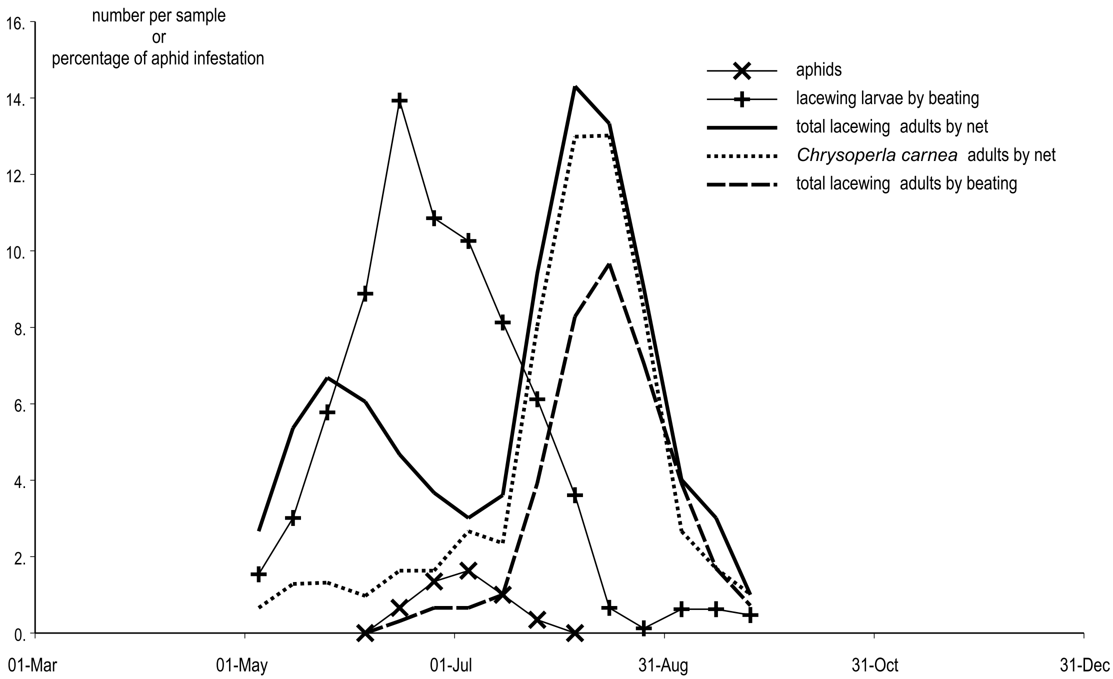

Fig. 24.4. Seasonal trends of aphid infestation and lacewing captures in hedge of site N, 1983. (From Pantaleoni & Sproccati, 1987.)

& Ticchiati, 1990). A clumped pattern was obtained only in the apple orchard and was probably due to the internal variability of the plot and not to the bioecological characteristics of the species. In agreement with Taylor's power law (Taylor, 1961, 1984) the aggregation index *b* for this chrysopid has in fact been calculated obtaining a particularly low value (1.11) near random (Pantaleoni & Ticchiati, 1990).

In 1987 in the area U, with samples collected by beating, research was carried out on predatory insects present in three groups of four pear orchards each. Group 'a' was mainly treated with several organophosphates and pyrethroids, group 'b' with Anziphosmethyl, and group 'c' with *Bacillus thuringiensis* and Diflubenzuron. Lacewings captured are listed in Table 24.7 (Nicoli *et al.*, 1988). Apparently the species found were much more numerous than in previous surveys, but, in fact, for each plot their number varied only from two to five. There was clearly a reduction in the total number of species, and also individuals, passing from group 'a' to group 'c'. *Chrysoperla carnea* was the most common species only in the pear orchards of group 'a'; in the other two groups, in relation to greater mite population densities, *Coniopteryx esbenpeterseni* represented 50% of the captures. The samples collected by beating however make it possible to record the presence of coniopterygids more efficiently than by net.

The preceding surveys were repeated in three other plots during 1990, in the plains area on the border of the provinces of Ferrara and Bologna. The principal differences with the 1987 studies were higher frequency of samples and choice of three orchards in which only low quantities of chemical pesticides were used, decreasing in the following order: site V, site W, site X (Table 24.7) (Marzocchi & Pantaleoni, 1995). In this case the number of species and individuals collected also increased with the reduction in pesticide use. Especially the hemerobiids reacted positively reaching in site X unusual high abundance for the plain. The seasonal trend of abundance of the coniopterygids presented a peak in August, that of the hemerobiids in July and October, and that of the chrysopids in October (Fig. 24.6).

Lastly, it is of interest to report for comparison the unpublished data coming from an untreated plot of apple orchard located to the extreme north of Pianura Padana (San Martino Buonalbergo, Verona) and regarding only the chrysopids collected by net in 1985

Table 24.5. *Relative abundance of species collected by insect net on some crops in the Forlì province*

Relative abundance[a]	Site Q[1] *Vicia faba minor* fodder crop Vecchiazzano 1979/80	Site Q[2] potato crop Vecchiazzano 1979/80	Site Q[3] vineyard Vecchiazzano 1979/80	Site R[1] peach orchard S. Martino Villafranca 1979/80	Site R[2] apple orchard S. Martino Villafranca 1979/80
66%–100%		*Chrysoperla carnea*		*Chrysoperla carnea*	*Chrysoperla carnea*
33%–66%	*Dichochrysa prasina*		*Chrysoperla carnea*		
16%–33%	*Chrysopa formosa* *Chrysoperla carnea*		*Dichochrysa prasina*		
8%–16%		*Chrysopa formosa*	*Chrysopa formosa* *Chrysopa viridana*		*Chrysopa pallens*
4%–8%			*Chrysopa pallens*	*Dichochrysa prasina*	
1%–4%	*Dichochrysa clathrata* *Chrysopa pallens*		*Dichochrysa flavifrons* *Dichochrysa clathrata*	*Chrysopa formosa* *Chrysopa pallens*	

Note:
[a] The species are in order of decreasing abundance.

Table 24.6. *Relative abundance of species collected in some orchards*

Relative abundance[a]	Site S Apple orchards Ravenna 1979–80 insect net	Site T[1] Apple orchard Tamara 1984 chemical knockdown	Site T[2] Pear orchard Tamara 1984 chemical knockdown	Site T[3] peach orchard Tamara 1984 chemical knockdown	Outside Site Apple orchard S. Martino Buonalbergo 1985 insect net
66%–100%		*Chrysoperla carnea*	*Chrysoperla carnea*	*Chrysoperla carnea*	
33%–66%	*Chrysopa pallens*				*Chrysopa perla*
16%–33%	*Chrysopa formosa* *Chrysoperla carnea*			*Micromus angulatus*	*Chrysoperla carnea*
8%–16%	*Dichochrysa prasina*				*Chrysopa formosa*
4%–8%			*Micromus angulatus*	*Chrysopa pallens*	
1%–4%				*Hemerobius humulinus*	*Chrysopa pallens* *Dichochrysa prasina* *Chrysopa phyllochroma* *Dichochrysa flavifrons*
max 1%		*Micromus angulatus*			

Note:
[a] The species are in order of decreasing abundance.

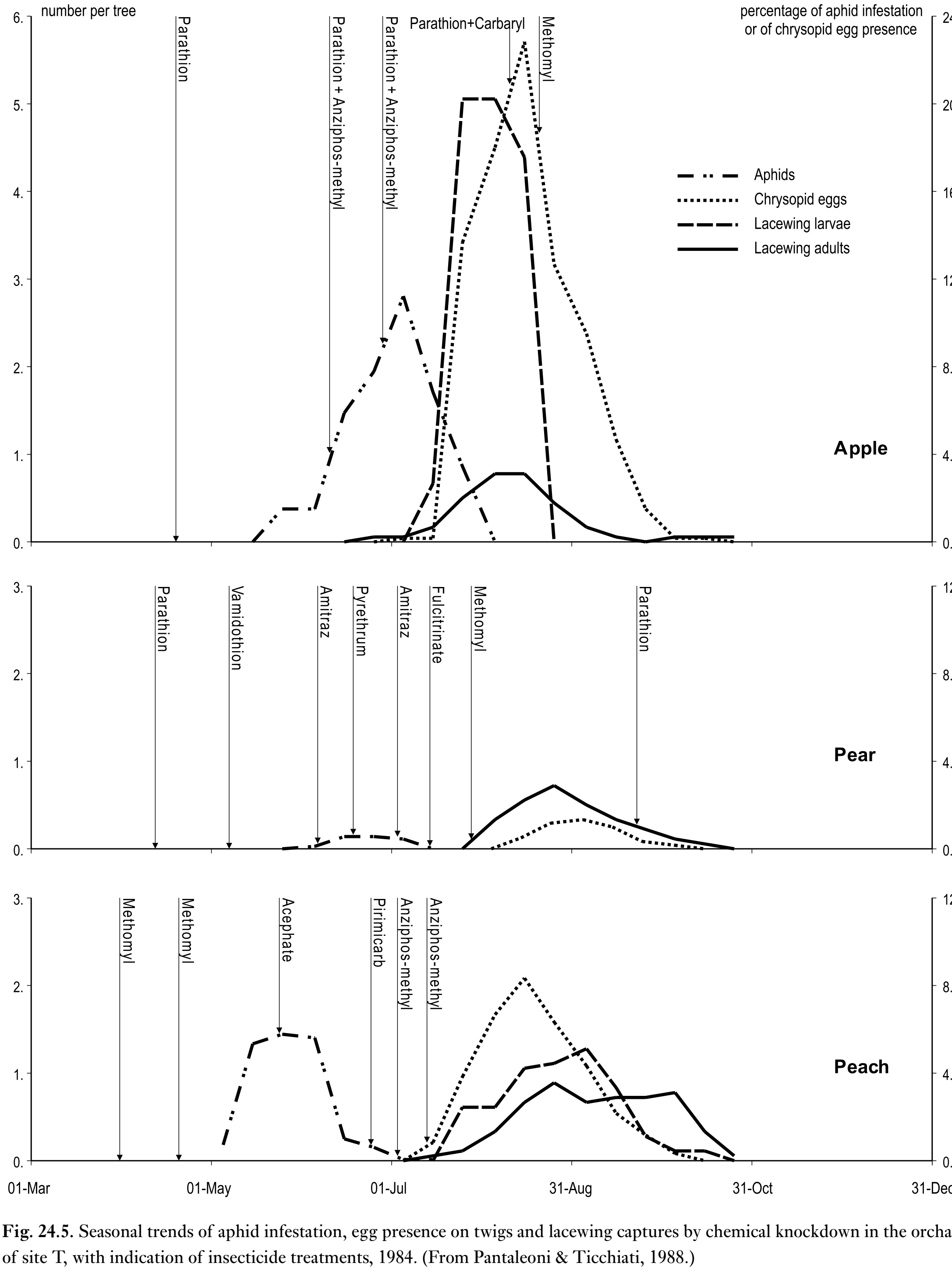

Fig. 24.5. Seasonal trends of aphid infestation, egg presence on twigs and lacewing captures by chemical knockdown in the orchards of site T, with indication of insecticide treatments, 1984. (From Pantaleoni & Ticchiati, 1988.)

Table 24.7. *Relative abundance of species collected by beating in pear orchards*

Relative abundance[a]	Area U Pear orchards Group a 1987	Area U Pear orchards Group b 1987	Area U Pear orchard Group c 1987	Site V Pear orchard Cento 1990	Site W Pear orchard Poggetto 1990	Site X Pear orchard S. Matteo della Decima 1990
33%–66%	*Coniopteryx esbenpeterseni*	*Coniopteryx esbenpeterseni*	*Chrysoperla carnea*	*Chrysoperla carnea* *Coniopteryx borealis*	*Chrysoperla carnea*	*Hemerobius humulinus*
16%–33%	*Chrysoperla carnea*	*Chrysoperla carnea*			*Hemerobius humulinus*	*Chrysoperla carnea*
8%–16%	*Micromus angulatus* *Coniopteryx haematica*	*Hemerobius humulinus*	*Coniopteryx esbenpeterseni*	*Micromus angulatus*	*Micromus angulatus* *Coniopteryx borealis* *Coniopteryx esbenpeterseni*	*Coniopteryx borealis* *Micromus angulatus*
4%–8%	*Chrysopa pallens*	*Micromus angulatus* *Wesmaelius subnebulosus*	*Hemerobius humulinus* *Chrysopa pallens*		*Wesmaelius subnebulosus*	*Wesmaelius subnebulosus*
1%–4%		*Chrysopa formosa* *Chrysopa pallens*	*Micromus angulatus* *Coniopteryx borealis* *Coniopteryx haematica* *Wesmaelius subnebulosus*	*Hemerobius humulinus* *Hemerobius micans*	*Hemerobius micans*	*Hemerobius micans*
max 1%						*Dichochrysa flavifrons*

Note:
[a] The species are in order of decreasing abundance.

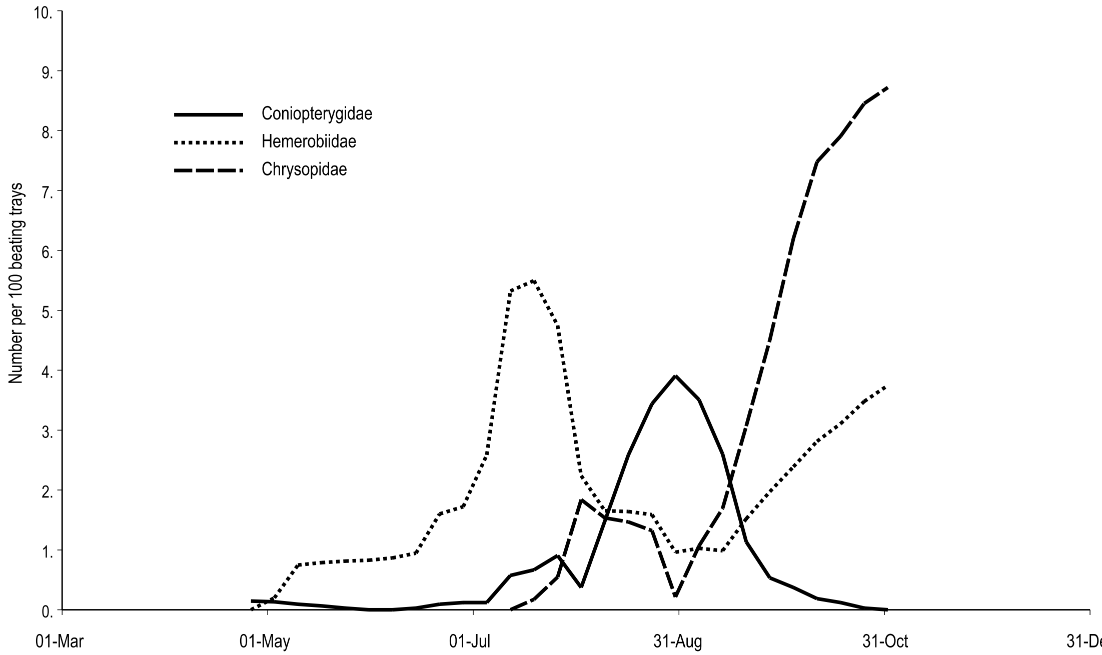

Fig. 24.6. Seasonal trends of lacewing captures (average of three plots) in pear orchards of sites V, W, and X, 1990. (From Marzocchi & Pantaleoni, 1995.)

(Table 24.6) (A. Biondani, unpublished data). Genus *Chrysopa* was present with four species out of seven. Among these *C. perla* represented almost two-thirds of all captures.

24.3.6 Crop fields

Data regarding lacewing occurrence on crop fields are limited to a very few specific studies, but fortunately various indirect information is also available.

Within the sphere of the research on crops in the province of Forlì (site Q), Pantaleoni & Tisselli (1985) studied the chrysopid taxocoenoses of *Vicia faba* var. *minor* (grown as a fodder crop) and of the potato (Table 24.5). A rather high number of species were found on the fodder crop, among others, those ecologically associated with tree and shrub *Chrysopa pallens*, *Dichochrysa clathrata*, and *D. prasina*. On the potato *Chrysoperla carnea* represented almost 90% of the captures.

Apart from a very high density of *Chrysopa formosa* recorded for a lucerne crop near Comacchio (Ferrara) (Pantaleoni, 1986), it is always and only *Chrysoperla carnea* that is cited as present on the crop fields, so too in the northeastern Pianura Padana. Ragusa & Paoletti (1985) and Paoletti *et al.* (1989) found it on maize and soya-bean, Zandigiacomo (1985) on broad beans, and again Vidano & Arzone (1987) on maize in the western Pianura Padana. Unfortunately other records provide only general indications 'chrysopids', see for example Ciampolini *et al.* (1987). Lastly, in some cases such as in weekly inspection of 400 stems in three wheat plots near to the pear orchards of sites V, W, and X no lacewings were found (Marzocchi & Pantaleoni, 1995).

24.3.7 Faunistic analysis

It is very probable that in Neuroptera, as within other animal groups (Brandmayr, 1982), the fauna complex of lowland forest, especially oak–hornbeam forest including clearings and ash–alder wood, was composed of hygrocolous, mesophilous, and sciophilous species. In the southeastern Pianura Padana this outline is complicated by a rising from south towards north of Mediterranean floro-faunistic elements in two corridors placed along the coast and at the base of the Apennines (Zangheri, 1950; Contarini, 1995). The activities of people over the centuries have, however, transformed the region into a culture steppe, heating and drying the environment with dramatic consequences for the fauna (Pesarini, 1995). Today the species associated with the native forest have disappeared or are confined to refuge habitats. The landscape is colonised by euryoecious or moderately thermophilous and xerophilous species.

The 51 species of Neuroptera recorded in this work have been subdivided in nine 'ecological groups' as shown in Table 24.8. The species were interpreted according to the 'Italian Checklist' (Bernardi Iori *et al.*, 1995) with the exception of *Chrysoperla carnea*, *Dichocrysa prasina*, and *D. flavifrons* which were always considered *sensu lato*.

From the point of view of the changes in fauna the most interesting group is without doubt group 3. This coincides with the remains of the ancient lowland forest coenoses. Among the component species, all with northern distribution, only two possess a marginally practical interest: *Hemerobius micans* and *Chrysopa perla*. The hemerobiid is the most widespread species of the family; it was found in practically all the coastal and Apennine sites, in the parks, and in some pear orchards subjected to low chemical insecticide treatments. The chrysopid on the other hand was present not only in the remnant plain woods, in some parks, in larger hedges but also in the clearings of the Apennine ridge. It was probably the most abundant species on the 'piantate' as it is again the most abundant species in damp and fresh habitats of other sectors of Pianura Padana (Arzone, 1979; A. Biondani, personal communication).

Groups 5 and 6 are composed of strongly xerothermophilous Mediterranean species that occupy the coastal belt and the pre-Apennine hills. This latter area hosts a much greater number of species than the first.

The species attached to deciduous oaks (group 2) are mainly present along the coast and in the hilly oak woods. They penetrate to the inner plain following their own host plants confined in the parks and in the hedges. Near the hilly areas they can also sometimes move on to crops for brief periods (vineyard of site Q). However further away from the Apennine oak woods these species become more sporadic (see Table 24.3).

Eleven species quite regularly occur on the crops: three coniopterygids, three hemerobiids, and five chrysopids (group 1).

The most common coniopterygid was *Coniopteryx esbenpeterseni*. It was the most abundant lacewing in some pear orchards and in a park (site M), but it was also present in the other parks, in other pear orchards, in gardens, and in the hilly areas (sites F, and G). As already demonstrated by Castellari (1980) this species preys on mites and normally its population density is correlated with phytophagous density. *Coniopteryx borealis* was less abundant, but equally well distributed. It was present in the coastal gardens, in the parks, in the larger hedges, in the pear orchards, especially those less treated with pesticides, and also in the glades of the Apennine beech woods. *Coniopteryx haematica* was the least common of the three. It was present in fewer sites that included however gardens, parks, hedges, and fruit orchards.

Hemerobius humulinus was the most widespread and common hemerobiid. It was present practically everywhere except on crops heavily treated with pesticides. *Wesmaelius subnebulosus* was both less abundant and less widespread than *H. humulinus*. However, it was present in some semi-natural sites of the coast, in parks, fruit orchards, and in the Apennine beech woods. Lastly, *Micromus angulatus* was the most widespread hemerobiid on the crops. Unlike *H. humulinus* this species can in fact exploit some aspects of its ethology, such as in particular its ability to develop on low vegetation and to overwinter as adult, which enables an easier and more widespread colonisation of the culture steppe.

Chrysopa formosa was clearly the most abundant species in the coastal sites and in a park (site L), and was still very abundant on the crops bordering the hilly areas (site Q), in the parks, in the hedges, and it was also present in some fruit orchards. This aphidophagous chrysopid is potentially able to develop on low vegetation and could be the most abundant lacewing in the southeastern Pianura Padana. However the spinning of the cocoon a few centimetres below the soil surface (Principi, 1947) means it does not survive ploughing and this limits its range enormously.

Chrysopa septempunctata, although never very abundant, was widespread and present almost everywhere. Unlike the previous species it is associated with trees and shrubs (Principi, 1940). Strictly aphidophagous and with a good flight capacity it is able to colonise even isolated fruit orchards quite easily.

Chrysoperla carnea is an *r*-strategy species, able to colonise every habitat even if only temporarily suitable for its development [refer to Duelli (1984*a*, *b*) on the

Table 24.8. *Ecological groups of lacewings recorded in this research*

Group	Species	Notes
1	*Coniopteryx borealis* Tjeder, 1930 *Coniopteryx haematica* McLachlan, 1868 *Coniopteryx esbenpeterseni* Tjeder, 1930 *Hemerobius humulinus* Linnaeus, 1758 *Wesmaelius subnebulosus* (Stephens, 1836) *Micromus angulatus* (Stephens, 1836) *Chrysopa formosa* Brauer, 1850 *Chrysopa pallens* (Rambur, 1838) *Chrysoperla carnea* (Stephens, 1836) *s. lat.* *Dichochrysa flavifrons* (Brauer, 1850) *s. lat.* *Dichochrysa prasina* (Burmeister, 1839) *s. lat.*	Euryoecious species, present with a certain regularity on the crops of the plain
2	*Conwentzia psociformis* (Curtis, 1834) *Semidalis aleyrodiformis* (Stephens, 1836) *Sympherobius pygmaeus* (Rambur, 1842) *Chrysopa viridana* Schneider, 1845	Associated with deciduous oaks
3	*Coniopteryx tineiformis* Curtis, 1834 *Hemerobius micans* Olivier, 1792 *Wesmaelius nervosus* (Fabricius, 1793) *Micromus variegatus* (Fabricius, 1793) *Chrysopa perla* (Linnaeus, 1758) (*sensu* Schneider, 1851) *Nineta flava* (Scopoli, 1763)	Hygrocolous and sciophilous species present in a few refuge habitats of the plain and in beech woods of the Apennine ridge
4	*Hemerobius lutescens* Fabricius, 1793 *Sympherobius elegans* (Stephens, 1836) *Cunctochrysa albolineata* (Killington, 1935) *Dichochrysa ventralis* (Curtis, 1834) *Hypochrysa elegans* (Burmeister, 1839)	Species found exclusively in beech woods of the Apennine ridge
5	*Coniopteryx arcuata* Kis, 1965 *Hemerobius gilvus* Stein, 1863 *Cunctochrysa baetica* (Hölzel, 1972)	Xerothermophilous Mediterranean species present in the coastal belt and in the pre-Apennine hills
6	*Helicoconis pseudolutea* Ohm, 1965 *Italochrysa italica* (Rossi, 1790) *Chrysopa walkeri* McLachlan, 1893 *Dichochrysa clathrata* (Schneider, 1845) *Dichochrysa zelleri* (Schneider, 1851)	Xerothermophilous Mediterranean species present only in the pre-Apennine hills
7	*Conwentzia pineticola* Enderlein, 1905 *Semidalis pseudouncinata* Meinander, 1963 *Hemerobius handschini* Tjeder, 1957 *Hemerobius stigma* Stephens, 1836 *Chrysopa dorsalis* Burmeister, 1839	Species confined to conifers (mainly *Pinus* and Cupressaceae) present in the coastal belt and in the Apennine areas
8	*Coniopteryx pygmaea* Enderlein, 1906 *Hemerobius contumax* Tjeder, 1932 *Sympherobius pellucidus* (Walker, 1853)	Species confined to conifers (mainly *Abies* and *Picea*) present only in the Apennine areas

Table 24.8 (*cont.*)

Group	Species	Notes
	Nineta pallida (Schneider, 1845) *Peyerimhoffina gracilis* (Schneider, 1851)	
9	*Coniopteryx lentiae* Aspöck & Aspöck, 1964 *Hemerobius perelegans* Stephens, 1836 *Sympherobius luqueti* Leraut, 1991 *Chrysopa abbreviata* Curtis, 1834 *Chrysopa nigricostata* Brauer, 1850 *Chrysopa phyllochroma* Wesmael, 1841 *Nineta guadarramensis principiae* Monserrat, 1980	Species with little-known ecology or linked to particular biogeographical distributions

eco-ethology of this species]. This chrysopid was present in all the sites studied. Its relative abundance reached very high levels in the more degraded environments, such as crops heavily treated with pesticides, but also in hedges, and stayed much lower in natural or semi-natural areas and in the parks.

The two *Dichochrysa* species have, as far as we know, similar ecological requirements. *Dichochrysa prasina* was the most abundant lacewing in open natural habitats (sites E, F, G). It was also common in gardens, parks, hedges, and some crops. *Dichochrysa flavifrons* on the other hand was slightly less widespread and abundant. For both of these the critical vital period for survival in agroecosystems is overwintering as free larvae (Principi, 1940, 1956). Winter insecticide treatments, which are carried out on the trunks of fruit trees and frequently adopted in Emilia Romagna, in fact greatly affect the larvae sheltering in the cracks of the bark.

Neuroptera taxocoenoses decreased in richness from coastal and Apennine territories to the semi-natural areas of the inner plain (parks, hedges, wood remnants) and from these to the crops. Only some pear orchards in which a very advanced IPM was applied (site W, and X) showed a slightly contrary trend. Human activities are the cause of alteration of habitats suitable for many species, especially the use of pesticides. The effects of the heavy insecticide treatments are clearly demonstrated by the results obtained in the fruit orchards in site T (Fig. 24.5).

The habitat characteristics, such as dimensions and distance from the Apennine oak-wood area, would appear to have a great influence on the distribution of the species associated with deciduous oaks (group 3). Nevertheless there are insufficient data to enter the debate on the equilibrium theory of insular biogeography (MacArthur & Wilson, 1963) and on its applicability to pest management schemes (Price, 1976; Rey & McCoy, 1979; Liss *et al.*, 1986; Duelli, 1988).

In the coastal gardens (site A) the seasonal trend of lacewing captures showed a spring maximum prevalently due to *Chrysopa formosa* (Fig. 24.3), in the large hedge (site N) this maximum becomes a secondary peak (Fig. 24.4), while it disappears altogether in the pear orchards (sites V, W, and X) (Fig. 24.6). The tendency of this chrysopid, or of *C. perla* which substitutes it in some situations, to disappear is of high practical importance. These species have a life cycle correlated in some way with the density of aphids, which are their preferred prey. Almost 70% of annual captures are concentrated in fact in May and June. About two-thirds of the first larval brood go into diapause and overwinter as prepupae while the remaining one-third emerge giving life in the same year to a second generation which can be followed by a third (Principi, 1947; Pantaleoni, 1982).

At the same time as the decrease in *C. formosa* there is a relative increase of *Chrysoperla carnea* which shows a seasonal maximum in late summer or in autumn. However this trend is characteristic of habitats with trees, such as gardens, hedges, and orchards. This chrysopid in fact colonises the crop fields more quickly, when environmental conditions are still favourable for development. It then moves on after the harvest towards hedges or fruit orchards. The arrival from the crop fields anticipates the search for and the reaching of overwintering sites that almost certainly are chosen within the same orchards, which represent in many areas of southeastern Pianura Padana the only woody vegetation.

The migration phenomena of entomophages from and towards hedges, wood remnants, spontaneous vegetation, and orchards of the Pianura Padana were pointed out by Paoletti & Lorenzoni (1989), Nicoli & Marzocchi (1993), Marzocchi & Pantaleoni (1995), and others. They always concern species overwintering at the adult stage such as ladybirds and flower bugs. Of the lacewings, other than *C. carnea*, *Micromus angulatus* also appears to have this behaviour (L. Marzocchi, personal communication).

24.4 CONCLUSIONS

How many lacewings lived on crops of the Pianura Padana at the time of maximum diffusion of the 'piantata'? Of course, there is no way of knowing for sure, but it is possible that there were at least 20 corresponding to the first three groups of Table 24.8. This number is not very different from that recorded in the coastal gardens (site A) where the vegetation has a similar physiognomy to that of the 'piantata' systems.

According to Pimentel *et al.* (1989) one of the principles that underlie a low-input sustainable agriculture is adapting the agricultural system to the environment of the region, including soil, water, climate, and biota present at the site. In this context traditional agricultural practices can provide a solid starting-point for modern pest control techniques of agroecosystem manipulation. In the southeastern Pianura Padana it might not be possible to go back to the 'piantata' but the testing of techniques such as minimum-tillage, no-tillage, intercropping of perennial and annual crop with wild plants, or intercropping of two or several crops has now become necessary.

In the agroecosystems of Pianura Padana the absolute priority should be the restoration of minimal survival conditions for *Chrysopa formosa*, or *C. perla*. Even without allocating a part of territory to non-productive functions creating uncultivated strips, a good result could be obtained by adopting minimum-tillage or no-tillage techniques in some annual crops (Paoletti, 1983). The two chrysopids could permanently colonise the fields especially if there are neighbouring reservoir areas. Their cocoon-spinning under the surface of the ground might also enable integrated management with some herbicides without damaging lacewing populations.

The restoration of the hedges and other woody areas would seem to be another necessary practice. These habitats would act as winter refugia for species overwintering as adults and would maintain a greater species diversity in the landscape.

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