

Comparison Between Green Lacewing Assemblages (Neuroptera: Chrysopidae) in the Lower Valleys of the Danube (Rumania) and the Loire (France)

Dominique THIERRY*

Mihaela PAULIAN**

Michel CANARD***

*12 rue Martin Luther King, F-49000 Angers, FRANCE; **Aleea Zvoristea 3, Bat A 42, Sc B, Ap 19, RO-77426 Bucuresti, RUMANIA; ***47 chemin Flou de Rious, F-31400 Toulouse, FRANCE; e-mail: dominique.thierry@equipement.gouv.fr

ABSTRACT

Quantitative surveys were carried out in two European fluvial lower valleys, in Rumania (Danube Plain) and in France (Val-de-Loire). Various sites were investigated by various collecting methods. Faunistic richness is higher in Val-de-Loire whilst the diversity indices (Shannon and Hurlbert) show that the Plain of the Danube exhibits a significantly greater level of biodiversity. Seventeen species appear jointly in samples of the two valleys. The Plain of the Danube harbours characteristic Eurosiberian elements: *Chrysopa dasyptera* and *Chrysopa hungarica*, Val-de-Loire shows Westmediterranean ones: *Dichochrysa picteti*, *D. inornata* and *Chrysoperla mediterranea*. Concerning actual numbers of individuals, the Plain of the Danube is dwelt equally by chrysopids glyco-palynophagous and aphidophagous as adults (50/50 %) contrarily to Val-de-Loire which is essentially by glyco-palynophagous species (98 %), overwintering as adults (89 %) or larvae (9 %).

Key words: Neuroptera, Chrysopidae, Plain of the Danube, Val-de-Loire, biodiversity, adult diet, overwintering.

INTRODUCTION

The European fauna of Neuroptera is well known and large amounts have been published on it over recent years (Aspöck *et al.*, 2001). Most of these works are relative to faunistics, pointing to elaborating diversity, but they do not provide quantitative information on the actual frequency of and balance between species. Qualitative surveys most often feature occasional encounters of rare specimens in the samples, highlighting their occasional occurrence and so give readers a biased perspective of actual species assemblages.

The goal of the present study is to give an accurate assessment of green lacewing populations and so to help typify the chrysopid assemblages of similar biotopes situated in two opposite parts of Europe, southern Rumania and northwestern France.

SAMPLE SITES AND METHODS

The fauna of Chrysopidae of Rumania is composed of 33 species (Kis *et al.*, 1970; Paulian, 2002), including the sibling species which constitute the complex *Chrysoperla carnea* (Stephens, 1836) *sensu lato*, so-called “the common green lacewings”. Twenty three species are identified in the Rumanian part of the Danube Plain at the moment. The lower valley of the Loire (Val-de-Loire) harbours 27 amongst 35 green lacewing species which occur in the northern part of France (Canard *et al.*, 2007b).

Biotopes in which the surveys are performed are both fluvial valleys in their terminal part (Fig. 1). That of Danube is located east of 24° E on a distance of about 500 km, from Dabuleni to the Delta (Uzlina), between 43° 30' and 45° 30' N. All sites consist of crops and neighbouring zones covered with spontaneous vegetation mainly weeds; only Dabuleni lies on sandy soils, parcelled out by wind-screen hedges. The low Loire valley investigated belongs to departments of Loire-Atlantique, Maine-et-Loire and Indre-et-Loire, namely about 200 km of the flood plain, east of 2 °W, at a latitude comprised between 47° and 48° N. The studied biotopes were meadows flooded in winter (Saint-Aubin Island), river banks (Vouvray), low crops and neighbouring zones, fallows, hedges, bushy underwoods.

Data result from samples obtained by various methods [light traps (LT), yellow traps (YT), beating and hand net sweeping (HN) and hand suction-trap (Vac)], which were combined together in to provide significant quantitative results.

The abundance scale chosen is the following: a species is considered;

- dominant (DOM) if its frequency (Q) exceeds 50 % within the overall sample,
- very common (V. COM) if $30 < Q \leq 50$ %,
- common (COM) if $15 < Q \leq 30$ %,
- uncommon(UNC) if $5 < Q \leq 15$ %,
- rare (RAR) if $1 < Q \leq 5$ %,
- casual (CAS) if $0.1 < Q \leq 1$ %,
- and exceptional (EXC) if $Q \leq 0.1$ %.

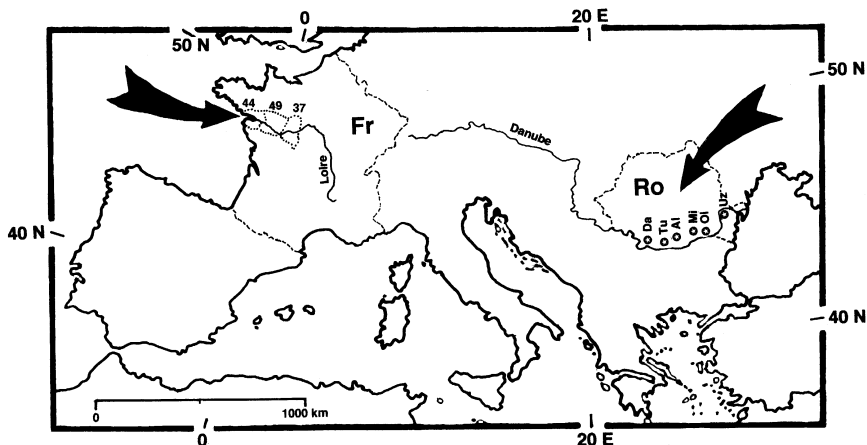


Fig. 1. Map of Europe showing the sites in which surveys were performed. In western France, 44 = Loire-Atlantique, 49 = Maine-et-Loire, 37 = Indre-et-Loire. In Rumania, Da = Dabuleni, Tu = Turnu Magurel, Al = Alexandria, Mi = Mitreni, Ol = Oltenitza, Uz = Uzlina.

Species richness and relative abundance were appraised by several well-known indices. We computed (i) Margalef's index (I_M) to characterise the approximate faunistic richness, (ii) Shannon's diversity or heterogeneity index (H') as the relative importance of each species and the ratio between the total number of species and individuals, and (iii) Hurlbert's equitability or evenness index (E_H) which measures the relative heterogeneity, featuring the distribution of the species and specimens occurring in each unit and assessing the dominance of the more abundant species. Shannon's diversity index ranges from 0 to $\log S$ (S = number of species) being greatest in stable ecosystems; Hurlbert's equitability index varies from 0 to 1, being zero when almost all captured specimens belong to a single species and reaching one when each species is represented by the same number of individuals.

RESULTS AND DISCUSSION

A total of 33 species were found, listed in Table I together with the numbers of specimens collected in each site. Table II shows ordinate data and relative frequencies of each species for each site which also appear in Fig. 2. Table III gives the relevant biodiversity indices.

The Danube Plain

Rumanian records show that 15 species are actually present in the samples, 8 others missing (shadow species), either because they are linked to a peculiar plant

support, like conifers for *Chrysopa dorsalis* and *Peyerimhoffina gracilis*, or too rare to appear regularly in random collections. Two species constitute more than 80 % of the total. They are, firstly, the common green lacewings (DOM) or more precisely all true species of the complex, always dominant in all anthropised European biotopes, followed by the carnivorous *Chrysopa formosa* (V. COM). This later species was present in all local samples, with a high frequency ranging from 16.1 (Dabuleni) to 62.1 % (Mitreni) in the local communities. Such a strong occurrence of *Ch. formosa* was also registered in the Italian Plain of the Po, as well in the coastal sites and parks as on crops and in some fruit orchards (Pantaleoni, 2001). Beyond, but more or less common, we show *Ch. pallens* (UNC) occurring everywhere from 1.8 (Turnu Magurel) to 10.1 % (Uzlina). Besides, there are three rare species, in decreasing order *Ch. nigricostata* (RAR), *Ch. phyllochroma* (RAR) and *Ch. abbreviata* (RAR). All others are occasional, except *Ch. abbreviata* locally common (>15 %) in Dabuleni district, due to the peculiar sandy nature of the soil.

Val-de-Loire

Data coming from France initially gave approximately the same actual faunistic richness (16 species), and 11 shadow species. Some of the latter are missing because of a specificity, such as coniferous plant support for *Peyerimhoffina gracilis* and *Chrysoperla mediterranea*, or the environment in which they develop like sandy and gravelous biotopes for *Chrysopa abbreviata*, swampy wetland for *Chrysoperla renoni*. Others are known everywhere as rare species, such as *Nineta inpunctata*, or possibly misidentified, such as *Dichochrysa mariana* morphologically very close to *D. prasina*. Consequently, these may escape capture in small samples or mislead the watchfulness of collectors.

In western France, the common green lacewings were absolutely dominant (DOM) in the four local samples, exhibiting frequency from 71 (Vouvray) to 98 % (Saint-Aubin Island). Only three other species, considered rare according to the scale of abundance, namely *Dichochrysa prasina* (RAR), *D. flavifrons* (RAR) and *D. inornata* (RAR), comprised about 9 % of overall chrysopid assemblages. All other green lacewings were occasional. *Chrysoperla mediterranea* and *Dichochrysa picteti* reach here the utmost border of their northern extension.

Comparison

The two samples provided similar numbers of species ($S = 15-16$) displaying identical Margalef indices (I_M). The Plain of the Danube manifest both the highest diversity (H') and equitability indices (E_H).

Table I. List of green lacewing species collected and numbers of specimens recorded in the Plain of the Danube (Romania) and Val-de-Loire (France). * indicates a species occurring in the sites (after recorded from the literature) but not collected in the present samples, shaded lines indicate species absent in the relevant biotopes, full lines indicate characteristic species. Collection methods are: HN = hand net; LT = light trap; YT = yellow trap; Vac = hand vacuum apparatus.

Site	#	Species	No. of specimens	Frequency	Abundance scale	Diet of adult	Overwintering
Plain of the Danube	31	<i>Chp. carnea</i> s.l.	895	48.43	V. COM	Gph	adult
	16	<i>Ch. formosa</i>	599	32.41	V. COM	Aph	prepupa
	21	<i>Ch. pallens</i>	131	7.09	UNC	Aph	prepupa
	20	<i>Ch. nigricostata</i>	73	3.95	RAR	Aph	prepupa
	17	<i>Ch. phyllochroma</i>	70	3.79	RAR	Aph	prepupa
	14	<i>Ch. abbreviata</i>	28	1.52	RAR	Aph	prepupa
	10	<i>Ch. perla</i>	18	0.97	CAS	Aph	prepupa
	25	<i>D. prasina</i>	15	0.81	CAS	Gph	larva
	19	<i>Ch. viridana</i>	5	0.27	CAS	Aph	prepupa
	22	<i>D. flavifrons</i>	3	0.16	CAS	Gph	larva
	27	<i>D. ventralis</i>	3	0.16	CAS	Gph	larva
	28	<i>C. albolineata</i>	3	0.16	CAS	Gph	prepupa
	29	<i>C. baetica</i>	3	0.16	CAS	Gph	prepupa
	11	<i>Ch. walkeri</i>	1	0.05	EXC	Aph	prepupa
	32	<i>Chp. venoni</i>	1	0.05	EXC	Gph	adult
Val-de-Loire	31	<i>Chp. carnea</i> s.l.	2246	87.67	DOM	Gph	adult
	25	<i>D. prasina</i>	121	4.72	RAR	Gph	larva
	22	<i>D. flavifrons</i>	79	3.08	RAR	Gph	larva
	24	<i>D. inornata</i>	42	1.64	RAR	Gph	larva
	10	<i>Ch. perla</i>	19	0.74	CAS	Aph	prepupa
	19	<i>Ch. viridana</i>	17	0.66	CAS	Aph	prepupa
	3	<i>H. elegans</i>	13	0.51	CAS	(Pph)	(pupa)
	9	<i>Cht. ciliata</i>	5	0.20	CAS	Gph	prepupa
	17	<i>Ch. phyllochroma</i>	4	0.16	CAS	Aph	prepupa
	1	<i>No. fulviceps</i>	3	0.12	CAS	Gph	prepupa
	16	<i>Ch. formosa</i>	3	0.12	CAS	Aph	prepupa
	21	<i>Ch. pallens</i>	3	0.12	CAS	Aph	prepupa
	5	<i>Ni. flava</i>	2	0.08	EXC	Gph	prepupa
	7	<i>Ni. principiae</i>	1	0.04	EXC	Gph	prepupa
	12	<i>Ch. dorsalis</i>	1	0.04	EXC	Aph	prepupa
23	<i>D. picteti</i>	1	0.04	EXC	Gph	larva	

Comparing chrysopid fauna of the two valleys shows a closely related composition: 17 species occur simultaneously, either present in the samplings (## 10, 16, 17, 19, 21, 22, 25, 31), or potentially present (## 1, 5, 11, 14, 18, 27, 28, 30, 32, see Table I). All are usual European elements, extending from the Iberian Peninsula to the Caspian Sea, such as *Nineta flava* or *Chrysopa walkeri*, or having a more septentrional distribution area, such as *Ch. abbreviata* which is known from the Polar Circle to Bulgaria and longitudinally from the British Isles to the Black Sea. One species only is in Rumania at the extreme eastern border of its range: *Nothochrysa fulviceps*.

Six species were recorded in the Plain of the Danube but not in Val-de-Loire (## 4, 6, 13, 15, 20, 29, see Table 1). *Italochrysa italica* and *Cunctochrysa beatica* were only captured in the utmost south of Rumania, near the Bulgarian frontier; their Mediterranean habits do not allow them to reach northern France up to Val-de-Loire, whilst *Chrysopa nigricostata* categorized Holomediterranean does not reach north-western Europe. Besides, two species are more particular in the Danube valley: *Ch. hungarica* considered Pontomediterranean, and *Ch. dasyptera* here on the farthest southern limit of its distribution area, known elsewhere in Finland, Carelia, Poland (Aspöck *et al.*, 2001) and Hungary (Szabó & Szentkirályi, 1981).

Ten species were collected in Val-de-Loire and were absent in the Plain of the Danube (## 2, 3, 7, 8, 9, 12, 23, 24, 26, 33, see Table I). Nevertheless, some of them are registered elsewhere in the Rumanian fauna such as *Nothochrysa capitata*, *Hypochrysa elegans*, *Chrysotropia ciliata* and *Chrysopa dorsalis*, already found in the centre of the country and *Nineta inpunctata* recorded only in the montane zone of Transylvania (Paulian *et al.*, 2001). Others cannot appear because their distribution areas do not include Rumania: exclusively Atlantomediterranean (*Dichochrysa picteti*), not distributed eastwards beyond Hungary (*D. inornata*) (Aspöck *et al.*, 2001), Greece and Slovakia (*Chrysoperla mediterranea*) (Henry *et al.*, 1999).

Amongst all the 6 significant chrysopids ($Q > 1\%$) found in the Danube valley, only the common green lacewings have a glyco-palynophagous diet as adult (Table II). In the overall Rumanian specimen collection, there is the same number of individuals feeding on sweet juices and pollens rather than preying on aphids or other arthropods (*Chrysopa*) (923 vs 925). In most species, overwintering (Table II) is insured as diapausing prepupa protected within the cocoon (*Chrysopa*, *Cunctochrysa*), just followed by free adults in ovarian diapause (*Chrysoperla*). Thus the wintering populations of chrysopids in the Danube Pain involve very few (about 1%) diapausing larvae (*Dichochrysa*). Such balances in feeding and overwintering are basically differ-

ent of these found in western Europe where glyco-palynophagous diet for adults (98 %) and overwintering as active instars are the rule in a high majority (Canard *et al.*, 2007a). They survive winter as adults (89 %) in different sites according to their actual identity within the *carnea*-complex (Thierry *et al.*, 1994) or larvae (9 %).

Table II. Ordinate data recorded in the Danube and Loire valleys, relative frequency (%), abundance scale (see text), diet of adult and overwintering instar (after Canard, 2005) for each species. Aph = aphidophagous diet, Gph = glyco-palynophagous diet, Pph = palynophagous diet.

Sites	Plain of the Danube						
	Dabuleni	Turnu Magurel	Alexandria	Mitreni	Oltenitza	Uzlina	Total
No. of species	8	6	5	7	11	6	15
Richness of Margalef (I_M)	0.87	0.74	0.66	0.82	1.17	0.51	1.29
Diversity of Shannon or heterogeneity (H')	1.69	1.40	1.45	1.60	2.06	1.52	1.97
Equitability of Hurlbert or evenness (E_H)	0.52	0.46	0.54	0.51	0.56	0.58	0.49
Sites	Val-de-Loire						
	Wetland St-Aubin Island	Vouvray	Crops	Various	Hedges and river banks	Total	
No. of species	9	7	9	8	12	16	
Richness of Margalef (I_M)	0.84	0.67	0.81	1.16	1.3	1.33	
Diversity of Shannon or heterogeneity (H')	0.18	1.35	0.66	1.09	1.07	0.85	
Equitability of Hurlbert or evenness (E_H)	0.02	0.46	0.18	0.14	0.2	0.20	

Diversity indices are shown in Table III. Faunistic richness given by the Margalef's index is slightly higher in Val-de-Loire than in the Plain of the Danube (+ 3 %); such a difference may be a consequence of the difference between the total numbers of specimens collected, about 1.4 time more in France than in Rumania. Within the two sites, the index varies more than twice between biotopes, being minimal in the Delta (Uzlina) despite a large sample ($n = 882$). The Shannon's and the Hurlbert's indices, which betoken the relative importance of and the equitability between species, are both higher in Rumania than in France (+ 57 % an 59 %, respectively). The biotope showing the more homogeneous lacewing community is the St-Abin Island, probably due to the regular winter flooding inducing a high mortality in immobile wintering instars; then, every year the biotope must be re-invaded by outside species such as *Ch. carnea* whose nomadism has been known for some time (e.g. Duelli, 1980).

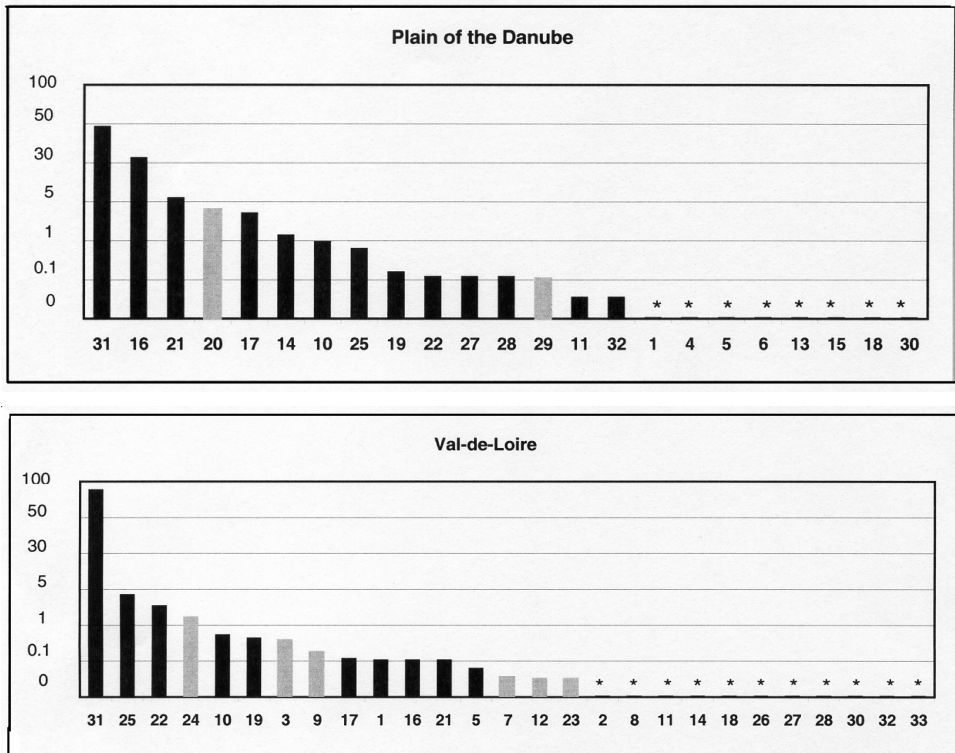


Fig. 2. Relative frequency (%) of each chrysopid species collected in the Plain of the Danube and Val-de-Loire. Shaded bars indicate species occurring in one valley only. * indicates that species although occurring in the biotope is missing in the present samples. Identification of species is that (#) appearing in Table I.

Table III. Indices of biodiversity calculated in the Danube and Loire valleys.

Species (and collection method)	Dabuleni (HN)	Turmu Magareu (HN)	Alexandria (HN)	Mitrei (LT)	Oiteniza (LT)	Uzliina (HN)	Total Danube	49 - St-Aubin Island (LT)	37 - Vouvray, river banks (HN)	49 - Brassica crops (HN + YT + Vac)	44, 49 - various sites (HN)	49 - river banks (HN)	Total Loire
<i>Nothochrysa fulviceps</i> (Stephens, 1836)							*	1			1	1	3
<i>Nothochrysa capitata</i> (Fabricius, 1793)													*
<i>Hypochrysa elegans</i> (Burmeister, 1839)									2		3	8	13
<i>Italochrysa italica</i> (Rossi, 1790)							*						
<i>Nineta flava</i> (Scopoli, 1763)							*	1				1	2
<i>Nineta vittata</i> (Wesmael, 1841)							*						
<i>Nineta principiae</i> Monserrat, 1980											1		1
<i>Nineta inpunctata</i> (Reuter, 1894)													*
<i>Chrysotropia ciliata</i> (Wesmael, 1841)								1	1			3	5
<i>Chrysopa perla</i> (Linnaeus, 1758)	5	2	3	4	2	2	18	1	8	4	1	5	19
<i>Chrysopa walkeri</i> McLachlan, 1893	1						1						*
<i>Chrysopa dorsalis</i> Burmeister, 1839												1	1
<i>Chrysopa hungarica</i> Klapálek, 1899							*						
<i>Chrysopa abbreviata</i> Curtis, 1834	26	1	1				28						*
<i>Chrysopa dasyptera</i> McLachlan, 1872							*						
<i>Chrysopa formosa</i> Brauer, 1850	42	45	36	100	191	185	599			3			3
<i>Chrysopa phyllochroma</i> Wesmael, 1841	7			1	6	56	70			4			4
<i>Chrysopa commata</i> Kis & Újhelyi, 1965							*						*
<i>Chrysopa viridana</i> Schneider, 1845					5		5	2	12	1		2	17
<i>Chrysopa nigricostata</i> Brauer, 1850					73		73						
<i>Chrysopa pallens</i> (Rambur, 1838)	9	2	2	11	18	89	131	1		1		1	3
<i>Dichochrysa flavifrons</i> (Brauer, 1850)					3		3		38	35	1	5	79
<i>Dichochrysa picteti</i> (McLachlan, 1880)								1					1
<i>Dichochrysa inornata</i> (Návas, 1901)								5		33	2	2	42
<i>Dichochrysa prasina</i> (Burmeister, 1839)				7	8		15		80	12	2	17	121
<i>Dichochrysa mariana</i> (Návas, 1905)													(*)
<i>Dichochrysa ventralis</i> (Curtis, 1834)	3						3						*
<i>Cunctochrysa albolineata</i> (Killington, 1935)				1	2		3						*

Table III continued.

<i>Cunctochrysa baetica</i> (Hölzel, 1972)		2			1		3						
<i>Peyerhimoffina gracilis</i> (Schneider, 1851)							*						*
<i>Chrysoperla carnea</i> (Stephens, 1836) s.l.	167	56	25	37	61	549	895	714	344	886	55	247	2246
<i>Chrysoperla renoni</i> (Lacroix, 1933)						1	1						*
<i>Chrysoperla mediterranea</i> (Hölzel, 1972)													*
No. of specimens	260	108	67	161	370	882	1848	727	485	979	66	198	2562
No. of species	8	6	5	7	11	6	15	9	7	9	8	13	16

CONCLUSION

The environment of the Plain of the Danube and of Val-de-Loire exhibits a significantly greater level of biodiversity in the Plain than Val-de-Loire. There is a conspicuous similarity between faunistic structures of the two sites surveyed seeing that more than half the number of recorded green lacewings are the same. Only few species are distinctive: For the Danubian zone, they are *Chrysopa dasyptera*, a Siberian element coming from North, and *Ch. hungarica* typical of Central Europe and Anatolia; *Dichochrysa picteti*, *D. inornata* and *Chrysoperla mediterranea*, all of East-Mediterranean origin coming from the South, for Val-de-Loire.

The most noticeable difference between the two valleys is the numerical balance of species within assemblages and incidentally, their predatory activity. Both data tables indeed give *Chrysoperla carnea* as the best represented species, but it is really dominant only in the Val-de-Loire. In the latter site, most of individuals have an imaginal glyco-palynophagous diet contrarily to a greater part of Danubian populations, constituted with predaceous green lacewings. Overwintering also exhibits different modes at the two locations. In the Danube valley, the majority of species overwinter as hidden and motionless instars, i.e. diapausing prepupa within the cocoon, whereas in Val-de-Loire, overwintering is by active instars: adults or free larvae. Consequently resumption of predatory activity in spring and impact on early aphid colonies are of course different due to these life-history traits (Canard, 2005).

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