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The actual annual occurrence of the green lacewings of northwestern Europe (Neuroptera: Chrysopidae)

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Abstract. Quantitative surveys of chrysopids from northwestern Europe were analysed. A total of thirty-five species are known within the zone although only twenty-six were recorded. Only the common green lacewings (i.e. the sibling species of the *Chrysoperla carnea* complex, here not differentiated) were elsewhere abundant comprising more than 3/4 of the specimens in all countries and reaching 97 % in Belgium. For the scarcer species, comments are given on their enhanced geographic range. The French fauna shows 19 species, six are exceptional (< 0.1 %) such as the Atlanto-Mediterranean *Dichochrysa picteti*. Five species are considered rare ($1 < Q \leq 5$ %): *Chrysopa perla*, *Ch. phyllochroma*, *Dichochrysa flavifrons*, *D. inornata* and *D. prasina*. The fauna of both Great Britain and Ireland has the same faunistical richness but manifests a more balanced equitability. *Chrysopa perla*, *Dichochrysa flavifrons* and *Cunctochrysa albolineata* are uncommon ($5 < Q \leq 15$ %), the others are at least rare. Belgium and Luxemburg gave 16 species and a very low diversity. *Hypochrysa elegans*, *Nineta vittata*, *N. principiae* and *Chrysopa pallens* are exceptional. Comments are given on some underestimated species, such as *Dichochrysa mariana* and *Cunctochrysa bellifontensis* not unanimously agreed, and *D. abdominalis* too recently re-instated to be identified in many collections.

Key words: Neuroptera, Chrysopidae, green lacewing, faunistics, northwestern Europe, biodiversity

Introduction

The European Neuropteran fauna is well known, and relative data have been published in major general works (e.g. Aspöck *et al.*, 1980, 2001) and a variety of recent accounts. Most surveys are qualitative, and the occasional encounters of rare species in the samples are often highlighted by collectors. Such disproportionate attention may give readers a biased perspective of actual occurrence of species. Accurate studies quantifying the relative abundance and overall incidence of Neuroptera are scarce, probably because such work is deemed less rewarding.

In a previous paper (Canard *et al.*, 2007a), the chrysopid fauna of southwestern Europe was examined to assess the actual species abundance and determine whether the listed species are indeed as frequent in the field as the literature purports. The differences between the different investigated zones and the origin of rare species was also assessed. The goal of this second study is to continue in this way, in order to help typify the assemblages of Chrysopidae in northwestern Europe.

Material and methods

The geographical zone of the survey is limited southward by 45° N in France; it encompasses west to east from 10° W to the French boundaries with Switzerland and Germany; it includes Luxemburg and Belgium on the

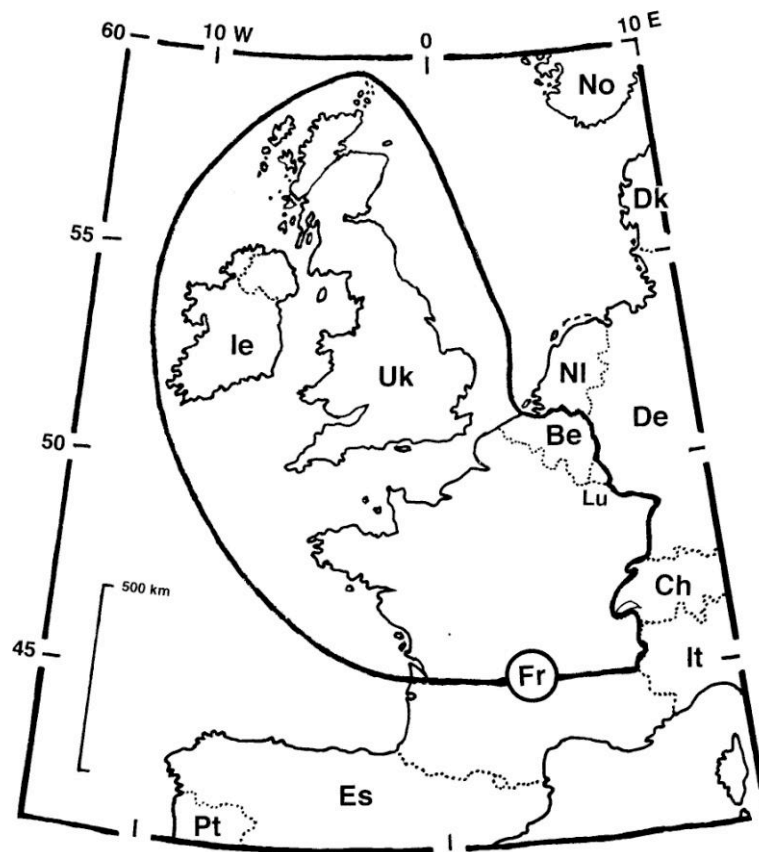


Fig. 1. Northwestern Europe showing the surveyed zone.

continent, together with the northwest European archipelago (Fig. 1). Chrysopid captures were assembled by means of various methods: light traps, yellow traps, suction traps, beating, hand net sweeping and hand suction-fan, providing significant quantitative data. Only adults collected during their active period were registered, excluding so any diapausing winter crowding. Occurrence is thus expressed as the proportional number of the relevant species with respect to the whole yearly recorded specimens.

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 $Q \leq 0.1$ %.

The results are grouped into three sub-zones, namely (i) Great Britain and Ireland so-called GB/I, (ii) France north of 45° N so-called NF, (iii) Belgium and Luxemburg so-called B/L. They come from personal data gathered by the authors and colleagues, some revisions in museum collections, together with reappraisal of previously published papers.

Concerning Great Britain and Ireland, the data refer to 70 papers and short notes in British literature whose 21 are partially accounted for by the National Biodiversity Network database; concerning northern France: Canard *et al.* (2007b), Thierry *et al.* (2005), Trouvé *et al.* (2002), Villenave & Rat-Morris (2005); concerning Belgium: Bozsik (2000, 2002, 2003), Mignon *et al.* (2003); concerning Luxemburg: Hoffmann (1962), Carrières (2001). The list of the full fauna refers to species distribution given by Aspöck *et al.* (2001) completed in some recent papers by Plant (1997), Carrières (2001), Bozsik (2002), San Martin (2004), Canard & Jacquemin (2006), Canard *et al.* (2006).

S being the number of species, N the total number of individuals in the community, n_i the number of individuals in each species and p_i the relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals, we computed the species richness and the relative abundance by several well-known indices. First Margalef's index

$$I_M = (S - 1) / \text{Log}_n (\text{to base } \theta) N$$

characterises the approximate faunistic richness. Shannon's diversity or heterogeneity index

$$H' = - \sum [1 \text{ to } S] p_i * \text{Log}_n p_i$$

is the relative heterogeneity as the relative importance of each species and the ratio between the total number of species and individuals. Hurlbert's equitability or evenness index

$$E_H = H' - H'_{\min} / H'_{\max} - H'_{\min}$$

$$\text{in which } H'_{\max} = \text{Log}_n N$$

$$H'_{\min} = \text{Log}_n N - \{(N - S + 1) * \text{Log}_n (N - S + 1)\} / N$$

measures the relative heterogeneity of populations, 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 $\text{Log } S$ 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.

Table 1. List of northwestern European chrysopids and numbers of specimens recorded in each geographic zone.

* indicates a species occurring in the sites (after the literature) but not collected in the present samples.

Species	Northern France n	Belgium and Luxemburg			Great Britain and Ireland			Total NW Europe
		nB	nL	n(B+L)	nGB	nI	N(GB+I)	
1 <i>Nothochrysa fulviceps</i> (Stephens, 1836)	3	* ?	9	9	19		19	31
2 <i>Nothochrysa capitata</i> (Fabricius, 1793)	*	* ?			181		181	181
3 <i>Hypochochrysa elegans</i> (Burmeister, 1839)	19	1	1	2				21
4 <i>Nineta flava</i> (Scopoli, 1763)	6	13	17	30	721	9	730	766
5 <i>Nineta principiae</i> Monserrat, 1980	1	1		1				2
6 <i>Nineta vittata</i> (Wesmael, 1841)	*	2	2	4	486	4	490	494
7 <i>Nineta inpunctata</i> (Reuter, 1894)	*				1		1	1
8 <i>Nineta pallida</i> (Schneider, 1846)	*	12		12	*			12
9 <i>Chrysotropia ciliata</i> (Wesmael, 1841)	13	19	44	63	654	5	659	735
10 <i>Chrysopa perla</i> (Linnaeus, 1758)	61	76	28	104	1066		1066	1231
11 <i>Chrysopa walkeri</i> McLachlan, 1893	*							0
12 <i>Chrysopa dorsalis</i> Burmeister, 1839	1				66		66	67
13 <i>Chrysopa abbreviata</i> Curtis, 1834	*				56	2	58	58
14 <i>Chrysopa formosa</i> Brauer, 1850	3	* ?						3
15 <i>Chrysopa dubitans</i> McLachlan, 1887	*							0
16 <i>Chrysopa phyllochroma</i> Wesmael, 1841	62	6		6	77		77	145
17 <i>Chrysopa commata</i> Kis & Újhelyi, 1965	*	*			117		177	117
18 <i>Chrysopa viridana</i> Schneider, 1845	17							17
19 <i>Chrysopa nigricostata</i> Brauer, 1850		*						0
20 <i>Chrysopa pallens</i> (Rambur, 1838)	4	2	1	3	237		237	244
21 <i>Dichochrysa flavifrons</i> (Brauer, 1850)	107	9	6	15	946		946	1068
22 <i>Dichochrysa picteti</i> (McLachlan, 1880)	2							2
23 <i>Dichochrysa inornata</i> (Navás, 1901)	53							53
24 <i>Dichochrysa prasina</i> (Burmeister, 1839)	150	28	21	49	377	5	382	581
25 <i>Dichochrysa abdominalis</i> (Brauer, 1850)		*						0
26 <i>Dichochrysa mariana</i> (Navás, 1905)	*							0
27 <i>Dichochrysa zelleri</i> (Schneider, 1851)	*							0
28 <i>Dichochrysa ventralis</i> (Curtis, 1834)	29	7	11	18	573	1	574	621
29 <i>Dichochrysa venosa</i> (Rambur, 1842)	*							0
30 <i>Cunctochrysa albolineata</i> (Killington, 1935)	8	16	15	31	1069	20	1089	1128
31 <i>Cunctochrysa bellifontensis</i> Leraut, 1988	*				11		11	11
32 <i>Peyerhimofoffina gracilis</i> (Schneider, 1851)	1	12	2	14	39		39	54
33 <i>Chrysoperla carnea s.l.</i> (Stephens, 1836)	2713	7079	586	7665	10761	31	10577	20955
34 <i>Chrysoperla mediterranea</i> (Hölzel, 1972)	*	*	*					0
35 <i>Chrysoperla renoni</i> (Lacroix, 1933)	*							0
Number of specimens	3253	7277	743	8026	17457	77	17319	28598
Number of species collected	19	15	13	16	19	8	19	26
Number of species occurring	33			22			20	35

Table 2. Ordinate data and relative frequency of each species (%) in each geographic zone.

Northern France			Belgium and Luxemburg			Great Britain and Ireland			Total NW Europe		
Species	n	Q %	Species	n	Q %	Species	n	Q %	Species	n	Q %
Dominant			Dominant			Dominant			Dominant		
<i>Chp. carnea</i>	2713	83.40	<i>Chp. carnea</i>	7665	95.57	<i>Chp. carnea</i>	10546	61.16	<i>Chp. carnea</i>	20955	73.29
Very common			Very common			Very common			Very common		
Common			Common			Common			Common		
Uncommon			Uncommon			Uncommon			Uncommon		
Rare			Rare			<i>C. albolineata</i>	1089	6.32	Rare		
<i>D. prasina</i>	150	4.61	<i>Ch. perla</i>	104	1.30	<i>Ch. perla</i>	1066	6.18	<i>Ch. perla</i>	1231	4.231
<i>D. flavifrons</i>	107	3.29	Casual			<i>D. flavifrons</i>	946	5.49	<i>C. albolineata</i>	1128	3.94
<i>Ch. phyllochroma</i>	62	1.91	<i>Ch. ciliata</i>	63	0.79	Rare			<i>D. flavifrons</i>	1068	3.74
<i>Ch. perla</i>	61	1.88	<i>D. prasina</i>	49	0.61	<i>Ni. flava</i>	730	4.23	<i>Ni. flava</i>	766	2.69
<i>D. inornata</i>	53	1.63	<i>C. albolineata</i>	31	0.39	<i>Ch. ciliata</i>	659	3.82	<i>Ch. ciliata</i>	735	2.57
Casual			<i>Ni. flava</i>	30	0.37	<i>D. ventralis</i>	574	3.33	<i>D. ventralis</i>	621	2.17
<i>D. ventralis</i>	29	0.89	<i>D. ventralis</i>	18	0.22	<i>Ni. vittata</i>	490	2.84	<i>D. prasina</i>	581	2.03
<i>H. elegans</i>	19	0.58	<i>D. flavifrons</i>	15	0.19	<i>D. prasina</i>	382	2.21	<i>Ni. vittata</i>	494	1.73
<i>Ch. viridana</i>	17	0.52	<i>P. gracilis</i>	14	0.17	<i>Ch. pallens</i>	237	1.37	Casual		
<i>Ch. ciliata</i>	13	0.40	<i>Ni. pallida</i>	12	0.15	<i>No. capitata</i>	181	1.05	<i>Ch. pallens</i>	244	0.86
<i>C. albolineata</i>	8	0.25	<i>No. fulviceps</i>	9	0.11	<i>Ch. commata</i>	177	1.03	<i>No. capitata</i>	181	0.63
<i>Ni. flava</i>	6	0.18	Exceptional			Casual			<i>Ch. phyllochroma</i>	145	0.51
<i>Ch. pallens</i>	4	0.12	<i>Ch. phyllochroma</i>	6	0.07	<i>Ch. phyllochroma</i>	77	0.45	<i>Ch. commata</i>	117	0.41
Exceptional			<i>Ni. vittata</i>	4	0.05	<i>Ch. dorsalis</i>	66	0.38	<i>Ch. dorsalis</i>	67	0.23
<i>No. fulviceps</i>	3	0.09	<i>Ch. pallens</i>	3	0.04	<i>Ch. abbreviata</i>	58	0.34	<i>Ch. abbreviata</i>	58	0.20
<i>Ch. formosa</i>	3	0.09	<i>H. elegans</i>	2	0.02	<i>P. gracilis</i>	39	0.23	<i>P. gracilis</i>	54	0.19
<i>D. picteti</i>	2	0.06	<i>Ni. principiae</i>	1	0.01	<i>No. fulviceps</i>	19	0.11	<i>D. inornata</i>	53	0.19
<i>Ni. principiae</i>	1	0.03				Exceptional			<i>No. fulviceps</i>	31	0.11
<i>Ch. dorsalis</i>	1	0.03				<i>C. bellefontensis</i>	11	0.06	Exceptional		
<i>P. gracilis</i>	1	0.03				<i>Ni. inpunctata</i>	1	e	<i>H. elegans</i>	21	0.07
									<i>Ch. viridana</i>	17	0.06
									<i>Ni. pallida</i>	12	0.04
									<i>C. bellefontensis</i>	11	0.04
									<i>Ch. formosa</i>	3	0.01
									<i>Ni. principiae</i>	2	0.01
									<i>D. picteti</i>	2	0.01
									<i>Ni. inpunctata</i>	1	e

Results and comments

Thirty-five species of green lacewings dwell the full zone, listed in Table 1, together with the numbers of specimens collected in each of the above-mentioned countries. That is scarcely more than half of the total European fauna (Aspöck *et al.*, 2001). Table 2 shows ordinate data and relative frequencies of each species for the entire region of study and for each sub-zone. Table 3 gives the relevant biodiversity indices.

Abundance of species

One taxon is strongly dominant everywhere in the whole zone (Fig. 2), namely the common green lacewing *Chrysoperla carnea*, here comprised *sensu lato* because of the heterogeneity of data from various springs and so not taking in account the precise nature of sibling species. It reaches more than 97 % in Belgium, where the samples are in majority taken from agricultural environments. All other species are divided amongst remaining specimens but none exceeds 5 %, except three considered uncommon in GB/I: *Cunctochrysa albolineata*, *Chrysopa perla* and *Dichochrysa flavifrons*. Several species are considered exceptional (Table 2), 6 in NF, 5 in B/L, 2 in GB/I, and 8 in the whole zone.

Biodiversity

A strong disparity appears between the zones, showing a decrease of biodiversity from West to East. Northern France exhibits the highest faunistic richness I_M whilst the B/L sub-zone has the lowest one (Table 3). Great Britain and Ireland show both the highest heterogeneity and equitability, and Belgium and Luxemburg are the more skeletal zone with respect to the chrysopid assemblages, strongly dominated by the common green lacewings. In comparison, the Spanish Peninsula, in quasi-continuity with North-Africa, manifests a high originality (Monserrat and Marín, 1994) and the peninsular Italy has trans-Alpine taxa of Siberian origin: they exhibit high faunistic richness ($I_M = 2.78$ and 2.82 , respectively) and diversity indices ($H' = 2.71$ and 3.09 , respectively) (Canard *et al.*, 2007a).

Origin and distribution of species

There are no endemic nor subtropical green lacewings in the northwestern Europe fauna. Three species occur which did not appear in the southwestern part of Europe: *Chrysopa dubitans* (EXC), *Ch. commata* (CAS) and

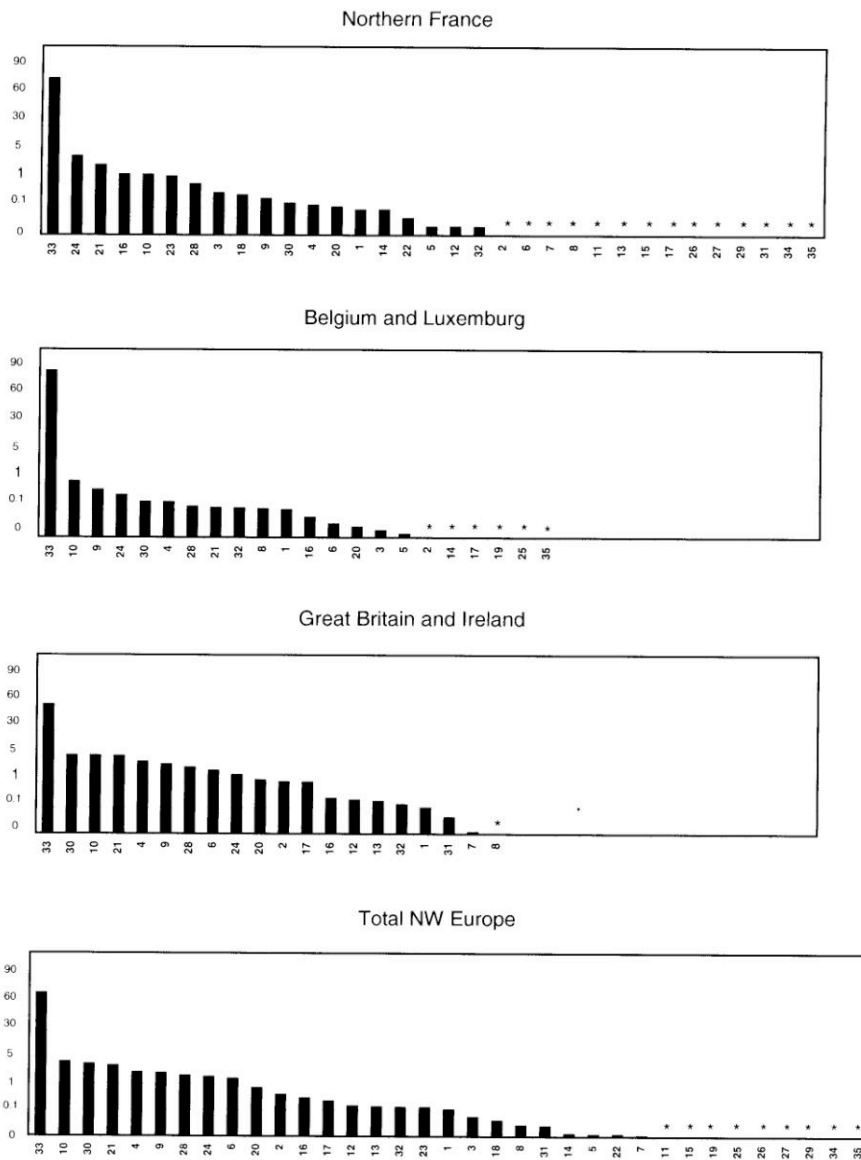


Fig. 2. Relative frequency (%) of each chrysopid species collected in each sub-zone and in the full zone. Species are identified as numbered in Table 1.

Chrysoperla renoni (EXC). The first one is largely distributed in Asia from China to West-Anatolia and Cyprus, extending to the south through Israel, North-Africa and Spain (Aspöck *et al.*, 1980) where it was however considered dubious by Monserrat & Marin (1994), and to the north, through Greece and eastern France where it was recently recorded (Canard & Jacquemin, 2006). *Chrysopa commata* is a Siberian element common in Central Europe and not extending southwards to 48° N except in the Hungaro-Balkan zone. The distribution of *Chrysoperla renoni* is so little known that it is incautious to comment about it here.

Many of the green lacewings occurring are largely distributed and considered pan-European elements:

- occurring on the whole continent, from the Atlantic Ocean to the sea of Japan: *Nineta vittata* (RAR), *Chrysotropia ciliata* (RAR), *Chrysopa perla* (RAR), *Ch. pallens* (CAS), *Dichochrysa prasina* (RAR) and *Cunctochrysa albolineata* (RAR),
- bounded at east by the Caspian Sea, north Iran and the Ural mountains: *Nineta flava* (RAR), *Chrysopa dorsalis* (CAS), *Ch. abbreviata* (CAS), *Ch. phyllochroma* (CAS) and the closely related *Ch. commata* (CAS), *Ch. nigricostata* (EXC) more scarce in northern locations, *Dichochrysa flavifrons* (RAR), *D. ventralis* (RAR) and *Peyerimhoffina gracilis* (CAS),

Table 3. Indices of biodiversity calculated for the three sub-zones and the full zone.

Indices	Northern France	Belgium and Luxemburg	Great Britain and Ireland	Total NW Europe
Richness of Margaleff (I_M)	1.54	1.16	1.28	1.69
Diversity of Shannon (H')	1.16	0.41	2.31	1.78
Equitability of Hurlbert (E_H)	0.26	0.10	0.54	0.38

– having the same eastern extension but not reaching westwards the Channel shore: *Hypochrysa elegans* (EXC). In the same category, *Ch. dubitans* (EXC) is rare enough to remain hidden in the samples,
 – not extending eastwards far from the limits of Europe: *Nothochrysa fulviceps* (CAS) and *N. capitata* (CAS), *Nineta inpunctata* (EXC) and *N. pallida* (EXC) not occurring beyond Romania and the Ukraine, respectively.

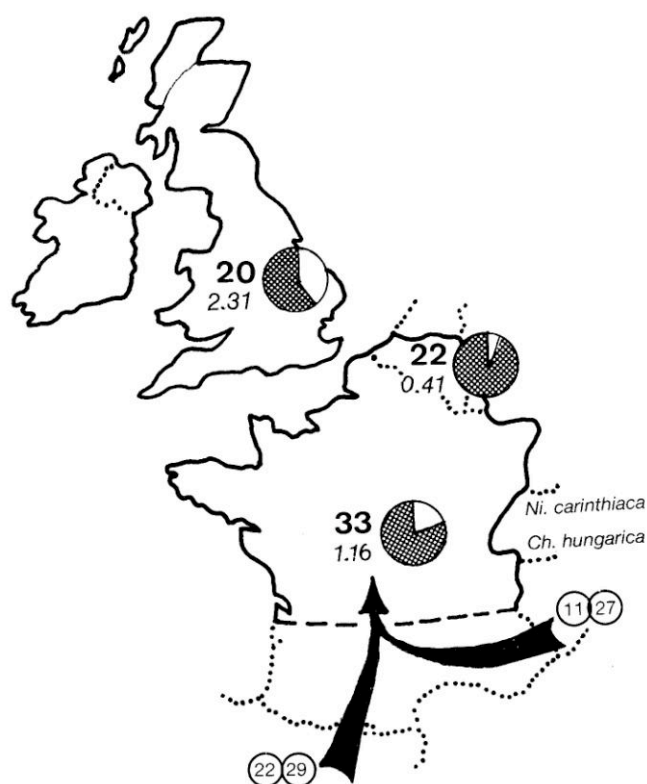
Species of southern distribution, occurring in the Mediterranean zone and so reaching the utmost border of their northern extension in the surveyed countries, but also Austria, Switzerland and Germany (in peculiar dry and sunny biotopes) include: *Chrysopa formosa* (EXC), *Ch. viridana* (EXC) and *Dichochrysa inornata* (CAS). Two others, *Chrysopa walkeri* (EXC) and *Dichochrysa zelleri* (EXC) have similar northern limits, but do not reach westwards to the Iberian Peninsula (# 11 and 27 in Fig. 3).

Some species have a special status. *Nineta principiae* (EXC) is distributed from France to Anatolia, but the possible confusion with *N. gadarramensis* (Pictet, 1865) *sensu stricto* (Canard *et al.*, 1998) misleads the interpretation of its actual extension. It is registered here for the first time in the Belgian fauna. *Dichochrysa mariana* (EXC) and *D. abdominalis* (EXC) were long ago synonymized with *prasina*, but now re-instated good species by Duelli (1989) and Hölzel (1998), respectively. They are now surveyed in France and in Belgium, respectively and are probably underestimated, because of misidentification within the *prasina* group. *Cunctochrysa bellifontensis* (EXC) whose status is not yet universally accepted is recognized in Britain (Plant, 1993); it seems to occur in Belgium, although not formally cited (San Martin, 2004); it may be more frequent than appearing here.

Besides, a special attention must be borne to other conspicuous species. *Dichochrysa venosa* (EXC) (# 29 in Fig. 3) shows a distribution qualified as polycentric (Aspöck *et al.*, 2001). It occurs on one hand in North Africa, Spain and extreme south of France, but on the other hand, in Asia, from Anatolia up to Mongolia. Some specimens caught in the French Jura, i.e. near the Swiss frontier (Réal, 1990) might attest of its presence under European continental climate. *Chrysoperla mediterranea* (EXC) has a distribution mainly circum-Mediterranean, with some northern locations in the Alps and Slovakia (Henry *et al.*, 1999). It was registered from Belgium (Ch. Fallote rec.) and Luxemburg (É. Carrières rec.), however, its actual occurrence remains doubtful, because it might be misidentified with *Chrysoperla renoni* (EXC) according to Duelli's opinion (Carrières, 2001), a stenotopic green lacewing associated with wetland vegetation. This species was originally described from western France and was already recorded from the Danube Delta, Romania (Paulian *et al.*, 1996) and the Carpathian basin, from Hanság, a wetland near the lake Fertő and from a lowland East of the river Tisa, Hungary (Sziráki, 1998, 2007).

Other species not (yet?) collected in the investigated countries reach borders of NW Europe: *Chrysopa hungarica* Klapálek, 1899 which comes from East (Caucasus and Anatolia) up to Austria and Switzerland; *Nineta carinthiaca* (Hölzel, 1965) considered extending far east, keeping in mind the possible confusion with *N. alpicola* (Kuwayama, 1956) (Canard, 2004) and not extending westwards far from the Alps in Austria and Switzerland (Duelli *et al.*, 2006) (Fig. 3).

Fig. 3. In each geographic zone, (i) bold types indicate number of species occurring; (ii) italic types, the diversity index of Shannon; (iii) squarred sector in circle, proportion of *Chrysoperla carnea sensu lato* with respect to the whole chrysopid population collected throughout the year. Species reaching northern France from south (arrows) are identified as numbered in Table 1.



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