BioRisk 5: 141–153 (2010)
doi: 10.3897/biorisk.5.855
http://biorisk-journal.com/

RESEARCH ARTICLE

A peer-reviewed open-access journal
BioRisk

When south goes north: Mediterranean dragonflies (Odonata) conquer Flanders (North-Belgium)

Geert De Knijf, Anny Anselin

Research Institute for Nature and Forest (INBO), Kliniekstraat 25, B-1070 Brussels Belgium

Corresponding authors: *Geert De Knijf* (geert.deknijf@inbo.be), *Anny Anselin* (anny.anselin@inbo.be)

Academic editor: *Jürgen Ott* | Received 20 August 2010 | Accepted 10 September 2010 | Published 30 December 2010

Citation: De Knijf G, Anselin A (2010) When south goes north: Mediterranean dragonflies (Odonata) conquer Flanders (North-Belgium). In: Ott J (Ed) (2010) Monitoring Climatic Change With Dragonflies. BioRisk 5: 141–153. doi: 10.3897/biorisk.5.855

Abstract

Since 1980, eight southern dragonfly species have been regularly recorded in Flanders. They show a significant increase in relative abundance, relative area as well as indications of reproduction since the beginning of the nineties, with peak occurrence mainly in the 1995–1999 period. Since 2000, numbers are lower but more species were simultaneously present. Three species, *Lestes barbarus*, *Crocothemis erythraea* and *Sympetrum fonscolombii*, show a combination of earlier arrival, earlier reproduction with a higher frequency and higher maximum ranges and can be considered as having stable populations in Flanders. All other southern species show in general a later arrival, only one confirmed or probable reproduction and have much lower maximum ranges. Two other species, reaching their northern limit of distribution in Flanders, *Erythromma viridulum* and *E. lindenii* have clearly expanded their relative area since the eighties. Their relative abundance also increased although this shows more fluctuations.

Keywords

Odonata, dragonflies, range extension, Belgium, climate change, relative abundance

Introduction

Climate change on Earth is causing a growing concern. It is still not fully understood whether this is part of normal global climate fluctuations or mainly the result of human activities. Whatever the cause, it is clear that the rate of warming during the last 30 years has been greater than at any other time during the last 1000 years and atmos-

pheric CO2 concentrations have never been so high (IPCC 2001). Increasing concern over the implications of this "global warming" for biodiversity have resulted in a large amount of studies on a wide array of taxa, communities and ecosystems (Parmesan and Yohe 2003). Ecological responses are already clearly visible on different levels, although in many regions there is an asymmetry in the warming and in the precipitation regimes that undoubtedly will contribute to heterogeneity in ecological dynamics across the system (Hughes 2000; Peňuelas et al. 2002; Walther et al. 2002). As a result of the predicted future increase in global temperatures, between 1.4 and 5.8°C (IPCC 2001; Stainforth et al. 2005), a number of species are expected to shift their ranges in response, rather than adapt to warmer temperatures *in situ* (Huntley 1991).

Among insects, some European butterflies have shifted or expanded their ranges northwards (Parmesan et al. 1999). It is expected that other winged insect species will show similar responses to climate change. However, few studies have focussed on other groups of insects. In particular, there is not much information available on taxa with aquatic larval stages such as dragonflies, and data are often lacking or conflicting (Hickling et al. 2005).

In Flanders (Northern Belgium) the distribution and abundance of dragonflies is well known over a long time (De Knijf et al. 2006). Flanders is situated in Northwest-Europe, somewhat halfway between the Mediterranean region and Fennoscandia. Moreover, it lays in the smallest part of the (Central) transition zone between the so-called Northern and Southern climatic zones, determined by the 18°C mean July temperature and the 2500 degree day (www.worldclimate.com). Therefore, it seems an interesting region to check for changes in fauna composition which could be due to increasing temperatures. Like most insects, dragonflies have short life cycles and often a high reproduction rate and dispersal capacity. They have the ability to react relatively quickly to changes in climate.

The aim of this contribution is to analyse in general to what extend southern dragonfly species have expanded their range into Flanders. In another paper (in preparation) we will threat in more detail the relations between these distribution patterns and climatic and other environmental variables. This will allow us comparisons with the recent analysis of Goffart (2006) for the adjacent Walloon region.

Material and methods

Data sources

Data are derived from the *Gomphus* Dragonflies Working Group's distribution database of Flanders. At the end of 2005 it contained about 55.000 records on 66 species, including historical data going back to the 19th century (Selys 1888). All records up to 2004 were used for the analysis. The Odonata were mapped using Universal Transverse Mercator (UTM) 5×5 km grid squares as units. Special efforts have been made to achieve a good coverage of the territory during the last 15 years. For the more

recent records the database includes information on precise locality, date and number of observed individuals and life-cycle stage (larva, exuvium, teneral, male, female, adult-copulation, egg-laying) thus providing indications of reproduction and/or permanent populations. For reproduction, three categories were considered: confirmed (exuvium, larva or tenerals), probable (tandem or egg-laying) and possible (population with high number of individuals). For historical records however, population and life-cycle information is often lacking or difficult to interpret, in particular from literature sources.

Selection of species

For our analysis we selected 10 species which have their main distribution area in the Mediterranean part of Europe (Askew 1988; d'Aguilar and Dommanget 1998) but are actually present in Flanders (De Knijf et al. 2006). We distinguished two groups:

– group A: 8 species for which Flanders is no part of their historical distribution area (< 1980): *Lestes barbarus* (Lb), *Aeshna affinis* (Aa), *Anax parthenope* (Ap), *Orthetrum brunneum* (Ob), *Crocothemis erythraea* (Ce), *Sympetrum fonscolombii* (Sf) and *S. meridionale* (Sm), and *Coenagrion scitulum* (Cs) although the status of the latter is less clear-cut than for the other 7 species due to its much more fragmented southern distribution range and the probability of its historical distribution area having reached Flanders.

– group B: 2 species that reach in Flanders the northern limit of their distribution range: *Erythromma lindenii* (El) and *E. viridulum* (Ev).

Analysis

To detect general changes in range and numbers, we used Relative Area and Relative Abundance in time per Group (combined), and per species. We define Relative Area in a period as the percentage of different 5×5 km UTM squares occupied by the selected species (or by a group) compared to the total number of different squares occupied by all dragonfly species in that period. A higher percentage does not *a priori* mean a greater "range" (enlargement of occupied territory) as squares can be clustered without really "enlarging" the range. However, an analysis of the distribution maps per species for the different periods (years) showed that higher relative percentages resulted in a real increase of occupied territory. Therefore, we decided to use this as a measure for broad changes in range. Relative Abundance is the percentage of the combined record numbers of a group or species compared to the total number of records. We compared first the data for 8 time periods. To obtain sufficient records, we used two broader categories <1900 and 1900–1949 for the "historical data". From 1950 on, data were grouped in five decades (and one pentade 2000–2004). To better visualize the recent evolution in the last 25 years (1980–2004), figures are given per year. To determine permanent and

non-permanent populations, we used reproduction frequencies and categories as well as presence patterns of distribution and abundance during the last 25 years.

Results

Relative area, relative abundance and reproduction per time period (Table 1)

For each species group, relative area and abundance are highly correlated (Spearman-Rank A:0.88, B:0.89, $p < 0.05$). Before 1900 species of Group A were found in 13.8% of the investigated squares. From 1900 onwards the proportion is much lower but in the 1990ties we see a remarkable increase (27%). In the pentad 2000–2004 the proportion reaches even 34.6%. For the species of Group B, proportions increase from the 1980ties but vary in the earlier periods. The relative abundance of Group A and B show a similar pattern as the relative area. Both species of Group B have been present in all but one time period. Group A species have been recorded in each time period but numbers are higher before 1900 and since 1990. Indications of reproduction are also higher since that decade. For Group B, reproduction can not always be confirmed in the older data.

Relative area and abundance by groups per year in the recent period (1980–2004)

For each species group, relative area and abundance are again highly correlated (Spearman-Rank A:0.97, B:0.87, $p < 0.05$). The cumulative relative area for both groups during the last 25 years (Fig. 1) gives for almost all years a higher percentage for Group B than for Group A, except in 1996 and 2003. Compared to the first 15 years, Group A shows a clear increase in relative distribution during the last decade. There is a prominent peak in 1996.

Table 1. Relative area, relative abundance, number of species and reproduction confirmation for Group A (8 spec.) and Group B (2 spec.) in the 8 time periods (****** = confirmed reproduction, ***** = probable reproduction, see also Material & Methods).

time period		Relative area		Relative abundance		Number of species	
		Group A	Group B	Group A	Group B	Group A	Group B
1	<1900	13,8	17,2	4,4	2,7	6 (2*?)	2**
2	1900–1949	1,8	8,0	0,4	1,4	2	2 (1*?)
3	1950–1959	2,5	2,5	0,5	0,5	1	1*?
4	1960–1969	3,1	14,4	1,3	2,8	3	2(1*+1*?)
5	1970–1979	1,6	1,6	0,2	0,2	2	2 (1**)
6	1980–1989	2,4	18,2	0,2	1,5	4 (1*)	2**
7	1990–1999	27,1	39,9	2,1	3,8	7 (4**)	2**
8	2000–2004	34,6	41,1	2,1	2,9	8 (4**, 3*)	2**

The cumulative relative abundance for both groups (Fig. 2) gives a very similar pattern to the cumulative relative area (see Fig. 1).

Relative area and distribution by species per year in the recent period (1980–2004)

The relative area and abundance per year for each species of Group A separately shows again a clear increase in presence and number of occupied squares in the last 10 years (Fig. 3, 4). Four species (*Coenagrion scitulum*, *Anax parthenope*, *Orthetrum brunneum* and *Sympetrum meridionale*) remain at a very low percentage and have an irregular presence pattern. *Aeshna affinis* has slightly higher numbers but is also frequently absent. *Lestes barbarus, Crocothemis erythraea* and *Sympetrum fonscolombii* show a rather stable presence although numbers fluctuate. In *Lestes barbarus* the area is smaller during the last five years. All three species have a greater or maximum range in 1996, with *Sympetrum fonscolombii* showing an extreme peak.

In Fig. 4 the recent cumulative distribution of *Crocothemis erythraea* for four consecutive time periods (a = < 1990, b = 1990–1994, c = 1995–1999 and d = 2000–2004) is given. We also indicate the investigated squares (dotted) for each time period. The species shows since 1990 a real increase in distribution area in Flanders.

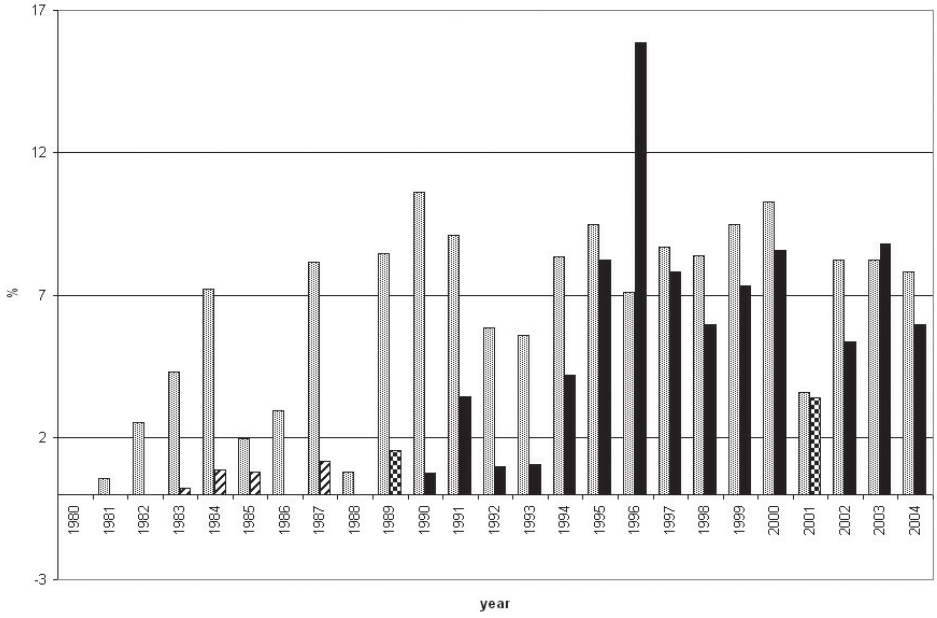

Figure 1. Cumulative relative area per year from 1981–2004 for the 2 species of Group B (left: dotted bars) and the 8 species of Group A (right: barred, checkered and black bars indicating respectively no reproduction, probable and confirmed reproduction of at least one species of the group).

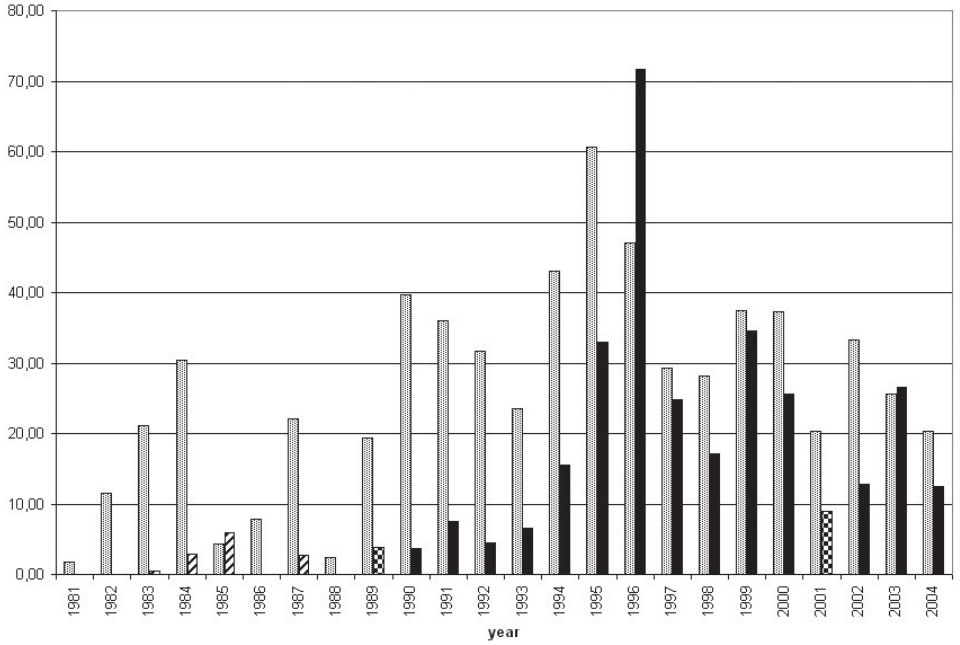

Figure 2. Cumulative relative abundance (%) per year from 1981–2004 for the 2 species of Group B (left: dotted bars) and the 8 species of Group A (right: barred, checkered and black bars indicating respectively no reproduction, probable and confirmed reproduction of at least one species of the group).

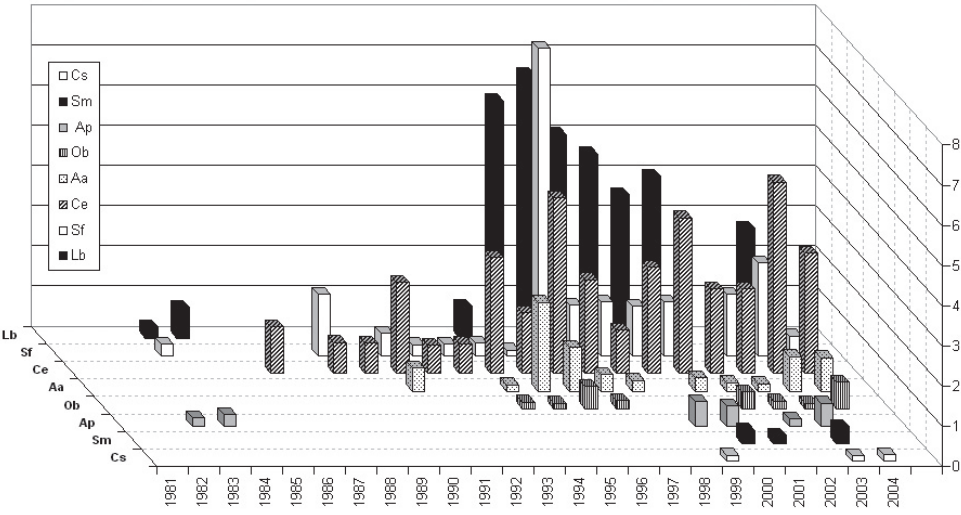

Figure 3. Relative area for the 8 species of Group A in Flanders during the period from 1980–2004. **Lb** = *Lestes barbarus* **Cs** = *Coenagrion scitulum* **Ap** = *Anax parthenope* **Af** = *Aeshna affinis* **Ob** = *Orthetrum brunneum* **Ce** = *Crocothemis erythraea* **Sf** = *Sympetrum fonscolombii* and **Sm** = *Sympetrum meridionale*.

First presence, confirmed reproduction and maximum range

Table 2 summarises a number of presence and reproduction data. Three species (*Lestes barbarus, Crocothemis erythraea* and *Sympetrum fonscolombii*) show a combination of earlier arrival, earlier confirmed reproduction with a higher frequency and higher maximum ranges. All others (*Coenagrion scitulum*, *Aeshna affinis*, *Anax parthenope, Orthetrum brunneum* and *Sympetrum meridionale*) show only one (more recent) confirmed (or probable) reproduction and have much lower maximum ranges.

Discussion

In the 19th century, six southern species have been observed in Flanders. However, little is known about their distribution area and population abundance. In historical references like Selys (1859, 1888) and Bamps and Claes (1893), comprehensive descriptions often lack and there is certainly a bias resulting from heterogeneous sampling, low visiting effort and 'collectioning'. In the following periods, southern species were very rarely observed. Towards the last decades of the 20th century, this changed. Since 1980, eight southern dragonfly species have been recorded in Flanders. The first in row were *Anax parthenope* (1983), *Lestes barbarus* and *Sympetrum fonscolombii* (1984) and *Crocothemis erythraea* (1987). They were followed by *Aeshna affinis* (1991), *Orthetrum brunneum* (1994), *Coenagrion scitulum* (1999) and finally *S. meridionale* (2000). In general the present data of this group shows a clear increase in relative abundance as well as relative area since the beginning of the 1990ties, with "peak" occurrence mainly in the 1995–1999 period. Since 2000, numbers are lower but more species were simultaneously present. However, not all the members of the group have achieved a similar level of 'expansion' succes and permanence. Only three of them can actually be considered as having a "permanent" population: *Lestes barbarus*, *Crocothemis erythraea* and *Sympetrum fonscolombii*. Until 1980, only 6 records of *Lestes barbarus* are known from Flanders, three of them dating from the hot summer of 1976, without proof of permanent populations. In 1984 and 1985, the species was seen in several locations, and at one site there was a very small "population" present but reproduction could not be confirmed. In 1994 and in particular in 1995 there was an invasion of the species in North West Europe (Monnerat 2002; Parr 2003). Since then, the species maintains permanent populations in Flanders (De Knijf 1994; Stoks 1994; Stoks and De Block 1997). *Sympetrum fonscolombii* has been recorded 10 times before 1980, and although only isolated or very few individuals have been seen, the species might have reproduced in the past (Selys 1859). In the eighties the species had been observed in two sites, but since the nineties it occurs yearly and has been reproducing. Populations of more then 50 individuals have been sighted. Since a peak in 1996 during an invasion in North Western Europe (Dijkstra and van der Weide 1997; Lempert 1997), *S. fonscolombii* now is present in several tens of squares and maintains populations on several sites, also in the southern part of Belgium (Goffart 1999; Paternoster 2000). *Crocothemis eryth-*

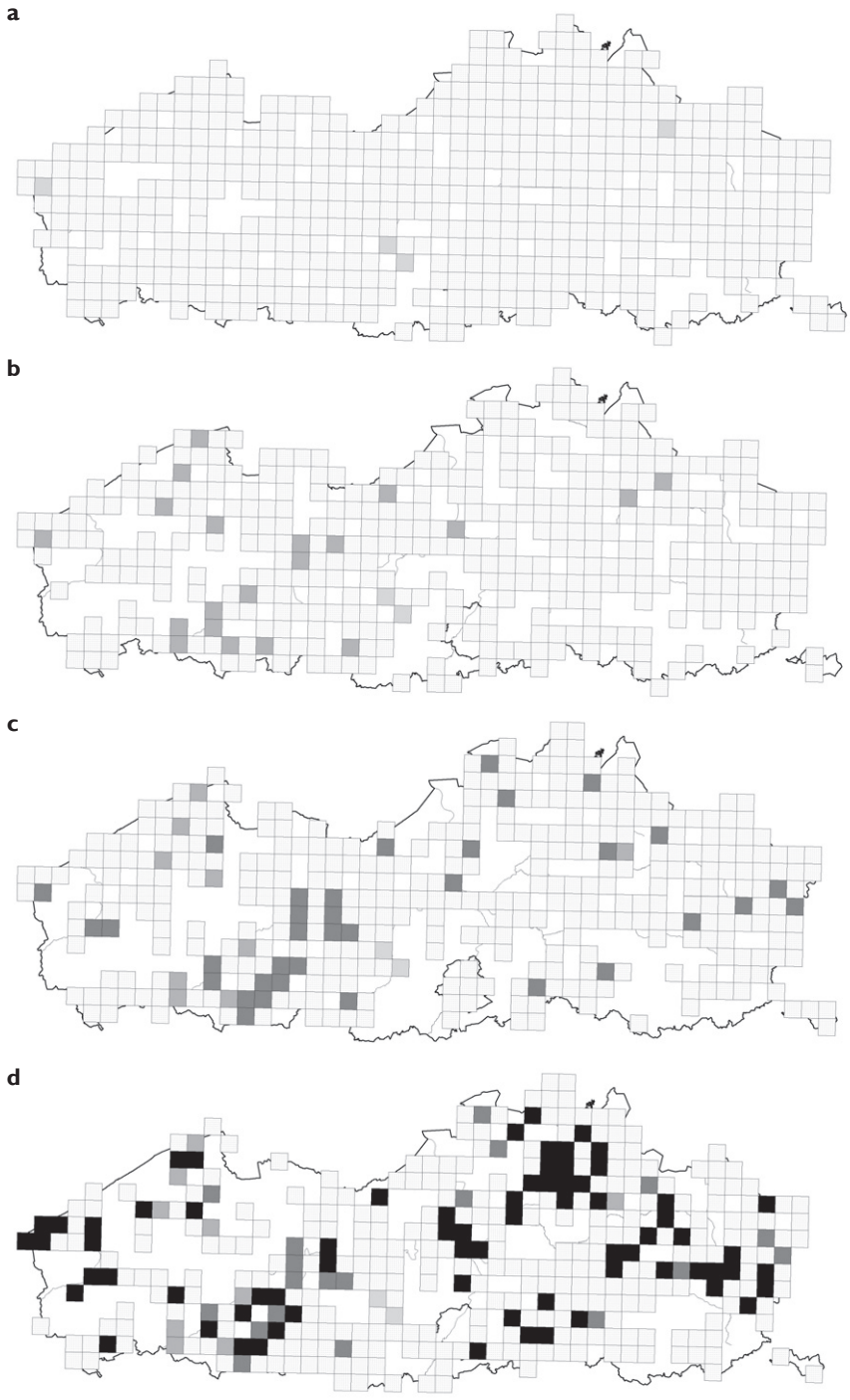

Figure 4. Cumulative distribution of *Crocothemis erythraea* in four consecutive time periods (**a** =< 1990, **b** = 1990–1994, **c** = 1995–1999 and **d** = 2000–2004) in Flanders, based on 5 × 5 km squares. For each time period the investigated squares are given as dotted squares in the background.

Table 2. Presence during the first five time periods (1–5) (see also Tab. 1) and year of first and last record in the period 1980–2004; Recent reproduction: first (Y1) and last year (Y2), time interval between Y1 and Y2 and frequency of reproduction in that period for confirmed** and probable* together; Maximum "range" recent: cumulative number of occupied 5×5 km squares in the period 1980–2004. Lb = *Lestes barbarus*, Cs = *Coenagrion scitulum*, Ap = *Anax parthenope*, Af = *Aeshna affinis*, Ob = *Orthetrum brunneum*, Ce = *Crocothemis erythraea*, Sf = *Sympetrum fonscolombii* and Sm = *Sympetrum meridionale*.

	Lb	**Sf**	**Ce**	**Ap**	**Aa**	**Ob**	**Cs**	**Sm**
Records								
Non-recent time (period 1–5)	1, 2, 5	1, 3, 4	4	1	4	1	1, 2, 5	1
Recent time (period 6–8) first	1984	1984	1987	1983	1991	1994	1999	2000
Recent time (period 6–8) last	2004	2004	2004	2003	2004	2004	2004	2003
Reproduction recent								
First: Y1	1994* 1995**	1989* 1992**	1990**	2003*	1996**	-	2003*	2003**
Latest: Y2	2004*	2004**	2004*	2003*	1996**	-	2003*	2003**
Y1 - Y2	11	16	15	1	1	-	1	1
Frequency in Y1 - Y2	11	9	13	1	1	-	1	1
Max. "range" recent	115	63	100	15	33	9	2	6

reae is without doubt the most successful of all southern species. The species has been observed in the past (Selys 1878), but permanent populations or reproduction have never been recorded. Apart from observations in 1963 (Cammaerts 1967; Dumont 1967), the species was only seen more regularly since the eighties when first reproduction was proved but is now present in more then 20% of all squares (De Knijf 1989, 1995; Tailly 1991). *Anax parthenope* has only once been observed in the surroundings of Brussels in 1884 but after this, the species was not recorded anymore until the eighties when there are several observations (all males) (Lerner 1984, Michiels 1984). In the nineties however, *Anax parthenope* has been recorded in 6 localities in Flanders, mostly individual males, with a small invasion in 1999 (De Knijf 1999). Probable reproduction was only recorded in 2003. It is clear that the species has still no permanent populations in Flanders. *Aeshna affinis* has never been observed in Flanders before 1900 and there is only one record (1969) before 1980. The species was again observed in 1991 and present in almost every year since 1994. An invasion in 1995 with higher numbers probably resulted in the first proof of reproduction in 1996 (Van de Meutter 1995; Andries 1997; Van den Berghe 1999). At several localities the species has been seen in consecutive years, but it cannot yet be considered as having permanent populations in Flanders. From *Orthetrum brunneum* there exist only a very few historical records although it might have reproduced in the past (Bamps and Claes 1893). Since 1980, the species was first recorded in 1994 (Verstraeten 1996) and has been present regularly but in very small numbers (Van de Meutter 2004). Reproduction occurred probably in 2005. *Orthetrum brunneum* has to be considered as an irregular and very rare species in Flanders. *Coenagrion scitulum* has been mentioned a few times by Selys (1868) but in contrary with the Walloon region without proof of reproduction in Flanders.

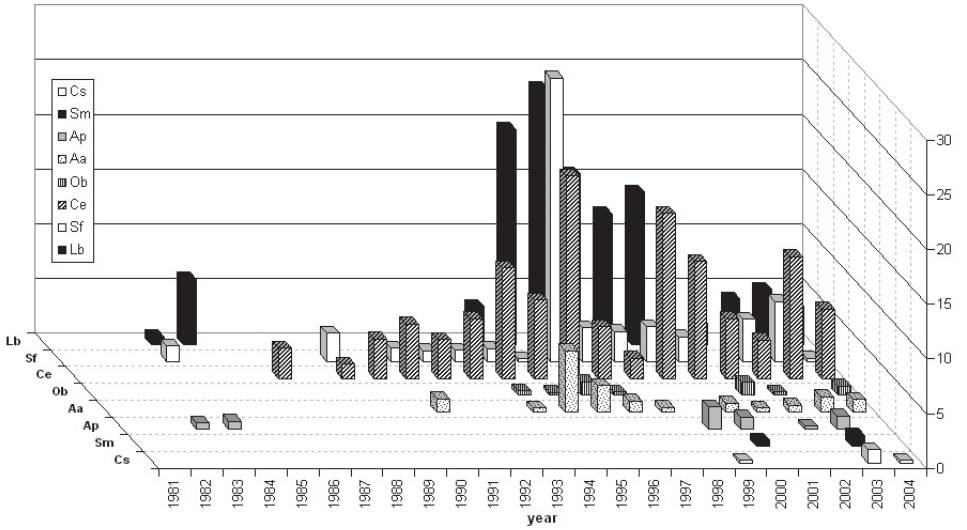

Figure 5. Relative abundance for the 8 species of Group A in Flanders in the period 1980–2004. **Lb** = *Lestes barbarus* **Cs** = *Coenagrion scitulum* **Ap** = *Anax parthenope* **Af** = *Aeshna affinis* **Ob** = *Orthetrum brunneum* **Ce** = *Crocothemis erythraea* **Sf** = *Sympetrum fonscolombii* and **Sm** = *Sympetrum meridionale*.

Later only a few records are known from 1949 and 1973. Since 1980, the species has only been observed in 1998, in 2003 and in 2004, and although most probably there are now some small local populations present where reproduction may occur, the species can not be considered as permanently established yet (De Knijf 2004). The only known record of *Sympetrum meridionale* from the past dates from 1886 (Bamps and Claes 1893). In 2000 the species was seen again at two different localities, with even a young male at one site (Versonnen et al. 2002). In 2001 only one female was seen (Versonnen et al. 2002) and in 2002 no records are know. In 2003 reproduction took place at least at one site, with the observation of several tenerals. Since then, the species has not been observed again. Two species reaching their northern distribution range in the region, *Erythromma viridulum* and *E. lindenii* have permanently maintained it and even expanded their area (see also De Knijf 1995), although there are fluctuations in distribution and abundance.

The presented patterns of range extension of the southern species in Flanders are a part of a more general long-term expansion of these species into Northwest Europe (Reder 1993, Drees et al. 1996, Ott 1996, 2000, 2001, Dijkstra and van der Weide 1997; Lempert 1997; Vanderhaeghe 1999; Gonseth and Monnerat 2001; Guerold et al. 2001; Ketelaar 2002; Mauersberger 2003; Parr et al. 2004). However, whether in our region the observed patterns are only (or mostly) a result of increasing temperatures as is the case in Wallonia (Goffart 2006), or whether other environmental variables play also an important role, has still to be confirmed. This will be investigated in the next future.

References

Andries T (1997) Invasie van de Zuidelijke glazenmaker *Aeshna affinis*. Gomphus 13 (1/2): 14–18.

Askew RR (1988) The Dragonflies of Europe. Harley, Colchester. 291 pp.

Bamps C, Claes E (1893) Catalogue raisonné des Insectes Odonates de la Province de Limbourg (belge). Bull. Soc. Méloph, Hasselt 29: 71–88.

Cammaerts R (1967) Captures récentes de *Nehalennia speciosa* (CHARP.) et *Crocothemis erythraea* (BRULLE) en Belgique. Bull. Ann. Soc. R. Ent. Belg. 103: 30–31.

d'Aguilar J, Dommanget J-L (1998) Guide des Libellules d'Europe et d'Afrique du Nord. Seconde édition. Delachaux et Niestlé, Lausanne-Paris, 463 pp.

De Knijf G (1989) De libellen van Harchies. Euglena 8(2): 14–15.

De Knijf G (1994) Herontdekking van *Lestes barbarus* (Fabricius, 1798) in België. Gomphus 10(2): 45–49.

De Knijf G (1995) *Crocothemis erythraea* en *Cercion lindenii*, nu al in België en binnenkort ook in Nederland algemeen? Libellennieuwsbrief 4: 7–12.

De Knijf G (1999) Invasie van *Anax parthenope* (Sélys) in België in 1999. Gomphus 15(3): 119–129.

De Knijf G (2004) Libellen. pp. 298–311 In: Provoost S, Bonte D (Eds) Levende Duinen: een overzicht van de biodiversiteit aan de Vlaamse kust: 298–311. Mededelingen van het Instituut voor Natuurbehoud 22, Brussel, 416 pp.

De Knijf G, Anselin A, Goffart P, Tailly M (Eds) (2006) De libellen (Odonata) van België: verspreiding - evolutie - habitats. Libellenwerkgroep Gomphus ism Instituut voor Natuur- en Bosonderzoek, Brussel. 368 pp.

Dijkstra K-D, van der Weide M (1997) De Zwervende heidelibel (*Sympetrum fonscolombii* (Sélys)) in Nederland in 1996. Brachytron 1(1): 16–22.

Drees C, Eggers TO, Jökel I, Kühne B, Zeiss C (1996) Entwicklungserfolg von *Aeshna affinis* Vander Linden nach einem strengen Winter in Norddeutschland (Anisoptera: Aeshnidae). Libellula 15(3/4): 203–206.

Dumont HJ (1967) A possible scheme of the migration of *Crocothemis erythraea* (BRULLE) - populations from the Camargue (Odonata: Libellulidae). Biologisch Jaarboek Dodonaea 35: 222–227.

Goffart P (1999) Un premier cas de reproduction effective de *Sympetrum fonscolombei* Sélys, 1840 en Wallonie. Gomphus 15(1): 12–17.

Goffart Ph (2010) Southern dragonflies expanding in Wallonia (south Belgium): a consequence of global warming?. In: Ott J (Ed) Monitoring Climatic Change With Dragonflies. BioRisk 5: 109–126.

Gonseth Y, Monnerat C (2003) Recent changes in distribution of dragonflies in Switzerland (Odonata). In: Reemer M, van Helsdingen PJ, Kleukers RMJC (Eds) Changes in ranges: invertebrates on the move: 23–31. Proceedings of the 13th International Colloquium of the European Invertebrate Survey, Leiden, 2–5 September 2001. European Invertebrate Survey, the Netherlands, Leiden, 137 pp.

Guerold F, Boudot J-P, Jacquemin G (2001) Première preuve de la reproduction d'*Aeshna affinis* Vander Linden, 1820 (Odonata, Anisoptera, Aeshnidae) et nouvelles observations d'Odonates rares en Lorraine. Martinia. Bulletin des Odonatologues de France 17 (3): 77–87.

Hickling R, Roy DB, Hill JK, Thomas CD (2005) A northward shift of range margins in British Odonata. Global Change Biology 11: 502–506.

Hughes L (2000) Biological consequences of global warming: is the signal already apparent? Trends in Ecology & Evolution 15 (2): 56–61.

Huntley B (1991) How Plants Respond to Climate Change - Migration Rates, Individualism and the Consequences for Plant-Communities. Annals of Botany 67: 15–22.

IPCC (2001) Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. [Houghton JT, Ding Y, Griggs DJ, Noguer M, van der Linden PJ, Dai X, Maskell K, and Johnson CA (Eds)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 881 pp.

Ketelaar R (2002) The recent expansion of the Small Red-eyed Damselfly *Erythromma viridulum* (Charpentier) in The Netherlands. Journal of the British Dragonfly Society 18 (1/2): 1–8.

Lempert J (1997) Die Einwanderung von *Sympetrum fonscolombii* (Selys) nach Mitteleuropa im Jahre 1996 (Anisoptera: Libellulidae). Libellula 16 (3/4): 143–168.

Lerner S (1984) Tweede waarneming voor België van de Zuidelijke Keizerlibel (*Anax parthenope*) te Zemst-Laar in Brabant. Gomphus 1 (1): 8–9.

Mauersberger R (2003) *Crocothemis erythraea* im Nordosten Deutschlands (Odonata: Libellulidae). Libellula 22 (1/2): 55–60.

Michiels N (1984) *Anax parthenope*: een nieuwe waarneming. Gomphus 1 (5): 7–8.

Monnerat C (2002) *Lestes barbarus* (Fabricius, 1798) (Odonata: lestidae) en Suisse: indigène ou hôte irrégulier? Bulletin de la Société Neuchâteloise des Sciences naturelles 125: 77–91.

Ott J (1996) Zeigt die Ausbreitung der Feuerlibelle in Deutschland eine Klimaveränderung an? Mediterrane Libellen als indicatoren für Änderungen in Biozönosen. Naturschutz und Landschaftsplanung 28 (2): 53–61.

Ott J (2000) Die Ausbreitung mediterraner Libellenarten in Deutschland und Europa: die Folge einer Klimaveränderung? NNA-Berichte 2: 13–35.

Ott J (2001) Expansion of mediterranean Odonata in Germany and Europe - consequences of climatic changes. In: Walter GR et al. (Eds) Fingerprints of Climate Change: 89–111. Kluwer Academic/Plenum Publishers, New York/London.

Parmesan C, Ryrholm N, Stefanescu C, Hill J, Thomas C, Descimon H, Huntley B, Kaila L, Kullberg J, Tammaru T, Tennent W, Thomas J, Warren M (1999) Poleward shifts in geographical ranges of butterfly associated with regional warning. Nature 399: 579–583.

Parmesan C, Yohe G (2003) A globally coherent fingerprint of climate change impacts accross natural systems. Nature 421: 37–42.

Parr AJ (2003) Migrant and dispersive dragonflies in Britain during 2002. Journal of the British Dragonfly Society 19 (1/2): 8–14.

Parr AJ, De Knijf G, Wasscher M (2004) Recent appearances of the Lesser Emperor *Anax parthenope* (Sélys) in north-western Europe. Journal of the British Dragonfly Society 20 (1): 5–16.

Paternoster T (2000) Implantation récente du Sympetrum ŕ nervures rouges (*Sympetrum fonscolombii* Selys, 1840) dans le bassin de la Haine. Gomphus 16 (1): 61–68.

Peňuelas J, Filella I, Comas P (2002) Changed plant and animal life cycles from 1952 to 2000 in the Mediterranean region. -Global Change Biology 8: 531–544.

Reder G (1993) Erste Nachweise der Südlichen Mosaikjungfer (*Aeshna affinis*) und der Südlichen Heidelibelle (*Sympetrum meridionale*) in Rheinhessen (Insecta: Odonata). -Fauna Flora Rheinland-Pfalz 7 (1): 187–193.

Selys-Longchamps E de (1859) Catalogue des Insectes Odonates de la Belgique. Ann. Soc. ent. Belg. 3: 145–164.

Selys-Longchamps E de (1868) *Agrion scitulum* DE RAMBUR (doit être ajouté aux espèces de la faune belge). Ann. Soc. ent. Belg. 11 (C.-r.): 90–91.

Selys-Longchamps E de (1878) La *Libellula erythraea* en Belgique. -Ann. Soc. ent. Belg. 21 (C.-r.): 133–134.

Selys-Longchamps E de (1888) Catalogue raisonné des Orthoptères et des Névroptères de Belgique. Ann. Soc. ent. Belg. 32: 103–203.

Stainforth DA, Aina T, Christensen C, Collins M, Faull N, Frame DJ, Kettleborough JA, Knight S, Martin A, Murphy JM, Piani C, Sexton D, Smith LA, Spicer RA, Thorpe AJ, Allen MR (2005) Uncertainty in Predictions of the Climate Response to Rising Levels of Greenhouse Gases. Nature 433: 403–406.

Stoks R (1994) Eerste Belgische voortplantingswaarneming van *Lestes barbarus* (Fabricius, 1798). Gomphus 10 (3): 84–87.

Stoks R, De Block M (1997) Successful reproduction in Belgium of the damselfly *Lestes barbarus* (Fabricius, 1798) (Odonata Lestidae). Bull. Ann. Soc. r. belge Ent. 133: 303–308.

Tailly M (1991) *Crocothemis erythraea* in Zuid-West-Vlaanderen in 1991. Gomphus 7 (3/4): 18.

Van de Meutter F (1995) Populatie van *Aeshna affinis* in het Blaasveldbroek te Willebroek. Gomphus 11 (1): 3–6.

Van de Meutter F (2004) De Zuidelijke oeverlibel (*Orthetrum brunneum* Fonscolombe, 1837): een schuchtere nieuwkomer in Vlaanderen. Gomphus 20 (1): 16–20.

Van den Berghe J (1999) De Zuidelijke glazenmaker *Aeshna affinis* nu vijf jaar in Vlaanderen. Wielewaal 65 (2): 54–55.

Vanderhaeghe F (1999) Een beknopt overzicht van de huidige verspreiding en status van *Coenagrion scitulum* (Rambur, 1842) in België en Noord-Frankrijk. Gomphus 15 (2): 69–85.

Versonnen B, De Knijf G, Vercruysse W, Verhaeghe W, Van Wichelen T (2002) Waarnemingen en eerste voortplantingsbewijs van *Sympetrum meridionale* uit België. Gomphus 18 (1/2): 3–13.

Verstraeten F (1996) Zuidelijke libellensoorten in Limburg. In: Stevens J (Ed) Jaarboek 1995. LIKONA: 34–38. Limburgse Koepel voor Natuurstudie, Hasselt. 86 pp.

Walther G-R, Post E, Convey P, Menzel A, Parmesan C, Beebee TJC, Fromentin J-M, Hoegh-Guldberg E, Bairlein F (2002) Ecological responses to recent climate change. Nature 416: 389–395.