# Dragonflies (Odonata) in Latvia – history of research, bibliography and distribution from 18th century until 2010

**Mārtiņš Kalniņš** [1, 2]

1 – Nature Conservation Agency, Baznīcas iela 7, Sigulda, Siguldas novads, LV-2150, Latvia
2 – The Entomological Society of Latvia, Kronvalda bulvaris 4, LV-1586, Rīga, Latvia; e-mail: martins.kalnins@biology.lv

KALNIŅŠ M. 2012. DRAGONFLIES (ODONATA) IN LATVIA – HISTORY OF RESEARCH, BIBLIOGRAPHY AND DISTRIBUTION FROM 18TH CENTURY UNTIL 2010. – *Latvijas Entomologs* 51: 91-149.

**Abstract:** This work is to summarize large number of the available unpublished data and to make - distribution maps and to present the results in an article. The existing faunistic data were presented in 82 publications up to the end of 2010. Distribution maps were developed for 59 species. For several species of dragonflies were found notable changes in the distribution.

**Key words:** Dragonflies, Odonata, bibliography, distribution maps, Latvia.

## Introduction

Collection and analysis of historical data and literature are used in investigation of various invertebrates. Frequently the amount and quality of the historical data allows to draw conclusions about the changes in species composition, number and other changes in a longer period of time. The first localizable information on the occurrence of dragonflies in Latvia dates from the second half of the 18th century (Fischer 1778). Until now only one publication (Спурис 1956) synthesizing knowledge of the dragonflies' distribution and occupancy in Latvia can be found. Therefore, the distribution of dragonflies in Latvia has never been critically analysed and synthesized recently, apart from works on several separate species published recently (cf. Kalniņš et al. 2011). Data sparseness in numerous publications makes their use very difficult. Many publications were written in Latvian and Russian languages. This is an additional problem for studies carried out by foreign specialists. During

the last 20 years the number of different nature research projects has increased, where a part of the gathered information has been included in project and study reports, but has not been published. These data are not published, they have been available and usable only for their authors or the organizations they represent. No unified species' distribution maps have been developed to date in Latvia. Distribution maps of specific species has been represented based on various outlines of Latvia (depending on the sources available to the authors), freely distributing dots. There are no larger works encompassing systematic units, such as families or orders, regarding species' distribution, as can be found, for example, on dragonflies in Estonia (Martin et al. 2008) and in Poland (Bernard et al. 2009). The following objectives were selected for this work: to summarize large number of the available unpublished data and to make distribution maps and to present the results in an article.

## The dragonfly fauna and distribution research in the territory of Latvia

Dagonflies have been first mentioned in the second half of 18th century in Latvia. Jacob Benjamin Fischer (1778) in his book about nature of Livland has mentioned 5 dragonfly species. Two of them, *Aeshna grandis* (Linnaeus) and *Coenagrion puella* (Linnaeus), judging from the description have been indentified incorrectly. Several years later, the author has mentioned five more species (Fischer 1784). In the second reviewed edition of this book (Fischer 1791) only the previous information has been repeated. Thus, at the end of the 18th century there were mentioned 8 species of dragonflies to be identified with certainty and they are as follows: *Calopteryx splendens* (Harris), *Gomphus vulgatissimus* (Linnaeus), *Cordulia aenea* (Linnaeus), *Orthetrum cancellatum* (Linnaeus), *Libellula depressa* Linnaeus, *Libellula quadrimaculata* Linnaeus, *Sympetrum flaveolum* (Linnaeus), *Leucorrhinia rubicunda* (Linnaeus). Fisher has not mentioned in his publications where the dragonflies were found and, thus, a question may arise, whether the mentioned species were really observed in Latvia, as the territory, called Livland, included not only Vidzeme, but also a part of the contemporary Estonia (therefore Livland should not be interpreted as Vidzeme). However, it is known that Fisher has lived in Riga and supposedly investigated the fauna of Riga vicinity (Gebhardt 2006). Based on that, it can be assumed that

the dragonfly species, mentioned by Fisher, were really found in Latvia.

John Heinrich Karl Kawall (1864) has published a list of dragonflies found in Kurzeme. In the vicinity of Puze (Pussen) he has observed 18 species, one of which *Agrion elegantulum* Zetterstedt cannot be deciphered (probably *Coenagrion pulchellum* (Vander Linden) (Steinmann 1997)). Additionally, with reference to the information given by Eduard Lindemann, he has listed 10 species in Jelgava (Mitau). Later Kawall published phenological observations, mentioning 5 species of dragonflies (*Lestes sponsa* (Hansemann), *Calopteryx virgo* (Linnaeus), *Gomphus vulgatissimus* (Linnaeus), *Libellula depressa* Linnaeus un *Libellula quadrimaculata* (Linnaeus), however, without any details regarding the place of observation (Kawall 1865, 1866), perhaps in the vicinity of Puze, where he lived.

Also Andre Bruttan (1878, 1881) has published information about dragonflies in Latvia. Dragonflies were investigated near Daugavpils, in the region of Krustpils (Kreutzburg) – from Līvāni (Liewenhof) to Stukmaņi (Stockmannshof). Near this stretch along the River Daugava, 24 species were observed. Totally in all the mentioned publications from second half of the 18th century, 27 species of dragonflies have been listed for Latvian territory.

First data on dragonflies in the publications of 20th century appear by Guido Schneider as a brief description of a mass flight of *Sympetrum danae* (Sulzer) (Schneider 1910). The same observation is later described by Edgars Ozols (1936) where the northern species *Leucorrhinia albifrons* (Burmeister) was firstly mentioned for Latvia. Information about dragonflies can be also found in work by Ferdinand Erdmann Stoll (1930), where mass death of *Libellula quadrimaculata* is mentioned and picturesque description of *Aeshna cyanea* (O.F.Müller) feeding habitats. Slightly later H. Stoll's description (with comment by Nikolai Heinrich fon Transehe) of a mass flight of dragonflies has been published (Stoll 1934). But John Cowley (1937) has published information about 21 species, collected by Felix Brandt near River Amata.

More focused and extensive research of Latvian dragonfly fauna is presented by Bruno Bērziņš. A short paper on mass flights of *Libellula quadrimaculata* Linnaeus and *Leucorrhinia rubicunda* (Linnaeus) was published (Bērziņš 1934). In 1938 he started a more extensive research by observing dragonflies in south Latgale, in area of Sīvers and Drīdzis Lakes and in the same year reported

17 species (Bērziņš 1938). After four of years an overview of Latvian dragonfly fauna followed (Bērziņš 1942). It is based on comparatively extensive materials and encompassed 47 species. The overview was later extended to include *Coenagrion armatum* (Charpentier), found in 1944 near Sloka by Bērziņš (Bērziņš 1950). In 1942 Aleksander Grosse reported about observation of *Sympetrum striolatum* (Charpentier) in Latvia (Grosse 1942).

Zandis Spuris systematically studied dragonflies in 1940 in Jēkabnieki rural municipality. His observations on the dragonfly local fauna were published in 1943 (Spuris 1943). 35 species were observed, including *Lestes virens* (Charentier), which was found in Latvia for the first time. In the overview monograph (Спурис 1956) already 53 species were mentioned, including *Sympetrum fonscolombii* Sélys, which have appeared in Latvia in 1938. Much new information on dragonfly distribution was published in 1963 (Spuris 1963a). With finding *Coenagrion johanssoni* (Wallengren) (Спурис 1964), the number of dragonfly species in Latvia reaches 54. The author explains that this includes 53 local species (that breeds in Latvia) and one that have strayed in. In 1980 a dragonfly catalogue was published (Spuris 1980), in which 54 Latvian dragonfly species were listed. The catalogue was based on the faunistic literature available at that time. Additionally the information from the publications on hydrobiology was included, as the authors, when describing macrozoobenthos or feeding of the fish, have also mentioned dragonflies. However, this information has been used rather carefully, as the identification of dragonfly larvae in the publications of hydrobiologists has been doubted by Z. Spuris. The three main reasons for that were as follows:

- very often in the hydrobiology papers the species of dragonflies have not been identified;
- in general in publications on macrozoomacrobenthos, some large species have been identified, while others, equally large, have not;
- hydrobiologists make many mistakes in a species' identification.

After the publishing of the aforementioned catalogue, several papers by Spuris and other authors followed on dragonflies in central Latvia (Spuris 1968, 1974, 1990, 1992) and in other places in Latvia (Spuris 1950, 1952, 1997, 1996, 1998, Liepa 1963, Спурис 1951, 1954, 1966). In 1993 an identification book (Spuris 1993) is published, in which 53 dragonfly species are listed for Latvian fauna, as well as seven potential species. It is also

important to note reviews (not publications) of several investigations by three foreign researchers - Mogens Holmen, Joachim Matthes and Hinrich Matthes, in which information on rare species (*Ischnura pumilio* (Charpentier), *Coenagrion johanssoni* (Wallengren)) and species with unclear status (*Aeshna caerulea* (Ström), *Sympetrum fonscolumbii* Sélys) is presented. In 1995 in Pape Ornithological station (south-west Latvia) Thomas von Rintelen (1997) observed a new dragonfly species in Latvia – *Anax ephippiger* (Burmeister). Brief information may be found also in a letter written by Kārlis Grigulis, which is included in the materials of Natural History Museum of Latvia.

Separate research was done on the changes of dragonfly wing enervation (Spuris 1960; Спурис 1958, 1962) and dragonfly mass flights (Spuris 1963b). Information about dragonflies may be also found in publications on topics of hydrobiology – macrozoobenthos or the feeding of the fish (Spuris 1953, 1958, Kačalova et al. 1962, Качалова 1959, 1960, 1962, 1966, 1972). Usually in such works the species are not identified and only higher taxa are mentioned; nevertheless, it is possible to find information about quantitative data of dragonflies, for example, density of population, biomass or inhabited substrates.

Information about dragonflies can also be found in the partially published studies carried out by the Laboratory of Hydrobiology of the Institute of Biology (BI) of the University of Latvia (LU) (earlier Latvian Academy of Sciences) (Балоде и др. 1981, Качалова, Пареле 1987, Цимдинь и др. 1989, Kačalova, Parele 1987, Parele 2001, 2003, 2007a, 2007b, 2008, Volskis 1999, Druvietis et al. 2010). Unfortunately not all the results of the LU BI researches are published and accessible. These results include hydrobiological monitoring data (zoobenthos data) from various territories and various years:

- Monitoring of the water bodies of Teiči strict nature reserve – 1994, 1998, 2001, 2002;
- Monitoring of Engure lake specially protected natural area (the status of the territory has changed frequently) – 1995-2002;
- Monitoring of Salaca river basin – 1995-2001;
- Monitoring of limnic systems of North-Vidzeme mires (swamp lakes that are currently part of nature reserve ‘Ziemeļu purvi’) – 1997-2002.

The above mentioned publications and reports often include taxa, without species’ identification, or the species are listed for the water

bodies at full length or area (the River Venta, the River Daugava), which prevents precise identification of the place where the species has been collected. Similar issues are related to the investigations of the lakes of Ķemeri National Park, carried out by Latvian Environmental Data Centre (later – Latvian Environment Agency) from 1995 to 1999 and the Institute of Biology of the University of Latvia in 2001. During the project '*Identification of long-term pollution in river Gauja*', carried out by Young Nature Lovers centre 'Rīgas Dabaszinību skola' in 1998, rather comprehensive information about water invertebrates, including dragonflies in Gauja was obtained. The original data were included in a database. Part of the results was published (Kalniņš 2000, 2006a, 2006b, Kalniņš, Poppels 2000). Information about specific dragonfly species can also be found in the surface water (small lakes and rivers) quality monitoring research, performed by the Environment, Geology and Meteorology Centre of Latvia (earlier – State Hydrometeorological Administration, Environment, Geology and Meteorology Agency). The biological quality of the small streams (rivers) was assessed by the saprobity index of macrozoobenthos. The research encompasses comparatively extensive period of time (from 1992 to 2010). It could encompass more years, as only part of the research reports are currently available to general public.

Several works on observation of rare (Bernard 2002, 2005, Bernard, Wildermuth 2005, Kalniņš 2008a) and new dragonfly species in Latvia have been published in the last decade: *Sympetrum pedemontanum* (Allioni) (Kalniņš 2002), *Aeshna crenata* Hagen (Bernard 2003), *Orthetrum brunneum* (Fonscolombe) (Kalniņš 2007c) and *Anax parthenope* (Sélys) (Kalniņš 2009). A book on fauna, flora and vegetation of Silene Natural Park with list of dragonfly species was also published (Barševskis et al. 2002), as well as a book on biological diversity in Gauja National park with chapter on invertebrates, including dragonflies (Kalniņš et al. 2007) in this period. Lately several papers were also published on distribution of species and ecology (Kalniņš, Inberga-Petrovska 2005, Kalniņš 2006a, 2006b, 2007b, 2011a, 2011c), as well as phenology and the relation of species to habitats (Inberga-Petrovska 2003, Kalniņš 2006c, 2007a, Kalniņš, Medne 2007). Also the distribution of southern dragonfly species in Latvia and adjacent territories has been described recently (Kalniņš 2008b, 2011b). Totally in the above-mentioned publications 59 dragonfly species have been described

for Latvia.

## Methods

The dragonfly geodatabase was developed in Microsoft (MS) Office Access in order to aggregate information about the distribution of dragonflies. The basic unit of a record is an observation of a species in one location in one day. The geodatabase includes:

1. all published data;
2. author's own unpublished data collected between 1991 and 2010;
3. unpublished data collected by Latvian entomologists before 2011;
4. the materials found in enthomological collections of various institutions – Natural History Museum of Latvia (Rīga), Museum of Zoology of the University of Latvia (Rīga), Local History Museum of Naujene, Culture board of Daugavpils District (Naujene), Institute of Biology of the University of Latvia (Salaspils), Department of Zoology and Animal Ecology of the Faculty of Biology of the University of Latvia (Rīga);
5. the materials included in various research and nature management plans, including nature management plans of specially protected natural areas (http://www.daba.gov.lv, http://www.lva.gov.lv/monitor/monitorings.htm);
6. data (including digital photographs), available in websites (www.dabasdati.lv, www.fotki.lv etc.) and from different people (non entomologists).

A more detailed list of sources is included in the chapter 'References used in preparation of maps' at the end of this paper. Most of author's data obtained from 2005 till 2010. They constitute almost 29 % of all data included in MS Access database.

According to Geospatial Information Law (2010) the geodetic co-ordinate system of Latvia (1992), the topographic map system (1993) and the normal heights system of the Baltic States (1977) shall be used in the acquisition, preparation and maintenance of the basic data of geodetic information. Distribution of dragonflies was mapped using a basic grid of 5x5 km squares in the Baltic grid system on a Transverse Mercator projection (TM-1993) of Latvia. Current map is based on 1:50 000 scale maps available for Latvia. These maps are graduated at 1x1 km (=1 $km^2$) squares and the border of 5x5 km squares coincide with the every fifth km line. The total terrestrial territory of Latvia is divided into 2791 5x5 km squares (part of the squares are not complete due to country border configuration). In this paper, a division between two periods is used: historical, between

the years 1778 and 1990, and current – from 1991 to 2010.

The occupancy is given with the use of descriptive categories. The species are classified into the category on the basis of frequency of recorded squares occupied by the species within all studied squares:

1. very common – frequency of occupied squares >25.1 %,
2. common – frequency of occupied squares 15.1-25 %,
3. moderately represented – frequency of occupied squares 5.1-15 %,
4. localized (rare) – frequency of occupied squares 1.1-5 %,
5. sporadic (accidental) – frequency of occupied squares 0.1-1 %.

## Results

At present, 12065 entries (rows) are included in the database, comprising the data collected between 1778 and 2010. In case of 48 entries, a specific location cannot be deciphered – either a vast territory (Curonia) or water body (River Daugava, River Venta) is indicated, also, some location cannot be correctly found in maps (Lake Tabora, Lake Zubru), different locations with identical names are given (Lake Lukno, Lake Lukņu, Lake Luknas) or the location is unidentified. In case of 5 historic entries, the names of the species cannot be deciphered in line with the modern taxonomy. The data was collected from 839 squares that constitute 30 % of all squares covering Latvia. Besides, many areas well-covered by the studied squares and some areas covered to a small extent are recognizable on the map (Fig. 1).

The quality of the data is not uniform. This is reflected in the number of species recorded within one grid square (Fig. 2). For 53 % of the studied squares the quality of data is low as the number of recorded species does not exceed 5. The data is qualitatively moderate (6-10 species / square) for 22 % of studied squares, good (11-20 species / square) for 19 %, and very good (>20 species / square) for 6 % of the units. The maximal value is 39 species per one square.

Historical data was collected for 369 squares (13 % of all squares covering Latvia), and current data for 655 squares (23 %). This difference reflects a significant intensification of odonatological exploration in the last 10 years in comparison to the preceding 160 years. In the current period, studies have been expanded into many previously unexplored territories. Only part of the areas of historical exploration has also

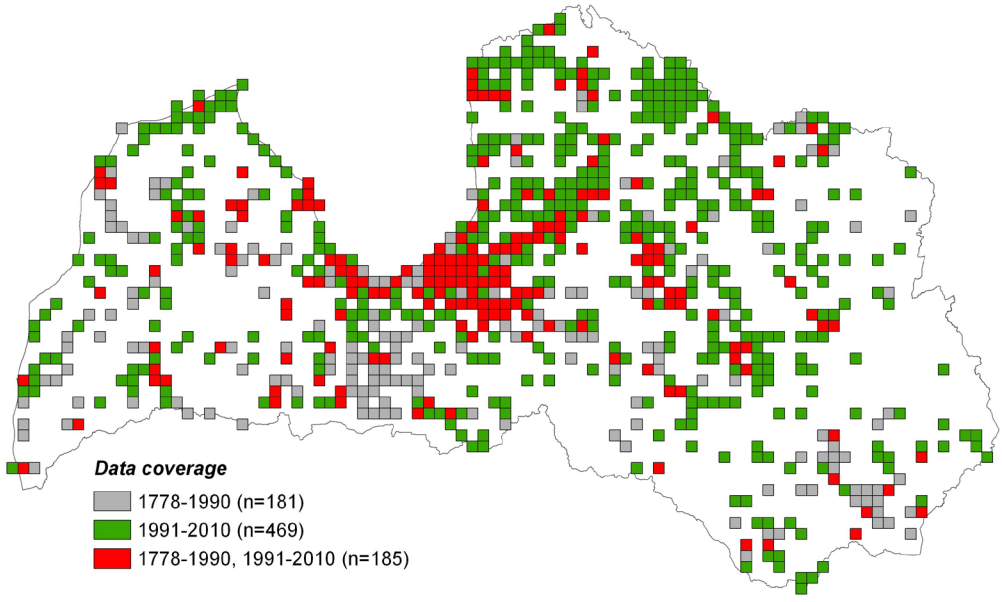



Figure 1. Coverage of squares with data collected in the historical and current period.

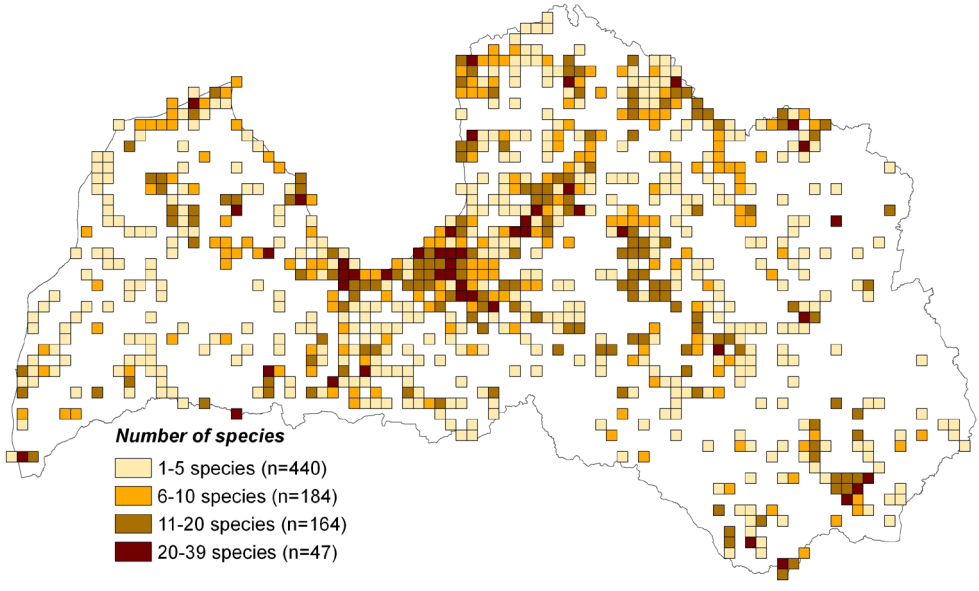



Figure 2. Coverage of squares, expressed as the number of species recorded in a grid square.

studies in the current period. Despite the presence of still unexplored or inadequately surveyed areas, the coverage of the country by the data and their quality are certainly sufficient to analyse the species' occurrences on a national scale and to synthesize a reliable picture of their extent.

## Discussion

Altogether 59 dragonfly species have been recorded in the fauna of Latvia until 2010. However, the formation and transformation of faunas is a continuous process (Peters, Lovejoy 1992; Gates 1993). The changes in the dragonfly fauna and distribution may occur due to climate changes (Ott 2001; Corbet 1999; Termaat et al. 2010) and habitat (including anthropogenic) changes (Kalkman et al. 2010). It seemed interesting to analyse discovery of new species for fauna of Latvia over time. The trend on figure 3 shows that the discovery of new species for fauna of Latvia has three exponential growth phases. The first two phases (1860-1880 and 1930-1950) are most likely related to more intensive research during the corresponding period and less intensive research beforehand. The third phase (since 2000) is most likely connected to the aforementioned climate change.

There has been a recent discussion

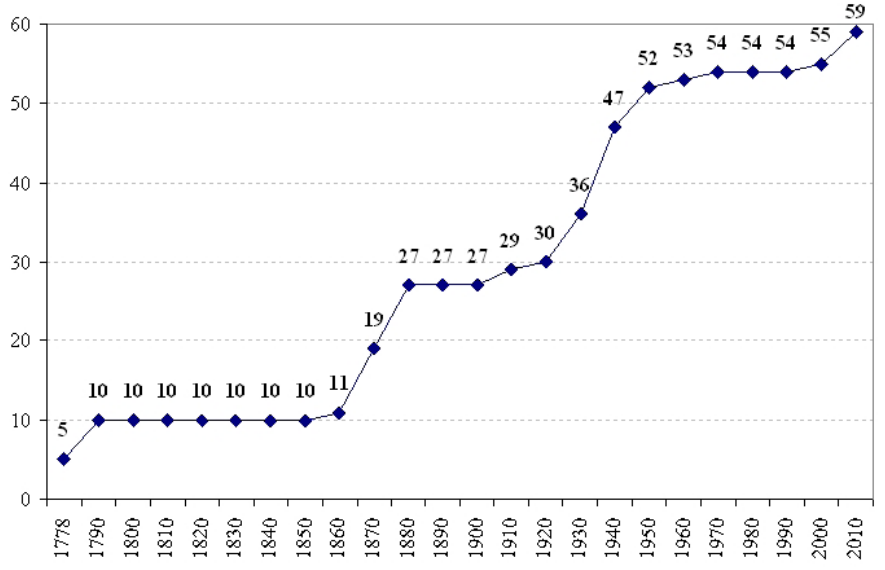



Figure 3. Discovery of Latvia's dragonfly species (y axis) based on decades of their first finding (x axis).

on the changes of the dragonfly fauna in Latvia and adjacent territories during last 20 years, in the course of which prognosis for future changes were provided (Kalniņš 2011b). As a result of the study, 19 species were identified in case of which the borders of the distribution areas or separate localities are relatively close to the territory of Latvia (neighbouring countries or their closest regions and Poland) or which are known as species that rapidly distribute to the northern direction. Seven species from these are mentioned in the literature as probable for Latvia (Spuris 1993). At the same time 5 species that are included in this list were recorded for the first time in Latvia during the last 20 years. The list of the potential species for the fauna of Latvia is given (Table 1). The *Sympetrum eroticum* (Sélys, 1883) that has been mentioned previously (Spuris 1993) as a potential species for the fauna of Latvia, is excluded from this list as it is not reliable possibility, because species spread in China, Japan, Korea, the Far East of Russia (Wilson 2009). The identification accuracy of specimens founded in Lithuania is unlikely (P. Ivinskis, personal communication).

The status of *Aeshna serrata* should be discussed. *A. serrata* was mentioned as a probable species for Latvia by Spuris (Spuris 1993). The main distribution area of *A. serrata* is located in Central Asia, a separate part of the population is situated at the Baltic Sea to the North of Latvia – in Estonia, Finland, and Sweden (Dijkstra 2006) and one locality is also known in the eastern part of Turkey (Boudot et al. 2009). *A. serrata* has a stable population in Estonia. Nevertheless, the status of the species is not clear. *Aeshna osiliensis* (Mierzejewski 1913), as described in Estonia, forms local populations at the Baltic Sea to the north of Latvia – in Estonia, Finland and Sweden. Some authors (Dijkstra 2006) regard this species as synonymous to *A. serrata*, pointing out that differences are insignificant. The only thing that testifies in favour of the status of a separate species is the geographical argument. At the same time, other authors (Sahlen et al. 2004) acknowledge that the status of *A. osiliensis* is not strictly fixed, although recently this taxon is used as a separate species. The potential finding of the species in Latvia is very credible, because the distance between the localities of the species in Estonia and Latvia is insignificant.

When comparing the distribution of *Calopteryx splendens* and *Calopteryx virgo* in the historic and current period, it is clear that in the current period and in both, current and historical, periods the number

of squares inhibited by *Calopteryx virgo* has grown. At the same time, the number of cases when *Calopteryx splendens* has been observed is greater.

For *Lestes* genus, the main changes were found for *Lestes dryas* (decreased distribution) and *Lestes virens* (increased distribution). The causes for the decrease of *Lestes dryas* distribution are not clear. The increase of *Lestes virens* distribution might be connected to the climate change, as in the historic period the species was mentioned as a southern element of Latvian fauna (Спурис 1951) and was found mainly in the western and southern part of Latvia. In the modern period new species' localities have been found in the central and northern part of Latvia.

The localities of *Sympecma paedisca* in the historic period were mostly concentrated around the areas of Rīga and Jelgava, while the modern period localities can be found throughout the territory of Latvia. This is most likely related to the increase of the mobility of researchers, especially the studies of protected nature territories and targeted search for the species.

For Coenagrionidae family, the main changes were found for several species. *Ischnura pumilio* was a southern element in the dragonfly fauna of Latvia (Спурис 1951); however, today the species has been recorded in three locations in the north (Kalniņš 2011b). The higher number of new localities for several species in the current period can be explain by increase of casual data, including collecting photographs, have an impact on the localities of the number of common species (e.g. *Coenagrion puella*, *Coenagrion pulchellum* and *Pyrrhosoma nymphula* as an visual attractive species). The diminishing of the *Coenagrion armatum* and *Coenagrion johanssoni* localities in the current period may be due to the lack of targeted research, as well as the fact that the current studies mainly concentrate on the areas previously unexplored. The areas that have data from the historic period are surveyed less frequently. For the *Nehalennia speciosa* some regional differences in habitat selection and, accordingly, the distribution are established (Kalniņš et al. 2011).

For several species of Aeshnidae family notable changes in the distribution where found, while some species are new for Latvia or their status is unclear. The status of *Aeshna caerulea* is still disputable. There are three records of the species in Latvia. The first specimen was a male, which was captured 04.06.1929, in Bauņi, former Valmiera district (Bērziņš 1942). The specimen was not preserved. The

second one was captured 09.08.1999, near the Lake Plaužu, former Cēsis district (S. Inberga pers. com.). The specimen was not preserved. The third specimen was observed 20.08.1997, in the Lake Liepsalas, Teiči nature reserve, former Jēkabpils district (investigation by Joachim Matthes and Hinrich Matthes in 1997, unpublished data). According to the literature data, the species belongs to boreo-mountain species and are most common above the treeline. The typical habitat is small water bodies in mountain peat bogs and moors, heaths and tundras. Its flight season is from mid-July to mid-September in most of the Europe; however, in Scotland the first imagines are observed in May (Dijkstra 2006; Bernard et al. 2009). The nearest reliable localities are in Estonia, north from Latvia (Martin et al. 2008). The first and second observation was made outside of typical habitats and the first record can be regarded as a very early observation as well. The last observation was made in a typical habitat and season for the species; however, the observers stressed that the observation is not totally reliable. To approve the status of *A. caerulea* in Latvia, the focused search for this species in future should be carried out.

*Aeshna crenata*, *Anax ephippiger* and *Anax parthenope* are relatively new species in Latvian fauna. *Aeshna crenata* in Latvia was found in 2002 (Bernard 2003), *Anax ephippiger* – in 1995 (Rintelen 1996) and *Anax parthenope* in 2008-2009 (Kalniņš 2009). As in *Aeshna crenata* locality several individuals and larvae were found and *Anax parthenope* has been found two years in a row in various localities, these species can be considered resident in Latvia. For *Anax parthenope* it is due to the expansion of the species area in northern direction and, if the current tendencies of the climate change remain, the number of localities may grow considerably. The climate change may explain also the growth of number of *Aeshna isoceles, Anax imperator* localities and identification of new *Aeshna mixta* localities in the northern part of Latvia (Kalniņš 2011b). The higher number of new localities for *Aeshna cyanea* and *Aeshna grandis* in the current period partly can be explained by increase of casual data, including collecting photographs, have an impact on the localities of the number of common species. The second reason for the growth of number of the localities of these two species is the changes in the research methodology – active collecting and identification of exuviae (since 2005). Perhaps the number of species' localities was influenced also by the growing number

of household and garden ponds in the last 10-15 years (unpublished data by the State Environmental Service). For the *Aeshna subarctica*, some regional differences in habitat selection and, accordingly, the distribution is established (Kalniņš 2011b). When comparing the historical and current period in case of *Aeshna viridis*, it is clear that the number of species' localities has grown only a little. However, almost half of the current localities form a group of localities. This may be explained by the suitable habitats – oxbows, ponds with *Stratiotes aloides* – found along the River Gauja, as well as the intensive research of the water bodies of the River Gauja basin (Kalniņš, Inberga-Petrovska 2005; Kalniņš et al. 2007).

For the species of Gomphidae family, comparing the historic and current period, the main changes were found for *Ophiogomphus cecilia*. *O. cecilia* is included in the EU Habitat directive (Council… 1992) as well as a focused search for this species has been carried out in Latvia. Noticeably more new localities have been found in the current period compared to the historical period. However, almost all localities were found in Vidzeme. Partly it can be explained by the intensive studies of the River Gauja invertebrates, carried out by the author. But this does not explain the absence of the species in the south-western and south eastern part, where specially protected nature areas with suitable habitats are and where focused searches have been carried out. However, the history of decline has been noticed in many areas in Europe (Dijkstra 2006). The low number of localities of *Gomphus flavipes* found both in the historic and current period may be due to the lack of species-oriented research. At the same time in rivers (Salaca, Gauja, partially Venta), where there has been a targeted research of Gomphidae species, *Gomphus vulgatissimus* and *Onychogomphus forcipatus* have been found in almost all places suited for the species.

One of the increases of *Cordulegaster boltonii* localities in the current period is related to the more intensive research of small rivers and streams – both surveying this particular species and researching other water invertebrates.

The higher number of new localities for Corduliidae, except *Somatochlora arctica*, in the current period can be explained by new and improved methods – exuviae search, especially for *Epitheca bimaculata* localities). The higher number of new localities for *Somatochlora arctica* is the result of more intensive raised bog studies. The larger number of new *Cordulia aenea* and *Somatochlora metallica* localities may be explained

by more intensive dragonfly research in specially protected nature territories, for example, the Protected Landscape Area Ziemeļgauja, restricted natural areas near Lake Burtnieks, Gauja National Park and elsewhere.

In case of Libellulidae family, for some species substantial changes in the distribution were found, while some species are new for Latvia or their status is unknown. The number of *Libellula depressa* localities was influenced by the growing number of household and garden ponds in the last 10-15 years (unpublished data by the State Environmental Service). This is reflected also in the casual data – in photographs (it is a visually attractive, comparatively easy to photograph species, which found in anthropogenic habitats). The second reason is that the increase of casual data, mainly photographs, has an impact on the localities of a number of common species. These two reasons are partially referable also to the number of *Libellula quadrimaculata* localities. Another reason for the increase of the number of *L. quadrimaculata* localities is more intensive surveys of specially protected nature areas. For *Libellula fulva* no significant differences for historic and current period were found; however, the number of species' localities in the northern part of Latvia has grown, which may be related to the expansion of the species area in the northern direction and, if the current climate change tendencies remain, the number of species' localities will grow.

*Orthetrum brunneum* is considered a new species in Latvia, found once, in one locality in the northern part of Kurzeme (Kalniņš 2007c). However, in the later years the locality has not been surveyed and there have been almost no targeted surveys of the habitats suitable for the species – small, warm, shallow streams, running ditches and seepages with poor vegetation in places with early stages of succession, such as freshly cleaned ditches etc. (Dijkstra 2006; Bernard et al. 2009). Also *Sympetrum pedemontanum* is a relatively new species for Latvia fauna (Kalniņš 2002). Also the first locality of this species has not been subsequently surveyed; however, the finding of the species in 2010, as well as the expansion of the species in northern direction (Kalniņš 2011b) means that the number of species' localities may grow.

The species with disputable status long time was *Sympetrum fonscolombii*. Two localities of *S. fonscolombii* have been mentioned in literature until 2010. One specimen was caught on 10.08.1938 at the Lake Sīvers in Krāslava district in the south-

eastern part of Latvia (Bērziņš 1938). The other was caught on 3.09.1997 in Teiči Strict Reserve located in the Jēkabpils district in the south-eastern part of Latvia. Nevertheless, the observers mention that this observation is not reliable because the caught specimen fled away before all the characteristic features of the species were determined (Matthes, Matthes 1997). Spuris regards *S. fonscolombii* as a species that has casually wandered into Latvia and therefore cannot be included in the fauna of Latvia (Spuris 1993, 1996). The northern border of its distribution area reaches the north-eastern part of Poland. *S. fonscolombii* is regarded as a pronounced migrant that can suddenly form colonies in places where it has not previously been recorded (Dijkstra 2006). The typical habitats of the species are warm, standing, more often open and shallow waters – quarries, newly made ponds, coastal lagoons. As the life cycle of the species differs from the other representatives of the genus *Sympetrum,* adult specimens can be found from the end of May to October (Dijkstra 2006). Several observations of the species have been recorded:

1. At least 2 specimens of *Sympetrum* were observed and one photographed 5 km to the south-west of Dobele in racetrack 'Ceļa Ēzelis' (the central-southern part of Latvia) at a shallow pond on 28.06.2009 (Photo by A. Klepers, www.dabasdati.lv 2011). The species was identified after photographs as *S. fonscolombii* (det. M. Kalniņš, R. Bernard).

2. One specimen was photographed over a ditch in Kaltenes Kalvas (the south-western part of Latvia) by patrolling along the forest edge on 25.07.2010 (Photo by A. Klepers, www.dabasdati.lv 2011). The species was identified after photographs as *S. fonscolombii* (det. M. Kalniņš).

3. Three males of *S. fonscolombii* (from several tens of *Sympetrum* dragonflies) were caught in Embūte (the south-western part of Latvia) on 10.09.2009 (M. Kalniņš, unpublished data). It is possible that the species was present in larger numbers but the recording was hindered by the lack of the catching equipment (the caught specimens were caught by hands).

Now, the species occasional presence in Latvia is confirmed; however, the larval development has not been established.

The number of *Sympetrum danae*, *Sympetrum flaveolum*, *Sympetrum sanguineum* and *Sympetrum vulgatum* localities was influenced by the growing number of two, correlative reasons – increase household and garden ponds in the last 10-15 years (unpublished data by the State Environmental Service) and increase

of casual data, mainly photographs, have an impact on the localities of the number of common species. The higher number of new localities for *S. danae* partly is a result of more intensive raised bog studies as well.

Some other peculiarities on *Leucorrhinia* should be noted. In Latvia, the *Leucorrhinia albifrons*, *L. caudalis* and *L. pectoralis* can be found in the whole territory of Latvia. The comparison of the historical and current species' distribution data reveals that the number of *L. pectoralis* and *L. albifrons* localities has grown considerably. However, this mainly can be attributed to specific, targeted search for *L. pectoralis*, which is included in EU Habitats Directive (Council… 1992), during the development of specially protected territories (2001-2004), as well as during the drawing of further environment management plans for specially protected territories. In the course of these studies, other protected species have been registered. On the other hand, the number of *L. caudalis* observations has diminished, which may point to the diminishing of the population of the species in Latvia. The population trends of all species in Europe (Kalkman et al. 2010) show that the numbers of *L. pectoralis a*re growing smaller, while *L. albifrons* and *L. caudalis* populations remain stable.

**Acknowledgements**

This work partly has been supported by the European Social Fund within the project 'Support for Doctoral Studies at University of Latvia'.

I am greatly indebted to Dr. Rafał Bernard (Department of General Zoology, Adam Mickiewicz University, Poznań, Poland), Dr. Paweł Buczyński (Department of Zoology, Maria Curie-Skłodowska University, Lublin, Poland), Dr. Grzegorz Tończyk (Department of Invertebrate Zoology and Hydrobiology, Łódź, Poland) and M.Sc. Jacek Wendzonka (Gostyń, Poland) for ideas and examples from 'A distribution atlas of dragonflies (Odonata) in Poland' to this work!

Special thanks to Dr. Dmitry Telnov (The Entomological Society of Latvia, Rīga, Latvia) for consulative and disscussions in scientific field and practical and moral support and to Oskars Beikulis (Rīga, Latvija) for support in work with GIS!

I am very grateful to all Data Authors who delivered their data for this work. I am very grateful to Zane Pīpkalēja (Sigulda, Latvia), Dr. Voldemārs Spuņģis (Entomological Society of Latvia; Faculty of Biology, University of Latvia, Rīga, Latvia), Arkādijs Poppels (Riga ZOO, Rīga, Latvija) and to Dr. Ivars Druvietis

(Faculty of Biology, University of Latvia, Rīga, Latvia), for various assistance and valuable suggestions useful in the preparation of the final version of the article!

I am very grateful to Dr. Vincent J. Kalkmann (Netherlands Centre for Biodiversity, Leiden, the Netherlands), Dr. Andrius Petrašiūnas (Vilnius University, Vilnius, Lithuania), Dr. Povilas Ivinskis (Institute of Ecology, Vilnius, Lithuania), Dr. Jolanta Rimšaitė (Institute of Ecology, Vilnius, Lithuania), Dr. Eduardas Budrys (Institute of Ecology, Vilnius, Lithuania), Dr. Giedrė Višinskienė (Institute of Ecology, Vilnius, Lithuania), Dr. Rasa Bernotienė (Institute of Ecology, Vilnius, Lithuania), Dr. Dalius Dapkus (Vilnius Pedagogical University, Vilnius, Lithuania), Dr. Vytautas Tamutis (Kaunas T. Ivanauskas Zoological Museum, Kaunas, Lithuania) un Dr. Mati Martin (University of Tartu, Tartu, Estonia) on providing scientific literature!

## References

References used in preparation of maps

Below are listed publications which include the following information, concerning dragonfly species in Latvia – the original data concerning the species occurrence that are sufficiently precise to be localized in the squares of the grid; the original data using more general localizations which could be used in interpretation maps; the data describing the habitats, populations, conservation status and threats to particular species in national scale. The titles of publications are given in original language their are published. In square brackets [ ], English translation of each title is given.

Barševskis A., Savenkovs N., Evarts-Bunders P., Daniele I., Pētersons G., Pilāts V., Zviedre E., Pilāte D., Kalniņš M., Vilks K., Poppels A. 2002. *Silenes dabas parka fauna, flora un veģetācija [Fauna, flora and vegetation of the Silene Nature Park]*. Daugavpils, Baltijas Koleopteroloģijas institūts: 107 pp.

Bernard R. 2002. *Coenagrion johanssoni* (Wallengren) in Lithuania (Zygoptera: Coenagrionidae). – *Notulae odonatologicae* **5**, No. 10: 117-120.

Bernard R. 2003. *Aeshna crenata* Hag., a new species for the fauna of Latvia (Anisoptera: Aeshnidae). – *Notulae odonatologicae* **6**, No. 1: 8-10.

Bernard R. 2005. First record of *Aeshna affinis* Vander Linden,

1820 in Lithuania (Anisoptera: Aeshnidae) and corrective notes on the Lithuanian Odonata checklist. – *Notulae odonatologicae* **6**, No. 6: 53-55.

Bernard R., Wildermuth H. 2005. *Nehalennia speciosa* (Charpentier, 1840) in Europe: A case of a vanishing relict (Zygoptera: Coenagrionidae). – *Odonatologica* **34**, No. 4: 335-378.

Bērziņš B. 1934. Insektu masu parādības [The phenomen of mass in insects]. – *Daba un Zinātne* **1**, No. 5: 157.

Bērziņš B. 1938. Piezīmes par spārēm (Odonata) [Notes on dragonflies (Odonata)]. – *Daba un Zinātne* **5**, No. 6: 186.

Bērziņš B. 1942. Beitrag zur Kenntnis der Odonatenfauna Lettlands. – *Folia Zoolgica et Hydrobiologica* **11**, No. 2: 329-350.

Bērziņš B. 1950. Eine für Lettlands Fauna neue Libellen-Art. – *Opuscula entomologica* **15**, No. 2: 134.

Bruttan A. 1878. Die Odonaten Liv- und Estlands. – *Sitzungsberichte der Naturforscher-Gesellschaft bei der Universität Dorpat* **4**, No. 3: 420-426.

Bruttan A. 1881. [Nachtrag über Odonaten Liv- und Estlands]. – *Sitzungsberichte der Naturforscher-Gesellschaft bei der Universität Dorpat* **5**, No. 1: 114-115.

Cowley J. 1937. Some Odonata from Livonia (Latvia). – *The Entomologist* **70**: 61-63.

Druvietis I., Spriņģe G., Briede A., Kokorīte I., Parele E. 2010. A Comparative Assessment of the Bog Aquatic Environment of the Ramsar Site of Teiči Nature Reserve and North Vidzeme Biosphere Reserve, Latvia. In: Kļaviņš M. (ed.). *Mires and peat.* Riga, University of Latvia Press: 19-40.

Fischer J.B. 1778. *Versuch einer Naturgeschichte von Livland.* Erste Auflage. Leipzig: 155-156.

Fischer J.B. 1784. *Zusätze zu 'Versuch einer Naturgeschichte von Livland'. Im Buche 'J.J.Ferbers Anmerkungen zur physischen Erdbeschreibung von Kurland, nebst J.B. Fischers Zusätzen zu seinem Versuch einer Naturgeschichte von Livland'.* Riga: 84-85.

Fischer J.B. 1791. *Versuch einer Naturgeschichte von Livland.* Zweite Auflage. Köningsberg, XXIV: 335-337.

Grosse A. 1942. [Einige phänologische Mitteilungen aus dem laufenden Jahr (1938).] – *Korrespondenzblatt des Naturforschenden Vereins zu Riga* **64**: 29-30.

Inberga-Petrovska S. 2003. Spāru faunas un ekoloģijas pētījumi Engures ezera dabas parkā [Research on fauna and ecology of dragonflies in Engure Lake Nature Park.] – *Daba un Muzejs* **8**: 59-67.

Kačalova O., Parele E. 1987. Slīteres Valsts rezervāta upju zoobentoss [Zoobenthos of the Slītere Nature reserve rivers]. – *Mežsaimniecība un mežrūpniecība* **3**, No. 119: 35-37.

Kačalova O., Kumsāre A., Kundziņš M. 1962. *Lielie ezeri Rīgas apkārtnē* [*Large lakes in Riga surrounding*]. Rīga, Latvijas PSR Zinātņu Akadēmijas izdevniecība: 67 pp.

Kalniņš M. 2000. Gaujas ūdens kukaiņu fauna [Fauna of aquatic insects of the River Gauja]. DPU 8. ikgadējās zinātniskās konferences rakstu krājums A11. DPU Saule: 26-28.

Kalniņš M. 2002. Banded Darter *Sympetrum pedemontanum* (Allioni, 1766) (Odonata, Libellulidae) a new dragonfly species in the fauna of Latvia. – *Latvijas Entomologs* **39**: 44-45.

Kalniņš M., Inberga-Petrovska S. 2005. Distribution and ecology of dragonflies *Aeshna viridis* (Eversmann, 1835) and *Ophiogomphus cecilia* (Fourcroy, 1785) in Latvia. 3rd International Conference 'Research and Conservation of biological diversity in Baltic region'. Book of abstracts. Daugavpils University. Daugavpils, Latvia, 20-22 April: 68-69.

Kalniņš M. 2006a. Upjuspāru (Odonata: Gomphidae) izplatība un sastopamības biežums Gaujā [The distribution and occurence frequency of Gomphidae (Odonata: Gomphidae) in river Gauja]. Latvijas Universitātes 64. zinātniskā konference. Ģeogrāfija. Ģeoloģija. Vides zinātne: Referātu tēzes. Rīga, Latvijas Universitāte: 298-301.

Kalniņš M. 2006b. The distribution and occurence frequency of Gomphidae (Odonata: Gomphidae) in river Gauja. – *Acta Universitatis latviensis* **710**, *Biology*: 17-28.

Kalniņš M. 2006c. An investigation of dragonfly (Odonata) ecology at the Tītmaņu oxbow, Gauja National park, Latvia. – *Acta biologica Universitatis daugavpiliensis* **6**, No. 1-2: 103-108.

Kalniņš M., Medne M. 2007. The spatial allocation of dragonflies (Odonata) communities in raised bogs of Latvia. 4th International Conference 'Research and Conservation of biological

diversity in Baltic region'. Daugavpils, 25-27 April. Book of abstracts. Daugavpils University Academic Press 'Saule': 50.

Kalniņš M. 2007a. Spāru (Odonata) izlidošanas laika izmaiņas Latvijā [Changes in dragonfly (Odonata) emerging time in Latvia]. Latvijas Universitātes 65. zinātniskā konference. Ģeogrāfija. Ģeoloģija. Vides zinātne: Referātu tēzes. Rīga, Latvijas Universitāte: 88-290.

Kalniņš M. 2007b. Protected Aquatic Insects of Latvia – *Leucorrhinia pectoralis* (Charpentier, 1825) (Odonata: Libellulidae). – *Latvijas Entomologs* **44**: 24-30.

Kalniņš M. 2007c. Brown Orthetrum *Orthetrum brunneum* (Fonscolumbe, 1837) (Odonata, Libelullidae) a new dragonfly species in Latvia. – *Acta Biologica Universitatis Daugavpiliensis* **7**, No. 1/2: 109-111.

Kalniņš M., Juceviča E., Karpa A., Salmane I., Poppels A., Teļnovs D. 2007. Bezmugurkaulnieki. [Invertebrates]. In: Pilāts V. (ed.) *Bioloģiskā daudzveidība Gaujas Nacionālajā parkā*. Sigulda, Gaujas Nacionālā parka administrācija: 106-149.

Kalniņš M. 2008a. Protected Aquatic Insects of Latvia – *Leucorrhinia albifrons* (Burmeister, 1839) and *L. caudalis* (Charpentier, 1840) (Odonata: Libellulidae). – *Latvijas Entomologs* **45**: 5-13.

Kalniņš M. 2009. Lesser Emperor *Anax parthenope* (Selys, 1839) (Odonata: Aeshnidae) – a new dragonfly species in Latvia. – *Latvijas Entomologs* **47**: 16-20.

Kalniņš M. 2011a. The distribution mapping of dragonflies (Odonata) in Latvia. 6th International Conference 'Research and Conservation of biological diversity in Baltic region'. Daugavpils, 28-29 April. Book of abstracts. Daugavpils University Academic Press 'Saule': 61.

Kalniņš M. 2011b. The distribution of southern dragonfly (Odonata) species in Latvia and adjacent territories. – *Environmental and Experimental Biology* **9**: 43-52.

Kalniņš M., Bernard R., Miķelsone I. 2011. Protected Aquatic Insects of Latvia – *Nehalennia speciosa* (Charpentier, 1840) (Odonata: Coenagrionidae). – *Latvijas Entomologs* **50**: 41-54.

Kalniņš M. 2012. The ecology and conservation of the Bog Hawker *Aeshna subarctica* Walker, 1908 (Odonata: Aeshnidae) in Latvia. – *Latvijas Entomologs* **51**: 40-57.

Kawall J.H. 1864. Die Orthopteren un Neuropteren Kurlands. – *Correspondenzblatt des Naturforschenden Vereins zu Riga* **14**: 155-168.

Kawall J.H. 1865. Chronik phänologischer Beobachtungen in Kurland. – *Correspondenzblatt des Naturforschenden Vereins zu Riga* **15**, No. 4/5: 47-67.

Kawall J.H. 1866. Phänologische Beobachtungen (Fortsetzung). – *Correspondenzblatt des Naturforschenden Vereins zu Riga* **15**, No. 10/11: 146-165.

Liepa V. 1963. Spāre *Aeschna isosceles* Müll. Zemgales līdzenumā [The dragonfly *Aeschna isosceles* Müll. in Zemgale plain]. – *Latvijas Entomologs* **7**: 20.

Ozols E. 1936. Latvijas kukaiņi. [Insects of Latvia]. – In: *Latvijas zeme, daba, tauta.* 2. sējums. Rīga, Valters un Rapa: 520-576.

Parele E. 2001. Daugavas zoobentosa fauna posmā Līvāni-Pļaviņas [Fauna of zoobenthic fauna of River Daugava's section from Līvāni to Pļaviņas]. Latvijas Universitātes 59. zinātniskā konference. Ģeogrāfija, ģeoloģija, vides zinātne. Referātu tēzes. Rīga, Latvijas Universitāte: 128-131.

Parele E. 2003. Kaņiera ezera zoobentoss. [The zoobenthos of the Lake Kaņieris]. Latvijas Universitātes 61. zinātniskā konference. Ģeogrāfija, ģeoloģija, vides zinātne. Referātu tēzes. Rīga, Latvijas Universitāte: 254-256.

Parele E. 2007a. Ilggadīgo zoobentosa organismu sastāva novērojumu analīze Engures ezerā [Long-term observations of zoobenthic organisms composition in Lake Engure]. Latvijas Universitātes 65. zinātniskā konference. Ģeogrāfija. Ģeoloģija. Vides zinātne: Referātu tēzes. Rīga, Latvijas Universitāte: 309-319.

Parele E. 2007b. Ādažu poligona ūdenstilpju zoobentosa sabiedrību struktūra un faunistiskais sastāvs [Structure of zoobenthos societies and faunistic composition of waterbodies in Ādaži firing-ground]. Latvijas Universitātes 65. zinātniskā konference. Ģeogrāfija. Ģeoloģija. Vides zinātne: Referātu tēzes. Rīga, Latvijas Universitāte: 302-309.

Parele E. 2008. Ventas upes makrozoobentosa biocenotiskā struktūra un tās faunistiskais sastāvs no 1963. līdz 1999. gadam [Biocenotical structure and faunistic composition of macrozoobenhos in River Venta from 1963 to 1999]. In: Plikša I. (ed.) *Klimata mainība un ūdeņi. Rakstu krājums*. Rīga, Latvijas Universitāte: 92-103.

Rintelen T. von 1997. Eine Vogelreuse als Libellenfalle: Beobachtungen in der Vogelwarte Pape, Lettland. – *Libellula* **16**, No. 1/2: 61-64.

Schneider G. 1910. Libellenzug.

– *Korrespondenzblatt des Naturforschenden Vereins zu Riga* **53**: 110.

Spuris Z. 1943. Quelques données nouvelles sur la faune odonatologique de la Lettonie. – *Folia Zoologica et Hydrobiologica* **12**, No. 1: 87-91.

Spuris Z. 1950. Materiali par Latvijas blakšu (Heteroptera) faunu. I [Materials on fauna of bugs (Heteroptera) in Latvia. I]. – *Latvijas PSR Zinātņu Akadēmijas Vēstis* **8**, No. 37: 83-94.

Spuris Z. 1952. Jaunas ziņas par Latvijas PSR spāru (Odonata) faunu [New data on fauna of dragonflies (Odonata) of the Latvian SSR]. – *Latvijas PSR Zinātņu Akadēmijas Vēstis* **6**, No. 59: 160-161.

Spuris Z. 1953. Par Latvijas PSR ezeru pamatbiotopu svarīgākām dzīvnieku sugām un to izplati [On important species of animals and their distribution in basic habitats in lakes in the Latvian SSR]. – *Latvijas PSR Zinātņu Akadēmijas Vēstis* **9**, No. 74: 67-82.

Spuris Z. 1958. *Mūsu ezeru bioloģija.* [*The biology of our lakes*]. Rīga, Latvijas valsts izdevniecība: 100 pp. (Odonata: 46-59).

Spuris Z. 1960. Spārnu dzīslojuma mainība spāru ģintī *Leucorrhinia* Britt. [Variations in wing venation of the dragonflies of the genus *Leucorrhinia* Britt]. – *Latvijas Entomologs* **1**: 53-59.

Spuris Z. 1963a. Jaunas ziņas par spāru izplati Latvijā [New data on distribution of dragonflies in Latvia]. – *Latvijas Entomologs* **7**: 21-40.

Spuris Z. 1963b. Spāru masu lidojumi [The mass flight of dragonflies]. – Dabas un vēstures kalendārs 1964. Rīga, Latvijas PSR Zinātņu Akadēmijas izdevniecība: 73-75.

Spuris Z. 1968. Pētījumi par ūdens kukaiņiem Gaujas senlejā pie Siguldas. [Studies on aquatic insects in ancient valley of River Gauja near Sigulda]. – *Latvijas PSR Zinātņu Akadēmijas Vēstis* **12**, No. 257: 137-139.

Spuris Z. 1974. Spāres Gaujas senlejā pie Siguldas. [Dragonflies in ancient valley of River Gauja near Sigulda]. – *Latvijas Entomologs* **16**: 33-46.

Spuris Z. 1980. Latvijas kukaiņu katalogs. 1. Spāres (Odonata) [Catalogue of insects of Latvia. 1. Dragonflies (Odonata)]. – *Latvijas Entomologs* **23**: 5-19.

Spuris Z. 1990. Jaunas ziņas par spārēm Latvijas centrālajā daļā [New data on dragonflies in the central part of Latvia]. – *Latvijas Entomologs* **33**: 81-89.

Spuris Z. 1992. Jaunas ziņas par spāru (Odonata) izplati Latvijas

centrālajā daļā [New data on the distribution of dragonflies (Odonata) in the Central Latvia]. – *Acta Hydroentomologica Latvica* **2**: 61-73.

Spuris Z. 1996. Latvijas kukaiņu katalogs. 12. Spāres (Odonata), papildinājums [Catalogue of insects of Latvia. 12. Dragonflies (Odonata), supplement]. – *Acta Hydroentomologica Latvica* **3**: 30-36.

Spuris Z. 1997. Daži novērojumi par ūdenskukaiņu faunu 1996. gadā Latvijā [Some observations on the water insect fauna in Latvia 1996]. – *Acta Hydroentomologica Latvica* **4**: 21-28.

Spuris Z. (ed.) 1998. *Latvijas Sarkanā grāmata. Retās un apdraudētās augu un dzīvnieku sugas. 4. sējums. Bezmugurkaulnieki. [Red Data Book of Latvia. Rare and threatened species of plants and animals. Volume 4. Invertebrates]*. Rīga, LU Bioloģijas institūts: 388 pp.

Stoll F.E. 1930. *Tier- un Pflanzenleben am Rigaschen Strande.* Riga, Valters un Rapa: 21, 94.

Stoll H. 1934. Libellenzüge. – *Korrespondenzblatt des Naturforschenden Vereins zu Riga* **61**: 125-126.

Volskis R. (ed.) 1999. *Hydrobiological research in the Baltic Countries. Part I. The Rivers and the Lakes.* Vilnius, Institute of Ecology: 397 pp.

Балоде М., Гаиле М., Зандмане А., Звайгзне М., Звайгзне М., Зембаха Р., Качалова О., Кумсаре А., Лиепа Р., Матисоне М., Мелберга А., Пареле Е., Родинов В., Цимдинь П., Цукурс Т. 1981. *Гидробиологический режим малых рек в условиях антропогенного воздействия. [Hidrobiological regime of small rivers under antropogenical impact]*. Рига, Зинатне: 167 pp.

Качалова О.Л. 1960. Донная фауна озера Резнас и ее распредепение по биотопам [Benthic fauna of Lake Reznas and its assignement by habitats]. – *Рыбное хозяйство внутренних водоемов Латвийской ССР* **5**: 103-122.

Качалова О.Л. 1962. Местонахождение поденки *Prosopistoma foliaceum* Fourc. в реке Даугава [Locality of mayflay *Prosopistoma foliaceum* Fourc. in the River Daugava]. – *Latvijas Entomologs* **6**: 44-46.

Качалова О.Л. 1966. Ручейники в составе зообентоса реки Венты в пределах Латвии [Caddisflies in zoobenthic constitution of River Venta in Latvia]. – *Latvijas Entomologs* **11**: 59-76.

Качалова О.Л. 1972. *Ручейники рек*

*Латвии. [Caddisflies of Latvian rivers]*. Рига, Зинатне: 216 pp.

Качалова О.Л., Пареле Е.А. 1987. Формирование структуры донной фауны [Formation of structure of benthic fauna]. In: Andrušaitis G. (ed.) *Евтрофирование малых озер Латвии*. Рига, Зинатне: 151-181.

Спурис З.Д. 1951. Южные элементы в фауне стрекоз (Odonata) Латвийской ССР [Southern elements in fauna of dragonflies (Odonata) of Latvian SSR]. – *Энтомологическое обозрение* **3-4**: 500-503.

Спурис З.Д. 1954. Некоторые особености фауны озер юго-восточной Латвии [Some individualities in lakes fauna of south-eastren Latvia.] – *Известия Академии Наук Латвийской ССР* **3**, No. 80: 79-84.

Спурис З.Д. 1956. *Стрекозы Латвийской ССР [Dragonflies of Latvian SSR]*. Рига, Издательство Академии наук Латвийской ССР: 96 pp.

Спурис З.Д. 1958. Изменчивость стрекозы *Libellula quadrimaculata* L. в Латвийской ССР. [Variability of dragonfly *Libellula quadrimaculata* L. in Latvian SSR]. – *Известия Академии наук Латвийской ССР* **11**, No. 136: 109-114.

Спурис З.Д. 1960. Лимнологическая характеристика озера Энгурес [Limnological characteristics of Lake Engure]. – *Рыбное хозяйство внутренних водоемов Латвийской ССР 5. Труды 17*. Рига: 167-198.

Спурис З.Д. 1962. Жилкование крыльев стрекозы *Aeschna grandis* L. из Латвийской ССР [Wing venation of dragonfly *Aeschna grandis* L. from Latvian SSR]. – *Latvijas Entomologs* **5**: 41-46.

Спурис З. 1964. Стрекоза *Coenagrion concinnum* Jон. в Латвийской ССР [Dragonfly *Coenagrion concinnum* Jон. in Latvian SSR]. – *Latvijas Entomologs* **9**: 77-86.

Спурис З. 1966. Шесть новых и несколько редких видов ручейников для фауны Латвии [Six new and several rare caddisfly species in the fauna of Latvia]. – *Latvijas Entomologs* **11**: 85-97.

Other references

The ‘References’ chapter include publications which are used for material and method descriptions etc. This subchapter NOT includes publications which include information about dragonflies

in Latvia. The titles of publications are given in original language their are published. In square brackets [ ], English translation of each title is given.

Bernard R., Buczyński P., Tończyk G., Wendzonka J. 2009. *A distribution atlas of dragonflies (Odonata) in Poland.* Poznań, Bogucki Wydawnictwo Naukowe: 1-256.

Boudot J.-P., Kalkman V.J., Azpilicueta Amorín M., Bogdanović T., Cordero Rivera A., Degabriele G., Dommanget J.-L., Ferreira S., Garrigós B., Jović M., Kotarac M., Lopau W., Marinov M., Mihoković N., Riservato E., Samraoui B., Schneider W. 2009. Atlas of the Odonata of the Mediterranean and North Africa. – *Libellula*, Supplement **9**: 1-256.

Briliūtė A., Budrys E. 2007. New record of damselfly *Lestes barbarus* in the South of Lithuania (Odonata: Lestidae). – *New and Rare for Lithuania Insect Species* **19**: 10-12.

Buczyński P., Pakulnicka J. 2000. Odonate larvae of gravel and clay pits in the Mazurian Lake District (NE Poland), with notes on extremely northern localities of some Mediterranean species. – *Notulae Odonatologicae* **5**, No. 6: 69-72.

Buczyński P., Dijkstra K.-D.B., Mauersberger R., Moroz M. 2006. Review of the Odonata of Belarus. – *Odonatologica* **35**, No. 1: 1-13.

Corbet, P.S. 1999. *Dragonflies – Behaviour and Ecology of Odonata.* Colchester, Harley Books: 829 pp.

Council Directive 92/43EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora.

Dijkstra K.-D.B. 2006. *Field Guide to the Dragonflies of Britain and Europe.* Dorset, British Wildlife Publishing: 320 pp.

Gates D.M. 1993. *Climate Change and its Biological Conequences.* Sinauer Associates, Sunderland, Massachusetts: 280 pp.

Gebhardt L. 2006. Fischer Jakob Benjamin. - Die Ornithologen Mitteleuropas. Teil 1. Wiebelsheim, Aula-Verlag: 44.

Geospatial Information law. 2010. http://www.likumi.lv/doc.php?id=202999 [last accessed 13.07.2011].

Junevičienė I., Stankevičiūtė J., Bartkevičienė G., Raudonikis L. 2007. Pajūrio regioninio parko dalies (Nemirsetos smiltpievių ir Pajūrio kopų) gamtotvarkos planas [Seaside regional park (Nemirseta meadows and

coastal dunes) management plan]. Vilnius: 1-65 http://www.zvejone.lt/life/gallery/File/Pajuris_planas_20070821_pataisytas.pdf [last accessed: 20.09.2011].

Kalkman V.J., Dijkstra K.-D.B. 2000. The dragonflies of the Bialowieza area, Poland and Belarus (Odonata). – *Opuscula zoologica fluminensia* **185**: 1-19.

Kalkman V.J., Boudot J.-P., Bernard R., Conze K.-J., De Knijf G., Dyatlova E., Ferreira S., Jović M., Ott J., Riservato E., Sahlén G. 2010. *European Red List of dragonflies*. Luxembourg, IUCN & Publications Office of the European Union: 28 pp.

Martin M., Luig J., Ruusmaa J., Heidemaa M. 2008. *Distribution maps of Estonian insects, 3. Odonata, maps 166-219*. Eesti Loodusfoto, Tartu: 68 pp.

Ott J. 2001. Expansion of Mediterranean Odonata in Germany and Europe – cosequences of climatic changes. In: Walther G.-R., Burga C.A., Edwards P.J. (eds) *'Fingerprints' of Climate Change. Adapted Behaviour and Shifting Species Ranges*. New York, Kluwer Academic Publishers: 89-111.

Peters R.L., Lovejoy T.E. (eds.) 1992. *Global Warming and Biological Diversity*. New Haven & London, Yale University Press: 505 pp.

Prüffer J. 1952. Uwagi o ważkach Wileńszczyzny [Notes of the Dragon-Flies of the Wilno District]. – *Sprawozdania Towarzystwa Naukowego w Toruniu* **4**: 105.

Skvortsov V.E. 2010. *The dragonflies of Eastern Europe and Caucasus: an illustrated guide*. Moscow, KMK Scientific Press: 623 pp.

Spuris Z. 1993. *Latvijas spāru (Odonata) noteicējs [Identification key to the dragonflies (Odonata) of Latvia]*. Rīga, Zinātne: 67 pp.

Stanionytė A. 1963. Некоторые данные о стрекозах Odonata Литовской ССР [Some data on dragonflies of Lithuanian SSR]. – *Lietuvos TSR Mokslų akademijos darbai* Serija C, 1, No. 30: 51-62.

Stanionytė A. 1991. *Orthetrum coerulescens* Fabr. – новый для Литвы вид стрекоз (Odonata), обнаруженный в 1990 г. [*Orthetrum coerulescens* Fabr. – new to Lithuania Odonata species found in 1990]. – New and rare for Lithiuania insect species. Records and descriptions of 1991. Vilnius, Institute of Zoology and Parasitology Academy of Science of Lithuanian SSR: 9-11.

Stanionytė A. 1993. The check-list of dragonflies (Odonata) of Lithuania. – New and rare for

Lithiuania insect species. Records and descriptions of 1993. Vilnius, Institute of Ecology: 50-60.

Steinmann H. 1997. *World catalogue of Odonata. Volume I. Zygoptera.* Berlin, New York, De Gruyter: 476 pp.

Termaat T., Kalkman V.J., Bouwman H.J. 2010. Change in the range of dragonflies in the Netherlands and the possible role of temperature change. In: Ott J. (eds) *Monitoring Climatic Change with Dragonflies. BioRisk* **5**: 155-173.

Tishchikov G.M., Tishchikov I.G. 2000. Faunističeskij sostav donnyh makrozoobezpozvonočnych vodostokov besseina ozera Naroč [Faunal composition of benthic macrozooinvertebrates of rivers in Lake Naroch basin]. In: Lake ecosystems: Biological processes, anthropogenic transformation, water quality. Materials of the International Scientific Conference, September 20-25, 1999. Minsk - Naroch. Minsk, Belarussian State University: 448-458.

Wilson, K. D. P. 2009. *Sympetrum eroticum*. In: *IUCN 2011. IUCN Red List of Threatened Species*. Version 2011.1. http://www.iucnredlist.org [last accsessed: 20.09.2011].

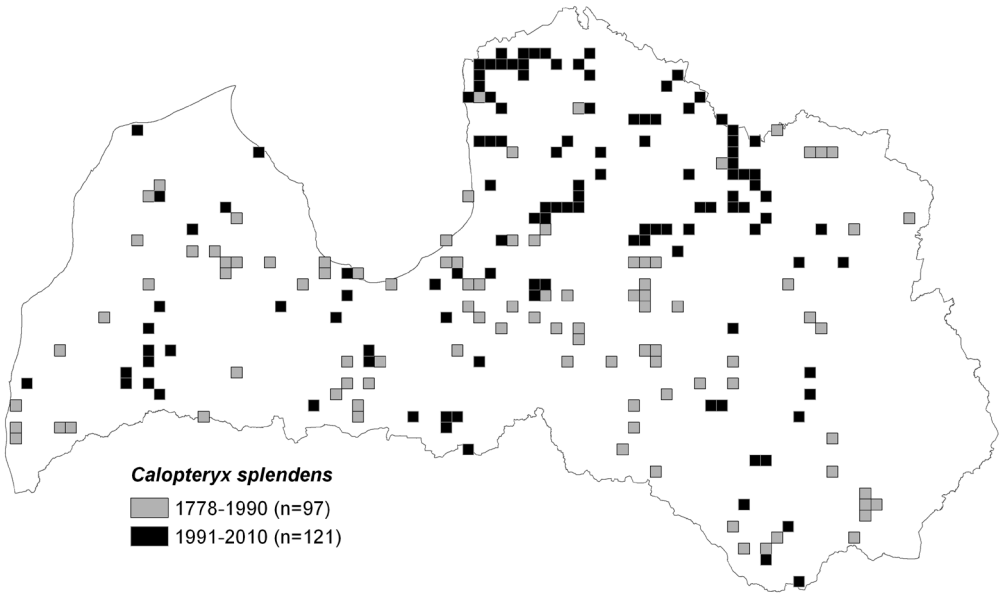
Шешурак П.Н. 1999. К изучению энтомофауны национального парка Припятский. Стрекозы (Odonatoptera) [To the knowledge of the insect fauna of the Prypyatskiy national Park. Dragonflies (Odonatoptera)]. In: *Биологическое разнообразие Национального парка Припятский и других особо охраняемых природных территорий.* Туров-Мозырь, Национальный парк Припятский: 217-221.

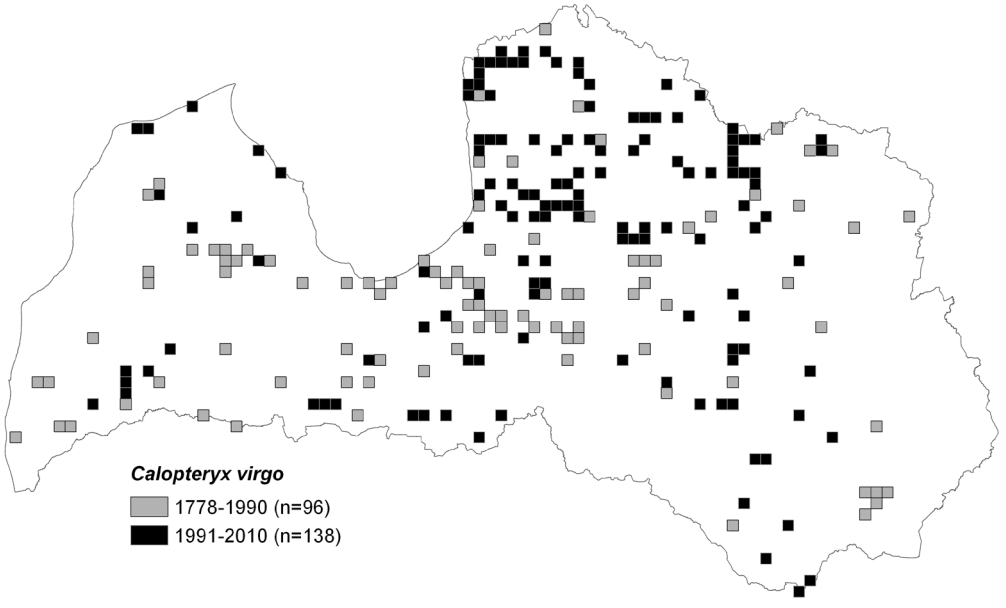
Received: December 28, 2011.

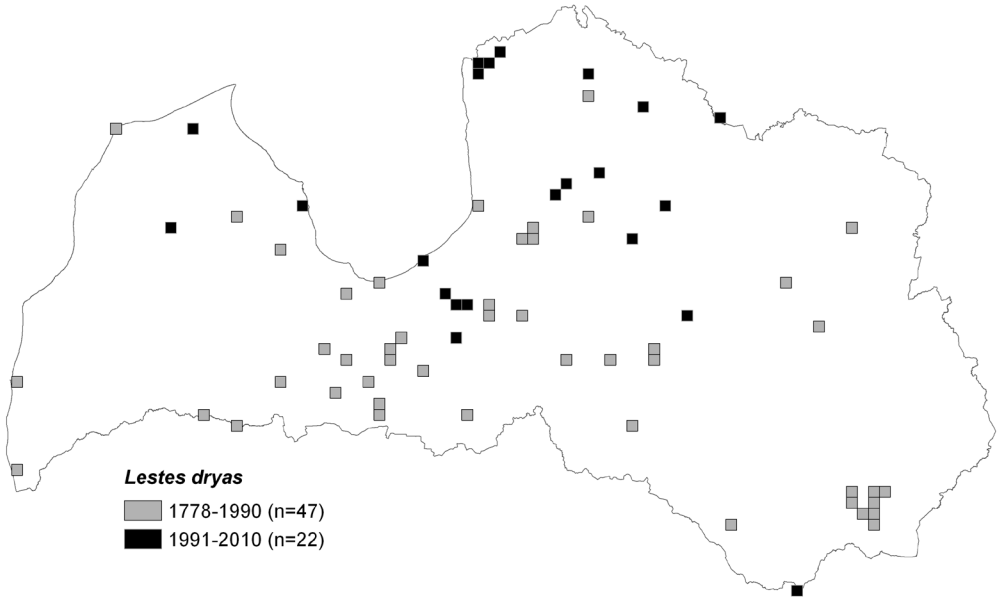
Table 1. Potential species of dragonflies (Odonata) for the fauna of Latvia. For each species the approximate distance (D) in kilometres to the nearest foreign locality and the source of this record is given. The presence of each species is indicated for the adjacent countries – Estonia (EE), European part or Russia (RU), Belarus (BY), Lithuania (LT) and Poland (PL) (modified after Kalniņš 2011b).

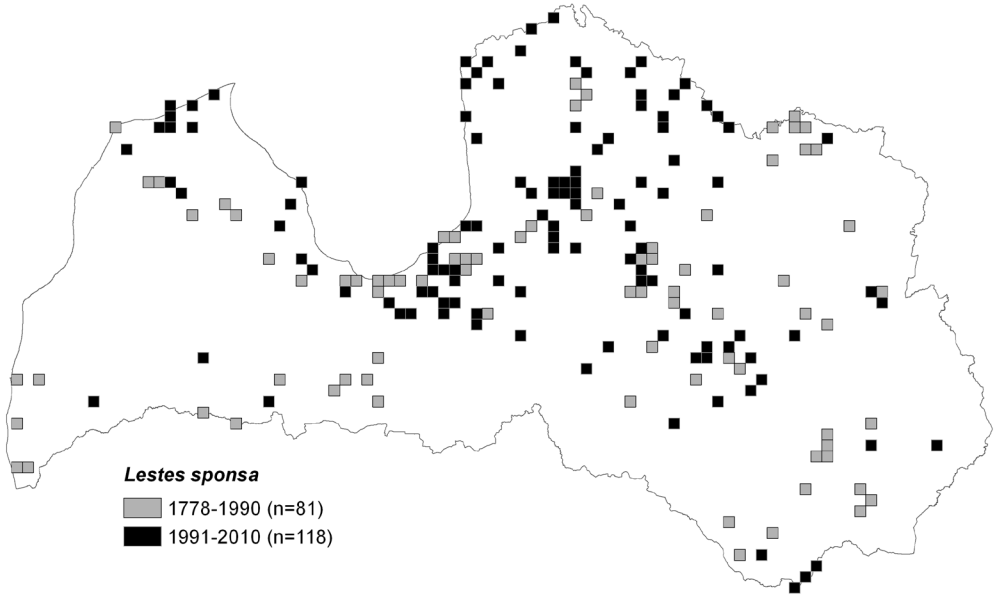
| Species | D | Source | EE | RU | BY | LT | PL |
|---|---|---|---|---|---|---|---|
| *1. Lestes barbarus* (Fabricius, 1798) | 130<br>230 | Prüffer 1952 (historical data); Briliūtė, Budrys 2007 (contemporary data) | - | + | + | + | + |
| *2. Lestes viridis* (Vander Linden, 1825) | 130 | Stanionytė 1993 | - | - | + | + | + |
| *3. Sympecma fusca* (Vander Linden, 1820) | 30<br>230 | Junevičienė et al. 2007; Bernard et al. 2009 | - | + | + | + | + |
| *4. Coenagrion ornatum* (Sélys, 1850) | 180 ?<br>~400 | Buczyński et al. 2006; Шешурак 1999 | - | + | + | - | + |
| *5. Erythromma viridulum* (Charpentier, 1840) | ~100 | Tishchikov, Tishchikov 2000 | - | + | + | + | + |
| *6. Aeshna affinis* Vander Linden, 1820 | 60 | Bernard 2005 | - | + | + | + | + |
| *7. Aeshna serrata* Hagen, 1856 | 50 | Martin et al. 2008 | + | + | - | - | - |
| *8. Orthetrum albistylum* (Sélys, 1848) | 250 | Buczyński, Pakulnicka 2000 | - | + | + | - | + |
| *9. Orthetrum coerulescens* (Fabricius, 1798) | 60 | Stanionytė 1993; Martin et al. 2008 | + | + | - | + | + |
| *10. Sympetrum depressiusculum* (Sélys, 1841) | 10 | Stanionytė 1963, 1991 | - | + | + | + | + |
| *11. Sympetrum meridionale* (Sélys, 1841) | 300 | Bernard et al. 2009; Skvortsov 2010 | - | + | + | - | + |
| *12. Crocothemis erythraea* (Brullé, 1832) | 350 | Kalkman, Dijkstra 2000 | - | +? | - | - | + |

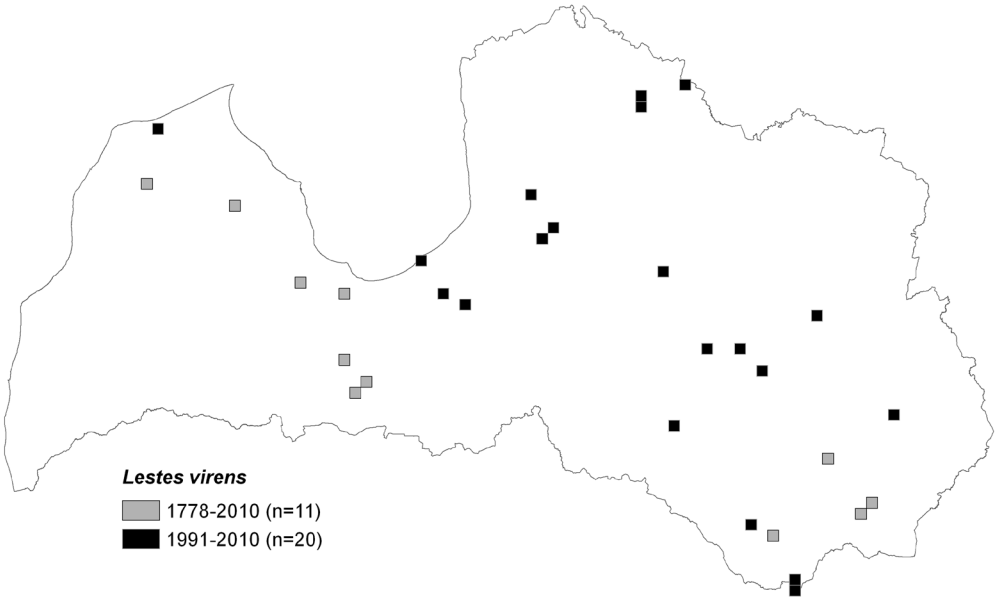
## Distribution maps

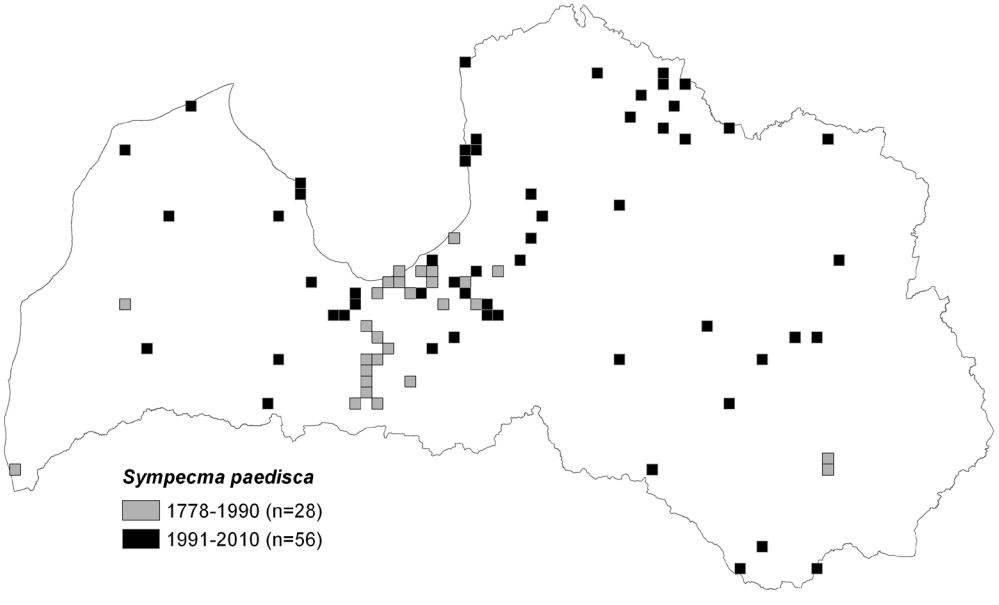


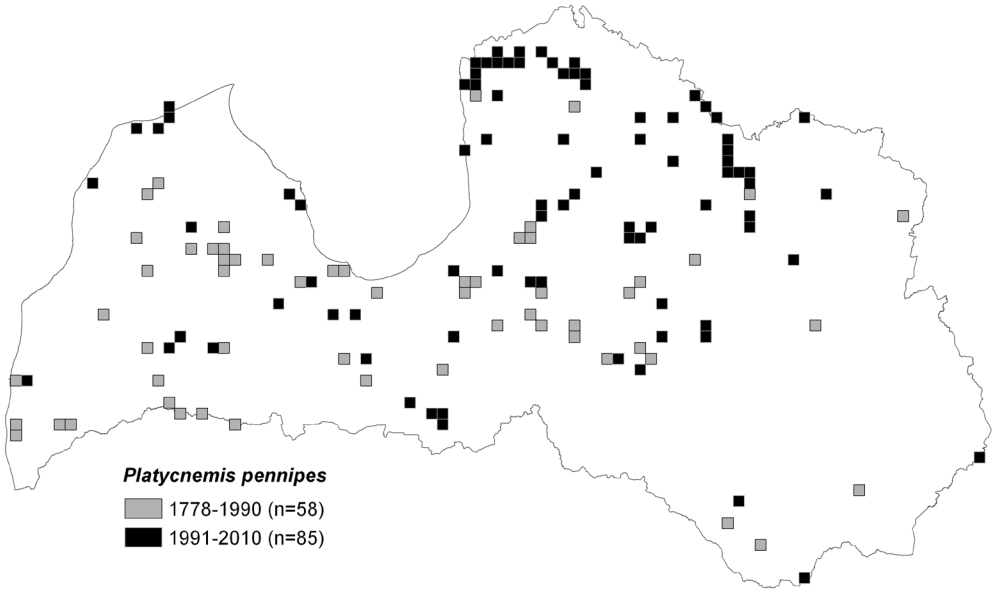



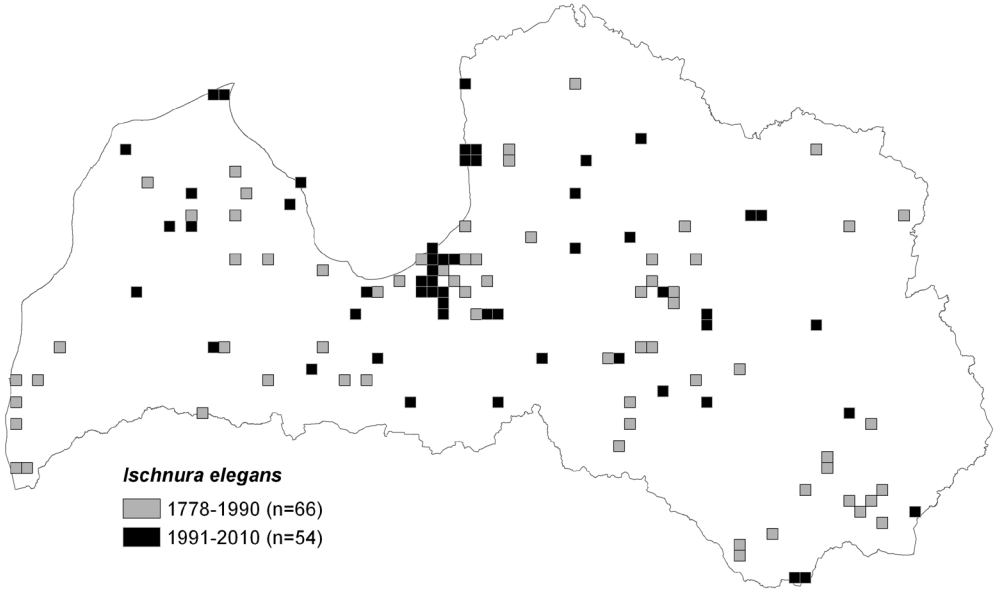

Lestes dryas
1778-1990 (n=47)
1991-2010 (n=22)

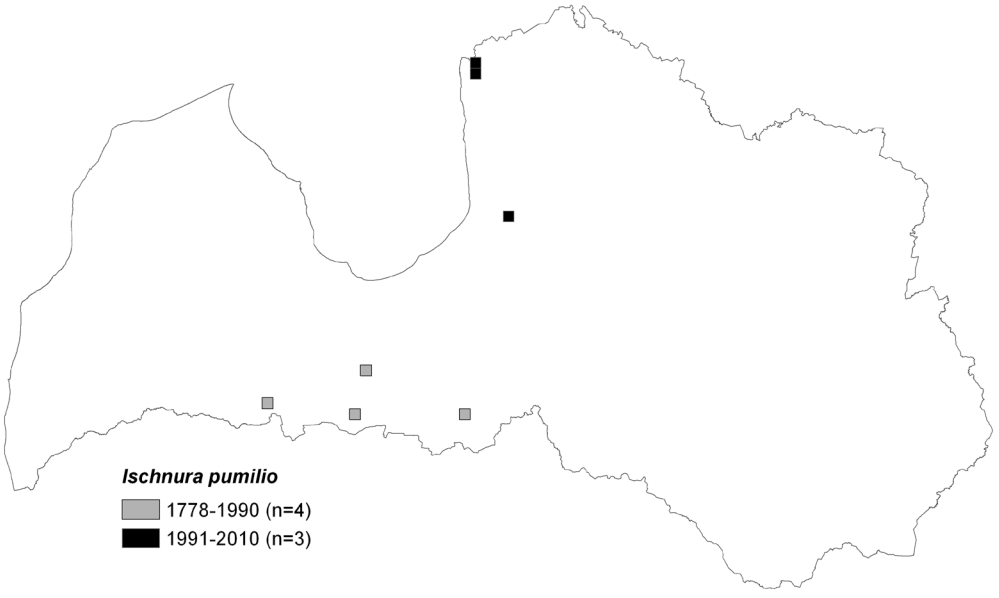

Lestes sponsa
1778-1990 (n=81)
1991-2010 (n=118)

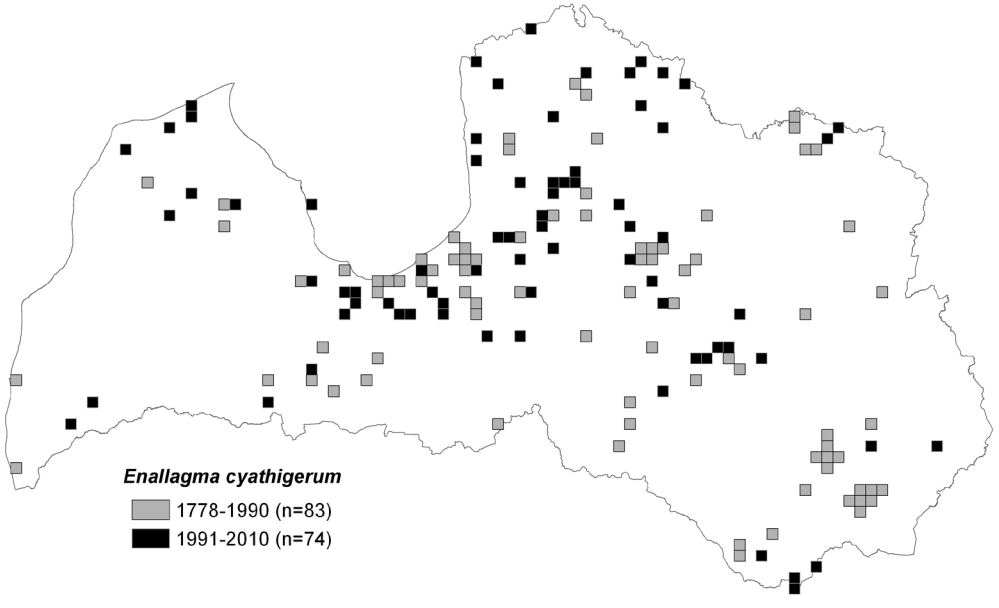

Lestes virens
1778-2010 (n=11)
1991-2010 (n=20)

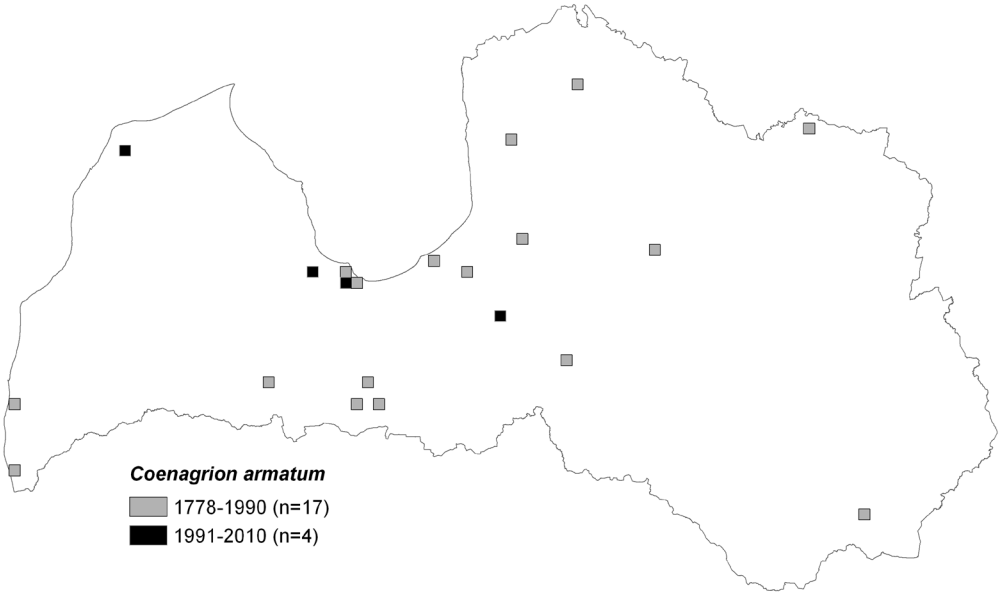

Sympecma paedisca
1778-1990 (n=28)
1991-2010 (n=56)

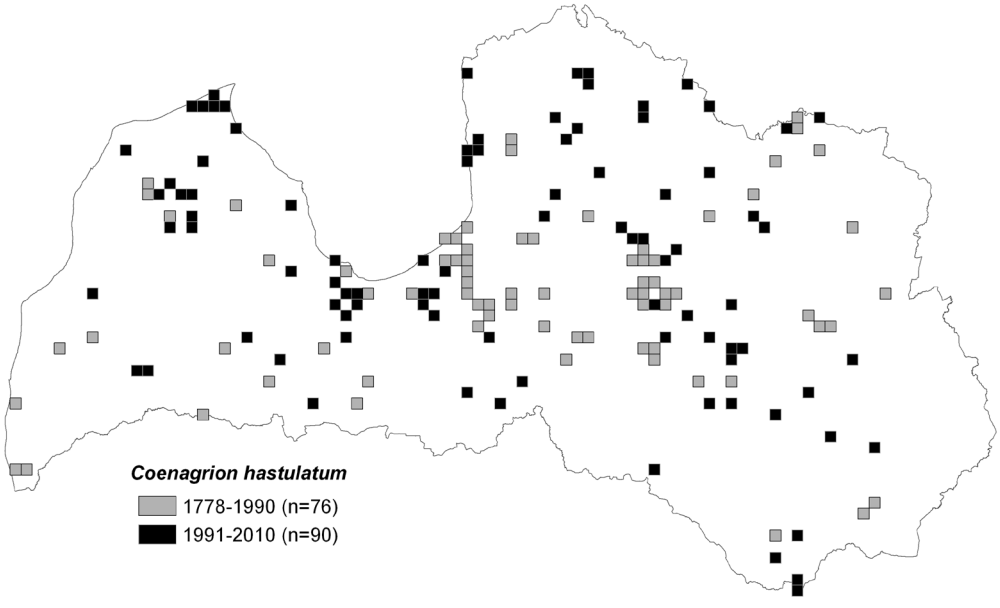

*Platycnemis pennipes*
1778-1990 (n=58)
1991-2010 (n=85)

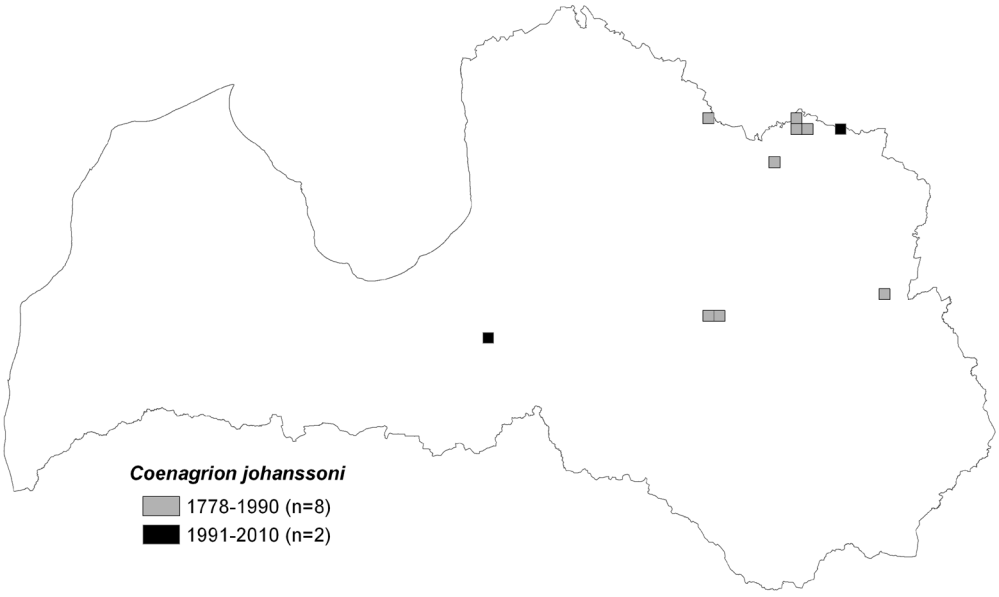

*Ischnura elegans*
1778-1990 (n=66)
1991-2010 (n=54)

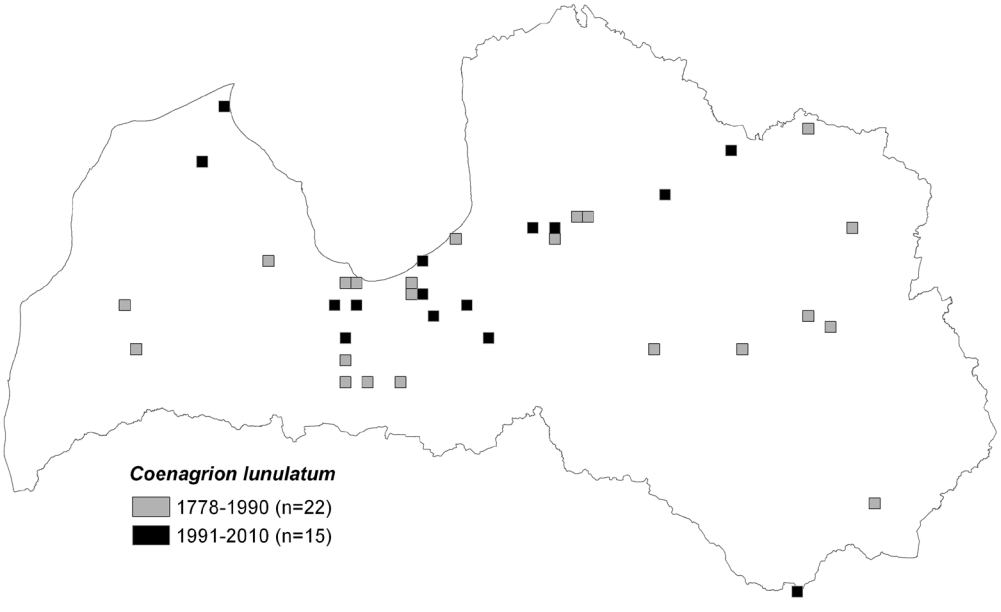

Ischnura pumilio
1778-1990 (n=4)
1991-2010 (n=3)

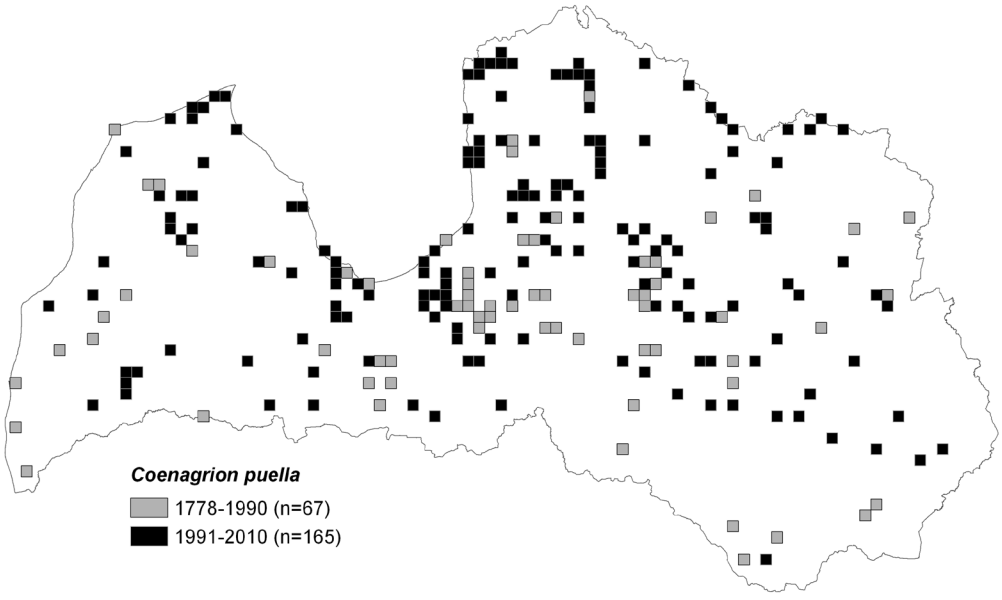

Enallagma cyathigerum
1778-1990 (n=83)
1991-2010 (n=74)

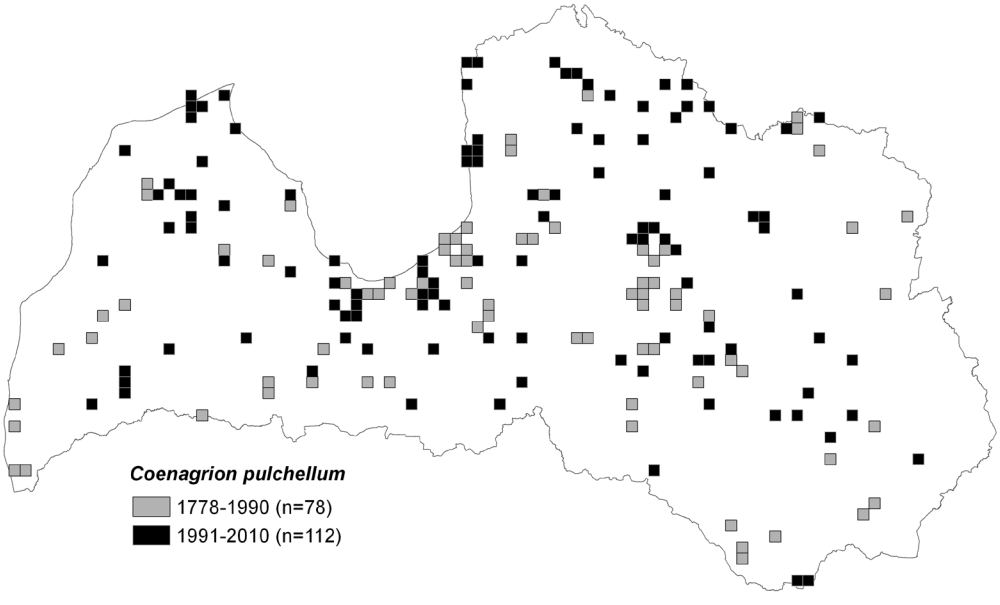

Coenagrion armatum
1778-1990 (n=17)
1991-2010 (n=4)

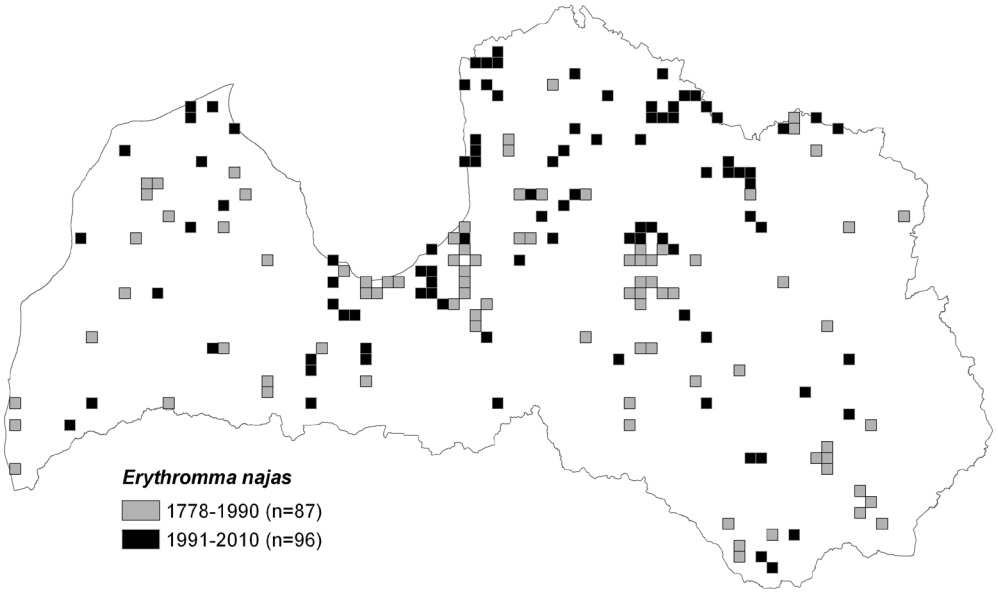

Coenagrion hastulatum
1778-1990 (n=76)
1991-2010 (n=90)

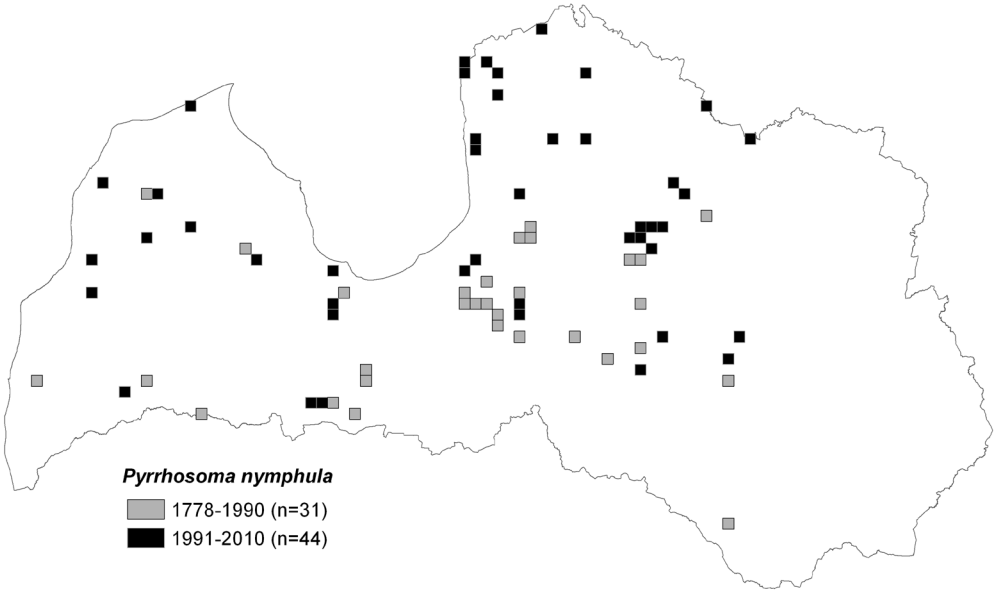

Coenagrion johanssoni
1778-1990 (n=8)
1991-2010 (n=2)

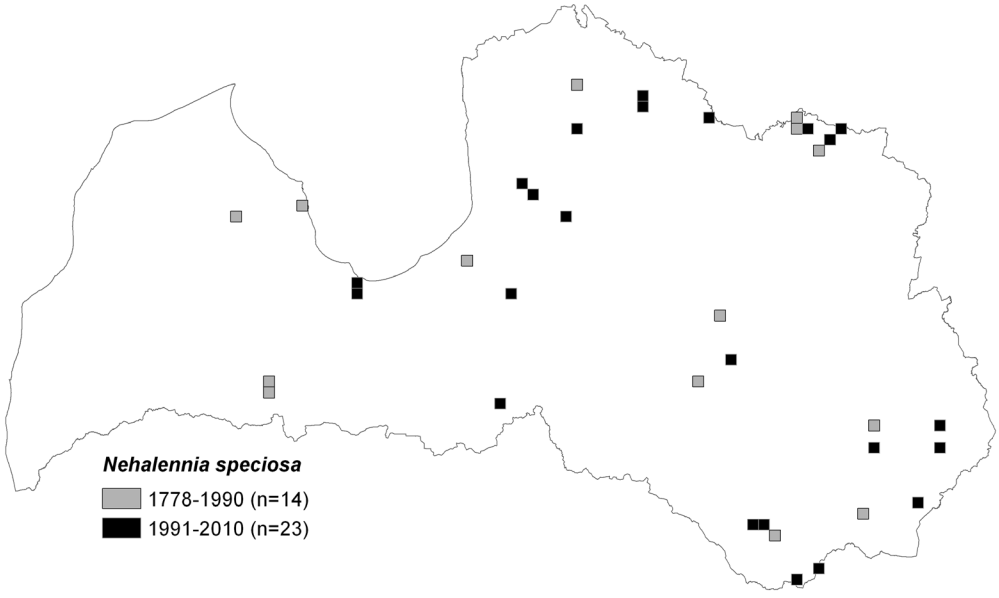

Coenagrion lunulatum
1778-1990 (n=22)
1991-2010 (n=15)

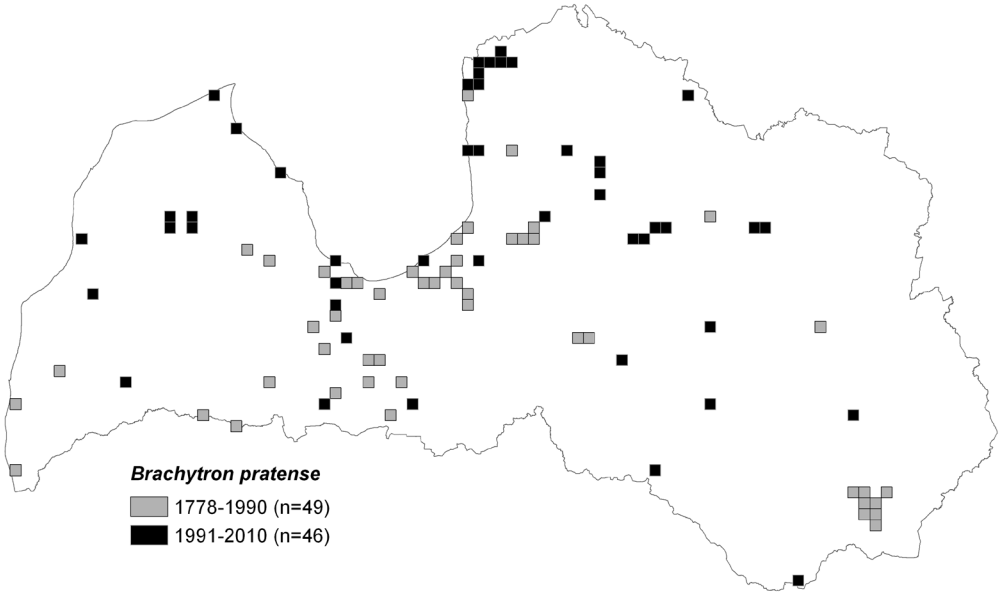

Coenagrion puella
1778-1990 (n=67)
1991-2010 (n=165)

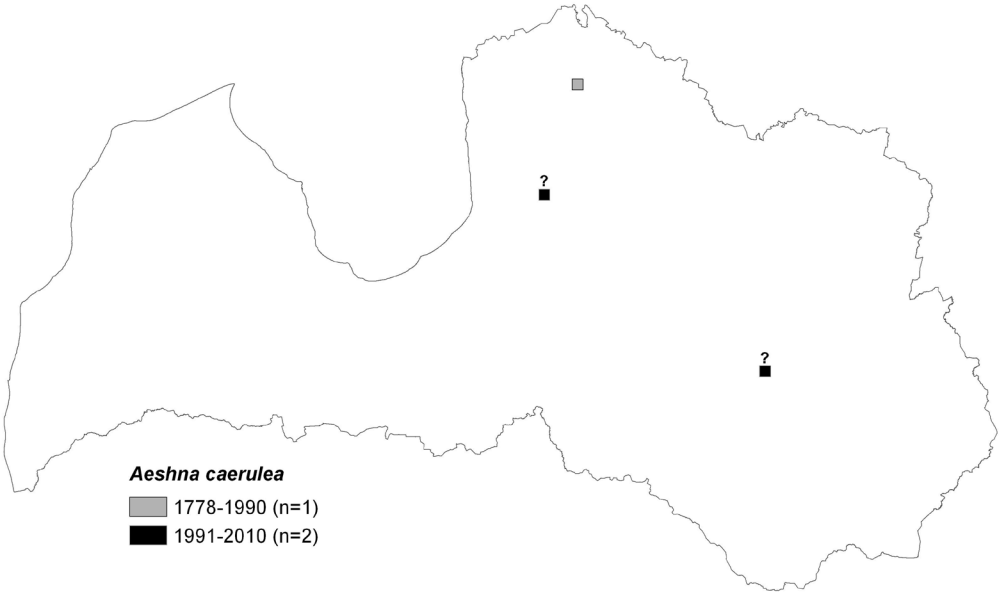

Coenagrion pulchellum
1778-1990 (n=78)
1991-2010 (n=112)

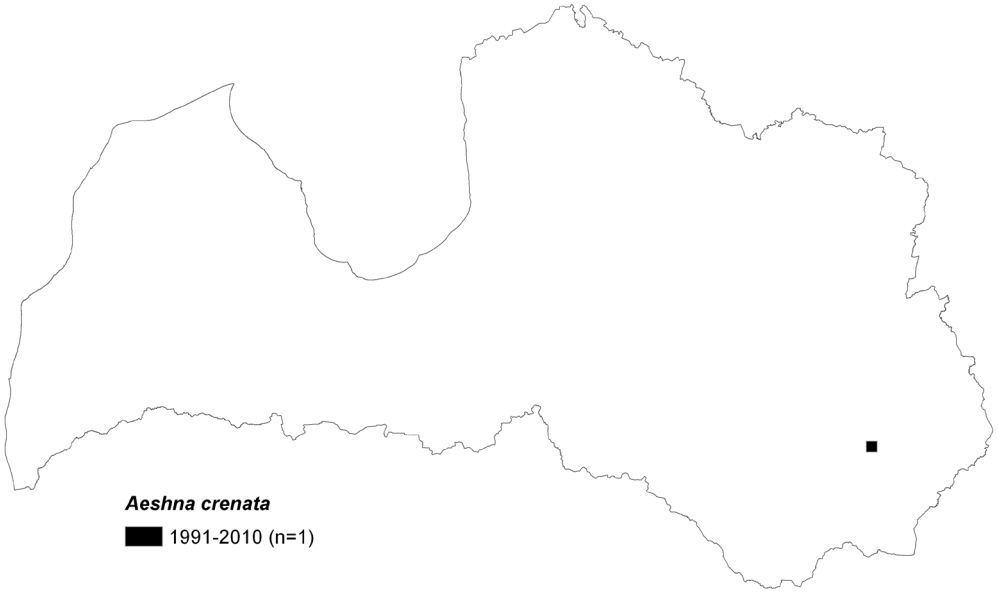

Erythromma najas
1778-1990 (n=87)
1991-2010 (n=96)

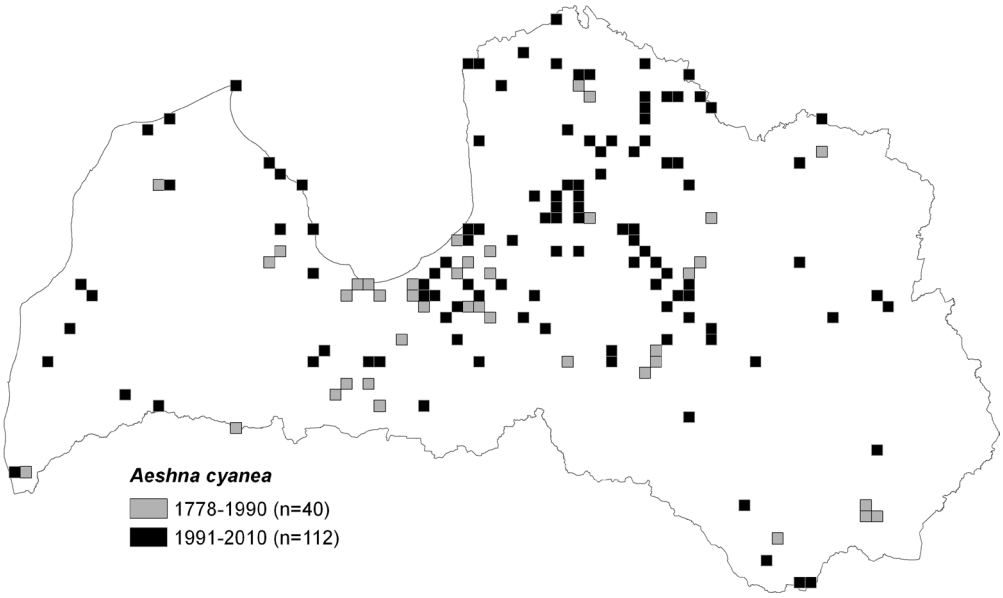

Pyrrhosoma nymphula
1778-1990 (n=31)
1991-2010 (n=44)

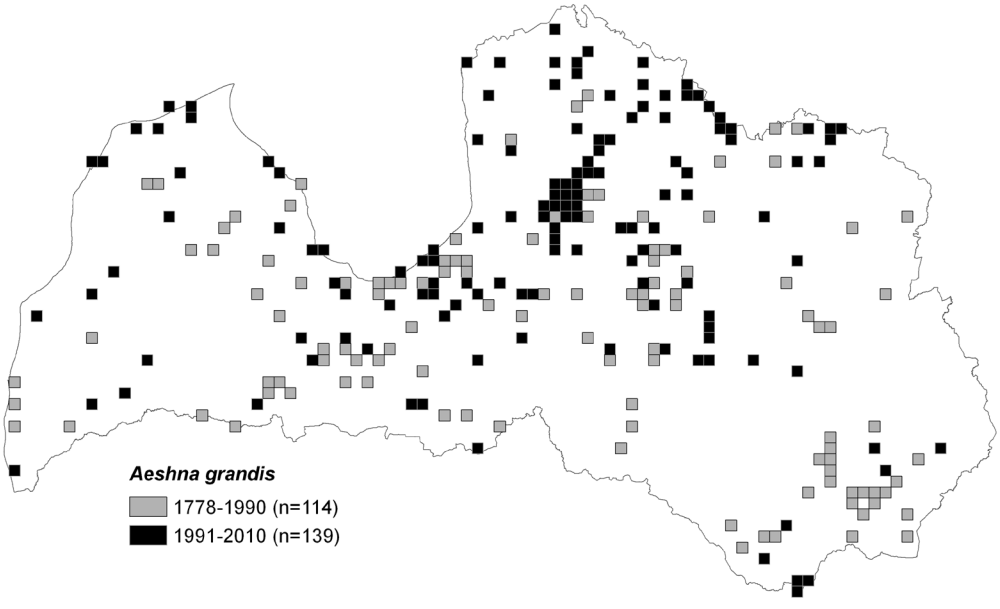

Nehalennia speciosa
1778-1990 (n=14)
1991-2010 (n=23)

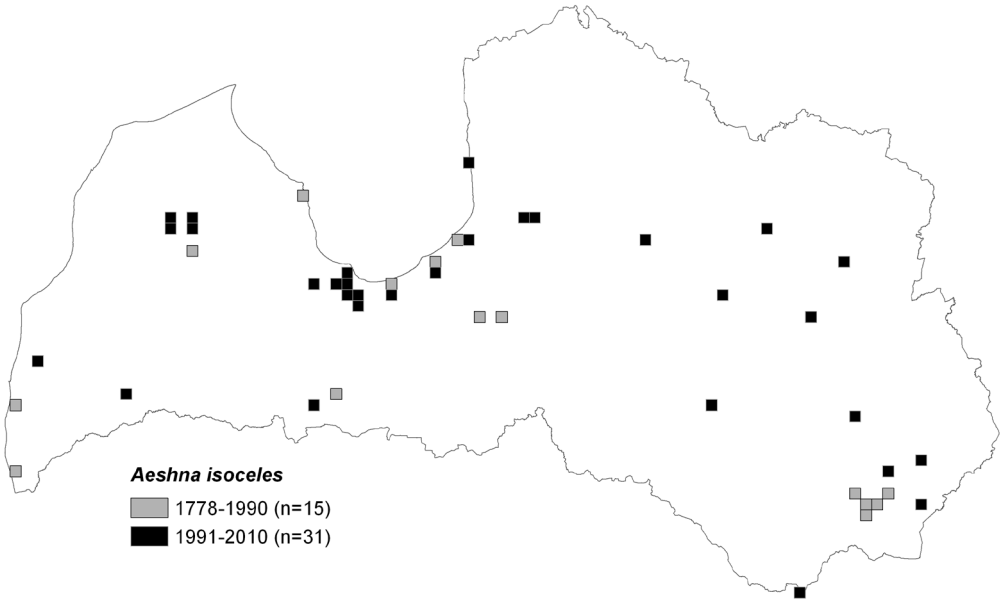

Brachytron pratense
1778-1990 (n=49)
1991-2010 (n=46)

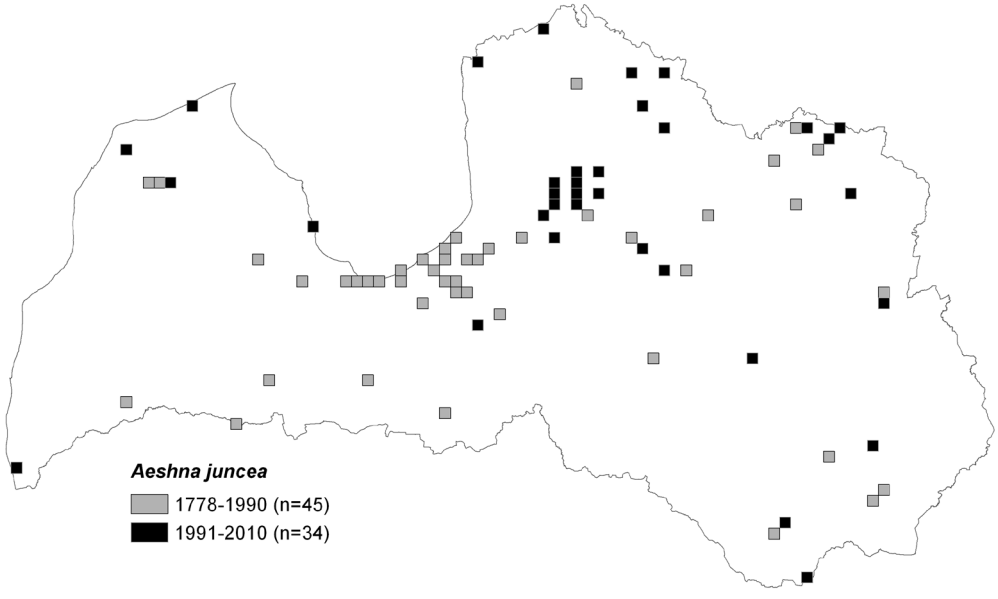

?
?
Aeshna caerulea
1778-1990 (n=1)
1991-2010 (n=2)

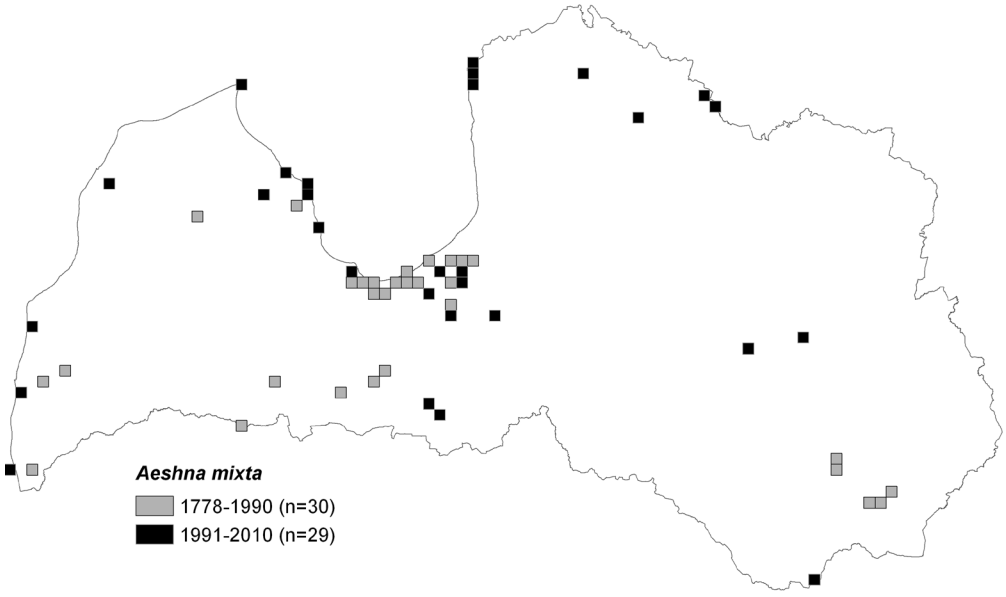

Aeshna crenata
1991-2010 (n=1)

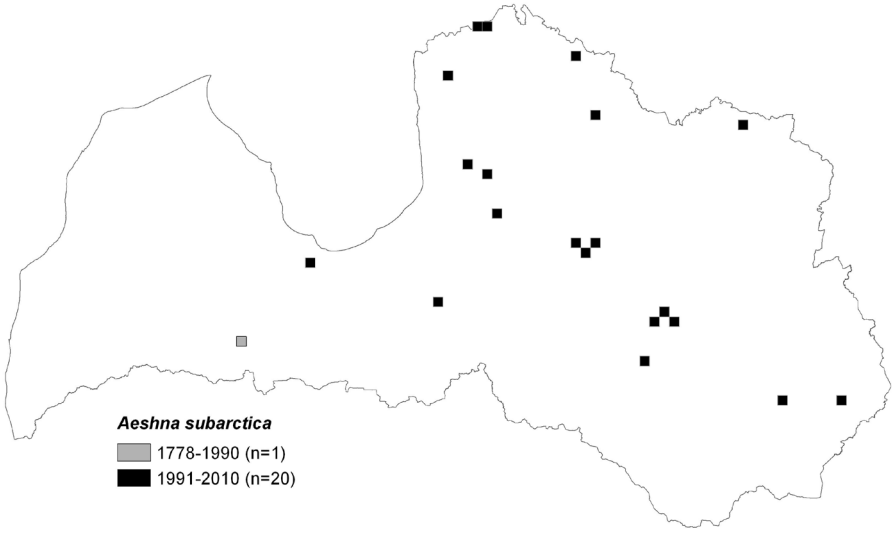

Aeshna cyanea
1778-1990 (n=40)
1991-2010 (n=112)

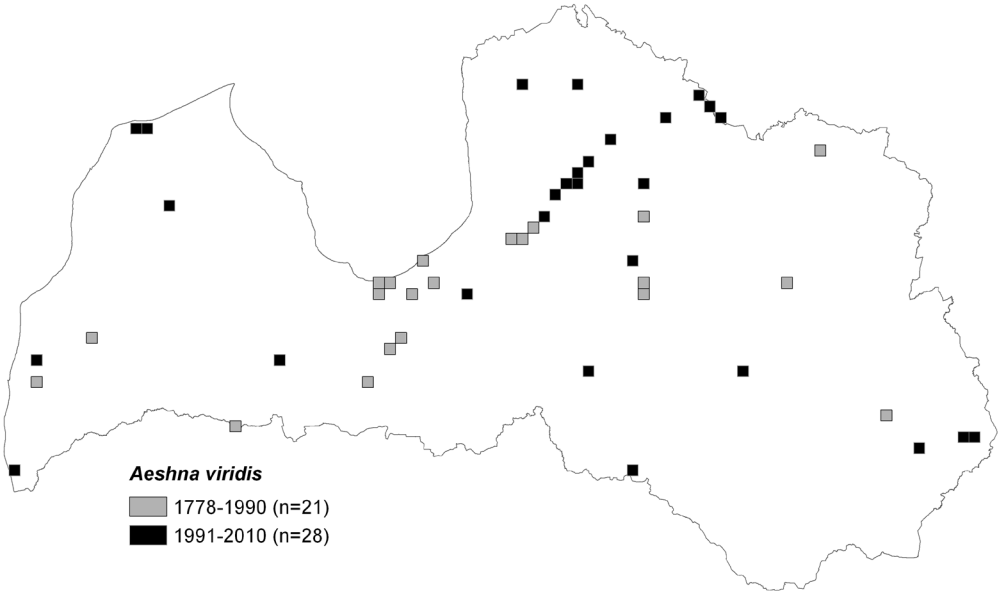

Aeshna grandis
1778-1990 (n=114)
1991-2010 (n=139)

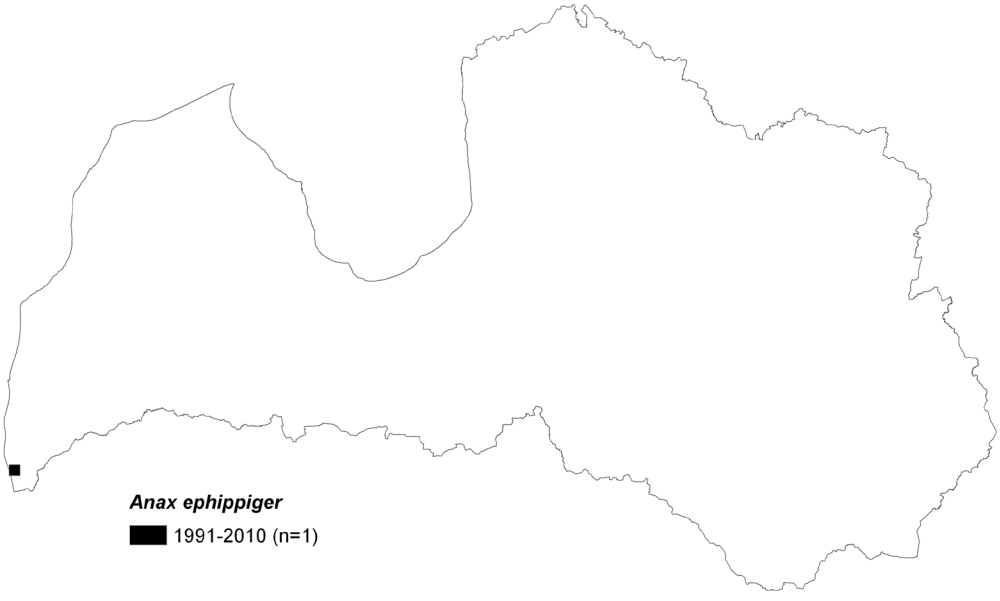

Aeshna isoceles
1778-1990 (n=15)
1991-2010 (n=31)

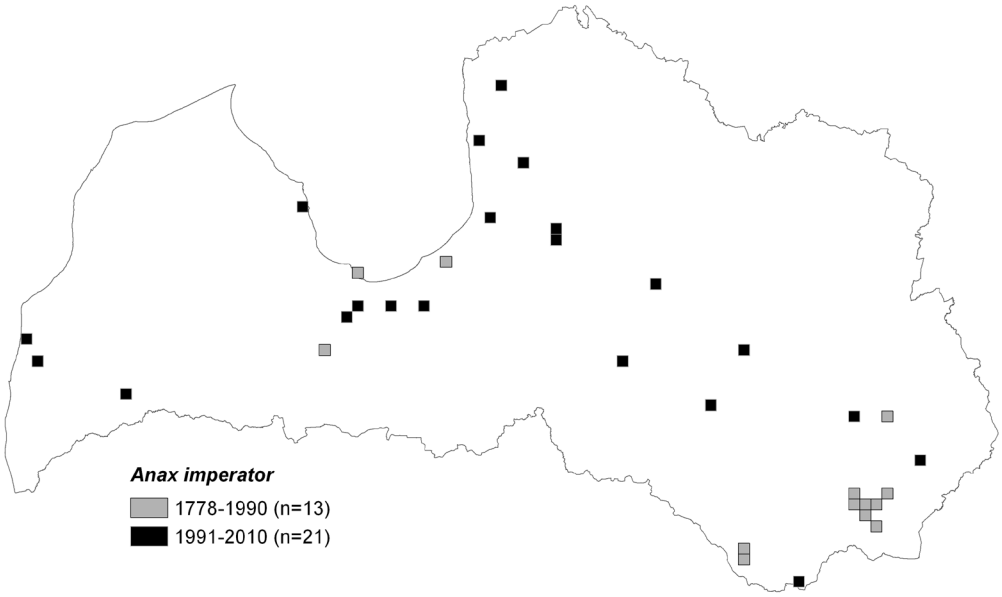

Aeshna juncea
1778-1990 (n=45)
1991-2010 (n=34)

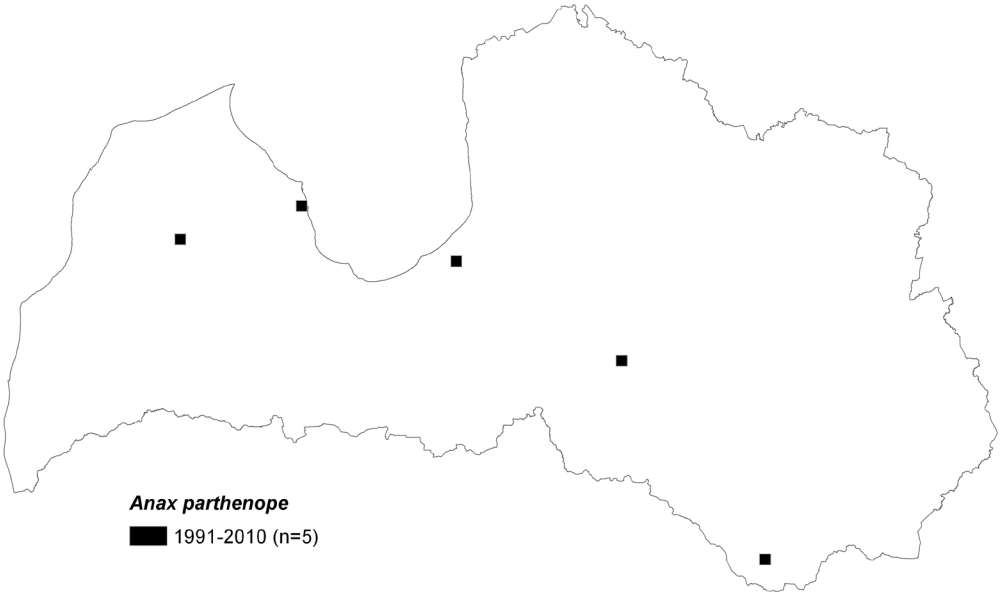

Aeshna mixta
1778-1990 (n=30)
1991-2010 (n=29)

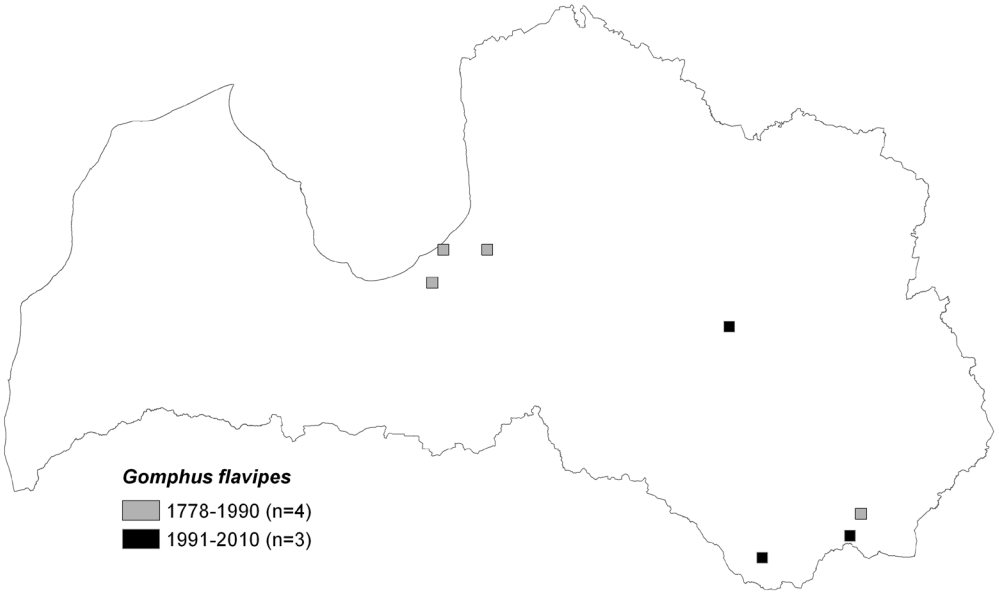

Aeshna subarctica
1778-1990 (n=1)
1991-2010 (n=20)

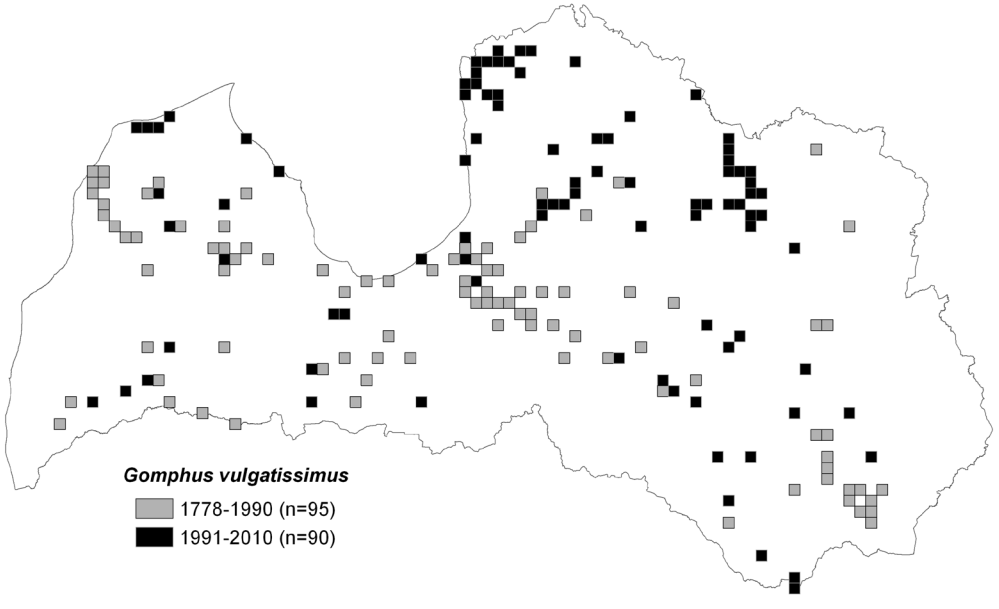

Aeshna viridis
1778-1990 (n=21)
1991-2010 (n=28)

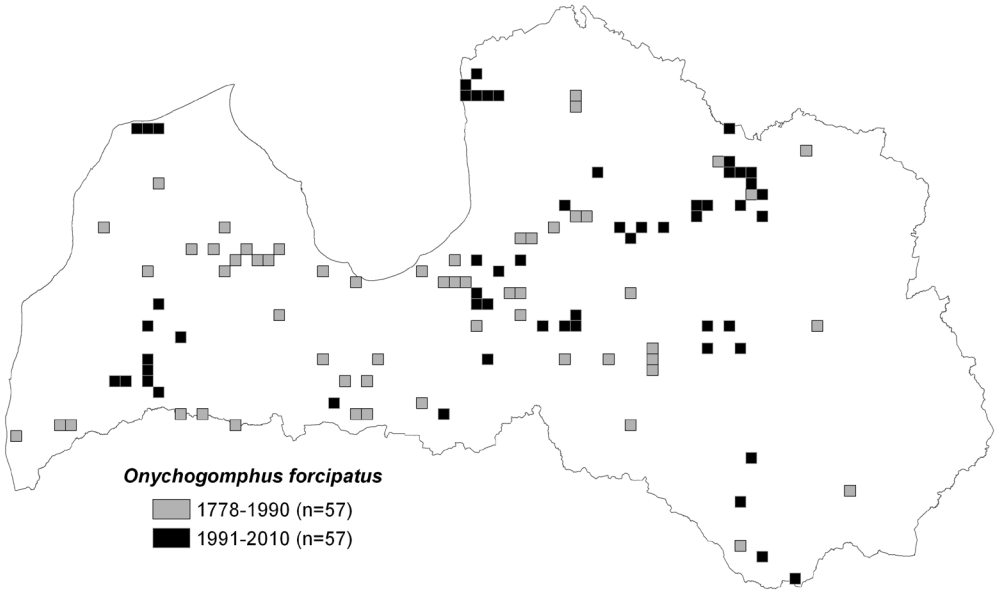

Anax ephippiger
1991-2010 (n=1)

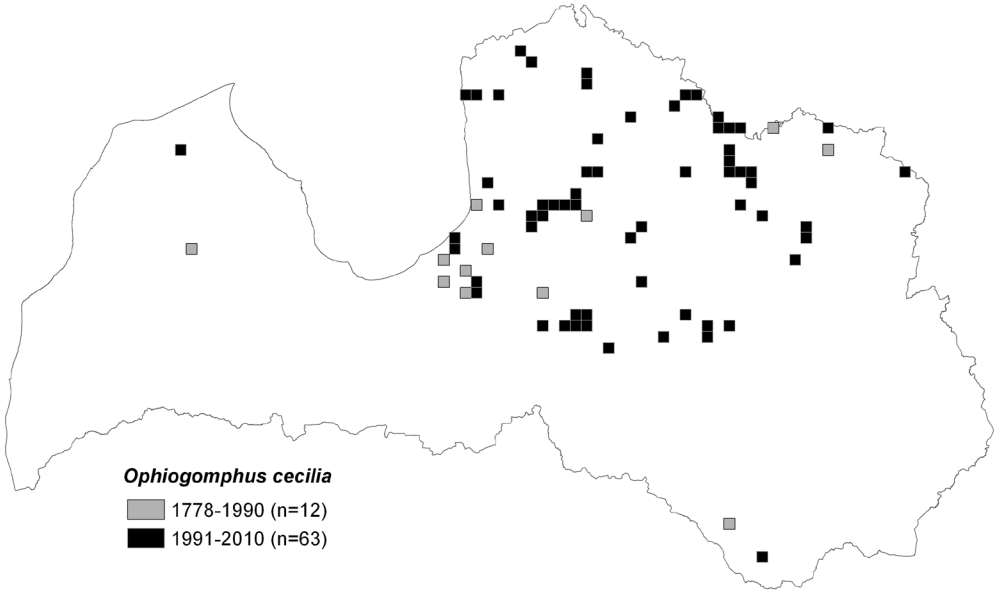

Anax imperator
1778-1990 (n=13)
1991-2010 (n=21)

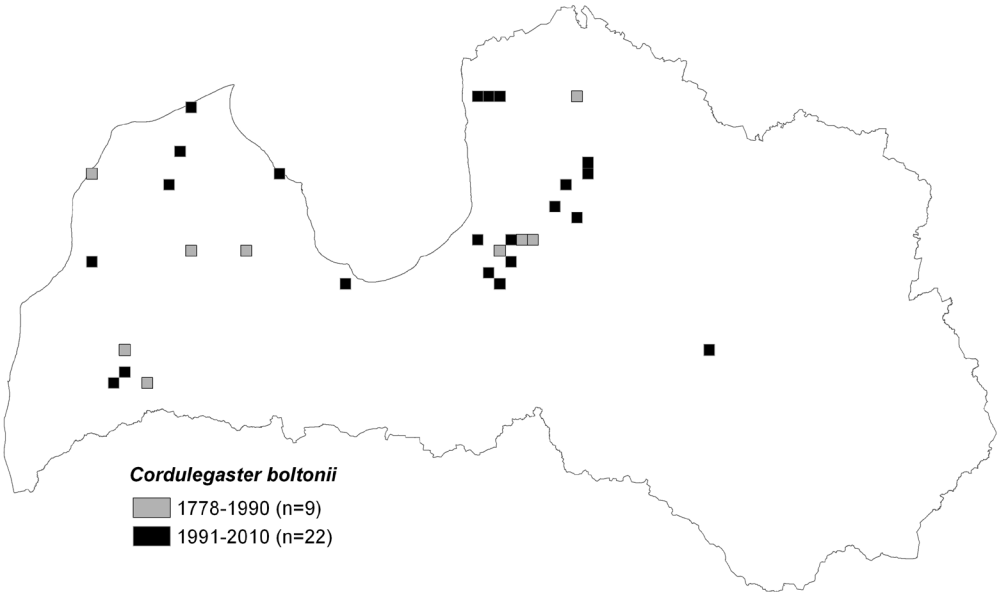

Anax parthenope
1991-2010 (n=5)

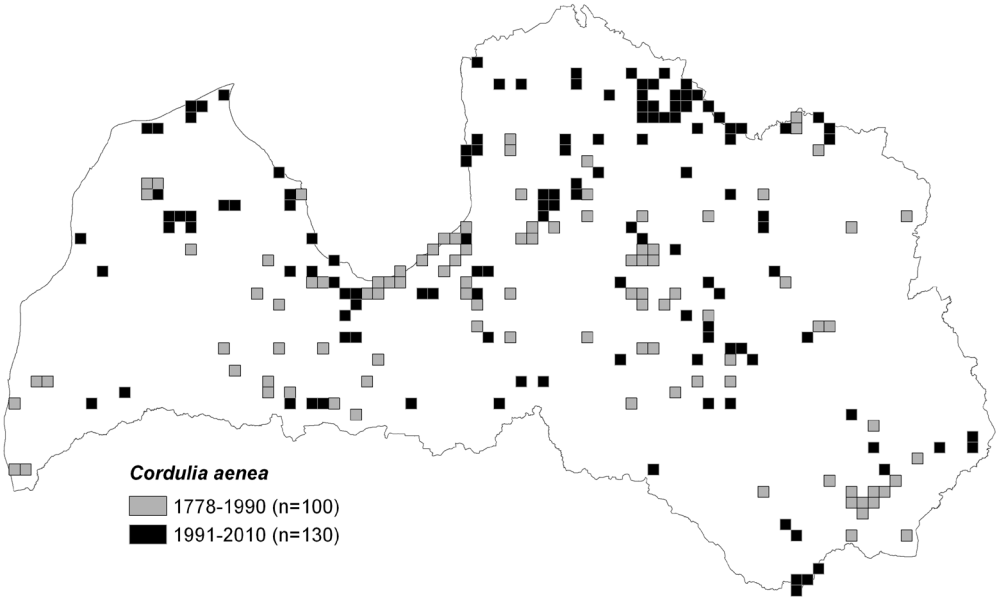

Gomphus flavipes
1778-1990 (n=4)
1991-2010 (n=3)

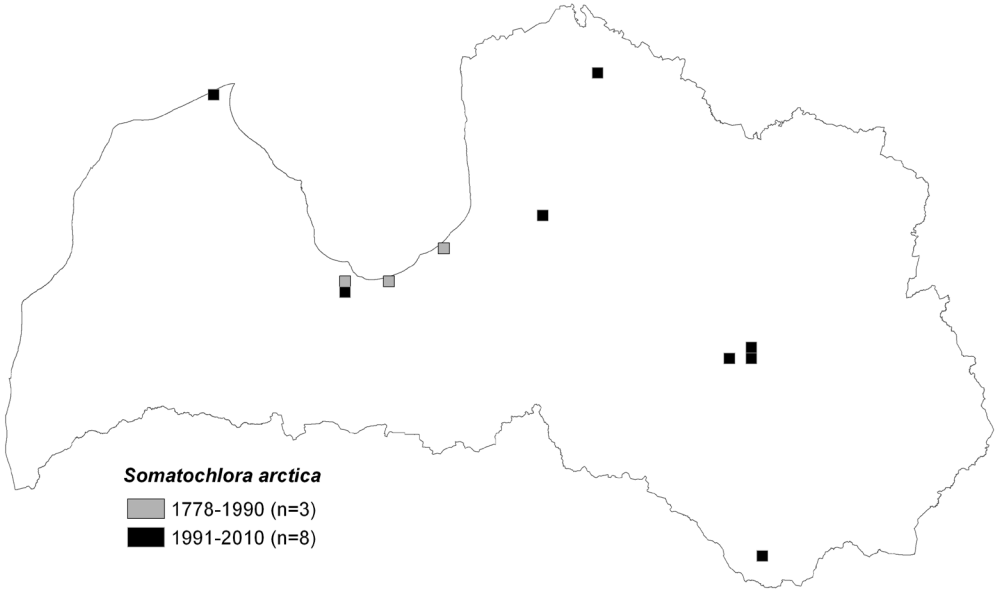

Gomphus vulgatissimus
1778-1990 (n=95)
1991-2010 (n=90)

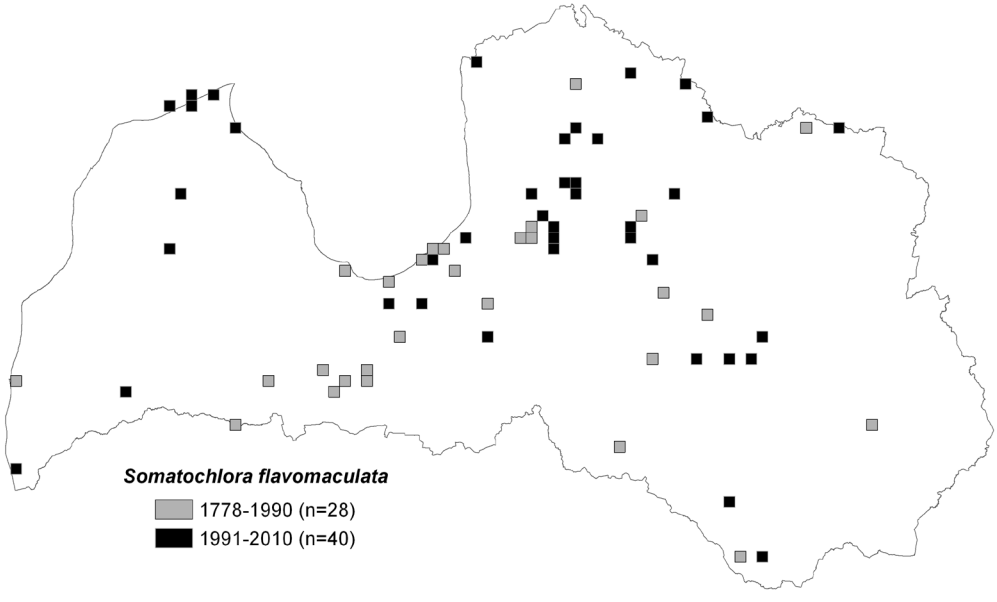

Onychogomphus forcipatus
1778-1990 (n=57)
1991-2010 (n=57)

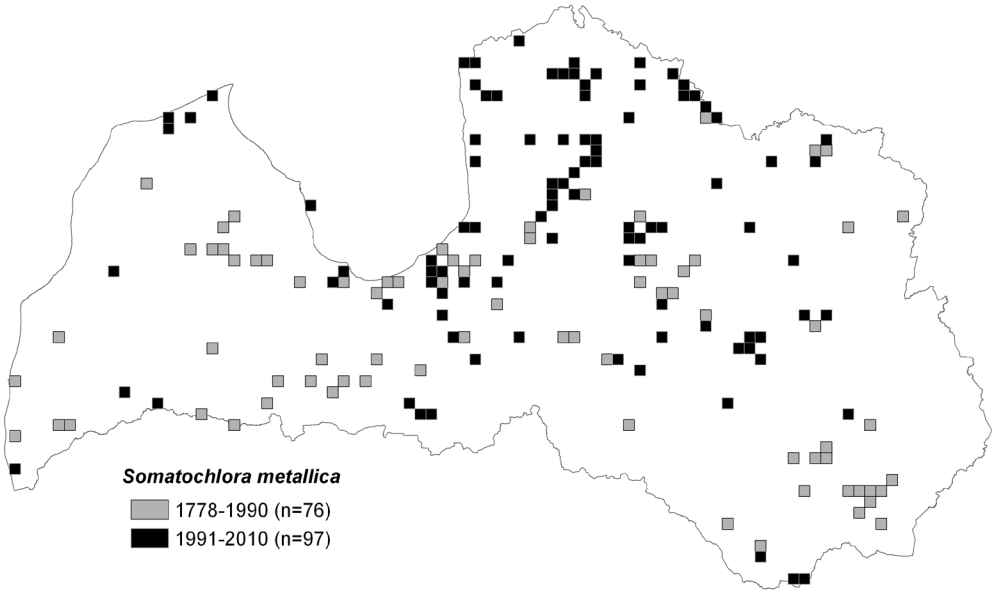

Ophiogomphus cecilia
1778-1990 (n=12)
1991-2010 (n=63)

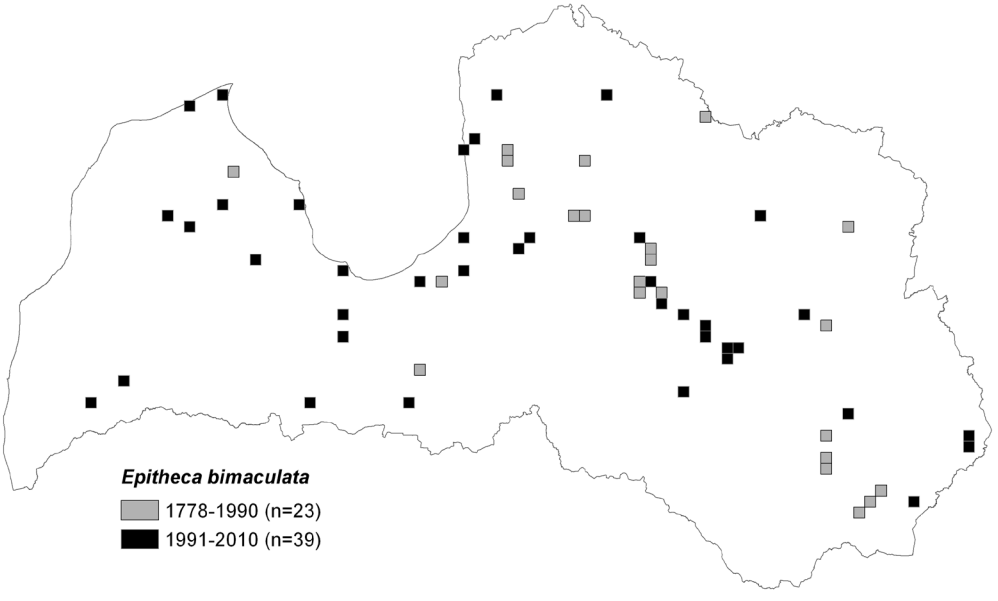

Cordulegaster boltonii
1778-1990 (n=9)
1991-2010 (n=22)

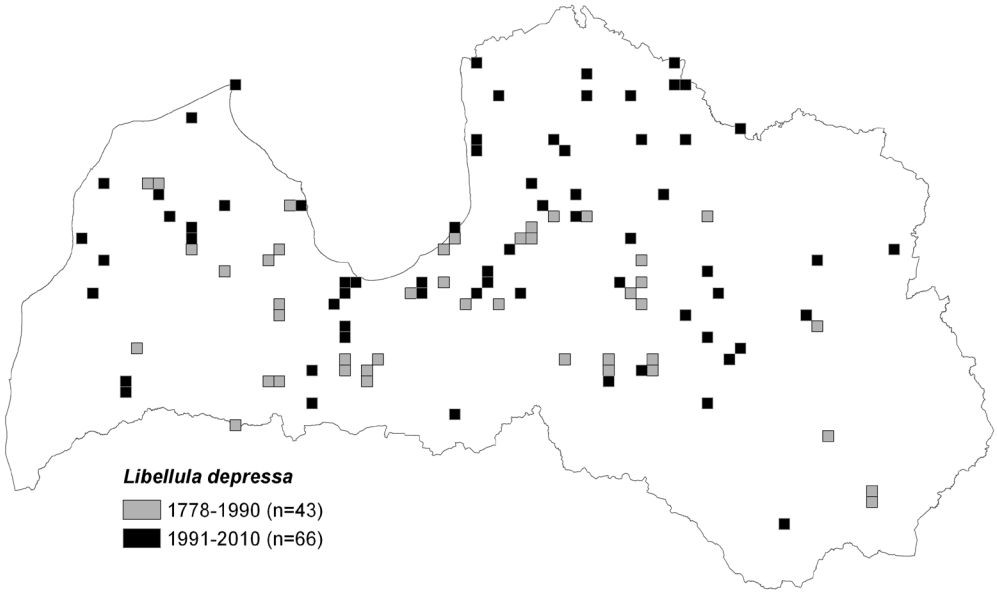

Cordulia aenea
1778-1990 (n=100)
1991-2010 (n=130)

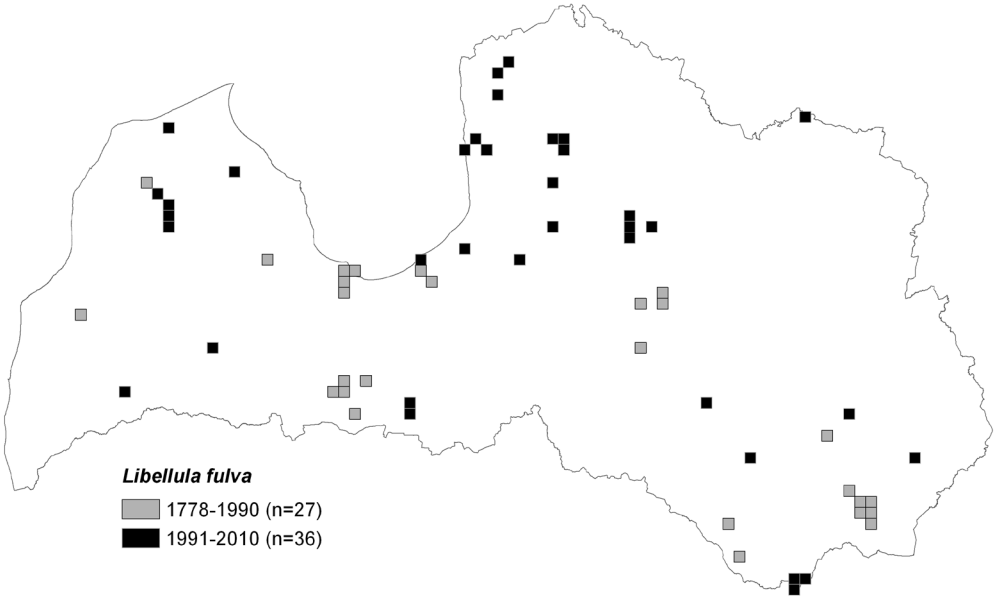

Somatochlora arctica
1778-1990 (n=3)
1991-2010 (n=8)

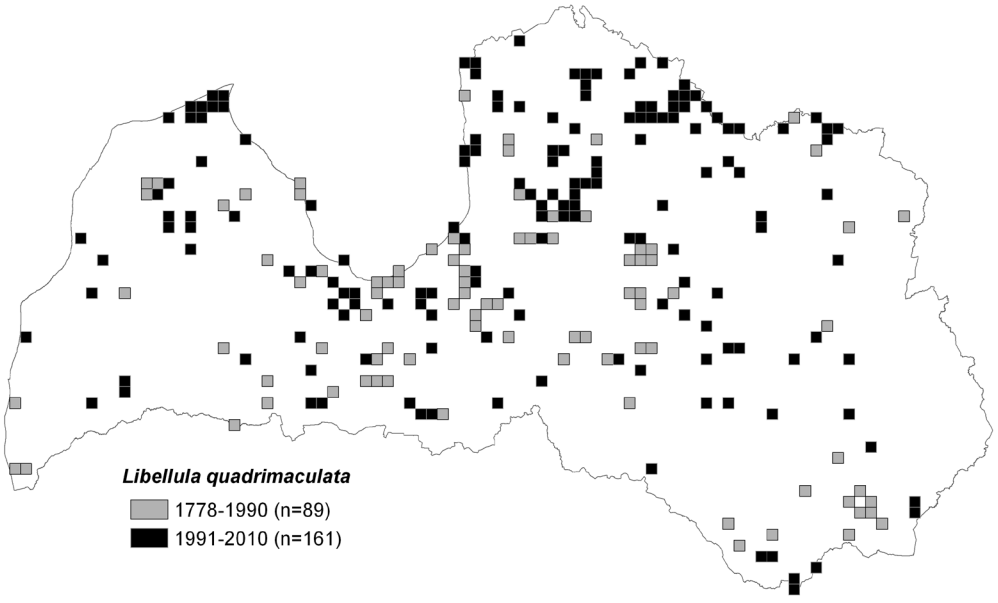

Somatochlora flavomaculata
1778-1990 (n=28)
1991-2010 (n=40)

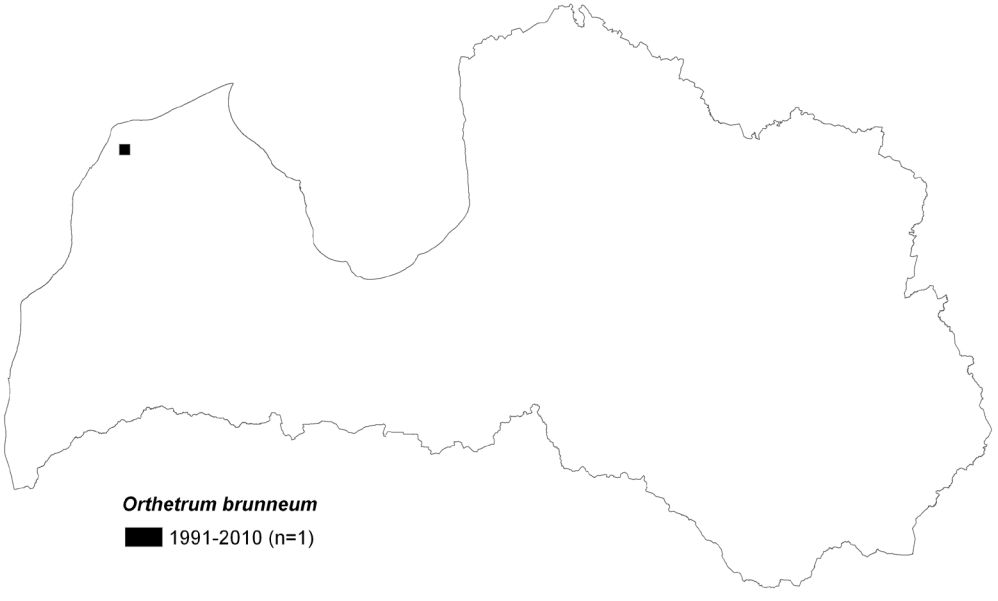

Somatochlora metallica
1778-1990 (n=76)
1991-2010 (n=97)

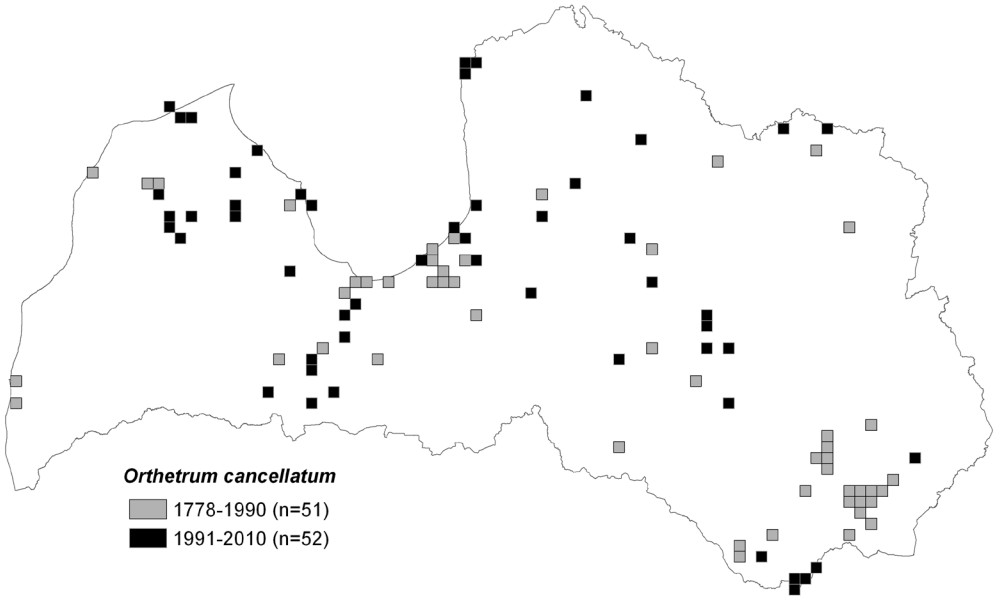

Epitheca bimaculata
1778-1990 (n=23)
1991-2010 (n=39)

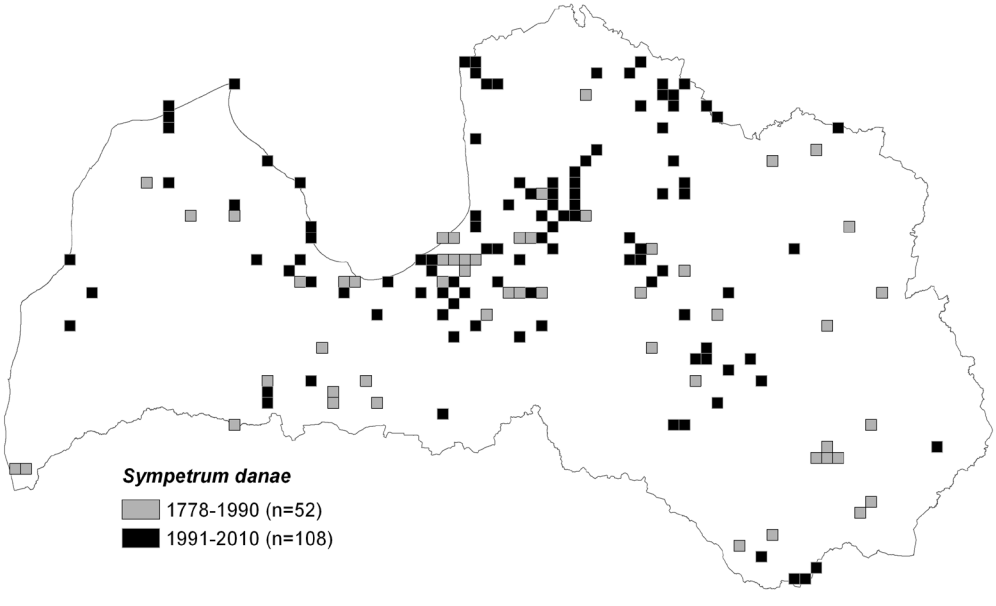

Libellula depressa
1778-1990 (n=43)
1991-2010 (n=66)

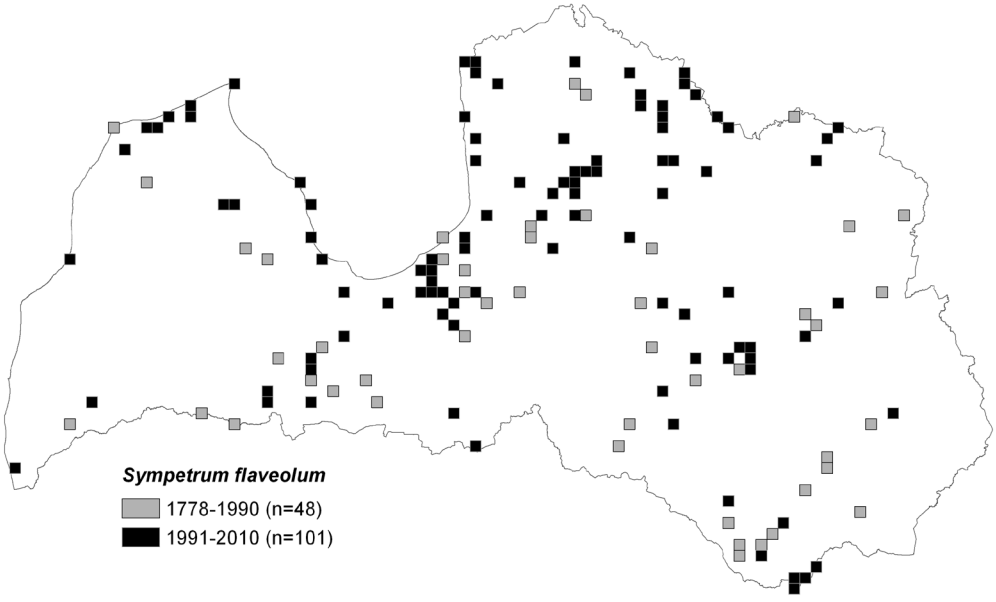

Libellula fulva
1778-1990 (n=27)
1991-2010 (n=36)

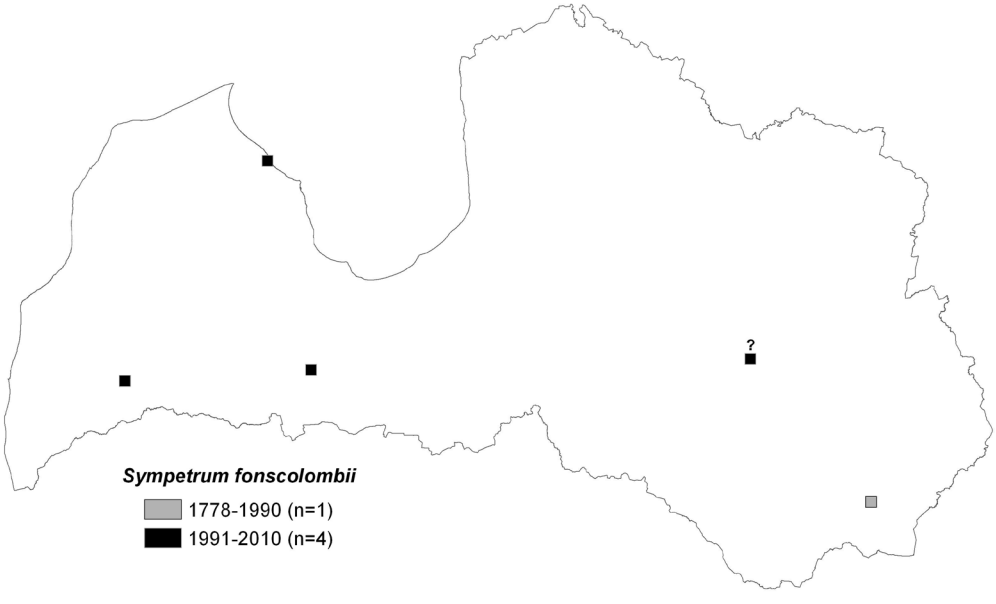

Libellula quadrimaculata
1778-1990 (n=89)
1991-2010 (n=161)

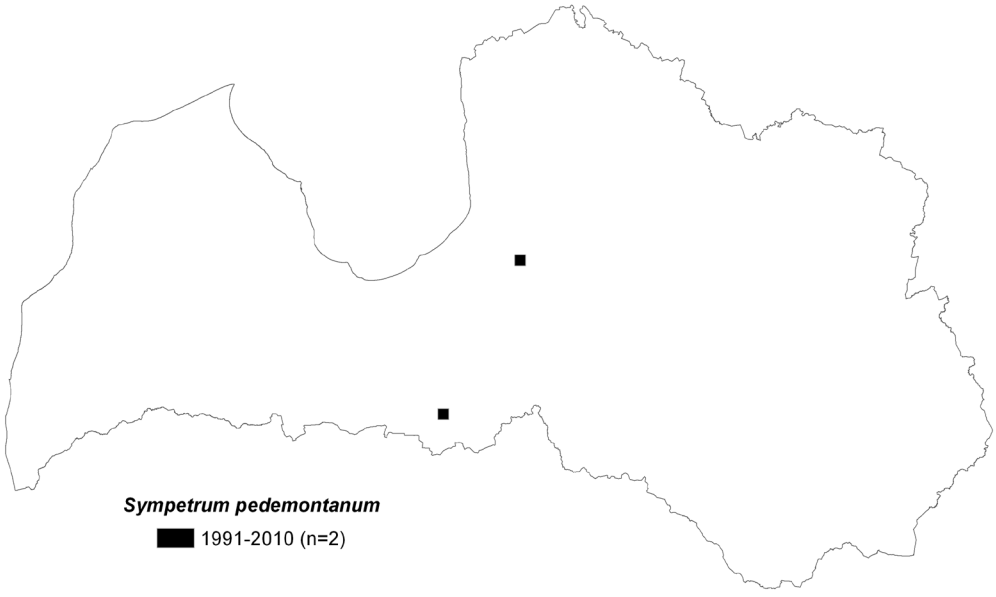

Orthetrum brunneum
1991-2010 (n=1)

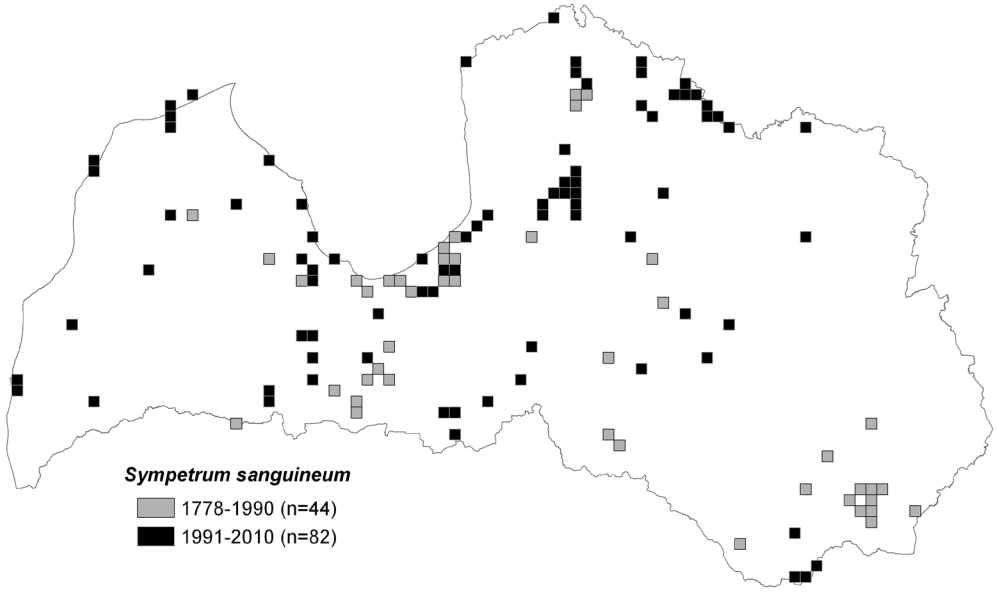

Orthetrum cancellatum
1778-1990 (n=51)
1991-2010 (n=52)

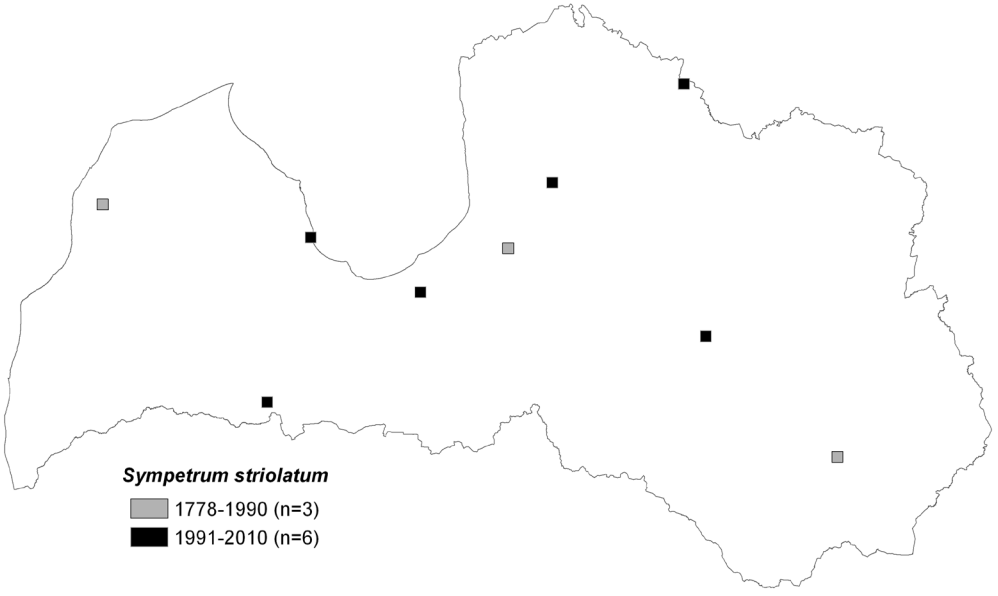

Sympetrum danae
1778-1990 (n=52)
1991-2010 (n=108)

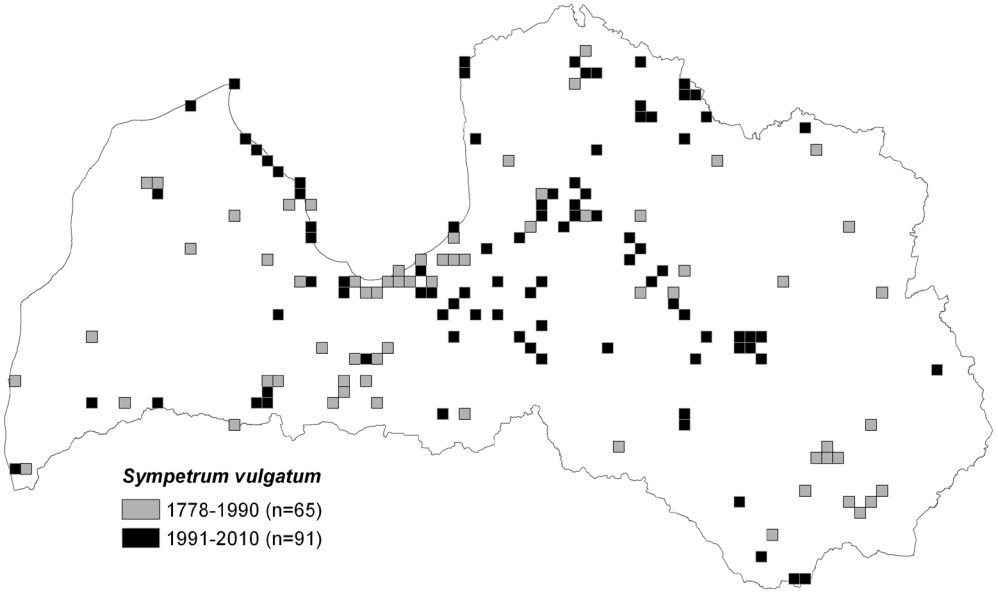

Sympetrum flaveolum
1778-1990 (n=48)
1991-2010 (n=101)

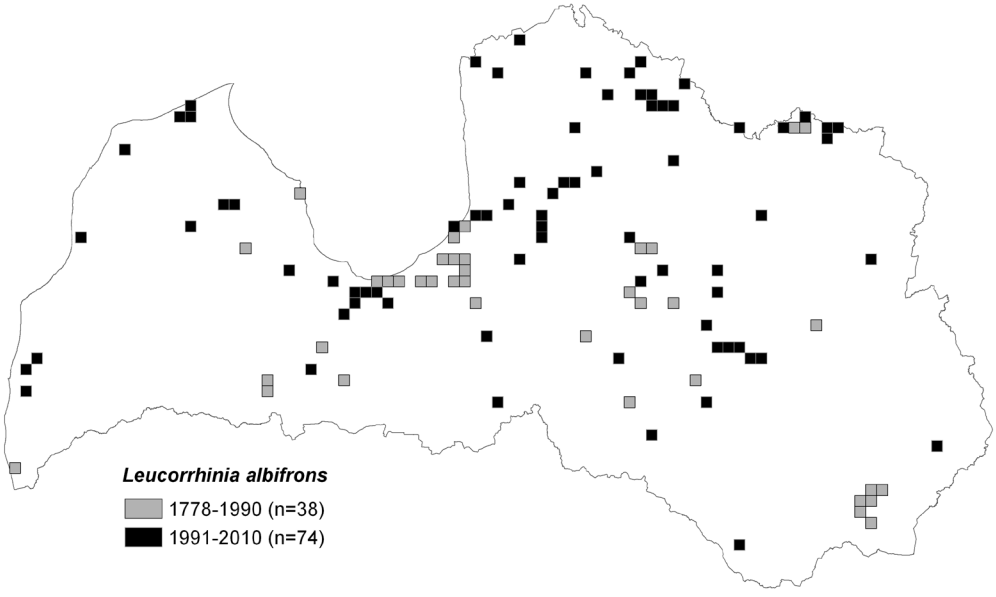

?
Sympetrum fonscolombii
1778-1990 (n=1)
1991-2010 (n=4)

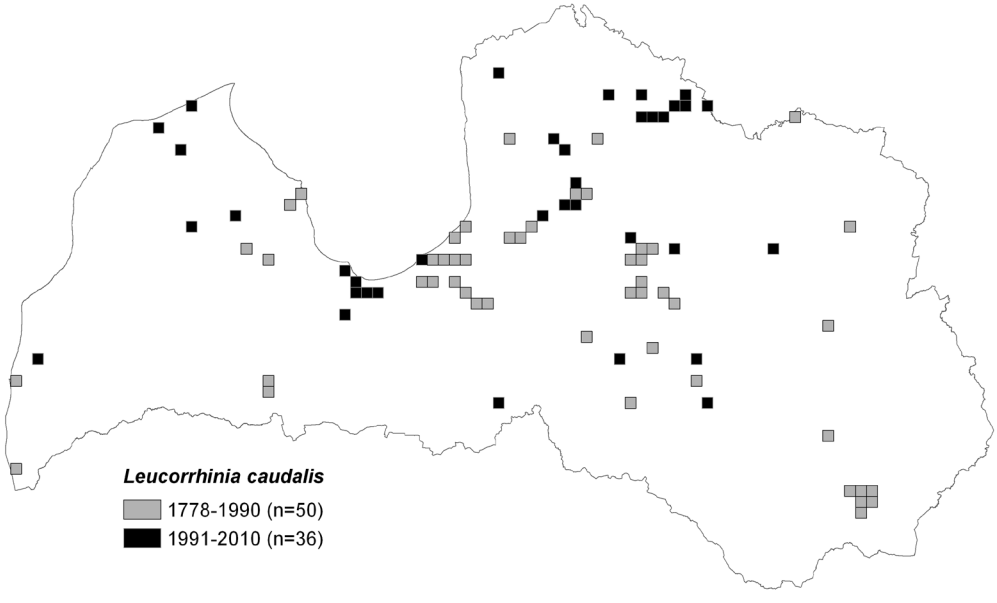

Sympetrum pedemontanum
1991-2010 (n=2)

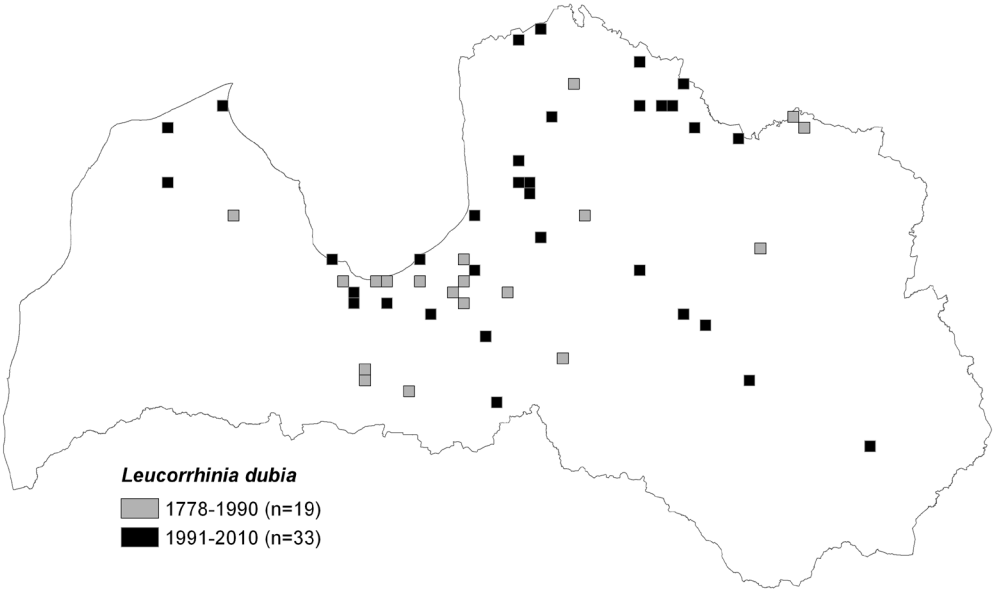

Sympetrum sanguineum
1778-1990 (n=44)
1991-2010 (n=82)

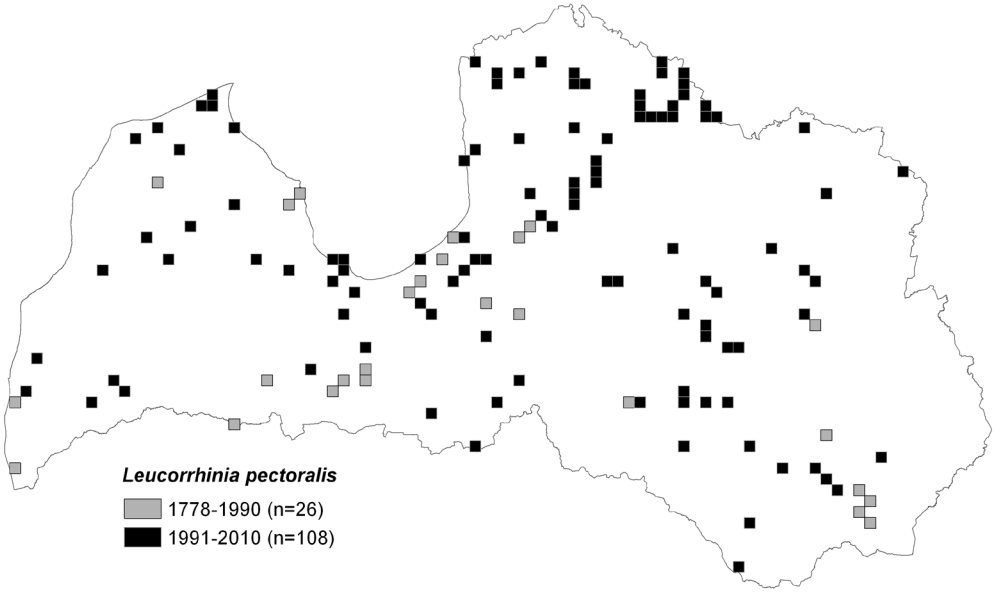

Sympetrum striolatum
1778-1990 (n=3)
1991-2010 (n=6)

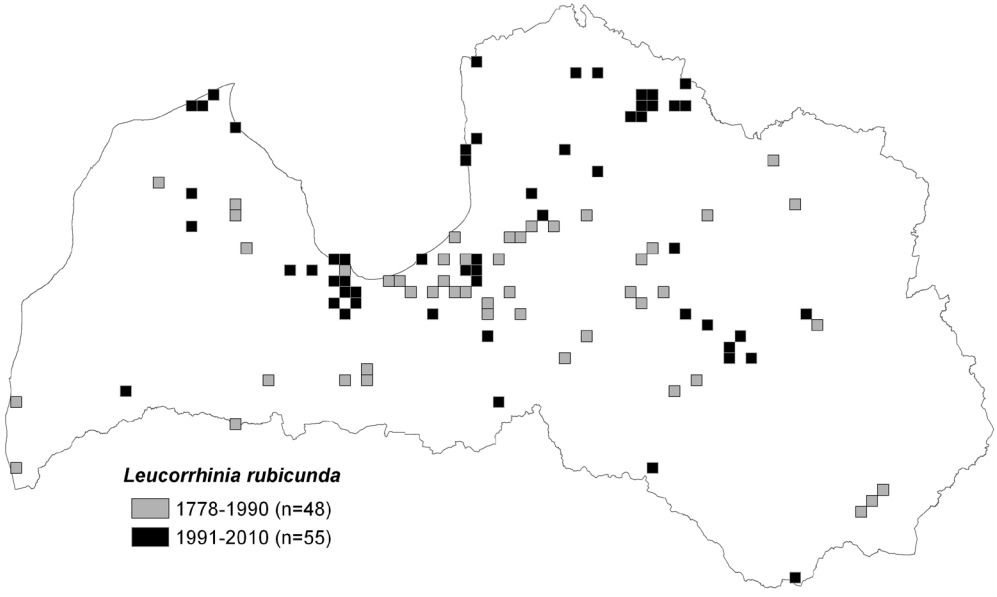

Sympetrum vulgatum
1778-1990 (n=65)
1991-2010 (n=91)


Leucorrhinia albifrons
1778-1990 (n=38)
1991-2010 (n=74)


Leucorrhinia caudalis
1778-1990 (n=50)
1991-2010 (n=36)


Leucorrhinia dubia
1778-1990 (n=19)
1991-2010 (n=33)


Leucorrhinia pectoralis
1778-1990 (n=26)
1991-2010 (n=108)


Leucorrhinia rubicunda
1778-1990 (n=48)
1991-2010 (n=55)