

The distribution of southern dragonfly (Odonata) species in Latvia and adjacent territories

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Abstract

The aim of the present study was to summarize published and unpublished information on changes of the dragonfly fauna in Latvia and adjacent territories during the last 20 years and to provide a prognosis of future changes. All published and unpublished data were summarized for the selected species. Unsystematic inspection of the potential habitats was carried out in the field, mostly in southern and central parts of the country. The identification of specimens in collections was checked. In total 19 species were identified whose borders of distribution areas or separate localities are relatively close to the territory of Latvia or which are known as species that rapidly disperse in the northern direction. Seven of these species are mentioned in the literature as probable for Latvia. Five of the species that are included in the lists were recorded for the first time in Latvia during the last 20 years.

Key words: distribution, dragonfly, Latvia, Odonata, southern species.

Introduction

The first most complete review of Latvian dragonfly (Odonata) fauna included 47 species (Bērziņš 1942). Fourteen years later, already 53 species were reported for Latvia (Spuris 1956). Forty years later several publications mentioned 53 to 54 recorded species, as well as seven probable species for the dragonfly fauna of Latvia (Spuris 1980; 1993; 1996). Several new and rare dragonfly species have been recorded in Latvia during the last 15 years. Thus, altogether 59 dragonfly species have been recorded in the fauna of Latvia until 2009 (Kalniņš 2009).

The climate and its changes are forming and transforming fauna (Peters, Lovejoy 1992; Gates 1993). A general rise of air temperature has been documented for the last decades (Bissolli 1999; Lizuma et al. 2007). Changes of dragonfly fauna both in separate countries and in Europe, are often associated with global change (Ott 2001; Corbet 1999; Termaat et al. 2010). Previously, only one published study has been devoted to the distribution of southern dragonfly species in Latvia (Spuris 1951). The present distribution of southern dragonfly species, as well as reasons of the appearance of new species during the last 15 years, has not been analyzed. Documentation of species distribution at a local scale within a country is important for the analysis of species distribution at a global scale.

Hypothetically, it can be assumed that changes in the dragonfly fauna of Latvia have occurred during last 15 or so years. Due to regional changes of the dragonfly fauna in Europe, mostly as a result of dispersal of southern species

to the north, an increase of dragonfly fauna is expected in Latvia. The aim of the present study was to summarize published and unpublished information on the changes of the dragonfly fauna in Latvia and adjacent territories during last 20 years and to provide a prognosis for future changes.

Materials and methods

Dragonfly species complying with the following criteria were chosen: (i) species are mentioned in literature as probable for Latvia; (ii) borders of the distribution area or separate localities are relatively close to the territory of Latvia (either in neighbouring countries or their closest territories) or they are known as species that quickly disperse in the northern direction; (iii) species were recorded for the first time in Latvia during the last 20 years.

The distance from Latvia to the closest locality of a species was calculated by measuring the closest distance from the locality to the border of Latvia.

For southern species recorded in Latvia, the difference of latitude degrees between the newest northernmost locality recorded in the last 20 years and the previous northernmost locality was calculated. All distances were measured by using Google Earth software.

Published and unpublished data on distribution of these species in Latvia were summarized for the selected species. The information was derived from records and publications on distribution. The published information on the species in the neighbouring territories – Estonia, the

European part of Russia, Belarus and Lithuania was also reviewed. In some cases literature from other countries was also reviewed. Also, an unsystematic inspection of potential habitats was carried out, mostly in the southern and central parts of the country. The identification of specimens in collections (collections of the Department of Zoology and Animal Ecology of the Faculty of Biology of the University of Latvia, collections of the Institute of Biology of the University of Latvia, collections of the Natural History Museum of Latvia) was performed.

The review of distribution and habitat preference was based on: (i) all published data, (ii) our own unpublished data collected between 2002 and 2010; (iii) unpublished data collected by Latvian entomologists before 2011, including in the project “Analysis of the Specially Protected Nature Territories in Latvia and the Establishment of the EMERALD/Natura 2000 Network” in 2001–2002; (iv) material found in collections of the Department of Zoology and Animal Ecology of the Faculty of Biology of the University of Latvia, Riga; Institute of Biology of the University of Latvia, Salaspils; and the Natural History Museum of Latvia, Riga. Both historical and recent data, in total 11 225 records, were included in a Microsoft Office Access database prepared by the author.

Results

During the investigation 19 species were identified whose borders of distribution areas or separate localities are located relatively close to the territory of Latvia (neighbouring countries or their closest regions) or which are known as species that rapidly disperse in the northern direction. Of those, seven species from have been reported in the literature as probable for Latvia. In addition five species included in these lists were recorded for the first time in Latvia during the last 20 years (Table 1).

A total of 303 specimens of dragonfly species in collections were among the probable species (Table 2). *Orthetrum brunneum* was found in collections, while *Sympetrum fonscolombii* and *S. pedemontanum* were found as newreports according to photographs. Specimens of the genus *Crocothemis* were not represented in the checked collections. *Coenagrion ornatum* was identified as potential for the fauna of Latvia only in the present study and no focused search in collections or nature was carried out. A total of 84 potential localities of species were checked by carrying out search for the species in its natural habitats (Table 2). Two new species for Latvia were recorded – *Anax parthenope* and *S. fonscolombii*.

By comparing the fauna of Latvia with that of the adjacent territories (the neighbouring countries) a prognosis can be made of the changes of the dragonfly fauna of Latvia. Eleven dragonfly species not yet found in Latvia have been recorded in adjacent territories. Active dispersal in the northern direction has been recorded for

two other species (Dijkstra 2006; Termaat et al. 2010). Thus, there are 13 potential species for Latvia (Table 3).

Discussion

Changes in the distribution of dragonfly species indicate the increasing presence of southern species. Eight species were mentioned as southern elements by Spuris (1951) in the dragonfly fauna of Latvia: *Sympecma paedisca*, *Lestes virens*, *Ischnura pumilio*, *Aeshna mixta*, *A. isoceles*, *Anax imperator*, *Sympetrum striolatum* and *S. fonscolombii*. This division was based on the information that northern borders of distribution areas of these species have crossed into Latvia. However, this division is no more well-founded due to the following reasons. *Sympecma paedisca* can not be regarded as a southern species, as its distribution area is located mainly to the east and south-east of Latvia (Dijkstra 2006; Skvorcov 2010). Today, this species has been recorded in Latvia in at least 39 localities (80 observations) to the north of the previous northernmost locality (57°03') mentioned by Spuris (1951). Several localities of the species are found in the northern part of Latvia, the furthest one approximately 90 km to the north (57°51').

The main distribution area of *Lestes virens* is situated south of Latvia (Dijkstra 2006). Today the species has been recorded in at least 15 localities (24 observations) north of the previous northernmost locality (56°37') mentioned by Spuris (1951). Several localities of the species are known in the northern part of Latvia, the furthest one – approximately 110 km to the north (57°41').

The main distribution area of *Ischnura pumilio* is situated south of Latvia (Dijkstra 2006). Today the species has been recorded in three localities north of the northernmost locality (56°35') mentioned by Spuris (1951). Today the furthest locality of the species is situated approximately 140 km to the north (57°51').

The main distribution area of *Aeshna mixta* is situated south of Latvia (Dijkstra 2006). Today the species has been recorded in at least 12 localities (27 observations) to the north of the previous northernmost locality (57°03') mentioned by Spuris (1951). Several localities of the species are known in the northern part of Latvia, the furthest approximately 90 km to the north (57°51').

The main distribution area of *Aeshna isoceles* is situated to the south of Latvia (Dijkstra 2006). Today the species has been recorded at least in ten localities (18 observations) to the north of the previous northernmost locality mentioned by Z. Spuris (57°04'). Several localities of the species are known in the northern part of Latvia, the furthest one – approximately 50 km to the north (57°27').

The main distribution area of *Anax imperator* is situated south of Latvia (Dijkstra 2006). Today the species has been recorded at least in 22 localities (32 observations) north of the previous northernmost locality (56°40') mentioned by Spuris (1951). Presently, several localities of the species are

Table 1. List of recorded, probable and new dragonfly species for Latvia with references

Species	Probable for Latvia	Close or increasing distribution	New for Latvia
1 <i>Lestes barbarus</i> (Fabricius, 1798)	Spuris 1993	Dijkstra 2006	
2 <i>Lestes viridis</i> (Vander Linden, 1825)		Stanionytė 1993; Dijkstra 2006; Buczyński, Moroz 2008	
3 <i>Sympetma fusca</i> (Vander Linden, 1820)	Spuris 1993	Dijkstra 2006; Buczyński, Moroz 2008; Ivinskis, Rimšaitė 2010	
4 <i>Coenagrion ornatum</i> (Selys, 1850)		Buczyński et al. 2006	
5 <i>Erythromma viridulum</i> (Charpentier, 1840)		Dijkstra 2006; Buczyński, Moroz 2008; Ivinskis, Rimšaitė 2010	
6 <i>Aeshna affinis</i> Vander Linden, 1820		Bernard 2005; Dijkstra 2006; Boudot et al. 2009	
7 <i>Aeshna crenata</i> Hagen, 1856		Dijkstra 2006	Bernard 2003
8 <i>Aeshna serrata</i> Hagen, 1856	Spuris 1993	Dijkstra 2006	
9 <i>Anax parthenope</i> (Selys, 1839)		Dijkstra 2006	Kalniņš 2009
10 <i>Anax ephippiger</i> (Burmeister, 1839)		Dijkstra 2006	Rintelen 1996
11 <i>Orthetrum albistylum</i> (Selys, 1848)		Askew 1998; Dijkstra 2006; Buczyński et al. 2003	
12 <i>Orthetrum coerulescens</i> (Fabricius, 1798)	Spuris 1993	Stanionytė 1993; Dijkstra 2006; Martin et al. 2008	
13 <i>Orthetrum brunneum</i> (Fabricius, 1837)		Bernard, Ivinskis 2004; Dijkstra 2006; Buczyński, Moroz 2008	Kalniņš 2007
14 <i>Sympetrum depressiusculum</i> (Selys, 1841)		Askew 1998; Dijkstra 2006	
15 <i>Sympetrum fonscolumbii</i> (Selys, 1840)	Spuris 1993	Dijkstra 2006; Boudot et al. 2009	
16 <i>Sympetrum meridionale</i> (Selys, 1841)		Dijkstra 2006	
17 <i>Sympetrum eroticum</i> (Selys, 1883)	Spuris 1993	Stanionytė 1989	
18 <i>Sympetrum pedemontanum</i> (Müller in Allioni, 1766)	Spuris 1993	Dijkstra 2006	Kalniņš 2002
19 <i>Crocothemis erythraea</i> (Brullé, 1832)		Ott 2001; Dijkstra 2006	

known in the northern part of Latvia, the furthest being approximately 120 km to the north (57°44').

The main distribution area of *Sympetrum striolatum* is situated south and south-west of Latvia (Dijkstra 2006). Today the species has been recorded only in a single locality (57°20') north of the previous northernmost locality (57°05') mentioned by Spuris (1951) that is situated approximately 30 km to the north.

For all of the species mentioned above, except *Sympetrum fonscolumbii*, there are records also north of Latvia in Estonia, Finland, Sweden (Dijkstra 2006; Martin et al. 2008).

Lestes barbarus

L. barbarus was mentioned by Spuris (1993) as probable for Latvia, although without support. The northern border of its distribution area reaches the Kaliningrad Region of Russia and it is found in southern Belarus. *L. barbarus* is regarded as a pronounced migrant that can suddenly form large and permanent colonies in places where it has not been previously recorded. Beginning in the mid-1990's a pronounced dispersal of the species to the north was recorded (Dijkstra 2006). The species prefers temporal water bodies (coastal pools, meadow ponds, shallow pools). Adult specimens were also been observed in the northern part of the distribution area from July till August (Dijkstra 2006).

Lestes viridis

The northern border of the distribution area of *L. viridis* reaches southern Belarus (Buczyński, Moroz 2008), the Kaliningrad Region of Russia and south-eastern Poland (Dijkstra 2006). The species has been found also in southern Lithuania, but in recent years it has been recorded also in eastern Lithuania (Ivinskis, Rimšaitė 2009). *L. viridis* is not regarded as a pronounced migrant, although dispersal of the species to the north is possible (Dijkstra 2006). The species prefers almost any type of standing water bodies or slowly flowing watercourses (but not temporal water bodies). Adult specimens occur in the northern part of the distribution area from the end of July till September (Dijkstra 2006).

Sympetma fusca

S. fusca was mentioned by Spuris (1993) as probable for Latvia, although without support. The northern border of its distribution area reaches southern Belarus (Buczyński, Moroz 2008), the Kaliningrad Region of Russia and Lithuania (Ivinskis, Rimšaitė 2010). It is found in southern Sweden in Skone region and along the coast between Stockholm and Kalmar and in Gotland (Dijkstra 2006). The northern border of the distribution area of the species in Sweden is situated to the north from Latvia. *S. fusca* is regarded as migrant, which can be explained by

Table 2. The results of the mentioned, probable and new for Latvia localities of dragonfly species and the check of the collections (with * are marked species that were identified after photographs from www.dabasdati.lv)

Checked/ searched taxon	The number of checked specimens in collections	The number of checked sites in nature	Target species	Recorded individuals	
				In collections	In nature
<i>Lestes</i>	77	5	<i>Lestes barbarus</i>	-	-
		8	<i>Lestes viridis</i>	-	-
<i>Sympecma</i>	11	15	<i>Sympecma fusca</i>	-	-
-	-	-	<i>Coenagrion ornatum</i>	-	-
<i>Erythromma</i>	25	2	<i>Erythromma viridulum</i>	-	-
<i>Aeshna</i>	40	4	<i>Aeshna affinis</i>	-	-
		-	<i>Aeshna crenata</i>	-	-
		-	<i>Aeshna serrata</i>	-	-
<i>Anax</i>	4	10	<i>Anax parthenope</i>	-	4, different localities, (Kalniņš 2009)
		-	<i>Anax ephippiger</i>	-	-
<i>Orthetrum</i>	11	10	<i>Orthetrum albistylum</i>	-	-
		-	<i>Orthetrum coerulescens</i>	-	-
		7	<i>Orthetrum brunneum</i>	1, (Kalniņš 2007)	-
<i>Sympetrum</i>	135	9	<i>Sympetrum depressiusculum</i>	-	-
		5	<i>Sympetrum fonscolumbii</i>	2*	1
		5	<i>Sympetrum meridionale</i>	-	-
		-	<i>Sympetrum eroticum</i>	-	-
		4	<i>Sympetrum pedemontanum</i>	1*	-
<i>Crocothemis</i>	0	-	<i>Crocothemis erythraea</i>	-	-

Table 3. Potential southern species for the fauna of Latvia. For each species the approximate distance 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), Europe part or Russia (RU), Belarus (BY) and Lithuania (LT)

Species	Distance (km)	Source	EE	RU	BY	LT
1 <i>Lestes barbarus</i>	440	Buczyński et al. 2006	-	+	+	-
2 <i>Lestes viridis</i>	130	Stanionytė 1993	-	-	+	+
3 <i>Sympecma fusca</i>	430	Buczyński, Moroz 2008, Ivinskis, Rimšaitė 2010	-	+	+	+
4 <i>Coenagrion ornatum</i>	180	Buczyński et al. 2006	-	+	+	-
5 <i>Erythromma viridulum</i>	150	Buczyński, Moroz 2008, Ivinskis, Rimšaitė 2010	-	+	+	+
6 <i>Aeshna affinis</i>	60	Bernard 2005; Buczyński, Moroz 2008	-	+	+	+
7 <i>Aeshna serrata</i>	50	Martin et al. 2008	+	+	-	-
8 <i>Orthetrum albistylum</i>	430	Buczyński, Moroz 2008	-	+	+	-
9 <i>Orthetrum coerulescens</i>	60	Stanionytė 1993; Martin et al. 2008	+	+	-	+
10 <i>Sympetrum depressiusculum</i>	10	Stanionytė 1963, 1991	-	+	+	+
11 <i>Sympetrum meridionale</i>	300	Skvorcov 2010	-	+	+	-
12 <i>Sympetrum eroticum</i>	5/>1000	Stanionyte 1989; Kosterin 2010	-	+	-	+
13 <i>Crocothemis erythraea</i>	600	Skvorcov 2010	-	+	-	-

hibernation of adult specimens and wanderings before the period of hibernation. The species is rare, with a fluctuating northern border of its distribution area. A fast expansion of the species in the northern direction has been recorded (Dijkstra 2006). The species prefers different types of

standing water bodies, particularly those with floating reed or rush vegetation. Adult specimens occur in the northern part of the distribution area from April till May and from August till September (Dijkstra 2006).

Coenagrion ornatum

The northern border of *C. ornatum* reaches north-western Poland and southern Belarus (Dijkstra 2006). It has been recorded also in north-eastern Belarus (Buczyński et al. 2006). The species inhabits sunlit brooks and flowing ditches, particularly those with calciferous and structured vegetation. Adult specimens occur in the northern part of the distribution area from May till August (Dijkstra 2006). A specific search for the species in Latvia has not been carried out.

Erythromma viridulum

The northern border of the distribution area of *E. viridulum* reaches northern Poland (Dijkstra 2006) and Lithuania (Ivinskis, Rimšaitė 2010). The species has been recorded also from Belarus, including its north-western part (Buczyński, Moroz 2008). *E. viridulum* is not regarded as a pronounced migrant, although its dispersal to the north has been recorded (Dijkstra 2006). The species prefers eutrophic standing waters – water bodies with rich vegetation consisting of algae, *Ceratophyllum* and *Myriophyllum*. Adult specimens in the northern part of the distribution area occur from July till August (Dijkstra 2006).

Aeshna affinis

The northern border of the distribution area of *A. affinis* reaches the northern part of Poland and it can be found in the southern part of Belarus. During hot summers *A. affinis* can migrate to the north and form temporary populations (R. Bernard, personal communication). In 2003 the species was recorded in Lithuania; the young female caught in a habitat suitable for the development of the species suggests a stable future population in Lithuania (Bernard 2005; Dijkstra 2006). The dispersal of the species to the north starting in the beginning of 1990's has been recorded also by other authors (Bernard 2005). The species prefers small, shallow, often temporary water bodies in sunlit and wind-sheltered places. Adult specimens occur in the northern part of the distribution area from the end of July till the beginning of August (R. Bernard, personal communication; Dijkstra 2006).

Aeshna crenata

A. crenata was recorded in Latvia in 2002 (Bernard 2003). Nevertheless, it can not be regarded as a southern species, as its distribution area extends from the Baltic Sea across Siberia to as far as Japan (Dijkstra 2006).

Aeshna serrata/osiliensis

A. serrata was mentioned as a probable species for Latvia by Spuris (1993). The main distribution area of *A. serrata* is located in Central Asia; a separated 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

known also from eastern Turkey (Boudot et al. 2009).

Anax parthenope

The northern border of the distribution area of *A. parthenope* reaches the Kaliningrad Region of Russia and approaches also Latvia along the border of Lithuania and Belarus (Dijkstra 2006). The species has been found also in several places in southern and eastern Lithuania (Kovács et al. 2008; Švitra 2009). The species is not regarded as a pronounced migrant. Beginning in the 1990's a pronounced expansion of *A. parthenope* to the north has been recorded (Dijkstra 2006). According with the opinion of various researchers (R. Bernard, personal communication), this represents a typical expansion caused by climate change. Large standing water bodies are typical habitats of the species. The typical flying period of the species in the northern part of its distribution area lasts from June till August (Dijkstra 2006).

Anax ephippiger

The main distribution area of *A. ephippiger* is in Africa and South-east Asia. In Europe the species may be associated with the Mediterranean basin. The species is regarded as a pronounced migrant that can suddenly form colonies in places where it has not been known earlier (Dijkstra 2006). The typical habitats of the species are shallow and warm, often temporal ponds and lakes. The finding of the species in Latvia near Pape in 1995 (Rintelen 1996) is not regarded as a typical case and therefore focused search for the species in Latvia has not been carried out.

Orthetrum albistylum

The northern border of the distribution area of *O. albistylum* reaches Poland and the species is common in southern Belarus (Askew 1998; Buczyński, Moroz 2008). The species is not regarded as a pronounced migrant. The expansion of *O. albistylum* to the north direction has been recorded (Askew 1998). The species prefers open ponds and lakes. Adult specimens occur from the end of May till mid-September (Dijkstra 2006).

Orthetrum coerulescens

O. coerulescens was mentioned by Spuris (1993) as probable for Latvia, although without support. It is not regarded as a southern species, as the northern border of its dispersal area in Scandinavia reaches Oslo in Norway, Gävle in Sweden and Tampere in Finland. The species has been recorded also in south-eastern Estonia and the north-eastern Lithuania (Stanionytė 1993; Dijkstra 2006; Martin et al. 2008).

Orthetrum brunneum

The northern border of the distribution area of *O. brunneum* reaches into central Lithuania (Bernard, Ivinskis 2004; Dijkstra 2006) and it has been recorded in the Grodna and the Brest Regions in Belarus (Buczyński,

Moroz 2008). The species is not regarded as a pronounced migrant. A pronounced expansion of *O. brunneum* to the north has been recorded (Bernard, Ivinskis 2004). The species prefers flowing waters (brooks, ditches in swampy places). Adult specimens are found in the northern part of the distribution area from June till August (Dijkstra 2006). One young (recently fled out) male of this species was found in material collected by V. Spungis in 2005 (Kalniņš 2007).

Sympetrum depressiusculum

The northern border of the distribution area of *S. depressiusculum* reaches the Kaliningrad Region of Russia and approaches also Latvia along the border of Lithuania and Belarus. The species is regarded as a pronounced migrant that can suddenly form colonies in places where it has not been previously known (Dijkstra 2006). A pronounced expansion of *S. depressiusculum* to the north has been recorded (Askew 1998), and cases of its expansion to the east are also known (Dijkstra 2006). The species most likely prefers fish ponds and seasonally drying out lakes. Adult specimens are found most often in August (Dijkstra 2006).

Sympetrum fonscolombii

Two localities of *S. fonscolombii* have been reported in the literature until 2010. One specimen was caught on 10 August 1938 at Lake Sīvers in Krāslava District in the south-eastern Latvia (Bērziņš 1938). The other was caught on 3 September 1997 in Teiči Strict Reserve located in Jēkabpils District in south-eastern Latvia. Nevertheless, the observers mention that this observation is not reliable, because the caught specimen fled away before all of the characteristic features of the species were checked (Matthes, Matthes 1997). Spuris (1993) regards *S. fonscolombii* as a species that has casually wandered into Latvia and therefore cannot be included in the fauna of Latvia. The northern border of its distribution area reaches north-eastern 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 this species differs from other representatives of the genus *Sympetrum*, adult specimens can be found from the end of May till October (Dijkstra 2006). Several observations of the species have been recorded.

At least two specimens of *Sympetrum* were observed and one photographed 5 km to the south-west of Dobeles in the racetrack „Ceļa Ēzēlis” (central-southern Latvia) at a shallow pond on 28 June 2009 (photo by A. Klepers, Dabasdati.lv 2011). The species was identified after photographs as *S. fonscolombii* (det. M. Kalniņš).

One specimen was photographed over a ditch in Kaltenes Kalvas (south-western Latvia) by patrolling along the forest

edge on 25 July 2010 (photo by A. Klepers, Dabasdati.lv 2011). The species was identified after photographs as *S. fonscolombii* (det. M. Kalniņš).

Three males of *S. fonscolombii* (from several tens of *Sympetrum* dragonflies) were caught in Embūte (south-western Latvia) on 10 September 2009 (M. Kalniņš, unpublished data). It is possible that the species was present in larger numbers but recording of the species was hindered by the lack of the catch equipment (the caught specimens were caught by hands).

Sympetrum meridionale

The northern border of the distribution area of *S. meridionale* reaches south-eastern Belarus and southern Poland (Dijkstra 2006). The species is not regarded as a pronounced migrant, although separate rare observations are known far from its main distribution area (Askew 1998). The species prefers shallow, standing waters with rich vegetation (ponds, oxbow lakes, seasonally flooded areas). Adult specimens occur in the northern part of its distribution area from June till October (Dijkstra 2006).

Sympetrum eroticum

S. eroticum has been mentioned by Spuris (1993) as probable for Latvia based on the observation of one specimen of the species in Lithuania in 1988 (Stanionyte 1989). It is regarded as a species of East Asia and therefore is not included in the fauna of Europe (Dijkstra 2006). According to the opinion of Bernhard (2005) the record of the species in Lithuania is not reliable. Therefore, a search for the species in Latvia has not been carried out.

Sympetrum pedemontanum

Spuris (1993) has described *S. pedemontanum* as probable in south-eastern Latvia. In 2001, one young male of the species was caught in Riga District (central Latvia) (Kalniņš 2002). The northern border of the distribution area of the species reaches the Kaliningrad Region of Russia, south-eastern Lithuania and embraces the greatest part of Belarus. *S. pedemontanum* is regarded as a pronounced migrant (Dijkstra 2006). Exact habitats of the species are not known, but it is known to prefer shallow and sunlit water bodies with not too dense vegetation. Adult specimens are found in the northern part of the distribution area from mid-July till the beginning of September (Dijkstra 2006). One male specimen of the species was photographed on 11 August 2010 at the bank of River Mūsa in Bauska (central-southern Latvia) (photo by K. Širve, Dabasdati.lv 2011).

Crocothemis erythraea

The northern border of the distribution area of *C. erythraea* reaches central Poland and southern Belarus (Dijkstra 2006). The species is not regarded as a pronounced migrant, although it has gradually dispersed in the northern direction (Ott 2001). The species inhabits almost all types

of open, standing water bodies (Dijkstra 2006). A special search of the species was not carried out.

Estonia

Altogether 54 dragonfly species have been recorded thus far in Estonia (Martin et al. 2008). Of these, only *Aeshna serrata* and *Orthetrum coerulescens* have not been recorded in Latvia (Table 3). *Aeshna serrata* has a stable population in Estonia. Nevertheless, the status of the species is not clear. *Aeshna osiliensis* Mierzejewski, 1913 has been described from Estonia, where it forms local populations near the Baltic Sea north of Latvia – in Estonia, Finland and Sweden. Some authors (Dijkstra 2006) regard this species as a synonym of *A. serrata*, pointing out that differences between the species are insignificant. The only factor indicating status of a separate species is the geographical distribution. Other authors (Sahlen et al. 2004) acknowledge that the status of *A. osiliensis* is not strictly fixed, even though this taxon is used as a separate species. Therefore, this species cannot with certainty be regarded as a northern or southern species. In this article, it is not regarded as a southern species, because the closest part of its distribution area to Latvia is situated to the north of Latvia and the southern part of its distribution area does not comply with the criteria of selection of southern species. The probable finding of the species in Latvia is very credible, as the distance between the localities of the species in Estonia and Latvia is small. Also, there are suitable habitats for the species along the Latvian coast near the border with Estonia – shallow lagoons with brackish water and overgrown with reeds. *Orthetrum coerulescens* has been mentioned for Estonia only once, in an article by Bruttan (1878). Although the species is included in the list of Estonian dragonflies (Martin et al. 2008) the authors of the list themselves point out that these data are not confirmed or checked.

Russia (European part)

All the species that are mentioned in the Table 3 as potential southern species for Latvia, except *Lestes viridis*, have been recorded also in Russia (Skvorcov 2010). Nevertheless, the arrival of the mentioned species in Latvia from Russia is not likely since the localities and distribution areas of the species are situated further than the closest locality (Table 3) and lie to the east of the territory of Latvia. The closest localities of *Sympetrum meridionale* and *Crotochnemis erythraea* to Latvia are known in Poland, at distances of 280 km and 360 km, respectively (Bernard et al. 2009). It is also noted that the dragonfly fauna in the European part of Russia has been investigated very irregularly.

Belarus

A total of 63 dragonfly species have been recorded thus far in Belarus (Buczyński et al. 2006; Buczyński, Moroz 2008). Of these, nine species have not been yet observed in

Latvia (Table 3). At least eight dragonfly species have been recorded in Belarus during the last 10 to 15 years, which is associated with improved accessibility of Belarus to researchers from Western countries (Buczyński et al. 2006). Almost all of the new Belarusian species are southern species. Moreover, reproduction has been observed for *Sympecma fusca*, *Lestes viridis* and *Orthetrum albistylum* in Belarus. The authors regard the expanded distribution of these species with climate change. Also 12 of 14 species considered as potential for Belarusian fauna are regarded as Mediterranean species *sensu lato* (Buczyński, Moroz 2008).

Lithuania

A total of 63 dragonfly species have been recorded and confirmed in Lithuania (Stanionytė 1993; Bernard, Ivinskis 2004; Ivinskis, Rimšaitė 2010) and there are two more species with records regarded as doubtful (Bernard, Ivinskis 2004). Five confirmed species – *Lestes viridis*, *Sympecma fusca*, *Erythromma viridulum*, *Orthetrum coerulescens* and *Sympetrum depressiusculum* have not been recorded from Latvia (Table 3). It is difficult to predict the probable arrival of *L. viridis* from Lithuania, as the species is found in south-eastern Lithuania (Vilnius, Vilkaviškiai), and there is little information given on this record (Stanionytė 1993). The arrival of *O. coerulescens* from Lithuania into Latvia is more likely, because the species has been recorded relatively close to Latvia (Table 3). Also, three males and one female were recorded at this site (Švenčionė) which suggests reproduction of the species (Stanionytė 1991).

The arrival of *S. depressiusculum* from Lithuania into Latvia is probable as it was recorded relatively close to Latvia (Table 3). Five larvae and ten exuviae with imago were found in this site (Verkiai, Zarasai, Vilnius) (Stanionytė 1963; Stanionytė 1991). However, P. Ivinskis (Ivinskis, personal communication) considers the identification as probably unreliable.

The finding of *Aeshna caerulea* (= *squamata*) (in larval stage) in Lithuania (Stanionytė 1963b) is doubtful because it is a boreal species that is found in Europe in some mountain regions of Central Europe, Scandinavia and British Isles (Dijkstra 2006). The species has been recorded also in Estonia (Martin et al. 2008) and in the southern part of Poland from Western and Central Sudet Mountains (Bernard et al. 2009).

The finding of *Sympetrum eroticum* (one juvenile male) in Lithuania (Stanionytė 1989) is also doubtful because the main distribution area of the species embraces China, Japan, Korea and the Far East of Russia (Wilson 2009). The identification was verified by O. Kosterin (Ivinskis, personal communication).

The arrival of *S. fusca* and *E. viridulum* from Lithuania into Latvia is probable because the species have been found in several sites in Lithuania (Ivinskis, personal communication).

Habitats in Latvia

The distribution of dragonfly fauna in relation to habitats and their changes is treated further. Here, we use the classification of habitats of the Habitat Directive (Auniņš 2010). In some cases, other habitat classifications have been used for the characterization of habitat distribution and changes which are indicated. Dragonfly target species (potential species for Latvia) are mentioned for each habitat type in which the larval development stage has been observed.

Sea and brackish habitats

Target species: *Lestes barbarus*, *Aeshna serrata*.

In Latvia, sea and brackish habitats are minimally disturbed habitats, which can potentially develop up to a length of more than 450 km, constituting approximately 9/10 of the whole length of the coast in Latvia. Nevertheless, lagoons (1150, here and below – habitat code), which are important habitats for dragonfly reproduction, have reduced in area during the last centuries, and now occur only in three places. The most important area of this habitat is Randu pļavas, located at the north-east coast of the Riga Bay. Nevertheless, also in Randu pļavas, the meadows and lagoons are overgrowing due to decrease of agricultural land use (Cukurs 1983). It is supposed that habitats such as Perennial vegetation of stony banks (1220), Boreal Baltic coastal meadows (1630) and Boreal Baltic sandy beaches with perennial vegetation (1640) are less important for the development of dragonflies, since they are more subject to the influence of wind and waves. The finding of *L. barbarus* in these habitats is less probable in Latvia, because these habitats are situated mostly in the northern part of the country and are comparatively isolated. The finding of *A. serrata* is possible, because lagoons in the territory of Latvia are similar to those of Pärnu Bay and closely situated islands in Estonia where the species is found.

Freshwater habitats

As all the dragonfly species during the reproduction stage are associated with freshwaters these habitats are divided into four conventional groups.

Flowing freshwaters. Target species: *Coenagrion ornatum*, *Orthetrum coerulescens*. A common habitats type in Latvia, particularly slowly flowing rivers and brooks with sandy and muddy bottoms (Eipurs, Zīverts 1998). Calcareous brooks or ditches with structured vegetation, which are typical habitats for the development of *C. ornatum*, are found rarely. In general, rivers of Latvia are characterized by shaded banks, and banks of the smallest rivers are completely shaded. This is due to establishment of river protective zones during the Soviet time and the preservation of these also in the current legislation. The typical high macrophyte species are not found in shaded rivers (Kalniņš, Urtāns 2007), which causes a decrease and the simplification of invertebrate and also dragonfly communities (O'Grady 2006).

Eutrophic lake type. Target species: *Lestes viridis*, *Sympecma fusca*, *Erythromma viridulum*, *Aeshna serrata*, *Orthetrum albistylum*, *Crotochnemis erythraea*. The most common type of standing water body in Latvia. No increasing or decreasing trends in area have been observed. Eutrophication and dystrophication are factors that influence the habitat quality.

Pond type. Target species: *Sympecma fusca*, *Aeshna affinis*, *A. serrata*, *Sympetrum depressiusculum*, *S. meridionale*. Comparatively widely found in Latvia. Information on area and trends are lacking. With the general improvement of the economic situation during the period from approximately 2000 till 2008, new household ponds were constructed or the old ones renewed in the territory of the whole country. Therefore, it might be expected that the habitat area increased.

Small waters (temporal waters, bog pools, pools, shallow depressions). Target species: *Lestes barbarus*, *Aeshna affinis*, *Sympetrum depressiusculum*. Comparatively widely found in Latvia, but there is no information on trends. Nevertheless, it is supposed that, with the increase of woodlands and shrublands, the area of sunlit small waters is decreasing.

Mire habitats

Target species: *Erythromma viridulum*, *Orthetrum coerulescens* (partly), *Sympetrum meridionale*.

As the climatic conditions in Latvia are suitable for the development of mires, they are to be found throughout the country but their distribution is uneven. In the period from 1960 till 1980 the mire area rapidly decreased due to peat extraction. Nevertheless, habitats suitable for the development of dragonflies develop also in mire areas after peat extraction. Today the mire area is approximately 4.9% of area of Latvia. The greatest area is covered by bogs and transitional mires. Habitats suitable for the potential dragonfly species are found throughout the country.

Despite the decrease of mire area, five dragonfly species new to the fauna of Latvia, (3% of all species) have been recorded during last 15 years. Four of the new recorded dragonfly species are southern species. New localities in the north direction have been found for all of the eight dragonfly species recorded earlier in the dragonfly fauna of Latvia (Spuris 1951).

It is likely that five dragonfly species recorded in the territory of Lithuania – *Lestes viridis*, *Erythromma viridulum*, *Aeshna affinis*, *Orthetrum coerulescens* and *Sympetrum depressiusculum* will be found in the future also in Latvia.

The appearance of new species is associated with changes in the environment, which, in turn influences the life histories of the species – development, diapause, phenology, thermoregulation as well as ecology (Hassal, Thompson 2008). More attention should be paid in future studies both to factors that determine the arrival of new species into Latvia and to the influence of these factors

and the new species on the native species of the Latvian dragonfly fauna. For example, will the populations of *Anax imperator* decrease with the increase of those of *Anax parthenope*? Will the population of *Leucorrhinia dubia* decrease with the warming of the climate? Does the emergence and flying time (activity period) of dragonfly imago correlate with emergence and activity period (flying time) of their prey?

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