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NEW RECORDS OF ODONATA FROM ESTONIA, WITH NOTES ON BREEDING IN THE BALTIC SEA AND ON SPECIES ASSEMBLAGES OF RAISED BOG SYSTEMS

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Abstract – The records (1-21 July 1999, 14-24 July 2000) of 42 spp. are presented. *Ischnura elegans*, *Enallagma cyathigerum* and *Orthetrum cancellatum* were found breeding in the Baltic Sea. It is concluded that the northward extension of the ranges of *I. elegans* and *O. cancellatum* in the Baltic region is influenced by their occurrence in brackish habitats along the Baltic Sea. Waterbodies in different parts of intact raised bog systems could be distinguished by differences in species assemblages and species richness.

Introduction

KAURI (1949) summarised all Estonian records up to 1939 and presented distribution maps for 20 out of the 47 species known at the time. Since then, only a small number of papers dealing with the dragonflies of Estonia have been published (ELLWANGER & ZIRPEL, 1995; REMM, 1963; REMM, 1957, 1966; SPURIS, 1964, 1968, 1996). The small books by H. REMM (1957, 1966) and E. REMM (1963), in Estonian, were inaccessible to the authors. Some information contained in these works was kindly supplied by Dr R. Bernard. A checklist published in 1994 includes 54 species (RUUSMAA, 1994).

The first author visited Estonia from 5 to 16 July 1999 as member of a team of entomologists. One week was spent in the surroundings of the village of Kanepi (Polva prov.) in southeastern Estonia. This area is dominated by low-intensity farming and forestry. It holds a large number of natural lakes and small rivers. Another week was spent on the island of Saaremaa. Here aquatic habitats are scarce, consisting mainly of small rivers and pools. The adjacent Baltic Sea has low salinity and the shores are often covered by *Phragmites australis* or *Scirpus maritimus*.

The other authors visited Estonia as members of a group studying the fauna of raised bog systems in the framework of a Dutch research project on restoration and management of raised bogs. Due to human exploitation in western Europe raised bogs have almost disappeared, but recently much effort is being invested into their restoration. Estonia is known for its intact raised bog systems, including well preserved transitions to surrounding landscape types (MASING, 1997). Therefore, Estonia was visited to collect data on the fauna of intact raised bog systems. Yet, Estonian mires have suffered severely from human disturbance. Since 1950 34% of the ombrotrophic mires (rain-water dependent raised bogs) have disappeared because of peat exploitation. Less than 10% of the minerotrophic mires are still in a more or less natural state. Luckily, Estonia has recognised the natural and historical value of mires and today many of these areas are protected (MASING, 1997; PAAL et al., 1998). From 1 to 21 July 1999 and 14 to 24 July 2000 ten raised bog systems were visited. Not all spots were evenly well examined and weather conditions were not always favourable, thus comparisons must be made with care. Weather in 1999 was favourable with mostly sunny days and temperatures well above 20°C, whereas in 2000 temperatures hardly exceeded 20°C and rainy periods regularly occurred.

Also the 1999 springtime weather conditions were more favourable than those in 2000.

Localities

Sites 1-22 were visited by the first author, except sites 9 and 10, which were visited by R. van Grunsven. Localities 23-32 were visited by the group of Bargerveen Foundation.

Localities in the surroundings of the village of Kanepi:

(1) Lake Vaaba järv near Kooraste, Polva prov. (57°57'N 26°37'E). Large mesotrophic lake with a small stream running through. 5/10--VII-1999.

(2) Lake 1 km E of Lake Kooraste Koverjärv, Polva prov. (57°57'N 26°40'E). Large mesotrophic lake with a small stream running through. 5-VII-1999 & 7-VII-1999.

(3) Lokuoja, small stream in the village of Kooraste, Polva prov. (57°57'N 26°37'E). 6--VII-1999.

(4) Sillaotsa jõgi, small stream in the village Jogehara, Polva prov. (57°57'N 26°39'E). 6--VII-1999.

(5) Võhandu jõgi, stream directly N of Kanepi, Polva prov. (57°59'N 26°44'E). 7-VII-1999.

(6) Small pool in Kanepi village, Polva prov. (57°59'N 26°44'E). 7-VII-1999.

(7) Stream Võhandu jõgi at Jogehara, Polva prov. (57°57'N 26°42'E). 7-VII-1999.

(8) Lake Vähkjärv, 1 km N of Kanepi, Polva prov. (58°00'N 26°45'E). 7-VII-1999.

(9) Bog 20 km NE of Voru: Mennikunnu soo, lake Valgjärv (57°56'N 27°21'E). 7-VII--1999.

(10) Bog 20 km NE of Voru: Mennikunnu soo, lake Mustjärv (57°56'N 27°21'E). 7-VII--1999.

(11) Marsh area Koigera raba, 5 km S of Kanepi, Polva prov. (58°57'N 26°44'E). Large marsh area with artificial created peat ditches. 8--VII-1999.

(12) Lake 1 km N of Koigera raba, Polva prov. (57°57'N 26°44'E). Lake with mainly *Sphagnum* and *Carex* along the banks. 8-VII--1999.

Localities on Saaremaa and the adjacent mainland:

(13) Wooded meadows (reserve) near Virtsu, Laane prov. (58°34'N 23°31'E). Wooded meadows and reed vegetation on the shores of the Baltic Sea.11-VII-1999.

(14) Baltic Sea near wooded meadows (reserve) near Virtsu, Laane prov. (58°34'N 23°31'E). 11-VII-1999.

(15) Camping site N of Kihelkonna, Saaremaa prov. (58°22'N 22°02'E). 12-VII-1999.

(16) Small pool in forest, western part of Saaremaa, Saaremaa prov. (exact locality unknown). 12-VII-1999.

(17) Surroundings of Lake Laialepa laht, Saaremaa prov. (58°29'N 21°52'E). Large lake with banks with reeds. 13-VII-1999.

(18) Lake West of Kurevere, Saaremaa prov. (58°26'N 21°57'E). 14-VII-1999. Small shallow lake.

(19) Surroundings of abandoned harbour Jaagarahu, Saaremaa prov. (58°24'N 21°59'E). Reed vegetation on the shore of the Baltic Sea. 14-VII-1999.

(20) The road linking the isles of Saaremaa and Muhu, Saaremaa prov. (58°34'N 23°05'E). Reed vegetation on the shore of the Baltic Sea. 16-VII-1999.

Other localities:

(21) Pool near Ardu, Harju Prov. (59°05'N 25°22'E). Small pool in farmland. 5-VII--1999.

(22) Endla Nature Reserve, Laane-Viru prov. (59°09'N 26°17'E). Large oligotrophic lake and small *Sphagnum* pools. 9-VII-1999.

Raised bog systems visited by Bargerveen Foundation:

(23) Nigula State Nature Reserve (58°00'N 24°41'E). Raised bog pools were observed and seven were sampled. 1/2-VII-1999 & 14--VII-2000.

(24) Nätsi-Võlla (58°28'N 24°03'E). Raised bog pools, the bog stream Punaoja and a transitional mire were visited and eight samples were taken. 5/6-VII-1999 & 19-VII--1999 & 18-VII-2000.

(25) Soomaa National Park. A constellation of four raised bogs with river floodplains and forests. Central bog pools and edge bog pools of Kuresoo (58°28'N 25°03'E & 58°28'N 25°12'E) and the transitional mire of Valgeraba (58°27'N 25°15'E) were visited and seven pools were sampled. 7/8-VII-1999 & 15/17-VII-2000.

(26) Endla Nature Reserve (58°52'N 26°14'E). A large system of several raised bogs, lakes, rivers and springs. Central (secondary) and primary bog pools, edge bog pools, a lagg

zone and a transitional mire were visited and fourteen waterbodies were sampled. 9/18--VII-1999 & 19/23-VII-2000.

(27) Sirtsi raba (59°17'N 26°46'E). A raised bog system at 30 km dinstance from a cement factory. The bog does not seem to be affected by chalk deposition. Two pools were sampled. 12-VII-1999 & 21-VII-2000.

(28) Uljaste soo (59°22'N 26°45'E). A raised bog at 20 km distance from a cement factory. The bog is locally affected by chalk deposition. Two bog pools were sampled. 13-VII-1999 & 21-VII-2000.

(29) Sämi raba (59°24'N 26°40'E). A raised bog at 13 km distance from a cement factory. The bog is strongly affected by chalk deposition. Two bog pools were sampled. 13-VII-1999 & 21-VII-2000.

(30) Varudi raba (59°26'N 26°35'E). A raised bog at 7 km distance from a cement factory. The bog is extremely affected by chalk deposition. Several bog pools were visited, one pool was sampled. 13-VII-1999.

(31) Avaste soo (58°42'N 24°11'E). A eutrophic mire developing into a transitional bog with reed, sedges and *Sphagnum* hummocks. 16--VII-1999.

(32) Läänemaa-Suursoo (59°11'N 23°48'E). A large raised bog system area of which the primary lake Tänavjärv was visited and sampled at two sites. 21-VII-1999.

List of recorded species

Numbers refer to the number of individuals seen, p indicates that the species was present but individuals were not counted. The number of collected individuals is given in square brackets. The collected specimens of locations 1-22 are in the collections of the RMNH. All mentioned larvae are in the collection of the Bargerveen Foundation. Abbreviations: t – teneral, la – larvae, x – exuviae.

– *Calopteryx splendens* (Harris): (1) 20 [3♂] (3) 2 (4) 10 (5) 4 [2♂] (9) 1♂ (24) 1♂ (25) 4♂, 1♀.
– *Calopteryx virgo* (L.): (1) 100 (2) 1♀ (3) 10 (4) 50 (5) 20 [2♂] (7) 50 (9) 1♀ (11) 2♂ (12) 2♂ (15) 50 (26) 2♂ (24) p, 11a (25) 1♂.
– *Lestes dryas* Kirby: (16) 30, 2 copula.
– *Lestes sponsa* (Hansemann): (2) 5♂ (8) 5♂ [1♂] (9) 3 (10) 10 (11) 5 (12) 1t (18) 5 (22) 20, t [1♀] (23) p, t, 11a (24) p, 8la, 13x (25) 5, 27x (26) 27♂, 7♀, 8la (27) 2, copula, 2la (28) p, copula, 7la (29) 8, copula, 11a.
– *Lestes virens* (Charpentier): (18) 1♂, 1♀ [1♂, 1♀].
– *Platycnemis pennipes* (Pallas): (1) 20 (3) 10 (4) 50, 10 copula (5) 4, 2 copula (7) 1 (8) 1 (25) 4♂.
– *Ischnura elegans* (Vander Linden): (8) 1♂, 1♀ (13) 10 (18) 2, 2 copula (19) 25, t (21) 1 (22) 1.
– *Pyrrhosoma nymphula* (Sulzer): (4) 2, 1 copula (5) 2 (24) 20.
– *Enallagma cyathigerum* (Charpentier): (2) 1 (9) 15 (10) 100 (12) 3♂ (13) 100, 10t (15) 1♂ (17) 5 (18) 3 (19) 50, 10t (22) 100, copula, t (23) 20, 2la (24) 8la, 8x (25) p, 7x (26) 26♂, 5♀, t, copula, 14la (27) p, 3la (28) p, 11a (29) p, 11a (30) p, 2la (32) p.
– *Coenagrion hastulatum* (Charpentier): (2) 10 (6) 2♂ [2♂] (11) 5♂, 2♀ (12) 10♂, 2♀, 2 copula (21) 10 (22) 2♂ (25) 2 (26) p, oviposition, 11a (30) 11a.
– *Coenagrion lunulatum* (Charpentier): (24) 8la (26) 4la (28) 3la.
– *Coenagrion johanssoni* (Wallengren): (12) 15♂, 1♀, 2 copula [2♂].
– *Coenagrion puella* (L.): (2) 100 (5) 20 (6) 15 (8) 20 (12) 2♂ (21) 10 (27) 1♂.
– *Coenagrion pulchellum* (Vander Linden): (2) 20 [1♂] (8) 10 [3♂] (12) 2♂ (18) 1 copula (22) 10 (24) 1♂ (26) p, copula.
– *Erythromma najas* (Hansemann): (1) 50 [2♂] (2) 100 (8) 20 (21) 5 (22) 10 (24) 1♂ (26) p (32) p, 11a.
– *Gomphus vulgatissimus* (L.): (3) 2 [1♂] (5) 1 (25) 1.
– *Ophiogomphus cecilia* (Fourcroy): (4) 2 [1♂] (7) 3 (11) 1♂.
– *Onychogomphus forcipatus* (L.): (2) 1♂, 1♀ [1♀] (4) 5 [1♂] (7) 1 (26) 1♂, t.
– *Brachytron pratense* (O.F. Müller): (1) 1♂, 1♀ [1♂, 1♂].
– *Aeshna cyanea* (O.F. Müller): (9) 1♂ (11) 1♂ (24) 2la (25) 1♂ (26) 1♂.
– *Aeshna grandis* (L.): (1) 40 [1♀] (2) 1 (5) 1 (8) 1♀ oviposition (9) 1 (11) 1 (15) 2 (16) 2 (17) 15 (18) 3 (21) 1, 1t (22) 60 (24) 3 (25) 3 (26) 18, 2♂ (27) 3 (29) p, 2la (30) 11a (32) p, 11a.
– *Aeshna juncea* (L.): (11) 1♀ oviposition [1♀] (22) 3 (23) 3x (24) p, t, 5la, 9x (25) 11a, 4x (26) 1, 2la (27) 1 (28) p, copula, 11a (29) p, 4la.
– *Aeshna (serrata) osiliensis* (Mierzejewski): (13) 4♂ [2♂] (14) 3♂ (16) 1 (17) 2♂ (20) 1♂.
– *Aeshna subarctica* Walker: (9) 10 (11) 1 (12) 4, 2t, 2x [1♂] (22) 2 (23) 6la, 10x (25) 11a (26) 1♀, oviposition, 3la (27) 3la (28) 11a.
– *Anax imperator* Leach: (22) 2♂ (23) 1♂ (26) 2, 1♂, 3la, 1x.
– *Cordulegaster boltonii* (Donovan): (2) 1.

– *Cordulia aenea* (L.): (1) 100 [1♂] (2) 10 (5) 1 (8) 10 (9) 4 (22) 10 (23) 1, 1♂ (24) 11a (25) 2 (26) 1, 1♂, 2la (27) 3la (29) 1, 11a (30 (11a (31) 1 (32) 3la.
– *Somatochlora arctica* (Zetterstedt): (11) 1 copula [1♂, 1♀] (22) 2 (25) 4la (26) 11a.
– *Somatochlora flavomaculata* (Vander Linden): (1) 10 [1♂] (2) 3 [1♂] (15) 20 (16) 1♀ (17) 20 (18) 10 (22) 10 [1♂] (24) 2, 11a (25) 3 (26) 5 (28) p (31) p.
– *Somatochlora metallica* (Vander Linden): (1) 20 (2) 2 (5) 1♂ (6) 1 (8) 10 oviposition (9) 1 (16) 1♂ (17) 1♂ (22) 10 (23) 1♂ (24) 7la (25) 2, 12la 2x (26) 2, 7la (27) 1 (29) p (32) 1.
– *Epitheca bimaculata* (Charpentier): (1) [1♀], 2 batches of eggs (26) 1x.
– *Libellula depressa* (L.): (5) 1♂ [1♂] (26) 1.
– *Libellula fulva* (O.F. Müller): (1) 10 [1♂, 1♀] (5) 2♂, 1 copula, 1♀ oviposition (8) 3♂.
– *Libellula quadrimaculata* (L.): (1) 10 (2) 20 (5) 2 (6) 2 (8) 4 (9) 5 (10) 5 (11) 3 (16) 3 (17) 2 (18) 15 (19) 1 (21) 3 (22) 10 (23) 3la, 2x (24) 2 (25) 11a, 1x (26) 4 (28) 1, 11a (30) 11a.
– *Orthetrum cancellatum* (L.): (1) 1♂, 1♀ (13) 20 (15) 20 (17) 50 (18) 100 (19) 100, 2x (20) 25 (21) 1 (26) 1.
– *Sympetrum danae* (Sulzer): (4) 1 (11) 10, 2t (18) 1t (23) p, 2x (24) p, 4la (25) 3x (26) p (27) p (28) p.
– *Sympetrum flaveolum* (L.): (1) 10 [1♂] (4) 1 (11) 2 (18) 5, 1t (23) p (24) 1 (25) p (26) p (29) 1.
– *Sympetrum sanguineum* (O.F. Müller): (2) 3t [1♂M, 1♀].
– *Sympetrum vulgatum* (L.): (8) 1♂ [1♂] (18) 1 (26) 3, 1t.
– *Leucorrhinia albifrons* (Burmeister): (9) 10♂, 1♀ (10) 5 (12) 7♂ (22) 100, copula [4♂, 2♀] (23) 10♂, 1♀, oviposition, 6x (24) p, 2la, 2x (26) 9, 3♂, oviposition, 11a (28) 1 (29) p, 2la (30) 11a (32) p.
– *Leucorrhinia caudalis* (Charpentier): (1) 15♂, 2 copula (22) 3♂, 1 copula [1♂, 1♀] (26) 3 (28) 11a (29) 2la.
– *Leucorrhinia dubia* (Vander Linden): (9) 20 (11) 30 [3♂, 1♀] (12) 40 (16) 2 (22) 60, copula [1♀] (23) p, 2la, 3x (24) 11a (25) 3, 5x (26) 10, 1♂ (27) p, copula (28) 1, copula, 3la (29) p, 8la (30) 3la.
– *Leucorrhinia rubicunda* (L.): (9) 15 (26) 1, 3la.

Discussion

In total 42 species were recorded, comprising 80% of the 54 known Estonian species. Although the number of species known from Estonia is rather low, the species diversity on a small scale is high. This is shown by the fact that alone in the visited part of Kanepi (approximately 20 by 20 km) 38 species were found. The work of KAURI (1949) is the main source of information on the fauna of Estonia. Some of the species that are rare according to KAURI (1949) or that are considered of ecological interest are discussed below.

Lestes virens (Charp.) – 1 male and 1 female were collected at a small, shallow lake on Saaremaa. No mating or teneral individuals were seen, therefore it is uncertain whether the species is indigenous to the island.

Coenagrion johanssoni (Wallengren) – It was not recorded by KAURI (1949) and was first mentioned for Estonia by H. REMM (1957) from a single locality and later by SPURIS (1964) from four other localities. SPURIS (1980) states that the species is very rare in Latvia and only 6 Latvian records are known to date (SPURIS, 1964). The maps of its distribution in Finland show that the species is not rare in the southern part (VALTONEN, 1980). Probably it is rare but widespread in the mainland of Estonia. In 1999 the species was only recorded at one locality, a bog lake surrounded by forest. The banks were dominated by *Spaghnum* and *Carex*. In May 2001 four larvae were found in the transitional mire of Valgeraba (Soomaa National Park) with a vegetation of *Sphagnum* and *Carex* (unpublished data of Bargerveen Foundation).

Coenagrion puella (L.) – Judging from the distribution maps in KAURI (1949) this species was remarkably rare prior to 1939. Only 5 localities from the mainland and 6 from the islands are presented. In 1999 it was recorded at 7 different continental localities. This would suggest that the species has increased in the second half of the twentieth century. The northern limit of its range is reached in Estonia and Finland (VALTONEN, 1980) and the increase in Estonia might be due to the higher temperatures in the last decades.

Pyrrhosoma nymphula (Sulz.) – It was encountered 3 times, all at running waters. As already stated in KALKMAN & DIJKSTRA (2000) and in DIJKSTRA & KOESE (2001), in northeastern Europe the species seems to prefer running waters.

Aeshna (serrata) osiliensis Mierzejewski – KAURI (1949) gives this species only from areas adjacent to the Baltic Sea, where it was found in shallow lagoons. Oviposition was recorded in both fresh and brackish water (KAURI, 1935). During our stay in Estonia we observed it only at or close to the Baltic Sea. Males were seen patrolling along

reeds bordering the Baltic Sea. Although a brief search did not reveal any exuviae it is likely that larvae are to be found in the waters of the Baltic Sea amidst the reeds. Hunting males were seen at a forest clearing a few hundred metres from the Baltic Sea.

Aeshna subarctica Walker – It was mainly observed in rainwater dependent *Sphagnum* bogs, although it was also found in more minerotrophic fens and transitional mires. Larvae were collected at 6 places, in more or less dense *Sphagnum* vegetation. Ten exuviae were collected on *Scheuzeria palustris* along a bog pool in Nigula with a mat of dense *Sphagnum cuspidatum*. This fits well with the description of the habitat and the larval habitat structure given by STERNBERG (2000). In bog pools, where no *Sphagnum* mats were present, *A. subarctica* was not observed.

Anax imperator Leach – It was first reported from Estonia by ELLWANGER & ZIRPEL (1995) who found exuviae at a *Sphagnum* bog in Nigula State Nature Reserve. This record was also the first record of successful reproduction of *A. imperator* at a *Sphagnum* bog. Several times during our visit we saw habitats which, if located in central Europe, would be suitable for *imperator*. However, the species was only seen at raised bog pools in Nigula and Endla. This makes Endla Nature Reserve overall the most northern spot where *A. imperator* is known to reproduce successfully. These observations support the statement of ELLWANGER & ZIRPEL (1995) that *A. imperator* has an aberrant habitat preference in this part of Europe.

Somatochlora arctica (Zetterstedt) – On 2 spots larvae were collected, one in a lagg zone of Punaraba (Endla Nature Reserve) and 4 larvae at the edge of Kuresoo bog (Soomaa National Park). These localities are characterized by small pools with dense *Sphagnum* vegetation and perpendicular stems or leaves of vascular plants, with hardly any open water present. In all localities some water flow occurs when water supply is high (e.g. in spring). These circumstances match well with habitat requirements of *S. arctica* larvae as described by SCHORR (1990), although larvae can also be found in pools or gullies with dense growth of segdes without *Sphagnum* and without water flow in spring (STERNBERG, 2000).

Libellula fulva (O.F. Müller) – Observed at 3 localities in the Kanepi area. It was not mentioned by KAURI (1949) and was first reported from Estonia by REMM (1957). The maps given by KAURI (1949) of, for instance, *Platycnemis pennipes*, show that the Kanepi area was well-studied at that time. This gives reason to assume that *L. fulva* has increased in Estonia.

Breeding in the Baltic Sea

The Baltic Sea has a relatively low salinity and fauna, usually found in freshwater, occurs along its shores. Several accounts have been published on the occurrence of Odonata in the Baltic Sea or in habitats influenced by it (e.g. DIERSCHKE, 1998; LARSEN, 1936; LINDBERG, 1948). Lindberg states that about half of the Odonata present in the region breed in brackish water (Cl 3-6‰). Among the species found breeding in the Baltic Sea, there are several that are rarely or never found in brackish habitats elsewhere in Europe.

In 1999, several sites were visited on the Baltic Sea where *Enallagma cyathigerum*, *Ischnura elegans* and *Orthetrum cancellatum* were found in large numbers. Reproduction was proven by exuviae and teneral specimens. It is interesting to note that *E. cyathigerum* and *O. cancellatum* are much more widespread and abundant along the Baltic Sea than in the mainland of Estonia (KAURI, 1949). *I. elegans* is not common in Estonia (KAURI, 1949) and in 1999 high numbers were only encountered on Saaremaa. The maps of *I. elegans* and especially of *O. cancellatum* in VALTONEN (1980) show that in Finland they are also largely confined to the Baltic Sea coast. It is concluded that, at least in Estonia, brackish reed vegetation forms the optimum habitat for these species and that the northwards extension of their range is clearly related to the Baltic Sea.

Species assemblages of raised bog systems

Observations of thousands of adult dragonflies, 338 larvae and 127 exuviae, representing 29 species, were collected at bog waterbodies during our visits in 1999 and 2000. *Enallagma cyathigerum*, *Lestes sponsa*, *Leucorrhinia dubia* and *Libellula quadrimaculata* were the most frequently found species. Species found only on a few spots either have their main distribution outside bogs (e.g. both *Calopteryx* species, *Platycnemis pennipes* and *Pyrrhosoma nymphula*), or are mostly present in low numbers in their habitat (e.g. *Somatochlora arctica*). Some species might have been beyond their main flight period, like *Leucorrhinia rubicunda*. However, in undisturbed Estonian bog landscapes *L. rubicunda* is mostly absent from

central bog pools and it is more abundant in transitional mires (STERNBERG, 2000; unpublished data of Bargerveen Foundation). Presumably, also the time spent on a spot was too short for a reliable assessment of the occurrence of some species.

Waterbodies in different elements of the bog landscape could be distinguished by their species assemblage and species richness. Highest species number was found at the primary lake Männikjärv in Endla Nature Reserve. Most of the species observed in the bog systems were found in the central bog pools, partly so due to a higher collecting effort. Species assemblages of these pools were characterised by species that occupy a range of habitats, but reach high(est) abundances in acid, oligotrophic waters and by those species that are acid-tolerant and do not avoid central bog pools. Species assemblages at the lime infected bog pools were fairly similar to those at non-infected bog pools. However, larvae of *Leucorrhinia caudalis* were only found in the lime infected pools. Most species were not observed at the more minerotrophic waterbodies studied in the transitional mires and lagg zones. However, some species absent from the central bog pools were only found here, like *Somatochlora arctica*. Studying relationships between species and their environment in the different landscape elements of intact bog systems will help us in restoring the characteristic species diversity in Dutch raised bog remnants, and in the transitional habitat types (VAN DUINEN et al., 2000).

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