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The aims of the **British Dragonfly Society** (BDS) are to promote and encourage the study and conservation of Odonata and their natural habitats, especially in the United Kingdom.

The Journal of the British Dragonfly Society, published twice a year, contains articles on Odonata that have been recorded from the United Kingdom and articles on European Odonata written by members of the Society.

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- Use of these terms is acceptable: 'exuvia' for cast skin (plural: 'exuviae'); 'larva' (instead of 'naiad' or 'nymph'); 'prolarva' to designate the first larval instar.
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SCIENTIFIC AND ENGLISH NAMES OF BRITISH ODONATA

ZYGOPTERA	DAMSELFLIES		
Calopteryx splendens	*Banded Demoislle*	*Aeshna juncea*	*Common Hawker*
Calopteryx virgo	*Beautiful Demoiselle*	*Aeshna mixta*	*Migrant Hawker*
Lestes barbarus	*Southern Emerald Damselfly*	*Anax ephippiger*	*Vagrant Emperor*
Lestes dryas	*Scarce Emerald Damselfly*	*Anax imperator*	*Emperor Dragonfly*
Lestes sponsa	*Emerald Damselfly*	*Anax junius*	*Green Darner*
Lestes viridis	*Willow Emerald Damselfly*	*Anax parthenope*	*Lesser Emperor*
Sympecma fusca	*Winter Damselfly*	*Brachytron pratense*	*Hairy Dragonfly*
Coenagrion armatum	*Norfolk Damselfly*	*Gomphus flavipes*	*Yellow-legged Clubtail*
Coenagrion hastulatum	*Northern Damselfly*	*Gomphus vulgatissimus*	*Common Club-tail*
Coenagrion lanulatum	*Irish Damselfly*	*Cordulegaster boltonii*	*Golden-ringed Dragonfly*
Coenagrion mercuriale	*Southern Damselfly*	*Cordulia aenea*	*Downy Emerald*
Coenagrion puella	*Azure Damselfly*	*Somatochlora arctica*	*Northern Emerald*
Coenagrion pulchellum	*Variable Damselfly*	*Somatochlora metallica*	*Brilliant Emerald*
Coanagrion scitulum	*Dainty Damselfly*	*Oxygastra curtisii*	*Orange-spotted Emerald*
Erythromma najas	*Red-eyed Damselfly*	*Leucorrhinia dubia*	*White-faced Darter*
Erythromma viridulum	*Small Red-eyed Damselfly*	*Leucorrhinia pectoralis*	*Large White-faced Darter*
Pyrrhosoma nymphula	*Large Red Damselfly*	*Libellula depressa*	*Broad-bodied Chaser*
Enallagma cyathigerum	*Common Blue Damselfly*	*Libellula fulva*	*Scarce Chaser*
Ischnura elegans	*Blue-tailed Damselfly*	*Libellula quadrimaculata*	*Four-spotted Chaser*
Ischnura pumilio	*Scarce Blue-tailed Damselfly*	*Orthetrum cancellatum*	*Black-tailed Skimmer*
Ceriagrion tenellum	*Small Red Damselfly*	*Orthetrum coerulescens*	*Keeled Skimmer*
Platycnemis pennipes	*White-legged Damselfly*	*Crocothemis erythraea*	*Scarlet Darter*
		Sympetrum danae	*Black Darter*
		Sympetrum flaveolum	*Yellow-winged Darter*
ANISOPTERA	*DRAGONFLIES*	*Sympetrum fonscolombii*	*Red-veined Darter*
Aeshna affinis	*Southern Migrant Hawker*	*Sympetrum pedemontanum*	*Banded Darter*
Aeshna caerulea	*Azure Hawker*	*Sympetrum sanguineum*	*Ruddy Darter*
Aeshna cyanea	*Southern Hawker*	*Sympterum striolatum**	*Common Darter**
Aeshna grandis	*Brown Hawker*	*Sympetrum vulgatum*	*Vagrant Darter*
Aeshna isosceles	*Norfolk Hawker*	*Pantala flavescens*	*Wandering Glider*

* Includes dark specimens in the north-west formerly treated as a separate species, *Sympetrum nigrescens* Highland Darter.

Species list in accordance with Davies, D.A.L. & Tobin, P. (1984 & 1985) The Dragonflies of the World: A systematic list of the extant species of Odonata. Vols 1 & 2.

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Migrant and dispersive dragonflies in Britain during 2011

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Summary

The year 2011 was noteworthy for the large, indeed unprecedented, numbers of Vagrant Emperor *Anax ephippiger* noted throughout the year. There were at least three immigration waves – a slow trickle of sightings during the late winter of 2010/11, a surge of records during April and early May, and then a final run of records during October and November. Both the spring and autumn influxes were associated with spells of unseasonably hot weather with winds from the far south. Arrivals of Red-veined Darter *Sympetrum fonscolombii* were also noted during these periods. Although the summer weather was, by contrast, less spectacular, there were still significant immigrations of Lesser Emperor *Anax parthenope*, as well as of further Red-veined Darter. Three sightings of Norfolk Hawker *Aeshna isosceles* were also made well away from the species' current UK stronghold. Many of the other key events of the year related to the consequences of immigrations seen not in 2011 but in the preceding few years, where new local breeding populations of a number of species might potentially have become established. The recently-identified colony of Dainty Damselfly *Coenagrion scitulum* in Kent appeared to remain stable and there was to be proof of successful breeding by Southern Migrant Hawker *Aeshna affinis* following the 2010 invasion, when small numbers of exuvia were discovered at Hadleigh Country Park, Essex, during June. Numbers of mature adults seen later in the year were, however, low and give some concern as to the long-term viability of this colony. Numbers of Southern Emerald Damselfly *Lestes barbarus* seen at Cliffe, Kent, following breeding attempts also noted during 2010 were, however, higher and hopefully a stable colony may develop here.

Account of species

Notable sightings reported to the BDS Migrant Dragonfly Project during 2011 are detailed below; background meteorological information is from the Met Office (2012) and WeatherOnline (2012). For details of events during 2010, see Parr (2011a).

Lestes barbarus (Fab.) – Southern Emerald Damselfly

Following reports from five sites in 2010 (a UK record), rather fewer reports were received during 2011, though these included some important observations. The following records have been accepted by the Odonata Records Committee:

14 June–24 July	Up to double figures per day at Cliffe Marshes, Kent (J. & G. Brook *et al*.)
11 July	Male at Wat Tyler Country Park, Essex (B. Crowley)
3 Aug	Male at Ditchling Common, East Sussex (C. Cannon).

The Kentish records are at the site where breeding behaviour was noted during 2010 (Parr, 2011a) and an at least temporarily established colony is clearly present there. The record from Essex is also at a site were the species was seen in 2010 (Parr, 2011a) but, with only single individuals being involved in both years, the status of the species there remains unclear. Similarly, the nature of the Sussex individual is also uncertain, though it is perhaps most likely a primary immigrant.

Although the species' foothold in Britain currently seems somewhat tenuous – a previous colonisation attempt in Kent for instance having failed (Parr, 2006a) – Southern Emerald Damselfly has been very successful in establishing itself in The Netherlands since the mid 1990s (Termaat *et al*., 2010) and it will be important to continue monitoring the fate of the species in the UK.

Lestes viridis (Vander Linden) – Willow Emerald Damselfly

Willow Emerald Damselfly had a good year in 2011, with all key areas of its recently established range in southeast England (based upon south Norfolk, Suffolk, Essex and north Kent) continuing to produce sightings. Suffolk remains the species' stronghold, and damselflies have now been recorded from some 80 tetrads in the county, reaching as far inland as Sudbury and Stowmarket.

Several sites on the Suffolk coast recorded their first-ever sightings of Willow Emerald Damselfly during September 2011 – for instance at Minsmere on 16 September (SG) and at Thorpeness on 25 September (JMS). These sites are relatively close to the main centre of distribution of the species and the sightings probably reflect on-going range expansion. A male found near Cromer on the north Norfolk coast on 16 October (SC) was, however, some 40km away from the other known sites in Norfolk and is thus perhaps more likely to represent a fresh Continental immigrant.

Coenagrion scitulum (Rambur) – Dainty Damselfly

This species, previously extinct in Britain since the early 1950s (Merritt *et al*., 1996), was rediscovered on the Isle of Sheppey, Kent, during 2010 (Brook & Brook, 2011). With exuviae as well as adults being discovered, established breeding colonies seemed to be present. Reassuringly, Dainty Damselfly did indeed reappear during 2011, with small numbers of individuals being recorded from the ‘public’ site during the period 2 June–6 July (many observers); the two sites on private land discovered during 2010 were not surveyed in 2011.

No reports were received away from the Isle of Sheppey area but, given the on-going European range expansion by this species (Ott, 2010), the possibility for such finds in years to come cannot be discounted.

Erythromma viridulum (Charp.) – Small Red-eyed Damselfly

As for the last few years, there were to be no signs of any significant local range expansion by this recent colonist, the species having seemingly now reached equilibrium in the UK. There was also little sign of further major immigration during the year, though a count of 200+ on the Long Pits at Dungeness, Kent, on 25 July (DWa) probably reflects a migratory movement since only single figures had been seen the day before and numbers fell again to that sort of level by the end of the month.

Aeshna affinis (Vander Linden) – Southern Migrant Hawker

The year 2010 saw unprecedented arrivals of Southern Migrant Hawker in Britain. Oviposition was noted both at Hadleigh Country Park, Essex, and at Cliffe, Kent (Parr, 2011a), and there was optimism that this might lead to the establishment of permanent breeding colonies. Successful breeding was indeed proved to have taken place at Hadleigh Country Park when two emergents and a total of six exuviae were discovered during early June 2011 (Chelmick, 2011). Mature adults were then noted during the period 15 July–14 August. Numbers seen at Hadleigh were, however, low. Typically, only single individuals were reported, though three were seen on 31 July (JW) and two on 1 August (TC). All these records referred to males, no mature females being recorded during the summer. Away from Hadleigh CP, a female photographed at nearby Wat Tyler Country Park on 29 June (NP) was perhaps a dispersing individual from Hadleigh, whilst another female photographed on the North Kent Marshes on 1 August (DP) may indicate that the breeding attempt at Cliffe, Kent, seen during 2010, had also been successful.

Despite proof of breeding having being obtained during 2011, the low numbers of mature adults subsequently seen, the lack of reported mating (indeed even of the simultaneous presence of both sexes at any one site) and also the often indifferent weather during summer 2011, all combine to make the future of the British colonies of Southern Migrant Hawker somewhat uncertain. The species is, however, becoming an increasingly regular visitor to north-western Europe, so that further colonisation attempts seem likely in the years to come.

Aeshna isosceles (Müller) – Norfolk Hawker

There were to be three records from areas well outside the species' normal range; these involved single individuals seen at Stodmarsh, Kent over 4–8 June (WG), at Paxton Pits, Cambridgeshire over 3–15 July (SB *et al*.) and at Worth, Kent on 4 July (IH). The main UK population of Norfolk Hawker has been doing well in recent years, with signs of local range expansion. Some populations on the Continent have been doing similarly well (e.g. Termaat *et al*., 2010). The extra-limital records seen during 2011 may thus represent wanderers from either the British or Continental populations and maybe both are involved – though it is worth noting that early July in particular was a period of significant immigration from the Continent. It would be encouraging if breeding populations of this regionally 'Endangered' species were ultimately to become established away from Norfolk/Suffolk, where many current breeding sites are at long-term risk from changes in sea level.

Aeshna mixta Latreille – Migrant Hawker

It was a relatively quiet year for the species, with little in the way of large-scale migration being noted. A count of 50+ at Castle Water NR, East Sussex, around the end of August/early September was, however, thought to result from an influx (SS). There were, in addition, occasional reports of individuals attracted to UV moth traps throughout the season – most notably at St Margaret's-at-Cliffe, Kent, on the night of 15 July (AM) and on The Lizard, Cornwall, on 12 September (MT). Such records of dragonflies attracted to light frequently refer to migrants (Parr, 2006b).

Anax ephippiger (Burmeister) – Vagrant Emperor

The largest ever recorded number of UK arrivals of this highly mobile Afro-tropical migrant took place during 2011, with nearly 40 individuals being positively identified along with sightings of a further 20+ 'possibles' that were seen too briefly for fully conclusive identification; normally the species is seen in Britain less than annually. There were to be at least three distinct immigration phases – a slow trickle of sightings during January–March, a rush of records during April/early May, and then a final influx during October and November. The spring and autumn migration waves were both associated with spells of unseasonably warm weather, with frequent southerly or south-easterly winds (Met Office, 2012). Significant migrations were also reported from many other areas of Western Europe, particularly during April (Parr, 2011b).

County/Region	January-May		October-November	
	*Confirmed	'Possible'	*Confirmed	'Possible'
Scilly Isles	-	1	1	-
Cornwall	9	6	2	-
Devon	1	2	-	-
Somerset	-	1	-	-
Dorset	2	2	-	-
Isle of Wight	-	3	1	-
Hampshire	1	-	-	-
Sussex	-	-	1	-
Kent	4	1	-	-
Norfolk	-	-	1	?
Northamptonshire	-	1	-	-
Warwickshire	-	-	1	-
Glamorgan	2	1	1	-
Pembrokeshire	3	-	-	-
Gwynedd	1	-	-	-
Leicestershire	-	1	-	-
Cheshire	-	1	-	-
Lancashire	-	1	-	1
Cumbria	1	-	-	-
Isle of Man	-	-	1	-
Dumfries & Galloway	1	-	1	-
East Lothian	-	-	1	-
Fife	-	-	1	-
Outer Hebrides	1	-	-	-
Orkney Isles	1	-	-	-

Table 1. Number of individuals of Vagrant Emperor *Anax ephippiger* seen in Britain during 2011. *Confirmed records have been accepted by the Odonata Records Committee.

British sightings of Vagrant Emperor during 2011 have been documented by Parr (2011b, 2011c), and are summarised in Table 1. Although the species is known to have a short generation time (Corbet *et al*., 2006), the timing of the autumn influx coincided with the anticipated emergence period in sub-Saharan Africa (Parr, 2011b) and this, combined with the weather conditions and the concurrent arrival of numbers of mature Red-veined Darter *Sympetrum fonscolombii* (see below), strongly suggests that the autumn influx involved a second immigration from the species' strongholds in Africa and was not simply the result of dispersal of progeny from the spring influxes into western Europe. Interestingly, during the early part of the autumn influx a number of individuals were attracted to light overnight, suggesting that during this period dragonflies were continuing to migrate even at night. A female was, for instance, caught in a moth trap at Crows-an-Wra, Cornwall, on the night of 2 October (BH).

Oviposition – which usually, though not always, occurs in tandem (Dijkstra & Lewington, 2006) – was noted on The Lizard, Cornwall, on both 26 April and 28 October (SJ). These represent the first-ever reports of breeding attempts in the UK. At present, there is however no evidence that either attempt was successful.

***Anax parthenope* Sélys – Lesser Emperor**

Despite the frequently indifferent summer weather, this migrant species faired well, with reports from an above-average numbers of localities. There was to be a sighting from Lands End, Cornwall, on 3 June (CG) but most records came during the period 27 June–2 August, when sightings of presumed primary immigrants were made in Cornwall (2 sites), the Isle of Wight, Hampshire (3 sites), Oxfordshire, Cambridgeshire (2 sites), Worcestershire (2 sites), Warwickshire, Staffordshire, Nottinghamshire and West Yorkshire. The Isle of Man also recorded its first ever Lesser Emperor during summer 2011 (Manx National Heritage, 2011).

While still predominantly a migrant to our shores, this species has increasingly also been suspected of breeding in the UK on a regular (or semi-regular) basis. It has, for instance, now been reported from Dungeness in Kent each year for approaching a decade and a half, with oviposition frequently being reported. In 2011, there were to be numerous sightings of up to 3 individuals there during July and the first half of August, with oviposition reported on 28 July, 3 August and 17 August (DWa). Perhaps in part due to the large amounts of suitable habitat at Dungeness, finding exuviae and thus rigorously proving successful breeding has, however, yet to be achieved. Elsewhere in Kent, firm proof of breeding was, however, obtained at New Hythe Lakes, where up to three adults, including an ovipositing pair, were seen over the period 3–12 July (TL *et al*.) with a fresh exuvia being discovered on 4 July (JGB). Interestingly no individuals had been reported from this site in previous years, the initial breeding attempts having clearly been missed.

Sympetrum flaveolum (L.) – Yellow-winged Darter

There were to be no records of this species from the UK during 2011, though in the Channel Islands two were reported from Alderney during late September (DWe).

Sympetrum fonscolombii (Sélys) – Red-veined Darter

Although no particularly large counts were to be made at any one locality – the maximum being ten at a site on The Lizard, Cornwall, on 27 April (PHo) – the year was an eventful one for the species. This continues the trend that has developed over the last decade and a half, with sizeable immigrations of this once very rare migrant now taking place roughly every other year and significant numbers still being seen in the intervening periods.

The first reports for the year were from sites on The Lizard and at Porthgwarra, Cornwall, on 25 April (SJ, AP, JF) – these being the earliest-ever sightings of adults in the UK. It is highly likely that these individuals were associated with the unprecedented arrivals of Vagrant Emperor that were also taking place at this time. Although many of the Darters remained present for a few days, the subsequent month or more was to be quieter, with just a single male reported from Southease, Sussex, on 19 May (TH) and isolated individuals noted at Windmill Farm, Cornwall, in early June (AP). Late June/early July then saw a significant influx, with records received from Cornwall, Suffolk, Norfolk, Staffordshire, Lincolnshire, North Yorkshire and also from Lancashire – where a male was seen at Middleton on 27 June (PM). This Lancashire site had held a small breeding colony since the turn of the century, though this was thought perhaps to have now died out, with no records being forthcoming during 2010; it will be of interest to see whether the site may now have been re-colonised. Records continued at a lower level during high summer, with a male reported from Dungeness, Kent, on 24 July (DWa) and with further records from Windmill Farm, Cornwall, during late July and August (GT, CM). Single males were also noted at Southampton Common, Hampshire, on 1 August (PW) and at Sandown, Isle of Wight, on 2 August (DD).

In the autumn, individuals were reported from The Lizard, Cornwall, on 11 September (MT). Late September then saw the start of yet another significant immigration wave, with reports from Badminston, Hampshire, on 28 September (PW), from Skomer Island, Pembrokeshire, during late September or early

October, and with numerous records from the Isles of Scilly starting on 2 October. These Scilly Isles sightings were to come from many of the individual islands and lasted until 4 November at least. Of particular note was a record of a male caught in an actinic moth trap at Longstone, St Mary's, on the night of 21 October (WMS). Elsewhere, a late season record was also received from Windmill Farm, Cornwall, on 25 October (PHi). Autumn records of Red-veined Darter in Britain typically refer mainly to immatures – most likely dispersing second-generation individuals from Britain or elsewhere in (north)western Europe – but the 2011 sightings included a good number of fully mature insects. It is probable that further immigration from very southerly latitudes was involved, which would tie in with the arrivals of Vagrant Emperor that were also taking place during the autumn period.

Sympetrum striolatum (Charp.) – Common Darter

It was seemingly a very quiet year for migration by this species, though smaller-scale movements can be hard to detect. One was noted arriving in off the sea at Horsey, Norfolk, on 2 October (AB). Singles were also reported from moth traps at Church Cove, Cornwall, on the night of 2 September (MT), and from Bradwell-on-Sea, coastal Essex, on the nights of 28 September and 11 October (SD).

Conclusions

It was something of a mixed year for dragonfly migration in Britain. Whilst some typical migrant species appeared in only low numbers, if at all, other species were well-represented. In particular, unprecedented numbers of Vagrant Emperor were to be reported during the year and there were also significant arrivals of Lesser Emperor and Red-veined Darter. At least some of the movements of Vagrant Emperor and Red-veined Darter were associated with periods of unseasonably hot weather during both spring and autumn, bringing dragonflies up from southern Europe and/or North Africa. A spell of warm settled weather in late June/early July also saw significant immigration by several species, though in this case Vagrant Emperor was not amongst them. Much of the other news for the year related to observations of local breeding by recent immigrants. Southern Migrant Hawker was thus proven to have bred successfully, and both Dainty Damselfly and Southern Emerald Damselfly clearly also did so. Although not all colonies might ultimately prove to be stable, the trend for 'southern' species (i.e. those having their strongholds in southern Europe) to continue arriving, and even establishing themselves, in Britain is clearly being maintained. Indeed it seems likely that yet further southern species will soon start to appear in Britain; such species potentially include Small Emerald Damselfly *Lestes virens*, Goblet-marked Damselfly *Erythromma lindenii*, Southern Skimmer *Orthetrum brunneum* and Southern Darter *Sympetrum meridionale*. Observers in the UK may wish to be on the lookout for such species.

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Emergence, maturation time and oviposition in the Common Darter *Sympetrum striolatum* (Charpentier)

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Summary

The most successful period of oviposition in 2005 occurred during the last half of September. However, 9% of the emergences in 2006 occurred from a pond exposed from mid-October through November 2005, indicating a second, smaller, peak of oviposition. Over the period 1990-2011 the average date for the first sighting of individuals was 17 June and the average date when first seen patrolling was 14 July. The mean time between emergence and patrolling was 28 days.

Introduction

The Common Darter *Sympetrum striolatum* has a one-year life cycle, i.e. it is univoltine (Corbet, 1956; Samraoui *et al*., 1998). In Britain, emergence of *S. striolatum* can start in mid June and carry on until early October. It is commonest in August and September but its flight season may last through November and, occasionally, into December (Lucas, 1900; Longfield, 1937: Miller, 1997). This is much the same throughout northern Europe, although emergence has been observed on the continent in early June (Dijkstra & Lewington, 2006). In the Mediterranean region it occurs all year round. In Italy, after emergence in mid-June, the adults remain immature until reproduction starts in mid-September (Utzeri, 1992), while in northern Algeria emergence occurs in May and June in lowland regions (at about sea level), the adults then moving to nearby wooded, upland areas (500-1000 m a.s.l.) where they feed for over four months before returning to breed in late September or early October (Samraoui *et al*., 1998; Corbet, 1999), breeding then continuing through until February (Dijkstra & Lewington, 2006). In Britain, during an exceptionally hot summer, it was reported by Parr (1992) that adults did not return to water for nearly two months.

Material and Methods

The study site is a small nature reserve that lies next to the river Hamble in Hampshire (British National Grid Reference SZ4818). A description of the site can be found in Horne (2012).

Eight glass fibre Barracuda Bio Edge ponds were established on the reserve in May 2005. The maximum length and breadth of each was 3.60m and 2.65m respectively and the maximum depth was 0.75 m (2,925 litre capacity when full) (Plate 1A). The ponds were in a row running approximately from east (pond no. 1) to west (pond no. 8) and were sited 3 m apart. They were planted out with Curled Pondweed *Potamogeton crispus*, Broad-leaved Pondweed *Potamogeton natans* and Fringed Water-lily *Nymphoides peltata*.

A

B

Plate 1. (A) One of the ponds after filling. (B) Ponds showing the covers.

Six of the ponds were covered in netting, forming a dome about four feet high, thereby preventing any dragonflies from getting in while they were in place (Plate 1B). The netting over each of these ponds was removed for a period of four weeks at various times during 2005 to allow dragonflies to oviposit. The other two (ponds 1 and 8) were left open all year (Table 1).

In 2006 the number of emerging Common Darter *Sympetrum striolatum* was recorded each day from 27 June until 1 October. Notes were also made on other emerging species of dragonfly, including the Emperor Dragonfly *Anax imperator*. A 5-day running mean was used to smooth out the *S. striolatum* data since there were days when no emergences were recorded, for example, as a result of poor weather conditions.

From 1990 – 2012 records have been made of the dates of first emergence and first patrolling adult.

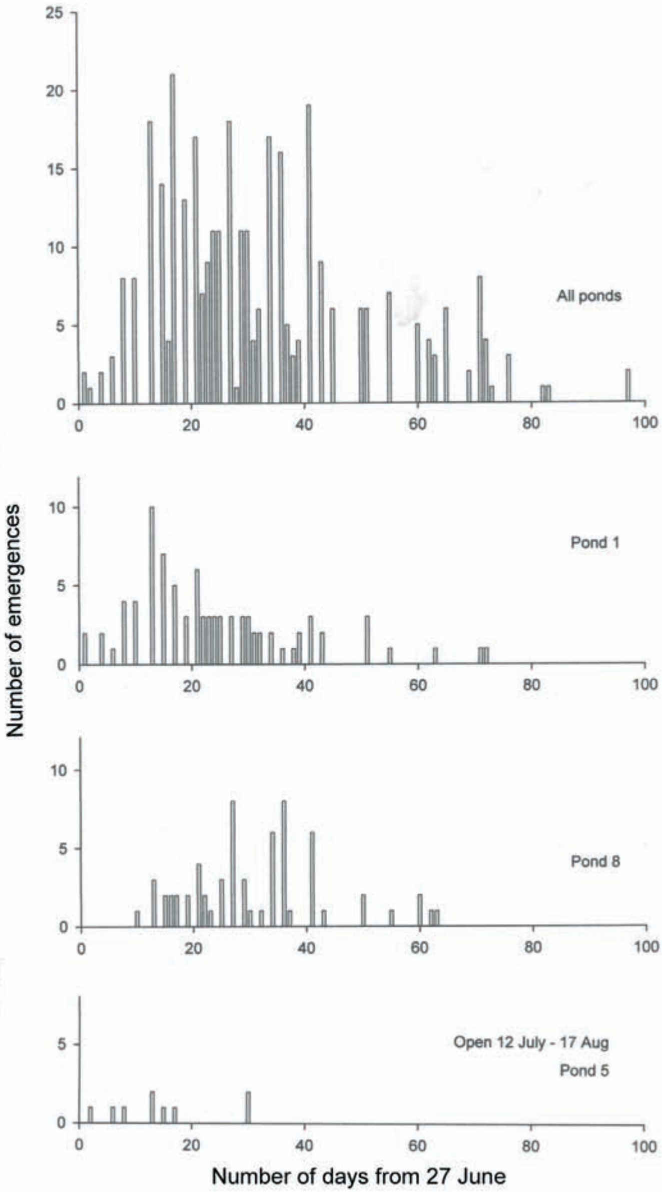
Table 1. Periods of opening of the eight ponds for oviposition in 2005 and the number of Common Darter *Sympetrum striolatum* and Emperor Dragonfly *Anax imperator* emerging in 2006.

	2005		No. emerging in 2006	
Pond	Open	Closed	*S. striolatum*	*A. imperator*
1	All year	-	87	11
8	All year		64	14
5	12 July	17 August	9	1
3	16 August	15 September	5	2
4	1 September	2 October	100	0
6	15 September	16 October	33	9
7	2 October	30 October	9	9
2	16 October	1 December	31	6

Results

There were 338 emergences of Common Darter *Sympetrum striolatum* recorded in 2006. Of these, 87 (26%) and 64 (19%) occurred in the two ponds that were not covered at all in 2005, thus allowing unrestricted oviposition. A further 100 (30%) were recorded emerging from the pond that had been left open for oviposition during September and 33 (10%) in the one where oviposition was restricted to the period mid-September to mid-October. Since only nine emergences were recorded from the pond exposed from mid July to mid August and a further five from the pond exposed from mid-August to mid-September, it is clear that very little successful oviposition had occurred before the middle of September in 2005. Furthermore, since only nine were recorded from the pond exposed during October 2005, the most successful period of oviposition in that year occurred during the last half of September. However, 31 (9%) emergences occurred from the pond exposed from mid-October through November, indicating a second, smaller, peak of oviposition in November 2005 (Fig. 1).

In 22 of the 23 years between 1990 and 2012 the first date on which *S. striolatum* was seen to emerge varied between 23 May and 5 July, the mean date for that period being 17 June. Similarly, the first date on which an adult was seen patrolling in 17 of those years varied between 28 June and 25 July, with a mean date of 14 July. In those 17 years the time taken between emergence and the


All ponds
Pond 1
Pond 8
Open 12 July - 17 Aug
Pond 5
Number of emergences
Number of days from 27 June

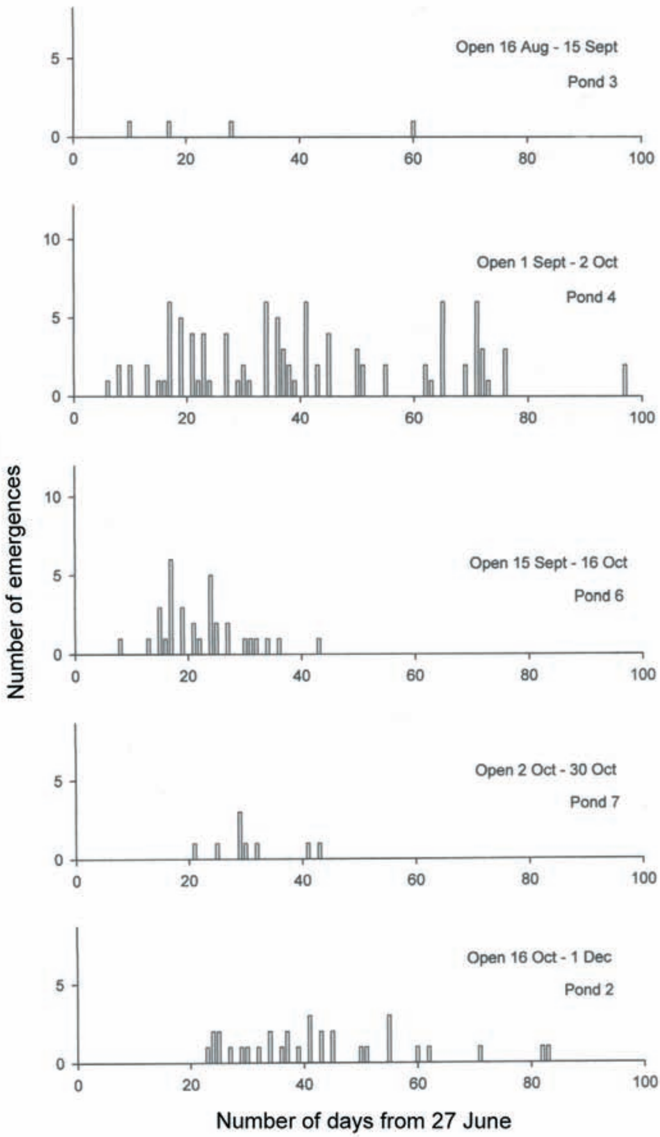


Figure 1. Number of emerging *Sympetrum striolatum* from all ponds and from each individual pond on each day from 27 June 2006 (day 1).

Table 2. Dates of first emergence and first patrolling adult of *Sympetrum striolatum* recorded over the period 1990-2012.

Year	First Emergence	First Patrolling	Days taken
1990	23 May	12 July	50
1991	15 June	14 July	29
1992	7 June	28 June	21
1993	13 June	-	-
1994	3 July	-	-
1995	26 June	18 July	22
1996	30 June	17 July	17
1997	29 May	6 July	38
1998	31 May	-	-
1999	-	-	-
2000	5 July	-	-
2001	24 June	25 July	31
2002	23 June	14 July	21
2003	13 June	9 July	26
2004	13 June	23 July	40
2005	13 June	10 July	27
2006	18 June	4 July	16
2007	3 June	3 July	30
2008	10 June	-	-
2009	23 June	23 July	30
2010	26 June	21 July	25
2011	25 June	24 July	29
2012	27 June	21 July	24
Means	**17 June**	**14 July**	**28**

first patrolling adult varied between 17 and 51 days, with a mean of 28 days (Table 2).

The first emergences recorded in 2006 were on 27 June, with the peak emergence period being from about 9 July to 6 August. Using the above mean of 28 days from emergence to patrolling implies that oviposition in 2006 should not start before early August, would peak later in August and last well into September.

Peak oviposition would thus appear to be slightly earlier than inferred for 2005. All of the emergencies recorded before 19 July 2006 would be from eggs laid during the main peak of oviposition in 2005. The data further suggest that the main emergence peak is followed by a smaller one somewhat later. This is not obvious from the graphed data, although three smaller peaks are apparent

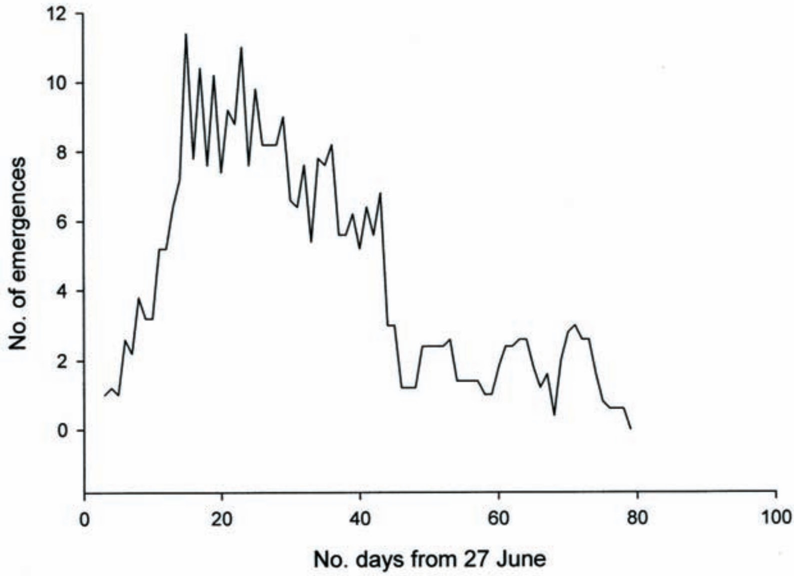


Figure 2. 5-day running average of the number of emerging *Sympetrum striolatum* from all ponds. Day 1 is 27 June 2006.

when the data are plotted as either 3-day or, especially, 5-day running averages (Fig. 2).

In general, on the reserve, small numbers of adult *S. striolatum* are present at the ponds by the end of July, increasing in August and reaching a peak by mid-September. Mating and oviposition occur soon after the first adults return to patrol. For example, in 1991 oviposition was observed seven days after the first adults were seen patrolling and in 2012 a pair was observed in tandem on the same day as the first patrolling adult.

Of the other anisopteran species observed, only the Emperor Dragonfly *Anax imperator* emerged in reasonable numbers. This species showed a single emergence peak in 2006 from ovipositions that had occurred from around the beginning of October 2005 onwards.

Discussion

The results of this study indicate that, on average, there is a period of about one month between emergence and the start of patrolling at water and that oviposition starts almost immediately after the adults return to water. However, the data obtained in 2005 indicates that very little oviposition appeared to have occurred before the end of August in that year with a peak period of oviposition in the latter half of September followed by a smaller peak in November. This is probably because peak emergence does not occur until the last three weeks of July and the first week of August and hence numbers of adults would be relatively low until about the middle of August. The small size of the ponds may also have been a factor in that they may have been less attractive for oviposition and were only used when the population density increased and oviposition sites became at a premium. Nevertheless, the situation in southern England is in marked contrast to that in northern Algeria, where reproduction is delayed for over four months after the first emergences are recorded (Samraoui *et al*., 1998).

The average number of days taken from emergence to the first adults seen patrolling was 28 days but it varied considerably (range 17 – 51 days). It is possible that the shorter periods were the result of adults that had emerged elsewhere at an earlier date visiting the ponds. Likewise, the longer periods could have resulted from missing a patrolling adult. Interestingly, in the hot, dry summer of 1991, Parr (1992) recorded a first emergence date of 4 June but did not see any returning adult until towards the end of July, which is well in excess of the 30 days recorded in 1991 in the present study.

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Species Review 6:

The Brilliant Emerald *Somatochlora metallica* (Vander Linden) and its close relative the Balkan Emerald *S. meridionalis* Nielson

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Introduction

Somatochlora is a genus in the family Corduliidae (superfamily Libelluloidea) and has representatives throughout the world except for Australasia (Davies & Tobin, 1985). *Somatochlora metallica* is widespread, but only locally abundant, throughout northern Europe, reaching northern Norway and Sweden and extending eastwards as far as central Siberia. To the west it occurs in south-east England and in Scotland but not in Wales or Ireland. It is found in most of the Netherlands, Belgium and France. To the south it extends as far as the Pyrenees and the alps of northern Italy. To the south-east it reaches the Balkans, parts of Romania and north-eastern Ukraine (Dijkstra & Lewington, 2006; Grand & Boudot, 2006).

According to Davies & Tobin (1985) *S. vera* Bartenef, 1914 is a subspecies of *S. metallica* (Vander Linden, 1825) that is found in eastern Russia, while *S. abocanica* Belyshev, 1955 and *S. meridionalis* Nielsen, 1935 are forms of *S. metallica*. However, *S. abocanica*, which is found in Siberia, is now accepted as a synonym of *S. metallica* (van Tol, 2006), whereas *S. meridionalis* which has also been considered as a subspecies of *S. metallica* by some authors (e.g. Askew, 1988) is now regarded as a separate species (e.g. Schmidt, 1957; Carchini 1983a, b; Dikstra & Lewington, 2006; Grand & Boudot, 2006; Schorr *et al*., 2006). *S. meridionalis* replaces *S. metallica* in south-east Europe, being found in the south-eastern corner of France and in northern central Italy, the Balkans, Greece, Bulgaria and about the southern third of Romania (Dijkstra & Lewington, 2006; Grand & Boudot, 2006). There is some overlap between *S. metallica* and *S. meridionalis*; where this occurs the former tends to be found at lakes and bogs at higher altitudes, the latter at lowland streams (Dijkstra & Lewington, 2006; Dijkstra & Kalkman, 2012).

Thus there are six species of *Somatochlora* in Europe, three of which are widespread (*S. metallica* Brilliant Emerald, *S. arctica* Northern Emerald and *S. flavomaculata* Yellow-spotted Emerald), two are rather restricted (*S. meridionalis* Balkan Emerald and *S. alpestris* Alpine Emerald) and one is confined to a very small region (*S. sahlbergi* Treeline Emerald). They can be divided into two groups. The '*arctica*' group, comprising *S. arctica*, *S. alpestris* and *S. sahlbergi*, are found in boreo-alpine or arctic habitats, whereas the '*metallica*' group, comprising *S. metallica*, *S. meridionalis* and *S. flavomaculta*, extend further to the south (Dijkstra & Kalkman, 2012). A hitherto seventh species, described originally as *S. borisi* Bulgarian Emerald) (Marinov, 2001), has been assigned to a new genus *Corduliochlora* based on adult characters (Marinov & Seidenbusch, 2007). However, its larva is similar to those of the '*metallica*' group of *Somatochlora* (Fleck *et al*., 2007; Dijkstra & Kalkman, 2012).

The Brilliant Emerald *Somatochlora metallica*

Description

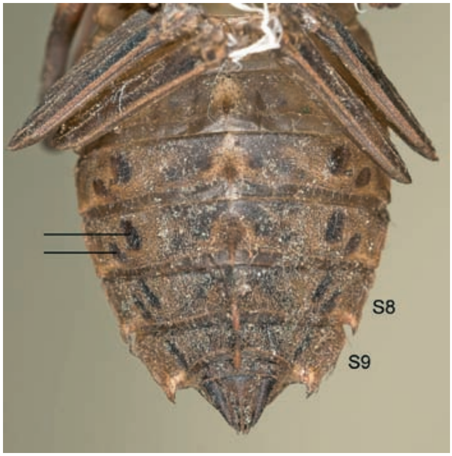
Egg

The eggs are elliptical and about 0.5 mm long and Lucas (1900) noted that there appears to be a thin outer, transparent layer with a slender pedicel at one end. In a more recent study Sahlén (1994) recorded the egg dimensions as 0.59 ± 0.08 mm x 0.42 ± 0.03 mm with an outer gelatinous layer which, when fully expanded, has a thickness of about 0.25 mm. The oocyte is surrounded by a vitelline envelope, outside which is an endochorion and an exochorion, the outer layer of the latter being gelatinous. The pedicel of Lucas (1900) is a micropylar process which bears two micropyle openings and the gelatinous layer does not extend over it

Larva

The labial mask of the larva is triangular and spoon-shaped and has a deeply serrated front margin. Rows of dark, dorso-lateral spots can often be seen on the abdomen and there are prominent mid-dorsal spines on S4 – S9, that on S7 being particularly prominent. There are also lateral spines on S8 and S9. The cerci are at least half as long as the paraprocts and the hind legs extend beyond the tip of the abdomen. In the final instar the wing cases are very broad and reach to the 6^{th} abdominal segment. The overall length of the final instar larva is 23-26mm (Plate 1) (Cabot, 1890; Lucas, 1930; Longfield, 1937; Smith & Smith, 1985; Vick, 2004; Cham, 2007).

A



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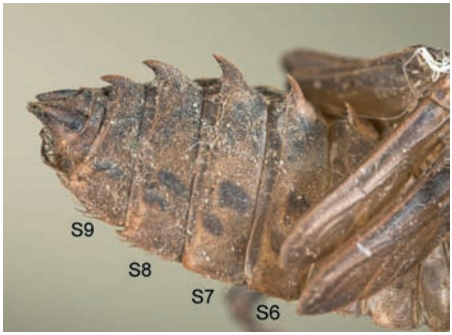

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Plate 1. Larvae and exuviae of *Somatochlora metallica*. (A) larva in dorsal view, (B) dorsal view of abdomen of an exuvia to show the lateral spines on segments 8 and 9 and the dark dorso-lateral abdominal markings (______), (C) larva in side view and (D) side view of abdomen of an exuvia to show the dorsal spines and dorso-lateral spots; S6-S9, abdominal segments 6-9. Photographs by Steve Cham.

Adult

The head, thorax and abdomen are all metallic emerald green. In young specimens the eyes are brown but become bright green with age. There is a yellow ‘L’-shaped band on each side of the frons, the lower arms of which almost meet in the mid-line to form a ‘U’ shape. There is also a pair of small yellow marks on each of abdominal segments 2 and 3. The wings are suffused with yellow and the anal triangle in the hind wings may be quite yellow. In the female the anal angle of the hind wings is rounded. In the male the abdomen is 'waisted' towards its anterior end. The inferior anal appendage is conspicuous and unforked while the superior anal appendages each bear a lateral spine and have an angular appearance (Plate 2). The abdomen of the female has parallel sides and the vulvar scale is conspicuous, projecting at an angle of almost 90^{o} from the ventral surface of the ninth abdominal segment (Plate 3) (Lucas, 1900; Longfield, 1937; Vick, 2004; Smallshire & Swash, 2004).

Habitat

In Britain *S. metallica* is found in areas where there are neutral or acidic ponds and lakes, often with steep banks. There are usually some bankside trees and also woodland nearby. In England they are also occasionally found in slow flowing waters such as canals and sluggish rivers where there are overhanging trees (Vick, 2004) and this is generally the case in continental Europe (Dijkstra & Lewington, 2006). In Scotland the species favours peaty lochs with marginal *Sphagnum* (Smith & Smith, 1995). In some parts of France it inhabits small forest streams and, in the Balkans and northern Italy, it is found in the slower flowing parts of large rivers as well as in lakes (Grand & Boudot, 2006). However, in the Jura it is found on montane lakes (Brooks, pers. com.). It has been recorded up to a height of 2,000 m above sea level in the Alps and Pyrenees in France (Grand & Boudot, 2006).

Distribution in the British Isles

In Britain *S. metallica* occurs in two widely separated regions – in south-east England and in the Highlands of Scotland (Figs. 1, 2):

South-east England. *S. metallica* occurs in south-west Kent, Sussex, Surrey, Berkshire and north-east Hampshire. In Sussex it is locally common, mainly in pine woodland on the northern ridges of the High Weald.

Scotland. *S. metallica* has been recorded from three separate regions (Smith & Smith, 1995):

a) Strathglass Region, Inverness-shire (Highland). The first British record, by B. White in 1869 (Lucas, 1900), was from this region. It is found in Glen Affric, Glen Strathfarra and Cannich, mostly in small to medium-sized acidic lochans (pH 4.10 – pH 6.3) at an altitude of 190-425m above sea level, and mainly within the remnants of the Old Caledonian Forest (J. M Boyd [Mr & Mrs] in Smith & Smith, 1995; A. D. Fox in Smith & Smith, 1995; Smith & Smith, 1995; Chelmick *et. al.*, in prep.). It is not particularly common here (T.

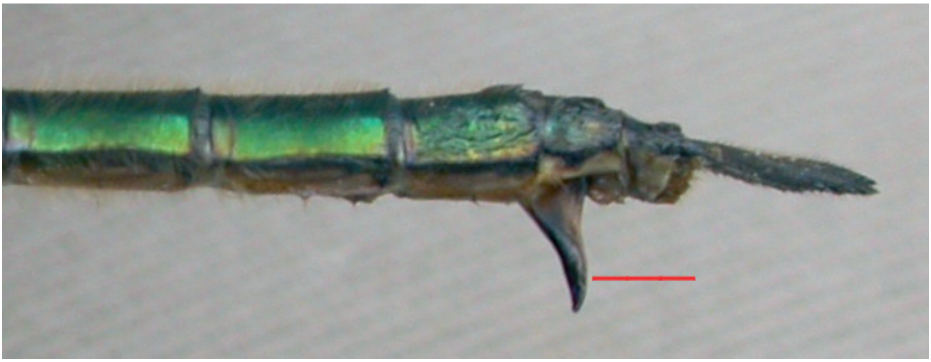
Beynon, pers. comm.) (Fig. 2).

b) Loch Bran Complex, Inverness-shire (Highland). The first record from Loch Bran was by C. A. Whittle in 1979 (Odonate Recording Scheme & pers. comm.) and it has now been recorded from several other adjacent small to medium-sized lochans to the east of Loch Ness and has been found as far to the south-west as Fort Augustus (Smith & Smith, 1995; Chelmick *et. al.*, in prep.) (Fig. 2).

c) Loch Awe Region, Ayrshire (Strathclyde) Found in hill lochs on either side of Loch Awe. It was first recorded in this region from Loch a' Chrion-doire by K. J. Morton who collected a male and a female (in the collection of the Royal Museum of Scotland) in 1922 but was probably not seen again in this locality until 1995 when several specimens were recorded from the two small lochans at this site. These are slightly alkaline with a pH of 7.5 (Smith & Smith, 1995; Chelmick *et. al.*, in prep.).

Plate 2. *S. metallica*. Young male (note the brown eyes). Photograph by Christophe Brochard.

A



B

Plate 3. *S. metallica*. (A) adult female in flight during oviposition (note the perpendicular vulvar scale (____) and upturned abdominal tip (____), (B) posterior end of a female abdomen to show the vulvar scale (____). Photographs (A) by Tim Caroen, (B) by Jonathan Willet.

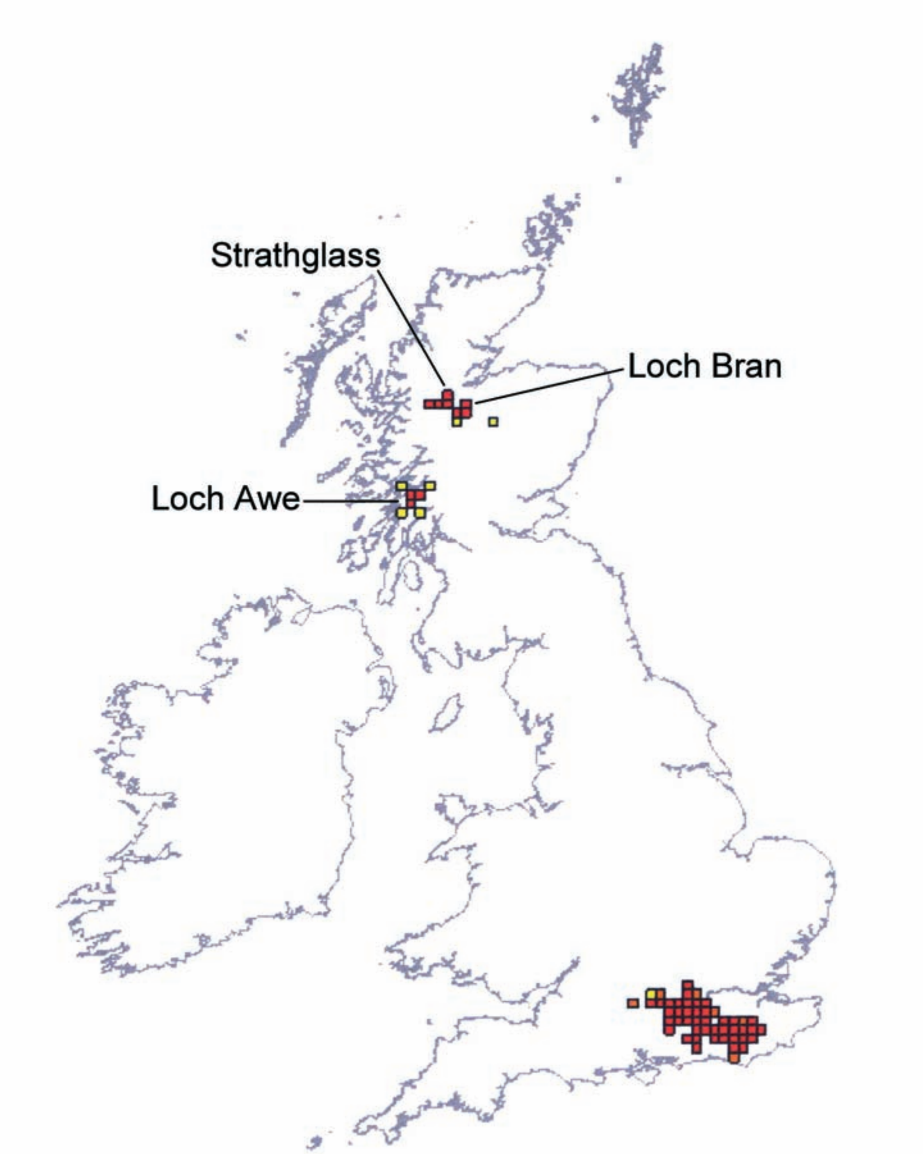


Figure 1. Distribution of *Somatochlora metallica* in Great Britain and Ireland at 10 km square resolution. © Crown copyright and database rights 2011 Ordnance Survey [100017955].
■, 1985 to 2004; ■, before 1985; ■, 2005 to 2011. **Note:** the '1985-2004' dates overlie the earlier ones where squares have records in more than one date class; similarly the 'before 1985' dates overlie the '2005-2011' ones where squares have records in both date classes. Thus the red squares show the core range over the 20 years from 1985-2004, the orange shows squares where no records have been obtained since before 1985 (range reduction) and the yellow shows squares where new records have been obtained since 2004 (range expansion).

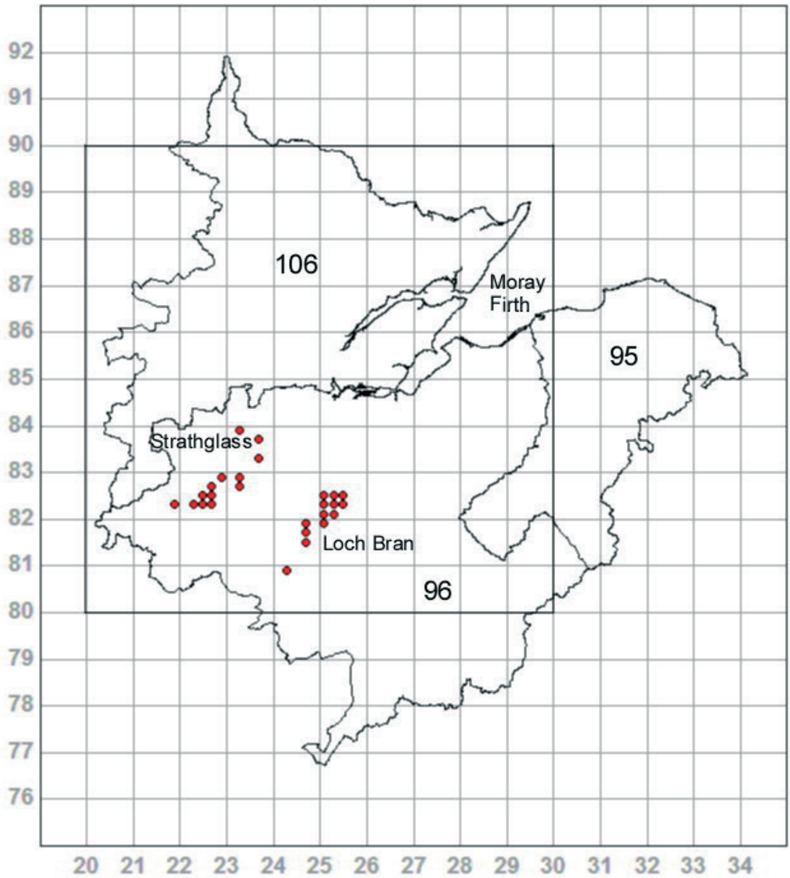


Figure 2. Distribution of *Somatochlora metallica* in East Inverness-shire (with Nairn) (VC96) at 2 km resolution to show the separation of the Strathglass and Loch Bran sites. To the north is East Ross (VC106); to the east is Moray (Elgin) (VC95). The outlined square is the 100 km square 28 (NH).

Life Cycle

Egg

The eggs may be laid directly into water or into a damp substrate. When they come into contact with water the coating of the egg swells and, if laid in open water, attaches the egg to any support the egg may have fallen on to (d'Aguilar *et al*., 1986). Hatching occurs four to ten weeks after oviposition (d'Aguilar *et al*., 1986; Grand & Boudot, 2006) but some of the eggs that are laid late in the season may enter diapuse and hatch the following spring (Grand & Boudot, 2006).

Larva

The larvae live in water for 2-3 years (d'Aguilar *et al*., 1986; Smith & Smith, 1995; Vick, 2004) and are found in areas where there is decaying plant debris. However, their habitat requirements differ slightly between the English and Scottish populations. In England they are found in ponds and lakes, particularly where the water is heavily shaded by overhanging trees and where there is muddy, decaying organic debris such as leaves and twigs in the water (Vick, 2004; Cham, 2007 & pers. comm.), whereas in Scotland they occur in peaty lochans with Bog-moss, *Sphagnum*, margins and, although they are often found in shady areas, this is not a strict requirement, although nearby tree cover appears to be obligatory (Smith & Smith, 1995).

Emergence

In Britain, emergence occurs in the morning, starting in early June and peaking in late June (Vick, 2004). At higher altitudes in France, Grand & Boudot (2006) note that emergence is synchronised, with about half of the emergences occurring within a period of five days at a given location. Emergence occurs on marginal vegetation, including long grasses, bushes and tree trunks, close to the edge of the water; exuviae have been found on trees up to 2 m above the water level (Vick, 2004, Cham, 2007).

Adult

The flight period in Britain is from June until late August or sometimes into early September (Vick, 2006)' Further south, in France, the flight period tends to be a bit longer; it sometimes starts in late May and can extend until the end of September, or even early October (Grand & Boudot, 2006; Rouillier, 2009).

The flight pattern has been suggested as being similar to that of the Downy Emerald *Cordulia aenea* (Hamond, 1977). However, there are differences. Thus the abdomen of *S. metallica* is held horizontal in flight, whereas that of *C. aenea* is usually tilted slightly upwards (Miller, 1995; Follett, 1996). Also males of *S. metallica* fly "with a characteristic head-down attitude, at a somewhat steeper angle than in *C. aenea*" (Beynon & Goddard, 2004).

Vick (1997) noted that adults are active from about 09.00 – 20.00 and that males fly around the perimeter of lakes whereas females spend a considerable amount of time in the tree canopy and in woodland clearings, with occasional visits to water. In contrast d'Aguilar *et al*. (1986) described the adults as "moving constantly between the water and tree-tops". In a detailed study in south-east England Ward-Smith *et al*. (2000) note that it is capable of flying at a wide range of speeds as well as hovering but that there are three main styles of flight:

a) When first visiting a water body individuals fly rapidly and erratically around it for, usually, no more than two minutes. Presumably they are assessing the suitability of the water body.

b) Males slowly patrol a regular beat between 2-6 m above the water surface with occasional pauses of hovering, usually keeping about 4-6 m from the edge of the pond. This appears to be territorial behaviour and is similar to the patrolling flight of the Emperor Dragonfly *Anax imperator*.

c) As noted by Vick (1997) males fly around the perimeter of lakes at a height of 0.8–1.3 m above the water and keeping 1-2 m from the edge of the water body, pausing (but rarely settling) when they encounter regions with overhanging vegetation; they may be looking for ovipositing females. This pattern is similar to that of *C. aenea* and the Southern Hawker *Aeshna cyanea*.

Reproduction

Mating lasts for several minutes and then the sexes separate. The females oviposit alone either into the water close to the edge in regions where there is a substrate of coarse organic matter or directly into wet mud, moss or decaying

Table 1. Trematode parasites found in *Somatochlora metallica*.

Lecithodendriidae		
Pleurogenoides medians (Olsson, 1876)	Czechoslovakia	Vojtek (1989)
Prosotocus confusus (Looss, 1894)	Czechoslovakia	Vojtek (1989)
Plagiorchiidae		
Plagiorchis elegans (Rudolphi, 1802)	USSR (CIS)	Krasnolobova & Iljushina (1991)
Prosthogonimidae		
Prosthogonimus cuneatus (Rudolphi, 1809)	USSR (CIS)	Krasnolobova & Iljushina (1991)
Prosthogonimus ovatus (Rudolphi, 1803	USSR (CIS)	Krasnolobova & Iljushina (1991)

leaves on shady, normally steep, banks above the water line. At Scottish sites they normally oviposit into mud, Sphagnum or peat either below the water or, more usually, above the water line. They may also choose sites among roots or weeds (Tienssu, 1945; d'Aguilar, et al., 1986; Smith, 1984; Pratz, 1989; Fox, 1991; Smith & Smith, 1995; Dijkstra & Lewington, 2006; Cham, 2007). When laying eggs into water the female dips the tip of her abdomen into the water and releases two or three eggs each time (Tiensuu, 1945; Robert, 1958; d'Aguilar *et al*. 1986; Askew, 1988). When laying into a damp substrate she inserts her vulvar scale repeatedly into the substrate to release the egg(s) After up to about 10 oviposition movements the female dips the tip of her abdomen into water, although whether this is to clean the abdomen or whether oviposition occurs at the same time is not known (Fox, 1989; Pratz, 1989; Richards, 1996). There are conflicting reports about the attitude of the abdomen during oviposition. In some cases the abdomen, including the tip, has been noted to be held completely horizontal (Smith, 1984; Beynon & Goddard, 2004); in others the tip of the abdomen has been recorded as bent upwards at an angle of about 90^{o} (Plate 3A) (Askew, 1988; Powell, 1999; Smallshire & Swash, 2004)

Epibionts and Parasites

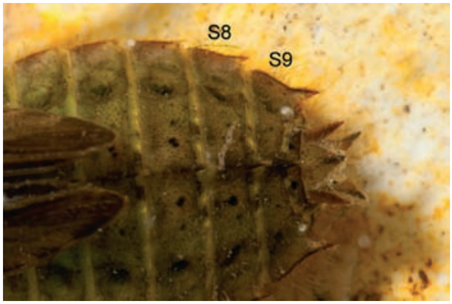
The larval cases of chironomids have been found attached to larvae of *S. metallica* (Wildermuth, 2001), thereby providing a substrate that is not only secure but does not get buried in silt (Corbet, 1961; Corbet & Brooks, 2008). As far as parasites are concerned, various trematodes have been found in samples of *S. metallica* from Czechoslovakia (Vojtek, 1989) and the USSR (CIS) (Krasnolobova & Iljushina 1991): see also Gibson *et al*. (2005) (Table 1).

Conservation

S. metallica is not endangered in continental Europe. However, it is classified as 'Endangered' in Britain, being a relatively rare species, locally common in both England and Scotland. In Scotland deforestation in the regions where it is found would have an adverse effect by opening up the lochans. Similarly, in England removal of bankside trees and dredging would both have an adverse effect (Vick, 2004).

Nevertheless, the populations in both Scotland and England appear to be generally strong. In Scotland there is a recent record well to the east of the Loch Bran region and it may be expanding its range slightly in all directions in the Loch a' Chrion-doire region (Fig. 1). However, caution should be exercised as recorder effort may have played a part in the apparent range expansion. In

A



B

C

D

Plate 4. Larvae of *S. meridionalis*. (A) dorsal view, (B) dorsal view to show the lateral abdominal spines on segments 8 and 9, (C) side view and (D) side view to show the dorsal abdominal spines. S6-S9, abdominal segments 6-9. Photographs by Christophe Brochard.

south-east England its range appears to be stable (Fig. 1).

The Balkan Emerald *Somatochlora meridionalis*

Description

Larva

The final instar larva of *S. meridionalis* (Plate 4) is similar to that of *S. metallica* (Plate 1) but differs in that, in the former, the lateral spines on abdominal segment 9 are longer and much more robust than those on segment 8 and reach at least to the middle of the cerci (Plate 4B). In comparison, in *S. metallica* the lateral spines on abdominal segment 9 are either shorter or just slightly longer than those on segment 8 and reach no further than about a third of the way along

Plate 5. *S. meridionalis*. Adult female Note the yellow mark (______) on the side of the thorax. Photograph by Christophe Brochard.

the cerci (Plate 1B) (Terzani, 1990; Fleck *et al*., 2007)). Furthermore, in *S. meridionalis* the basal width of the dorsal spine on segment 9 is no greater than the length of the distal part of the spine, whereas in *S. metallica* the basal width of the spine is greater than the length of its distal part (Plates 1D, 4D). There are also some slight differences in the relative lengths of the anal appendages in the two species (Seidenbusch, 1996).

Adult

The adults are very similar to those of *S. metallica*, the only difference being a yellow spot (sometimes two) on the side of the thorax, although the pale markings on abdominal segments 2 and 3 do tend to be larger than those in *S. metallica*. The overall length is 50-55 mm (Dijkstra & Lewington, 2006) (Plate 5).

Habitat

S. meridionalis differs from *S. metallica* in that the former breeds almost exclusively in streams and rivers. However, as noted above, *S. metallica* is found in similar habitats in some parts of its range (e.g. France). At lower altitudes *S. meridionalis* prefers, like *S. metallica*, shaded areas but, at higher altitudes, it may also breed in sunny areas (Dijkstra & Lewington, 2006). In Bulgaria at least, *S. meridionalis* can be seen in open, very sunny and virtually treeless areas (T. Beynon, pers. comm.).

Life Cycle

Adult

S. meridionalis is found on the wing from June to August. The males patrol along streams at a low level above the water and prefer shade, tending to avoid sunny regions. As with *S. metallica*, the flight is fast and is interrupted with bouts of hovering (Dijkstra & Lewington, 2006).

Conservation

S. meridionalis is endemic to south-east Europe. It is not uncommon and there are no obvious threats.

Acknowledgements

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A preliminary report on parasitism of Odonata by water mites from Bosnia and Herzegovina.

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Summary

The following Odonata, infested with mites, have been collected from a number of sites in Bosnia and Herzegovina - *Aeshna isosceles, Sympetrum flaveolum, Coenagrion pulchellum, Coenagrion puella, Coenagrion scitulum, Enallagma cyathigerum, Erythromma najas, Ischnura elegans, Ischnura pumilio, Lestes dryas, Platycnemis pennipes,* and *Pyrrhosoma nymphula*. The preferred site of mite attachment on the body is the posterior ventral surface of the thorax, behind the third pair of legs. In all but one of the species of zygopteran, mites were also found between the first and second pair and/or the second and third pair of legs and, in several species, on the abdomen. Mite loads varied for different species but preliminary results suggest that the larger anisopterans can carry more mites (in *S. flaveolum* mean 42, range 1-91) than the zygopterans, the highest recorded in the latter being in *C. pulchellum* (mean 37, range 1-68) and the lowest in *L. dryas* (mean 4, range 1-11). More mites were found on female damselflies than on males. Three distinct sizes of larval mite have been noted, indicating stages in their engorgement on the host.

Introduction.

Damselflies and dragonflies can be found infested with parasitic water mites, normally the larvae of the mite genus *Arrenurus* (although *Limnochares* spp. have also been recorded from Odonata), and they are known to have an impact on their hosts (Baker, 2011). The subject has also been reviewed by Smith (1988) and Davids (1997). Several species of mite are known to occur on one host and infestation may be very heavy at times, especially on the thorax.

The odonate fauna of Bosnia and Herzegovina is not well known and many records are old, although Jovic *et al*. (2010) have provided a recent review, including a database of previously unpublished as well as new work.

The present paper reports on Odonata parasitized by arrenurid water mite larvae. Previous work on these parasitic larval mites from Eastern Europe has been described by Baker *et al*. (2007; 2008) and, as a result of work by Zawal (2008), it is now possible to identify the mites to species. As far as is known, mites have not been previously described from odonates in Bosnia and Herzegovina.

Material and Methods.

Sixty infected Odonata were collected from a number of sites in Bosnia and Herzegovina between May and August 2011 at a range of altitudes from 5 to 1,778m (Fig. 1; Tables 1, 2) and the mites with their hosts were preserved in 70% ethanol. The odonates included two species of Anisoptera (*Aeshna isosceles* and *Sympetrum flaveolum*) and 10 species of Zygoptera (*Coenagrion pulchellum, Coenagrion puella, Coenagrion scitulum, Enallagma cyathigerum, Erythromma najas, Ischnura elegans, Ischnura pumilio, Lestes dryas, Platycnemis pennipes, Pyrrhosoma nymphula*). As far as we are aware, mites have been recorded previously on all these species of odonate from Europe, apart from *A. isosceles* and *C. pumilio*.

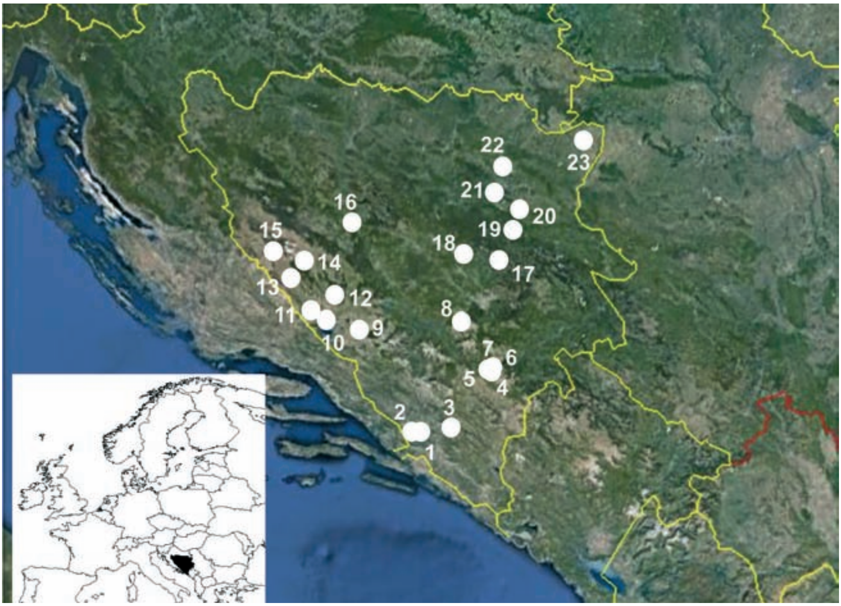

Figure 1. Map of Bosnia and Herzegovina showing the locations of the sites referred to in Table 1. Inset – location of Bosnia and Herzegovina.

Table 1. Details of the sites in Bosnia and Herzegovina where odonate collections were made. The numbers refer to the locations in Figure 1.

Map No	Locality	N	E	Altitude (m a.s.l.)
1	Stream at Londža, Hutovo blato	43°02’00’’	17°49’16’’	5
2	Pond at Svitava	42°59’50’’	17°48’30’’	327
3	Pond near Hodovo,	43°08’51’’	17°56’07’’	404
4	Ponds at Masna bara, Zelengora mountain	43°23’38’’	18°26’44’’	1470
5	Pond near Kladopolje	43°25’19’’	18°24’42’’	1375
6	Kladopoljsko lake	43°25’04’’	18°25’28’’	1395
7	Pond near Obalj, Kalinovik	43°27’52’’	18°21’20’’	995
8	Lokvanjsko lake	43°43’46’’	18°12’17’’	1778
9	Canal near Mandino selo, Duvanjsko karst polje	43°40’41’’	17°18’05’’	867
10	Pond at Ploča near Livno	43°44’31’’	17°00’50’’	800
11	Pond near Orguz, Livanjsko karst polje	43°47’19’’	16°52’18’’	706
12	Dragnić, Glamočko karst polje	43°53’58’’	17°00’40’’	886
13	Oxbow near Vrbica, Livanjsko karst polje	43°59’48’’	16°41’12’’	705
14	Ribnik stream, Glamočko karst polje	44°05’50’’	16°48’30’’	904
15	Šatorsko lake	44°09’55’’	16°36’06’’	1484
16	Malo Plivsko lake	44°20’58’’	17°13’55’’	422
17	Bakići near Olovo	44°05’58’’	18°32’57’’	824
18	Haljinići ponds	44°06’07’’	18°09’53’’	456
19	Stream near Stupari	44°21’28’’	18°40’16’’	307
20	Bašigovci lake	44°25’02’’	18°41’17’’	255
21	Pond near Prokosovići	44°30’51’’	18°27’28’’	203
22	Tinja river	44°46’29’’	18°30’51’’	136
23	Dašnica canal at Crnjelovo	44°50’24’’	19°10’42’’	78

Table 2. Details of the species of odonate collected in Bosnia and Herzegovina at the sites listed in Table 1. The numbers refer to the locations in Figure 1.

Map No.	Locality	Date	Species	Sex
1	Stream at Londža, Hutovo blato	19.05.2011	*Coenagrion pulchellum*	4F
2	Pond at Svitava	20.05.201	*Aeshna isoceles*	M
3	Pond near Hodovo	10.06.2011	**Ischnura pumilio**	M
	“	“	*Coenagrion scitulum*	2M + F
	“	“	*Ischnura elegans*	M
4	Ponds at Masna bara, Zelengora mountain	03.08.2011.	*Lestes dryas*	M
5	Pond near Kladopolje	03.08.2011	*Sympetrum flaveolum*	2M
6	Kladopoljsko lake	03.08.2011	*Enallagma cyathigerum*	2M
7	Pond near Obalj, Kalinovik	03.08.2011	*Ischnura pumilio*	M + F
8	Lokvanjsko lake	21.08.2011	*Sympetrum flaveolum*	F
9	Canal near Mandino selo, Duvanjsko karst polje	16.06.2011	*Lestes dryas*	3M
10	Pond at Ploča near Livno	17.06.2011	*Coenagrion puella*	M
11	Pond near Orguz, Livanjsko karst polje	24.06.2011	*Sympetrum flaveolum*	M
12	Dragnić, Glamočko karst polje	28.05.2011	*Ischnura pumilio*	M
13	Oxbow near Vrbica, Livanjsko karst polje	17.06.2011	*Lestes dryas*	M+2F
	“	“	*Sympetrum flaveolum*	2F
14	Ribnik stream, Glamočko karst polje	28.05.2011	*Coenagrion puella*	M
	“	24.06.2011	*Coenagrion puella*	M
	“	“	*Lestes dryas*	2F
15	Šatorsko lake	05.06.2011	*Ischnura pumilio*	M
16	Malo Plivsko lake	26.06.2011	*Coenagrion pulchellum*	M+2F
	“	“	*Enallagma cyathigerum*	2M+3F
	“	“	*Platycnemis pennipes*	F
17	Bakići near Olovo	11.08.2011	*Ischnura pumilio*	2M
18	Haljinići ponds	31.05.2011	*Coenagrion puella*	M
	“	“	*Coenagrion scitulum*	M + F
	“	“	*Lestes dryas*	2M
	“	14.06.2011	*Coenagrion scitulum*	M + F
19	Stream near Stupari	01.06.2011	*Pyrrhosoma nymphula*	M
20	Bašigovci lake	01.06.2011	*Coenagrion puella*	M
21	Pond near Prokosovići	01.06.2011	*Erythromma najas*	M
	“	“	*Ischnura elegans*	2M + F
22	Tinja river	02.06.2011	*Enallagma cyathigerum*	M
23	Dašnica canal at Crnjelovo	07.07.2011	*Coenagrion puella*	M

Each odonate was examined and each mite carefully removed and mounted in polyvinyl lacto-glycerol on a slide, this serving as both a mounting and clearing agent. One microscope slide was used to represent one host. The site of attachment of each mite on its host was noted and the total for each host recorded. It is essential that this procedure is adopted because the mites clump together, with some on top of each other, thus hiding others from view. Thus field and even laboratory counts of mites while attached to their host can give misleading figures of the numbers present. In some cases significant numbers had become detached from the host while in the fixative. It is important therefore that the fixative is also checked for unattached mites and that these numbers are included in the total counts from each host specimen.

Results.

Within the Zygoptera there were distinct variations in the numbers of mites parasitizing the different species of damselfly. For example, in *Enallagma cyathigerum* the mean number of mites per individual was 25.3, compared with *Lestes dryas* where the mean was only 4.2. Even within a genus there was considerable variability with *Coenagrion pulchellum* having a mean of 37.3, *Coenagrion puella* a mean of 17.0 and *Coenagrion scitulum* a mean of 7.4) (Table 3). When comparing these preliminary results with the figures obtained for the anisopteran, *S. flaveolum*, it would appear that larger hosts such as *Sympetrum* (mean = 42.0) can carry more mites (Table 3). Plate 1 illustrates the parasitic larval stage of a species of *Arrenurus*, although the species of mite found are yet to be determined.

The load or intensity of infestation per host varied considerably, even within one host species, and in some cases was quite low (*L. dryas* - 1 to 11). By contrast, in *C. pulchellum*, for example, there was a range of 1 to 68. With only small numbers of hosts from different collecting sites, it is difficult to draw any firm conclusions but the results appear to confirm that different species of odonate carry different mite loads.

Several host attachment sites were used by the mites (Table 4). Overall, the largest numbers of mites were found on the ventral side of the thorax behind the third pair of legs. Indeed, in *L. dryas* all of the mites that had not fallen off in the fixative were attached in this region. Overall figures for the Zygoptera were - between legs one and two 3%, between legs two and three 17%, behind legs three 49%, on abdominal segments 10% and in the fixative (sites unknown) 21%. In the case of the abdomen, the first two segments were the main attachment sites. In the anisopteran *S. flaveolum*, mites used abdominal segments and several mites were found on the wings of one specimen.

Table 3. The mite load on the different odonate species.

Odonate species	Mites			
	Number examined	Total	mean	range
Zygoptera				
Coenagrion puella	6	102	17	1-35
Coenagrion pulchellum	7	261	37.3	1-68
Coenagrion scitulum	7	52	7.4	3-11
Enallagma cyathigerum	8	203	25.3	0-57
Erythromma najas	1	12		
Ischnura elegans	4	22	5.5	0-17
Ischnura pumilio	7	80	11.4	0-40
Lestes dryas	11	46	4.2	1-11
Platycnemis pennipes	1	9		
Pyrrhosoma nymphula	1	81		
Anisoptera				
Aeshna isosceles	1	22		
Sympetrum flaveolum	6	252	42	1-91

The overall number of hosts was small but there is some evidence to suggest that there is a difference between the time of year when catches were made. Thus, in May – June the mean number of mites per individual was 16.6 (n = 49 odonates) compared to July-August when the mean was 25.3 (n = 11 odonates). Also, in a preliminary count of the mites on the zygopterans, more mites were recorded on female hosts (mean mites = 21; n = 19 females) than on males (mean mites = 12.2; n = 34 males). Meaningful figures on these topics require further collections and analyses.

Although different species of mite were of different sizes, three distinct larval size groups were found, indicating stages in their engorgement. The largest, fully engorged, easily detachable and ready to drop off, were seen by the numbers in the fixative in *S. flaveolum*. The smallest were probably recently attached (or have been dormant) and were about to start, or had just started, feeding. The middle sized larvae were actively feeding and showed a distinct white coloured,

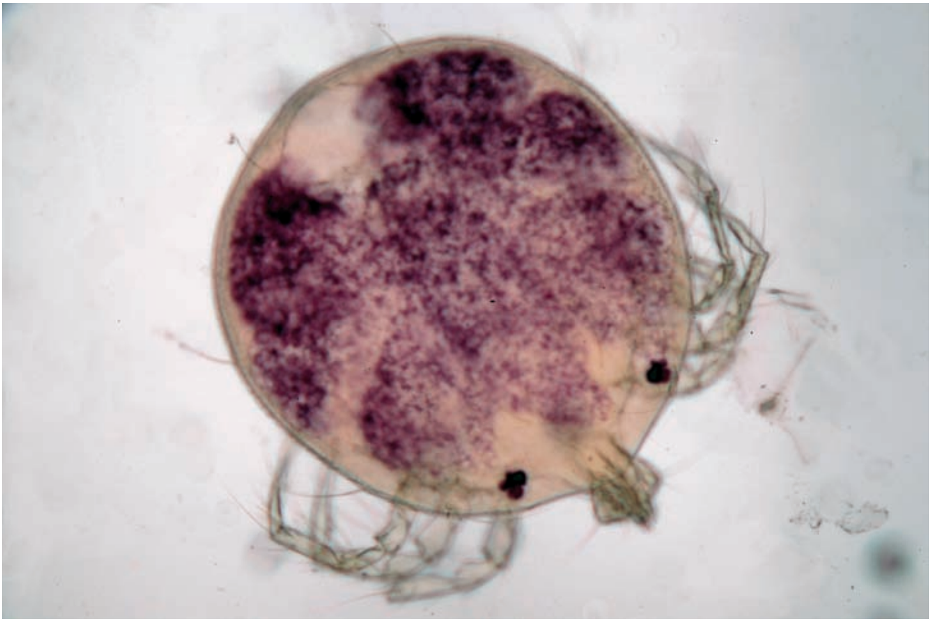

Plate 1. Parasitic larva of an arrenurid mite. It is about 150 - 200μm long.

active dorsal excretory organ.

Discussion.

One must take great care in drawing conclusions from such a small number of Odonata taken from a large number of sites and, as Corbet (1999) has cautioned, from isolated studies on single populations. Mite loads can vary from year to year, between habitats and populations and between species. Such matters have been discussed by Grant & Samways (2007) and Corbet (1999). However, in the main, the information obtained appears to be comparable with previous studies. Zawal (2004) examined ten infested species of odonate and found an overall load of between 1 and 103, with a majority of mite larvae being found in May and June. Also, in another study, Zawal (2006) examined eight infested odonate species and found an overall load of between 1 and 195. Rolff (2000), working on *C. puella*, parasitized by *Arrenurus cuspidator*, recorded a mean daily abundance range of 1 to 45 mites per host and Baker *et al*. (2008) recorded a mean of 8.8 mites on *C. puella*.

Site selection on the host has been discussed by several workers, including Baker *et. al*. (2007, 2008), Botman *et. al*., (2002), Rolff (2000), Zawal (2004,

Table 4. Sites of attachment of mites on the different odonate species.
*includes four attached to abdominal segment 3; **includes one attached to abdominal segment 5, five attached to abdominal segment 6 and one attached to abdominal segment 7; also three specimens found on the side of the thorax. *** excludes an additional 5 on the wings, 93 on the thorax and 6 on the abdomen, where the specific sites were not possible to determine.

Odonate species	Mite attachment site						Mites in fixative	Total mites
	Legs			Thor/ Abd	Abdomen			
	1/2	2/3	Behind 3		seg 1	seg 2		
Zygoptera								
Coenagrion puella		10	67				25	102
Coenagrion pulchellum	14	43	129		22	20	29	261*
Coenagrion scitulum		23	19				10	52
Enallagma cyathigerum	11	50	84		17		41	203
Enallagma najas		2	9				1	12
Ischnura elegans	1		1	9			1	22**
Ischnura pumilio		11	41		7		21	80
Lestes dryas			39				7	46
Platycnemis. pennipes		6	2				1	9
Pyrrhosoma nymphula		2	34		4		41	81
Anisoptera								
Aeshna isosceles			21				1	22
Sympetrum flaveolum			62				86	148***
Totals	26	147	508	9	50	20	264	1038

2006) and Zawal & Dzierzgowska (2012). Botman *et al*. (2002) found species-specific selection sites on the damselfly *Ischnura posita* for the attachment of *A. major* and *A. americanus*. Baker *et al*. (2007), working on seven species of zygopteran, found that, in *C. puella,* 82.3% were attached to the thorax and 14.5% were on the abdomen. Rolff (2000) found that the mites had a clumped distribution on their host. Zawal (2004, 2006) indicated that the abdomen of *Lestes sponsa*, *Platycnemis pennipes* and *Ischnura elegans* was a more specific site for attaching *Arrenurus* larvae, while the thorax was more specific for *Enallagma cyathigerum*, *Pyrrhosoma nyphula*, *Coenagrion puella*, and *C. pulchellum* but that both the thorax and abdomen were infected to the same level in *Erythromma najas*. The reason why the mites attach most frequently behind the third pair of legs could be related to the grooming behaviour of the host or to the fact that the cuticle may be easier to penetrate at this attachment site.

Among the list of host species, *Aeshna isosceles* is a new host record and only once before has another species of *Aeshna* been mentioned as a host for water mite larvae (Zawal, 2006). Anisopterans seem to be less frequently infected than zygopterans (Conroy & Kuhn 1977, Davids 1997, Zawal 2004, 2006) but there are fewer records of the former and the degree of infestation is still an open question. Although water mite larvae have frequently been mentioned in the literature on the larvae of anisopterans, these are phoretic larval mites (Zawal 2005, 2006; Zawal & Dzierzgowska, 2012.

In some cases no differences have been reported in parasite abundance due to host sex (Rolff, 2000), others have shown a bias towards female hosts (Robb & Forbes, 2006), whereas a positive male bias was recorded by Lajeunesse *et al*. (2004) and McKee *et al*. (2003). Baker *et al*. (2008) and Zawal (2004, 2006) indicated a preference for female hosts in the case of *C. puella* and, in the present study, overall figures for the zygopterans show the same result. Female odonates return to water to oviposit and therefore come into contact with water more frequently than do males. Hence attachment to females would be of advantage to a larval water mite in order for it to complete its life cycle. Adult arrenurid mites live in freshwater and are predators.

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The Impact of spring temperature on emergence patterns in five 'spring' species.

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Summary

The first emergence dates for five 'spring' species were monitored at a single site over a seven season period. During this time, average spring temperature was also monitored and the two related to determine the impact of average air temperature on the first emergence of each species. It was noted that during warm springs, for example 2007 and 2011, the five species emerged significantly earlier than in an average spring, for example 2010. During a cold spring, for example 2012, first emergence coincided with the dates for average springs. This implies that, for these species, spring air temperature is only a critical factor determining emergence if it is high, in which case day length is not a trigger but sun intensity may be. Cooler temperatures in spring have little or no impact on first emergence compared to an average spring, in which case day length may then be the critical factor determining emergence.

Introduction

Corbet (1954, 1962, 1999) categorised odonates into spring or summer species depending on the shape of their emergence curve. Species with emergence starting early in the year and with a short, highly synchronised emergence period with 50% of individuals emerging within a few days of the start of emergence (e.g. Hairy Dragonfly *Brachytron pratense*) were classed as 'spring' species, while those with an extended emergence period (e.g. Southern Hawker *Aeshna cyanea*) were classed as 'summer' species.

This classification can also be described in terms of larval diapause, where 'spring' species are those whose larvae enter winter diapause in the final instar and so do not undergo any further moults before emergence. In these species, reducing autumnal day length (i.e. photoperiod (Corbet. 1999)) induces diapause, resulting in larvae ready to emerge in a short space of time the following spring.

With the progression of spring, day length increases and temperatures rise and these two factors trigger the physiological changes required within the larva to stimulate emergence. Thus ‘spring’ species, in particular, are the ones whose emergence is most likely to be influenced by spring climate. Warmer springs will allow greater larval activity, notably feeding, and provide suitable weather conditions to aid survival of the flying adults.

In ‘summer’ species, larvae overwinter in the penultimate instar, or even the one before that, and only reach the final instar the following spring. Thus individuals will take varying lengths of time to reach the stage where they are ready to emerge.

Material and Methods

During regular recording of Odonata at Ditchford Lakes and Meadows Reserve, Northamptonshire, first emergence dates were recorded over the period 2006-2012. Ditchford Lakes and Meadows is a former gravel pit on the River Nene. It has five Spring species, namely Common Blue Damselfly *Enallagma cyathigerum*, Red-eyed Damselfly *Erythromma najas*, Blue-tailed Damselfly *Ischnura elegans*, Hairy Dragonfly *Brachytron pratense* and Four-spotted Chaser *Libellula quadrimaculata*. Over the time period of this study, a sixth Spring species, the Large Red Damselfly *Pyrrhosoma nymphula* had declined and is no longer a breeding species and is therefore not included in this study.

The spring of each year was noted as warm, average or cold, depending on the mean April air temperature in Northampton (Pitsford Hall Weather Station, 2012).

Results

During the period of this study there were two warm springs, 2007 and 2011, and in both of these years there was an early emergence in all five species, i.e. *Enallagma cyathigerum*, *Erythromma najas*, *Ischnura elegans*, *Brachytron pratense* and *Libellula quadrimaculata* (Table 1, Fig. 1.). There were two cold springs, 2008 and 2012. 2012 was notable due to an extended drought through February and March with above average temperatures, followed by severe and prolonged rain from early April until mid July (with occasional dry days in between) and lower than average air temperatures. The remaining springs (2006, 2009 and 2010) were classed as average. Emergence times in all five species varied relatively little between the cold and average springs but were clearly later than in the warm springs (Table 1, Fig. 1.). There is of course variability in the first emergence dates. However, this is less marked than the differences between

Table 1. First emergence dates and average spring air temperatures for each species from 2006 to 2012.

Species	Year						
	2006	2007	2008	2009	2010	2011	2012
Enallagma cyathigerum	03 May	26 April	06 May	05 May	05 May	22 April	06 May
Erythromma najas	09 May	26 April	10 May	09 May	05 May	23 April	07 May
Ischnura elegans	09 May	21 April	10 May	09 May	07 May	23 April	07 May
Brachytron pratense	03 May	19 April	06 May	03 May	05 May	22 April	05 May
Libellula quadrimaculata	23 May	30 April	18 May	13 May	18 May	1 May	18 May
Average April air Temperature (^{O}C)	14.1	17.1	12.5	15.0	14.5	18.1	11.8

warm years and the rest. In each year *Libellula quadrimaculata* emerged later than any of the other species.

To illustrate the differences more clearly, three years were selected as representative of cold, average and warm springs, i.e. 2012, 2010 and 2011 respectively, 2010 matching the mean April air temperature (Fig. 2).

Discussion

First emergence dates are known to be latitude dependent. For example, in Cornwall in 2012 the first emergence of *P. nymphula* was recorded on 25 March (Lane, 2012), whereas in Northamptonshire, the county of this study, *P. nymphula* was not recorded until 21 April (C. Emary, pers comm.). This phenomenon is a regular occurrence reported in the Hot News pages of the British Dragonfly Society (Lane, 2012), where southern counties regularly beat the midlands and northern counties in the race to record first emergence.

As day length is latitude dependent, Northamptonshire will receive longer daylight hours per day than Cornwall after the Spring Equinox. For example, on 1 April Cornwall (latitude 50 degrees North) receives 12.7 hours per day compared with Northampton (latitude 52 degrees North) with 12.8 hours (University of Nebraska-Lincoln Astronomy Education Group, 2012); even by 30 April the difference is still only 0.1 hour. Since this difference is small,

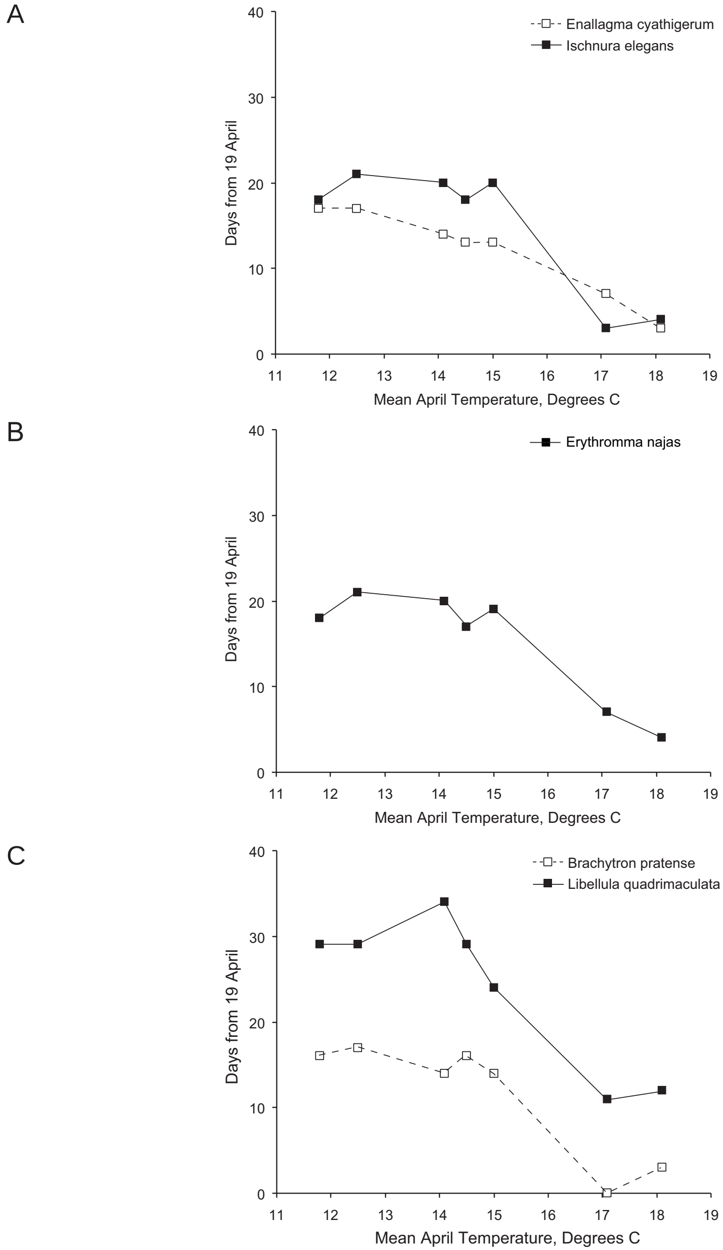

Figure. 1. The effect of mean April air temperature on emergence in (A) *Ischnura elegans and Enallagma cyathigerum*. (B) *Erythromma najas* and (C) *Brachytron pratense* and *Libellula quadrimaculata*. April 19 = Day 1.

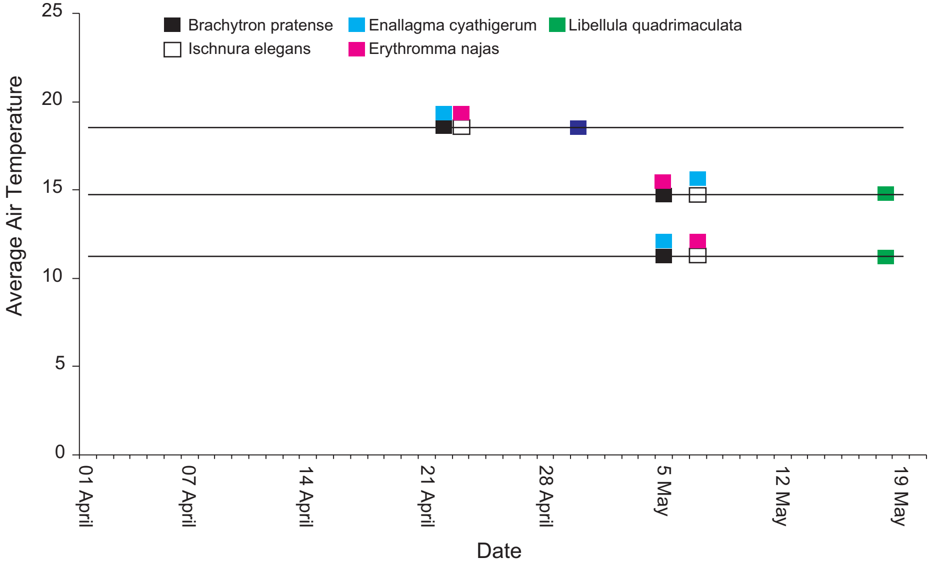

Figure. 2. First emergence in *Ischnura elegans, Enallagma cyathigerum*, *Erythromma najas*, *Brachytron pratense* and *Libellula quadrimaculata* for selected cold (2012), average (2010) and warm (2011) years. Where emergence dates coincide, the data are plotted vertically.

it implies that day length does not determine first emergence as it would be expected that, were this the case, Northampton would have emergence slightly before Cornwall or at least concurrently. Furthermore, if day length were the primary factor triggering emergence, it would be expected that average spring temperature would have no effect on first emergence patterns. However, this is known not to be the case and the plethora of early records published in the Hot News sections of the BDS website (Lane, 2012) testify that sunny, warm springs do lead to early emergence.

Thus temperature is presumably the primary trigger for emergence. If so, it might be expected that colder springs will lead to a delay in emergence. The present work indicates that, for the chosen study site and species, colder springs have no impact on first emergence and that larvae must undergo ecdysis more or less irrespective of weather conditions. This implies that the larvae are ready for emergence at a given time and that delay cannot occur for more than a few days. During warm springs, however, the higher temperatures may be indicative of extended periods of more intense sunlight that may stimulate the physiological changes in the larvae necessary for early emergence. This may result from an increase in water temperature.

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