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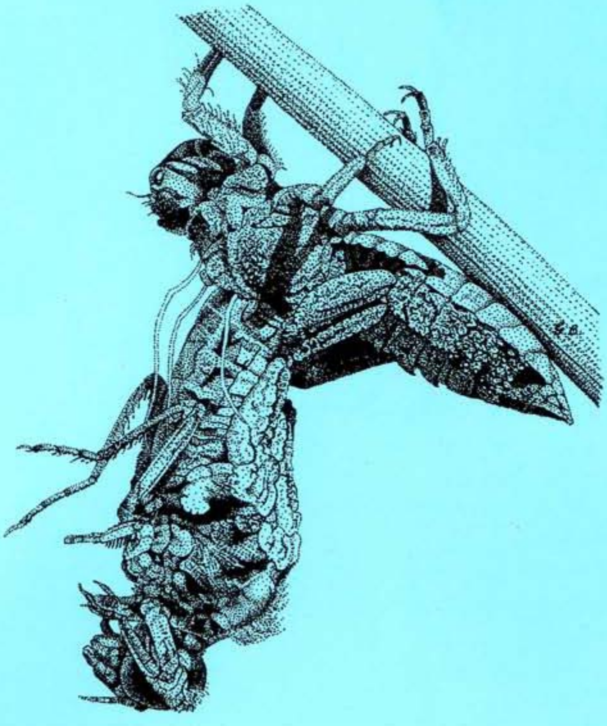

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Front cover illustration: The resting stage during the emergence of the Broad-bodied Chaser *Libellula depressa* on 25 May 1996, by Gill Brook

Dragonfly predation by European Hornets *Vespa crabro* (L.) (Hymenoptera, Vespidae)

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Introduction

The summer of 2003 turned out to be an exceptionally good year for the European Hornet *Vespa crabro* (L.) in south-eastern England. Various dragonfly e-mail forums had discussion 'threads' running on the subject of predation of Odonata by this species. There are few published reports of predation by vespid wasps, including Hornets and most refer to single, chanced upon observations (Corbet, 1999; Paine, 1992). Taylor (1994) describes the German Wasp *Vespula germanica* (Fabricius) taking the thorax of a Ruddy Darter *Sympetrum sanguineum* (Müller). An individual *V. crabro* was seen to attack and kill a Southern Hawker *Aeshna cyanea* (Müller) in a Bedfordshire garden (B. Nightingale, pers. comm.). Due to human intervention the Hornet was unable to find the dragonfly on its return and after searching the area several times it flew away. The dragonfly subsequently died.

In Bedfordshire, *V. crabro* were especially abundant at several sites, where they were seen hunting along lake margins. The high numbers at Priory Country Park led to the discovery of a nest in the rotting trunk of a fallen tree near to one of the lakes. Similarly, at Wrest Park numerous flying adults were seen around the lakes, although no nest was found. Single sightings were made elsewhere at dragonfly sites in the county.

Observations

Wrest Park, close to the author's home, is regularly visited throughout the Odonata flight season. A regular dragonfly walk is made to monitor Odonata present at the six lakes and ponds in the estate. Hornets were first seen in ones and twos during July, with numbers building up through August. In early September over 50 *V. crabro* were seen across the site during one visit. On 14 September, hornets were seen hunting along the margins of Broadwater. This lake represents the best area for Odonata on the estate. Hornets were observed actively hunting along the entire south facing margins of the lake, suggesting that this was a favoured feeding area. At this time of year the main potential dragonfly prey consisted of Migrant Hawker *Aeshna mixta* Latreille, Common Darter *Sympetrum striolatum* (Charpentier) and *S. sanguineum*.

Hornets appear to have good visual acuity and their strategy appears to be to fly purposefully around vegetation and dart at anything that looks alive and edible. They would repeatedly fly at any *A. mixta* that they encountered. Hornets would attempt attacks on dragonflies both resting and in flight. Over thirty unsuccessful attempts were recorded and on no occasion were any successful attacks made on male dragonflies during these observations. *S. striolatum* was in great abundance at this time, yet no hornet attacks were observed on this species.

On one occasion a hornet was seen to fly down into the area of sedges (*Carex* sp.) frequented by *A. mixta* and the rustling sound of dragonfly wings indicated that it had launched an attack on a dragonfly. Almost immediately a female *A. mixta* flew up in an agitated manner. It settled several metres away before flying off. This female had been attacked by the hornet whilst ovipositing and had managed to escape before it had the chance to sting. From these observations it appears that the success rate of attacks by hornets on dragonflies when the latter are most active is very low.

However, the risk of predation by hornets may be higher in conditions when dragonflies are less active, as the following observation suggests. A visit was made to Felmersham Nature Reserve on 7 September to photograph dragonflies along a sheltered hedgerow close to the lakes. This hedge is a favoured feeding and roosting place for a number of species at this time of year. Brown Hawkers *Aeshna grandis* (L.), *A. mixta* and *A. cyanea* are regularly encountered feeding and resting along this hedge. The day was warm and sunny, although when I arrived at 0930h there was little dragonfly activity as it was still quite cool after a cold night. As I walked along the hedge expecting to find roosting dragonflies, my attention was drawn to the characteristic sound of dragonfly wings in a patch of bramble (*Rubus* sp.). It was produced by an *A. mixta* being attacked by a hornet, which was trying to overcome the struggling dragonfly with its sting. As I watched, the hornet was stinging the dragonfly's body and biting into the thorax. It continued until the best part of the thorax and head had been amputated. At this point the hornet flew off with the part it had just removed, presumably in the direction of its nest. The still pulsating abdomen was left behind along with attached wings. This attracted a muscid fly (Diptera) to feed on the moist thoracic contents. I took several photographs and then decided to move on. As I moved off, my attention was drawn by the hornet returning to the site of the kill. It quickly located the remains of the dragonfly and dismembered the abdomen from the remaining wings and thorax. The hornet again flew off in the same direction, carrying the dragonfly flesh.

The wings were left behind, so I decided to collect these for later examination. Within minutes the hornet came back for a third time and started to search the area of vegetation where the kill had been made. It flew in and out of the bramble bush, presumably looking for any remains of the dragonfly. After about 45 seconds of searching it flew off and continued along the hedge exhibiting its normal hunting behaviour.

Conclusions

A relatively large dragonfly corpse such as *Aeshna mixta* is a bulky item for a hornet to carry. Here the hornet butchered its prey before returning to its nest with parts of the body. On one visit to Wrest Park a hornet attacked a bumble bee (*Bombus* sp.) that was feeding on the flower of a thistle (*Carduus* sp.). The hornet proceeded to paralyse the bumble bee with its sting and then bite off the wings. It then flew off with the whole body. These observations suggest that the weight limit on what a hornet can carry lies between the weight of a bumble bee and that of a hawker dragonfly.

The exceptionally high abundance of hornets during the year has enabled a more proactive study of predation to be made. It is suggested that dragonflies form a rich source of protein in the late summer and therefore any capture provides the hornet with a sizeable meal. Despite the high number of unsuccessful hornet attacks observed at Wrest Park, it may be worth the effort if they make a kill.

Although it may be difficult for hornets to catch active dragonflies, their chances increase when prey is incapacitated in some way. Ovipositing females are more vulnerable to hornet attack when they fly in confined spaces. The Felmersham observations indicate that hornets will search out roosting dragonflies, when they may be cooler and less active and, therefore, easier to catch.

An excellent photograph of hornet predation similar to that described above can be seen in Dijkstra *et al.* (2002).

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Rapid colonization of a newly dug pond on a Polish heathland

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On the 9 July 2003, I was visiting, with a group of heathland specialists, the sub-Atlantic inland heathlands in the Cedynski Landscape Park, near Chocianów in western Poland. These heathlands are botanically species poor, being dominated by Ling (*Calluna vulgaris*), with a scattering of invading seedlings, through to semi-mature trees of Birch (*Betula* sp.), Scots Pine (*Pinus sylvestris*) and occasionally Aspen (*Populus tremula*).

We were taken to see a large pond, approximately 30m × 10m, which had been created, principally for the benefit of local hunters, who wanted a watering place for Red Deer (*Cervus elaphus*). The pond is situated in open heathland, on a formally damp area, which appeared to have been dominated by Purple Moor-grass (*Molinia caerulea*). Except for a bushy 4m Scots Pine on a small *Molinia* covered island in the pond, it was a very open site. The sides of the pond had been gently graded and the water level is governed by the existing water table. At the time the water level was falling, but the pond appeared to be deep in the middle and unlikely to dry out.

Our arrival at this pond was during early afternoon, it was warm, partly overcast and a little breezy. A male Emperor Dragonfly *Anax imperator* Leach was quartering over the pond and at least 30 mature Common Blue Damselfly *Enallagma cyathigerum* (Charpentier), some of which were paired, darted over the water close to the pond margin. Along the edge of the pond two freshly emerged Black Darter *Sympetrum danae* (Sulzer) were put up, but a search failed to find their exuviae, although two recently emerged Emerald Damselflies *Lestes* sp. were found. The only emergent vegetation was a scattering of spikes of Bulbous Rush (*Juncus bulbous*), all about 5cm above the water, in the southern corner of the pond. On these spikes, two exuviae were found and collected. These exuviae were identified later by David Chelmick as the Scarce Emerald Damselfly *Lestes dryas* Kirby. It is probable these exuviae related to the two *Lestes* sp. put up from the pond edge vegetation close to the emergent Bulbous Rush.

I was interested in the pond, especially as it looked recent in excavation. On enquiring more about it, I was told it was created during early 2002. Apparently, open water is a scarce resource on these heathlands and the nearest water is 3km away. These observations illustrate the distance over which species usually considered as 'non-migratory' can disperse and rapidly colonize new breeding sites.

Recent appearances of the Lesser Emperor *Anax parthenope* (Sélys) in north-western Europe

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Summary

For much of the 20th century, *Anax parthenope* was a considerable rarity in north-western Europe. In 1983, the first individuals for 100 years were noticed in Belgium, and by the mid 1990s the species had also started to appear in The Netherlands and Britain. Records from all of these countries are now annual, with no fewer than 33 individuals reported from the region during 1999. This paper details and analyses the occurrences of *A. parthenope* in north-western Europe during recent years, and relates them to records of the species in other parts of northern Europe. The distribution of *A. parthenope* currently seems to be undergoing significant modification, possibly as a result of climate change. Most records in north-western Europe are apparently still of immigrants, though successful breeding was recorded in Britain during 1999 and could easily have been overlooked elsewhere. Reports from north-western Europe span a time period from late May to early September, with the greatest number of individuals appearing in July. Meteorological evidence suggests that many migratory events have a likely origin in Iberia or other regions surrounding the western Mediterranean.

Introduction

The Lesser Emperor Dragonfly *Anax parthenope* (Sélys) is widely distributed in the old world, occurring in southern Europe, North Africa (south to the Somali Republic), the Middle East, northern India, and extending, as the subspecies *A. p. julius*, as far as China and Japan (Askew, 1988). It has well-known migratory tendencies (Corbet, 1999) that can bring it north of its main breeding range, and in some areas of Europe it can apparently occur as both a resident and a migrant (A. Ambrus, pers. comm.; R. Bernard, pers. comm.). In Algeria the species flies from March/April to October (Samraoui & Menai, 1999), while in southern Europe the main flight period is from May to September (d'Aguilar *et al.*, 1986).

Writing in the 1980s, Askew (1988) described the species as widespread in Europe, though rarely common, south of about 45°N in the west and 48°N in the east, with only very sporadic records further to the north. This perhaps underplayed the regular records from what are now eastern Germany and western Poland (Hesse, 1922; Münchberg,

1931, 1939; Urbanski, 1948), but during the last 15–20 years the picture has clearly started to change, with regular and increasing penetration into north-western Europe. During 1983, the species was recorded in Belgium for the first time in 100 years (Goffart, 1984). Records continued the following year, and while sightings became erratic for a period in the late 1980s and early 1990s, *A. parthenope* has become annual in the region since 1994 (De Knijf, 1999 and unpublished). In Britain the first ever mention of the species was a poorly documented record from Cornwall in the mid 1980s (H.P.K. Robinson, unpublished), and by
(Phillips, 1997). Since then the species has been noted every year. The first substantiated record of *A. parthenope* in The Netherlands since 1938 (Lieftinck, 1952) occurred in 1997 (Goudsmits, 1997), although there had been a sight record of a 'possible' a few years earlier in 1994 (van Tol, 1995). Further records from this country have occurred on an essentially annual basis.

The shift from records based on specimens to records based on photographs or visual sightings that has occurred in Europe during the last few decades means that a quantitative comparison of records over the years is difficult. Also, it is unclear to what extent a greater awareness of the species may account for some of the increase in records in recent years. However, it is clear that *A. parthenope* is no longer an extreme rarity in north-western Europe, and appears to expanding its regular migratory range. This paper details recent sightings of *A. parthenope* in north-western Europe, with particular emphasis on the events of the late 1990s. It is hoped that this information will provide insight into the changing distribution of *A. parthenope* in Europe.

Recent Sightings

The number of individuals seen in various countries bordering the North Sea during recent years is shown in Table 1. Most records refer to isolated males, although it is likely that a disproportionate number of females have been overlooked because of their often drab colouration and more secretive behaviour. The great majority of individuals are clearly primary immigrants. Although oviposition has been recorded on at least two occasions from Belgium (in 2000 and 2002), as yet successful breeding has only been proven in Britain, when a total of five exuviae were found at two sites in Cornwall between 31 July and 4 September 1999 (Jones, 2000). A subsequent breeding attempt at

Table 1. The number of individuals of *Anax parthenope* recorded from Belgium, Britain and The Netherlands during the last decade of the twentieth century. "?" indicates an unconfirmed report. (Figures for Britain in later years are 2001 = 8 and 2002 = 4)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Belgium	0	0	0	0	1	2	2	1	2	14	15
Britain	0	0	0	0	0	0	1	3	10	11	11
The Netherlands	0	0	0	0	?	0	0	1	2	8	1

one of these sites was apparently unsuccessful (Parr, 2002). Adults that emerged in 1999 probably represent the progeny of individuals that arrived during the significant influx into the area seen in 1998, although no signs of attempted breeding were observed directly during that year, or during earlier years. This suggests that mating pairs may be very secretive and attempted breeding in north-western Europe may have occurred on more occasions than is currently recognized.

Figure 1 shows the time of the year (as half monthly periods) when each individual *A. parthenope* was first sighted. Figure 1A presents the data for Belgium, Britain and The Netherlands until the end of the twentieth century and Figure 1B shows each individual seen in Britain up until the end of 2002. Both datasets show a similar overall pattern of occurrence. However, each year does not necessarily produce parallel patterns of events in each country (see below and Table 2). The first individuals may occur in late May (the earliest record is 16 May 1997 from Belgium), while the month in which most *A. parthenope* appear is July. However, some individuals may not appear in the region until as late as September (the latest record is 14 September 1998 from Britain).

Many sightings were recorded in 1998 and 1999 in north-western Europe, and it is worth examining these records in some detail. Individual sightings are listed in Table 2. Where several records relate to the same site, unless there is evidence to the contrary, these have been treated as referring to the same individual if they were less than three weeks apart, but to different individuals if records were separated by more than three weeks. In Britain, at the time of writing, some 35 per cent of individuals have been seen on more than one day, with stays of up to 10 days being not unusual. The longest confirmed period of continual presence is 19 days with occasional longer stays possibly involving more than one individual. Close inspection of the records from north-western Europe during 1998 and 1999 indicate that major migratory events which affect the whole region can often be identified. One protracted event occurred during the first half of July 1999 and another shorter event took place on or around 20 June 1998, when additional records also came from northern France (K.-D. Dijkstra, unpublished). In contrast to these observations, several migratory events apparently only affected part of the region, e.g. the influx into Belgium in late May/early June 1999. The extent to which this represents under-recording rather than truly localized immigration is at present unknown.

Within Britain a large proportion of records are from coastal regions, particularly those in the south, and are often associated with obvious features such as headlands, promontories and islands (Figure 2). To some extent the distribution of records reflects the well-established effect of geography on immigration. On the Continent this influence of a sea crossing is of course absent, but records often reflect a habitat preference for water-bodies that are able to warm up very quickly. The combination of geographical effects on migration, and a tendency for individuals to settle in areas of particularly favourable habitat may explain why *A. parthenope* has been observed at specific sites in the region on several occasions, and where successful breeding is now starting to take place.

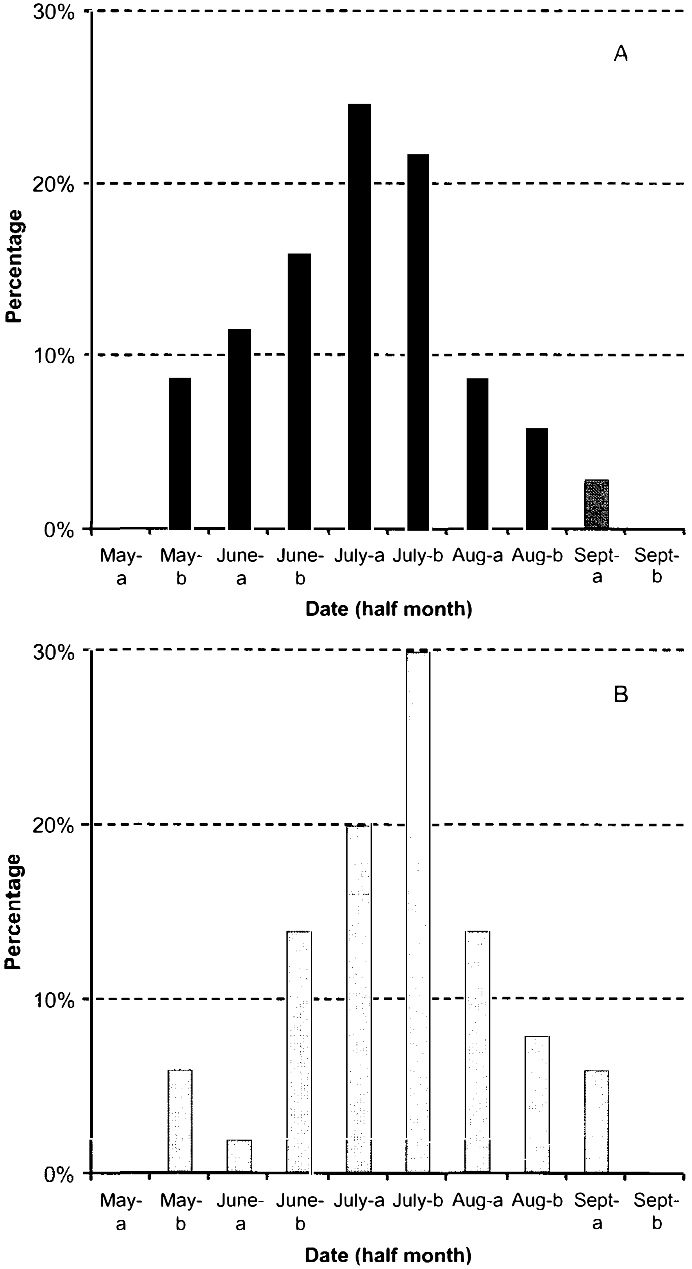

Figure 1. Proportion of all records of *Anax parthenope* occurring in specified half-monthly periods. A. Belgium, Britain and The Netherlands, 1980–1999; B. Britain, all records to 2002.

Table 2. Details of *Anax parthenope* seen in north-western Europe during 1998 and 1999. Individuals denoted [ ] not necessarily different to individuals recorded previously at the same site. m = male, f = female.

Britain:

1998	1999
17–18 May Drift Reservoir, Cornwall (m)	2–18 Jul Trerulefoot, Cornwall (2m with f on 12 Jul)
23 May Bonython, Cornwall (f)	10 Jul Dungeness, Kent (m)
20 Jun Holme Pierrepont, Nottinghamshire (m)	11 Jul Marazion, Cornwall (m)
30 Jun–7 Jul Marazion, Cornwall (2m)	12 Jul Forest of Dean, Gloucestershire (m)
1–2 Jul Kenfig, Glamorgan	12 Jul Barn Elms, Greater London
18–25 Jul Trerulefoot, Cornwall (m)	18 Jul Dungeness, Kent (m)
4 Aug Dungeness, Kent (m)	30 Jul Stithians Reservoir, Cornwall (m)
[8–17 Aug near Dungeness (m)]	12 Aug Trerulefoot, Cornwall (m)
8 Aug Rye Harbour, East Sussex (m)	31 Aug–6 Sep Marazion, Cornwall (m)
14 Sep St. Buryan, Cornwall (f)	4 Sep Luccumbe Down, Isle of Wight

Belgium:

1998	1999
4 Jun Latour (m)	30 May Longchamps (m)
21 Jun Hensies	1 Jun Etalle (m)
	1 Jun Latour (m & f)
	2 Jun Harelbeke
	16 Jun Lokeren
	2 Jul Elsegem (m)
	5 Jul Etalle
	9 & 12 Jul Harelbeke
	18 Jul Latour (3m)
	19 Jul Ename (m)
	28 Jul Elsegem (m)
	28 Aug Hensies (m)

The Netherlands:

1998	1999
16 & 25 May near Eindhoven (m)	15 Jun Rhenen
20 Jun Maastricht (m)	26 Jun Maastricht (2m)
	27 Jun Kuinderplas (m)
	3–4 Jul Asten-Heusden
	[3 Jul Maastricht]
	3–8 Jul Oranjezon
	8 Jul St. Philipsland
	6 & 12 Aug Waalre (m)

Following first appearances in the very south of the region, the most northerly record for *A. parthenope* in the Belgium, Britain and The Netherlands area before the end of the 1990s was at 52° 57'N (although Ritzau & Haeseler (1996) report a record from 1995 on the German island of Borkum at 53° 35'N). These records were overtaken during 2000 when two males were observed in County Durham, England, at 54° 55'N, and another was caught by a cat on the Scottish island of Sanday (Orkney) at 59° 17'N

(Parr, 2001). This latter record is apparently the most northerly for the species. Prior to the start of the recent range expansions, the most northerly record had been of an isolated individual from 54° 50'N on the island of Sylt, Germany during 1969 (Schmidt, 1974).

Possible Geographical Source of Immigrants

The arrivals in Belgium in the last days of May and early June 1999 were associated with thundery weather systems moving north out of Spain, pushing warm, humid, air from North Africa and the western Mediterranean into Western Europe. The arrivals of early July 1999 were similarly associated initially with a thundery weather system moving north out of Spain which brought warm, humid, air from the western Mediterranean

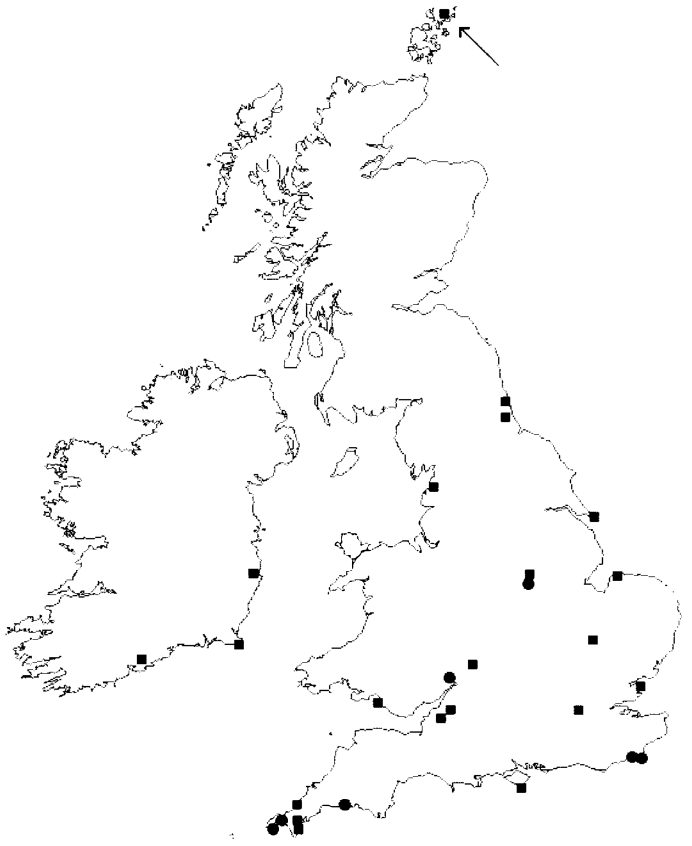

Figure 2. The distribution of records of *Anax parthenope* from Britain and Ireland (1996–2002). Squares indicate single records, circles indicate 10Km grid squares with 2 or more records. Irish data is from the DragonflyIreland website (see Nelson *et al.*, 2001 and updates).

into Western Europe. In the latter instance this airflow was abruptly cut off on 4 July as a more polar airflow became established over north-western Europe. However, north-easterly winds blew across Britain from the Low Countries and Germany from 9–12 July, and it is likely that this airflow may have extended the original immigration into north-western Europe from the Low Countries across the Channel and into southern Britain. This would explain why British records were slightly later than those on the Continent. In addition to the events of 1999, several other immigrations of *A. parthenope* into north-western Europe may also have originated in Iberia or the western Mediterranean. For example, the weather conditions associated with the arrivals into Britain during mid May 1998 were remarkably similar to those existing during the July 1999 influx, with warm humid southerly winds direct from Iberia and the western Mediterranean blowing across north-western Europe for several days, followed by the onset of north-easterlies on 14 May which may
individuals.

Discussion

Prior to 1983, *Anax parthenope* was an extreme rarity in north-western Europe. In that year several individuals were noted in Belgium, representing the first records for this country since 1884. Although records were erratic for a few years afterwards, a recovery started in 1994 and the species has now become annual in Belgium, with the number of individuals seen sometimes exceeding ten per year. Elsewhere, *A. parthenope* has started to occur regularly in Britain since 1996 and in The Netherlands since 1997.

The origin of the *A. parthenope* arriving in north-western Europe is not yet established. As multiple immigration events may occur throughout the year, several origins may be involved. There are signs of an association between arrivals of *A. parthenope* and the Red-veined Darter *Sympetrum fonscolombii* (Sélys). On many occasions in Britain, Belgium and The Netherlands, the two species have either been noted together or recorded from closely adjacent areas on the same dates. In Britain, the years in which *A. parthenope* was first recorded (1996), and first showed a major upturn in numbers (1998), were also notable for major influxes of *S. fonscolombii* (Parr, 1997; 1999). On the other hand, this association is not always obvious, and could in part be fortuitous, simply reflecting good conditions for immigration in general. During the early July 1999 influx of *A. parthenope*, arrivals of *S. fonscolombii* were not particularly prominent, but instead other southern species such as the Southern Migrant Hawker *Aeshna affinis* Vander Linden were seen, at least on the continental side of the English Channel (Ketelaar, 2000).

Appearances in late May/early June roughly coincide with the start of the main flight period in southern Europe (Askew, 1988), which suggests that this region may be the source of early season immigrants since *A. parthenope* often migrates when sexually immature (Corbet, 1999). Meteorological evidence also favours an origin in Iberia and the western Mediterranean. Since the flying season of the species in North Africa starts during March (Askew, 1988), the absence of a very early immigration phase in north-western Europe suggests that North Africa may not be a source area, at least not for primary immigrants. The origins of the influxes seen in July/August are less clear cut. If movements at this time have a similar geographical source to the spring influxes, then the implications are that either there is more than one phase of emergence in the region during the year, or that these migrations may result from the movements of sexually mature, rather than immature, individuals. Migration in both the immature and mature stages has been documented for species such as the Black Darter *Sympetrum danae* (Sulzer) (Michiels & Dhondt, 1989, 1991; Corbet, 1999), and may be a more widespread phenomenon. In addition, at least some late season records must have a different origin. Given the exuviae found in Britain during August and early September, locally bred individuals must occasionally be involved, and certainly the dragonfly seen at Trerulefoot, Cornwall, on 12 August 1999 is likely to have been locally bred since this site is one of those at which exuviae were found. Emergence in late summer/autumn has also been observed in parts of central Europe, e.g. in southern Germany (once as late as the end of October (Werzinger & Werzinger, 2001)), in Hungary (A. Ambrus, pers. comm.) and in Switzerland (R. Hoess, pers. comm.). If these emerging individuals are migratory, then they also form a potential source for late-season records in Britain and other countries bordering the North Sea.

Turning slightly further afield from Belgium, Britain and The Netherlands, *A. parthenope* has also been found in many other new areas within northern Europe during the last two decades and, in particular, during recent years. New records extend from Ireland (Nelson *et al.*, 2001) and western France (Charrier, 1996; Lett, 1997; Jourde *et al.*, 1999) through Germany and into the region of the Baltic States (Bertram & Haacks, 1999). In Ireland, the first records for the country occurred in 2000, when small numbers appeared in late July and early August (Nelson *et al.*, 2001) during an influx that also affected Britain. In north-western Germany, *A. parthenope* was recorded for the first time in 1964, with four more records up to the mid 1980s (Martens & Müller, 1989). Recent years have seen a further increase in records from the area (e.g. Ritzau & Haeseler, 1996; Schmidt, 1997; Rudolph, 1998), though the species remains a relative rarity. The situation here therefore bears some resemblance to that in Britain, Belgium, The Netherlands and Ireland. However, in eastern Germany the situation is more complex. Here the species has long been resident (Hesse, 1922; Munchberg, 1939). Some established populations in the Mark Brandenburg region have reportedly gone through a temporary period of decline (Peters, 1987 in Rudolph, 1998), possibly due to competition with the Emperor Dragonfly *Anax imperator* Leach (Rudolph, 1998) though it is now clear that cold winters also affect population levels in the region (Mauersberger *et al.*, 2002). During the last two decades new populations have, however, been discovered. Mauersberger *et al.* (2002) now report some 140 localities for *A. parthenope* in the Mecklenburg and Northern Brandenburg region, with breeding confirmed from 28 sites. There are also new and regular records from the nearby regions of Sachsen

Anhalt (Martens & Müller, 1989) and Thuringen (Kipping, 1997). The extent to which the discovery of these new sites results from increased observation rather than genuine colonization remains unclear. Perhaps increased observer effort is a contributing factor (A. Martens, pers. comm.), but a genuine increase does also seem to be involved. In Poland the situation is similarly complicated by the presence of long-established breeding populations. Urbanski (1948) listed *A. parthenope* from six regions of the country with the Poznan region being a stronghold. In recent years Poznan remains the centre of a strong population and the main distribution of the species is broadly similar to that in the first half of the twentieth century (R. Bernard & P. Buczynski, pers. comm.). There is, however, just a suggestion that the 1980s and 1990s may have seen a slightly wider spread of records, particularly in the north and east (e.g. Brockhaus, 1990; Buczynski, 1996; Kempke & Reinhardt, 1999). Further east than Poland data becomes scarce, but it is worth noting recent records of two males trapped in early September 1998 at *c.* 55°N on the Curonian Spit in Baltic Russia (Bertram & Haacks, 1999) and one seen at artificially-heated cooling ponds during 1999 at 55° 55'N in Latvia (M. de Jong via V. Kalkman, pers. comm.). Both these records exceeded the then northern limit for the species in Europe.

Although some of the records from new areas may simply reflect an increased number and awareness of observers, the general pattern of events indicates a genuine range expansion. More dramatic changes are apparent in Western Europe, with regular records now coming from many areas where the species was formerly unknown, although an expansion of numbers and/or range also seems to be occurring in eastern regions. The start of the expansion phase in Europe clearly goes back at least to the early 1980s, so that the phenomenon is unlikely to be purely transitory. This date roughly corresponds to the general amelioration in the European climate associated with 'global warming' (Burton, 1998). As a highly mobile species, *A. parthenope* is well placed to respond to environmental change. Changes in distribution, typically with expansions to the north and west, are now being documented for many other insects in the western Palaearctic (e.g. Silfverberg, 1995; Burton, 1998; Hill *et al.*, 1999). In the dragonfly context, the expansion of the Small Red-eyed Damselfly *Erythromma viridulum* (Charpentier) has already attracted attention (Cham, 2002; Ketelaar, 2002), and Ott (2000) describes the northwards expansion of many other Mediterranean-based species, including the Scarlet Darter *Crocothemis erythraea* (Brullé). There is good, though sometimes circumstantial, evidence that climate change is indeed the driver for several of these changes (Hill *et al.*, 1999; Ott, 2000). In the case of *A. parthenope*, it may also be no coincidence that Iberia, the proposed source of many of the immigrants now appearing in north-western Europe, is the area in Europe where long-term climate change as a result of 'global warming' has been most pronounced (Mann *et al.*, 1998).

Clearly these are complex and interesting times, and range changes of the European Odonata deserve to be monitored closely.

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Variation in the 'mercury mark' of the Southern Damselfly *Coenagrion mercuriale* (Charpentier) in Britain

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Introduction

Mayo & Welstead (1983) first drew attention to variation in the shape of the black colouration on the second abdominal segment of males of the Southern Damselfly *Coenagrion mercuriale* (Charpentier), the so-called 'mercury' mark, from which the species gets its scientific name. Mercury's 'corporate logo' is often described as representing the messenger's caduceus or wand with two snakes curled around it. In some versions of the logo's origin it is said to be Mercury in his winged hat or petasos. This seems to be the version followed by odonatologists. Mayo & Welstead pointed out that the form of the mark in the newly rediscovered populations in the Test and Itchen valleys was rather more dissected than the marks they were used to seeing in New Forest populations (more akin to Figures 1c and d than to Figures 1a and b). The shape of the mercury mark was also mentioned by Paul (1998) who noted that males at the Oxford site resembled Figure 1c too, possibly suggesting that the Test or Itchen might be the source of the newly discovered Oxfordshire population. In this paper we present data that indicates that there are within and between site variations in the form of this mercury mark.

Population studies

As part of ongoing population work on *C. mercuriale* at Liverpool University, we have undertaken two major mark-release-recapture (MRR) studies, the first in 2001 in the Itchen Valley, the second in 2002, on Beaulieu Heath in the New Forest. In 2001, we marked 7554 individual males and in 2002, 8370. In addition we have looked at small samples from all of the known British sites for *C. mercuriale*, resulting in the examination of a further 3000 specimens. On each occasion when a male was captured the mercury mark on the second abdominal segment was scored on a scale of 1 to 5 according to the photographs shown in Figures 1a–e, with 1 corresponding to Figure 1a, 2 corresponding to Figure 1b, etc. These assignments were carried out by students who had been given drawings that corresponded with the photographs (2001) and photocopies of the photographs (2002) and received training on handling and scoring the mercury mark.

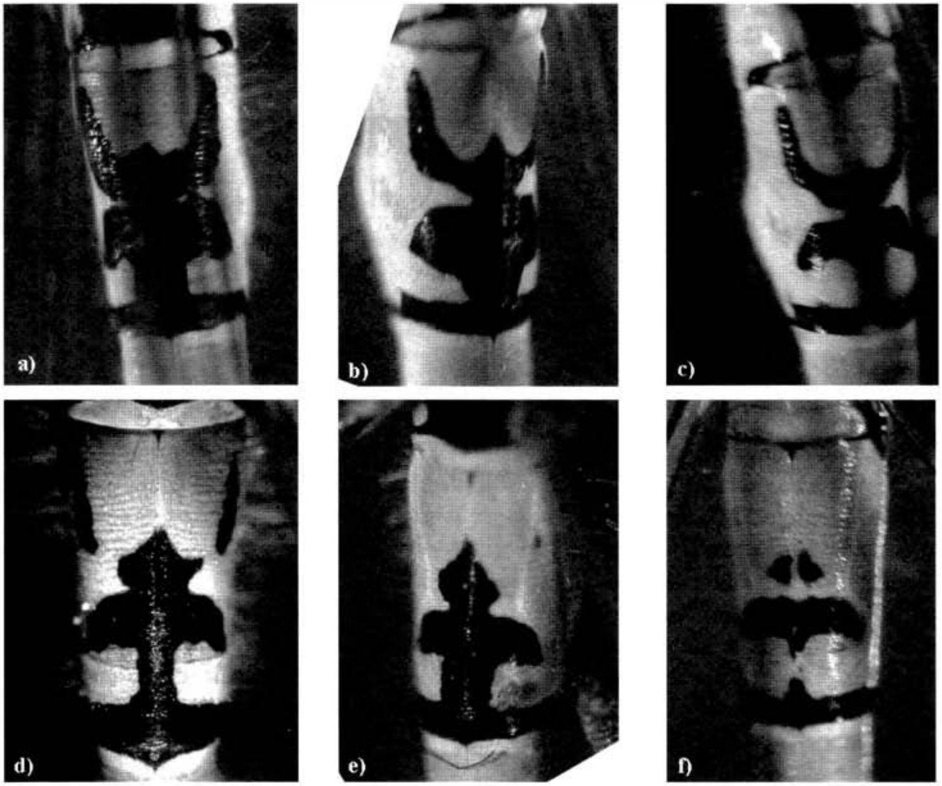

Figure 1. Examples of the variation in mercury mark on the second abdominal segment of males of *Coenagrion mercuriale*. Figure 1a corresponds to category 1, 1b to category 2, etc. (see text). Figure 1f shows an unusual mark found only once in the study.

Results

Figures 2a–d show the data plotted as percentage frequency against mercury mark score for the four largest centres of population of *C. mercuriale* in Britain: Mynnyd Preseli in Pembrokeshire, Itchen Valley and New Forest (specifically Beaulieu Heath, the site of the MRR project), both in Hampshire, and the Dorset Heaths. These are also the areas from which we have the largest sample sizes. The difference between these distributions is highly statistically significant (χ^2contingency $=3439$, df$=16$, $P<0.001$). Each distribution is also significantly different from each of the others. The Preseli and New Forest populations are both dominated by males whose mercury mark is closest to 2, while in the Dorset sites the dominant mark is 1. The sites in the Itchen Valley are the most distinct, with a score of 3 being the commonest and individuals with marks corresponding to 4, and even 5, being relatively common. The individual whose photograph is shown in Figure 1f, beyond our scale, was also found in the Itchen Valley.

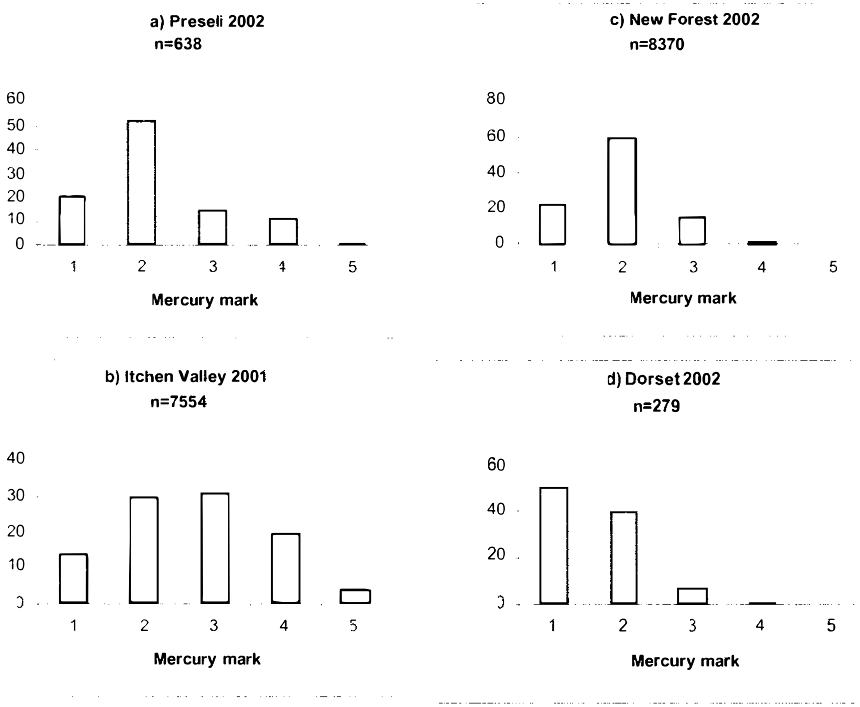

Figure 2. Variation in the mercury mark on the second abdominal segment of *Coenagrion mercuriale* at the four largest population centres in Britain.

Figures 3a–c show the distribution of mercury marks for three isolated populations, those from Oxfordshire (Figure 3a), Anglesey (Figure 3b) and the larger Dartmoor site (Figure 3c). It is difficult to draw firm conclusions about the distribution of mercury marks from these data because the sample sizes are small. However, the Oxfordshire site is dominated by males with mercury marks of 2 and 3, with 2 being the more frequent. This distribution is closer to the New Forest type than the Itchen Valley. The Anglesey site is dominated by males with a mercury mark of 1. Individuals with marks of 3–5 were not represented in this sample. In terms of the distribution of mercury marks, the larger Dartmoor site was arguably the most interesting of all of the sites examined. On this site mercury marks of 3 and 4 were the commonest, making this site closer in distribution to the Itchen Valley than any of the rest of the British sites.

Discussion

There are some problems with the methodology reported in this study that need to be addressed. First it is not completely straightforward to assign a male to a particular

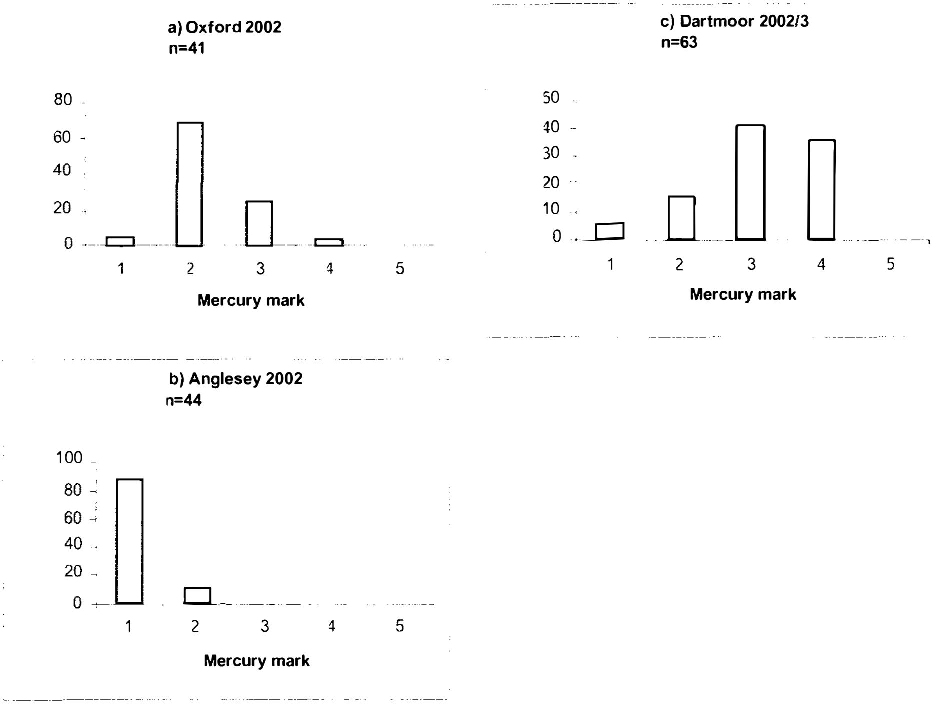

Figure 3. Variation in the mercury mark on the second abdominal segment of *Coenagrion mercuriale* at three isolated sites in Britain.

mercury mark category. There is, in reality, a continuum. This is not such a problem for categories 3, 4 and 5, though occasionally category 4 was missing one or other of the wings of the helmet. The difficulty lies with categories 1 and 2. It would be possible to make a case that our category 2 should have been scored as category 1. It was not, because we took thickness of the wings of the helmet to be our most important criterion in drawing up the scale, rather than, for example, height of the base of the helmet (compare Figures 1a and 1b). That in itself is not a problem. The problem is that it was simply more difficult to use the scale at the low end so it is hard to be convinced of the significance of differences between sites that differ in the relative frequency of categories 1 and 2. There were trade-offs between thickness of the wings and height of the base of the helmet. Although all the field assistants used the same drawings there are likely to be some differences in interpretation.

There is clearly variation in the distribution of mercury marks in the British population of *C. mercuriale*. Mayo & Welstead (1983) were correct in pointing out that the Itchen Valley populations are quite different to those of the New Forest. Within the New Forest, individual populations are similar to one another. The distribution of mercury marks in the most isolated site within the New Forest, Acres Down, is not significantly different from that of the Crockford stream. The Preseli sites are also similar to one another.

The Itchen Valley populations are also different from everywhere else in Britain with the exception of the larger Dartmoor site. This is a puzzle. Does it mean that the founders of the Dartmoor site came from the Itchen Valley, or perhaps the survivors of a genetic bottleneck at the Dartmoor site were, by chance, those with mercury marks of 3 or 4? This presupposes that variation in the mercury marks is genetically determined which we presume it is. The purpose of taking samples from all of the known British sites was to look for the extent of genetic variation. When these samples are analysed we hope to be able to relate the genetic markers we are using to visual polymorphisms such as mercury mark and female morph.

Aguesse (1968) shows three drawings of the first three abdominal segments of *C. m. mercuriale*, the sub-species found in Britain. The first, depicting a male from the east of the Pyrenees, shows a mercury mark close to Figure 1a, the second, from the region near the mouth of the Rhone, shows a mark close to Figure 1c, while the third, from Spain, shows a mark closest to Figure 1d. Jacquemin & Boudot (1990) show drawings of the abdomen of Spanish specimens which demonstrate considerable variation in the mercury mark in that country. Clearly variation in the shape of the mercury mark is present across Europe. It is not clear if there is variation within individual populations as there is in Britain, but we presume that it is likely.

Acknowledgements

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The domestic cat: a regular dragonfly predator?

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Having seen the short report by Goddard (2003) of a cat preying on a Migrant Hawker *Aeshna mixta* (Latreille), we thought that it would be useful to record the following observations.

On 27 July 2001 we watched our 12 year old cat walking down the garden path, looking somewhat poorly, as if she was trying to be sick. We went outside and on approach our cat promptly regurgitated an adult male Southern Hawker *Aeshna cyanea* (Müller). On examination, the dragonfly although dead, was completely whole.

On 4 September 2003 the same cat was observed looking at a dragonfly flying approximately 3m above the lawn towards the house. I was able to get into the garden as the cat started to pursue the dragonfly. The 'dragonfly' landed on the lawn and turned out to be a pair of Common Darters *Sympetrum striolatum* (Charpentier) in tandem. The pair then flew off over a neighbour's roof towards a local lake approximately 0.4km away.

This cat often chases birds, butterflies, flies and spiders and recently it appears to have taken an active interest in dragonflies. Has the decline in some of the commoner fauna, such as butterflies, due to increased urbanisation, and the increase in urban ponds that attract dragonflies into gardens, altered the range of insect prey available to domestic cats?

Acknowledgement

We would like to thank Mark Tyrrell (Northamptonshire Dragonfly Recorder) for his helpful suggestions in the preparation of this short note.

Reference

Goddard, D. 2003. The domestic cat: a new dragonfly predator. *Journal of the British Dragonfly Society* **19**: 39

Dragonfly populations of peat-bog pools in north-east Scotland

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Introduction

This study was prompted by my discovery of two pools in a Scots Pine forest east of Loch na Bo near Lhanbryde in Morayshire, approximately 7km from the coast and at an altitude of 60m above sea level (asl) (Site A). These pools appeared as rich, if not richer, in both numbers and species of dragonflies than comparable pools close to the coast. This observation suggested that pools in this area might show a relationship between dragonfly population densities and height above sea level. After studying the Ordnance Survey map of this area and visiting the nearest Forestry Commission office, two more pools were identified, both with relatively easy access, which appeared suitable sites at which to investigate any such relationship. The first is located in Whiteash Hill Wood, 2km east of Fochabers, and the second lies in Teindland Forest, 4km north of Rothes.

Site Description

The three sites are identified A, B and C in ascending order of altitude.

Table 1. Location, altitude and perimeter length of the peat-bog pools at Sites A, B & C

Site	OS Landranger 28 28 grid reference	height above sea-level metres	length of water margin metres
A	NJ 286598	60	500 (total both pools)
B	NJ 364584	150	130
C	NJ 284534	250	80

The two pools at Site A are roughly circular, whereas those at B and C are pear-shaped. All three sites had the following characteristics in common: water pH 5; bank-side vegetation of rushes, sedge, grass and some Cottongrass (*Eriophorum* sp.), then a ring of *Sphagnum* 1–2m in width, next an outer ring of Heather (*Calluna vulgaris*) and/or *Rhododendron ponticum* surrounded by mature Scots Pine (*Pinus sylvestris*) forest with a sprinkling of Silver Birch (*Betula pendula*). The height and proximity of the pine trees to the water meant that at any given time of the day or year some 25–75 per cent of the margin was in shadow. The pools are deep, ranging from 30–100cm at the margin, and the water is dark brown in colour.

Local geography dictated a route of B to C to A round the sites on each survey. Surveys were completed on the same day to ensure, as far as possible, similar weather conditions at each site. The sites are approximately 7–10km apart and a complete survey took 3–3.5 hours. The time lapse between the start of each count varied from 1 hour from B to C to 30 minutes from C to A. At each site the same path was followed round the pool, and the same method of counting was adopted, so that any tendency to error or miscount would be the same at all three sites throughout the season. At sites B and C, where numbers were low, precise counts were made. At Site A, where numbers could be very high, the bank was divided where necessary into short sections of 5–10m and all dragonflies in the section were totalled to the nearest 5 or, when many individuals were flying over the water, to the nearest 10. At each of the four pools, the counting circuit took 15–20 minutes on average. At sites B and C, where the margins were much shorter than at A, this reflected the greater degree of difficulty in negotiating a circuit round the water's edge. Sunshine, expressed as a percentage, was estimated for the duration the count, and was intended to indicate, irrespective of air or water temperature, whether it was a good, bad or indifferent day for dragonfly activity. Wind speeds were estimated using the Beaufort Scale (e.g. 3 = gentle breeze, leaves and small twigs in constant motion). During 2001, air temperature was measured out of direct sunlight at approximately 2m above ground level, and water temperature at 15–20cm below the surface. Only relative estimates of air temperature are available for 2000.

Species Distribution

The first survey was carried out on 29 August 2000 and the last on 27 August 2001. To provide a composite coverage of a 'full season', the data from 2000 are included after those for 2001 (Table 2).

The results show that, for these three sites, the number of species and the abundance of those species decreases with altitude, with the possible exception of the Common Hawker *Aeshna juncea* (L.) at Site C (see Figure 2). The flight period of a species begins later at the higher sites (where water temperatures are generally lower) and a similar reverse progression applies at the end of the season. I have also observed a similar time gap between Site A and pools at sea-level in this area. The Southern Hawker *Aeshna cyanea* (Müller) was only occasionally present at Site A and not recorded at all at either of the two higher sites. However, it is nearly as numerous as *A. juncea* at other sea-level pools in Morayshire.

From Table 2 it would appear that Site C at 250m asl could be near the upper altitude limit for the Emerald Damselfly *Lestes sponsa* (Hansemann) in this area. A similar altitude limit may apply to two further species, the Four-spotted Chaser *Libellula quadrimaculata* L. and the Black Darter *Sympetrum danae* (Sulzer). It would be interesting to test this theory if suitable pools can be found above this altitude.

Table 2 (a). Weather and abundance of dragonfly species recorded during surveys of Site A (a = adult, m = mating pair, e = egg laying)

	(%)		Temp (°C)		*L. sponsa*		*P. nymphula*		*E. cyathigerum*		*I. elegans*	*A. juncea*		*L. quadrimaculata*		*S. danae*	
	sun	wind	air	water	a	m	a	m	a	m	a	a	e	a	e	a	m
2001																	
21-May	nil	W2	20	14			1										
25-May	100	SW3	23	19			27	12	18	1				20			
12-Jun	100	NE2	17	17			24	4	25	6	18			33			
18-Jun	100	N3–4	14	16			14	2	42+	1	6			32+	1		
02-Jul	100	SW4	24	20	40+		12	1	40+	4	3			40+			
16-Jul	90	nil	16	15	135+	14	3		90+	5	3	4		5		2	
31-Jul	30	S1	15	16	320+	6			35+	1						20+	
17-Aug	10	nil	15	17	335+	85+			15			3				8	2
27-Aug	25	NW3	15	16	260+				15				1			5	
2000																	
29-Aug	20	N2	cool		95+	10			19			4	1			40+	6
30-Aug	haze	W1	mild		150+	18			14	2		5	2			50+	13
19-Sep	100	SE3	cool		26	2			1			5	1			32	2
26-Sep	hazy	SE3	cool		50							1	2			5	
09-Oct	100	SE3	cool		5								1?			14	

One adult *A. cyanea* was recorded at Site A on 17 August and other single adults were probably present on 30 August and 9 October. One *E. cyathigerum* and one *L. quadrimaculata* were recorded egg laying on 18 June and two *S. danae* were egg laying on 29 August.

Table 2 (b). Weather and abundance of dragonfly species recorded during surveys of Site B (a = adult, m = mating pair, e = egg laying)

	(%)		Temp (C)		*L. sponsa*		*P. nymphula*		*A. juncea*		*L. quadrimaculata*		*S. danae*	
	sun	wind	air	water	a	m	a	m	a	e	a	e	a	m
2001														
21-May	90	SW1	19	12			6							
25-May	100	SE4	21	15			5							
12-Jun	100	N2	16	14			19	1			1			
18-Jun	80	N1	12	12			8		1					
02-Jul	100	NE1	24	17			12	5	2					
16-Jul	90	nil	16	14	11		5		1					
31-Jul	nil	N3	15	17	10									
17-Aug	10	E1	15	16	22	1								
27-Aug	10	NW4	12	15	13									
2000														
29-Aug	nil	N2	cool		23								2	
30-Aug	100	nil	warm		40+				1				3	
19-Sep	100	SE3	cold		4				1					
26-Sep	50	SE2	cool		3									
09-Oct	hazy	SE4	cold											

Table 2 (c) Weather and abundance of dragonfly species recorded during surveys of Site C (a = adult, m = mating pair, e = egg laying)

	(%)		Temp (°C)		*L. sponsa*		*P. nymphula*		*A. juncea*		*L. quadrimaculata*		*S. danae*	
	sun	wind	air	water	a	m	a	m	a	e	a	e	a	m
2001														
21-May	10	W1	21	12										
25-May	100	SW5	23	14			5				2			
12-Jun	100	NE3	15	13			21	2			5	1		
18-Jun	100	NE1	13	10			3				3			
02-Jul	100	SW4	23	14			14	1			5			
16-Jul	75	NE1	17	12			1		2					
31-Jul	10	N2	15	14			1		1					
17-Aug	10	SW1	15	14	1				2				2	
27-Aug	80	NW5	15	12	3									
2000														
29-Aug	20	N2	cool		2				4	2			6	
30-Aug	90	nil	mild		6				10				7	2
19-Sep	100	S3	cool		1								3	
26-Sep	50	SE2	cool							2			1	
09-Oct	100	SE1	cold											

One *S. danae* was recorded egg laying at Site C on 30 August.

Initially I thought that at this latitude (57° 35' N) and on this type of pool, Table 2 could be interpreted as showing a cut-off altitude for the Blue-tailed Damselfly *Ischnura elegans* (Vander Linden) and the Common Blue Damselfly *Enallagma cyathigerum* (Charpentier) somewhere between Sites A and B (60–150m asl), until Mrs Betty Smith suggested that environmental factors might provide a better explanation. *I. elegans* breeds in pools with a fairly dense growth of sedges, a characteristic which certainly applies at Site A, but not nearly as much at Sites B and C. *E. cyathigerum* prefers open water which, as the season progressed and surface vegetation spread, was lacking at Site B and almost non-existent at Site C. Both species were found at another site a few miles away at 140m asl, although *I. elegans* was scarce whereas *E. cyathigerum* was present in large numbers. This site is a series of man-made pools with deep, open water (pH 6) excavated from heavy clay less than a decade ago and has only sparse bank-side vegetation of clumps of rank grasses, rushes and cultivated irises, making the habitat much more suited to *E. cyathigerum* than *I. elegans*. It therefore remains to be established whether, given the right conditions, the cut-off for both species might be around 150m asl, or whether either species can be found at much higher altitudes.

Of the nine species of dragonflies found in this area, only the Common Darter *Sympetrum striolatum* (Charpentier) was not recorded in this survey. *S. striolatum* was first recorded in this area on a sea-level pool in 1997 and three years later it was present at a loch at a slightly lower altitude than Site A, but only 1km away. It may only be a matter of time before it bridges the gap.

Population Densities

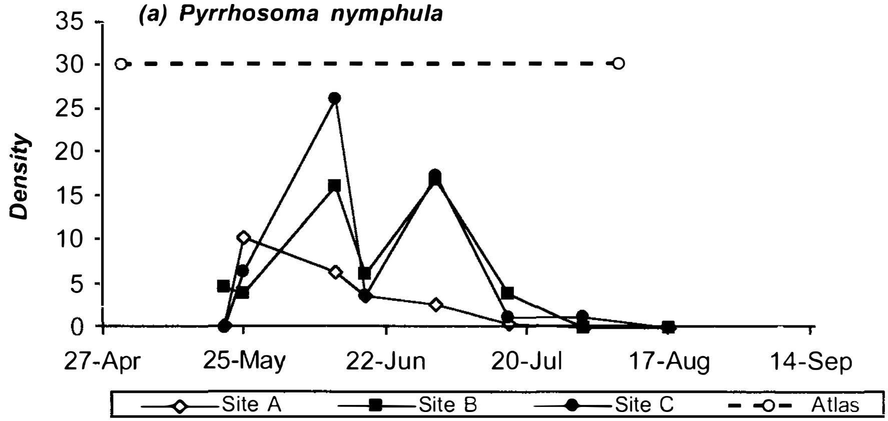
Where the data in Table 2 permits, the species density (individuals per 100m of water's edge) at each of the three sites was calculated and is presented in Figure 1. For clarity the data for 27–30 August have been amalgamated into a single data point.

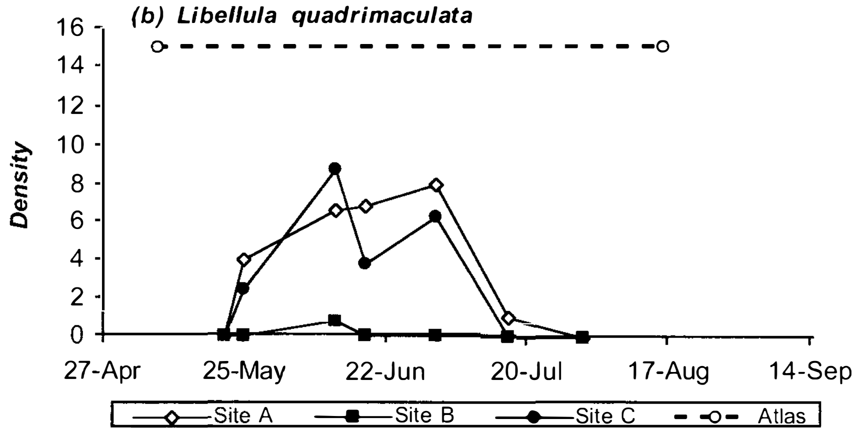
Figures 1 (a) to (e) highlight that the peak densities of each species occur at the same time at all three sites, notwithstanding the shorter flight periods at the higher altitude sites. It would be very interesting to see if this observation was replicated over a wider range of altitudes within a geographical region, as well as over a wider range of species.

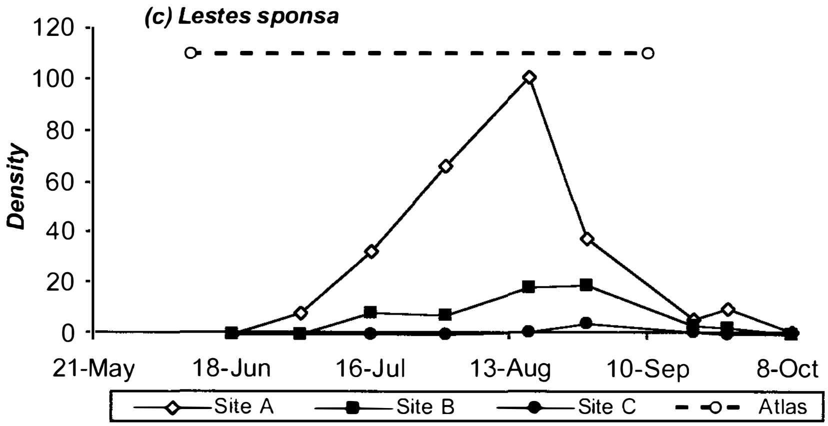
Despite being the smallest and highest pool, Site C is prolific for the Large Red Damselfly *Pyrrhosoma nymphula* (Sulzer), *L. quadrimaculata* and *S. danae*. The densities of these three species appear consistently higher at Site C than at Site B and more in line with the pools at Site A, despite Site A being 190m lower.

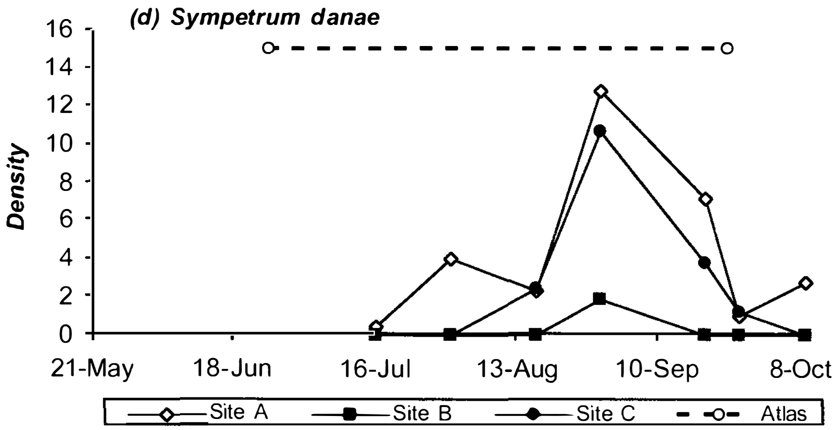
It might have been expected that the dragonflies of these peat-bog pools in Northern Britain would exhibit shorter flight periods than those quoted by Merritt *et al.* (1996), much the same as many other natural seasons are shorter than in more southerly parts of Britain. Data recorded for first sightings of dragonflies at these sites indicates that, at least in 2000, these were up to three weeks later than indicated by 'the Atlas' (Figure 1).

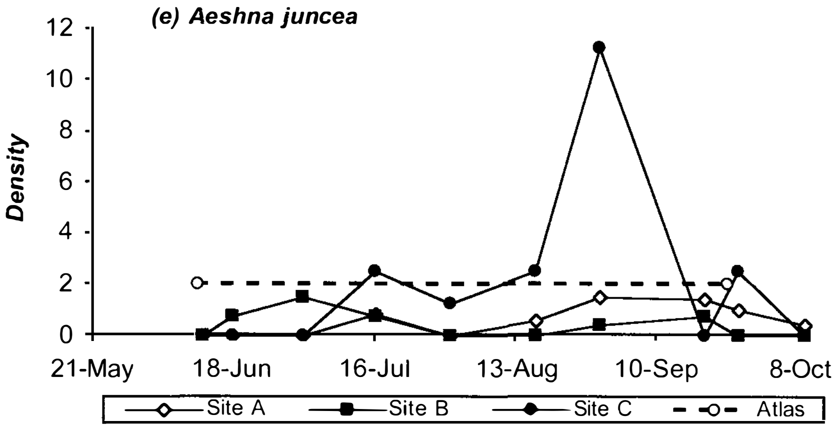
Figure 1. Population densities (individuals per 100m of water margin) of five species at Sites A, B & C compared with the flight periods (Table 5 of Merritt *et al.* (1996) excluding isolated outlying records) and highest steady densities quoted in the same 'Atlas'.






(c) Lestes sponsa
120
100
80
60
40
20
0
Density
21-May
18-Jun
16-Jul
13-Aug
10-Sep
8-Oct
Site A
Site B
Site C
Atlas


(d) Sympetrum danae
16
14
12
10
8
6
4
2
0
Density
21-May
18-Jun
16-Jul
13-Aug
10-Sep
8-Oct
Site A
Site B
Site C
Atlas


(e) Aeshna juncea
12
10
8
6
4
2
0
Density
21-May
18-Jun
16-Jul
13-Aug
10-Sep
8-Oct
Site A
Site B
Site C
Atlas

Of the five species presented in Figure 1, the two early season species, *P. nymphula* and *L. quadrimaculata* finished before the 'the Atlas', whilst the other three, all tended to exceed 'the Atlas' by up to two weeks. The observed flight period of *E. cyathigerum* was almost identical to 'the Atlas' but *I. elegans* ended over one month earlier. Care should be taken in interpreting these data as they represent a composite of observations from two different years.

The distribution and density of *A. juncea*, particularly at Site C, merits special mention. In many respects, e.g. size, shape, vegetation, Site C appears very similar to Site B, but Site C consistently had a higher (sometimes much higher) population density of this species than either of the other two sites. The ten *A. juncea* seen at Site C on 30 August 2000 were all males with, at any one time, two or three pairs of these males embroiled in territorial disputes, leaving the remainder to patrol the water margin until they too became embroiled in disputes of their own. It was a glorious sight, and I doubt I shall see the like of it again.

Now that my knee no longer permits rough walking, perhaps someone younger and fitter with access to peat-bog pools between 400–600m asl will continue, and perhaps extend, this study.

Acknowledgement

My grateful thanks are due to Mrs Betty Smith for all her help and encouragement in the preparation of this article and its related field work.

Reference

Merritt, R. Moore, N.W. & Eversham, B.C. 1996 *Atlas of the dragonflies of Britain and Ireland.* ITE research publication no. 9. HMSO, London. 149pp.

Observations on an inland population of the Small Red-eyed Damselfly *Erythromma viridulum* (Charpentier) with notes on the first discovery of larvae in Britain

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Introduction

Following the well-publicised colonization of south-east England by the Small Red-eyed Damselfly *Erythromma viridulum* (Charpentier) it was unclear at first whether the species had established viable breeding colonies. It is known that other migrant species, such as the Yellow-winged Darter *Sympetrum flaveolum* (L.) and the Red-veined Darter *Sympetrum fonscolombii* (Sélys), have attempted to breed in Britain but have been unable to sustain long-term colonies. Several field workers have made attempts to gain proof of *E. viridulum* breeding in Britain and during July and August 2002 exuviae of *Erythromma viridulum* were found in Kent (G. Brook, pers. comm.; Brook, 2003) and on the Isle of Wight (D. Dana, pers. comm.). The difficulties experienced in finding exuviae suggest that larvae typically do not approach the bankside for emergence. The situation was also made more difficult by problems of identification and the reliability of the morphological characters used in the published keys (Brook, 2003).

Early reports from coastal sites in East Anglia seemed to suggest that colonization was taking place in waves (Cham, 2003). Some of these colonies were short lived with no records in subsequent years following first discovery. It has been suggested that these sites may have been sub-optimal and only selected as first stopping point, after migration in from the continent (A. Parr, pers. comm.). As the species has become established in south-east England, it seems likely that it is now more selective of the habitats where it occurs. Therefore, inland colonies where it has persisted for several years are of significance to establish its preferred habitat requirements. Currently the sites of greatest interest are at the leading north-westerly edge of the species range. Breeding colonies in this zone are the ones most likely to lead to further range extension.

In Bedfordshire, the species had been recorded from 16 sites by the end of 2003, which represent the most inland and westerly sites. Definitive proof of breeding this far inland was therefore of importance in determining the nature of these colonies and their potential for further spread. The first records for Bedfordshire were made at a series of old gravel pit lakes at Priory Country Park near Bedford in 2001. It has been recorded at this site each year since. *E. viridulum* occurs along with the Red-eyed Damselfly *Erythromma najas* (Hansemann) on the Finger Lakes, which are the least disturbed of all the lakes in the park. Here there is an abundance of aquatic plants mainly dominated by Yellow Water-lily (*Nuphar lutea*) and Rigid Hornwort (*Ceratophyllum demersum*) where ovipositing tandems have been recorded. Despite intensive searching of these prime areas through June to August, it has not been possible to find exuviae or emerging adults around the margins of these lakes.

Fieldwork

Priory Country Park, Bedford (O.S. Grid Reference TL 076493) was visited regularly during May and June to monitor the Odonata present. Despite reports of the first emergence of *E. viridulum* from Essex in June, none were seen at this, or any other, Bedfordshire site at this time. On 24 June 2003, just prior to the expected period of emergence, areas of Hornwort and other submerged aquatic plants were sampled for larvae. These areas were in the middle of the lake where *E. viridulum* had been observed ovipositing in the two previous years. A small boat was used to reach areas approximately 25–50 metres from the bank. A standard pond net was used to collect clumps of Hornwort, which were placed into a tray for inspection on the boat. Sampling was made difficult by the large size of the Hornwort clumps and by the problems of handling such clumps in a small boat.

Observations

Larvae of *E. viridulum* were found with relative ease in patches of actively growing Hornwort in water at a depth of 1–3 metres. The overall colour of the larvae was bright green and well matched the colour of the plants in which they were found (see photograph in Cham, 2004). Larvae were placed into pots for later identification. With a 10× magnifier it proved difficult to see the setae on the ventral surface of the first and second abdominal segments (Brook, 2003) in the field, especially with a film of water covering the body. Identification of larvae was therefore carried out later using a Leica M3Z stereomicroscope at approximately 100× magnification.

Two larvae were retained for later observation in a small glass tank. They were kept in the tank containing Hornwort, which best replicated the conditions in which they had been found. Several upright stems of Spike-rush (*Eleocharis* sp.) were also added to provide suitable supports for emergence. A range of small invertebrates was added to the tank to provide an adequate food supply leading up to emergence. At times, the larvae proved very difficult to observe and were often well hidden amongst the leaf whorls of the Hornwort. On one occasion it was thought they had escaped from the tank but after the Hornwort was removed careful examination revealed both larvae still to be present, yet well camouflaged. The female emerged on 5 July at approximately 1500h followed by the male three days later.

Observations of adults were made throughout the summer at Priory Country Park to determine the adult flight period for the site. Throughout July and August 2003 more adults were recorded than in previous years. They were first seen on 6 July when they were already mature and, therefore, had probably emerged during the previous week. Numbers reached a peak between 24 and 27 July when over one hundred tandem pairs were seen ovipositing into areas of Hornwort. They were present in high numbers through August, slowly declining until the last few individuals were seen on 4 September.

It was noticeable that, when compared to *E. najas*, *E. viridulum* requires brighter, warmer conditions for activity. On a number of occasions when sites were visited during overcast conditions no *E. viridulum* were seen, although *E. najas* was present in reasonable numbers.

Discussion

One of the major factors at the Bedfordshire sites appears to be the presence of Hornwort. When sites where this plant is known to occur were visited during the flight period, *E. viridulum* was usually discovered within minutes of searching with binoculars. At several sites, such as lakes at Woburn Park, it was observed way out in the middle of the lake on Hornwort along with *E. najas*. Such habitats may necessitate the use of a telescope to confirm the identification of the species. The life cycle of Hornwort may also play a role in the ecology of *E. viridulum*. It overwinters at the bottom of still waters and starts to grow in the spring. It lacks roots and as it grows it starts to rise to the surface in late May to early June. The lack of roots is one of the reasons why it is rarely recorded from running water habitat. As the plants rise larvae would experience warmer temperatures which would allow the later stages of development to be completed more rapidly prior to emergence. By early July the Hornwort is growing rapidly and forms large patches and rafts on the water surface. Very few larvae and exuviae are found on the lake margins and it seems likely that they emerge on these rafts. During the larval sampling in June, the exuviae of other coenagrionid species were present on Hornwort and other plants in the middle of the lakes.

Towards the end of August, as cooler night time temperatures are experienced, the rafts of Hornwort start to sink. At Priory Park and Wrest Park, large expanses of Hornwort were sinking in the last week of August. The last few individuals of *E. viridulum* were seen during the first week of September. The only two individuals seen on the 4 September spent a lot of time flying between the remaining patches of Hornwort, exhibiting much greater activity than previously observed. This may have been in response to a scarcity of females and therefore the need to search more actively.

The observations reported here contribute to the understanding of the habitat requirements of *E. viridulum*. It has now been proven to breed at inland colonies giving the species a firm foothold to continue range expansion across southern and central

England. The presence of Hornwort and, to a lesser extent, other floating 'weeds', may provide an indication as to where best to look for this species.

Acknowledgements

I would like to thank Dave Dana for his work collecting exuviae on the Isle of Wight and Gill Brook for exchange of observations relating to the species colonization in Kent. Finally, I am indebted to Rosie Pallister for allowing me to accompany her on the boat at Priory Park.

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Brook, G. 2003. Identification of the exuvia of the Small Red-eyed Damselfly *Erythromma viridulum* (Charpentier). *Journal of the British Dragonfly Society* **19**: 44–46

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Cham, S. A. 2004. *Dragonflies of Bedfordshire*. Bedfordshire Natural History Society. 145pp.

Honest signals and female damselflies

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Female coenagrionid damselflies always have the option of refusing to copulate with males that attempt to mate with them, but usually they do not. Whilst they may be able to outmanoeuvre males and so resist being grabbed on some occasions, they have to comply by bending their abdomens to complete the 'wheel' (or 'heart') position on every occasion.

Most females do not actually need to mate more than once. Cordero (1991) demonstrated that females of *Ischnura graellsii* (Rambur) stored enough sperm from one mating to fertilize fourteen clutches of eggs. Most females are forced to mate on every occasion when they visit a preferred oviposition site. This is a cost they must pay in order to avoid continual harassment from males while they are ovipositing. Females rarely manage to oviposit alone in non-territorial species. If they are taken in tandem, takeovers by harassing males rarely happen (Banks & Thompson, 1985) even though there may be some attention from single males. Nevertheless, there is no doubt that many species that we normally think of as ovipositing in tandem, such as the Azure Damselfly *Coenagrion puella* (L.), are perfectly happy to oviposit alone and indeed do so frequently at the end of the season if the sex ratio becomes female biased.

Of course, there are advantages for females of ovipositing in tandem. Males can sometimes pull them out of trouble if aquatic predators such as newts or even aeshnid larvae grab their abdomens and, for those species that oviposit completely underwater, males can be of great benefit in pulling the female out of the surface tension of the water (Fincke, 1986). There are also advantages to females of multiple matings, not the least of which is increased genetic variation in their offspring.

Females arriving at the breeding site with a full clutch of eggs to lay are bound to be harassed by males until they enter tandem. The same females leaving the breeding site with no mature eggs to lay signal to males that they are not worth mating with and males believe them. Females might like to persuade males to leave them alone when they approach the breeding site, but invariably they do not. Why are they able to do it on the way out, but not on the way in? The answer would seem to be that they have an honest signal on the way out, a signal to males with which they are unable to convey false information, an honest signal. When leaving a breeding site, female coenagrionid damselflies, if approached by males, bend their abdomens down outrageously, at an angle close to ninety degrees. Males seem to get the message that these females are not worth chasing. Females are quite unable to do this when they approach a breeding site because their abdomens are completely full of mature eggs such that it is impossible to bend them at such angles. So bending the abdomen at such an angle is an honest signal because it is impossible to cheat on this signal. The abdomen can only be bent to such a large extent when it is empty of mature eggs.

A much fuller discussion of all aspects of female refusal behaviour is given by Corbet (1999).

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Fincke, O. M. 1986. Underwater oviposition in a damselfly (Odonata: Coenagrionidae) favors male vigilance and multiple mating by females. *Behavioral Ecology & Sociobiology* **18**: 405-412

INSTRUCTIONS TO AUTHORS

Authors are asked to study these instructions with care and to prepare their manuscripts accordingly, in order to avoid unnecessary delay in the editing of their manuscripts.

Word-processed manuscrips may be submitted in electronic format either on disk or by e-mail.

Typewritten manuscripts should be produced using black ribbon, double-spaced, on one side of the page only and with margins at least 25mm at the left, top and bottom. Text pages should be numbered and footnotes avoided.

Words that are to appear in italics (e.g. names of genera and species, though not of families) should be underlined if an italic font is not available.

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.

Dates in the text should be expressed in the form: 24 July 1994.

References cited in the text should be in the form '(Longfield, 1949)' or '... as noted by Longfield (1949)'. All references cited in the text (and only these) should be listed alphabetically at the end of the article in this form:

Hammond, C. O. 1983. *The dragonflies of Great Britain and Ireland.* 2nd edition (revised by R. Merritt). Harley Books, Colchester. 116 pp.

Longfield, C. 1949. The dragonflies of the London area. *The London Naturalist* **28**: 90–98.

Titles of journals should be written out in full.

Tables should be presented, each on a separate, unnumbered page.

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Figures should be prepared in black ink, and scaled to allow a reduction of 1.5 to 3 times.

The legend for each table and illustration should allow its contents to be understood fully without reference to the text. The approximate position of each table and figure should be indicated in the text.

SCIENTIFIC AND ENGLISH NAMES OF BRITISH ODONATA

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

A full checklist can be found on the inside back cover of Dragonfly News.

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