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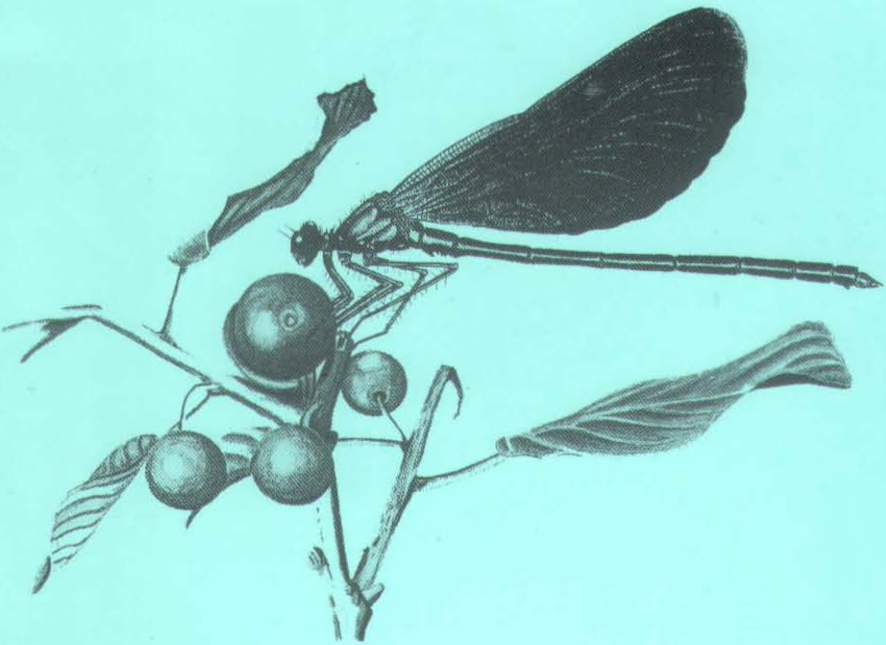

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Front cover illustration of male *Calopteryx virgo* (L.) at rest by Roderick Dunn

Calopteryx splendens (Harris) at edge of range sites in North-East England

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Abstract

A survey of adult Banded Demoiselles *Calopteryx splendens* (Harris) in the middle section of the River Wear, County Durham, was undertaken over the summers of 1994–96. The species was found in one new 10km square in the county (vice-county 66) and the survey confirmed its regular presence in another two. Flows in the Wear are regulated by inter-basin water transfers and pumped minewater releases, both of which result in considerable short-term flow change. Several sites occupied by *C. splendens* were also found to suffer water quality problems associated with sewage treatment works and contamination from minewaters. *C. splendens* may be more widespread in Durham than previously thought and there is increasing evidence that it is present on many suitably slow-flowing rivers in north-east England. However, the species' presence at some sites on the Wear with relatively poor water quality and variable daily flow patterns remains puzzling.

Introduction

Odonata are generally considered sensitive to habitat degradation. Wetland drainage, canalization and loss of hinterland have all been implicated in the demise of Britain's odonate fauna (Hammond, 1983). Additional disturbance to dragonfly habitats arises from river regulation schemes and pumped drainage from agricultural land which can result in rapid fluctuations in water-level. Water quality is seen as critical in determining odonate species richness and abundance, and it has been suggested that Odonata could be used as 'indicators' of ecosystem health (Aguilar *et al.*, 1986).

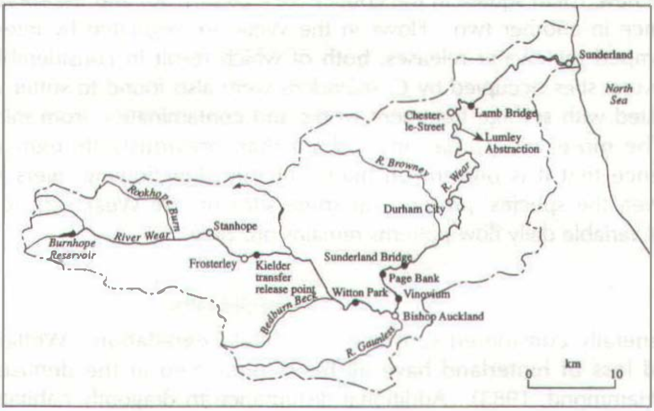
The Banded Demoiselle *Calopteryx splendens* requires well-oxygenated watercourses with flow regimes which allow the development of aquatic vegetation (Askew, 1988). A well-vegetated riparian (river bank) zone is also important although areas with excessive shade are avoided. Both in-stream emergent and marginal vegetation are important, providing perches for the adult insect during display flights (Merritt *et al.*, 1996). In discussing the water quality requirements of *C. splendens*, Gabb & Kitching (1992) and Brooks (1997) state that it is intolerant of pollution.

Data in Hammond (1983) show *C. splendens* reaching the northern limits of its UK range in the Tees catchment on the border between Yorkshire and Durham. The lack of post-1961 records in the north-east of England led Hammond to conclude that the species was declining in the northern parts of its range. However, more recent information shows it to be present as far north as the rivers Blyth and Wansbeck in Northumberland (Merrit *et al.*, 1996) and the River Wear in central Durham (Jessop, in prep.; Stewart, pers. comm.). No work on the distribution or stability of these northern outpost populations had thus far been undertaken so in 1994, 1995 and 1996 suitable areas along the River Wear were surveyed. This paper presents the findings of the surveys and describes some of the basic water quality and hydrological characteristics of River Wear sites found to support *C. splendens*. Its distribution in relation to these characteristics is discussed.

Hydrology and water quality of the River Wear

The River Wear lies between 54.5° and 55°N, flows approximately west to east and extends through the counties of Durham and Tyne and Wear (Fig. 1a). Killhope and Burnhope Burns rise on the eastern slopes of the Pennines (c. 650m amsl) and converge at Wearhead to form the River Wear. The river enters the North Sea at Sunderland having travelled 120km. Sixteen kilometres of the river are tidal.

(a)



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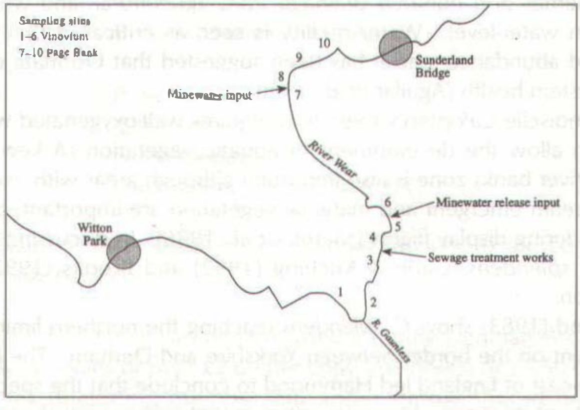


Figure 1. The River Wear catchment, north-east England, showing study sites and major influences on water quality and flows. Fig 1a shows the catchment as a whole; Fig 1b a section of the river from Witton Park to Sunderland Bridge. Sampling sites used for detailed water quality analysis are numbered 1–10.

To the west of Witton Park the Wear is typically upland, characterized by steep gradients, coarse substrates (boulder, cobble and pebble), a relatively straight or sinuous channel form and limited macrophyte growth. Channel meanders become more pronounced around Witton Park and, downstream of Bishop Auckland, an active floodplain develops. Here, the river changes in character, with extensive pool sections and increased macrophyte cover. The tidal limit is at Lamb Bridge. In terms of its physical characteristics, this part of the Wear (from Bishop Auckland to Lamb Bridge) provides apparently suitable habitat for *C. splendens*.

A number of factors contribute to the hydrological and water quality characteristics of the Wear between Bishop Auckland and Lamb Bridge. Transfers of water from the Kielder system enter the Wear at Frosterley and are used to support a public water-supply abstraction at Lumley (Fig. 1a). Transfers ensure that the Wear's prescribed Minimum Maintained Flow (MMF) of 2.0 cubic metres per second (cumecs) is not violated as a result of abstractions. When used, transfers can give rise to sudden and marked changes in flow. Flows at Frosterley can double over a one-hour period as a result of transfers although changes are less marked further downstream (Fig. 2). The Coal Authority currently operates a number of minewater pumping stations in the catchment. These pump water out of the mineworkings to prevent flooding, with the abstracted water released to the Wear and its tributaries. The largest releases are at Vinovium (78,500 cubic metres per day) and Page Bank (24,000 cubic metres per day). These minewaters represent an important source of flow augmentation. Because of cheaper electricity tariffs, minewater pumping occurs at night and this leads to substantial fluctuations in river flow (Fig. 2b) in addition to those arising intermittently from Kielder transfers. The water quality and consequent ecological impacts of these pumped minewater releases have never been fully assessed.

One hundred and forty-three sewage treatment works are located in the catchment and a number of these have adverse impacts on the receiving watercourses (National Rivers Authority* (NRA), 1994). The lower section of the River Gaunless (Fig. 1) which is a major tributary of the Wear, failed to meet its NRA water quality target class as a result of combined sewer overflows, and downstream of the Gaunless confluence the Wear shows a tendency toward eutrophication (Inverarity & Clegg , 1995).

Methods

The survey aimed to answer two questions: (i) what is the distribution of *C. splendens* along the Wear, and (ii) what are the water-quality characteristics of some of the occupied sites? The Wear from Bishop Auckland (NZ 213 310) to Lamb Bridge (NZ 294 524) was surveyed over the summers of 1994 to 1996. In each year a number of accessible points along the river were visited and the presence or absence of adults recorded; no attempt was made to determine abundance. All surveys were undertaken on warm sunny days between 1100 and 1600h. Several authors have discussed survey methods appropriate to recording the distribution of *Calopteryx* species (Zahner, 1960; Macan, 1970; Prendergast, 1988). Counts or observations of adults rather than larvae are considered suitable since (i) its distribution is apparently dependent more on the habitat requirements of adults than larvae, and (ii) adults

* Now the Environment Agency

do not stray far from their emergence sites and return to them regularly for reproduction. So, more than most odonates, the regular presence of good numbers of adults, notably females, can be taken as an indication of breeding.

Two of the areas found to support *C. splendens* were studied in detail in 1995 and 1996. Page Bank and Vinovium were selected as they are located in a part of the river subject to a complex series of problematic discharges (Fig. 1b). Pumped minewater discharges enter each area, while Vinovium is also influenced by the River Gaunless and Vinovium sewage treatment works. Both areas also suffer flow variability arising from Kielder transfers.

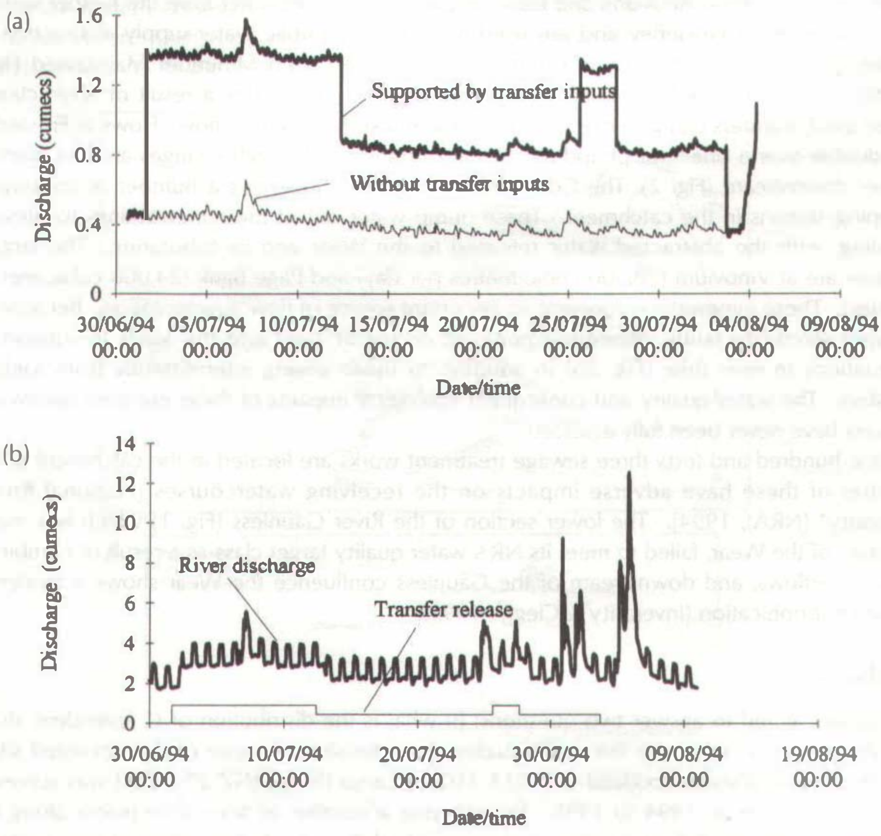


Figure 2. Discharge at two sites on the River Wear, 30 June to 8 September, 1994: (a) Frosterley, (b) Sunderland Bridge. Flows with and without the input of water released from the Kielder transfer system are shown in Fig. 2a; the contribution of the Kielder transfer water to river flow is shown along with total discharge in Fig. 2b. Diel† fluctuations in flow at Sunderland Bridge arise from pumped minewater discharges from Vinovium and Page Bank.

† Diel changes or patterns are those which occur within a 24-hour period, with the changes repeated in the following 24 hour period. Daily changes refer to differences between 24 hour periods.

A broad water-quality sampling strategy was developed to allow consideration of minewaters, the sewage treatment works and the River Gaunless. Water-quality data were collected both up- and downstream of each discharge in each area. A total of ten sites was monitored (Fig. 1b): six at Vinovium (numbered 1-6) and four at Page Bank (numbered 7-10). Each site was visited on five separate occasions between 10 July 1995 and 5 August 1996. All visits were during the summer on days when the *C. splendens* surveys were being undertaken. On each visit, a number of water-quality determinands were measured at each of the ten sites (see Figs 4-6). Dissolved oxygen (DO), pH, conductivity and temperature were measured in the field using a Grant 3800 water-quality logger. Alkalinity and total hardness were determined in the field using a digital titrator. For nitrates, phosphates and metals, water samples were taken back to the laboratory for subsequent analysis. Sediment samples were taken from the same localities to allow comparison of metal contamination in river water and sediments. All samples and measurements were taken at river margin locations, 0.5m from the bank.

Water was analysed for nitrates and phosphates using a CAMLAB DR2000 spectrophotometer and for metals using a Perkin Elmer 2380 atomic absorption spectrophotometer. Sediments were digested in aqua regis in a CEM MDS81D microwave and analyzed using the Perkin Elmer spectrophotometer.

Results and discussion

Distribution of *C. splendens*

Adults were recorded from Bishop Auckland downstream as far as Chester-le-Street. Upstream of Bishop Auckland the river is relatively shallow, turbulent, has larger modal substrate sizes and lacks in-stream macrophyte vegetation. Gibbins (1996) collected over 200 samples of invertebrate larvae from the river bed in this area between 1991 and 1994. Larval *C. splendens* were not found in any of the samples and adults were not seen during the fieldwork periods. We can therefore be confident that the species is not regularly present upstream from Bishop Auckland. The

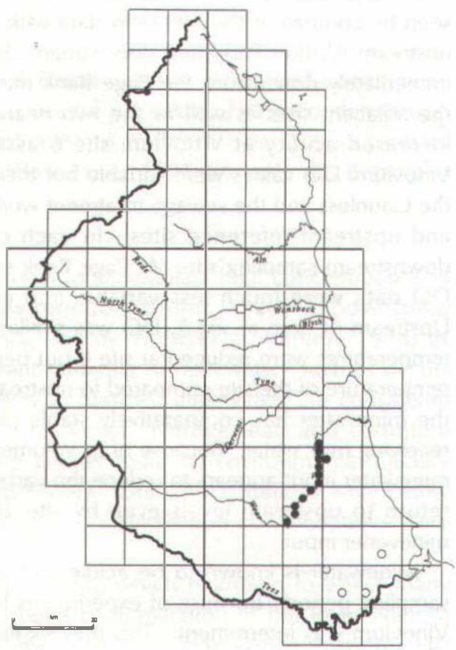


Figure 3. Distribution of *Calopteryx splendens* in the north-east of England. Dots indicate presence in 2km squares.

Key for figure

● River Wear records from the 1994-96 survey

○ Records (pre-1961) shown in Hammond (1983)

□ Additional records (1988-96) shown in Jessop (in prep.)

river from Bishop Auckland downstream to Chester-le-Street represents the spatial extent of flow conditions which allow the development of Branched Bur-reed *Sparganium erectum* and Floating Sweet-grass *Glyceria fluitans*, the plant species with which most sightings along the Wear were associated. The tidal limit is only 2km downstream from Chester-le-Street and so *C. splendens* seemed to occupy the maximum range within which its physical habitat requirements could be met.

C. splendens was found at the same sites in both 1994 and 1995; some sites which were also checked in 1996 again held *C. splendens*. These surveys suggest a regular and spatially continuous presence at sites which extend across three 10km squares (Fig. 3). Levels of abundance were not specifically assessed but the three years' work suggested that the species is not uncommon along the Wear.

Water quality

Given that only one sample was collected at each of the ten sites on each occasion (i.e. no spatial replicate samples were taken) detailed statistical analysis was not carried out. However, since we have data obtained on a number of occasions from each site, some general patterns can be described. Determinands specifically referred to in the text are depicted in Figs 4 and 5; others not discussed in detail are presented in Fig. 6. To illustrate the range of values at each site, individual sample measurements are presented along with respective means.

Physico-chemical characteristics

The overall impact of the individual point discharges on temperature, DO and pH can be seen by comparing the 1995–96 data with mean statistics for NRA gauging stations located upstream (Witton Park) and downstream (Sunderland Bridge) of our sampling areas. Site 8, immediately down from the Page Bank minewater input, was consistently more acidic than the adjacent sites as well as the two nearest gauging stations. There was no evidence of increased acidity at Vinovium site 6 associated with the minewater release point. At Vinovium, DO values were variable but there is a suggestion of reduced levels at sites below the Gaunless and the sewage treatment works, relative to both long-term gauging station data and upstream reference sites. In each case however, recovery is evident by the next downstream sampling site. At Page Bank sites 8–10 downstream from the minewater input, DO data were much less variable and consistently lower than gauging station values. Upstream of here at site 7, DO was similar to the gauging data statistics. Mean Page Bank temperatures were reduced at site 8 but perhaps more noticeable was the relatively constant temperature of the site compared to upstream and downstream sampling sites. It is likely that the minewater has comparatively stable physico-chemical characteristics, distinct from the receiving river water. Because of its volume relative to the receiving river flow, the Page Bank minewater input appears to reduce the variability of river temperature and DO. DO does not return to upstream levels even by site 10, approximately 300m downstream from the minewater input.

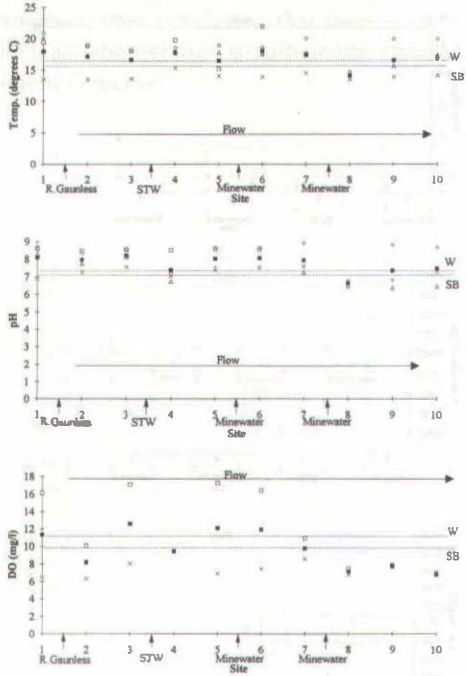
Minewater is known to be acidic and was being released at Page Bank throughout the sampling period. Because of experiments being undertaken by NRA, minewater pumping at Vinovium was intermittent. This may explain the lack of pH reduction in river water below

Figure 4. Temperature, pH and dissolved oxygen (DO) measurements along the River Wear at the ten sites studied.

In Figs 4–6, water-quality characteristics of sites at Vinovium (1–6) and Page Bank (7–10) on the River Wear, July 1995 to August 1996 are shown. Data are compared to long-term mean values (dotted lines) from Witton Park (W) and Sunderland Bridge (SB) gauging stations (means are based on July-September data over a 17-year period). Environmental Quality Standards (EQS) are indicated where appropriate. The position of minewater releases, sewage treatment works (STW) and the River Gaunless confluence are shown in relation to the sampling points. The direction of river flow is indicated.

Key for Figures 4–6

■ Mean	□ 12 July 1995
∆ 5 Aug. 1995	◊ 8 Aug. 1995
x 17 Sept. 1995	+ 5 Aug. 1996



the Vinovium minewater release point. Younger & Bradley (1994) catalogued uncontrolled minewater discharges in the Durham coalfield and used a pH value of <7.6 combined with conductivity levels of >770 µS/cm (0.770 mS/cm) to indicate possible minewater contamination. Of the ten River Wear sites monitored over 1995-96, only site 8 samples regularly breached these thresholds.

Metals and nutrients

Water resident for some time in deep mines is known to accumulate high concentrations of some dissolved metals (Younger, 1993). Jarvis (unpubl.) found greatly impoverished invertebrate faunas in two of the streams highlighted by Younger & Bradley (1994) as suffering uncontrolled acid mine drainage. Constant pumping of minewaters such as occurs on the Wear does not allow such accumulation and so pumped minewaters are considered less problematic than uncontrolled seepages. However, average lead and cadmium concentrations at sites on the Wear (Fig. 5) were greater than the Environmental Quality Standards (EQS) of 0.020mgl^{-1} and 0.005mgl^{-1} respectively. Zinc concentrations were below the EQS (specific to hard water (>100mgl^{-1} $CaCO_3$)) and average iron concentrations were below the EQS except for Page Bank site 8 (Fig. 5).

The North Pennines area has a legacy of lead mining which is known to affect many streams in the region. Armitage (1980) studied metal contamination in the River Nent, a tributary of the Tyne, and classified sites according to their zinc concentration. His

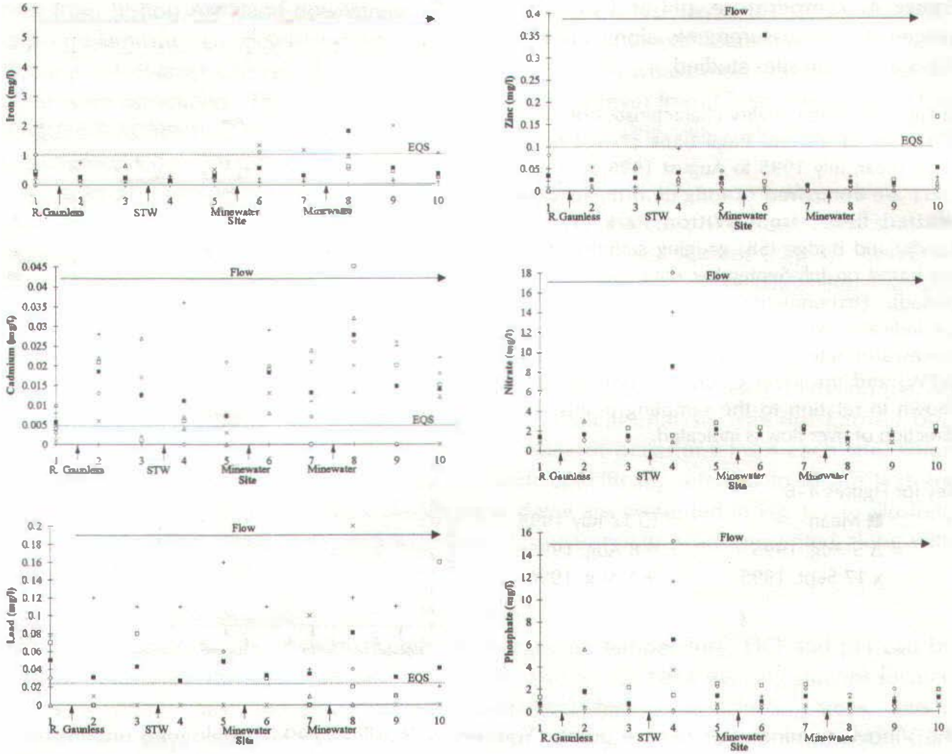


Figure 5. (Left) Iron, cadmium and lead concentrations at the ten monitoring sites along the River Wear. (Right) Zinc, nitrate and phophate levels at the same ten sites.

classification divided sites into those with low (0.02-0.36 mgl^{-1}), medium (0.77-1.64 mgl^{-1}) and high (2.0-7.6mgl^{-1}) zinc concentrations. Armitage found that the structure of invertebrate assemblages differed between sites falling into different classes. All Wear samples fall within the lowest zinc contamination class, suggesting that although affected by minewaters, neither the Vinovium nor Page Bank areas are grossly contaminated. In terms of the range of water-quality measures used here, only site 8 was consistently anomalous.

Nitrate levels from 1995-96 data (Fig. 5) were below 25mgl^{-1}, the threshold not to be exceeded in drinking water. Both nitrate and phosphate levels downstream of the Vinovium sewage treatment works were higher on average and more variable than all other sites. Downstream of the River Gaunless, a tributary which failed to attain its Rivers Ecosystem target class due to sewage inputs (NRA, 1994), phosphate and nitrate levels in the Wear were twice as high as the immediate upstream reference site. So, in absolute terms, nitrate and phosphate concentrations in the Wear were not extremely high although some sites appear to be affected by point sources such as Vinovium STW. Inverarity &

Clegg (1995) noted high orthophosphate levels and low DO at sites in this part of the river, features indicative of eutrophication. However, they concluded that there is only a 'tendency toward eutrophication and it is unclear whether this is sufficiently strong to warrant action under the EC Wastewater Treatment Directive'.

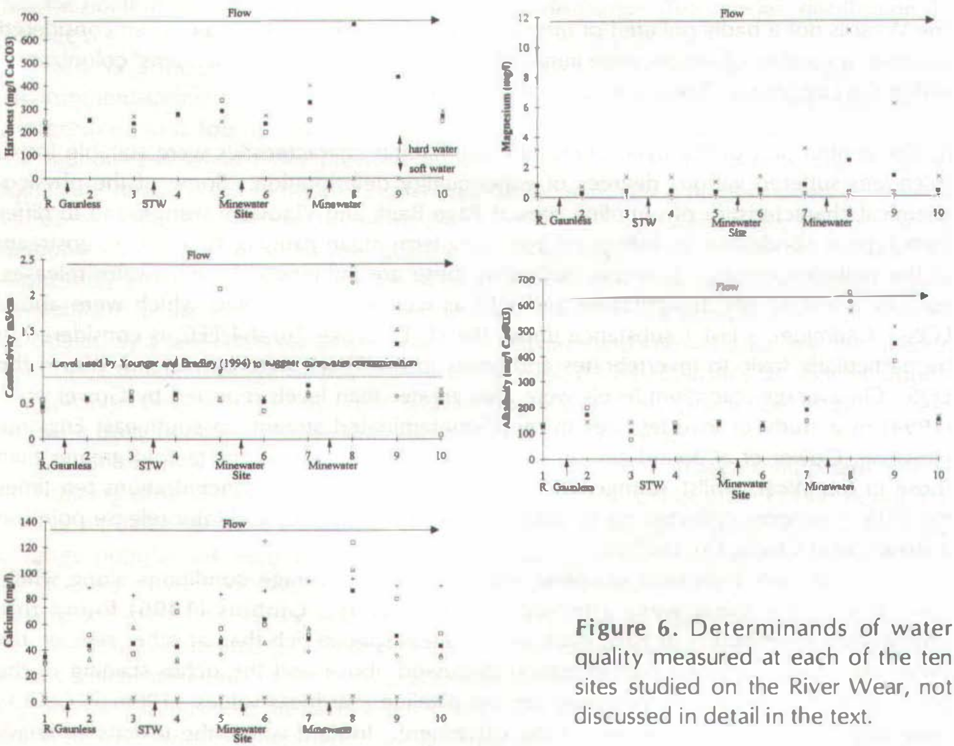


Figure 6. Determinands of water quality measured at each of the ten sites studied on the River Wear, not discussed in detail in the text.

Sediment contamination

When acidic, metal-contaminated minewater meets an alkaline watercourse, iron is deposited on the stream bed producing a red-ochre stain. This staining was evident at site 8 of Page Bank but not in the Wear at the Vinovium minewater site. Unlike Page Bank where the minewater outlet releases water directly to the Wear, the Vinovium outlet discharges into a tributary at a point approximately 0.5km upstream from its confluence with the Wear. Ochre deposits were present in the tributary but not the Wear itself. Although such deposits are unsightly, they are not considered hazardous to health and are therefore not a high priority for water pollution control authorities.

There were no strong patterns to the levels of sediment contamination at the Wear sites and so data are not presented in detail. Lead showed no pattern in relation to the pollution sources, but cadmium and zinc showed increases downstream of the Page Bank minewater discharge and the Vinovium sewage treatment works. However, sample values from each site varied between sampling dates. Unlike water quality, there are no EQSs for metals in river sediments, although cadmium, lead and zinc in Wear sediments were all higher than typical levels found in English soils (Bullock & Gregory, 1991).

Summary and Conclusions

The Wear is not a badly polluted or intensively regulated river. However, when considered together, a number of factors were initially thought likely to limit *C. splendens'* colonization within the catchment. These are summarized below.

(i) The central part of the river where physical habitat characteristics were suitable for *C. splendens* suffered various degrees of water-quality deterioration. Some of the physico-chemical characteristics of sampling sites at Page Bank and Vinovium were found to differ from typical conditions (as estimated from long-term mean gauging station data upstream of the pollution inputs). It seems likely that these are influenced by minewater releases, notably affecting pH, temperature and DO as well as some metals which were above EQSs. Cadmium, a List 1 substance under the EC Directive 76/464/EEC, is considered to be particularly toxic to invertebrates and levels in the Wear were consistently above the EQS. On average, cadmium levels were also greater than levels reported by Gower *et al.* (1994) in a study of invertebrates in metal-contaminated streams in south-east England. However, Gower *et al.* found zinc in stream water in concentrations tenfold greater than those in the Wear, whilst Younger & Bradley (1994) found iron concentrations ten times the EQS in samples collected up to 300m downstream from a minewater release point on a stream near Crook, Co. Durham.

In general, only individual sampling sites rather than average conditions along whole stretches of the Wear were affected by minewaters. Gibbins (1996) found that invertebrate assemblages at Page Bank were no less species-rich than at other sites on the Wear, despite the specific contamination discussed above and the ochre staining of the bed. Both Page Bank and Vinovium are net alkaline (hardness values >100mgl^{-1} $CaCO_3$) reflecting the geology in this part of the catchment. In hard water, the toxicity of heavy metals is known to be reduced and this may play a role in limiting the impact of minewaters on *C. splendens* and other invertebrates.

(ii) Increased levels of nitrates and phosphates were found in the Wear and this may lead to eutrophication problems in the central part of the catchment. This is particularly so in the summer months when flows are low, temperatures elevated and DO levels reduced.

(iii) Because of minewater pumping, the two sites studied in detail have been subject to large diel fluctuations in river discharge. Pumping takes place only at night and so flows can change by around 70 per cent when pumping stops or starts (Fig. 2b). Such changes in discharge affect water-levels and velocities, both of which are important for river invertebrates.

(iv) Periodic water transfer releases made from the Kielder system act to further alter river discharge. Transfer releases can increase discharge at Page Bank by up to 50 per cent during the summer and early autumn months, changes which are in addition to minewater impacts.

Despite these factors, *C. splendens* was found at sites throughout the lowland, non-tidal section of the river and males were seen displaying within 10m of both the minewater release point at Page Bank and the Vinovium STW discharge. The species' distribution did not seem to be correlated with individual point sources of pollution.

There is a mounting literature which questions the neat, deterministic view of environment-species relationships. For example, Brooks (1994) reviewed odonate pH preferences and found little evidence of pH being an important variable, despite assumptions pervading many previous studies. Prendergast (1988) was unable to detect significant relationships between *C. splendens* abundance and a number of environmental variables, including pH, in his work on the River Wey system. The present study demonstrates that apparent water-quality problems were not sufficient to exclude this supposedly pollution-sensitive species, even at sites on the edge of its UK range. Causal mechanisms underlying distribution patterns are clearly more complicated than can be elucidated by a few, relatively simple chemical measures and correlations. We also need to consider the whole range of physical instream habitat characteristics as well as trophic relationships between species. The relative importance and interaction of all of these factors is likely to differ between sites and may change over time.

It is increasingly recognized that past and unusual events play an important role in determining observed distribution and abundance patterns; Drake *et al.* (1994) noted that 'history and chance rule the world of ecology'. This may be particularly relevant for edge-of-range populations such as *C. splendens* occupying rivers in north-east England. For populations existing at sites within central parts of their range, minor changes in water quality, for example, may be relatively unimportant. But at edge-of-range sites where a number of environmental parameters are on the limit of the species' tolerance, coincidental events which cause only minor change may lead to temporary local extinctions.

Long-term trends and the factors governing the current distribution of *C. splendens* on the Wear and other northern rivers are far from clear. In 1769, Wallis found a *Calopteryx* species, possibly *C. splendens*, to be 'common by shadowy running streams' in Northumberland (cited in Jessop, in prep.) whilst Heslop-Harrison (1946) recorded *C. splendens* from the Tees, 'before the last war'. The earliest reports from the Wear are from the late 1980s (Dunn, 1989) although its earlier presence in adjacent catchments to the north and south suggests a lack of recording effort on the Wear. While records from the north-east certainly date back over two hundred years, it may be that the species is now more widespread and abundant. Such an expansion could have occurred because of improvements in water quality which have paralleled the decline in heavy industry in the region. Alternatively, or in addition, climatic changes may allow *C. splendens* to colonize and maintain viable populations in northerly latitudes where previously populations had fluctuated and occasionally suffered local extinctions.

Our surveys focused on water quality and instream habitat characteristics. No detailed information on the riparian zone was collected and it may be that this is a key habitat feature which allows *C. splendens* to maintain populations in parts of the river which otherwise seem less than ideal. Interestingly, at some of the more wind-exposed Northumberland sites, shelter is provided by the high banks of the incised channel rather than riparian vegetation. In this respect, comparative population density information, riparian habitat surveys and water-quality information for the Blyth, the Wansbeck and the Wear would help explain observed patterns. More detailed research, including micro-scale surveys of larval distribution at minewater sites and more focused water-quality sampling and physical habitat assessment is needed on the Wear. The results presented here probably raise more questions than they answer; the existence of *Calopteryx splendens* at northern, edge-of-range sites such as Vinovium and Page Bank remains intriguing.

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References

Aguilar, J. d', Dommanget, J. L. & Préchac. R. 1986. *A field guide to the dragonflies of Britain, Europe and North Africa.* Collins, London. 336pp.

Armitage, P. D. 1980. The effects of mine drainage and organic enrichment on the benthos in the River Nent system, Northern Pennines. *Hydrobiologia* **74:** 119-128.

Askew, R. R. 1988. *The dragonflies of Europe.* Harley Books, Colchester. 291pp.

Brooks, S. 1994. How much does acidity affect the distribution of 'acidophilic' dragonflies? *Journal of the British Dragonfly Society* **10** (1): 16-18.

Brooks, S. 1997. *Field guide to the dragonflies and damselflies of Great Britain and Ireland.* British Wildlife Publishing, Hook. 160pp.

Bullock, P. & Gregory, P. J. (Eds.) 1991. *Soils in the urban environment.* Blackwell, Oxford. 174pp.

Dunn, T. 1989. Record of *Agrion splendens. Vasculum* **74**: 14-15.

Drake, J. A., Flum, T. & Huxel, G. R. 1994. On defining assembly space: a reply to Grover and Lawton. *Journal of Animal Ecology* **63**: 488-489.

Gabb, R. & Kitching, D. 1992. *The dragonflies and damselflies of Cheshire.* National Museums and Galleries on Merseyside. 62pp.

Gibbins, C. N. 1996. *The impact of inter-basin water transfers on the macroinvertebrate fauna of the River Wear.* PhD thesis January 1996. University of Northumbria at Newcastle.

Gower, A. M., Myers, G., Kent, M. & Foulkes, M. E. 1994. Relationships between macroinvertebrate communities and environmental variables in metal contaminated streams in south-west England. *Freshwater Biology* **32**: 199-221.

Heslop-Harrison, J. W. 1946. Notes. *Vasculum* 31: 15.
Hammond, C. O. 1983. *The dragonflies of Great Britain and Ireland*. 2nd edition (revised by R. Merritt). Harley Books, Colchester. 116pp.
Inverarity, R. & Clegg. E. 1995. Macrophyte and water quality monitoring for the Urban Waste Water Treatment Directive. *In* Gibbins, C. N. and Turnbull. D. (Eds), *Human impact on freshwater systems*, pp. 28-40. University of Northumbria.
Jarvis, A. (unpubl.). *The impact of acid mine drainage on the chemistry and invertebrate fauna of two streams in the Durham coalfield*. Unpublished MSc. thesis, University of Newcastle upon Tyne.
Jessop, L. (in preparation). *An atlas of the Odonata of Northumberland and Durham*. Northumberland Biological Research Centre, Publication No. 6.
Macan, T. T. 1970. *Biological studies of the English lakes*. Longman, London. 260pp.
Merritt, R., Moore, N. W. & Eversham, B. C. 1996. *Atlas of the dragonflies of Britain and Ireland*. ITE publication no. 9. HMSO, London. 149pp.
NRA 1994. *River Wear catchment managment plan consultation document*. NRA, Newcastle upon Tyne. 88pp.
Prendergast, N. H. D 1988. The distribution and abundance of *Calopteryx splendens* (Harris), *C. virgo* (L.) and *Platycnemis pennipes* (Pallas) on the Wey river system (Hampshire and Surrey). *Journal of the British Dragonfly Society* **4** (2): 37-44.
Younger, P. L. 1993. Possible environmental impact of the closure of two collieries in County Durham. *Journal of the Chartered Institution of Water and Environmental Management* 7: 521-540.
Younger, P. L. & Bradley, K. F. 1994. *Application of geochemical mineral exploration techniques to the cataloguing of problematic discharges from abandoned mines in North-east England*. 5th International Minewater Congress, Nottingham, UK. September, 1994.
Zahner, R. 1960. Über die Bindung der Mitteleuropäischen *Calopteryx* Arten (Odonata, Zygoptera) an den Lebensraum des strömenden Wassers. II. Der Anteil der Imagines an der Biotopbindung. *Internationale Review der gesamten Hydrobiologie und Hydrographie* 45: 101-123.

Predation of adult *Anax imperator* Leach by the Hobby (*Falco subbuteo* L.) – how frequently does this occur?

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Odonata are 'monomorphically volant', i.e. all species, like all Ephemeroptera, have the power of flight (Roff, 1994). Hence it is reasonable to expect birds to be major predators of adult dragonflies in flight. Populations of many British farmland bird species have declined, and their ranges have contracted, since the 1970s; the timing of these decreases suggests that a major cause is agricultural intensification (Fuller *et al.*, 1995). Contrary to this trend, one farmland bird species that has increased and expanded its range in the Midlands and eastern England, over the period from 1972–1991, is the Hobby (*Falco subbuteo* L.) (Gibbons *et al.*, 1993); a rapid increase has occurred in Essex since 1990 (Dennis, 1996). The Hobby is a small raptor specializing in feeding on small birds such as hirundines and large insects such as dragonflies (Newton, 1979). Some species of Odonata have also increased in Britain in recent years. The most frequently quoted example is the Migrant Hawker (*Aeshna mixta* Latreille) for which there is clear evidence of a northward extension in range since 1980 (Branson, 1990; Harding, 1991; Merritt *et al.*, 1996), but other species are involved, amongst them the Emperor Dragonfly (*Anax imperator* Leach). It has been suggested that there is a causal link between the increase in dragonflies and increased post-fledging survival in the Hobby (Clarke *et al.*, 1996; Prince & Clarke, 1993). This paper reviews what is known of the dragonfly prey of the Hobby in general, and reports on the incidence of *A. imperator* as a prey item in particular.

In Oxfordshire the Hobby has been found to occupy 8.6 per cent of the available tetrads over the period from 1985–1988 (Brucker et *al.*, 1992); an intensive study has shown a density of 3–4 pairs per 100 sq km on farmland in this part of the south Midlands (Fuller *et al.*, 1985). *A. imperator* has colonized Oxfordshire since first being recorded in 1940 and over the period from 1980–1995 it has been recorded from 11.8 per cent of the available tetrads, breeding widely on lakes and ponds down to 0.0225ha (Brownett, 1996). One such breeding site for *A. imperator* is a pond of 0.71ha situated at 100m O.D. at Lower Court Farm, Chadlington (SP323212). Excavated in 1989, it is now fringed by *Carex* spp. and *Typha latifolia* and 15 species of Odonata were recorded in 1996, including the Rare Dragonfly Project target species, the Downy Emerald (*Cordulia aenea* (L.)). At 1400h B.S.T. on 15 July a Hobby was observed to fly low over the pond, rise with an adult *A. imperator* in its talons, and fly round dropping fragments; it flew low two or three more times before it caught and ate another dragonfly and then made off in a northerly direction (U. Fenton, pers. comm.). *A. imperator* also occurs in slow-flowing riverine locations in Oxfordshire; whether it breeds in them is uncertain. In South African studies, the species occupied both lentic and lotic habitats, including reservoirs rich in sedges (Cyperaceae), but showed a significant positive correlation with flowing water (Clark & Samways, 1996; Samways & Steytler, 1996; Steytler & Samways, 1995). Even if breeding were confined to lakes and ponds in Oxfordshire, *A. imperator* must come within range of most Hobbies.

Insect-feeding in birds may be studied in a variety of ways, from field observations to pellet analysis (Miles, 1952). There has been a number of previous studies of the ecology of the Hobby in both summer quarters (Fiuczynski, 1978, 1987; Fiuczynski & Nethersole-Thompson, 1980; Milsom, 1987; Parr, 1985; Schuyl *et al.*, 1936) and winter quarters (Pepler, 1993), but these were concerned – insofar as they are relevant to odonatology – with insect-hunting activity and not with the dragonfly composition of the diet. The sum of anecdotal evidence (Table 1) shows that the Hobby targets Anisoptera species with a range of wet weights upwards of *c.* 200mg, and takes both emergents and mature adults; there is no record of any Zygoptera being taken,.presumably being precluded by the operation of prey-size selection. Feeding rates are clearly related to prey density: the records of feeding on territorial males refer to a few individuals whereas those of feeding on emergents, or congregations of non-territorial individuals, involve predation of large numbers. Time and again in the literature, insect-feeding in the Hobby is related to superabundances - for instance, great numbers of the mayfly *Ephemera vulgata* L. (Ephemeroptera: Ephemeridae) in Oxfordshire, large numbers of swarming crickets *Gryllus bimaculatus* (DeGeer) (Orthoptera: Gryllidae) in South Africa, and Black-tailed Skimmers (*Orthetrum cancellatum* (L.)), emerging in thousands in Cambridgeshire (Bannerman & Lodge, 1956; Fowling, 1993; Pepler 1993). The mean date of clutch completion in the Hobby is 15 June, with a standard deviation of 5.6 days (data of Fiuczynski & Nethersole-Thompson, 1980). Assuming a normal distribution, 68 per cent of completion dates should lie between 9 and 21 June. Superimposed on this variation is an incubation period of 28-31 days, nestling period of 28-34 days, and post-fledging period of perhaps 30-40 days, so the breeding cycle of the Hobby in southern England occupies a period of three months or so from mid-June to mid/late-September; in general, insects form part of the diet at all times, with the exception of food brought to the nest by the male during the nestling period from mid-July to mid-August, when birds form the staple diet (Brown, 1976; Cramp, 1980). To what extent does *A. imperator* fit into this scenario? Are instances like that observed at Lower Court pond exceptional or commonplace?

The flight period of *A. imperator* in southern England is of four months' duration, from mid-May to mid-September. Apart from a 19th-century French record (Martin, 1892) cited by Corbet (1962), there does not seem to be any previous record of mature *A. imperator* as prey of the Hobby. In an intensive study over four seasons (1950-1953) at Fish Pond on Wokefield Common in Berkshire (SU652662, at 95m O.D.), Corbet (1957) failed to observe any predation on adult *A. imperator* which were engaged in territorial activity peaking around 1300h BST. He did observe a single instance of predation on *A. imperator* during the crepuscular feeding flight, at 21.15h on 17 July 1951, but the raptor involved was considered

Table 1. Observed dragonfly prey of the Hobby

Dragonfly prey	Source
Aeshna affinis	Martin (1892)
Aeshna grandis	Brownett (1996)
Aeshna mixta	Clarke *et al.* (1996); Piotrowski (1988); Prince & Clarke (1993)
Anaciaeschna isosceles	Martin (1892)
Anax imperator	Brownett (this study); Khan (1983); Martin (1892)
Cordulegaster boltonii	Cramp (1980)
Crocothemis erythraea	Martin (1892)
Libellula quadrimaculata	Martin (1892); Welstead & Welstead (1984)
Orthetrum cancellatum	Clarke *et al.* (1996); Fowling (1993)
Sympetrum sp.	Fiuczynski & Nethersole-Thompson (1980)
Sympetrum striolatum	Fowling (1993)

Study methods were field observations and pellet analysis. Presumed prey, i.e. insect-feeding observed where dragonflies were present in the study area, have been omitted. All observed prey items were Anisoptera; wet weights of these species range from c.200mg (*Sympetrum*) to c.1,200mg (*Anax*).

to be a Kestrel (*Falco tinnunculus* L.) and not a Hobby, though Fish Pond clearly falls within the breeding range of the Hobby (Standley *et al.*, 1996). No mention was made either of the predation of emergent *A. imperator* by the Hobby and, to the best of my knowledge, this too has been observed on only one occasion. This was at a pond in Haldon Forest in Devon, where in June 1981 a Hobby was observed to take a large number of recently emerged *A. imperator* at the time of their maiden flight (Khan, 1983).

On the face of it, the evidence presented in this paper suggests that the answer to the question posed in the title is 'not very often'. There are a number of possible reasons why this should be so.

First, there is nocturnal emergence. From counts of exuviae, the Fish Pond study showed a total season-long emergence of 1,951-4,368 *A. imperator* with 90 per cent emerging in the first ten days of the emergence period (Corbet, 1951, 1954, 1957, 1962). Potentially this represents a rich food source for Hobbies, but normally emergence is nocturnal with the maiden flight of emergents pre-sunrise, around 04.30h BST, unless upset by environmental factors when delayed or divided emergence would render individuals open to diurnal predation. Presumably this explains the observations by Khan (1983). It is hard for the observer not to take an adaptationist viewpoint and ascribe a purpose to any observed behaviour pattern (Maynard Smith, 1991a), and nocturnal emergence seems to be a predator-avoidance strategy.

Secondly, there is territorial behaviour. Moore (1964), who studied the adult male dragonfly populations of 18 ponds on the Arne Peninsula in Dorset over seven years from 1954-1960, found that the 'highest steady density' of *A. imperator* was two adult males per 100m of water's edge. The relationship between the highest steady density of territorial males of *A. imperator* and the area of a circular body of water is therefore given by:

$$\text{Number of males} = \frac{\pi}{25} \cdot \sqrt{\frac{A}{\pi}} = \sqrt{\frac{\pi \cdot A}{625}}$$

where A is the area of water in square metres. On this basis, a circular water of area 1ha is likely to have a population of seven males, one of 2ha ten males, and so forth, whilst the smallest water capable of supporting the species would be 0.02ha (in agreement with the observed value in Oxfordshire). Similarly, the rectangular-shaped waters of Fish Pond and Lower Court pond, with perimeters of 201 and 298m, would support four and six males respectively. Clearly territorial behaviour acts to impose a ceiling on the population of adults found on any water. A low steady density must be less likely to attract predators than a free-for-all. This is only one of the possible functions of territory; Moore (1957) proposed a multiplicity of functions in dragonflies.

Odonata have 'male matrix territory' systems (Gould & Gould, 1997) in which the males defend contiguous areas which the females then visit. They provide the focus for studies of the interrelated subjects of sexual selection, lifetime reproductive success and sexual dimorphism. They have received much attention in recent years. There are a number of useful monographs (Andersson, 1994; Cronin, 1991; Gould & Gould, 1997; Newton, 1989), and recent reviews (Maynard Smith, 1991b; Willson, 1990), while Sibly (1989) has supplied mathematical proof of the relationship between lifetime reproductive success and fitness. *A.*

imperator is a species that shows not only strong territorial behaviour but also marked sexual colour and size dimorphism, males being larger than females, presumably as a result of sexual selection. I do not know of any study of either lifetime reproductive success or sexual selection in this species, but there is a growing number of studies along these lines in other Odonata (e.g. Andersson, 1994; Banks & Thompson, 1987; Grether, 1996; Koenig, 1990; Moore, 1990; Waltz & Wolf, 1988). If territorial behaviour acts not only to maximize fecundity but also to minimize mortality rate for the individual territory-holder, then selection for it would be very strong.

A third possible reason for the low incidence of predation by the Hobby on *A. imperator* is simply phenological. The peak period for territorial/sexual activity in *A. imperator* coincides with the nestling period of the Hobby from mid-July to mid-August, when the diet switches from insect to bird. By the time of the post-fledging period from mid-August to mid/late-September, emphasised by Prince & Clarke (1993) as the time when dragonfly-hunting is particularly important, only the tail-end of *A. imperator*'s flight period remains.

If the above considerations apply, it follows that there should be a higher incidence of predation on Anisoptera by the Hobby: (a) where, for whatever reason, there is diurnal emergence; (b) in species that have a high steady density at breeding sites or where territorial activity is weak or absent; and (c) in species with peak populations falling either before or after the nestling period. It may be no coincidence that the species mentioned by Prince & Clarke (1993) as being particularly prone to predation by Hobbies in the post-fledging period are *Aeshna mixta* (notably non-territorial and gregarious) and the Common Darter (*Sympetrum striolatum* (Charpentier)) (occurring at relatively high density). Both Odonata such as these, and Hobbies, are reported to have increased in eastern England. Whether this is due to the provision of more dragonfly habitat (Prince & Clarke, 1993) or to global warming (Burton, 1995) is open to conjecture. Prince & Clarke (1993) have argued that a population increase of the Hobby is due to population increase of dragonflies and that this in turn is due to the increased availability of suitable dragonfly habitat such as gravel pits. Is this not a *post hoc ergo propter hoc* scenario? Could it not be that increased numbers of Hobbies and increased numbers of Anisoptera, increasing for different reasons, have come into contact more frequently, resulting in increased predation? The answer to these questions awaits a comprehensive study of the Hobby's diet and, I think, a lot more work needs to be done before the causal link suggested by Prince & Clarke (1993) can be accepted.

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References

Andersson, M. 1994. *Sexual selection*. Princeton University Press, Princeton. 599pp.

Banks, M. J. & Thompson, D. J. 1987. Lifetime reproductive success of females of the damselfly *Coenagrion puella*. *Journal of Animal Ecology* **56**: 815–832.

Bannerman, D. A. & Lodge, G. E. 1956. *The birds of the British Isles.* Volume 5. Oliver & Boyd, Edinburgh. 350pp.

Branson, A. 1990. The Biological Records Centre - 25 years of recording. *British Wildlife* **1**: 197-201.

Brown, L. 1976. *British birds of prey.* Collins, London. 400pp.

Brownett, A. 1996. *The dragonflies of Oxfordshire.* Brookside Books, Banbury. 60pp.

Brucker, J. W., Gosler, A. G. & Heryet, A. R. 1992. *Birds of Oxfordshire.* Pisces Publications, Newbury. 284pp.

Burton, J. F. 1995. *Birds and climate change.* Helm, London. 376pp.

Clark, T. E. & Samways, M. J. 1996. Dragonflies (Odonata) as indicators of biotope quality in the Kruger National Park, South Africa. *Journal of Applied Ecology* **33**: 1001-1012.

Clarke, A., Prince, P. A. & Clarke, R. 1996. The energy content of dragonflies (Odonata) in relation to predation by falcons. *Bird Study* **43**: 300-304.

Corbet, P. S. 1951. The emergence and sex ratio of *Anax imperator* Leach (Odon., Aeshnidae). *Entomologist's Monthly Magazine* **87**: 176-179.

Corbet, P. S. 1954. Seasonal regulation in British dragonflies. *Nature* **174**: 655.

Corbet, P. S. 1957. The life-history of the Emperor Dragonfly *Anax imperator* Leach (Odonata: Aeshnidae). *Journal of Animal Ecology* **26**: 1-69.

Corbet, P. S. 1962. *A biology of dragonflies.* Witherby, London. 247pp.

Cramp, S. (Ed.) 1980. *Handbook of the birds of Europe, the Middle East and North Africa.* Volume 2. Oxford University Press, Oxford. 695pp.

Cronin, H. 1991. *The ant and the peacock.* Cambridge University Press, Cambridge. 490pp.

Dennis, M. K. 1996. *Tetrad atlas of the breeding birds of Essex.* The Essex Birdwatching Society, Colchester. 312pp.

Fiuczynski, D. 1978. Zur Populationsökologie des Baumfalken (*Falco subbuteo* L., 1758). *Zoologische Jahrbücher Abteilung für Systematik, Ökologie und Geographie der Tiere* **105**: 193-257.

Fiuczynski, D. 1987. *Der Baumfalke.* Ziemsen, Wittenburg. 208 pp.

Fiuczynski, D. & Nethersole-Thompson, D. 1980. Hobby studies in England and Germany. *British Birds* **73**: 275-295.

Fowling, R. J. 1993. Systematic list Cambs.: Honey Buzzard to Crane. *Cambridgeshire Bird Report* **1992**: 28-29.

Fuller, R. J., Baker, J. K., Morgan, R. A., Scroggs, R. & Wright, M. 1985. Breeding populations of the Hobby *Falco subbuteo* on farmland in the southern Midlands of England. *Ibis* **127**: 510-516.

Fuller, R. J., Gregory, R. D., Gibbons, D. W., Marchant, J. H., Wilson, J. D., Baillie, S. R. & Carter, N. 1995. Population declines and range contractions among lowland farmland birds in Britain. *Conservation Biology* **9**: 1425-1441.

Gibbons, D. W., Reid, J. B. & Chapman, R. A. 1993. *The new atlas of breeding birds in Britain and Ireland:. 1988-1991.* Poyser, London. 520 pp.

Gould, J. L. & Gould, C. G. 1997. *Sexual selection.* 2nd edition. Scientific American Library, New York. 277 pp.

Grether, G. F. 1996. Intrasexual competition alone favours a sexually dimorphic ornament in the Rubyspot Damselfly *Hetaerina americana*. *Evolution* **50**: 1949–1957.

Harding, P. T. 1991. National species distribution surveys. In *Monitoring for conservation and ecology*. Ed. F. B. Goldsmith. Chapman & Hall, London. 275 pp. (pp. 133–154).

Khan, R. J. 1983. Observations of Wood-mice (*Apodemus sylvaticus*) and Hobby (*Falco subbuteo*) feeding on dragonflies. *Journal of the British Dragonfly Society* **1**: 15.

Koenig, W. D. 1990. Territory size and duration in the White-tailed Skimmer *Plathemis lydia* (Odonata: Libellulidae). *Journal of Animal Ecology* **59**: 317–333.

Martin, R. 1892. Bulletin des séances et bulletin bibliographique: séance du 25 novembre 1891 communications. *Annales de la Société entomologique de France* **60**: 169–171.

Maynard Smith, J. 1991a. Dinosaur dilemmas. *The New York Review of Books* **38**: 5–7.

Maynard Smith, J. 1991b. Theories of sexual selection. *Trends in Ecology and Evolution* **6**: 146–151.

Merritt, R., Moore, N. W. & Eversham, B. C. 1996. *Atlas of the dragonflies of Britain and Ireland*. Her Majesty's Stationery Office, London. 149 pp.

Miles, P. M. 1952. The entomology of bird pellets. *Amateur Entomologists' Society Leaflet* **24**: 1–8.

Milsom, T. P. 1987. Aerial insect-hunting by Hobbies *Falco subbuteo* in relation to weather. *Bird Study* **34**: 179–184.

Moore, A. J. 1990. The evolution of sexual dimorphism by sexual selection: the separate effects of intrasexual selection and intersexual selection. *Evolution* **44**: 315–331.

Moore, N. W. 1957. Territory in dragonflies and birds. *Bird Study* **4**: 125–130.

Moore, N. W. 1964. Intra- and interspecific competition among dragonflies (Odonata). *Journal of Animal Ecology* **33**: 49–71.

Newton, I. 1979. *Population ecology of raptors*. Poyser, Berkhamsted. 399 pp.

Newton, I. (Ed.) 1989. *Lifetime reproduction in birds*. Academic Press, London. 479 pp.

Parr, S. J. 1985. The breeding ecology and diet of the Hobby *Falco subbuteo* in southern England. *Ibis* **127**: 60–73.

Pepler, D. 1993. Diet and hunting behaviour of the European Hobby (*Falco subbuteo*) in Africa. In *Biology and conservation of small falcons*. Eds. M. K. Nicholls & R. Clarke. The Hawk and Owl Trust, London. 250 pp. (pp. 163–170).

Piotrowski, S. H. 1988. Hobby taking Migrant Hawker dragonflies. *Transactions of the Suffolk Naturalists' Society* **24**: 7–8.

Prince, P. & Clarke, R. 1993. The Hobby's breeding range in Britain – what factors have allowed it to expand? *British Wildlife* **4**: 341–346.

Roff, D. A. 1994. The evolution of flightlessness: is history important? *Evolutionary Ecology* **8**: 639–657.

Samways, M. J. & Steytler, N. S. 1996. Dragonfly (Odonata) distribution patterns in urban and forest landscapes, and recommendations for riparian management. *Biological Conservation* **78**: 279–288.

Schuyl, G., Tinbergen, L. & Tinbergen, N. 1936. Ethologische Beobachtungen am Baumfalken (*Falco s. subbuteo* L.). *Journal für Ornithologie* **84**: 387–433.

Sibly, R. M. 1989. What evolution maximizes. *Functional Ecology* **3**: 129–135.

Standley, P., Bucknell, N. J., Swash, A. & Collins, I. D. 1996. *The birds of Berkshire.* The Berkshire Atlas Group, Reading. 388 pp.

Steytler, N. S. & Samways, M. J. 1995. Biotope selection by adult male dragonflies (Odonata) at an artificial lake created for insect conservation in South Africa. *Biological Conservation* **72**: 381-386.

Waltz, E. C. & Wolf, L. L. 1988. Alternative mating tactics in male White-faced Dragonflies (*Leucorrhinia intacta*): plasticity of tactical options and consequences for reproductive success. *Evolutionary Ecology* **2**: 205-231.

Welstead, N. & Welstead, T. 1984. *The dragonflies of the New Forest.* New Forest Odonata Study Group for Hampshire & Isle of Wight Naturalists' Trust, Romsey. 41 pp.

Willson, M. F. 1990. Sexual selection in plants and animals. *Trends in Ecology and Evolution* **5**: 210-214.

Migrant and dispersive dragonflies in Britain during 1997

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Introduction

Until the major insect immigrations of 1995 and 1996, the recording of dragonfly migration had received relatively little attention in recent years. Although 1997 was by-and-large a fairly average year for insect migrants, the increased attention being paid by naturalists both to dragonflies in general, and to migration in particular, was amply rewarded. Important information was thereby gained in relation to the influxes of dragonfly species which also have resident populations in Britain, and as well as to the arrival of scarcer species to our shores. This article summarizes the information received by the Migrant Dragonfly Project during 1997; for a report of events in 1996, see Parr (1997b).

Aeshna mixta Latreille – Migrant Hawker

1997 – *A. mixta* had a very good year in 1997, appearing in unprecedented numbers in several locations, and reaching as far north as Cleveland. The species is currently expanding its breeding range in Britain and it is often difficult to identify the presence of migrants, but 1997 would appear to have seen significant immigration. The precise origins of individuals seen at the limits of the species' range remain largely uncertain, but several east coast sites reported periods when the species was unexpectedly abundant; the following is a selection of records where the sudden appearance of locally notable numbers might suggest a migratory origin: 200 at East Hills, Wells, Norfolk, on 16 August (JMcC), 500 at Wisbin Pit, Lincolnshire, on 10 September (via PHi); and 80 at Filey, Yorkshire, on 2 October (PM). One was attracted to a UV moth trap at Holkham on the night of 31 August (MTu). Several Migrant Hawkers were also reported during October 1997 from the Scilly Isles, an area apparently without a resident breeding population (BM).

Aeshna isosceles (Müller) – Norfolk Hawker

1997 – One was seen and photographed at Messingham sand quarry, Lincolnshire, on the unusually late date of 28 August 1997 (JD). This record is some way away from known breeding sites, and must represent either a migrant or an accidental introduction. There is one previous record from Landguard Point, Suffolk, on 1 August 1991 (Parr, 1996) which shows some similarities. Perhaps very mature individuals show an enhanced tendency to wander. The Landguard record came from a period when meteorological conditions were favourable for immigration, and this wandering may thus possibly include the occasional arrival of dragonflies of continental origin.

Anax parthenope (Sélys) – Lesser Emperor

1997 – Following the first British record in 1996 (Phillips, 1997), single males were found near Perranporth, W. Cornwall, on 25 May 1997 (SJ) and near Cambridge during late July (Thomas, 1997). The Cornish individual appeared only briefly in an area of stabilized coastal dunes, and was presumably still on active migration. The Cambridge individual took up territory, and remained in the area for at least nine days. As yet no females have been reported from Britain.

Libellula depressa L. – Broad-bodied Chaser

1997 – In the first few days of May there were records from unexpected localities, including suburban gardens, on the coasts of Dorset and Kent. Some were accompanied by immigrant Lepidoptera such as *Vanessa atalanta* (Red Admiral). This raises the possibility of a small immigration at this time, but no definitive information is available.

Libellula quadrimaculata L. – Four-spotted Chaser

1997 – Little of note was reported. One was seen together with a single male *Sympetrum flaveolum* (L.) (Yellow-winged Darter) at a remote spot on the coast near Wells, Norfolk, on 16 August (JMcC).

Orthetrum cancellatum (L.) – Black-tailed Skimmer

1997 – This species continued its range expansion within England, with records from many new sites. Most probably arose as a result of relatively local scale dispersion. A male at Tatton Park, Cheshire on 17 August (BR) – apparently only the third county record – however appeared concurrently with a group of *Aeshna mixta* and unusual numbers of *Sympetrum sanguineum* and *S. danae* (Ruddy and Black Darters). The simultaneous appearance of so many locally noteworthy species rather suggests a migratory event, though given the westerly location of the site, the individuals involved were perhaps of British rather than Continental origin.

Crocothemis erythraea (Brullé) – Scarlet Darter

1997 – The first British record of this species was from Cornwall in August 1995 (Jones, 1996). During 1997 a single male was photographed near Lake, Isle of Wight, on 8 September (Butler & Butler, 1998). The species is a well-known migrant, and has bred sporadically just over the English Channel (there are, for instance, recent records from Belgium), so further occurrences of this spectacular species seem highly likely.

Sympetrum striolatum (Charpentier) – Common Darter

1997 – A number of records from coastal UV moth traps during August, e.g. one at Cley, Norfolk, on 1 August (MTu) and one at Holkham, Norfolk, on 22 August (MTu), suggest a small-scale immigration during this month. Signs of small arrivals were also noted at Landguard Point, Suffolk, during 20–26 August (NO), and near Kingsgate, Kent, on 24 August (via FS). There then followed a substantial influx on the east coast over several days near the start of September. On 6 September, 800–1000 were noted at the waterless Great Yarmouth Cemetery, Norfolk (Dudley, 1998). Good numbers were present on 7 September on the Dunwich section of the Suffolk coast during a period of visible butterfly migration (AP), and a small but obvious influx was also seen at Landguard Point, Suffolk, on 7 September and for a few days afterwards (NO). Also on 7 September at least 120 flew south along Spurn Point, Yorkshire (MP, BS). Numbers present on the Spurn Peninsula were clearly augmented during the period 7–10 September, with dragonflies also being unexpectedly conspicuous in nearby villages during this period, often being seen ovipositing in garden ponds (BS). On 9 September some 2000+ *S. striolatum* were recorded at Gibraltar Point, Lincolnshire (KW), and on 10 September almost 400 (some four times the count a few days previously) were at Filey Dams, Yorkshire (PM). The majority of these Filey individuals were paired when first seen. Small numbers of other migratory Darter species, including *S. flaveolum*, were noted at many of the above-mentioned sites during the period (see below), supporting the assumption that the dragonflies were immigrants. Further smaller influxes apparently continued to occur on the East Coast into October. Over 1000 *S. striolatum* were at Heigham Holmes, Norfolk, on 17 September (MTe), though the proportion of these which were of local origin is unknown, and during routine monitoring sudden increases in numbers seen were noted at Landguard Point on 18 September and 1 October (NO), and at Filey on 6 October (PM).

Sympetrum vulgatum (L.) – Vagrant Darter

1997 – A single individual, seen at close range, was reported from Wombourne, West Midlands, on 15 and 17 August (AF). This suggests that the Darter influxes of late summer 1997 may have contained a small proportion of *S. vulgatum* which remained largely overlooked. Apparently only at Great Yarmouth on 6 September were the arriving *S. striolatum* checked closely, and even here, although no *S. vulgatum* were seen, only about 25 per cent of the individuals could be scrutinized (Dudley, 1998).

***Sympetrum fonscolombei* (Sélys) – Red-veined Darter**

1996 – A late report of one photographed at Beddington Sewage Farm, Surrey, on 15 June 1996 (BO) was typical of the large influx which occurred during June of that year (Parr, 1997a).

1997 – Although no wide-scale invasion was noted during 1997, the year was still very eventful. On 8 June a singleton was seen near Kingsgate, Kent (via FS), on 13 June, and on 19 June a single male was reported from Barn Elms, London (NA, GM), and during the second half of June up to two males were present at Filey Dams, Yorkshire (PM). This suggests a spring influx resembling that of 1996, but on a much smaller scale. Late May and early June also saw *S. fonscolombei* reported from three sites in Cornwall, though, as the first of these were seen before weather conditions normally associated with their near-annual appearance in this region had arrived (SJ), it is perhaps possible that locally-bred individuals as well as immigrants were involved. July saw further records from several sites in Cornwall (SJ, GT, MTu) and a group of up to six males and one female was present for 12 days at a pond on Spurn Point, Yorkshire (MP, BS). Ovipositing *S. fonscolombei* were observed at this very same pond during 1996, so it is possible that these Spurn individuals were British-bred, though the dragonflies seem to have been relatively mature when first noted. Also in July, a singleton was seen briefly near Christchurch, Dorset, on 18 July (KG). Despite breeding in the county during 1996 (Parr, 1997a,b) this was the only confirmed 1997 record from Dorset, but the main 1996 breeding site was visited only infrequently, and had dried up by late summer. August was quite a dramatic month, with Cornwall returning to the centre of attention, though a single was present at Barn Elms, London, on 17 August (NA). In east Cornwall a site was discovered which held large numbers of mature adults, the count peaking at 45 males on 19 August (RBe, LT). In the southwest of the county, emergences of British-bred individuals resulting from spring ovipositing began to be noticed, with the first tenerals seen on 16 August (SJ). On 10 September a male was recorded from the southern tip of Glamorgan (JP), and records of tenerals continued from Cornwall during autumn, with breeding being proved in at least two sites. The year ended on 1 November, with a single teneral seen at the main Cornish breeding site (SJ).

Breeding of *S. fonscolombei* has now been recorded from Britain in two successive years, with substantial autumn emergences being observed following spring oviposition. The spread in emergence dates at the main Cornish breeding site shows a great variation in larval development rates. Also of note is the fact that at this well-watched site, almost all individuals observed in autumn were teneral. No sexually mature individuals were seen, and emerging adults clearly dispersed away from the area permanently. It is possible that a record from near Porthgwarra, Cornwall, on 14 September (JP), and maybe also the Welsh record, could have related to dispersing British individuals. The fate of the Cornish breeding colonies will be monitored with interest in 1998.

***Sympetrum flaveolum* (L.) – Yellow-winged Darter**

1996 – There was a late .report of one or two teneral individuals at Rutland Water on 7 July 1996 (SS).

1997 – Although no very major influx took place, a scattering of records from the East Coast throughout much of August and early September, usually of singletons, indicated that a light but probably protracted immigration did occur. Most records were from the north Norfolk coast, but this might reflect the distribution of recorders at this time as much as the distribution of arrivals. Records from further afield include one or two from Spurn Point, Yorkshire, on three days during August, plus one on 7 September (MP, BS *et al.*), and two at Gibraltar Point, Lincolnshire, on 13 August (KW). A 'probable' was seen at Spey Bay Nature Reserve, Grampian, on 26 September (via ES), but unfortunately this interesting record could not be confirmed.

Although no *definite* emergences from breeding sites established following the big 1995 influx were reported, it seems highly probable that they did in fact occur. At four out of five sites in the Norfolks Broads where breeding was proved/presumed in 1995 and 1996, *S. flaveolum* was again present, with some counts in double figures (PHe). At the breeding site in the Norfolk Brecks the species was also noted once more (AP). These records are thought not to refer to fresh immigrants, since no inland records away from these established breeding sites were reported from Norfolk during 1997. It would seem that the East Anglian breeding population may be holding its own. Away from East Anglia, the other main recent breeding area forms a strip through the West Midlands (Parr, 1997b). Here again *S. flaveolum* was noted in 1997, at a total of four sites in Worcestershire, West Midlands and Staffordshire (MA, TB *et al.*). Numbers of individuals seen in this area were however very low – the maximum count being three. Interestingly at some sites the species reappeared after an apparent absence in 1996. Perhaps some individuals were missed in that year. An alternative explanation could be that the life cycle may take two years, rather than one, in some instances. Maybe even eggs laid in drier areas that did not become flooded in 1996 might have survived for another year before hatching in the wetter spring of 1997.

In addition to the records summarized above, reports were also received of small numbers of *S. flaveolum* in Kent. Some, such as three seen with unusual concentrations of *A. mixta* and *S. striolatum* in the Kingsgate area on 24 August (via FS) were probably immigrants. Others, however, could well have been locally bred, for example two different individuals seen inland at Egerton, near Ashford, on 14 and 20 August (SK). Further searches for breeding sites in Kent may well turn up interesting results.

Sympetrum sanguineum (Müller) – Ruddy Darter

1997 – There were relatively few records of this species during 1997 which could clearly be ascribed to migrants, though small numbers apparently accompanied the influxes of other *Sympetrum* species which occurred in late summer. Three were caught at UV light at Holkham, Norfolk, on 22 August (MTu), and one arrived at Spurn Point on 7 September (BS) along with other immigrant species. Two were seen on 2 September near Seal Sands, Cleveland (via PHi), a site which is unusually far north.

Sympetrum danae (Sulzer) – Black Darter

1997 – The August and early September influxes of various *Sympetrum* species noted on the east coast included a few *S. danae*. Most records were of one or two seen for one day only, at sites such as Sandwich Bay (SW), the Norfolk Broads and nearby coast, and Spurn Point

(RBo). Four were present at Gibraltar Point on 10 September (KW). At Filey, two males arrived on 2 September and up to two males and one or more females were present during the following fortnight; a further record of a single male on 6 October probably represented a fresh arrival, since numbers of *S. striolatum* also increased on this day (PM). Several *S. danae* were also seen at unexpected localities to the west of the country during 1997, including at least two sites in Worcestershire (MA), a county in which the species is relatively unusual. It is still not completely clear whether these more westerly individuals were associated with the Darter influxes, or were simply individuals from the British population showing enhanced mobility.

Discussion

Numerous observations relating to the immigration of species which also have a resident population were received in 1997. This is helping in the understanding of the extent to which population levels of these species are influenced by events outside Britain. By virtue of the difficulties inherent in detecting the phenomenon, the extent of such immigration must, however, surely still be underestimated. One of the major discoveries of the year was an invasion of *Sympetrum striolatum* (Common Darter) on the east coast during early September. August/September also saw minor arrivals of many other *Sympetrum* species, including *S. danae* (Black Darter). As for the less common species, large numbers of *S. fonscolombei* (Red-veined Darter) were reported from Cornwall during 1997, with autumn emergences of locally-bred individuals being noted from at least two sites. This is the second year in a row that the species has been proved breeding in Britain, though in different regions. Two species previously reported from Britain on only a single occasion, i.e. *Anax parthenope* (Lesser Emperor) and *Crocothemis erythraea* (Scarlet Darter), were recorded again in 1997. This may simply reflect increased observer numbers and awareness, but several dragonfly species do currently seem to be expanding their ranges northwards.

Acknowledgements

I would like to thank all those individuals who submitted records; their efforts are starting to produce major advances in our knowledge of dragonfly movements. The following individuals and groups have been identified in the text by appropriate initials: N. Anderson (NA); M. Averill (MA); R. M. Belringer (RBe); T. G. Beynon (TB); R. Bolton (RBo); J. Davidson (JD); A. Ferguson (AF), K. Goodyear (KG); P. Heath (PHe); P. Hill (PHi); S. P. Jones (SJ); S. A. Kirk (SK); J. McCallum (JMcC); G. Martin (GM); B. Milne (BM); P. Mountain (PM); N. Odin (NO); Beddington S. F. Ornithological Group (BO); A. J. Parr (AP); N. J. Phillips (JP); M. Pilsworth (MP); B. Roberts (BR); B. Shaw (BS); E. M. Smith (ES); F. Solly (FS); S. Spalding (SS); M. Telfer (MTe); G. H. Thomas (GT); L. A. C. Truscott (LT); M. Tunmore (MTu); S. R. Warry (SW); K. Wilson (KW).

References

Butler, A. & Butler, E. 1998. Scarlet Darter *Crocothemis erythraea* (Brullé) on the Isle of Wight - the second British record. *Atropos* **4**: 13-14.

Dudley, S. 1998. Large numbers of Common Darter *Sympetrum striolatum* in Great Yarmouth Cemetery, Norfolk. *Atropos* **4**: 37.

Jones, S. P. 1996. The first British record of the Scarlet Dragonfly *Crocothemis erythraea* (Brullé). *Journal of the British Dragonfly Society* **12**(1): 11-12.

Parr, A. J. 1996. Dragonfly movement and migration in Britain and Ireland. *Journal of the British Dragonfly Society* **12**(2): 33-50.

Parr, A. J. 1997a. The 1996 Red-veined Darter *Sympetrum fonscolombei* (Sélys) influx into Britain. *Atropos* **2**: 44-46.

Parr, A. J. 1997b. Migrant and dispersive dragonflies in Britain during 1996. *Journal of the British Dragonfly Society* **13**(2): 41-48.

Phillips, J. 1997. Lesser Emperor Dragonfly *Anax parthenope* (Sélys) in Gloucestershire; the first British record. *Journal of the British Dragonfly Society* **13**(1): 22-24.

Thomas, R. 1997. Lesser Emperor Dragonfly *Anax parthenope* (Sélys) in Cambridgeshire. The third British record. *Atropos* **3**: 55-56.

Breeding of the Southern Hawker *Aeshna cyanea* (Müller) in rock pools

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During an entomological meeting on the Island of Mull, a 5.5mm long *Aeshna* larva was collected by Garth Foster, a coleopterist, from a rock pool. It was obviously not *A. juncea* (L.). On the following day, 29 June 1997, the pool at the south-east corner of the island was visited by EMS and RWJS. The pool was about 3 x 2m in extent and 30cm deep. It was on bare rock some 5m beyond the tide mark of the adjoining Firth of Lorne and protected only by a narrow 60cm high rock barrier, perhaps one metre higher than the highest tides. The only aquatic vegetation was a tiny patch of sedge at the edge of the pool and there was a substrate detritus of rotting seaweed on the rock base. Dragging the pond-net lightly over the top of the detritus produced four more larvae similar to the first, between 4.5 and 5mm long. They proved to be *A. cyanea*. Four *Pyrrhosoma nymphula* (Sulzer) larvae of around 7mm were also caught.

Further along the shore and within 300m were two similar pools although rather less exposed to the high-tide splash zone. One was 4 x 3m and 40cm deep with some overhanging *Myrica gale* and a very few emergent *Juncus* spp. The substrate was of muddy detritus on a rock base. Six *A. cyanea* larvae were found including two final instar, one larva at 19mm and three at 5-7mm. One *P. nymphula* larva, a few newt tadpoles and a snail were also noted. The third pool was about 2.0 x 1.5m and 30cm deep with no emergent vegetation, a little *M. gale* at one edge and a little detritus on the rocky floor. This produced a 15mm *A. cyanea* larva during a hasty inspection in limited time.

On 11 September 1996, PMB saw two male *A. cyanea* in the area of Cour Bay on the east coast of the Mull of Kintyre opposite Arran and some 40 miles south of the site on Mull. One male was flying over a small burn with damp runnels but no standing water. The other was flying over coastal brackish pools which looked completely unsuitable for any odonate breeding. After hearing of the Mull record PMB returned to the area on 26 August 1997. One rock pool just beyond the splash zone had, on the first visit, a triangular surface area 2.5 x 2.5m but this was reduced by drought to 1.5m x 30cm and 15cm deep. There had been a small inflow runnel but this was completely dry. There was no aquatic vegetation but twelve *A. cyanea* larvae were found, all clinging to the underside of stones just like stone-fly larvae. These varied in size, one measuring 30mm long, the remainder between 15 and 22mm. The adjacent pools held no larvae and were probably too saline, but another pool 100m to the north held three final instar *A. cyanea* larvae. This pool was in a similar situation but protected from the sea by a rocky barrier. It was 2 x 2m, 30cm deep and edged with *Glyceria fluitans*.

On 17 September 1997 PMB investigated a similar area of coastline 8km to the north, just south of Claonaig, and about one km in length. Six pools, all with very high water levels, varied in area from 1.0 x 1.5m to 1 x 8m, and in depth from 50cm to 1m. All contained either larvae or exuviae of *A. cyanea*. Some were just beyond the splash zone, 7-20m in from the sea. Two pools were in bare rock with no vegetation, and as well as *A. cyanea*, one of them had an *A. juncea* exuviae. The others were bog-pools with sparse *Eleocharis palustris* or *Potamogeton polygonifolius*, or had a surround of *M. gale*. Six *A. cyanea* larvae were found, ranging between 12-24mm in size and there were two exuviae. Larvae of *Sympetrum striolatum* (Charpentier), *Aeshna juncea*, *Enallagma cyathigerum* (Charpentier) and *P. nymphula* were also present in some of the vegetated pools. Three male *A. cyanea* were patrolling the area, visiting all of the pools. A female *A. cyanea* was egg-laying at a seventh pool 2m x 50cm and 70cm deep with no vegetation. It was ovipositing into mud and crumbly rock, and into the detritus in cracks between rocks, some 2-10cm above the water surface. No male was present at the time.

Interesting aspects of these records are the small size and depth of the pools and the proximity to the coast. There are no suitable waters further inland. The pools nearest to the sea have protecting low, rock walls which will keep out most of the salt water during gales. All sites are on east-facing coasts with a not-too-distant opposite shore line which will limit the force of onshore waves. Some of the pools have little or no vegetation and only *A. cyanea* and, to a lesser extent, *P. nymphula* and *A. juncea* have been recorded in these. The others, with more vegetation, had up to five odonate species present as larvae. All other known breeding sites of *A. cyanea* in Scotland are in inland fresh waters, albeit never far from the coast.

These records extend the known distribution of *A. cyanea* on the west coast of Scotland. The finding of breeding populations in this hitherto unsuspected type of odonate site will surely result in further records, leading to a better understanding of the distribution in Scotland of *A. cyanea*.

A Hertfordshire record of the Small Red Damselfly *Ceriagrion tenellum* (Villers)

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The only record of this species for Hertfordshire refers to a male and three females seen by the writer on the east side of the River Beane near Stapleford on 19 July 1959 (Lloyd, 1961). In a recent useful review of the Odonata of Hertfordshire, Gladwin (1997) states that the record was published without comment, and that 'None were captured and thus examined, and no detailed description was provided.' Since these comments are incorrect and the record is of historical interest, it is desirable that the true facts be placed on record in the national journal.

The insects were observed on a marshy section of a grazing pasture immediately adjacent to the river. The vegetation included Square-stalked St. John's-wort *Hypericum tetrapterum*, Water Mint *Mentha aquatica*, and *Juncus* species. The male and a female *in copula* were resting on this vegetation and were observed at a range of approximately 30 centimetres. During the period 1956-1972, I was engaged in extensive fieldwork on dragonflies in Wales, and was thus very familiar with both this species and the Large Red Damselfly *Pyrrhosoma nymphula* (Sulzer) the only species with which the former could be confused. Nevertheless, some brief notes were made as a matter of routine. The record was published without comment by Lloyd (1961) since neither of us realised at the time that this was the first record of the species for Hertfordshire. I sent a reprint of the 1959 county dragonfly report to the late Miss Cynthia Longfield at the British Museum (Natural History), and it was she who then pointed out to me that this was the first Hertfordshire record. On a subsequent visit to London I showed her my brief field notes and she confirmed the identification. The fact that this was the first county record was pointed out in the county dragonfly report for 1960 by Lloyd (1962).

In habitat terms the record is unusual in that this species normally breeds in acid pools. However, it is known to occur in ponds, marshes and sometimes slowly flowing ditches on the Continent, and in Britain has been recorded at a few calcareous sites in Norfolk, Oxfordshire and Wales.

References

Gladwin, T. W. 1997. A review of the species of Dragonflies (Odonata) recorded as having been observed in Hertfordshire. *Transactions of the Hertfordshire Natural History Society*. **33**: 56–61.

Lloyd, S. 1961. Report on Dragonflies observed in Hertfordshire in 1959. *Ibid* **25**: 164–166.

Lloyd, S. 1962. Report on Dragonflies observed in Hertfordshire in 1960. *Ibid* **25**: 197–199.

Leucorrhinia dubia (Vander Linden) at Chartley Moss NNR, Staffordshire, in 1997: a postscript

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Unlike the previous three years, (Beynon, 1995, 1997a, 1997b), no thorough study of the White-faced Dragonfly (*Leucorrhinia dubia* (Vander Linden)), was done. In retrospect this was a pity as 1997 was again a very different season from earlier years as far as weather was concerned. Compared with 1994/5/6, only 22 visits were made during the flight period between 1 May and 8 August, although time spent at the pool was about 60 hours. Only 724 emergers were estimated, roughly half the usual annual population.

Emergence began on 1 May - a day earlier than the previous earliest date, recorded by Bailey (1992) who suspected that 2 May 1990 might 'be the earliest record for *L. dubia* in Britain'. Between 6 and 15 May 1997 there were cold days, often with heavy rain and/or hail, odd frosts at night, and even snow on two days. Probably all the early emergers died, and few if any emerged in this period. Emergence restarted on 15 May. Fair numbers emerged in good weather over the next ten days, and this emergence continued steadily up to 21 June, with a few poor days (9–15 June) due to the weather. An extraordinarily wet period then set in. Perhaps 15 to 20 emerged intermittently on the occasional reasonable day after this date, but it is likely that normal emergence ended on 21 June; and at the very latest 30 June. This is nearly three weeks earlier than usual, almost certainly due to the weather. However, one of three seen on 24 September was not more than a week old, producing an unprecedented latest emergence date of about 17 September.

Actual and estimated daily totals counted between 1 May to 21 July were:
2, 20, 33, 8, 2, 0, 0, 0, 0, 0, 0, 2, 3, 0, 0, 5, 10, 33, 46, 34, 0, 0, 0, 20, 40, 5, 2
0, 20, 20, 20, 20; 20, 20, 20, 20, 20, 20 ,20, 20, 20, 20, 20, 10, 10, 2, 2, 20, 2
0, 20, 20, 10, 0, 0, 0, 0, 0, 0, 0, (?5, ?5, ?5) = 724.

This figure is a minimum. Given the fewer visits it is possible that another 100–200 emerged. What is indisputable is the heavy loss caused by the poor weather. The size of the 1999 population will be interesting.

The first mature adults were seen on 20 May. None were in evidence on the previous two days. These could have been survivors from the first emergence, whose maturation was delayed by poor weather, as has happened before. More likely they were rapid maturers in the very good weather at the start of the second emergence period. The most seen were c.200 on 9 June, together with 40+ Four-spotted Chasers (*Libellula quadrimaculata* L.), with much copulation and ovipositing from both species. Poor and wet weather then set in. No adults were seen on 14 June, although there were a few pre-maidens and cripples from the previous day. In slightly better weather the next day the survivors maidened, and 4 adults were found sitting it out in the surrounding vegetation. There were 30–40 on 8 July, c.15 on 23 July, and none on 8 August. On 20 September, a party of botanists with the site manager reported seeing a 'white-faced dragonfly' near Wood Pool. Given the date, he was somewhat sceptical of the record until I telephoned him to say that a colleague and I had seen three on 24 September: a male at Wood Pool, and a male and a female on the path opposite Log Pool. The female was no more than a week old and she spent some time perched on my arm. These are unprecedented dates. However, I have traced another late 1997 record from Black Lake, Delamere Forest, Cheshire, where the Honorary Reserve Manager Joan Fairhurst saw one on 4 October (Paul Hill, pers. comm.). The age of the Chartley female indicates an extremely delayed and aberrant emergence almost certainly caused by the weather. (Like other semi-voltine spring species, some precocious individuals will take one year from egg to adult, but these will appear in the spring after diapause in the final instar).

The first copulating pairs seen were two on 25 May, when there were about 20 adults about, although windy conditions depressed activity. On 31 May copulating pairs were coming off at 2 per minute around 1300h and there were probably 80 or so adults about. The last copulating pairs seen were two on 23 July.

Ovipositing was first seen on 4 June when there were many adults about and lots of copulating pairs coming off. As in earlier years, it is likely oviposition occurred earlier, as females can be very secretive. On this day when the shade temperature was 21°C, the water temperatures were 28°C at the surface, and 25°C at a depth of 5cm. Semi-submerged *Sphagnum* clearly acts as a heat-sink. This phenomenon must aid the development of larvae. Also two male/male/female triples were seen at 1515h and 1525h, both in the NW corner. I have only ever seen one before. No predation by *Pardosa amenata* (Clerck) was seen, nor any by ants, *Drosera*, aeshnids or birds. *Araneus diadematus* Clerck caught numbers as usual in their webs, these being mainly copulating pairs. *Tetragnatha striata* L. Koch extracted emergers from their cases as before.

References

Bailey, M. P. 1992. The White-faced Dragonfly *Leucorrhinia dubia* (Vander Linden) at Chartley Moss National Nature Reserve, Staffordshire. *Journal of the British Dragonfly Society* **8**(1): 1-3.

Beynon, T. G. 1995. *Leucorrhinia dubia* (Vander Linden) at Shooters Pool, Chartley Moss, Staffordshire, in 1994. *Journal of the British Dragonfly Society* **11**(1): 1-9.

Beynon, T. G. 1997a. *Leucorrhinia dubia* (Vander Linden) at Chartley Moss NNR, Staffordshire, in 1995. *Journal of the British Dragonfly Society* **13**(1): 4-14.

Beynon, T. G. 1997b. *Leucorrhinia dubia* (Vander Linden) at Chartley Moss NNR, Staffordshire, in 1996. *Journal of the British Dragonfly Society* **13**(2): 33-40.

Lesser Emperor Dragonfly *Anax parthenope* (Sélys) in East Cornwall in July 1998

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On 18 July 1998 at 1330h BST, I arrived at the Bake Farm Fishing Lakes, near Trerulefoot, East Cornwall, to look for dragonflies, especially Red-veined Darter (*Sympetrum fonscolombei* (Sélys)), a large number of which had been seen at this site in 1997. The first dragonfly I encountered in fact was a male *S. fonscolombei*! However, as I approached the second lake, I noticed what I first thought were three Emperor Dragonflies (*Anax imperator* Leach), but one of them looked decidedly different from the other two. In size and shape it was very similar to *A. imperator*, perhaps slightly smaller and more slender, but the most obvious feature was its overall dark brown appearance with the blue segments at the base of the abdomen shining out almost like a blue light. I thought: 'That's a Lesser Emperor'. Although I had seen Vagrant Emperor (*Hemianax ephippiger* (Burmeister)) before, I had never seen *A. parthenope* (Sélys), but having recently perused Richard Lewington's illustration in Brooks (1997) and Steven Jones' 1997 photograph (Jones 1998), I was in no doubt as to the insect's identity as *A. parthenope*, the extent of the blue abdominal segments being the clincher. Unfortunately, this individual was extremely active and never once settled for close examination, but it did pass quite close to me on several occasions during the next hour. Its movements and behaviour were similar to those of *A. imperator*: hawking, patrolling and clashing with the other Emperors over the lake. At least six *S. fonscolombei* were also present during this visit, including a pair in tandem and ovipositing on another lake.

I contacted Rod Belringer later the same afteroon and we returned at about 1730h just as the sky clouded over and all the dragonflies disappeared! We decided to wait and were rewarded when, as the sky cleared again, the first dragonfly to re-appear was *A. parthenope*.

The following day it was seen intermittently from 1100h onwards by eight observers and was present until at least 25 July.

References

Brooks, S. 1997. *Field guide to the dragonflies and damselflies of Great Britain and Ireland.* British Wildlife Publishing. 160pp.

Jones, S. P. 1998. *Cornwall Dragonfly Group Newsletter, May 1998.*

Book Review

Field Guide to the Dragonflies and Damselflies of Great Britain and Ireland
British Wildlife Publishing, Hampshire RG27 9BG (1997) 160pp. £18.95 (softback)
Steve Brooks (Editor); illustrated by Richard Lewington ISBN 0 9531399 0 5

As befits the title 'Field Guide', this book will fit into a good-sized pocket, and roughly two-thirds of its 160 pages are devoted to identification. The book begins, however, with substantial introductory sections on the biology, distribution and habitats of dragonflies, together with twenty pages highlighting key sites throughout the country. These sections are supported by explanatory photographs and a map.

The actual identification begins with a glossary and diagrams of typical adults and larvae. Seven detailed pages follow on larval identification, the keys supported by photographs. A simple key to adult dragonflies brings the reader to the individual species' descriptions. These have been written by different specialists, each familiar with the characteristics and behaviour of the given species. The descriptions include thirteen rarities currently considered as visitors to or as extinct in Great Britain and Ireland. All the descriptions are supported by Richard Lewington's colour illustrations.

The book has colour-coded page numbers, so that, as one holds it in one's hand, it subdivides instantly into introduction, regional guides, larval identifications, adult zygopteran identification and adult anisopteran identification.

This summer at the National Dragonfly Museum, we have listened to many comments about this book. We have heard the views of seasoned dragonfly veterans and those of complete beginners. What follows is an attempt at a distillation of the collective opinion of visitors and volunteers.

This is a very good book indeed and extremely good value for money. It is a superbly practical field guide. When trying to identify adults, Richard Lewington's meticulous illustrations are a real aid; and, as one watches the real thing in action, some of the specialists' descriptions of individual species' behaviour are uncannily precise.

Steve Brooks' introduction is readable, enthusiastic, clear and neatly compressed.

The section on larval identification is very good and is very well assisted by Robert Thompson's sixteen crystal-clear photographs.

We have heard very few criticisms. Several people mentioned that it might be helpful to have been given sizes or lengths, for example as a means of differentiating between Migrant and Southern Hawkers. Perhaps also a fuller glossary? Am I alone in being ignorant of the meaning of the word 'dichotomous', which appears twice on the same page as the glossary?

The diagram (on p. 49) setting out the external features of a typical adult dragonfly is very clear, but a note beside it would be useful, referring the reader to the glossary opposite for further details. Working on Variable Damselflies in the field, and noting from Lewington's drawing that the pronotum was a useful identification feature, I spent some time puzzling over its absence from the diagram; only to find a definition of it in the glossary some weeks later.

However, this really is being hypercritical. In the opinion of many, this book is the best all-rounder so far. Indeed, it may be worth finishing with a comment overheard from a volunteer to a visitor at the Museum: 'If you buy only one book on dragonflies, this should be the one!'

R. Mackenzie-Dodds

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.

Manuscripts should be typewritten using black ribbon, double-spaced, on one side of the page only and with margins at least 25 *mm* at the left, top and bottom; text pages should be numbered. Footnotes should be avoided.

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

Use of these terms is acceptable: 'exuviae' for cast skin or skins (singular and plural); '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 typed, each on a separate, unnumbered page.

Legends for illustrations should be typed together in sequence on a single unnumbered page.

Illustrations (figures) should be prepared in black ink, and scaled to allow a reduction of 1.5 to 3 times. Lettering should be neat and uniform.

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

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