

# Journal of the British Dragonfly Society

Volume 25 Number 1 April 2009



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Front cover illustration: Male Common Darter Sympetrum striolatum at Shorne Wood Country Park, Kent, 15 August 1987. by Gill Brook

## Professor Philip S. Corbet, 21 May 1929 – 13 February 2008

## MICHAEL J. PARR

Hele Barton, 9c St James's St., South Petherton, Somerset, TA13 5BS <mima37@tiscali.co.uk>

Philip Corbet was a most remarkable man who became a close friend of mine over many years, and I feel deeply honoured to be asked to write this appreciation of his life. Whilst he will be remembered as an entomological biologist of considerable distinction, he possessed many other facets to his personality which made him a man of wide interests, including the environment, natural history book collecting, music, sport, and not forgetting his sense of humour as an engaging raconteur.

My first meeting with Philip was at the XIIth International Congress of Entomology in London in 1964 when we were introduced by our friend and fellow odonatologist Robert Gambles. At that time Philip was a research scientist with the Canadian Department of Agriculture working on the reproductive physiology of mosquitoes in the High Arctic. However, as Philip chatted with Robert and me it became clear that his primary interests lay with the Odonata, having studied the development and ecology of *Sympetrum striolatum* in his University of Reading B.Sc. dissertation and the seasonal regulation of dragonfly life cycles for his Ph.D. at Cambridge.

Philip was born in 1929 in Malaya where his father, a first rate naturalist and entomologist, was a microbiologist at the Rubber Research Institute, later becoming Deputy Keeper, Department of Entomology in the British Museum. It seems that the love of biology, and entomology in particular, must have been stamped on the Corbet genes, as his grandfather's hobby was entomology; Sarah (Sally), his sister is a biologist specialising on pollination and the behaviour of bumble bees; and his maternal aunt, Ethelwynn Trewavas, was a noted taxonomist of cichlid fishes.

In the period 1954-1962 Philip was employed successively by the East African Freshwater Fisheries Research Organisation and the East African Virus Research Institute in Uganda. In the first of these posts he produced the definitive account of the food of non-cichlid fishes in Lake Victoria basin, and made studies of the insect food of the Nile Crocodile and the behaviour of various groups of aquatic insects including caddis flies. From 1957-1962 he specialised on the behaviour and ecology of mosquitoes, discovering the mosquito vector of O'nyong-nyong Fever, an arborvirus with Dengue-like symptoms causing an epidemic among humans in Uganda and Kenya in 1959.



Plate 1. Philip as a young man.

During this time dragonflies were not forgotten! He described the larvae of numerous African Odonata species in a series of papers published in the Entomologist through the1950's. These publications are exquisitely illustrated with detailed line drawings and are indispensable for anyone studying the larval stages of African species. In one of these papers he described the larvae of *Brachythemis leucosticta* and *Zyxomma flavicans*. The latter species has only recently been recognised as being a *Brachythemis* and this is clearly demonstrated by Philip's descriptions and drawings. During this busy period he co-authored with Norman Moore and Cynthia Longfield the ground-breaking and immensely popular New Naturalist volume no.41, Dragonflies.

Philip's own contributions to the understanding of odonate ecology, behaviour and life cycles were numerous and varied. His studies of *Pyrrhosoma nymphula, Anax imperator, Lestes sponsa* and *Aeshna cyanea* life cycles recognised two types of British dragonflies, namely spring and summer species. *P. nymphula and A. imperator* have a closely synchronized spring emergence as a consequence of having a final larval instar diapause. In contrast, summer species as represented by *L. sponsa and A. cyanea* lack a diapause in the final instar and typically have an extended emergence period. Philip demonstrated in *A. imperator* that the change in successive lengths of day is the critical factor resulting in final instar larvae entering diapause. Philip maintained his interest in life cycles throughout his career and, for example, published with Manuel Ferreras-Romero an account of *Cordulegaster boltonii* in Southern Spain in 1999. Other topics which Philip explored in his researches included an early (1962) assessment of methods for age-determination in adult dragonflies, and tree-holes and other plant-associated water impoundments (phytotelmata) as larval habitats for dragonflies.

His study with A. McCrae (1981) reported the first time anisopteran larvae (*Hadrothemis scabrifrons*) had been found in a natural tree cavity in Africa. In 1996, with two other colleagues, he recorded the second species of this genus using phytotelmata as breeding places, in Kenya.

Philip's study of the suppression of the mosquito Aedes aegypti in Rangoon, Myanmar using larvae of Crocothemis servilia reflected his interest in applied entomology. A. aegypti is the main vector of dengue haemorrhagic fever, a frequently lethal disease. The mosquito larvae occurred in domestic water-storage containers and laboratory-reared C. servilia larvae placed in these resulted in a greatly reduced adult mosquito population.

Corbet's professional work on mosquitoes continued with his appointment in the Entomology Research Institute, Canada. It was here that he discussed the phenomenon of facultative autogeny – a hitherto unrecognised reproductive strategy in mosquitoes. This entails the ability of females of blood-sucking species to retain two options for oogenesis. If she fails to obtain the normally essential blood meal before egg-development, the female can dedicate her scant energy resources to developing at least a few eggs. This strategy is of particular importance in the High Arctic where sources of vertebrate blood are sparse and unpredictable.

In 1967 Philip was appointed as Director of the Canadian Department of Agriculture Research Institute at Belleville, Ontario. Under his direction the Institute adopted the broad remit of discovering and developing methods for pest control that avoided or greatly reduced the use of synthetic organic pesticides. He clearly saw the critical role of human population pressure in destabilising ecosystems, and also in precipitating pest outbreaks. This work led to Professorships at the University of Waterloo, Ontario, and in 1974 at the University of Canterbury, New Zealand. His work in New Zealand centred on environmental planning, resource education and nature conservation. In 1978 Philip was awarded a Commonwealth visiting Professorship in the Department of Applied Biology at the University of Cambridge, and in 1980 he accepted the foundation chair of Zoology in the Department of Biological Sciences at the University of Dundee.

He retired as Professor Emeritus from his post in Dundee and continued to work in an honorary capacity at the Department of Zoology, University of Edinburgh until 1996. The time in Edinburgh allowed him to complete the major part of his eagerly awaited book on Dragonflies: the Ecology and Behaviour of Odonata, which brought up to date and greatly expanded his 1962 Biology of Dragonflies. This latest definitive text on dragonfly biology is a magnificently detailed, and yet



Plate 2. Philip in Christchurch 1977

eminently readable, work which covers 829 pages, appearing in the Japanese translation in 2006. It will surely be very many years before this volume is superseded in the odonate literature. The Royal Society of Edinburgh recognised his monumental achievement when he was awarded that Society's Neill Medal for Natural History in 2002.

His final years were spent in retirement at Crean Mill, a beautiful and secluded house in the far west of Cornwall. But Philip was still a power of activity even in Cornwall, where he served on the Council and Executive of the Cornwall Wildlife Trust and as foundation chair of the Trust's Conservation Strategy Committee. And furthermore, in his final years, despite suffering a stroke in 2001, he coauthored with Steven Brooks, the splendid New Naturalist volume no.106, Dragonflies (2008).

Philip Corbet's numerous awards include higher doctorates from the universities of Reading, Cambridge, Edinburgh and Dundee; the Gold Medal for Outstanding Achievement from the Entomological Society of Canada; election to Fellowships of the Institute of Biology, Entomological Society of Canada, Royal Society of Tropical Medicine and Hygiene, the Royal Society of Arts and the Royal Society of Edinburgh. He served as an applied entomological consultant for the FAO and WHO of the United Nations and for the European Economic Community. In addition Philip held Honorary membership of three national dragonfly societies and, of great importance to members of the BDS, he was elected inaugural President of our Society in 1983, in which position he served with distinction.



Plate 3. Philip in his study 1990.

Philip was respected as much for his human qualities as for his prowess as an international biologist. He was always very willing to share his knowledge, treating both young and older odonatologists as equals, so that numerous entomologists at all levels have been inspired by his enthusiasm, encouragement and expertise. He made it abundantly clear how much one's own knowledge and research was valued, making him an easy and pleasing person with whom to communicate.

As a post-graduate student at Cambridge Philip played the clarinet in a quartet including the bassoonist Stanley Sadie, recording music by Schubert and Mozart. He enjoyed music throughout his life, having an interest in classical works as well as traditional jazz.

His participation in sport was largely through table tennis and swimming, which he participated in competitively whilst at Reading University. Philip's interest in table tennis was life long, and I understand that even in his seventies he could still give the members of Sarah Jewell's family a good game.

Philip had an immense sense of right and wrong and this was severely tested on numerous occasions in the organisation and during the demise of Societas Internationalis Odonatologica (SIO), and in the problematic periods of both the BDS and the Worldwide Dragonfly Association (WDA). When correct constitutional procedures were not being followed, or if he perceived.(usually correctly) that a warped version of events was being projected, he would be amongst the first to object and attempt to rectify matters. This was not easy and he was not always successful. However, I have the highest regard for his sense of justice and fairness and his willingness to 'put his head above the parapet', never fearing to argue forthrightly for a just cause.

Philip was married three times and he has a daughter, Katarina, by his second wife. In his later years Philip was indeed fortunate to have Sarah Jewell as his partner. Sarah's interest and support in his dragonfly work were hugely important to him and greatly appreciated: she has been a veritable tower of strength to him through their time together. Sarah and Philip rejoiced in each other's company which they clearly found so fulfilling and pleasurable. Philip was also fortunate to have his sister Sally so close by throughout his time in Cornwall. With both Sally and Sarah in close proximity he was indeed a lucky man.

Philip was a wonderful friend, engaging companion and extraordinary scientist to many people. He is sorely missed by family, friends and dragonfly lovers far and near, but he lives on through his unparalleled contributions to odonatology and our memories of a special human being.

Received and accepted 31 October 2008

# Variation in wing spot size and asymmetry of the Banded Demoiselle *Calopteryx splendens* (Harris, 1780)

## CHRISTOPHER HASSALL & DAVID J. THOMPSON

School of Biological Sciences, University of Liverpool, Liverpool, L69 7ZB

## Summary

Wing pigmentation of calopterygid damselflies has received considerable attention due to its role as an honest signal of male quality. We describe a quantitative analysis of this trait in two populations of the Banded Demoiselle, *Calopteryx splendens* (Harris 1780) in England. One population, sampled close to the northern limit of its range in Northumberland, exhibited substantially smaller wing spots than a population sampled in Hampshire. Wing asymmetry (in terms of length and area) did not vary between the two populations, nor did it co-vary with the size of the wing spots. We propose that the decline in wing spot size is the result of variation in climate between the two sites. Such variation in immunocompetence could contribute to the determination of range margins in this species.

## Introduction

In most higher animals there is a dichotomy between the sexual strategies of males and those of females. Males are limited in their ability to pass on their genes by the number of females with whom they can mate. Females, on the other hand, often have access to excess mates and can concentrate on choosing which of those mates would give them the highest quality offspring. Indeed, a range of mating systems has evolved (see Corbet, 1999).

The link between odonate breeding and freshwater means that females are limited in their breeding sites. This results in territoriality in a large number of odonate species where a small number of oviposition sites are dominated by a small proportion of the total male population. What determines the outcome of these contests appears to vary between species but residency (Gribbin & Thompson 1991), fluctuating asymmetry (Harvey & Walsh 1993), body size (an advantage of being larger (Fincke 1984) and smaller (Convey 1989) have both been demonstrated) and flight morphology (De Block & Stoks 2007) have all been implicated.

Female choice has resulted in a range of sexual ornaments which have been

suggested as being arbitrarily chosen (Fisher 1930), either on the basis of the traits' function as a handicap to the male (Zahavi 1975) or as a reflection of immune response to parasites (Hamilton & Zuk 1982). The often extensive courtship displays of calopterygid dragonflies involve the use of the pigmented wings by the males. The pigment that is deposited in the wings of males during maturation (leading to a "band" or "spot") is melanin, which is also involved in the immune response of a range of invertebrates.

Having established that variations in male wing pigmentation affected female choice (Siva-Jothy 1999), Siva-Jothy went on to demonstrate the mechanistic link between wing pigmentation and the response to eugregarine parasites in *Calopteryx splendens xanthostoma* (Siva-Jothy 2000). This relationship has been confirmed in subsequent studies looking at encapsulation of mite feeding tubes (Rantala *et al.*, 2000).

Historically, *Calopteryx splendens* was restricted to the rivers of southern and central England. However, two exceptions exist in the form of clusters of populations on the Solway Firth dating back to 1936 (Clarke 1999) and on several rivers in Northumberland (Jeffries 2001). Populations in northeast England are relatively well connected, although low recorder effort makes this difficult to verify (Ward & Mill 2004). On the other hand, the populations in the extreme northwest of England represent an isolated, though established, outpost. It has been suggested that further range expansion may be inhibited by the lack of suitable habitat (Ward & Mill 2004), although habitat studies suggest that *C. splendens* is relatively catholic in its requirements (Jeffries *et al.* 2005).

In this study we investigated the degree of wing pigmentation of two English populations of *Calopteryx splendens* sampled close to the northern limit of its range (in Northumbria) and 400km south of that (in Hampshire). The degree of pigmentation is compared between the two sites and regressions are carried out against another putative indicator of male quality, fluctuating asymmetry, which has been linked to melanotic encapsulation in previous studies (Rantala *et al.* 2000). Finally, an attempt is made to explain the observed variation in pigmentation in terms of climate.

## Materials and Methods

Specimens of male *Calopteryx splendens* were collected from Finchampstead Bridge on the River Blackwater (British National Grid Reference SU775625) between 24<sup>th</sup> June and 28<sup>th</sup> June 2006 and from Bellasis Bridge on the River Blyth (NZ190776) between 4<sup>th</sup> July and 6<sup>th</sup> July 2006 (see Fig. 1 for locations of the sites relative to the range margins of *C. splendens*). Individuals were caught using a butterfly net and placed in ziploc bags inside a coolbox to keep them alive.



**Figure 1.** Map showing sampling sites for *Calopter yx splendens* in relation to the range of the species (dark grey). Scale bar is 100km

Each individual was subjected to  $-18^{\circ}$ C for 150 seconds. This immobilised the animal for sufficient time to enable a digital scan to be taken of the body and wings using a Canon Canoscan LiDE 25 flatbed scanner. During scanning, animals were immobilised using microscope slides. Images were analysed using ImageJ (Rasband 1997-2007) to find wing area.

The area of pigmentation was judged by adjusting the threshold on a greyscale image until only the pigmented region remained. The area of this region was then calculated using ImageJ. Light levels varied between scans and so the standardised methods of Siva-Jothy (1999) were not usable. The area of the pigmented region was divided by the area of the wing to give the proportion of the wing that was pigmented.

Wing length was defined as the length from the costal end of the vein separating the arculus from the discoidal cell to the tip of the wing. It was not possible to take the area of the whole wing due to interference from the body in the scan, so the wing area excluded the portion defined by the junction of the first antenodal cross-vein and the costa, the margin of the arculus and across the anal crossing to the hind margin (Fig. 2). Wing length, area and wing spot measurements were all checked for repeatability by randomly choosing five individuals from each site and remeasuring all four wings (where they were undamaged). Correlations between measurements were all extremely high: wing length, n=40, r=0.999, p<0.001; wing area, n=39, r=0.998, p<0.001; wing spot, n=39, r=0.974, p<0.001.



**Figure 2.** The shaded area indicates the proximal portion of the wing excluded from measurement of wing area (see text for details). Arc, arculus.

Wing fluctuating asymmetry (FA) was calculated for both wing area and wing length. Differences between left and right wings for both fore- and hindwings were determined. Each was divided by the mean value for that trait to give a FA value standardised against body size. Each pair of wings was then averaged to give a mean wing area FA and a mean wing length FA.

The two populations were compared to test for differences in the proportion of the wing that was pigmented, mean wing area FA and mean wing length FA using two-sample, two-tailed t-tests. An analysis of covariance (ANCOVA) was employed with FA as the response, site as a factor and the proportion of pigmentation as a covariate to test for a correlation between these two measures (FA and size of pigment spot) of male quality.

Climate data was extracted from two Meterological Office weather stations for the period 1 June – 31 July 2006. These weather stations were "Reading University: Whiteknights" (source identification 830, 11km northwest of Finchampstead Bridge) and "Wallington" (source identification 300, 16km northwest of Bellasis Bridge). A paired t-test was used to test for difference between the two time-series.

## Results

The proportion of the wing that was pigmented was significantly lower in the northern population from Bellasis Bridge compared to the southern population from Finchampstead Bridge (FB) (t=-8.87, p<0.001). Mean proportion of wing area pigmented was  $0.435 \pm 0.011$  (S.E.) in the northern population compared to  $0.545 \pm 0.006$  in the southern population (Figs. 3, 4).



Figure 3. Mean proportion of the wing that was pigmented in specimens of *Calopteryx splendens* caught at Bellasis Bridge (North) and Finchampstead Bridge (South). Numbers in brackets are sample sizes and error bars are 95% confidence intervals.



Figure 4. Illustration of variation in wing spot size in *Calopteryx splendens* specimens from Hampshire (above), proportion of wing pigmented = 0.525 and Northumbria (below), proportion of wing pigmented = 0.339).

There was no difference between sites for either wing area FA (t=1.11, p=0.272) or wing length FA (t=0.86, p=0.395). Furthermore, there was no significant

relationship between wing area FA (site: F=71.02, p<0.001; wing area FA: F=1.38, p=0.244) or wing length FA (site: F=74.92, p<0.001; wing length FA: F=1.79, p=0.186) with the proportion of the wing that was pigmented. The same was true when absolute wing spot size was used instead of the proportion of the wing that was pigmented.

An analysis of the climate data showed that the mean temperature at Finchampstead Bridge was  $19.03^{\circ}C \pm 0.44$  compared to  $15.30^{\circ}C \pm 0.38$  at Bellasis Bridge, an average difference of  $3.73^{\circ}C$ . This difference was statistically significant (paired t-test, t=14.33, p<0.001, Fig. 5).



**Figure 5.** Variation in mean daily temperature between Finchampstead Bridge (dotted line) and Bellasis Bridge (solid line). Ordinal date is days since 1st January, so 152 is 1st June.

## Discussion

We are not aware of such an inter-population difference in wing spot size having been demonstrated previously. Other analyses have focused on within-population variation to investigate patterns of reproductive behaviour.

We have good reason to suspect that the difference in ambient temperature between the two sites has influenced the development of this trait. First, haemocyte (melanotic cells in the haemolymph) concentrations are higher at higher temperatures in butterflies (Pandey *et al.* 2007). Thus there may be a larger circulating pool of melanin in the haemolymph to be deposited in the wings during maturation at the southern site. Second, atmospheric temperatures are likely to play the main role in the development of this trait as wing pigmentation develops entirely after emergence from the water. Odonate larvae can use microclimates within water bodies to lessen the impacts of environmental temperature variation (Sternberg 1997) but such buffering microclimates are rarer in terrestrial habitats. Finally, higher temperatures have been shown to increase melanotic encapsulation of the feeding tubes of ectoparasitic mites in *Lestes forcipatus* (Robb & Forbes 2005). Previous analyses have shown that absolute fluctuating asymmetry (FA) of wing spot area correlates with the rate of melanotic encapsulation of mite feeding tubes in *Calopteryx splendens* (Rantala *et al.*, 2000). This physiological phenomenon involves the envelopment of foreign objects (such as pathogens or parasites) by melanised cells in the haemolymph and forms the basis of the invertebrate immune response. The absence of a relationship between wing FA and wingspot size in the present study is surprising given the vital role that *C. splendens* wings play in courtship behaviour, the pigmented spot being of particular significance. However, the ability of studies such as this to detect FA has been questioned in the past on the grounds that the magnitude of any effect is small relative to measurement error and that traits vary in their susceptibility to FA.

A recent study has shown that wing shape deviates from normal in populations of *Coenagrion puella* close to its northern limit near Forfar, Scotland (Hassall *et al.*, 2008). The authors suggested that this deviation may contribute to the maintenance of its northern range margin in which region deformed wings hinder flight. In the same way, a decline in immunocompetence closer to the northern range margin in *C. splendens* could serve to increase mortality, thereby contributing to the processes that limit its northern distribution. Another possibility is that an energetic trade-off is taking place between the maintenance of dispersal-related traits and investment in immune function.



**Figure 6.** Mean monthly temperature variation during 2007 at Leeming, England (54.3°N, 1.5°W), open circles, solid line and Kajaani, Finland (64.3°N, 27.7°E), closed circles, dashed line). Data available from http://data.giss.nasa.gov/gistemp/station\_data/.

The variation in the latitude of the range margin between Britain (c.  $55^{\circ}N$ ) and continental Europe (c.  $64^{\circ}N$  in Finland) highlights some aspects of regional climate that are important to *C. splendens*. The Scandanavian populations experience

extremely cold winters against which larvae are largely protected by the buffering effects of their lotic, aquatic environment. However, when this environment is left after emergence during the summer, temperatures are comparable between the two regions (Fig. 6). Furthermore, the longer daylengths during summer at higher latitudes increase the amount of solar radiation that the damselflies can make use of through basking. It may be that summer temperatures are the limiting factor in the distribution of *C. splendens* and such a limitation may be tied to some aspect of adult physiology such as the immune response suggested here.

## Acknowledgements

We would like to thank the Blagdon Estate for access to the River Blyth and the Meterological Office and NASA for access to climate data. CH was supported by a NERC Studentship.

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Received 28 July 2008, revised and accepted 15 September 2008

## Variations in key features of the final instar larvae and exuviae of the Azure Damselfly *Coenagrion puella* (Linnaeus)

## KEN CRICK

29 Village Way, Yateley, Hants, GU46 7SE

## Summary

A number of key features used for species identification of zygopteran final instar larvae and exuviae, published in the United Kingdom can be shown to have levels of variability exceeding the published limits. This paper seeks to record those variations as they apply to *Coenagrion puella*, based on the population contained within the Blackwater Valley catchment area located on the Hampshire/Berkshire border; outlining in detail specific variations found through close examination of 387 individuals. The features addressed include the species-specific characteristics of the caudal lamellae, the prementum and the post ocular region of the head; also some that are not found in current published keys, such as the setae on the labial palps and the lateral carinae on the second abdominal segment. The need to address a combination of key factors and to be aware of the areas of morphology where significant variations occur within species cannot be over emphasised.

## Introduction

The Blackwater Valley is home to eleven species of Zygoptera (Crick & Bennett, 2003) and the eight most commonly encountered are currently under investigation. The water bodies providing Azure Damselfly *Coenagrion puella* exuviae for this study are mildly acidic, man-made ponds, scrapes and one lake. This paper addresses *C. puella* with occasional reference to other species. Larvae and exuviae of *C. puella* closely resemble other *Coenagrion* species, in particular the Variable Damselfly *C. pulchellum*. Close attention was given to the antennae, post ocular region of the head, labial palps, prementum, caudal lamellae and the lateral carinae. A record of the key features observed on each individual was compiled and the results are presented here.

## Material and Methods

**Collection area:** Exuviae were collected over six seasons. The main sources of supply were a complex of ponds and scrapes on Bramshill Common (British National Grid Reference SU750620), other sites in the River Blackwater

catchment area (including local garden ponds) and Ancells Farm Nature Reserve (SU824557). Netting at Moor Green Lakes Nature Reserve (MGL) (SU805628) in support of water quality monitoring produced a limited number of near mature larvae that were bred on in captivity. MGL also contributed some exuviae.

## Methods

The identification keys used were those of Gardner (1954 & in Hammond, 1977), Askew (1988) and Brooks (1997). Although not a key, field characters are provided in Smallshire & Swash (2004). To ensure that each specimen was in the final instar of development only emergent exuvia cases were used, these being collected largely from marginal vegetation. The exuviae of all Zygoptera, regardless of species, were collected between April and August from 2003 to 2008 inclusive. Only those exuviae that appeared at the outset to be structurally intact were used. Ten individual larvae were reared to successful emergence in an aquarium to confirm that larvae characterized by the key features employed in this survey did indeed undergo a metamorphosis that resulted in adult *C. puella.*"

The procedure followed that of Crick (2005). The antennal segments counted on each complete exuvia and any markings on the head behind the eyes were noted, as was the head's general outline. The caudal lamellae were removed from the abdomen with a sharp scalpel. Although they had become stuck together, they were easily separated by soaking them in a small amount of water. In order to remove the prementum and its labial palps without causing damage it was sprung free of the head by applying pressure to the base of the prementum.

Using a microscope with an objective of x4 and an eyepiece of x10 the number and character of setae on the lateral field of the prementum were recorded, as were the number of setae on the labial palp. The absence of a small spine located at the base of the anterior palpal seta on its outer surface, the presence of which is believed to be unique to the final instar of the Common Blue Damselfly *Enallagma cyathigerum* (May & Corbet, 2001), was noted. Having separated the caudal lamellae, one from another, the median was selected. Very occasionally, when the median one was missing, an outer caudal lamella was used and this deviation was noted. The length and width of the caudal lamellae were recorded, as were the disposition of the nodal line, and the presence and character of any stout setae on the margins.

In addition, as a result of observations noted by Seidenbusch (1996), three further features were recorded from the end of May 2007 onwards. These were the number

and disposition of a row of setae above the lateral carinae on the second abdominal segment, the number of twists observed in the caudal lamellae primary tracheae prior to the nodal line and the included angle formed by two notional straight lines projected through the follicles of the major setae on the lateral field of the prementum with the labium viewed in its naturally curved form. A fine transparent film of the type used for making view foils on an inkjet printer was inscribed with lines forming included angles of 80°, 85° and 90°. Back projection through the film and the labium, at the same magnification as above, allowed measurement of the included angle of the premental setae to 2.5° either side of the stated value.

## Results

Three hundred and eighty seven exuviae of *Coenagrion puella* were positively identified and their details recorded over the six-year period. The identification was based on the presence of seven antennal segments in combination with the shape of the head and spots to the rear of the eyes, as referred to in Gardner (1954 & in Hammond, 1977), Askew (1988) and Brooks (1997), plus the concurrent absence of *C. pulchellum* (the other British species that shares these key features) from the catchment area.

The survey included ten larvae bred to maturity in an aquarium. When introduced to the aquarium none of these could be described as green (*cf* Gardner, in Hammond 1977; Brooks, 1997). A change of instar was observed; the cast off exuvia was brown and the newly emerged larva light green (Plate 1). Whatever the colour of the larvae, the resulting exuviae in this sample varied in hue from light straw to brown. Colour is not a key feature to which I would give any weight.



Plate 1. A brown exuvia just cast off by a light green larva of Coenagrion puella.

**Head.** All but two exuviae of *C. puella* were found to have spots present on the rear of the head behind the eyes. The contrast between the colour of the spots and the background cuticle varied markedly between specimens, and they ranged from strongly defined to occasionally difficult to see. Similar spots were often observed on the thorax.

**Labial palps.** For 348 of the exuviae, both labial palps possessed six stout long setae. Twenty-eight specimens had both labial palps populated with five long setae and 11 specimens had other paired combinations, i.e. 4 + 6, 5 + 6, 6 + 7 or 7 + 7. Only nine specimens had different numbers of setae on the two sides.

**Spine on anterior palpal seta.** Evidence of a small spine at the base of the anterior palpal seta, found on final instar *E. cyathigerum*, was looked for on all 387 specimens and never found.

**Prementum.** The lateral field of the prementum supports two sets of stout setae; one set either side of the centre line. Published keys vary on the number of setae. Askew (1988) has a sketch with four long and one short setae (4.5) and Gardner (in Hammond, 1977) describes a "labium with premental setae 5 + 5....may vary in having premental setae 4 + 4...." In the Blackwater Valley study, 55 specimens matched Askew's sketch exactly, i.e. only 14.3% of the total. As for the Gardner combinations, 4 + 4 long setae occurred 101 times (26.3%) with 5 + 5 long setae being observed on 56 specimens (14.6%) (Table 1). In all, there were a total of thirty-seven combinations of lateral field stout setae. The arrangement was exactly equal on the two sides for 66% of the sample. There were specimens with combinations varying from 1 + 1 to 6 + 6, although many of the combinations of setae included hairs one half to one quarter the length of the majority of their near neighbours. If the relative lengths of the setae are ignored, we are still left with nine combinations of which 48% of the specimens had five setae and 28% four setae either side of the centre line.

**Prementum setae included angle.** The sample size was limited to 173 specimens collected in 2007 and 2008. The included angle was fairly evenly distributed between 80°, 85° and 90° (Table 2). Each specimen was assigned to the closest match. In no case was 90° exceeded. An angle below 80° was noted only once and this was quite obviously at 75°.

**Table 1.** Number and size of the setae on the prementum of *Coenagrion puella*. 1 = one seta of maximum length;  $\frac{1}{2}$  = one seta one half the maximum length;  $\frac{1}{2}$  = one seta one quarter the maximum length. Sample size = 387.

Setae to one side of the centre line	Setae to the other side of the centre line	Sample size (frequency)	
1	1	2(0.5%)	
1	1,1,1,1	1 (0.3%)	
1,1,1	1,1,1,1,1	2 (0.5%)	
	4+3		6
			(1.6%)
1,1,1,1	1,1,1	5 (1.3%)	
1,1,1,1	1/2,1,1	1 (0.3%)	
	4+4		110
			(28.4%)
1,1,1,1/4	1,1,1,¼	1 (0.3%)	
1,1,1,1/4	1,1,1,1	2 (0.5%)	
1,1,1,1/2	1,1,1,½	2 (0.5%)	
1,1,1,1/2	1,1,1,1	3 (0.8%)	
1,1,1,1	1,1,½,1	1 (0.3%)	
1,1,1,1	1,1,1,1	101 (26.3%)	
	4+5 or 5+4		68
			(17.6%)
1,1,1,1/2	1,1,1,1,½	5 (1.3%)	
1,1,1,1/2	1,1,1,1,1,1/4	1 (0.3%)	
1,1,1,1/4	1,1,1,1,1/4	2 (0.5%)	
1,1,1,1	1,1,1,1,1,1/2	24(6.0%)	
1,1,1,1	1,1,1,1,1/4	10 (2.6%)	
1,1,1,1	1,1,1,1,12,12	1 (0.3%)	
1,1,1,1	1,1,1,1,1	22(5.7%)	
1,1,1,14,14	1,1,1,1	1 (0.3%)	
1,1,1,1,1/2,1/4	1, 1/2, 1, 1	1 (0.3%)	
1,1,1,1,1/2,1/4	1,1,1,¼	1 (0.3%)	
	5+5		184
			(47.6%)
1/2 , 1, 1, 1, 1, 1/2	1/2, 1, 1, 1, 1	1 (0.3%)	
1,1,1/2,1,1/2	1/2 , 1 , 1/2 , 1 , 1	1(0.3%)	
1,1,1,1,1,1/4	1,1,1,1,1,1/4	38 (9.9%)	
1,1,1,1,1,½	1,1,1,1,1	5 (1.3%)	
1,1,1,1,1,1/2	1,1,1,1,1,1/4	7 (1.8%)	
1,1,1,1,1,½	1,1,1,1,½	55 (14.3%)	
1,1,1,1,½	1,1,1,1,1	21 (5.4%)	
1,1,1,1,1	1,1,1,1,1	56 (14.6%)	
	5+6 or 6+5		8
		2 (0.00)	(2.1%)
1,1,1,1,1,1/4	1,1,1,1,1,1/4	3 (0.8%)	
1,1,1,1,1	1,1,1,1,1,1	2 (0.5%)	
1,1,1,1,1 1/4	1,1,1,1,1	1 (0.3%)	
1,1,1,1,1,1/2,1/4	1,1,1,1,1,1/4	1 (0.3%)	
1,1,1,1,1,1,1/2,1/2	1,1,1,1,1	1 (0.3%)	
	6+6		6
1111 1 1/1/	111111	1 (1 00)	(1.6%)
1,1,1,1,1/2, 1/4	1,1,1,1,1 1/4	4(1.0%)	
1,1,1,1,1/2, ½	1,1,1,1,1,1/2, 1/2	1(0.3%)	
1,1,1,1,1 1/4	1,1,1,1,1,14,14	1(0.5%)	

Table 2.	Prementum inclue	ded angle forme	d by the prementa	al setae in C	oenagrion p	uella. S	Sample
size $= 173$	3.						

Included angle	Number of times observed	
75	1(0.6%)	
80	48(27.7%)	
85	59(34.1%)	
90	63(36.4%)	
1 + 1 setae	2(1.2%)	

**Caudal lamellae setae and nodal line**. Invariably, the caudal lamellae of *C. puella* had a set of stout setae on both margins. On many examples, the margin with the loosely packed stout setae (i.e. the median's lower margin) was populated in this manner for significantly less than one half of its overall length, the stout setae terminating at the nodal line. Setae on both margins never extended beyond the point where the nodal line intersects the margin. At no time did the number of setae on the lower margin equal or exceed that on the upper margin. The counting of this feature was discontinued by August 2003, though the nature of the packing continued to be noted. The nodal line is described as "about at right angles to the long axis" by Askew(1988) and "oblique" in text and sketch by Brooks (1997) and Smallshire & Swash (2004). In the present study the character of the nodal line proved to be somewhat variable. The line could be clearly defined (Plate 2) or it could be almost indiscernible (Plate 3). Where visible the line tended towards the vertical above the primary tracheae but below it varied from almost vertical (Plate 4) to a decidedly curved anterior sweep (Plate 2).

**Physical dimensions of the caudal lamellae.** For a sample size of 382 individuals the length of the majority of caudal lamellae varied from 5mm to 6.5mm. Only twenty-two specimens had caudal lamellae outside this range, with the shortest being 2.2mm and the longest 7mm. The width generally lay between 1.0mm and 2.0mm, with just ten specimens outside this range, the narrowest being 0.5mm and the widest being 2.1mm. The length to width ratio lay between 3.3:1 and 5:1 in 81% of the measured sample. Eleven specimens were discounted as they were very small and believed to represent re-growth that had had insufficient time to reach mature proportions. At the extremes, the length to width ratio was 2.7:1 and 5.9:1.

**Caudal lamellae: primary tracheae twist prior to the nodal line.** It was observed that the primary tracheae could be relatively straight. However they could also deviate from the mean axis in a number of undulations without actually twisting about one another (plate 2). Furthermore, they can twist about one another, the presence of diamond shapes within the tracheae denoting the twist (Plate 3). The sample size was 165 relating to samples from 2007and 2008. No twist was

detected in 114 specimens (69%) and 33 specimens had a single twist (20%) (Table 3). The maximum number of times the primary tracheae was observed to twist about one another prior to the nodal line was three and this on only four occasions (2.5%).



**Plate 2.** Caudal lamella of *Coenagrion puella* showing a clearly defined nodal line, which is almost vertical above the primary tracheae but which has a marked anterior sweep below them.



**Plate 3.** Caudal lamella of *Coenagrion puella* with an indistinct nodal line. Note the double twist in the primary tracheae prior to the nodal line



**Plate 4.** Caudal lamella of *Coenagrion puella* with a nodal line which is almost vertical both above and below the primary tracheae.

Table 3. Pre-nodal twist(s) in the primary tracheae of the caudal lamellae of *Coenagrion puella*. Sample size = 165.

Number of pre-nodal twists	Number of times observed		
0	114(69%)		
1	33(20%)		
2	14(8.5%)		
3	4(2.5%)		

**Setae above the lateral carinae on the second abdominal segment.** The sample size was limited to 159, the feature only being recorded from the beginning of 2007. In eight cases the carina had curled in on itself on both sides, completely obscuring the view of the setae. The number of stout setae normally varied from none to seven and very occasionally more (Table 4).

**Table 4.** Setae on the carinae of the second abdominal segment of *Coenagrion puella*. Sample size = 159 but the setae were obscured on eight of these.

Number of setae on the carinae	Number of times observed
0	3 (2%)
1	1(0.6%)
2	4 (2.6%)
3	10 (6.6%)
4	44 (29.1%)
5	33 (21.8%)
6	24 (15.9%)
7 or more	32 (21.1%)

## Conclusions

- Colour of the larvae is an unreliable guide.
- For any given species, the number of antennal segments appears to be constant. In *Coenagrion puella* the number is seven.
- Although sometimes difficult to see, the spots on the rear of the head were discernable in over 99.5% of the sample and hence this constitutes a valuable key feature.
- In general, Gardner's assertion (Gardner, 1954; in Hammond, 1977) that the number of setae on each labial palp can vary from five to seven

holds true. Only nine specimens (2.3%) had a different number of setae on the two sides and only one of these (4 + 6) lay outside of Gardner's limits.

• The stout setae on the lateral field of the prementum are a variable feature. Ignoring the relative length of the setae there are nine combinations. 48% of the specimens had five setae and 28% had four setae on each side of the centre line (Table 1). The two specimens with 1+1 mimic the Small Red Damselfly *Ceriagrion tenellum* but the shape of the labium in this latter species is more tapered (Plate 5).



Plate 5. The prementum of (a) the Small Red Damselfly *Ceriagrion tenellum* and (b) *Coenagrion puella*.

- The real value of the setae on the lateral field of the prementum may lie in the included angle formed by two notional straight lines projected through the follicles of the major setae. In all but one of the 173 specimens the included angle was between 80° and 90°.
- The number of stout setae on the margins of the caudal lamellae is so variable as to offer no useful reference feature.
- The nodal line varies between specimens from being almost at right angles to the long axis to being obliquely disposed. The shape of this line often resembles a Cupid/Eros bow with the grip at the primary tracheae. Some specimens have clearly defined nodal lines; in others they are less so.

• The stout setae above the lateral carina of the second abdominal segment proved to be an extremely variable feature and there were combinations of stout and fine setae.

## Discussion

Variable damselfly *Coenagrion pulchellum* and *C. puella* larvae have many key features in common. I am confident that the specimens featured in the report are all *C. puella*, since the specimen collection area does not support *C. pulchellum*. The work carried out on the exuviae of *C. puella* found in the Blackwater Valley shows significant levels of variability in some of the characteristics offered as key features.

The spotted region to the rear of the head behind the eyes is a clear indication in the UK of one of four species. Fortunately, in combination with another fixed key feature, seven segments to the antennae, the number of possible species is reduced to two. If the area of study only accommodates *C. puella* then, without further examination, one could stop here.

Other features, such as the number of setae distributed either side of the prementum centre line and the number of setae on the labial palp, are sufficiently variable that some combinations match declared key features for other species. There is clearly a need when keying out specimens of Zygoptera to be aware of the potential for variability within declared key features. The variability stated in keys can be greater than indicated.

The use of the pointed tip to the caudal lamellae (Gardner, in Hammond 1977; Askew. 1988) for identification presents its own problems. The ten larvae in the breeding tank presented a pointed tip to the caudal lamellae. The eleven specimens discounted from the aspect ratio assessment all had rounded tips, though this was not the reason they were discounted. Exuviae suffer from the transformation process, weather and handling. The tips of caudal lamellae acquired from exuviae are often less than perfect. My work with *Enallagma cyathigerum* (Crick, 2005) has lead me to conclude that some individuals of this species also exhibit a similar pointed tip which, when combined with caudal lamellae with no banding, could lead to confusion. The length to width ratio reported on here indicates a slight overlap with that reported for *E. cyathigerum*; however in practice *C. puella* caudal lamellae are generally longer and narrower than those of *E. cyathigerum*.

The belated reading of Seidenbusch (1996) increased the number of features recorded from 2007 onwards. The three most readily assessed features proposed by Seidenbusch for the separation of *C. pulchellum* from *C. puella* were added to the

record for each specimen viewed. With no source of *C. pulchellum* in my area of operation I cannot make any direct comparisons. The number of stout seatae above the lateral carinae of the second abdominal segment proved to be of little taxonomic use as far as *C. puella* is concerned. The included angle formed by the long setae on either side of the prementum centre line remains a promising area of enquiry. Seidenbusch (1996) indicated an included angle for *C. pulchellum* of approximately 100°; should this prove to be the case within the UK population, then a potentially useful key feature will have been established. Seidenbusch (1996) indicated the number of twists which exist along the primary tracheae of the caudal lamellae prior to the nodal line for *C. pulchellum* varied between five and nine. To date the maximum number of twists that have been observed along the primary tracheae of the caudal lamellae prior to the nodal line for *C. puella* was three, offering another potentially useful key feature.

#### Acknowledgements

My thanks go to Des Sussex, Mike Hillman, Sarah Clark and Oliver Hine for collecting a number of exuviae from their garden ponds and Ancells Farm reserve.

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Received 23 August 2008, revised and accepted 24 October 2008

# The Scarce Emerald Damselfly *Lestes dryas* Kirby in East Sussex 1940 to 2007: an account of species extinction through changing agricultural practice.

## DAVID G. CHELMICK<sup>1</sup> & NORMAN W. MOORE<sup>2</sup>

<sup>1</sup>Macromia Scientific Ltd, 31 High Beech Lane, Haywards Heath, West Sussex, RH16 1SQ. <dgc@davidchelmick.com>

<sup>2</sup>The Farmhouse, 117 Boxworth End, Swavesey, Cambridge, CB24 4RA

## Abstract

Lestes dryas is a very local damselfly which, in England, is found only in a few localities in the extreme east, mainly in coastal areas. In the 1940's NWM discovered this species in East Sussex and carried out a detailed survey. DGC has visited the historical NWM sites and recorded the fauna now present. This paper covers a period of 67 years and compares the historical and modern habitat and faunal information. The paper first outlines the life history and distribution of L. dryas and, from these perspectives, considers how changes in agricultural practice have led to the extinction of L. dryas in East Sussex.

## Introduction

**Distribution**. Lestes dryas (Plates 1 - 3) is a circumboreal species found in both the Palearctic and Nearctic regions. In the Palearctic, its range is similar to that of the generally more common Lestes sponsa, which is restricted to the Palearctic. L. dryas has a more southerly distribution and occurs in Iberia and Italy where L. sponsa is virtually absent. L. dryas is nowhere common and was considered by many to be extinct in Britain until it was rediscovered in Essex in 1983 (Benton & Payne, 1983). In mid and southern Ireland it is proving to be locally common and widespread (N. Donnithorne pers. comm.). In England it is locally common in Kent and Essex along the Thames Estuary and is also found in Norfolk.



Plate 1. Male Lestes dryas.



Plate 2. Female *Lestes dryas* ovipositing, showing the huge ovipositor and square markings on the second abdominal segment.



Plate 3. Pair of *Lestes dryas* ovipositing in Sea Club-rush. The light blue eyes of the male are often useful in identification.

**Life History.** Corbet (1999) states that most species of Lestidae produce eggs in which the larvae develop to eye spot stage and then go into a period of arrested development (diapause) until conditions are right for hatching. In the case of *L. dryas* such conditions are provided by the wetting of the eggs resulting from filling of the ponds and/or decay of the vegetation (Sawchyn & Gillott, 1974).

Sawchyn & Gillott (1974) state that, in Canada, *L. dryas* overwinters in the egg stage. In this state the diapaused eggs can survive exposures to temperatures as low as -20°C. Hatching in *L. disjunctus* and *L. unguiculatus* (species that are found with *L. dryas*) takes place at 10°C and larval development is completed in 60 days. Corbet (1999) gives minimum larval development for *L. dryas* as 45 days. Gardner (1952) bred larvae which hatched on 17 November 1949 and emerged as adults on 31 May 1950, i.e. the larval development period was 195 days. Gardner recorded water temperatures from 8.9°C at hatching to 12.8°C in April 1950 when the final larval instar appeared.

Sawchyn and Gillott (1974) state that oviposition is in green stems of Club-rushes (*Scirpus* spp.) between 5 and 60 cm above the water surface. DGC observed *L. dryas* on many occasions in Essex in 2007 when oviposition took place almost exclusively in *Bolboschoenus* (*Scirpus*) maritimus (Sea Club-rush); it was always above the water level but often only 2.5 cm above the surface.

Corbet (1999) showed that *L. dryas* is reasonably tolerant of saline conditions, based upon measurement of surface conductivity at 25°C. Indeed *L. dryas* will tolerate conductivity levels which represent upto about 4% seawater. Drake (1990) measured the conductivity in 11 of the ditches where *L. dryas* occurred in Essex; these ranged from 2.2% to 4.5% seawater. In Britain it would appear that the majority of habitats in which *L. dryas* oviposits are dry by late summer, as observed by DGC in Essex in 2007, Gardner (1952) and Drake (1990 and 1991) in Essex and by Perrin (1995) in Norfolk. Drake (1991) stated that "larvae were remarkably tolerant of conditions ...Together with ten-spined sticklebacks (*Pungitius pungitius*), *Sympetrum* sp. and a few species of beetle larvae... [*L. dryas*] larvae were among the most conspicuous and numerous species in isolated, and desiccating pools less than 5 cm deep... [which] were all that remained of four ditches in May 1990..." Insufficient information is available to make any comment on the situation in Ireland.

In summary, today *L. dryas* is mainly found in fresh and brackish water pools and ditches which normally dry up in late summer. The eggs are laid above water, primarily in *Scirpus* or *Bolboschoenus* spp. They develop to eye spot stage and hatch on immersion in water. In Canada this often does not take place until the spring

when the larvae develop quickly (60 days). However, in Britain hatching usually takes place in the autumn with a resultant longer larval life. Nonetheless, if conditions are appropriate, larval development could take place, as long as water is present from February through to May/June and water temperature is sufficiently high for rapid larval development. In Britain this means that shallow water with abundant food is essential.

*L. sponsa*, which is often found with *L. dryas* and is very similar in appearance, differs in its behaviour in that it usually oviposits in tandem below the water surface (DGC *pers. obs.* Bryan Pickess *pers. comm.*). Clearly the hatching stimulus for *L. sponsa* must be water temperature.

This paper considers the historical records of *L. dryas* and the habitat changes that have taken place in East Sussex in the light of the life history and habitat requirements of this species.

## The 1940s Survey

NWM lived in Whatlington in East Sussex from 1934 until 1950. He recorded dragonflies from 1939 onwards, although his studies were greatly reduced when he was away on war service (October 1942 to April 1947). The geographical extent of his observations was limited by his means of transport, his bicycle. He surveyed an area within 28 miles of Whatlington and recorded the following species:

Zygoptera: Calopteryx splendens, C. virgo, Lestes dryas, L. sponsa, Ceriagrion tenellum, Coenagrion puella, C. pulchellum, Enallagma cyathigerum, Erythromma najas, Ischnura elegans, Pyrrhosoma nymphula, Platycnemis pennipes

Anisoptera: Aeshna cyanea, A. grandis, A. mixta, Anax imperator, Brachytron pratense, Cordulegaster boltonii, Cordulia aenea, Somatochlora metallica, Libellula depressa, L. quadrimaculata, Orthetrum cancellatum, O. coerulescens, Sympetrum flaveolum, S. fonscolombii, S. sanguineum and S. striolatum.

The area within 10 miles of Whatlington was recorded much more completely than that beyond; almost all the water bodies which supported dragonflies, apart from garden ponds, were visited. Hence the entire catchments of the rivers Rother, Brede, Tillingham, Combe Haven and Pannel Sewer, along with Pett Level and large areas of Walland Marsh and the Pevensey Levels were covered (Fig. 1). All species found within the 28-mile radius were also recorded within a radius of about 10 miles of Whatlington, except for *S. metallica* and *C. tenellum*, which were only found near Crowborough in Ashdown Forest. *Lestes dryas* was, therefore, part of

a very rich dragonfly fauna. The intensity of the surveys within the ten-mile radius makes it almost certain that no *L. dryas* populations were overlooked within it.



Figure 1. Map of East Sussex showing the eight catchment areas, their alluvial flood plains and historical sites for *Lestes dryas*; also the coastal boundary to the south and county boundary with Kent to the north. The Ordnance Survey grid shows mainly TQ with part of TV to the south. Significant coastal urban locations are Rye (TQ 9520), Hastings (TQ 8109) and Eastbourne (TV 6097). Each of the localities has been grouped into catchments as shown by numbers. 1, River Medway; 2, River Ouse; 3, River Cuckemere; 4, Pevensey Levels; 5, Combe Haven; 6, Rivers Brede and Tillingham; 7, Coastal Plain; 8 River Rother. The dotted circle shown is an approximate guide to the extent of NWM's regular observations. Visits outside of this circle were infrequent. alluvium; ●, NWN records; ●,1990 record.

Most of the *L. dryas* sites were ditches in grazing land in the flood plains. These ditches supported a variety of different marsh and aquatic plants. Horsetails (*Equisetum spp.*) were common in some of the best ditches for *L. dryas*. The grazing marshes were very similar throughout the study area, with most closely grazed. They all had high water tables which were maintained throughout the year and

none had been ploughed or treated with fertilisers or herbicides. They supported many plant species, mainly rushes and grasses, and clumps of rushes were a common feature. In one area of the Rother valley downstream from Bodiam (TQ 8025) there was a marsh with open water. Unlike the sites in Kent and Essex today, none of the Sussex sites were saline or temporary with the exception of one site at Camber (Table 1).

Birds were common in the grazing marshes. The characteristic breeding species were yellow wagtails, skylarks, lapwings, redshank and snipe. Mallard and sedge warblers bred in the dykes; shoveler bred in the marshes in the Rother valley

**Lestes dryas.** In the 1940s NWM discovered *L. dryas* in East Sussex. He and another local naturalist, H.G. Attlee, reported their findings in the Hastings and East Sussex Naturalist (Ticehurst [Compiler], 1941 - 1949). Attlee (1943) published a key to East Sussex dragonflies which included *L. dryas*. NWM's work represents an early example of single species study in a restricted area. A detailed list of the sightings is provided in Table 1. All NWM records for *L. dryas*, together with one more recent record, are shown on Fig. 1.

In 1978 NWM revisited all the sites where he had found *L. dryas* in the 1940s (Moore, 1980). He found no *L. dryas* in any of the localities and described the habitat changes in each site. In 2006 and 2007 DGC revisited all the sites and made detailed observations of the habitats as they exist today.

## Catchment 1 - River Medway

NWM made few observations in this area. In 1996 he surveyed the grazing marshes in the RSPB reserves of Northward Hill and Rye Street in the catchment of the River Thames very near the mouth of the Medway. He recorded *L. dryas* commonly in both reserves.

## Catchments 2 & 3 – Rivers Ouse & Cuckmere

NWM made visits to these river systems but never found *L. dryas*. However, his visits to these catchments were infrequent. DGC and other observers visited suitable localities in 2006 and 2007, particularly on the River Cuckmere, which has reasonable unimproved habitat, but with no success

## Catchment 4 - Pevensey Levels

This large alluvial floodplain surrounding the Wallers and Pevensey Havens consists of a wide range of ditch systems that would appear to offer favourable conditions for *L. dryas*, albeit that the agricultural systems are quite intensive today. NWM found no *L. dryas* here in the 1940s.

#### Table 1 - NWM Field notes with three HGA records

All records are for NWM unless stated otherwise.

Locality	Catch- ment	Map Ref	Date	Qty	Habitat
<b>1940</b> Bodiam	8	TQ8025	05 Aug	2 females	Large dyke south of river where Kent Ditch joins on north side.
<b>1941</b> Cadborough, Tillingham	6	TQ9020	26 Jun	About 20, most were in thick reeds of small pond	A small pond and a stagnant ditch
Powdermill Reservoir (West End) Sedlescombe	6	TQ7920	27 Jun	Masses of them - the reeds, grasses and flowers were alive with them	H G Attlee records similar numbers for same date
Brede Place	6	TQ8317	27 Jun	A good number of <i>L. dryas</i> in the reeds but none in the cleared dyke nearby	Very small pond close to the channel
Bodiam	8	TQ8025	21 Aug	Quite a number, at least as many as <i>L. sponsa</i> . Also observed upstream only a few yards from Bodiam castle	
Winchelsea – Pett Levels	7	TQ9016	30 Aug	Quite a few	Dyke running parallel to the Royal Military canal
1942 Whatlington - Water filled iron pit in Ducks Hall Shaw	6	TQ7619	14 Jun	One pair	Oak wood with hornbeam coppice. L. dryas appeared after an oak was felled and more light came in
Whatlington	6	TQ7619	15 Jun	One pair	
Whatlington	6	TQ7619	16 Jun	One pair	Not seen again despite frequent visits. A "one off" colonisation. Eventually the
Powdermill Reservoir	6	TQ7920	17 Jun	Many tenerals	site became shaded again
Sedlescombe - Black Brooks	6	TQ7717	29 Jun	one male and one female	Rush covered flooded meadow
Powdermill Reservoir	6	TQ <mark>792</mark> 0	31 Aug	One female	

Locality	Catch- ment	Map Ref	Date	Qty	Habitat
<b>1943</b> Sedlescombe - Black Brooks	6	TQ7717	13 Jun	one female	<i>d</i>
Powdermill Reservoir	6	TQ7920	14 Jun	20+	HG Attlee Record - Great sanders Reservoir
Powdermill Reservoir	6	TQ7920	1 <mark>7 Ju</mark> n	Many – one mature male	
Powdermill Reservoir	6	TQ7920	27 Aug	last seen	H G Attlee
1945					
Camber	7	TQ9519	17 Jul	Plentiful	Low ditch just north of Camber golf course with
1946					sedge ditenes
Wittersham (Kent)	8	TQ9026	09 Jul	Several	Ditches
1947					
Camber castle	7	TQ9218	24 Jun	At least one	
Cadborough	6	TQ9020	2 Jul	None seen	Improved drainage
Brede Waterworks Bodiam	6	TQ8117	14 Jul	Several	Dykes near waterworks
Northiam	8	TQ8025	13 Jul	None seen	Greatly improved drainage
Powdermill Reservoir	6	TQ7920	11 Aug	Several	
1952					
Powdermill Pond (West of Battle)	6	TQ7314	23 Aug	One male	Large pond surrounded by woodland
Bodiam	8	TQ8025	25 Aug	None seen	Greatly improved drainage

### Catchment 5 - Combe Haven

NWM visited this area but never recorded *L. dryas* even though he felt the habitat looked suitable. In 1990 Simon Davey (*pers. comm*) recorded a male *L. dryas* on this river system. Having recently discussed this record with Mr Davey, DGC believes that the record is genuine. Although the record was of only a single individual many of the NWM sightings were for very small populations and, in his Irish survey, Nick Donnithorne (*pers. comm*.) states that very low numbers are often the

norm. In 1952 NWM saw one *L. d*ryas at the west end of the Powdermill pond, Battle. This is a woodland site in the Combe Haven catchment a little over two miles from the grazing marshes.

The Combe Haven river system has been extensively altered recently as it is the location of the Hastings and Bexhill waste disposal tip. However, to the north of Bexhill (TQ765095) there are some fine ditches and rough pasture that could still harbour *L. dryas*.

#### Catchment 6 – Rivers Brede and Tillingham

The majority of NWM's records were from this area as he lived close by. Three habitats were recognised for *L. dryas*.

*Levels (Brooks)* - The drainage on both rivers has been greatly improved since the 1950s. The River Brede at Sedlescombe (British National Grid Reference TQ 775175) is little more than a narrow ditch at least 2.0m below the surrounding land. The lower floodplain around Little Knights Oast (TQ 835175) has some unimproved pasture but raised riverbanks prevent flooding. Land adjacent the Brede waterworks (TQ 815175), where NWM found "several" *L. dryas*, is now arable with extensive barley/wheat crops. NWM states that Yellow wagtail (*Motacilla flava*) once flourished in these pastures. The ditches which harboured *L. dryas* are now very choked and neglected, albeit still supporting good populations of *Sympetrum sanguineum*. The Black Brooks at Sedlescombe (TQ 775175) are still sheep grazed but the low water table evidenced by the river Brede leaves only choked ditches and little wet habitat. DGC was unable to locate the small pond near Brede Place which contained "a good number" of *L. dryas* in 1941. The River Tillingham has extensive emergent vegetation; the small cattle pond where NWM observed *L. dryas* has now disappeared.

**Powdermill Reservoir** – This reservoir (TQ 795205), known in the 1940s as Great Sanders Reservoir, which is how it is often referred to in the literature, was created on a tributary of the river Brede and in the 1940s was one of the best sites for *L. dryas*. DGC has examined an aerial photograph of the North West arm of the reservoir dated 1945. It clearly shows a wide-open area with little surrounding woodland. The shallow waters and macrophytes would doubtless have provided excellent habitat for *L. dryas*; falling water levels in late summer further favouring the insect. The area was revisited in 2007. The whole of this northern arm is extensively wooded and virtually impenetrable to the waters edge, rendering the habitat quite unsuitable for *L. dryas*. Huge populations of *Enallagma cyathigerum* can now be observed across the open waters of the reservoir but very little else. In the 1940s NWM observed *B. pratense, C. aenea, S. flaveolum* (1945 only), *S.* 

sanguineum, L. sponsa and I. elegans as well as L. dryas.

**Woodland** – The only woodland sites for *L. dryas* in East Sussex were the west Powdermill pond, Battle and the old iron pit in a wood at Whatlington, which was colonised briefly – probably from the Brede valley, when the felling of an oak allowed some sunlight into the pit. Woodland sites have been observed in Norfolk on pingos and in Ireland by NWM in 1980 and by Nick Donnithorne in his extensive studies there (*pers. comm.*)

## Catchment 7 – Coastal Plain

This area comprises low-lying ditch-drained habitats to the east and west of the Rother estuary (Catchment 8).

**Pett Levels** (TQ 905155) – During the Second World War much of this area was deliberately flooded to prevent enemy gliders from landing. After the war improvements were made to prevent flooding. Sheep grazing still predominates in this area and some excellent ditches are present with a wide range of macrophytic vegetation. *Lestes sponsa* and *Coenagrion pulchellum*, which are local in the eastern parts of Sussex, are found here. On the Royal Military canal, which forms the northern boundary of Pett levels, huge algal mats indicate agricultural run-off in the area. NWM does not recall any algal mats here. On the positive side, *Erythromma viridulum*, a recent immigrant to the UK, is very common on these mats.

*Camber Sands* (TQ 955185) - NWM found *L. dryas* plentiful in 1945 in this most easterly site in East Sussex. Much development has taken place here and it is now the site of a water sports centre. There are still dykes in this area; these have been widened to improve drainage and there appears to be little available habitat. Most of the dykes are brackish with extensive algal mats (*Enteromorpha* sp.) which harbour good populations of *E. viridulum*.

**Camber Castle and Rye Harbour Local Nature Reserve** (TQ 925185) – This extensive area to the west of the Rother Estuary is a complex of drained marshes and shingle habitats with temporary and permanent pools. NWM observed at least one *L. dryas* on the marshes at Camber Castle. The fields here were much like other habitats. Sedges (*Scirpus* spp.) were dominant in the ditches where *L. dryas* was present and there was much water crowfoot (*Ranunculus* spp.). These marshes are now very dry and intensively sheep grazed. The ditches are deep and either choked or quite clear of macrophytes. The shingle pools adjacent the sea were visited by NWM in the late 1940s but he found no *L. dryas*. The area has been transformed by gravel extraction and now forms the Rye Harbour Local Nature Reserve. The pools are very brackish and subject to regular inundations from the sea. The vegetation is mainly Common Reed (*Phragmites communis*) with extensive areas of Sea Club-rush (*Bolboschoenus maritimus*). DGC visited this area with John Luck following the report of a potential sighting of *L. dryas* on 11 August 2006 in an area comprising shallow brackish pools heavily choked with sea Club-rush. The photograph was examined by many observers and the general consensus is that it was a female *L. dryas*. Further searches in the area in 2006 and in 2007 have failed to locate any additional occurrences.

#### Catchment 8 - River Rother

This is the largest river in the region and the one that has suffered the greatest changes, indeed, the marshes at Bodiam mentioned above had been drained by May 1946. In addition to the raising of the banks and clearance of ditches, a full pumped drainage system was installed in the late 1960s. The pumping station at Iden (TQ 915255) extracts water from deep ditches that collect from subsidiary channels. Water level is maintained by pumping from the main ditches into the steeply banked river. This system provides control of the water table in the area, thus permitting arable crops to be grown in the river valley. The system largely eliminates flooding from the area. The water levels in the ditches are no longer maintained throughout the year. As a result, the rich aquatic flora has disappeared along with L. dryas. The ditches that remain are large and covered in algal mats and, as with much of the region, now populated by Erythromma viridulum. The impact of the pumped drainage is profound. In the Bodiam area (TQ 805255) some 12 km west of the Iden pumping station there are ditches in excess of 3.0m deep with but a trickle of water that is almost impossible to see through the choking vegetation. In 1940 and 1941 NWM recorded L. dryas from these ditches and there were quite a number present; at least as many as L. sponsa. Other L. dryas were observed upstream only a few yards from Bodiam castle.

## Discussion

Lestes dryas still occurs in southern England. It is most common in coastal marshes in Kent and Essex where it breeds in rather different habitat from that which it inhabited in Sussex in the 1940s. The Sussex sites were almost exclusively inland, not brackish and with a widely diverse aquatic flora not dominated by sea Clubrush (*Bolboschoenus maritimus*) as is the case in Essex and Kent. In addition, the Sussex sites were in permanently wet ditches. This unimproved inland floodplain habitat favoured by *L. dryas* in Sussex in the 1940s is today almost impossible to locate in south east England, although Amberley Wild Brooks (TQ035145) is such an area on the River Arun in West Sussex. In 1975 Amberley was threatened by a pumped drainage scheme similar to that on the River Rother. This would have converted the grazing marshes to arable land with a catastrophic reduction in biodiversity. Thanks to the efforts of the Sussex Wildlife Trust and local residents



Plate 4. Amberley Wild Brooks, West Sussex.



Plate 5. River Rother, Iden, East Sussex.



Plate 6. River Brede floodplain, Brede Waterworks.

the scheme, which went to public enquiry, was turned down and today the Wild Brooks remain unimproved and biologically rich (Plate 4). The tightly grazed pastures with scattered clumps of rushes must be as close as can be found in the southeastern corner of Britain to the appearance of the valleys of the Brede, Tillingham and Rother in the 1940s. Amberley Wild Brooks is in marked contrast to the sterile dryness of the Rother and Brede valleys (Plates 5 & 6). Ditches are still present in the Rother and Brede but they are either completely choked or deep and covered with algal mats; any marginal wet habitats have long since disappeared and arable crops can be seen almost down to the rivers' edges.

Early maps of the area show that the rivers described in this survey were much more extensive and broader than in the 1940s and later. Much of the undrained land bordering them must have been saline. If *L.dryas* was present in those days it would have occurred in habitats similar to those which it occupies in North Kent and Essex today. It appears that, as the rivers became canalised and the land was drained, the ditches became progressively less saline and *L.dryas* became adapted to the freshwater conditions present in the 1940s.

L. dryas was probably extinct in Sussex by the early 1950's. The records were so old that L. dryas demanded only brief mention in the form of a postscript in Belden et al. (2004). The origin of the population is unknown; it was probably present for many years prior to its discovery by NWM in 1940. The nearest colonies today are along the Thames estuary. The 2006 record of L. dryas at Rye Harbour demonstrates that windblown insects do occur and it is possible that Rye Harbour is where the colonisation originated. The largely unimproved floodplains of the Rivers Brede, Tillingham and Rother provided excellent habitat and supported a thriving stem population that would have migrated into surrounding woodland pools, ultimately colonising Powdermill Reservoir. The general improvement of drainage systems after the Second World War would have led to the reduction in quality of these habitats and would largely explain the extinction of L. dryas in East Sussex by the early 1950s. Later, pumped drainage of the Rother guarantees that these wetlands will not re-appear.

**Postscript provided by DGC.** Some of the footpaths through the now arid lands of the Rivers Rother and Brede have information panels. We quote with reference to the River Rother. "The latter is an important site rich in wildlife. Frogs can be heard calling in June." In 2006 DGC heard no frogs and saw only mallard. Perhaps the site of a few common birds now justifies the term "rich in wildlife". In the authors' opinion the current situation represents a huge impoverishment of biodiversity. *L. dryas* no longer occurs in these habitats and nor do the Yellow Wagtail, Shoveler and Snipe that were common in the 1940s. The removal of marginal habitats reduces biodiversity and leads to an increasingly monotonous world.

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Received 5 September 2008, revised and accepted 18 October 2008

## Species Review 1:

The Small Red Damselfly *Ceriagrion tenellum* (de Villers) and its close relative the Turkish Red Damselfly *Ceriagrion georgifreyi* (Schmidt)

## PAUL HOPE

2 English Bridge Court, Wyle Cop, Shrewsbury, Shropshire, SY1 1XH

## Summary

This review deals with the Small Red Damselfly *Ceriagrion tenellum* (de Villers), a widespread species in Europe, with Britain and Ireland at the northern end of its range. It also looks at its close relative, the Turkish Red Damselfly *Ceriagrion georgifreyi* (Schmidt), only discovered in 1953 and confined to a narrow fringe along the Mediterranean from Israel to southwest Turkey and three Greek islands.

## Introduction

The genus Ceriagrion belongs in the family Coenagrionidae and the sub-family Nehalenniinae. There are 12 species belonging to the Coenagrionidae resident in Britain and Ireland with Pyrrhosoma nymphula and Ceriagrion tenellum representing the red/black coloured species. Before being placed in the genus Ceriagrion, C. tenellum had a variety of names. It was described by de Villers (1789) and given the name Libellula tenella with the type locality given as France. Vander Linden (1823) gave it the name Agrion rubella and later Stephens (1835) named it Agrion rufipes. The genus Ceriagrion was instituted by Selvs (1876), who renamed the species Ceriagrion tenellum and he also described three female variants – f. erythrogastrum, f. intermedium and f. melanogastrum, as distinct from the most common one, f. typica. To further complicate matters, Kennedy (1920) named the genus Palaeobasis and Longfield (1937) used the name Palaeobasis tenella in her book on the dragonflies of the British Isles and also mentioned that some authors in Britain used the name Pyrrhosoma tenellum for the species (to which the only real similarity with P. nymphula is the red colouration), whereas on the continent it was known as Ceriagrion tenellum.

*Ceriagrion georgifreyi* was discovered at Sariseki (type locality) in Hatay province by Schmidt (1953) who described it as a subspecies of *C. tenellum* and named it *C. t. georgifreyi*. Both Dumont (1977) and Demirsoy (1982) also considered it to be a

subspecies. It was accorded full species status by Davies & Tobin (1984) but it was not until Schneider (1986) described the structural differences in both male and female between *C. tenellum* and *C. georgifreyi* that it became generally accepted as a separate species. Askew (1988) noted that it is found in Turkey and in Syria (north of the Jordan valley); Dijkstra (2006) states that it is "found in a narrow fringe along the Mediterranean from Israel to southwest Turkey" and on at least three Greek islands. A subspecies of *C. tenellum*, *C. t. nielseni* was also described by Schmidt (1953) and is noted in Davies & Tobin (1984) and is reported by Askew (1988) to occur in Sicily with its type locality in Lentini but is not mentioned by Dijkstra (2006).

## The Small Red Damselfly Ceriagrion tenellum

## Description

The Small Red Damselfly *Ceriagrion tenellum* is one of two red damselflies that occur in Britain. It is some 15% shorter than the Large Red Damselfly *Pyrrhosoma nymphula* (Smallshire & Swash, 2004). The male has a body length of 25-32mm and the female 29-34mm (Askew, 1988). In the male the abdomen is blood red, the thorax is bronze-black on top, with only the slightest hint of pale antehumeral stripes, and yellow on the sides with two broad black stripes. The legs are yellowish brown to reddish brown; the eyes and pterostigma are red.

Of the four female morphs described by Selys (1876), one, f. erythrogastrum, is an androchrome, resembling the male. The other three are gynochromes. F. typica has a bronze-black abdomen with S1-3 and S9-10 mostly red, f. melanogastrum has an almost entirely dark abdomen with the segmental divisions being pale and the last three reddish, and f. intermedium is largely red but has variable black markings, lying between f. melanogastrum and f. typica. A fifth female morph was described by Papazian (1988) which is very similar to f. typica but the red extends further back, the black starting at the base of the fourth abdominal segment. Andrés & Cordero (1999) have shown that, in populations in Galicia (northwest Spain) the female colour morphs are controlled by a single autosomal locus and that the dominance hierarchy is typica > melanogastrum > erythrogastrum.

The larva is short and squat with a distinct broad, angular head. It is 16-17mm in length, when fully grown. The lamellae are short and broad with faint blotches.

## Distribution

Ceriagrion tenellum is widespread in the western Mediterranean and extends into

northern Europe where it is locally common. It is most plentiful in southwest Europe where it is widespread in Spain (including Majorca), southern and western France (including Corsica) and Italy (including Sardinia). It is only local in southern England and Wales and in Belgium, Holland, Germany, Switzerland, Austria, Hungary, Romania and Yugoslavia (Askew, 1988) (Fig. 1).



Figure 1. Distribution of *Ceriagrion tenellum* (purple) and *C. georgifreyi* (green). A red cross indicates an isolated, extinct population of *C. tenellum*. Reproduced with permission from Dijkstra & Lewington (2006) *Field Guide to the Dragonflies of Britain and Europe*. British Wildlife Publishing, Gillingham.

In Britain, Longfield (1937) stated that *C. tenellum* is only found in the southern counties of England: Berkshire, Cornwall, Devon, Dorset, Hampshire, Surrey and Sussex with outposts in Cambridge and two more in Wales, in the counties of Caernarfon and Merioneth. In some of these places it was reported as being locally abundant but in general it was regular but sparse. She mentioned that there are two female forms in Britain (but more in other parts of Europe), which she described but attached no name to them. From her descriptions it is obvious that they were f. *melanogastrum* and f. *typica*. Parr & Parr (1979) mentioned that the species is restricted in Britain to areas adjacent to the southern seaboard but with outposts in Norfolk, Surrey, Sussex, Hampshire, Gwent and coastal Wales. McGeeney (1986) noted that it is locally common in southwest Britain, but on the heathlands of Surrey, Sussex, Hampshire and Dorset the species is increasingly threatened. Askew (1988) indicated that it is local in southern England and Wales, extending as far north as Anglesey and his distribution map includes a location in Norfolk. Brooks (1997a) confirmed that *C. tenellum* is restricted to southern

England and Wales where it may be locally abundant; his map indicates a more disjunct distribution than is indicated in Askew (1988) but also shows that it extends as far north as Anglesey. Brooks (1997a) noted that it is at the extreme northwestern limit of its range, suggesting that climatic factors restrict its distribution here. He gives details of sites where C. tenellum can be observed, including Dartmoor, Aylesbeare Common in Devon, the Somerset Levels, Moors Valley Country Park in Dorset, Upper Crockford Stream and Ober Water in the New Forest, Hartley Wintney in Hampshire, Wishmoor Bottom in Berkshire, Thursley Common in Surrey, Valley Bogs in Gwynedd (Wales) and Dowrog Common in Pembrokeshire. The last of those mentioned is a stronghold for the species. Smallshire & Swash (2004) described C. tenellum as being nationally scarce and a local species which can be abundant at breeding sites which are often isolated, therefore making it vulnerable to local extinctions. They suggested it is best looked for in the boggy heathlands of Surrey/Hampshire, the New Forest, Purbeck and Pembrokeshire and in old clay workings around Bodmin Moor and Dartmoor. Corbet & Brooks (2008) also refer to its patchy distribution in the south of England and in west Wales and note the isolated population in East Anglia. Although records from 2000 onwards indicate that C. tenellum is still present in most of the counties mentioned by the previous authors, it clearly occupies fewer sites within them, particularly in southwest England and west Wales, and appears to have become extinct in Sussex and Anglesey (Fig. 2) (DRN Database).



Askew (1988) stated that the most common form found in Britain is f. *typica*, with f. *melanogastrum* being uncommon and f. *erythrogastrum* generally rare, while Smallshire & Swash (2004) described f. *erythrogastrum* as uncommon. Askew (1988) noted that f. *intermedium* is only found in mainland Europe. However, this last form appears to be absent from the Iberian peninsula (Jödicke, 1996; Andrés & Cordero, 1999).

## Habitat

The distribution of C. tenellum is determined by the quality of the habitat and it requires sunny sites with shallow, oligotrophic waters. In the south of its range it seems to prefer small streams and seepages (often calcareous) but in the northwest, including England and Wales, it prefers mainly bogs and heathy lakes with peat moss (Sphagnum) and Marsh St John's-wort (Hypericum elodes) (Askew, 1988; Dijkstra, 2006). McGeeney (1986) stated that it is restricted to clean acidic Sphagnum bog, sluggish streams and runnels or pond margins with lush vegetation in the southwest of Britain. It requires very shallow, unshaded water. Askew (1988) stated that in Britain it is only found in acid conditions but Brooks (1997a) noted that it also occurs in base rich sites such as calcareous valley mires, fens or clay or marl pits where unshaded shallow water conditions exist. Ward-Smith & Sussex (2006), working at 16 sites in south-east Berkshire, found that two characteristics applied to each site where C. tenellum was recorded. These were a grassy (Molinia) area close to the water where adults are able to perch, move about and mate, and shallow margins with low-growing vegetation suitable for oviposition. Other sites in the study area included woodland ponds and balancing ponds but these lacked these two characteristics and no C. tenellum were recorded there.

In the northeastern part of its range on the continent the distribution of *C. tenellum* is limited by winter cold (Clausnitzer *et al.*, 2007). The species is restricted to southern Britain, where temperatures are sufficiently high for it to complete its life cycle. It is possible that the effects of global warming are likely to enable it to expand its range northwards.

## Behaviour

Adults flutter weakly, low down, amongst grasses and rushes which border the breeding site, while the sun is out and seem to disappear when the sun becomes obscured by cloud. Despite their red colouration they are very difficult to keep track of for long and seem to just disappear when they perch on low grasses or rushes. Powell (1999) noted that they can be found tucked away on fringing vegetation and that *C. tenellum* uses a hunting technique, also used by other

dragonflies, which involves flying amongst grasses, bumping into them to flush out prey.

**Reproductive Behaviour.** Mating takes place amongst the low grasses and can last from 40-90 minutes. Any intruding males are warned off by wing-flicking (Brooks, 1997a). Oviposition is carried out in tandem and usually into the vertical stems of submerged or emergent plants such as Marsh St John's-wort (*Hypericum elodes*) in shallow water or into Sphagnum moss. The pair often submerges during oviposition (Brooks, 1997a). *C. tenellum* is amongst a group of small Zygoptera that mate-guard, gaining benefit from the sentinel position when the female is ovipositing (Corbet & Brooks, 2008).

Life Cycle. The eggs hatch in about a month and the larvae live amongst Sphagnum mats, detritus and bottom sediments. It takes two years to complete development and the larva enters diapause over the second winter in its penultimate instar stage (Brooks, 1997a). Emergence takes place over a prolonged period, resulting in a flight season which lasts from early June to early September. Longfield (1937) stated that the species has a long season and two or more periods of emergence and egg-laying and that it is at its most plentiful at the end of June, in July and in August. Adults remain faithful to the breeding site and seldom move far from it, which means that they are slow to colonise new sites. Parr & Parr (1979) found that there was a predominance of males (72.7%) at water.

Population studies over two years (3 weeks in August) revealed that, in two populations in 1974, one remained stable at 150 for 7 days before declining over the following two weeks to around 80, the other declining from 130 to 55. In the following year only one population was studied and this declined from 135 to about 30 (Parr & Parr, 1979). Parr & Parr (1979) estimated life expectancy in one of the populations to be about 17.3 days in 1974 but only 8.6 days in 1975. They suggested that the greater decline in numbers and the lower life expectancy in the second year may be because of the warmer, drier summer in 1975, with the species having become adapted to the cooler weather normally found in Britain, whereas presumably the adults are adapted to higher temperatures and drier conditions further south in their range. If indeed this is the case then it cannot be the cooler climate further north that is stopping its advance, rather it has to be the lack of suitable habitat.

**Territoriality and Dispersal.** Moore (in Corbet *et al.*, 1960) carried out an experiment on territoriality in *Ceriagrion tenellum* on Hartland Moor Nature Reserve, Dorset. The area had been used for bombing practice by the RAF and many shell craters had been made. It was in one of these that he constructed an

artificial pond, 9ft<sup>2</sup> with three clumps of rushes at the edge. He caught a varying number of C. tenellum males each day, for a period of 22 days, from a nearby bog pool. Each day these were marked using cellulose paint and then released by his artificial pond. The following day he recorded the dragonflies present and added a further batch. He found that the maximum number of males that the pond could hold was four or five. On two days the number of males was abnormally high but this was put down to those two days being cloudy and with no territorial behaviour shown, as they remained perched amongst the rushes. These experiments were repeated in 1958 with the same results (Moore in Corbet et al., 1960). From this and observations on other species in Dorset he concluded that "each species has its own normal maximum density, which is not much affected by the presence of other species unless they are of similar size and appearance." He also noted that "the smaller the species the greater is its normal maximum density" but that those species that are confined to acidic water such as C. tenellum, were present in higher densities than other similar-sized species. One implication of this is that territorial behaviour reduces the population density of males at the site at which they emerge and initiates local dispersal (Moore in Corbet et al., 1960).

In another experiment, this time on dispersal, Moore (in Corbet*et al.*, 1960) chose two bomb craters on the Dorset heath, some 150yds apart. From each one he caught all the *C. tenellum* (and *I. elegans*) and marked them on the forewings using cellulose paint. He then transferred them to the opposite pond. Out of 119 dragonflies, 43 were caught again where they were released and two found elsewhere. However, none returned to the pond where they were originally caught. He suggested that this was because mature dragonflies show no tendency to home if caught away from their normal roosting area before release.

Parr & Parr (1979) carried out research on *C. tenellum* in the New Forest in Hampshire with the aim of studying distribution and habitat selection, population numbers, survival rates, dispersal movements and reproductive behaviour. The area was chosen because of its ecological importance as probably the last remaining large area of heathland in lowland Britain, large enough to support its characteristic plants and animals, especially *C. tenellum*, which is commoner here than elsewhere in Britain. Their study site was the Ober Heath stream near Brockenhurst where the area was ecologically diverse. In places the stream was up to two metres wide. Some areas were open and others shaded by small or large pine trees. The stream was marked off into sectors over the 1000 m study area, with each sector approximately 85 m long. Over the length of the stream, *C. tenellum* was abundant in those places where the stream was wide and boggy and with a dense growth of Marsh St John's-wort (*Hypericum elodes*). There were fewer present in the shaded sections and almost none where there was a gravel bottom. They found that only 18.6% of males and 16.9% of females changed sectors. This confirmed the view that this species shows little tendency to disperse far from a colonial group.

Males of *C. tenellum* defend small territories and may perch as close as 0.5m from each other on emergent stems, and spontaneous non-feeding flights were observed. These often resulted in aerial fights between two or more males and these fights resulted in spacing the males out within the colony (Kershaw, 1971). Clashes may also occur with other species, such as *P. nymphula* (Brooks, 1997a). Also, Parr & Parr (1979) found that such fights between males did not lead to their relocation out of the colony but merely adjusted their position locally. However, Moore (in Corbet *et al.*, 1960) observed that clashes resulted in some individuals leaving the water. Parr & Parr (1979) explained this difference by suggesting that, later in the season, male population numbers are stable or declining and so territorial clashes do not usually result in distant dispersal, whereas early in the season many more males are joining the flying populations daily and clashes result in distant dispersal.

Parr & Parr (1979) stated that, where habitats are susceptible to dry conditions caused by heat and lack of rain, or by drainage schemes, then the population may easily be depleted or even completely exterminated unless care is taken to conserve key breeding sites. They considered the species well adapted to the English climate, the limiting factor in their distribution being habitat requirements.

Ward-Smith & Sussex (2006) worked on *C. tenellum* in south-east Berkshire between the early 1990's and 2005. Improvements were made to a number of sites in the area. These included the removal of trees and shrubs from around pools, control of water levels by constructing steps of log dams in drainage ditches, construction of satellite pools and introducing cattle to create bog pools. These resulted in increases in the population of *C. tenellum* which had been very sparse. In fact, prior to 1990 there were records from only three sites. In the intervening years they spread to 13 new sites with evidence of breeding at 11 of them. No translocation of adults or larvae took place and the colonization was completely natural. Over a period of 10 years *C. tenellum* spread from the source pond to new sites up to 6km away. This rather contradicts previous statements that the species remains fairly static, rarely moving far from the breeding site.

## Parasites

Ectoparasites are generally visible, particularly the bright red or orange mites (Acarina) which are common on *C. tenellum*, and they attach themselves to the ventral surface of the thorax and abdomen. The egg of the parasite is laid under water and hatches in 1-3 weeks. A six-legged larva emerges and swims about until

it finds a suitable host dragonfly larva to which it attaches itself. When the dragonfly larva emerges, the mites transfer to the adult, where they penetrate the cuticle before it hardens. Here they remain for several days feeding on the host's haemolymph, swelling and becoming shiny red. When gorged they drop off into the water to complete their development Corbet & Brooks (2008). Andres & Cordero (1998) found that 98% of all teneral *C. tenellum* at their study site were parasitized and the parasitic load increased during the season. In one year they studied mature adults and found that heavily parasitized males showed a 25% lower probability of mating than lightly parasitized males. However, in the following year they looked at teneral males and found that parasitism had no effect on subsequent mating success. In both years mites had no effect on female lifetime mating success.

## Conservation

Having looked through the records of *C. tenellum* on the DRN Database it would appear that recent records (since 2000) indicate that there are healthy populations at several sites in each of the following counties: Berkshire, east Cornwall, Dorset, north Hampshire and south Devon. Reports from a smaller number of sites in Buckinghamshire, Camarthenshire, Caernarvonshire, Cardiganshire, Merionethshire, north Devon, north Somerset, Oxfordshire, Pembrokeshire and south Hampshire indicate that populations are isolated and under threat. The last record from Anglesey was in 1983 and from Cambridge 1938, east Norfolk 1939, east Suffolk 1950 and east Sussex 1995. It would be interesting to see if some form of management on sites with few recent records could increase population size; also if global warming will have any effect and enable the species to move northwards.

With its centre of distribution in the Mediterranean region *C. tenellum* has had limited success in Britain, where it is at the extreme limits of its ecological tolerance. Indeed, Parr & Parr (1979) stated that observations in the U.K. may not be typical of the species in Europe due to its U.K. habitats being sub-optimal. It has been lost from several sites where it once occurred for various reasons but mainly habitat degradation. Thus it may be adversely affected by eutrophication, afforestation, shading, lowering of the water table, dredging and industrial scale peat extraction (Brooks, 1997a; Corbet & Brooks, 2008) and indeed peat extraction has lead to its disappearance from the Somerset Levels (Merritt *et al.*, 1996; Brooks, 1997b). As several authors have pointed out, specific conditions have to exist for it to succeed, and in many places this can only be achieved by habitat management. This can be seen in south-east Berkshire, where conservation work involving the provision of a network of suitable sites within the local dispersal area has shown that individuals will move away from degraded sites and produce a more dispersed metapopulation

in an area that was previously vulnerable (Ward-Smith & Sussex, 2006).

## The Turkish Red Damselfly Ceriagrion georgifreyi

## Description

It is only possible to separate *Ceriagrion georgifreyi* from *C. tenellum* by close examination using a x10 lens. *C. georgifreyi* is slightly longer than *C. tenellum* (*C. tenellum* length 25-35mm, hind wing 15-21mm. *C. georgifreyi* length 35-40mm, hind wing 17-20mm (Dijkstra, 2006)).

In male *C. georgifreyi* the main difference is that the slightly raised dorsal tip of S10 bears a crown of black spines, whereas *C. tenellum* does not have these spines (Fig 3). In female *C. georgifreyi* there are two conspicuous upright lobes on the thorax, just behind the pronotum. These are higher than the hind rim of the pronotum whereas in *C. tenellum* these lobes are inconspicuous (Fig. 4) (Schmidt, 1953;



Plate 1. Scanning electron microgaphs of the male anal appendages (lateral view) of a) Ceriagrion georgifreyi and b) C. tenellum. Note the dorsal spines in C. georgifreyi. Scale 100μm. Photographs courtesy V. J. Kalkman (2005).



**Plate 2.** Scanning electron micrographs of the female prothorax (dorsal – slightly anterior – view) of a) *Ceriagrion georgifreyi* and b) *C. tenellum*. Note the two lobes behind the hind rim of the pronotum in *C. georgifreyi*. Scale 100µm. Photographs courtesy V. J. Kalkman (2005).

## Schneider, 1986; Dumont, 1991; Kalkman, 2006).



**Plate 3**. Female *Ceriagrion georgifreyi* f. *typica*. Photograph courtesy Roy Woodward.



**Plate 5**. Teneral male *Ceriagrion georgifreyi*. Photograph courtesy Roy Woodward.



Plate 4. Male *Ceriagrion georgifreyi*. Photograph courtesy Roy Woodward.



Plate 6. Female *Ceriagrion georgifreyi* f. *erythrogastrum*. Photograph courtesy Roy Woodward.



Plate 7. Female Ceriagrion georgifreyi f. melanogastrum. Photograph courtesy Roy Woodward.



Plate 8. Pronotum of female *Ceriagrion georgifreyi* f. *melanogastrum*. Photograph courtesy Roy Woodward.

Until recently only two female forms of *C. georgifreyi* had been described, f. *typica* and f. *erythrogastrum* (Dijkstra, 2006). The finding of a third female form f. *melanogastrum* is described below under 'Observations'.

## Distribution

*Ceriagrion georgifreyi* is found in a narrow strip along the Mediterranean from Israel to south-west Turkey (Koycegiz), also on the Greek islands of Thasos, Zakinthos

and Kerkira (Corfu) (Dijkstra, 2006). Thasos is at the northern end of the Aegean Sea, about halfway between Turkey and Greece; the other two islands are in the Ionian Sea to the west of Greece (Fig. 1).

## Habitat

The habitat of *C. georgifreyi* is basically the same as for *C. tenellum* (seepages and small streams) and its flight season is from the beginning of May to the end of September (Dijkstra, 2006). During my research on the species I have found that it extends into early November (3<sup>rd</sup> November) (Hope, 2007).

## The history of C. georgifreyi in Turkey

Twentyfive percent of the known distribution of *C. georgifreyi* lies within Turkey but its range within this country is limited (Fig. 3). Knowledge of its distribution is considered good but its habitat preferences are poorly known (Kalkman & van Pelt, 2006a,b). Recent recording of *C. georgifreyi* in Turkey has revealed sites in Icel (4), Antalya (3), Mugla (2), Burdur and Hatay (Kalkman *et al.* 2004b; Kalkman & van Pelt, 2006b). Kalkman *et al* (2004a) discovered four sites for this species at Koycegiz and one at Esen. All these records were new to the area and the Koycegiz sites are the westernmost records from Turkey to date. I discovered a new site for *C. georgifreyi* at Calis (Fethiye) in October 2004 (Hope, 2007) and a further two in June 2008 at Inlice (Gocek) and Dalaman (Hope, 2008). All these sites are east of Koycegiz (Fig. 3).

## Observations

Whilst leading a dragonfly tour in south-west Turkey in June 2008, a new site for *C. georgifreyi* was discovered at Dalaman. The location was a wide area of *Juncus sp.*, with the ground being wet and muddy, alongside Lake Alagol which is fringed with *Phragmites australis*. Walking through the *Juncus* towards the lake, we disturbed several *C. georgifreyi* which flew low amongst the rushes. The population at the site proved to be the largest so far discovered in the region.

Amongst the males were several females, f. *typica* and f. *erythrogastrum* forms. The species was a first for the group and they were keen to record the discovery on camera. Roy Woodward discovered a hitherto undescribed all black female, which we have named f. *melanogastrum* in line with the corresponding form of *C. tenellum*. He was able to photograph it in great detail. The dorsal surface of the abdomen, except for intersegmental incisures, is almost entirely bronze-black. The legs are the same colour as in the other morphs, i.e. yellow to reddish.



Figure 3. Records of *Ceriagrion georgifreyi*. a) Turkey; b) details of Mugla Province.
, records from Kalkman & van Pelt (2006b) and Hope (2007, 2008);
, record from Lopau (1991) (site since destroyed).

## Conclusions

The sighting of *f melanogastrum* was reported to the National Museum of Natural History, Leiden, The Netherlands (European Invertebrate Survey). It has been thought for a while that, if the closely related species *C. tenellum* has four female forms, then it is highly likely that *C. georgifreyi* has a similar number (Dijkstra, 2006). Before this sighting only two female forms were known to exist. During my research into the dragonflies of the region, the sites where *C. georgifreyi* has been recorded have had small populations with only two female forms observed. The Dalaman site was much larger than any previously recorded and therefore there was a greater chance of finding f. *melanogastrum* if it existed. The search to find the possible fourth form, f. *intermedium* will continue.

#### Acknowledgement

I am grateful to Roy Woodward, who found *Ceriagrion georgifreyi* f. *melanogastrum*, for allowing me to use his photographs.

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Received 30 October 2008, revised and accepted 23 November 2008.

## Revised list of Odonata recorded in the United Kingdom

## PAM TAYLOR<sup>1</sup>, DAVE SMALLSHIRE<sup>2</sup> & ADRIAN PARR<sup>3</sup>

<sup>1</sup> Decoy Farm, Decoy Road, Potter Heigham, Norfolk, NR29 5LX

<sup>2</sup> 8 Twindle Beer, Chudleigh, Newton Abbot, TQ13 0JP

<sup>3</sup> 10 Orchard Way, Barrow, Bury St Edmunds, Suffolk IP29 5BX

## Summary

The Trustees of the British Dragonfly Society recently decided that the species list used in all BDS publications should follow the same systematic order. Additionally it was felt that a system of categories for UK species is needed. The Odonata lists presented below follow the taxonomic sequence of Davies & Tobin (1984, 1985) and employ similar groupings to the example set by the British Ornithologists' Union Records Committee for its bird list, although it has not been sensible to use exactly the same categories.

## Introduction

Whilst scientific names are generally well established, their taxonomic sequence has been debated over the years and a wide variety of arrangements is currently seen in publications, even within our own Society. Constructing new species lists for any purpose frequently poses the question as to which order to use, so it has been decided to standardize the sequence, at least within future BDS publications.

To the best of our knowledge the first fully comprehensive, published world list of odonate species was produced by Davies and Tobin (1984, 1985). Within each suborder the scheme lists the superfamilies alphabetically, then the families within the superfamilies, and so on down through each level to species. Appropriate parts of this list were vetted by a number of taxonomists, including Henri Dumont, Robert Gambles, Bastiaan Kiauta, Maurits Lieftinck, Angelo Machado, Dennis Paulson and Minter Westfall. New species continue to be described and more recent lists have followed the same pattern as Davies & Tobin (1984, 1985). Thus Garrison (1991) produced a list of New World species and, more recently, a world dragonfly list, also following this scheme, including the alphabetic sequence within Genera, has appeared on the website of the Slater Museum of Natural History, University of Puget Sound (Schorr *et al.*, 2008). Thus it seems logical for the BDS to follow the same order of species.

Having agreed the overall sequence, the decision was made to revise the categories

used to describe each species' current status within the UK. Some former migrants can now be considered as established colonists, whereas the number of vagrants continues to increase. Category A species (Table 1) are either resident or not of sufficient rarity to be considered by the Odonata Records Committee (ORC). However records for species currently listed in Category B (Table 2) or rarer (Tables 3-5) do need to be submitted to the ORC for their consideration before the record can be accepted.

## The revised list and categories

This list comprises all species that have been recorded in Great Britain and Northern Ireland (i.e. the geographic region covered by the BDS) at 31 December 2008. It excludes a record of Blue Dasher *Pachydiplax longipennis* from an oil rig 140km east of the Shetlands in 1999. Vernacular names are those recommended by the BDS (Mill *et al.*, 2004); the names for species not included in that list are those used by Dijkstra & Lewington (2006) or (for Category E) various local sources.

It is envisaged that species will move between categories if their status changes. Thus a current vagrant that becomes a regularly recorded migrant will move from Category B to Category A, as Lesser Emperor *Anax parthenope* has already done. Similarly should any species that is on the Channel Islands only list have a record accepted from mainland Britain, then it would move from Category D to Category B. Winter Damselfly *Sympecma fusca* achieved this in December 2008. Movement between categories will be recommended by the Odonata Records Committee and agreed by the Dragonfly Conservation Group and BDS Trustees.

**Table 1. Category A: resident and/or migrant species recorded since 1970** This category comprises species with well-established breeding populations and migrant species that have been recorded regularly since 1970, the latter often attempting to establish temporary breeding populations.

> Calopteryx splendens Calopteryx virgo Lestes dryas Lestes sponsa Coenagrion hastulatum Coenagrion lunulatum Coenagrion mercuriale Coenagrion puella Coenagrion pulchellum Erythromma najas

Banded Demoiselle Beautiful Demoiselle Scarce Emerald Damselfly Emerald Damselfly Northern Damselfly Irish Damselfly Southern Damselfly Azure Damselfly Variable Damselfly Red-eyed Damselfly

Ervthromma viridulum Pyrrhosoma nymphula Enallagma cyathigerum Ischnura elegans Ischnura pumilio Ceriagrion tenellum Platycnemis pennipes Aeshna caerulea Aeshna cyanea Aeshna grandis Aeshna isosceles Aeshna juncea Aeshna mixta Anax imperator Anax parthenope Brachytron pratense Gomphus vulgatissimus Cordulegaster boltonii Cordulia aenea Somatochlora arctica Somatochlora metallica Leucorrhinia dubia Libellula depressa Libellula fulva Libellula quadrimaculata **O**rthetrum cancellatum **O**rthetrum coerulescens Sympetrum danae Sympetrum flaveolum Sympetrum fonscolombii Sympetrum sanguineum Sympetrum striolatum\*

Small Red-eved Damselfly Large Red Damselfly Common Blue Damselfly Blue-tailed Damselfly Scarce Blue-tailed Damselfly Small Red Damselfly White-legged Damselfly Azure Hawker Southern Hawker Brown Hawker Norfolk Hawker Common Hawker Migrant Hawker Emperor Dragonfly Lesser Emperor Hairy Dragonfly Common Club-tail Golden-ringed Dragonfly Downy Emerald Northern Emerald Brilliant Emerald White-faced Darter Broad-bodied Chaser Scarce Chaser Four-spotted Chaser Black-tailed Skimmer Keeled Skimmer Black Darter Yellow-winged Darter Red-veined Darter Ruddy Darter Common Darter\*

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

#### Table 2. Category B: vagrant species

Since 1998 records of these species have been assessed by the Odonata Records Committee.

Lestes barbarus\*\* Lestes viridis\*\* Sympecma fusca Southern Emerald Damselfly\*\* Willow Emerald Damselfly\*\* Winter Damselfly

Aeshna affinis	Southern Migrant Hawker
Anax epiphigger	Vagrant Emperor
Anax junius	Green Darner
Gomphus flavi pes	Yellow-legged Club-tail
Leucorrhinia pectoralis	Large White-faced Darter
Crocothemis erythraea***	Scarlet Darter***
Sympetrum pedemontanum	Banded Darter
Sympetrum vulgatum	Vagrant Darter
Pantala flavescens	Wandering Glider

\*\* Has bred. \*\*\* Has bred in the Channel Islands.

## Table 3. Category C: former breeding species not recorded since 1970

Any further records of these species will be assessed by the Odonata Records Committee.

Coenagrion armatum	Norfolk Damselfly
Coenagrion scitulum	Dainty Damselfly
●xygastra curtisii	Orange-spotted Emerald

#### Table 4. Category D: species recorded only in the Channel Islands

Orthetrum brunneum	Southern Skimmer
Sympetrum meridionale	Southern Darter

## Table 5. Category E: exotic species introduced accidentally

These records have come principally from aquatic nurseries (Parr, 2000).

Ar gia fumipennis	Variable Dancer
Ceriagrion cerinorubellum	Painted Waxtail
Enallagma signatum	Orange Bluet
Ischnura posita	Fragile Forktail
Ischnura senegalensis	Common Bluetail
Anax gibbosulus	Green Emperor
Anax guttatus	Lesser Green Emperor
Crocothemis servilia	Oriental Scarlet
Erythemis simp <b>li</b> cicollis	Eastern Pondhawk
Rhodothemis rufa	Spine-legged Redbolt
Tramea transmarina euryale	Ocean Glider
Urothemis bisignata	

#### References:

- Davies, D. A. L., & Tobin, P. 1984. The dragonflies of the world: A systematic list of the extant species of Odonata. Vol. 1. Zygoptera, Anisozygoptera. Societas Internationalis Odonatologica Rapid Communications (Supplements) 3: 1-127.
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Received and accepted 23 January 2009

#### INSTRUCTIONS TO AUTHORS

- Authors are asked to study these instructions with care and to prepare their manuscripts accordingly, in order to avoid unnecessary delay in the editing of their manuscripts.
- Word-processed manuscripts may be submitted in electronic format either on disk or by e-mail.
- Manuscripts should be one and a half-spaced, on one side of the page only and with margins at least 25mm on both sides and top and bottom. Footnotes should be avoided.
- Use of these terms is acceptable: `exuvia' for cast skin (plural: `exuviae'); `larva' (instead of `naiad' or `nymph'}; `prolarva' to designate the first larval instar.
- Dates in the text should be expressed in the form: 24 July 2009.
- 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 the following forms: Hammond, C. 0. 1983. The Dragonflies of Great Britain and Ireland 2nd edition (revised by R. Merritt). Harley Books, Colchester, 116 pp.
  - Longfield, C. 1949. The Dragonflies of the London area. The London Naturalist 28: 90-98.
  - Titles of journals should be written out in full.
- Tables should be presented on separate, unnumbered pages.
- Legends for figures should be presented together in sequence on a single, unnumbered page. Figures should be prepared in black ink, and scaled to allow a reduction of 1.5 to 3 times.
- The legend for each table and illustration should allow its contents to be understood fully without reference to the text.
   Please refer to a recent issue of the journal for further style details.

#### SCIENTIFIC AND ENGLISH NAMES OF BRITISH ODONATA

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

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

Norfolk Hawker

Species list in accordance with Davies, D. A. L. & Tobin, P. (1984 & 1985) The Dragonflies of the World: A systematic list of the extant species of Odonata. vols 1 & 2. Societas Internationalis Odonatologica Rapid Communications (Sapplements) 3 & 4

Pantala flavescens

Wandering Glider

Registered Charity No. 800196

Aeshna isosceles

J. Br. Dragonfly Society, Volume 25 No. 1, April 2009

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