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Front cover illustration: Large Red Damselfly *Pyrrhosoma nymphula* at Glen Ogle, Scotland, 19 June 1996, by Gill Brook

Red-veined Darters *Sympetrum fonscolombii* at Lound, Nottinghamshire in 2006

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Summary

684 Red-veined Darters *Sympetrum fonscolombii*, 94 mature adults and 590 second generation adults, were recorded at the Lound gravel pits complex, Nottinghamshire, from 25 June to 23 October 2006. All except 20 were recorded from around a shallow pit.

Introduction

The Red-veined Darter, *Sympetrum fonscolombii*, is widespread over southern Europe and north-west Africa. It is a migrant species and has often occurred further north in Europe, particularly during 'invasion' years, and it has become more common in recent years (Dijkstra, 2006). It frequently migrates as far as Britain, with major migrations having been reported in 1992, 1996, 1998, 2000 and 2002 (Parr, 1999, 2001, 2003; Brooks, 2004) and, although it has bred in England, most colonies disappear after a few years (Brooks, 2004), although Brooks noted that "there are currently breeding colonies in Kent and Cornwall that have been maintained over the last 3–5 successive years" (Brooks, 2004). Pellow (1999, 2000, 2001) has given details of one such site near Trerulefoot in south-east Cornwall, where he recorded 1,475 second generation emergences in 1998 but noted a considerable reduction in numbers (38) in 1999, with some indication of a recovery (338) in 2000. The number of adults seen in early summer in these three years was 50, 5 and 20 respectively. Indeed, 1999 was a "relatively poor year for *S. fonscolombii* in Britain" (Parr, 2000).

Records of adults were received from 35 sites in England in 2000, the furthest north being in County Durham (Parr, 2001). There were no spring emergences noted and the only autumn ones recorded were those in Cornwall mentioned above. 2001 was a fairly quiet year and Parr (2002a, b) noted that a regular pattern seemed to be developing with peaks of immigration in alternate years. In 2002, adults were recorded from 50 sites with the furthest north being in North Yorkshire. Mating and oviposition were seen at a number of sites and small numbers of second generation emergents were recorded from five sites (Cornwall, Wiltshire, Worcestershire, Hampshire and Norfolk) but numbers were low (Parr, 2003). Autumn emergence following spring breeding appears to be general in southern England (Parr, 1999; Pellow, 1999) but there may be a one-year

development in the north (Parr, 1999). In 2003 good numbers were recorded (Parr, 2004) and hence the trend of alternate good and poor migration years was broken. A few spring emergences were seen at two sites but second generation emergences were rather low in numbers (Parr, 2004). 2004 was a generally poor year (Parr, 2005) but there was a better immigration in 2005, particularly in the north of England, although no second generation emergences were reported in that year (Parr, 2006).

Prior to 2006 there have been only two previous sightings of Red-veined Darter in Nottinghamshire. The first, a mature male at Lound gravel pits, was found by D. Hursthouse settled on the pathway leading to the lookout point at Chainbridge Lane Nature Reserve on 16 July 2002. It was present for about 20 minutes before flying off into the confines of the reserve but was seen again by another fortunate observer.

The second record, a female at Attenborough, was found by A. O. Aitken on the edge of Clifton Pond at Attenborough Nature Reserve on 28 June 2004, remaining until 29 June. This latter identification was confirmed by other observers and excellent photographs were obtained.

Study Site

Lound gravel pits (British National Grid Reference SK705865) are part of the large complex of ponds situated alongside the River Idle between Retford and Mattersey in north Nottinghamshire. The ponds were formed through the extraction of sand and gravel which began during the 1960s and extraction is still taking place under the management of the principal landowner, Tarmac Limited.

Other modest commercial and agricultural interests are to be found within the area but, by and large, there is little disturbance and as a rule the ponds are unaffected, though there are a variety of leisure activities, including wind-surfing, water-skiing and fishing, and the entire site is well known for bird-watching, with an established local bird-watching club (Lound Bird Club).

A number of ponds have been set aside for nature conservation and during 2006, under the supervision of the Nottinghamshire Wildlife Trust, restoration work began on the larger ponds to re-contour banks, form shallow sides and build raised vantage lookout-points.

At present 360 hectares have been designated SSSI and in the near future the designated areas will become the responsibility of the Nottinghamshire Wildlife Trust.

The main area of study consisted of a shallow, saucer-shaped pit (Pit-A) that has no sudden drops in depth and, when full, has a water depth of about 80cm but during the unusually hot early summer of 2006 there was considerable evaporation and for much of the survey the depth was between 45–50cm. No floating or protruding vegetation was obvious but patchy beds of weed were clearly visible along the bottom.

The circumference of the shoreline measures 1441m, 1173m dominated by a sandy/shingle margin 2–4m wide, in places supporting clumps of soft-rush (*Juncus effusus*) mixed with other vegetation. The remaining 268m, mainly concentrated along two banks, support a 2–7m wide bed of phragmites broken in places by the sandy/shingle margin. Away from the shoreline, banks 6–20m wide with grasses up to a height of 60cm are dominant and are crisscrossed with eroded, bare sandy-earth animal pathways and some substantial rabbit-scoured patches. Immediately beyond the pit boundary fence, there is rank vegetation dominated with tall grasses, established bushes, trees (gorse, oak, pine, willow,

Results and Discussion

Searching the foreshore of the shallow gravel pit (Pit-A) within the large gravel pits complex at Lound, Nottinghamshire, on 25th June 2006 an adult male Red-veined Darter *Sympetrum fonscolombii* was found. A pleasing find but, although it was beginning to look like a very good year for the species with many reports of sightings from the neighbouring county of Yorkshire, no other individuals had been reported from the

Plate 1. Mature male Red-veined Darter *Sympetrum fonscolombii* photographed on 25 June 2006. Note the red veins near the wing bases, the yellow patch at the base of the hind wings, the black border around each pterostigma and the red face.

complex. It was still early (0930) with an air-temperature of 14°C and an encouraging forecast for the day. This prompted me to search other pits but by late morning only the usual common species, now reasonably plentiful, had been found so I returned to Pit-A hoping to have better fortune. Following the same route around the pit, 48 adult male Red-veined Darters *S. fonscolombii* were now present. A second circuit, carefully searching the bank from within 10m of the waters edge, improved on the previous count with 79 males and one adult female being seen. The female was in tandem with a male over the water. This good day encouraged further visits and a maximum of 80 adult males (Plate 1) and 12 adult females were recorded, although it was probably present than this. The last recorded were four adult males on 25 July. In addition, a further two adult males were found at other pits within the complex, one on 29 June at Pit-B, the other on 12 July at Pit-C.

Most adult male Red-veined Darters, *S. fonscolombii*, territories around bare earth patches, mainly along the animal-track pathways within 10m of the water, or on the sandy/shingle margin along the water's edge. Rarely were any seen in the vegetation. Defence of the territory was like that of the Common Darter, *Sympetrum striolatum*, with males aggressively chasing off intruding males, but at times up to three males were seen in close association, settled on bare earth within a linear metre.

Females were seen in tandem with males over water and only occasionally settled. When they did settle they were mainly hidden in vegetation. The only unattached female seen was on 1 July and she was close-inshore ovipositing.

No further visits to Pit-A were made until 25 August when, during a routine visit, I was confronted by three dragonflies, clearly teneral darters ('*Sympetrums*') but brighter looking than the Common Darter, *S. striolatum*, with yellow forewing veins. At the time I was not exactly sure what species I had seen but managed to take a reasonable digital image of one that, on examination later at home, strongly indicated a teneral male Red-veined Darter, *S. fonscolombii*. The suggestion of a second-generation Red-veined Darter, *S. fonscolombii*, however, was confusing, not being aware at the time that they could emerge in such a short period after egg-laying.

After completing a circuit of the pit on 28 August a further 19 bright tenerals were seen. Of these 12 were definitely males and six of them were photographed digitally, but no females were present and only one teneral Common Darter, *S. striolatum*, was seen. Studying the images, in addition to consulting literature and discussion with associates, confirmed that these were second-generation Red-veined Darters, *S. fonscolombii*. On a further visit to Pit-A with two associates on 3 September 49 tenerals were recorded, including the first females. In addition, another teneral female was found elsewhere in the complex (Pit-D).

It appeared that most second-generations tenerals were emerging in the phragmites areas

of Pit-A, but soon moved off when hardened for cover in the rank vegetation, very often beyond the pit boundary. Clearly wanting to gain some indication of their number I considered collecting exuvia but it was not feasible as the reedbed was not totally accessible without causing unnecessary disturbance. An alternative was to walk the waters edge counting tenerals, keeping to the same path on every visit, recording only those seen about the waters edge margin and ignoring any found away from the edge on the grassy banks or elsewhere. The method was not ideal. As already mentioned, most tenerals flew off as soon as they were hardened and it could be suggested a count in the morning and another in the afternoon may not actually record the same individuals. However, under-recording is acceptable, whereas duplication needs to be eliminated. As a precaution against duplication, only the greater number recorded was included on days of more than one visit. More importantly, at the height of the emergence at least one clear day between each visit was considered enough to eliminate any possibility of repetition, but towards the end, with only a few emerging, it was decided that consecutive visits would be acceptable.

Plate 2. Second generation male Red-veined Darter *Sympetrum fonscolombii* photographed on 15 September 2006. Note the yellow veins near the wing bases, the yellow patch at the base of the hind wing, the pale pterostigma with a black border and the greyish-blue underside of the eye.

Plate 3. Second generation female Red-veined Darter *Sympetrum fonscolombii* photographed on 15 September 2006. Note the yellow patch at the base of the hind wing, the pale pterostigma with a black border and the greyish-blue underside of the eye.

The next visit, on 5 September, was a sunny day with scattered clouds and good air temperature (23°C/24°C) and was obviously ideal for emerging dragonflies with the highest count of the survey (138) recorded and a further 16 found at another pit (Pit-D) within the complex. Expectations were high for the next visit on 8 September, another ideal day with an air-temperature of 18°C, but the mid-morning visit found only 26, although later in the afternoon 59 were present.

Two days later, 10 September, when it was sunny and warm with an air temperature of 22°C, numbers were again high, with 136 counted, but it looked as if the emergence was slowing down after the next visit (12 September). A sunny day with some minor scattered clouds and an air temperature of 22°C seemed perfect conditions, especially since lots of Common Darter, *S. striolatum*, and Migrant Hawker, *Aeshna mixta*, were on the wing, and a good count was expected. However, only 5 tenerals were recorded. There was no obvious explanation why so few were present, with the conditions being so good, especially as the following visit on 15 September produced 44 (Plates 2, 3) on a day less than perfect. However, over the following few visits it became obvious that the peak of

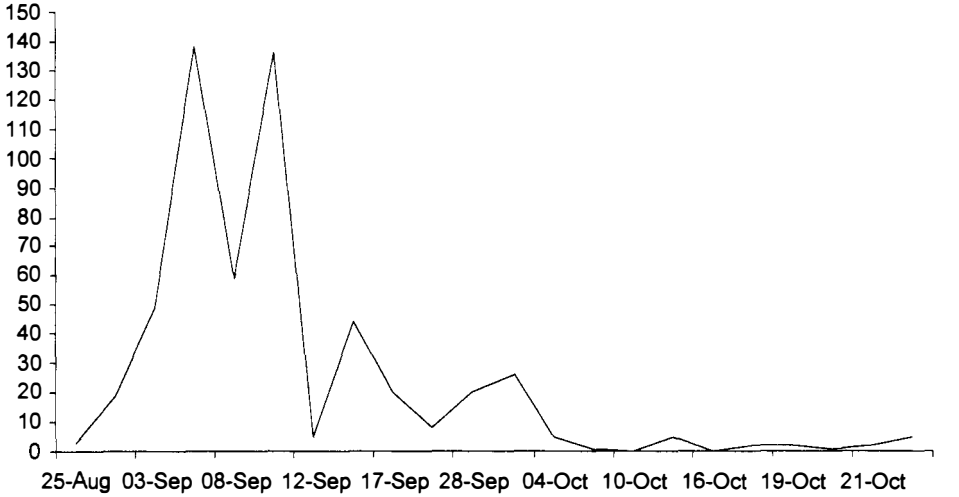

Figure 1. Numbers of teneral Red-veined Darters, *Sympetrum fonscolombii*, recorded from 25 August to 23 October at Pit-A.

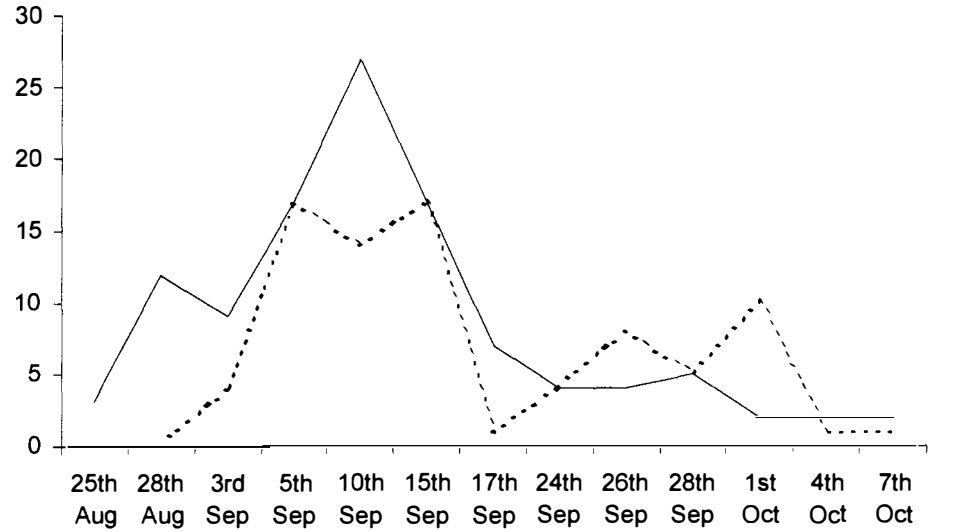

Figure 2. Numbers of male (—) and female (----) teneral Red-veined Darters, *Sympetrum fonscolombii*, present in small samples from Pit-A.

the emergence had passed and from then on only small numbers were recorded. From 4 October to 23 October, when the last teneral was seen, 20 more surveys during 10 visits to Pit-A recorded a maximum of only five tenerals, nine of these surveys actually producing nothing. Also during this period another teneral was seen at Pit-D.

In total, 572 second generation *Sympetrum fonscolombii* were recorded at Pit-A from 25 August to 23 October 2006 (Fig. 1) and a further 18 were found at Pit-D.

During some visits a proportion of these second generation individuals were examined to gain some idea of the sex ratio. Only males were known to be present during the first two visits (25 and 28 August), with the first females encountered on 3 September. From then until 7 October a further 10 comparisons between the emergent sexes were made. During the height of the emergence the male:female ratio approached 2:1. However, during the period from 26 September to 1 October, although only small numbers were available for comparison, females were found to be more numerous than males. These results may indicate that males tend to emerge earlier in the season than females.

On some occasions females taking flight were grabbed by a male Common Darter, *S. striolatum*, attempting to couple. However, most such males gave up within seconds, realising their mistake. One persistent male attempted three times in flight to couple with the same female, the final time falling to the ground before letting loose.

Acknowledgements

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Observations on final instar damselfly caudal lamellae with little or no evidence of secondary tracheae

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Summary

In the summer of 2006, 457 exuviae were collected from localities in Hampshire, and they produced an anomaly that occurred in four species, Common Blue Damselfly *Enallagma cyathigerum* (Charpentier), Azure Damselfly *Coenagrion puella* (L.), Red-eyed Damselfly *Erythromma najas* (Hansemann) and Large Red Damselfly *Pyrrhosoma nymphula* (Sulzer). Thus samples collected from three sites before the first week in June produced 29 exuviae that exhibited little or no evidence of secondary tracheae in their caudal lamellae.

Introduction

My study of variations in key features of the final instar larvae and exuviae (Crick, 2005) continues to present some strange anomalies. The caudal lamellae of damselfly larvae typically have two main tracheal trunks which give off branches to both sides (secondary tracheae) which in turn give rise to numerous fine tracheoles close to the surface of the gill (e.g. Wichard, 1979). The current paper describes the occurrence of caudal lamellae without secondary tracheae in four zygopteran species. This appears to be a phenomenon that has not yet been described; it is not mentioned in the most recent review of insect gills (Mill, 1998).

Material and Methods

The exuviae and one larva with caudal lamellae that lack all, or a significant percentage of, their secondary tracheae were collected from three geographically dispersed but local sites. One site was a garden pond at a location in Sandhurst, the second was my own garden pond at Yateley and the third location was limited to a single bay on the Moor Green Lakes Nature Reserve (British National Grid Reference SU805628) and included one of the reserve's chemical analysis sampling points.

The process of identifying each individual exuvia collected over the 2006 season did not commence until early October. Normally a small amount of water dispensed from an eyedropper is sufficient to separate the three caudal lamellae even after months of storage. However, when their structural integrity is compromised by a lack of secondary tracheae, the caudal lamellae of exuviae proved to be very difficult to separate by this method.

Results

For comparison purposes a typical example of caudal lamellae complete with secondary tracheae is included (Plate 1). Those caudal lamellae with fragmented or no visible secondary tracheae also lack the blotches or banding that are associated with individual species (Plate 2).

Plate 1. Azure Damselfly *Coenagrion puella* caudal lamellae with secondary tracheae intact.

A single *E. najas* larva caught on 28 March 2006 at Moor Green Lakes was the first specimen with caudal lamellae deficient in secondary tracheae (Plate 2). The unusual nature of the lamellae was sufficient for me to photograph it but unfortunately at the time I failed to attribute any greater significance to the record.

A total of 457 exuviae were collected in the summer of 2006. Of these 29 exhibited the same phenomenon to a greater or lesser extent. On 12 May 2006, the Yateley pond produced ten such exuviae of *C. puella* (Plate 3). On 31 May 2006, a search at Moor Green produced six *E. cyathigerum* and one *C. puella* exhibiting the same symptoms. Then on 3 June 2006 I was presented with a pot of exuviae from a garden pond in Sandhurst, which included six *P. nymphula* and six *C. puella* with defective secondary tracheae.

I have checked my reference specimens collected during the 2002 season; all have fully formed tracheae so I have discounted prolonged storage as a factor. One of the sites from

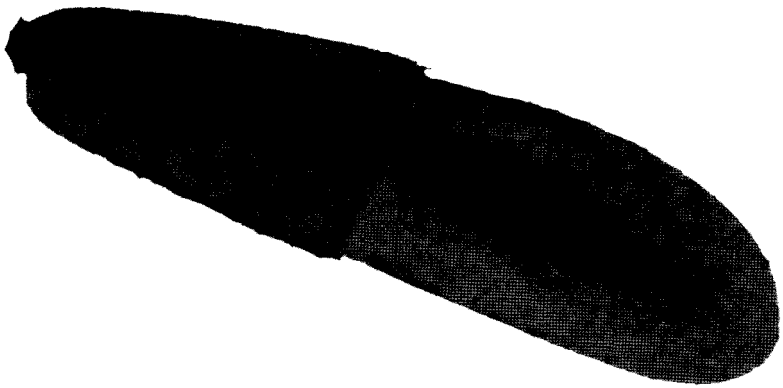

Plate 2. Red-eyed Damselfly *Erythromma najas* median caudal lamella deficient in secondary tracheae. Note the absence of the dark banding typical of this species. The lamella was from a larva collected at Moor Green Lakes Nature Reserve.

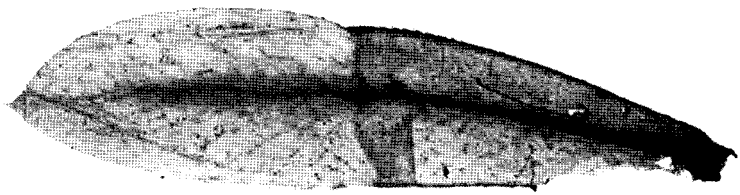

Plate 3. Azure Damselfly *Coenagrion puella* median caudal lamella deficient in secondary tracheae. The lamella was from an exuvia collected at the garden pond at Yateley.

which the affected specimens were collected (Moor Green Lakes) did suffer a significant increase in phosphate. Typical levels for the site up to and including 4 October 2005 were 0.30mg l^{-1} but this figure had risen to 2.61mg l^{-1} by 6 January 2006 and the next recorded normal levels were registered on 11 July 2006. The dissolved oxygen level dropped from 7.5 mg l-1 on 4 October 2005 to 6.8 mg l^{-1} by 6 January 2006 and then to 3.6mg l^{-1} on 4 April and 11 July 2006 but had recovered to 5.6 mg l^{-1} when last measured on 20 September 2006. Corbet (1999) quotes a normal environmental range for dissolved oxygen concentration of approximately 3 to 9mg l^{-1}. This chemical analysis is undertaken quarterly as part of the Moor Green Lakes site's management regime.

The apparent cause of the phosphate increase was due to slurry from cows entering the water. The cows are used as a grassland management tool and had remained on site longer than planned, resulting in the need to import feed. This feed was laid out adjacent to the polluted area of water, resulting in a prolonged concentration of cattle in a confined

area of the reserve. The faeces were washed into the water and marginal vegetation trampled. The site is a large water body but only exuviae removed from vegetation adjacent to the polluted area exhibited the loss of secondary tracheae. Exuviae collected elsewhere on site have proved to be normal, as have the quarterly chemical analysis results.

Discussion

It is tempting to attribute the loss or absence of secondary tracheae on the contamination incident. However, the other two sites that have produced specimens lacking secondary tracheae are both garden ponds generally protected from unfortunate pollution events but no chemical water analysis data are available. My own pond (Yateley) may well have been deficient in dissolved oxygen, as I cleared it of a significant amount of rotting leaf litter during the summer. The Sandhurst pond remained undisturbed and if next season's exuviae collected from the site also prove to be deficient in secondary tracheae then I have permission to take water samples for analysis.

If anyone has knowledge of this phenomenon from other sites then it would be very interesting to hear from them.

Acknowledgements

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On the odonates of Queen Elizabeth Country Park, Hampshire, with emphasis on the Azure Damselfly, *Coenagrion puella* (L.)

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Summary

Thirteen species of odonate were recorded in the summers of 2005 and 2006 from an artificial pond at Queen Elizabeth Country Park, Hampshire, in an area of the South Downs considered to be odonatologically depauperate. Surprising visitors included both *Calopteryx* species (frequently) and a single *Sympetrum fonscolombii*. All individuals of *Coenagrion puella* were individually marked and details of their arrivals as mature individuals at the pond were recorded. The study is unique in providing, as near as possible, exact numbers of *Coenagrion puella* attempting to breed at the same site in consecutive years.

Introduction

In the summers of 2005 and 2006 researchers from the University of Liverpool were present continuously from mid May until the end of July at the Visitor Centre Pond at Queen Elizabeth Country Park (hereafter QECP) in Hampshire. The main purpose of the study was to investigate lifetime mating success and fitness in the Azure Damselfly, *Coenagrion puella* (L.) using genetic profiling techniques. The site is interesting in that ponds in this part of the South Downs are a rare commodity and thus represent a challenge to colonisation to certain species. During 2005 the team recorded the presence of other odonate species at the pond somewhat casually, but did note first records of all species, the presence of 'unusual' species and the occurrence of breeding (oviposition) at the pond. A search of the British Dragonfly Society's database at the end of the first season revealed that only four species had been recorded previously from the site, *C. puella*, Large Red Damselfly, *Pyrrhosoma nymphula* (Sulzer), Emperor Dragonfly, *Anax imperator* Leach and Common Darter, *Sympetrum striolatum* (Charpentier). In 2006 more systematic recording of all odonate species present and breeding at the pond was

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undertaken. The aim of this paper is to report on this recording and to emphasize the importance of regular monitoring for the provision of an accurate species list for an isolated pond.

Study site and methods

The study site was an artificial habitat, the Visitor Centre Pond at QECP, in Hampshire (British National Grid Reference SU7188018447, elevation 104m). There has been a pond at this site for many years, but the present pond was refurbished completely in March 2000 with a new butyl liner on top of a geotextile layer and soft sand. The pond has a maximum length of 32m and width of 14m. The perimeter is roughly 75m and the maximum depth 1.5m. A wide variety of plants (approximately 40 species) including submerged oxygenators, those with floating leaves and shallow water's edge plants were planted or returned during the refurbishment (including, no doubt, odonate larvae). Marshy ground plants were also included in an overflow extension to the pond. In 2005/6 the dominant plants were Common Reed (*Phragmites communis* Trin.), Greater Reedmace (*Typha latifolia* L.), Branched Bur-reed (*Sparganium erectum* L.), Yellow Flag (*Iris pseudacorus* L.), Broad-leaved Pondweed (*Potamogeton natans* L.), Water Soldier (*Stratiotes aloides* L.), Water Forget-Me-Not (*Myosotis scorpionides* L.), Water Milfoil (*Myriophyllum* sp.), Bogbean (*Menyanthes trifoliata* L.), Greater Spearwort (*Ranunculus lingua* L.) and Yellow Water Lily (*Nuphar lutea* (L.)). The pond is adjacent to mature woodland on the southern side so is in shade until mid-morning.

From 11 May to 30 July 2005 and from 17 May to 29 July 2006 between one and six people were stationed at the study pond from 0930 hours until the last individual of *Coenagrion puella* left (typically 1530 to 1700 hours). All individuals of *C. puella* were captured and marked with a unique number on their left hindwing and a small dot of paint on the dorsum of the thorax. Thus the number of newly mature adults of *C. puella* arriving at the pond on each day of the season was obtained together with season long statistics on numbers present, sex ratio and numbers of different female morphs. In 2005 and 2006 the presence or absence of other odonate species was noted by individual recorders and the information collated at the end of each day. In addition, in 2006, one of the team (PKG) systematically estimated the numbers of each species present and noted whether oviposition occurred in the pond. The numbers were recorded according to the scheme used for the British Dragonfly Society/Biological Records Centre RA70 recording cards (A = 1 individual; B = 2–5; C = 6–20; D = 21–100; E = 101–500; F = 500+) following Phillips (2006).

Results

The numbers of unmarked (i.e. different) mature adults of *C. puella* visiting the study pond throughout 2005 and 2006 showed considerable variation from day-to-day with no clear peak of occurrence (Fig. 1). The beginning of the flying season for mature adults

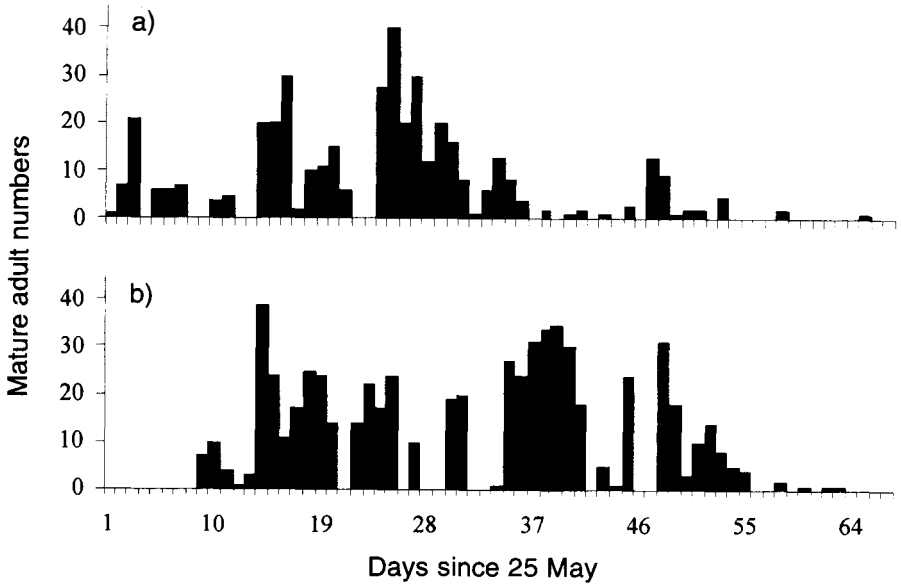

Figure 1. The numbers of previously unmarked mature adults of *Coenagrion puella* recorded daily at the Queen Elizabeth Country Park Visitor Centre Pond in a) 2005; b) 2006.

was eight days later in 2006 than in 2005. New mature adults arriving at the pond did so over 65 and 55 days in 2005 and 2006 respectively. Days on which no new individuals appeared before day 50 (in 2005) and between days 9 and 55 (in 2006) were generally days unsuitable for odonate reproductive activity (rain and/or heavy cloud or too windy). There were more such days in 2005 than in 2006. The number of individuals recorded was 51% higher in 2006 than in 2005. The sex ratio over the whole season was significantly male biased in both years (χ^2 = 19.3 and 5.7 for 2005 ($P<0.001$) and 2006 ($P<0.05$) respectively) (Table 1). In both years the ratio of gynomorph (normal) to andromorph (blue) females in the population did not differ significantly (χ^2 test, $P>0.05$) from the 3:1 ratio that would be expected for a Mendelian trait controlled by a single recessive gene with no substantial selective pressure.

Table 1. Basic statistics on numbers, sex ratio and the ratio of gynomorphs to andromorphs in *Coenagrion puella* at QECP Visitor Centre Pond in 2005 and 2006.

	2005	2006
Total individuals	420	633
Males	265	359
Females	155	274
Sex ratio	1.71	1.31
Ratio of gynomorph to andromorphs females	3.56	3.09

Table 2. Species recorded at QECP Visitor Centre Pond in 2005 and 2006, together with first dates on which mature adults were seen (and last dates in 2006); also records of emergence and oviposition, numbers of days on which each species was recorded and maximum number of individuals recorded in 2006.

Species	2005	2006					
	first date	first date	last date	max.[1]	days recorded	emergence recorded	oviposition recorded
Pyrrhosoma nymphula	11 May[2]	17 May[2]	29 Jul[3]	F	68	+	+
Coenagrion puella	25 May	2 Jun	29 Jul	E	58	+	+
Ischnura elegans	26 May	31 May	29 Jul[3]	D	58	+	+
Enallagma cyathigerum	24 Jun	15 Jun	24 Jul	B	6	+	+
Calopteryx virgo	8 Jun	4 Jun	20 Jul	A	13		
C. splendens	10 Jul	12 Jul	19 Jul	A	5		
Anax imperator	23 May	4 Jun	25 Jul	B	46	+	+
Aeshna cyanea	9 Jul	3 Jul	25 Jul	B	14		+
A. grandis	24 Jun	–	–	–	–		
Libellula depressa	15 May	2 Jun	4 Jul	B	24	+	+
Sympetrum striolatum	26 Jun	9 Jul	29 Jul[3]	D	15	+	+
S. sanguineum	–	14 Jul	29 Jul[3]	B	10		+
S. fonscolombii	–	12 Jul	12 Jul	A	1		

[1] A = 1 individual; B = 2-5; C = 6-20; D = 21-100; E = 101-500; F = 500+.
[2] Mature adults were probably present before this date, but this was the first day of the study.
[3] Mature adults were probably present after this date, but this was the last day of the study.

In total 13 species were recorded over the two years (Table 2). Ten species were recorded at the pond in both years; Brown Hawker, *Aeshna grandis* (L.) was recorded only in 2005 and Ruddy Darter, *Sympetrum sanguineum* (Müller) and Red-veined Darter, *S. fonscolombii* (Selys) were recorded only in 2006. Seven species oviposited at the pond in 2005, but this number increased to nine in 2006 with the addition of Southern Hawker, *Aeshna cyanea* (Müller) and *S. sanguineum*. Beautiful Demoiselle, *Calopteryx virgo* and Banded Demoiselle, *C. splendens* were regular visitors to the pond in both years, with 13 and five visits respectively in 2006. Both sexes of each species visited the pond but no oviposition was observed.

Discussion

QECP Visitor Centre Pond is an artificial pond situated in a cutting in the South Downs adjoining the A3 trunk road. Its relatively high elevation (104m) and the fact that it receives considerable shade from the woodland on its south side means that, in relation to other ponds at a comparable latitude, the flying season for *Coenagrion puella* is delayed somewhat. For example, at Titchfield Haven, a site further west in Hampshire but close to sea level (SU539035), there were hundreds of mature adult *C. puella* on 12 May 2005 but the first emerging adult from the study site was not observed until 13 May and the first mature adult on 25 May. The phenology of *C. puella* was more akin to the Cheshire

site (390km further north) studied by Banks & Thompson (1985) at which the first emergence occurred on 15 May and the first mature adult was seen on 4 June.

Numbers of mature *C. puella* present at the study site in 2005 and 2006 were quite different (420 and 633). However, interpretation of this difference is difficult to make as comparable data for other odonates are scarce. Direct counts of individuals within a population and estimates of population sizes (derived from capture-release-recapture studies) for odonate species at a single site in consecutive years are simply missing from the literature (Corbet, 1999). There are two potential reasons why the difference in *C. puella* numbers might have occurred other than by chance. Firstly, the weather was more appropriate (by common consent) for odonate activity in 2006 than in 2005. Secondly, the management of the pond. Thus some potential adults for the 2005 season may have been lost due to vegetation removal in autumn 2004, whereas removal of vegetation was not undertaken once the study had started, and hence none of the potential adults for the 2006 season would have been removed.

The sex ratio at the study pond was male biased but this is probably attributable to the longer maturation period of females. In the study of *C. puella* reported by Thompson (1989), in which adults were marked at emergence, the mean maturation period of males and females was 13.2±0.22 S.E. and 16.5± 0.34 S.E. days respectively. Thus increased mortality in the maturation period would account for sex ratio differences in mature adults assuming a 1:1 ratio at emergence, which seems likely given their genetic sex determination mechanism. Nonetheless, differential mortality during the larval stage cannot be ruled out. Factors influencing sex ratios in odonates were last reviewed by Corbet & Hoess (1998).

There is much speculation about the evolution and maintenance of female polymorphisms in coenagrionid damselflies (e.g. Andrés *et al.*, 2002; McKee *et al.*, 2005). Interestingly, this is one of few studies where the entire population was sampled and hence does not suffer from putative under-sampling that is frequently invoked to bias studies of polymorphisms in odonate populations.

Data were only collected for the second half of May, June and July and not for the whole summer. There were still species present when *C. puella* had ceased to fly at the end of July when the main study came to a close. However, with the possible exception of Migrant Hawker, *Aeshna mixta* Latrielle, all other potential species were on the wing.

There are a number of striking aspects revealed about the odonate fauna that visited the study pond. Firstly, even ponds in improbable locations in terms of odonate diversity can produce interesting species if monitored closely over a season. *Sympetrum fonscolombii* is not a species that would be expected, albeit for just one day, in an area as relatively depauperate odonatologically speaking as the South Downs. It can also be seen that close monitoring increased the species list for QECP from the four included in BDS records to 13 different species. Secondly, both of the UK's *Calopteryx* species were regular

visitors to the pond in both years, despite being predominantly species preferring running water. Surprisingly, visits to the pond were not fleeting and both species stayed for up to one hour, changing perches frequently, but they were not observed ovipositing. The nearest recorded sites for these species in the BDS records are on the River Rother at Rogate, approximately 10km away from QECP. The nearest recorded breeding sites are 14km for *C. splendens* (downstream of Mislingford Weir) and 17.5km for *C. virgo* (on the River Hamble). Clearly *Calopteryx* species have a greater dispersal potential than that recorded in other damselflies (Conrad *et al.* 1999, Purse *et al.* 2003). It is unusual for *C. virgo* and *C. splendens* to occur at the same site, though there are some at which both species occur; *C. virgo* occurs at 11.4% of sites from which *C. splendens* has been recorded and *C. splendens* occurs at 21.8% of *C. virgo* sites in the UK.

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Predation of odonate larvae by Otters (*Lutra lutra*)

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Summary

The occurrence of odonate larval remains in the faeces (spraints) of Eurasian otters (*Lutra lutra*) was assessed between March and April 2006 in two Welsh rivers. Spraints were collected individually during detailed field surveys every two weeks. Odonate remains identified as *Aeshna mixta* and *Cordulegaster boltonii* were found in 61% (11/18) of the spraints analysed and a minimum number of 66 individual larvae (45 *Aeshna mixta* and 21 *Cordulegaster boltonii*) were estimated in these spraints. This study clearly illustrates that vertebrate predators such as otters have the potential to consume large numbers of odonate larvae and highlights the need for applied research in this neglected area of odonate and otter ecology.

Introduction

During their developmental period, odonate larvae are exposed to a wide variety of predators, being eaten by birds, amphibians, fish, crustaceans and predatory insects, including the larvae of other odonate species (Corbet *et al*. 1960; Corbet, 1999). There is, however, a paucity of information in the literature on the occurrence of odonate larval predation by mammalian predators despite this group containing a number of specialised and opportunistic aquatic foraging species, including the water vole (*Arvicola terrestris*), water shrew (*Neomys fodiens*), polecat (*Mustela putorius*), American mink (*Mustela vision*) and Eurasian otter (*Lutra lutra*). The otter is an adaptable and efficient predator able to exploit a wide range of prey types, including fish, mammals, birds and a range of invertebrate species (Kruuk, 2006). Otters forage extensively in wetland systems inhabited by odonate larvae and due to the relatively functional response of this predator to its prey populations (prey items are consumed in proportion to their respective occurrences in the environment), otters inhabiting areas in which larval density is high are likely to consume such larvae. This study presents data on the occurrence and diversity of odonate larvae in the diet of otters inhabiting two small river systems in South Wales.

Material and Methods

Otter spraints (faeces) were collected under licence (Countryside Council for Wales

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licence number OTH: SA:53:2006) during detailed fortnightly surveys on the Burry (British National Grid Reference at its mouth: SS449939) and Clyne (British National Grid Reference at its mouth: SS618908) rivers, Gower peninsula, South Wales, between March and April 2006. All spraints collected were stored in separate plastic bags and were frozen at –18°C until analyses could be conducted. Intact and partially digested odonate larvae were clearly identifiable within spraints by their characteristic exoskeleton shape and general size (typically 50–80mm long) (Plate 1).

Individual spraints were soaked in a solution of biological detergent for a period of at least 24 hours before being gently rinsed with cold water through a 0.5mm sieve (Conroy *et al.* 1993). All odonate remains were removed for individual identification to species level using keys to larvae devised by Lucas (1930), Gardner (1954), Miller (1995), Brooks (1999) and Smallshire & Swash (2004). To ensure accurate identification, larval remains from each spraint were examined independently and verified by all the authors.

Results

A total of 61.1% (11/18) of the spraints recovered from the Burry and Clyne rivers during March and April contained the remains of odonate larvae. Intact body parts

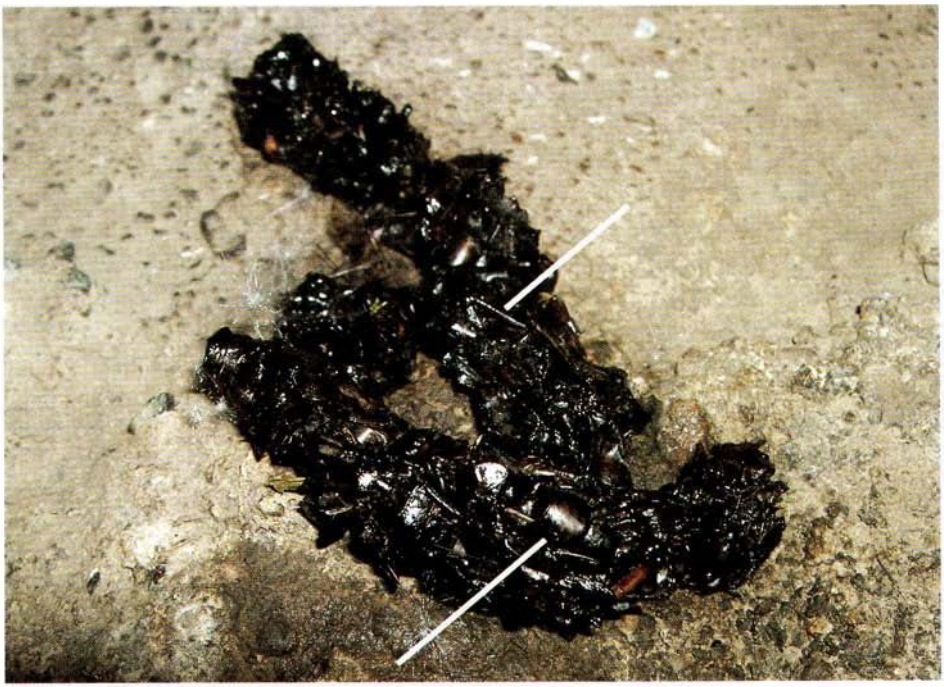

Plate 1. Otter spraint. The matrix of this spraint consisted only of odonate remains. Lines indicate an odonate leg and an abdomen.

Table 1. Table of the occurrence of odonate larval body parts that enabled identification and associated estimates of the minimum numbers of each species recovered from otter spraints

		Aeshna mixta				*Cordulegaster boltonii*			
Date	River	Whole labia	Partial labia	Epiprocts	Minimum number of individuals	Whole head	Individual palps	Individual maxillae	Minimum number of individuals
20/4/06	Burry	3	6	2	6	3	1	5	6
20/4/06	Burry	4	4	2	6	–	–	–	–
24/8/05	Clyne	3	5	2	6	–	3	–	2
9/5/06	Clyne	1	–	2	2	–	2	2	1
9/5/06	Clyne	–	1	3	3	–	2	4	2
9/5/06	Clyne	–	–	3	3	–	2	2	1
12/5/06	Burry	–	1	2	2	–	–	–	–
12/5/06	Burry	–	1	–	1	–	8	5	4
12/5/06	Burry	2	5	2	5	–	–	2	1
12/5/06	Burry	2	2	3	3	–	4	6	3
12/5/06	Burry	3	10	2	8	1	–	–	1
Total		18	35	23	46	4	22	26	21

(heads, labia, epiprocts and palps) were identified as originating from two species, the Migrant Hawker, *Aeshna mixta* and the Golden-ringed Dragonfly, *Cordulegaster boltonii*. Labia (in part or whole) and epiprocts were used to identify *A. mixta*; heads, palps and maxillae to identify *C. boltonii* (Table 1).

By counting the total number of mouthparts recovered from each spraint it was possible to estimate the minimum number of individuals of both species consumed by otters. The minimum number of *A. mixta* individuals recovered from each spraint was estimated by adding the total number of whole labium numbers to half the number of partial labia with the assumption that two partial labia may belong to one individual. Epiproct numbers were included only if the number per spraint exceeded that of the number of individuals estimated from labia counts. Minimum numbers of *C. boltonii* individuals were estimated by counting the total number of intact heads and adding this value to half the number of palps or maxillae (whichever was the highest count) from each spraint.

A minimum of at least 66 individual larvae (45 *A. mixta* and 21 *C. boltonii*) were recorded in the 11 spraints containing odonate remains. Interestingly, the number of each species recovered from such spraints differed significantly (independent samples t-test: $t = 2.52$, $p = 0.019$, d.f. $= 20$) with the average ($\pm$ S.E.) number of *A. mixta* and *C. boltonii* individuals found in each spraint being 4.1 ± 0.66 and 1.9 ± 0.55 larvae, respectively. The average ($\pm$ S.E.) number of individuals recovered in total per spraint was 6.0 ± 0.85 larvae.

Discussion

Few previous studies have noted the occurrence of odonate larvae in the diets of otters and this study provides the first detailed data on otter predation of odonate larvae identified to species level. Clearly odonate larvae form a component of the diet of Eurasian otters on the Gower peninsula, although it is worthy of note that the sample size used in this study was relatively small (n = 16 spraints). Similar findings, however, were found by Henshilwood (1981) during a more comprehensive analysis of a large number of spraints collected from Bosherton ponds (Pembrokeshire, South Wales), an area associated with a high density of odonate species (Forman, pers. obs. 2005). Elsewhere in Europe, few studies have reported specific predation of odonate larvae, a factor likely to be due to the inherent difficulties in the specific identification of invertebrate prey in the diets of active mammalian predators such as otters. In many instances authors frequently refer to a generic invertebrate prey category resulting in a poor understanding of the consumption of major aquatic invertebrate groups such as Odonata and Dytiscidae by otters. It is, however, clear that European otters eat odonate larvae and, as such, this study begins to address a previously poorly documented and understood aspect of the ecology of Odonata.

Although classification to species level was not conducted, in one of two papers specifically mentioning odonate prey items in otter diet, Brzeziński *et al*. (1993) reported that larvae were recovered from 3.1% of spraints collected from small river systems in Poland during the spring and summer months. Jacobsen & Hansen (1996), during captive feeding trials, recorded that otters actively pursue and consume odonate larvae occurring in pools in their pens, leading to a high occurrence of larvae recovered in their spraints. Interestingly, many of these spraints consisted entirely of the exoskeletons of large (*circa* 3-4cm) larvae and in many instances up to 14 individual larvae were found in each spraint examined, a finding mirrored by this current study. The occurrence of multiple individuals in otter spraints suggests that otters are engaging in localised search behaviours specifically for larvae. Foraging otters engage in highly explorative and localised search behaviours that include turning over rocks, probing through mud and flushing out prey species from emergent vegetation (Chanin, 1985; Kruuk 2006). Such foraging behaviour is likely to increase the probability of otters encountering odonate prey items. The behaviour of the two odonate species recovered from spraints in the current study is very different. *Aeshna mixta* actively hunts in vegetation and detritus whilst *Cordulegaster boltonii* acts as an ambush predator hiding under rocks and detritus (Brooks, 1999). This suggests that otters are able to both locate and predate a range of odonate species with differing life history strategies. Furthermore, Odonata are likely to be a profitable prey item even in comparison to larger fish prey as they are slower moving and therefore easier to catch and consume, and have a calorific value (per gram) at least equal to that of most fish species. For example, the mean calorific content of an average sized odonate larva (*Sympetrum internum*) is approximately 5.1 kcal g^{-1} (Driver, 1981) whereas the calorific values for 3-spined stickleback (*Gasterosteus aculeatus*), perch (*Perca*

fluviatilis) and common carp (*Cyprinus carpio*) are 0.47 – 1.95 kcal g^{-1}, 4.84 kcal g^{-1} and 6.98 kcal g^{-1}, respectively (Meakins, 1976; Schreckenbach *et al.* 2001).

The number of *A. mixta* larvae consumed by otters was about twice that recorded for *C. boltonii*, possibly reflecting the relative local abundance of these two species on the Gower. Clearly, more focused research is needed to evaluate the impact that otter (and other mammalian) predation might have on specific, localised populations of odonates. Due to the activity patterns and range sizes of otters in Europe (Chanin, 1985), it is difficult to envisage that otters play a significant part in regulating odonate populations. However, it is possible that larger, slower moving or sedentary species might be more vulnerable to foraging otters and that otter predation of such species might serve to promote odonate diversity in specific areas due to predator cascade effects (Schmitz *et al.* 2006).

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An experimental key for the differentiation of the exuviae of the Southern Darter *Sympetrum meridionale* (Sélys) and the Common Darter *S. striolatum* (Charpentier), with notes on the Ruddy Darter *S. sanguineum* (Müller)

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Summary

A study was carried out to develop a diagnostic key for identification of the exuviae of two species of *Sympetrum*, the Southern Darter, *S. meridionale* and the Common Darter, *S. striolatum*. Until now, no reliable key has existed to differentiate the exuviae of these very similar species. Previous keys have suggested that they can be discriminated using dorsal and lateral spines, features which in our experience have proved to be very variable and unreliable. Therefore, we propose an experimental key which separates these species without reference to such spines. About two thirds of the exuviae of *S. meridionale* and *S. striolatum* can be separated by the ratio of the width of the submentum to the length of the mentum. The remaining third fall into an intermediate section but can be separated by using further ratios of morphological measurements. In our experience, using all the diagnostic features presented in this paper will allow exuviae of these species to be separated reliably.

Introduction

The Southern Darter, *Sympetrum meridionale* (Sélys) is, as might be expected from its name, a southern species within Europe. It breeds throughout the southern part of the Iberian Peninsula, southern France, Italy, the Balkans, around the Mediterranean and into central Europe (Askew, 2004). It has been recorded in the British Isles, but not since 1901 (Corbet *et al.* 1960). However, with the recent northward range expansion of many European species, it is possible that *S. meridionale* will soon visit the British Isles again. It has recently been recorded in the Netherlands, providing a second record for that country and the first in recent years (Tromp & Wasscher, 2000). Recently it has also been recorded from various sites in Germany.

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Whilst the diagnostic characteristics of the adults of *S. meridionale* and the Common Darter *S. striolatum* (Charpentier) are well documented (e.g. Askew, 2004), no key exists for their separation on the basis of exuviae characteristics. This was the situation with the Azure Damselfly *Coenagrion puella* (L.) and the closely related Variable Damselfly *C. pulchellum* (Vander Linden) until it was resolved by Seidenbusch (1996).

Collection sites and methodology

The diagnostic key was developed by comparing exuviae collected from various regions (Table 1) using the following methods:

Reference method: exuviae identified by rearing field-collected larvae to emergence or by collecting during emergence. This method is the most reliable.

Exclusion method: exuviae from sites in central Europe where *S. striolatum* is found but *S. meridionale* has never been recorded.

Inclusion method: exuviae from habitats where emergence of both species had been observed and exuviae of both species (*S. meridionale* and *S. striolatum*) or of one of the species together with exuviae of *S. sanguineum* are included in a collection.

Over 300 exuviae were examined using a stereo-microscope and measurements of various morphological features were made using an eyepiece graticule calibrated to read c.29 units to 1mm. Therefore, measurements taken are accurate to approximately 0.03mm. The measurements of the labium were made direct from non-pressed, dry slide preparations.

Table 1. Location of collections of exuviae.
Excl, exclusion method; Incl, inclusion method; Ref, reference method.

Country	Location	Collector	Method
Austria	Neusiedel	Arlt	Incl
Bulgaria	Bourgas	Marinov	Incl
Croatia	Podgora	Seidenbusch	Incl
Cyprus	Germasogeia, Pomos	Lopau	Incl
Cyprus	Khalassa, Kapothanni	Seidenbusch	Incl
France	Port Plat, Loire	Kalkmann	Excl
France	Olonne	Butler	Ref
France	St Symphorien	Jourde	Excl/Ref
Germany	Witten	von Hagen	Excl
Germany	Amberg	Seidenbusch	Excl/Ref
Israel	Capernaum	Seidenbusch	Ref
Mallorca	Campos	von Hagen	Incl
Morocco	M`Diq	Seidenbusch	Incl
Montenegro	Ulcinj	Seidenbusch	Ref
Tunisia	Sedjenane, Bizerte	Seidenbusch	Ref
Tunisia	El Guiar, Lac Twirif	Kunz	Excl
Turkey	Demirtas, Kösreli, Aydinlar	Seidenbusch	Incl/Ref

Many measurements or ratios of measurements were discarded after comparison of results showed that they were too similar to be used to discriminate between the two species. The remaining measurements were used to establish diagnostic parameters and ratios. Comparison of exuviae collected from different regions and habitats showed both species exhibited considerable variation in body shape and colouration, as well as in the form and expression of spines.

Measurements of the basal width of the mentum often produce unreliable results, especially if the measurements are not made from consistent reference points or if the mentum has been pressed or is out of its typical form or position. Therefore, it is easier and better to use the basal width of the submentum, from joint-hole to joint-hole, which is nearly congruent to the darkened tubercles on the basal mentum. Care is needed as a folded mentum can be misleading, with the submentum appearing wider and the mentum appearing shorter in length. The basal width of the submentum is compared with the length of the mentum to provide a ratio that is useful for the separation of most specimens.

Other measurements taken were the lengths of antennal segments 5–7 and 6–7 (note that segment 7 is the most distal segment), the length of the epiproct and the width of the frontal tubercle as measured when viewed frontally or dorsofrontally by the length of the deep rim bordering its sides.

Results

Two 'forms' of exuvia were observed in both species. In *S. striolatum*, there is a typical *striolatum* form ('*striolatum*-typ'), which is large with pale-grey to dark brown mottling and an intermediate *meridionale*-like form ('*striolatum*-me') which is smaller, more slender and yellow-orange-brown. The latter is known from the Iberian Peninsular and Mediterranean areas and is often mixed with the pale *striolatum*-typ form. In *S. meridionale*, the typical *meridionale* form ('*meridionale*-typ') is slender with orange-brown tinges or dark grey mottling, whereas the intermediate form ('*meridionale*-sa') is *sanguineum*-like and is small but pale and generally reminiscent of the Ruddy Darter *S. sanguineum* (Müller) in shape. The *meridionale*-sa form has been found in Cyprus, Croatia, Neusiedel Lakes (Austria) and in southern Turkey and is also often sympatric with the orange tinged *meridionale*-typ form. This wide range of size, shape, colour and mottling in *S. striolatum* and *S. meridionale* (and also in the Ruddy Darter, *S. sanguineum*), together with the considerable variability in dorsal and lateral spines, could possible depend on habitat type, climatic conditions or generation cycles.

Diagnostic characters

The width of the submentum may vary by up to 50 per cent and the length of the mentum by up to 30 per cent. The ratio between these variables of checked exuviae ranged from 4.2–6.8. All exuviae at the lower end of the range (with a ratio of 4.2–4.9)

were undoubtedly *S. striolatum*, while all exuviae at the higher end of the range (with a ratio of 5.6–6.8) were *S. meridionale* (Table 2; Plate 1). About two thirds of the exuviae of *S. meridionale* and *S. striolatum* can be recognized using this ratio.

The intermediate ratios, from 4.9–5.6 include both species, although *S. striolatum* is dominant below 5.3 and *S. meridionale* above 5.3. Therefore, for specimens falling within this intermediate range, further discriminating features are needed (Tables 2, 3; Plates 2–4). These can be found in the ratios between:

- the length of antennal segments 5–7 and the length of the epiproct;
- the length of antennal segments 6–7 and the width of the frontal tubercle;
- the length of the epiproct and the length of the mentum.

Table 2. Experimental key for separating *Sympetrum meridionale* and *S. striolatum*.

Width of basal submentum : length of mentum		
1 : 5.6–6.8	1 : 4.9–5.6	1 : 4.2–4.9
S. meridionale	**Intermediate**	***S. striolatum***
1 : <1	Length of antennal segments 5 to 7 : length of epiproct	1 : ≥ 1
1 : <1.2	Length of antennal segments 6 & 7 : width of frontal tubercle	1 : ≥ 1.2
1 : ≥ 3.6	Length of epiproct : length of mentum	1 : <3.6
S. meridionale	**Intermediate***	***S. striolatum***

**If specimen is still 'Intermediate' see Tables 4 & 5*

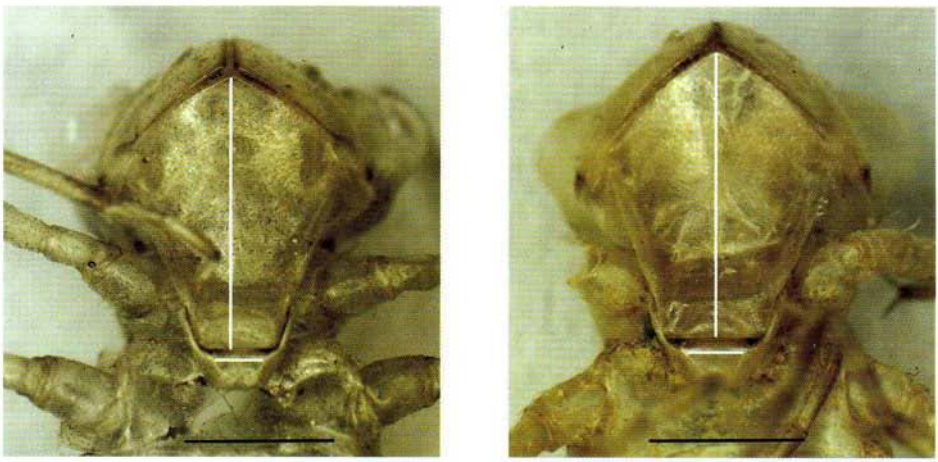

Plate 1. Labia of *Sympetrum meridionale* (left) and *Sympetrum striolatum* (right). White lines indicate the length of the mentum and the width of the submentum. Scale bar 2mm.

Table 3. Useful ratios for separating *Sympetrum meridionale* and *S. striolatum* when they fall into the intermediate range in the experimental key (Table 2).

S. striolatum	
length of antennal segments 5 to 7 : length of epiproct	1 : ≥ 1
length of antennal segments 6 & 7 : width of frontal tubercle	1 : 1.2 to 1 : 1.35
length of epiproct : length of mentum	1 : 3.1 to 1 : 3.55
S. meridionale	
length of antennal segments 5 to 7 : length of epiproct	1 : <1
length of antennal segments 6 & 7 : width of frontal tubercle	1 : 1.0 to 1 : 1.18
length of epiproct : length of mentum	1 : 3.6 to 1 : 3.95

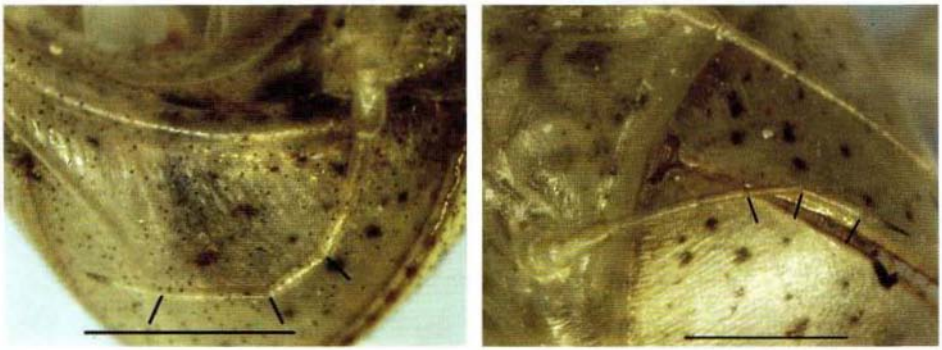

Plate 2. Antennae of *Sympetrum meridionale* (left) and *Sympetrum striolatum* (right). Lines indicate separation between the distal antennal segments. Scale bar 1mm.

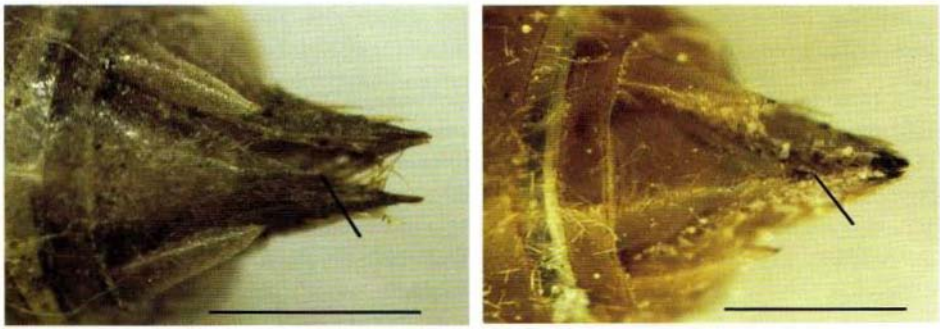

Plate 3. Epiprocts of *Sympetrum meridionale* (left) and *Sympetrum striolatum* (right). Line indicates the tip of the paraproct. Scale bar 1mm.

If there is still any doubt, the width of the frontal tubercle in *S. striolatum* is slightly wider than in *S. meridionale* and is rectangular or elliptical, whereas in *S. meridionale* it is narrower and more quadrangular or circular to ovoid (Table 5; Plate 4). Also the epiproct in *S. meridionale* is normally shorter than in *S. striolatum* (Table 4; Plate 3), whilst the antennal end segments are usually longer than in *S. striolatum* (Plate 2). In our

Table 4. Length of the epiproct (mm) in *Sympetrum meridionale* and *S. striolatum*.

S. meridionale	Overlap	*S. striolatum*
0.90 to 1.07	1.10 to 1.21	1.24 to 1.34
≈ 1mm	1.1 – 1.2mm	> 1.2mm

Table 5. Width of the frontal tubercle (mm) in *Sympetrum meridionale* and *S. striolatum*.

S. meridionale	Overlap	*S. striolatum*
0.86 to 0.97	1.00 to 1.04	1.07 to 1.14
<1mm	≈ 1mm	>1mm

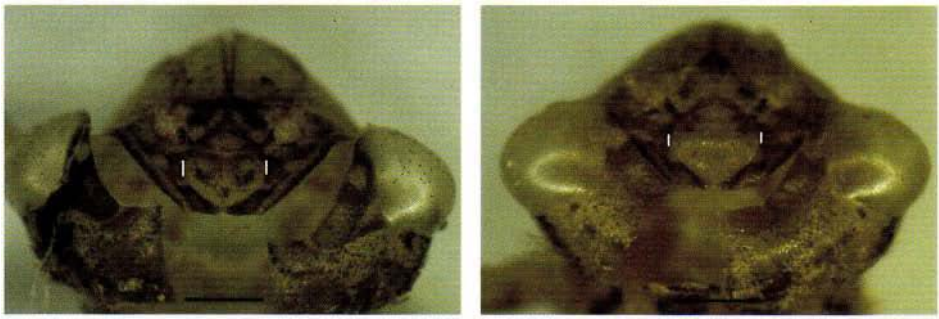

Plate 4. Frontal plates with frontal tubercle of *Sympetrum meridionale* (left) and *Sympetrum striolatum* (right). White lines indicate the grooves at the sides of the dorsal tubercle. Scale bars 1mm.

experience, combining all the diagnostic features presented in this paper will lead to a reliable identification, even when one of the ratios falls outside the range quoted.

The most difficult situation occurs when all the ratios and parameters noted in tables 2–5 fall into the overlap or intermediate sector. In these cases some additional, minor features may be useful. Thus the length of antennal segments 6+7 compared to the distance between the antennal sockets (basoscapal rings) is usually 1 : < 1.3 in *S. meridionale* but 1 : ≥ 1.3 in *S. striolatum*. In *S. striolatum*, the accessory genitalia of the male on sternite 3 are normally more parallel sided and the lobes protrude very little and are separated by a distal cleft that reaches nearly half the length of the sternite. In *S. meridionale*, the accessory genitalia of the male on sternite 3 normally have more circular sided lobes separated by a distal cleft that reaches only about one third the length of the sternite. In *S. striolatum*, the male genitalia on the sternite of segment 9 have two lateral circular imprints with, at their inner border, distinct hook-like tubercles and a larger median protrusion than in *S. meridionale*. In *S. striolatum* females, the genitalia on sternite 9 show two circular imprints that are larger and more widely separated than in *S. meridionale*. The posterior border of the pronotum in *S. meridionale* is more swollen and outwardly has an abruptly narrowing bulge whereas in *S. striolatum* the bulge is flatter and steadily

narrows. However, these features are not always constant and sometimes are very weakly expressed. Thus, they can be hard to use without high magnification and good illumination.

Practical use of the key

When using the key to check the identifications of our own collections as well as borrowed specimens, it was surprising to see how often collections had previously been inaccurately sorted and identified. Using the following criteria for identification and separation of the two species may have led to errors:

- use of dorsal and lateral spines only;
- use of colouration only;
- use of occurrence at sites and/or habitats based exclusively on imaginal observations.

The third point requires further explanation. At three small sites near the Mediterranean, where only *S. meridionale* was observed on the wing and no *S. striolatum* were seen, keying out the exuviae collected from each site produced about 70% *S. striolatum*. However, the following observation from a swamp in Turkey, which was visited several times during a three-week period, may provide an insight into this apparent anomaly. On the first visit, at the beginning of May, the emergence of *S. striolatum* had begun, no *S. meridionale* were to be seen and the exuviae collected proved to be exclusively *S. striolatum*. Three weeks later, no *S. striolatum* were seen on the wing but it was the main emergence period for *S. meridionale*. Without the first visit we would have concluded that all the exuviae collected should belong to *S. meridionale*, but there had been a mix of both species. A visit in late June would probably have shown the coexistence of adults of both species. However, collections in late summer can also lead to errors because adults may change sites. Also *S. striolatum* stays on the wing longer, and *S. meridionale* may already have vanished from a site at which it may breed.

We are not aware of which features other specialists may prefer to use to separate exuviae of *S. meridionale* from *S. striolatum*. We should be very interested in the results of re-examining their collections with this experimental key. It may be possible to make improvements by adding other useful but yet unpublished features. Only by rearing more larvae of both species will we be able to define the intermediate (overlap) sector with more precision. We hope this experimental key will prove to be a valuable step on the way to the improved separation of the exuviae and larvae of these similar species.

Sympetrum sanguineum

Exuviae of *S. sanguineum* are more similar to those of *S. meridionale* than to those of *S. striolatum* in having a narrow submental width, long antennal end segments, a short epiproct and a circular frontal tubercle. A study of these two species would, however, probably also produce intermediate forms that would be difficult to separate. In the meantime the following will help to distinguish *S. sanguineum* from *S. meridionale*:

1. The eyes protrude more laterally and point forwards (in dorsal view) and are more upwards orientated (in frontal view) than in *S. meridionale*.
2. The lateral spine on segment 8 is normally less than half of the epiproct length but is more than half the epiproct length in *S. meridionale*.
3. The lateral border of segment 9, including the spine, is nearly straight but in *S. meridionale* it is wavy with an outwardly curved spine and often an inwardly oriented tip.
4. The distal border of the frons is almost straight, with low medial lobes and a weak notch whereas in *S. meridionale* the distal border is wavy with larger medial lobes and a deeper notch.
5. The dorsal spines on segments 6–8 are normally more erect and broad-based than those of *S. meridionale* which are flat and oblique.
6. The lateral bumps on the distal mentum are circular and erect whereas in *S. meridionale* they are slightly flatter and more asymmetrically curved.
7. The hind border of the pronotum has a flatter and progressively narrowing bulge but in *S. meridionale* it is thicker and abruptly ends in a bulge.
8. The ratio between the width of the frontal tubercle and the width between the bases of the antennae is normally 1 : <1.25 compared to it being normally 1 : >1.25 in *S. meridionale*.
9. The males' genital print on sternite 3 is nearly half the length of the sternite but in *S. meridionale* it is only about one third of the sternite length.

However, the above can be confused by the presence of the intermediate form of *S. meridionale*, i.e. *meridionale*-sa, and possibly by an intermediate form of *S. sanguineum*, '*sanguineum*-me' with features intermediate between *S. sanguineum* and *S. meridionale* (pers. obs.)

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We thank S. G. Butler, H. Von Hagen, B. Kunz, W. Lopau, Dr M. Marinov, Dr T. Van Trigt for loaning exuviae in their collections. We also thank Dr P. J. Evennett most sincerely for taking the photographs of exuviae.

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

Use of these terms is acceptable: 'exuvia' for cast skin (plural: 'exuviae'); 'larva' (instead of 'naiad' or 'nymph'); 'prolarva' to designate the first larval instar.

Dates in the text should be expressed in the form: 24 July 2004.

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

SCIENTIFIC AND ENGLISH NAMES OF BRITISH ODONATA

ZYGOPTERA	DAMSELFLIES
Calopteryx splendens	Banded Demoiselle
Calopteryx virgo	Beautiful Demoiselle
Lestes sponsa	Emerald Damselfly
Lestes viridis	Willow Emerald Damselfly
Lestes dryas	Scarce Emerald Damselfly
Sympecma fusca	Winter Damselfly
Platycnemis pennipes	White-legged Damselfly
Coenagrion puella	Azure Damselfly
Coenagrion pulchellum	Variable Damselfly
Coenagrion scitulum	Dainty Damselfly
Coenagrion hastulatum	Northern Damselfly
Coenagrion lunulatum	Irish Damselfly
Coenagrion mercuriale	Southern Damselfly
Coenagrion armatum	Norfolk Damselfly
Coenagrion johannsoni	Common Blue Damselfly
Erythromma najas	Red-eyed Damselfly
Erythromma viridulum	Small Red-eyed Damselfly
Ischnura elegans	Blue-tailed Damselfly
Ischnura pumilio	Scarce Blue-tailed Damselfly
Pyrrhosoma nymphula	Large Red Damselfly

ANISOPTERA	DRAGONFLIES
Aeshna caerulea	Azure Hawker
Aeshna cyanea	Southern Hawker
Aeshna grandis	Brown Hawker
Aeshna isoceles	Norfolk Hawker
Aeshna juncea	Common Hawker
Aeshna mixta	Migrant Hawker
Anax (Hemianax) ephippiger	Vagrant Emperor
Anax imperator	Emperor Dragonfly
Anax junius	Green Darner
Anax parthenope	Lesser Emperor
Brachytron pratense	Hairy Dragonfly
Gomphus vulgatissimus	Common Club-tail
Cordulegaster boltonii	Golden-ringed Dragonfly
Cordulia aenea	Downy Emerald
Oxygastra curtisii	Orange-spotted Emerald
Somatochlora arctica	Northern Emerald
Somatochlora metallica	Brilliant Emerald
Crocothemis erythraea	Scarlet Darter
Leucorrhinia dubia	White-faced Darter
Libellula depressa	Broad-bodied Chaser
Libellula fulva	Scarce Chaser
Libellula quadrimaculata	Four-spotted Chaser
Orthetrum cancellatum	Black-tailed Skimmer
Orthetrum coerulescens	Keeled Skimmer
Pantala flavescens	Wandering Glider
Sympetrum danae	Black Darter
Sympetrum flaveolum	Yellow-winged Darter
Sympetrum fonscolombii	Red-veined Darter
Sympetrum nigrescens	Highland Darter
Sympetrum pedemontanum	Banded Darter
Sympetrum sanguineum	Ruddy Darter
Sympetrum striolatum	Common Darter
Sympetrum vulgatum	Vagrant Darter

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