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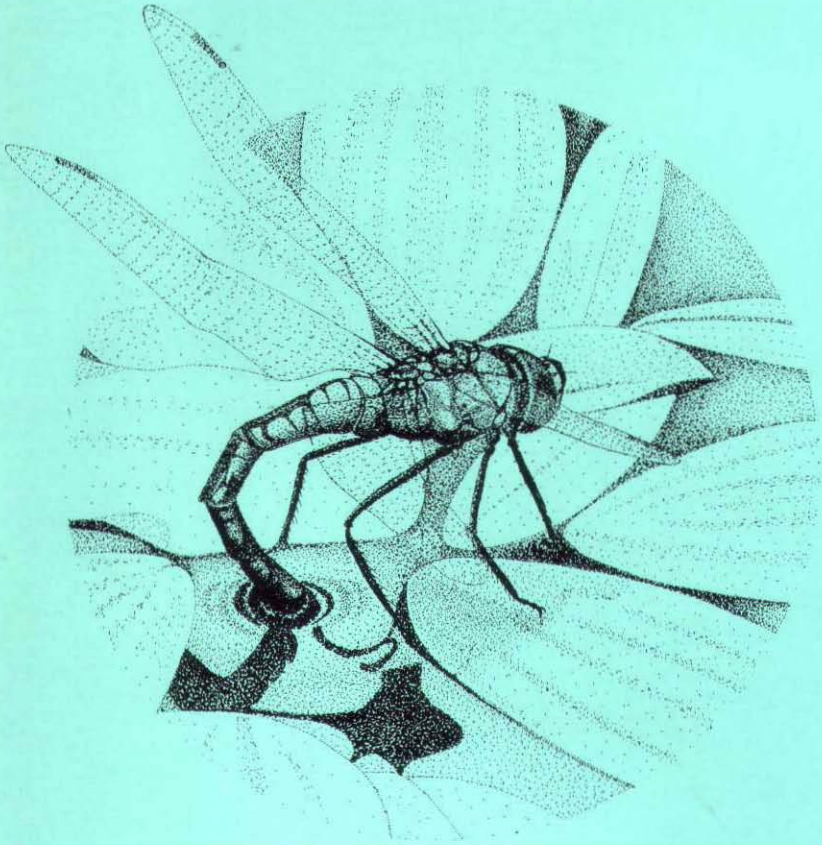

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The *Journal of the British Dragonfly Society*, normally published twice a year, contains articles on Odonata that have been recorded from the United Kingdom. The aims of the British Dragonfly Society (B.D.S.) are to promote and encourage the study and conservation of Odonata and their natural habitats, especially in the United Kingdom. The B.D.S. is a member of the Societas Internationalis Odonatologica (S.I.O.).

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Front cover illustration of *Anax imperator* by Steven Jones. April cover illustration by Philip Corbet reproduced by permission of Royal Entomological Society of London.

A population study of the Azure Damselfly *Coenagrion puella* (L.) in northern England

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Introduction

From October 1982 until September 1985 Michael Banks and I studied a population of the Azure Damselfly, *Coenagrion puella*, at a pond in northern England. Several aspects of this study have been published in scientific journals (Banks & Thompson, 1985a, b; 1987a, b; Thompson, 1989a, b; Thompson & Banks, 1989; Thompson, Banks, Cowley & Pickup, 1985). These have ranged from causes of mortality at emergence to lifetime mating success of adults. The aim of this paper is to provide a picture of the fate of damselflies emerging from, and coming to breed at, one small pond in one year. It draws upon some of the material previously published together with new data, particularly on animals that emerged and reproduced at the study pond.

Study site

The study was made at the Bungalow Pond, Wirral, northern England (N.G.R. SJ 234857). Bungalow Pond is a small, roughly circular pond with a diameter of about 20m and a maximum depth in summer of about 1.2m. The aquatic vegetation consists of *Nuphar lutea* and *Potamogeton crispus*, virtually all of which can be reached by wading. The emergent vegetation is mostly *Glyceria* sp., with one small patch of *Iris pseudacorus*. The other odonates recorded from the pond were *Ischnura elegans*, *Aeshna grandis*, *A. cyanea* and *Sympetrum striolatum*.

Methods

From the first day of adult emergence (16 May 1983) pondside vegetation was searched twice per day. Emerging adults were placed carefully into pots and taken to the laboratory. There they were weighed, their head widths measured, a number written in permanent ink on the left forewing and a dot of paint placed on the dorsum of the thorax. They were returned to the pond next morning. Damage and losses were negligible. Damaged animals were used to obtain dry weight data. The same measuring and marking procedure was adopted for unmarked adults that came to the pond to breed.

We attempted to record every single male and every tandem pair that visited the pond throughout the entire breeding season. The data were collected by experienced

observers armed with close-focussing binoculars and nets. At least two observers (and usually three) were present at the pond from 0900 to 1630 hours every day from the 15th May to 1st August. Reproductive activity had never begun before 0900 hours and was always over before we left the pond. The data on female reproductive success that required killing animals to determine egg numbers was carried out in 1984.

Results and Discussion

The pattern of emergence of the two sexes was similar, but females emerged significantly earlier than males (taking 16 May as day 1, mean emergence date of females was 13.9±0.15 (S.E.) days compared with 15.3±0.13 (S.E.) for males; $P<0.001$, $n=2714$). The sex ratio of animals marked at emergence was 1.0361:1 males to females. A further 1042 exuviae were encountered without adults (dispersed presumably, or predated, before we were able to collect them) bringing the total number of adults that emerged from the pond to 3756. Emergence was greatly affected by prevailing weather conditions. For example, the numbers of adults emerging on 27-29 May were 537, 12 and 380 respectively. May 28th was memorable as a cold, rainy day. More exuviae were found without adults on warm, sunny days when cuticles and wings take less time to dry than on cold days. The wet weights of adults emerging from the pond declined through the season ($r_s=-0.294$, $n=1335$, $P< 0.001$) for males, and $r_s=-0.298$, $n=1292$, $P< 0.001$) for females). Males coming to breed at the pond in early June typically weighed around 35mg, whereas those making their first appearance in mid-July weighed closer to 25mg. The same statistics for females are confounded by the weight of eggs they carried, but emergence weights for females at the beginning and end of season were 42 and 35mg respectively.

Of 2714 adults marked at emergence, 472 returned to breed at the study pond (23.2% of males and 12.7% of females). The mean length of the maturation period was longer for females than males (16.5±0.34 (S.E.) days compared with 13.2±0.22 (S.E.)). Males were almost twice as likely to return to their emergence site than females, but the difference can probably be attributed to greater mortality among females during their longer maturation period.

The nearest pond to Bungalow Pond (Top Pond) was about 800m away. No animal recorded as a mature adult at Bungalow Pond was seen at Top Pond, and none of 568 adults marked at Top Pond was ever recorded at Bungalow Pond. Eight individuals marked at emergence at Bungalow Pond were recorded as mature adults at Top Pond (7 males, 1 female). It would appear that there is little or no dispersal between ponds once adults have reached maturity.

Almost invariably males intercepted females at the pond. Few tandems were seen away from, or arriving at, the pond. Copulation (wheel position) lasted for an average

of 28 ± 2 (S.E.) min (n=14). Oviposition occurred *in tandem* except at the end of the season when there was a female-biased sex ratio. Oviposition lasted on average 86 ± 11 (S.E.) min (n=8). Including pairs for which the beginning of the wheel and the end of oviposition were observed, pairs remain *in tandem* for an average of 111 min.

During the course of the season 1354 adults attempted to breed at Bungalow Pond (801 males, 553 females). Of these we know that at least 37.7% of the males and 30.7% of the females emerged from Bungalow Pond. The analysis of the factors determining the number of matings obtained by different individuals is presented for

Table 1. Longevity and reproductive success statistics for three categories of adult *Coenagrion puella*.

	Early adults (Adults marked at emergence)	Early adults (Adults marked as mature in June)	Late adults (Adults marked as mature in July)
Mature adult lifespan (days); male			
Mean	4.1	4.0	5.4
SD	4.6	4.5	4.2
Sample size	302	313	186
Maximum	26	20	17
Mature adult lifespan (days); female			
Mean	3.1	4.2	5.5
SD	4.3	5.9	4.4
Sample size	170	209	174
Maximum	26	30	19
Matings; male			
Mean	1.13		3.98
SD	1.89		4.33
Sample size	615		186
Maximum	15		18
Matings; female			
Mean	1.82		3.85
SD	1.67		2.89
Sample size	379		174
Maximum	15		14

two separate data sets: the July data set, for which weather was not a complicating variable (only two overcast days in July 1983); and the June data set, which represents a more typical British summer (about half the days unsuitable for odonate reproductive activity). The analysis of mating success and longevity for males and females is shown in Table 1. Mean mating success was clearly higher when the proportion of sunny days was higher. A male might expect to obtain nearly four times as many matings, and a female more than twice as many, in a very good summer compared with a typical one. The mating success of males was not evenly distributed throughout the population. More than 45% of males in June and 20% in July obtained no matings at all. The major determinant of mating success in males of the July data set was lifespan, which accounted for about 70% of the variation. There were two important determinants in the June data set, namely lifespan (40% of variation), and 'number of sunny days on which a male was alive' (43%). Size, which is thought to have an important effect on reproductive success in many invertebrates, accounted for around 2% of the variation in mating success. The most successful male in the study emerged from Bungalow Pond, took 10 days to reach maturity, lived a further 26 days and obtained 18 matings!

Reproductive success in females is determined by the number of clutches laid and the size of the clutch. As with males, the most important determinant of reproductive success is lifespan which accounts for 70% of the variation. Females lay a clutch of eggs on almost every day of their reproductive lifespans. This does not mean that it takes one day to produce a clutch of eggs from scratch, but that eggs laid on one day were partially developed when the previous clutch of mature eggs was laid. Clutch size increases as the interval between clutches increases. The maximum clutch size is obtained after 5 days (400 eggs). The mean clutch size for 1-day clutches was 191 eggs. Thus a female that was able to lay a clutch of eggs every day for 5 days would lay on average 955 eggs, compared with 400 laid by the female that was only able to reach the breeding site on the fifth day. By catching females as they separated naturally from the tandem position, it was possible to determine that all mature eggs were laid at each visit to the pond. The most successful female lived for 30 days as a mature adult and produced 15 clutches (an estimated 4200 eggs).

No differences were found in the weights, wing lengths, lifespans and reproductive success between heteromorph (typical) and andromorph females (which made up about 5% of the emerging and 11% of the breeding females).

Five hundred and fifty-three females reproduced at Bungalow Pond in 1983. Taking the daily survival to be 0.82, which is the best estimate available from the data for female (0.83 for males), and assuming that 75% of the days in the summer were suitable for reproductive activity by *Coenagrion puella*, then from a simple simulation

model, the estimated egg input into Bungalow Pond in 1983 was 409,220. Two thousand four hundred and fifty-six adults successfully dispersed from Bungalow Pond in the following summer. Using the same survival probability but a more dismal summer(33% good days), the egg number might have been reduced to 237,790. Clearly the weather has an important influence on population egg production.

It is impossible to say whether writing numbers on the wing of a damselfly and placing a dab of paint on the thorax influences its behaviour or reproductive success. However, one check available to us was to see whether individuals with single digits written on the wing and a range of thorax colours survived for longer or obtained more matings than those with two digits. There was no statistically significant difference and, indeed, the most successful male had the number '89' written on his wing and a spot of orange paint on his thorax.

I hope that this note has been able to provide some of the basic population statistics on one of our commoner British species in one of its typical small pond habitats.

Acknowledgements

Sally Collings was the regular third data gatherer, and Jon Pickup was a valuable addition to the team at times of crisis.

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Changes in the Odonata populations between 1985 and 1989 at the Moors Valley Country Park, Dorset

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Introduction

In the mid 1980s East Dorset District Council started implementing a plan to create a country park in the valley of the Moors River, centred around King's Farm (SU104060), 5km west of Ringwood.

The Moors River, known as the River Crane in its upper reaches, rises from the chalk near Cranborne, some 10km to the north. After passing the west edge of the expanding town of Verwood, it flows through reclaimed meadows, to be joined ½km north of King's Farm by a minor tributary, the Ebblake Stream, from the east. This stream originates in the heathlands of Ringwood Forest and flows past an industrial estate, to which it gives its name, on the east edge of Verwood. Just before itsjunction with the Moors River, the stream skirts Ebblake Bog, a Site of Special Scientific Interest (SU105070), which is just within Hampshire. The waters of the Ebblake Stream are acidic, but of insufficient volume to affect significantly the alkalinity of the Moors River. However it does provide direct access to the Moors River for any pollutants from the industrial estate.

The plan for the 36ha country park involved *inter alia* constructing a nine hole golf course, diverting the Moors River just north of King's Farm and creating a large lake astride its old bed. Before any work started on the country park, at the request of the local office of the Nature Conservancy Council, I carried out a survey in 1985 of the Odonata of the Moors River and adjoining land between Potterne Bridge (SU094075), upstream of King's Farm, and St Leonards Bridge (SU098020), below it.

Work on the country park started in the summer of 1985, with the diversion of the river and excavation of the new lake. These were completed, and both parts of the new lake filled, by the end of 1985. The golf course was not formally opened until July

1988. By then the new lake and its surroundings had settled down and the scars of their construction had disappeared. I was interested to discover the effects on the local Odonata population of this recently constructed lake and decided to investigate during summer 1988.

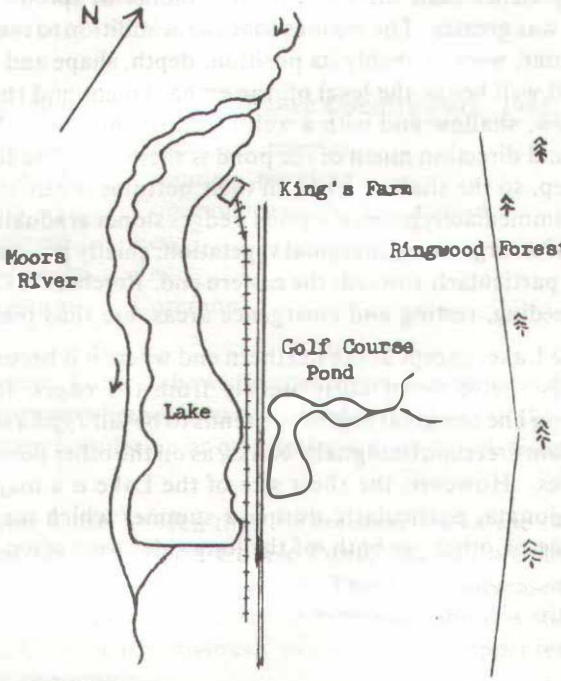

Figure 1. Moors Valley Country Park

The new lake is in two parts (Fig. 1), the larger portion — the Lake — running approximately north and south, and lying astride the old river bed. It is about 450m long and on average 80m wide, and is fed by the Moors River via a sluice at the north end. In late September 1988, pH readings of 8.2 were obtained, compared with 8.0 in the Moors River. The smaller part, the Golf Course Pond, lies amidst the golf course to the east, separated by an embankment which carries a road and a narrow-gauge steam railway. The two parts of the lake are nearly on the same level and connected by a large 30m long pipe. The Golf Course Pond, which is slightly the higher, is fed at its eastern end by two small ditches which originate in the nearby heathlands. These feeder ditches had, in late September 1988, a pH of 4.8, but 20m into the pond this had

risen to 5.0. Subsequent readings showed that the acidity of the pond decreased westwards towards the connecting pipe, where the water was usually about neutral.

The addition of this acidic pond to the otherwise alkaline waters of the locality could be expected to provide favourable conditions for a number of previously unrecorded species. In fact, from the first visit, it was apparent that the Golf Course Pond was not only richer than the Lake in the number of species, but the overall population density was greater. The reasons for this, in addition to the varying degrees of acidity of the water, were probably its position, depth, shape and vegetation. It is surrounded by, and well below the level of, the embankment and the golf course, as well as being narrow, shallow and with a well-indented shoreline. This means that, regardless of the wind direction much of the pond is sheltered. The feeder ditches are steep-sided and deep, so the shallow water in their bottoms is also usually out of the wind. The ground immediately along the pond's edges slopes gradually into the water, with a wide fringe of emergent and marginal vegetation; chiefly grasses and sedges, but also *Sphagnum* sp. particularly towards the eastern end. Perches for Odonata over the water, as well as feeding, resting and emergence areas, are thus plentiful.

By contrast the Lake, except at the northern end where it is becoming silted up, is deeper and its sides shelve down fairly steeply from the edges, resulting in little emergent vegetation. The marginal vegetation tends to be tall *Typha* sp. and Branched Bur-reed, *Sparganium erectum*, though the banks, as on the other pond, are uncut with plenty of tall grasses. However, the sheer size of the Lake is a major disadvantage when recording Odonata, particularly during a summer which was rarely without strong winds, as one or other, or both, of the long sides were often too exposed for many species.

Surveys

In 1985, as part of the survey of the Moors River between Potterne and St Leonards Bridges, the area now occupied by the Country Park was visited four times between 27 June and 12 September. The only habitat suitable for Odonata was the river itself and a few field ditches, so the survey was quick and easy to carry out.

In 1988, the Country Park, and in particular the Lake and Golf Course Pond, was visited on six days between 6 June and 1 October. Since visits were infrequent and the weather sometimes unfavourable, the survey was far from complete, but it does give some indication of the changes in the Odonata population as a result of the new Lake and Golf Course Pond. The records from the Lake are less complete than those from the Golf Course Pond, as after my first visit I decided to concentrate on the latter. A few further visits were made in summer 1989, and data from these have been incorporated in Table 2.

Results

During the 1985 survey, six species were found in the King's Farm stretch of the Moors River. The first four species in Table 1 were centred along the river itself. The only *O. coerulescens* found were a few tenerals which, on one visit, were by a ditch to the north of King's Farm, outside the 1988 study area. *S. striolatum* was not seen until after the Moors River had been diverted in late summer 1985, when it quickly colonised the bare banks of the new channel.

Table 1. Species recorded in Moors Valley Country Park, 1985.

Calopteryx splendens	Abundant, breeding
Pyrrhosoma nymphula	Common, breeding
Coenagrion puella	Common, breeding not proved
Cordulegaster boltonii	Few
Orthetrum coerulescens	Few
Sympetrum striolatum	Common

For each species, Table 2 shows the maximum number seen during any one visit during the 1988 survey, whether it was recorded on the Lake or the Golf Course Pond, or both, and whether copulation or ovipositing was observed. Some 1989 results have been included.

From the table it can be seen that the construction of the two new ponds, the alkaline Lake and the acidic Golf Course Pond, has had a dramatic effect on the number of species recorded in the study area. These have increased from 5 to 22. The 16 additions are all species whose preferred breeding habitat is still, or slow moving, waters. The 17th, *C. virgo*, has obviously strayed from the upper reaches of the Moors River, where it is common.

The results include six species which like slightly acid conditions, such as are provided by the Golf Course Pond, namely *L. sponsa, I. pumilio, A. juncea, O. coerulescens, L. quadrimaculata* and *S. danae*. Because of the close proximity of the alkaline Lake, it is not surprising that some of these were found there also — and similarly that alkaline-preferring species were found on the Golf Course Pond.

The nationally rare *I. pumilio* was found to be more common than *I. elegans*. It occurred mainly on the Golf Course Pond, but also at the north end of the Lake. No *aurantiaca* females were seen, though these are quite frequent on the ponds and ditches of the nearby Ministry of Defence petroleum depot (SU0904), where this population possibly originated. On the other hand, the female forms of *I. elegans —typica, violacea, infuscans* and *refuscens* — were all noted.

Table 2. Species recorded during 1988 and 1989 in Moors Valley Country Park.

Species	Max. Number		Breeding	Lake	Pond	Remarks
**Calopteryx splendens*	E		X	X	X	1.* Recorded in
Calopteryx virgo	(B)					study area in 1985.
Lestes sponsa	E		X	X	X	2. Numbers code.
**Pyrrhosoma nymphula*	C		X	X	X	A = 1, B = 2-5,
Ischnura elegans	C		X	X	X	C = 6-20, D = 21-100,
Ischnura pumilio	D		X	X	X	E = 101-500.
Enallagma cyathigerum	E		X	X	X	Numbers are max-
**Coenagrion puella*	D		X	X	X	imum seen on any
Erythromma najas	A	(D)	(X)	X	(X)	one visit.
Aeshna juncea	B		X		X	3. Additional 1989
Aeshna cyanea	A		X		X	records are in
Aeshna mixta	A			X	X	brackets. *C. virgo*
Aeshna grandis	(B)					and *A. grandis* were
Anax imperator	C		X	X	X	on the Moors River
**Cordulegaster boltonii*	B		X		X	beside the Lake.
Libellula depressa	C			X	X	
Libellula quadrimaculata	C	(D)	X	(X)	X	
Orthetrum coerulescens	C		(X)		X	
Orthetrum cancellatum	B			(X)	X	
**Sympetrum striolatum*	D		X		X	
Sympetrum sanguineum	(B)			(X)		
Sympetrum danae	C		X		X	
Number of species 1988	19		14	11	18	
Additonal species 1989	3		2	3	1	
Total	22		16	14	19	

The presence of *E. najas* was unexpected, as it is a scarce species in Dorset. One male was found among the grasses on the north-west bank of the Lake on 6 June 1988. No further specimens were seen in 1988, but as there are small beds of *Potamogeton* sp. on the Lake it was recognised as a possible breeding site. Expectations were fulfilled in 1989 when 23 were recorded on 24 June on the Lake, including copulating pairs, and there was a single male on the Golf Course Pond — with further records later.

The absence of breeding records for five of the Anisoptera was due, I believe, solely to lack of observation time, as all species were in suitable breeding habitat. The

abundance of *C. splendens, L. sponsa* and *E. cyathigerum*, in particular, but also other species, can be attributed at least in part to the sympathetic treatment of the waterside vegetation. It was left uncut by the wardens wherever possible, thereby providing valuable shelter, feeding and emergence areas for Odonata and other invertebrates.

Discussion

In my report to the local office of the Nature Conservancy Council on the 1985 Moors River Survey, I concluded:

"The construction of the King's Farm Lake could be extremely beneficial to the Odonata if — but only if — the water within it is kept free from pollution. It would appear from this survey that to achieve the level of purity required by the susceptible species, action will be necessary to clean up both the Moors River and the Ebblake Stream. If this cannot be done, a large pond which is fed by springs, drainage ditches or other sources independent of the two streams, would be an attractive alternative."

Superficially, the Moors River appeared in 1988 much as it had three years previously, but the growth of the Ebblake Industrial Estate gave cause for concern. I was informed that there had been pollution incidents attributable to this estate and, on one of my visits, the upper reaches of the Ebblake Stream, just after it passed the estate, appeared to be badly polluted. However, so far little of this pollution has apparently entered the Lake, as the sluice at the north end is usually kept closed, except in times of flood.

The Golf Course Pond would be less likely to be affected, as any polluted water in the Lake should be much diluted by the time it reached the connecting pipe. The Golf Course Pond, indeed, for all intents and purposes meets the characteristics of the "attractive alternative" mentioned in the 1985 report. The richness of its Odonata population seems to confirm this. However the Moors River is also important in its own right as *Libellula fulva* breeds on its lower reaches: which were, until the 1950s, the stronghold in Britain of *Oxygastra curtisii* — which is further reason for pressing for action to reduce the present level of pollution, and for the prevention of further pollution incidents.

Conclusion

The creation of the Moors Valley Country Park has, through the construction of the Lake and Golf Course Pond at King's Farm been extremely beneficial to the Odonata fauna. The Golf Course Pond, with its acidic feeder ditches, is especially valuable, and held 19 out of the 22 species recorded — the latter being an increase of 17 species over those found in the area in 1985.

The area of the Lake and Golf Course Pond, because of the number of species, now meets the requirements of a Site of Special Scientific Interest for Odonata. Because of the presence of breeding *I. pumilio* and *O. coerulescens*, it also qualifies as a potential Key Conservation Site.

Pollution from, in particular, the expanding Ebblake Industrial Estate poses a threat to both the Lake in the Country Park, and to the Moors River downstream.

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I am grateful to Mr Ian Cooper of the East Dorset District Council and to Mr David Crompton, the chief warden at the Country Park, and his assistants for their helpfulness.

Dragonflies of the Montgomery Canal

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The Montgomery Canal is a 57km branch of the Shropshire Union Canal which runs from Frankton in Shropshire southwards to Newtown in Powys. Closed as a commercial waterway since 1944, the canal still contains water for 46km, being dry for short stretches at both ends, and for an eight kilometre section through Shropshire. Today the canal is classed as a Remainder Waterway and is maintained as such by the British Waterways Board (B.W.B). However, large scale restoration work could allow the return of navigation and heavy boat traffic as early as the mid-1990's. At present much of the watered canal is classified as Sites of Special Scientific Interest (SSSI) and, with its unpolluted slow flowing water and shallow muddy bottom, is particularly rich in aquatic vegetation, being a stronghold for several rare Pondweeds (*Potamogeton* spp.). Closely associated with the thriving submerged and emergent flora is a diverse and often abundant invertebrate fauna (Hollier, Wistow and Walmsley, 1987).

The Montgomery Canal Ecological Survey (MCES) was established in 1985 to survey canal ecology and establish aquatic reserve areas where key species would survive after re-navigation (Briggs, 1988). As a part of the MCES the Odonata of the canal have been surveyed since 1985. The adults were surveyed as part of a preliminary survey in the summer of 1985, in a more complete quantitative survey in 1986 and from

Table 1. Distribution of Odonata adults on Montgomery Canal in 1985-1988

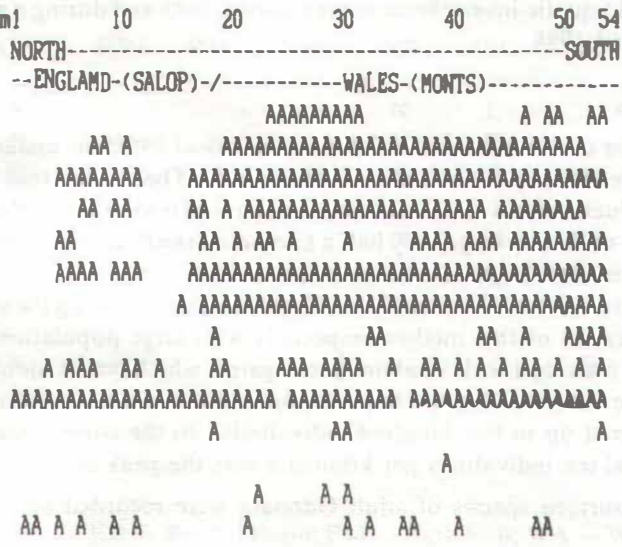

Table 2. Adult Odonata present on Nature Reserves on Montgomery Canal in 1985-88

	Reserves						
	GA	RB	PM	WA	VP	WC	AB
P. pennipes	A					A	A
E. najas	A				A	A	A
C. puella	A	A	A	A	A	A	A
E. cyathigerum	A	A	A	A	A	A	A
P. nymphula	A	A					A
I. elegans	A	A	A		A	A	A
C. splendens	A				A		A
C. virgo	A						
A. cyanea	A	A					A
A. grandis	A	A	A	A	A	A	A
G. vulgatissimus						A	A
L. depressa							
L. quadrimaculata	A						
S. striolatum	A		A				

Reserves: GA — Guilsfield Arm; RB — Rednal Basin; PM — Park Mill; WA — Wern Aqueduct; VP — Vyrnwy Ponds; WC — Wern Claypits; AB — Abbey Bridges

A — Adult present

reserve sites in 1987 and 1988. In addition, the larvae were recorded as part of a general aquatic invertebrate survey during 1985 and during a specific larval survey in 1986 and 1988.

Results

The quantitative adult Odonata survey of 1986 was undertaken as an attempt to indicate the population sizes of the canal. The survey took the form of counting individuals within each kilometre section. To save time where numbers of certain species were very large only half a kilometre (the first and third quarters) was counted. An estimated population was produced by multiplying the results by two. Each kilometre of water was surveyed at least three times during the summer. The inevitable inaccuracies of this method, especially with large populations, are obvious but the results provide a scale of abundance against which future monitoring may be gauged. For the common Zygoptera peak populations in any one kilometre, on any one day, numbered up to five hundred individuals. In the commonest anisopteran *(Aeshna grandis)* ten individuals per kilometre was the peak count.

Fourteen species of adult Odonata were recorded along the canal during the

Table 3. Distribution of Odonata larvae and other breeding evidence on Montgomery Canal 1985-88

N = larvae, E = egg-laying, M = mating. Priority given to larvae, then egg-laying so not all mating or egg-laying records shown.

Km	10	20	30	40	50	54
	NORTH----------					----SOUTH
	--ENGLAND-(SALOP)-/----------		WALES-(MONTS)----------			
P. pennipes			N M			
E. najas	M	NNENNNNNNNNNNNNNNNNN		NNNNNNNNNN		
C. puella	MN NNNNN	NENENNNNENNNEENNNNNMNNNNNNNNNNNNNNNNNNNNNMM				
E. cyathigerum	EE	N ENEN NN NNNNNNNNENNNNE		NEEN N E		
P. nymphula		M M				M
I. elegans	NN NNN	NMNENNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN				
C. splendens			M	M N		NM
C. virgo						
A. cyanea						
A. grandis	E EE	NE N	E	N E	E N	
G. vulgatissimus						
L. depressa				E		
L. quadrimaculata		E				
S. striolatum						

Table 4. Breeding evidence of Odonata on nature reserves on Montgomery Canal, 1985-88

	GA	RB	PM	WA	VP	WC	AB
P. pennipes							
E. najas	N				N	E	
C. puella	N	M	E		N	E	
E. cyathigerum	E				N	E	
P. nymphula	M						
I. elegans	N				N	M	M
C. splendens	M						
C. virgo							
A. cyanea							
A. grandis	N						E
G. vulgatissimus							
L. depressa							
L. quadrimaculata							
S. striolatum							

Reserves: GA — Guilsfield Arm; RB — Rednal Basin; PM — Park Mill; WA — Wern Aqueduct; VP — Vyrwy Ponds; WC — Wern Claypits; AB — Abbey Bridges

N — larvae; E — egg-laying; M — mating. Priority is given to larvae, then oviposition so not all the mating or oviposition records are shown.

survey; six of Anisoptera and eight of Zygoptera. These are listed with their distributions along the 57km of canal and the seven nature reserves in Tables 1 and 2.

The larval survey produced records from 43 of the 46km sections in water. Seven species were found. These were *A. grandis, Coenagrion puella, Ischnura elegans, Erythromma najas, Enallagma cyathigerum, Calopteryx splendens,* and *Platycnemis pennipes.* With additional egg-laying and mating records included as breeding evidence the number of breeding species increases to eleven with *Aeshna cyanea, Libellula depressa, Libellula quadrimaculata* and *Pyrrhosoma nymphula.* The distribution of larvae and breeding records is shown in Tables 3 and 4.

Anisoptera

Aeshna grandis (L.)

Much the commonest dragonfly on the canal, *A. grandis* was very widely distributed. This species is on the western edge of its British range along the canal.

Aeshna cyanea (Müller)

A wide distribution and a long flight period made this a familiar species

throughout the canal. Little confirmation of breeding was obtained, but the species would seem well established.

Gomphus vulgatissimus (L.)

This nationally scarce species, apparently not recorded in Montgomeryshire since 1947, was recorded from six one-kilometre sections, all in Wales. Solitary females were seen at the Wern Claypit reserve (GR 33(SJ) 259207) Pool Quay (GR 33(SJ) 257118), the Penarth Feeder (GR 30(SO) 140932), and twice from the Abbey Bridges reserve (GR 33(SJ) 248103). A male was seen at Carreghofa Locks (GR 33(SJ) 258207). It seems that all the individuals recorded originated from the nearby Severn or Vrynwy rivers. In addition a female was recorded from the Severn Road Bridge at Aberbechan (GR 32(SO) 143934).

Libellula quadrimaculata (L.)

This species was recorded from only four sites, all sightings occurring during early summer. The records only involved solitary individuals including an egg-laying female near Maerdy Bridge (GR 33(SJ) 265175).

Libellula depressa (L.)

L. depressa was only recorded from one site on the canal where three males, and an egg-laying female were seen on July 1st 1986 (GR 33(SJ) 205035).

Sympetrum striolatum (Charpentier)

This late summer dragonfly was uncommon on the canal. Its breeding status is uncertain.

Zygoptera

Platycnemis pennipes (Pallas)

This species was only recorded from the Welsh stretch of canal. Apparently unrecorded in Montgomeryshire since 1960, it was present in thirteen one-kilometre sections and three reserves during the survey. The main population occurred between Arddline and Welshpool where the damselfly was often common and evidence of breeding was recorded. Another smaller population was found at the southern end of the canal where the River Severn flows close by.

Erythromma

Another species unrecorded in Montgomeryshire since 1960, *E. najas* was common in the Welsh sections although restricted to an isolated length in the Shropshire section. It was frequently found in open unshaded areas of water: reedswamp dominated and shaded lengths were far less suitable. Larvae were often abundant in amongst the beds of aquatic plants.

Enallagma cyathigerum (Charpentier)

This was a very common and widespread species with large numbers of males

often seen flying low over the water surface, especially where the canal widened (eg. winding holes). It was absent from sections dominated with reedswamp.

Ischnura elegans (Vander Linden)

This was another abundant species, but with an adult preference for tall bank-side and towpath vegetation.

Coenagrion puella (L.)

C. puella was the most widespread damselfly of the canal. Like *I. elegans* the adults of this species were much less dependent on open water and could be found around *Glyceria* reedswamp and ranker vegetation, often some distance from water.

Pyrrhosoma

Found from only half the watered sections, *P. nymphula* was a regular but uncommon species. The largest populations were in the very southern Welsh sections.

Calopteryx splendens (Harris)

This striking species was common on the canal. Recorded from all the Welsh sections, it was absent from the northern Shropshire length. The established breeding population would seem to be supplemented from the River Severn, population peaks occurring at sections close to the river.

Calopteryx virgo (L.)

This species was occasionally recorded from the southern end of the canal. This species is a wanderer from fast flowing streams that pass under the canal, then into the River Severn. The canal would seem to be an unsuitable breeding habitat.

Discussion

The canal is of considerable local importance for Odonata. Though Shropshire has other canals and the meres, the Welsh length represents the only sizeable slow and still water habitat in the old county of Montgomeryshire. It seems likely that the canal has provided useful Odonata habitat for most of its history, however it has been largely ignored by naturalists. Only a handful of records exist in the Shropshire BRC (Ludlow) and there is only one paper published on the dragonflies of Montgomeryshire (Davies, 1947). This paper provides information on distributions and abundances within the Welsh section. It is particularly interesting because the canal in 1947 was in a similar condition to today with open water and little boat traffic. Davies recorded seventeen canal species in the Welshpool area. The three species not recorded during our survey period but listed by Davies were *Sympetrum danae, Cordulegaster boltonii,* and *Aeshna juncea.* The latter two species were regarded as common in 1947 and suggest a change in local status. There were unconfirmed records for *A. juncea* during the survey. From the brief descriptions given for the remaining species it seems their distributions have stayed largely the same. *Gomphus*

vulgatissimus was found in "fair numbers in one locality on the Severn below Welshpool".

With the recent passing of the British Waterways Act 1987, enabling restoration of the Montgomery Canal to a cruising waterway, restoration can commence on a large scale. If sufficient funding can be found it is possible that within five years there will be heavy boat traffic.

At present the clean undisturbed open water and associated luxuriance of aquatic and marginal plants is responsible for the rich aquatic invertebrate fauna. This habitat deteriorated in the 60s and early 70s with overgrowth of the canal by reed and scrub. In recent years renewed management by BWB and amenity groups has helped to restore this habitat. This management is the result of a resurgence of interest in the canal as a waterway.

With full restoration and the reconstruction of the dry sections more open water will be created and initially increase the distributions of Odonata. From my experience of re-habilitating overgrown canalside areas for aquatic reserves, Odonata will readily be able to recolonise. However, if boating levels on the restored canal exceed a critical level, deterioration of the aquatic environment results and species are lost.

Heavy boat traffic damages aquatic vegetation and their associated ecosystems in two main ways. The physical scouring action of the boat wash erodes submerged and emergent plant life through the battering of frequent passage. Turbidity caused by churning up of the substrate produces muddy water through which light levels are reduced and photosynthesis is prohibited. It is difficult to comment on the fate of individual Odonata species but it can be assumed that all breeding species will suffer to an extent. It is likely that two of the more sensitive species will suffer more than most; *E. najas* because of clearance of floating-leaved vegetation and *P. pennipes* due to susceptibility to pollution and oily water (Hammond, 1983).

The towpath, which forms important adult habitat is also under considerable pressure with high boating levels. If the towpath vegetation is trampled as well as mown and the marginal vegetation is lost through erosion then adults lose feeding areas and necessary shelter. Courtship and mating behaviour would also be disturbed.

Conservation

The MCES was set up as part of an agreement between the Nature Conservancy Council and BWB. This agreement allowed for full restoration and return of boating to the Montgomery Canal on condition that aquatic reserves were established beforehand. These reserves would provide areas within which the characteristic and

often rare flora and fauna of the canal could be retained. Since 1985 seven reserves have been established and more are planned. Several of these sites already have good Odonata populations.

The largest reserve is the Guilsfield Arm, a four kilometre branch of the canal that runs westward to the village of Guilsfield. It is wholly in Wales. The eastern half of the Arm was restored to open water in the spring of 1986 (between GR 33(SJ) 252146 and 243137) and within a few months had developed an aquatic and marginal flora with rarer species being introduced from canal localities. During the summer of 1986 ten species of Odonata were already recorded and in 1987 *P. pennipes* had colonised the reserve from the nearby mainline canal and *C. virgo* was seen at the far western end (straying from a nearby stream). In two summers twelve of the canal's fourteen species have therefore been recorded. It is now hoped to restore the dry and overgrown western half to water and reproduce the present canal habitat along the whole Arm.

The other six reserves are smaller but all have potential as Odonata habitats. They are Rednal Basin (GR 33(SJ) 352277), Park Mill (GR 33(SJ) 322249) (Shropshire), Wern Aqueduct (GR 33(SJ) 259207), Vyrnwy Ponds (GR 33(SJ) 253196), Wern Claypit (GR 33(SJ) 252142), Abbey Bridges (GR 33(SJ) 248103) (Powys). It is intended to create a total of seventeen reserves at regular intervals along the restored canal where colonies of the breeding Odonata species can be conserved. It is hoped that on the Guilsfield Arm and some of the larger reserves the population diversity and densities of the present mainline canal can be retained.

Acknowledgements

The Montgomery Canal Ecological Survey was funded jointly by British Waterways Board and the Manpower Services Commission. Several staff were involved with the Odonata work and special mention must be made of J. D. Briggs, P. A. Bannister, P. J. Braithwaite, A. Walmsley, C. A. Robinson and A. Barr.

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Two examples of male dragonflies grasping the males of mating pairs

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At about 13.30 GMT on 6th August 1988, by a pond near West Quantoxhead, Somerset, I saw a mated pair of *Ischnura elegans* (Vander Linden) flying in the wheel position. Suddenly, the pair was attacked, in the air, by a male of the same species; after a tussle, it grasped the pronotum of the paired male and flight was resumed. The three damselflies then settled to rest on a reed-mace leaf, with the wheel position of the original pair being maintained, but, after about a minute, a struggle occurred, with the insects separating and flying off.

Then, at about 13.00 GMT on 9th August 1988, at the same location, I saw a male *Sympetrum striolatum* (Charpentier) fly at a pair of conspecifics which were resting in the tandem position on willow vegetation. After a struggle, the head of the paired male *S. striolatum* was seized and the three dragonflies, arranged in one line, flew off; unfortunately, they disappeared from my view.

Corbet (1962) mentioned that male dragonflies sometimes behave sexually towards other males of the same species; he quotes Kormondy (1959) who described male *Tetragoneuria cynosura* trying to form tandems with other males. Corbet (1962) also stated that the finding of copulation marks on the eyes of male dragonflies, such as *Anax imperator*, indicates that males have attempted to mate with males.

However, in the two examples I have given, male dragonflies have, at least for a short time, grasped males of the same species which were already paired. Further, flight occurred, with the intruding males necessarily positioned at the front of the seized pairs.

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Emergence attitudes in *Gomphus vulgatissimus* (L.)

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Introduction

A note from the Field Meetings Organiser, in the Spring 1987 issue of the British Dragonfly Society *Newsletter*, commented on the emergence attitude of *G. vulgatissimus* and suggested that examples of vertical emergence were harder to find than horizontal emergence. I have been recording the life-cycle of the Club-tailed Dragonfly for several years and, following the note, decided to record its preferred attitude of emergence.

In general most species of dragonfly in preparation for emergence select a vertical surface to cling to and climb out of the water. This support is usually a stem of vegetation. It has been noted however that *G. vulgatissimus* often can be found lying horizontally and therefore parallel to the substrate.

G. vulgatissimus, prompted by increasing daylength and watertemperatures, has a synchronised emergence usually between the second week of May and the beginning of June. This varies slightly depending on the weather and in Worcestershire is usually about a week later than on the River Thames, the dragonfly's other stronghold.

Since 1985, as part of an annual assessment of population figures, I have been counting exuviae along a 75m stretch of the River Severn at Bewdley, Worcestershire, an area where the dragonfly is locally common. During 1987, 1988and 1989 I decided to record the preferred attitude of emergence as well.

Methods

Each day during the period of emergence, exuviae were examined and collected to avoid duplication of counts. At the study section the river is about 45m wide and approximately 2.5m deep in the middle, shelving gradually to the edge. The bank slopes gently to the water's edge and has two main ledges. Only the left bank (east side) of the channel was examined in the survey. The bankside vegetation is mostly grasses with creeping buttercup *(Ranunculus repens)*, dock *(Rumex* sp.), nettles *(Urtica dioica)* some water mint *(Mentha aquatica)* and dandelion *(Taraxacum* sp.). At the water's edge, burr reed *(Sparganium* sp.) stretches for about 20m along the bank.

For the purposes of the study, vertical was taken as lying at angles of between 80° and 90° to the substrate and horizontal as between 0° and 10° to the substrate. Any attitude between 10° and 80° was described as semi-vertical. It might appear that

semi-vertical constitutes a disproportionally large range for its category but in fact nearly all exuviae that were obviously not vertical or horizontal were at about 45°.

Results and discussion

The results (Table I) show a marked preference for vertical emergence. Semi-vertical exuviae were low in numbers except in 1987 when the proportion was 37.4%. This figure can be explained by the fact that the exuviae had climbed on to short grasses which were not able to bear the weight and so had drooped down. I believe that these exuviae would have been vertical had their attempt not been thwarted. Other supports for semi-vertical exuviae were creeping buttercup and dock. Horizontal exuviae were also found on creeping buttercup and dock as well as stone slabsand the general soil surface. A small proportion of exuviae that could not be assessed due to having become dislodged are also shown in Table I.

Table 1. Preferred attitude of *Gomphus vulgatissimus* during emergence shown as a percentage of total sample in each year

Year	Total numbers emerging	Vertical	Horizontal	Semi-vertical	Dislodged
1987	123	50.4%	8.1%	37.4%	4.1%
1988	106	67.0%	10.4%	16.0%	6.6%
1989	141	78.0%	3.6%	11.4%	7.0%

Table 2. Percentage of individuals emerging vertically showing their preferred supports

Year	Grasses	Burr Reed	Others
1987	73%	23%	4%
1988	69%	11%	20%
1989	54%	23%	23%

The chosen support for vertical exuviae is shown in Table 2. Since grasses were the predominant vegetation at the site a preference for vertical emergence might have been expected, yet there were plenty of opportunities for an individual to emerge horizontally on creeping buttercup, rock ledges or even the soil surface. Second

favourite as a support was burr reed. Interestingly more than half (55%) of the dragonflies in the section where burr reed grew, seemed to prefer to climb up the bank rather than go straight up the stems of burr reed and in fact, must have passed the latter to get out of the water. Other supports for vertical emergence ranged from the faces of rock ledges to water mint, dandelion and various dead dried stems of other plants.

Whilst collecting exuviae a note was made of the sex of each individual to ascertain if there was any preference here. In fact the numbers were always very evenly balanced and in 1989, for example, while 53.2% of the total population was male, 56% of the vertical sample were also male. Of the sixteen examples of horizontal emergence in 1988/89 nine were male. The distance of the point of emergence from the water's edge was also noted. Here no particular bias was found and in 1988/89, for vertical exuviae not choosing burr reed, the distance was 103cm. The average distance for semi-vertical exuviae was 96cm while horizontal examples were 83cm.

Conclusion

The total numbers of larvae choosing horizontal emergence are very low. There is no preference in either sex for horizontal emergence and such larvae travel about the same distance from water's edge to those favouring vertical emergence. However, horizontal emergers are found on plants with a high proportion of flat surface area ie. creeping buttercup, dock (eleven out of sixteen were on these in 1988/89). It could be that these particular larvae were unable to find a vertical surface on which to emerge.

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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.

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.

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

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

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

The titles of journals should be written out in full.

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

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

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

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

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