Odonatologica 30(3): 289-298 *September 1, 2001*

CHANGES IN THE DRAGONFLY COMMUNITIES AT THE TWENTY PONDS AT WOODWALTON FEN, CAMBRIDGESHIRE, UNITED KINGDOM, SINCE THE STUDY OF 1962-1988*

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Received December 4, 2000 / Reviewed and Accepted January 22, 2001

The pattern of the number of spp. per pond changed completely between 1988 and 2000. The growth of scrub on the edges of the ponds caused a decline in the number of dragonfly spp. when more than 50% of pond edge was shaded by bushes. When the ponds were completely shaded they lost all their dragonfly spp. The decline in spp. appeared to be caused by shading rather than changes in the aquatic flora caused by shading. When the scrub was not controlled the ponds were inhabited by dragonflies from 26 to at least 39 yr. In ponds where no scrub developed, or where it was controlled, *Coenagrion puella, Ischnura elegans, Aeshna cyanea, Libellula quadrimaculata, Sympetrum striolatum* and *Sympetrum sanguineum* were still continuing to inhabit the ponds after 39 yr. *Aeshna grandis*, which had occurred most yr. in the 1962–1988 period, was still present in 2000. *Pyrrhosoma nymphula* and *Brachytron pratense*, which had bred from 1964 to 1972 and 1968 to 1973 respectively, both reappeared after 20 yr. absence. Their return to the ponds appeared to be connected with their increase in adjacent habitats at Woodwalton Fen in the 1989–2000 period. *Anax imperator* and *Libellula fulva*, which had also increased at Woodwalton Fen, were seen for the first time at the ponds during this period. The reason for the recent disappearance of *Lestes sponsa* from the ponds and adjacent habitats is not known. This study yet further emphasises the need to conserve large core populations of dragonflies, and it reiterates the need for really long term monitoring.

INTRODUCTION

Twenty small ponds were dug at Woodwalton Fen National Nature Reserve (208 ha) at Cambridgeshire, England in 1961. They are steep-sided, have a circumference of about 16 m and are about 20 m apart. Their dragonfly populations were recorded

* This paper is dedicated to the memory of Elliot P i n h e y who did so much to establish the scientific base for the conservation of African dragonflies.

from 1962 to 1988 (MOORE, 1991). Although there were differences between the populations of the different ponds they all developed in the same way, in that an initial pioneer stage of one year with *Sympetrum striolatum* (Charp.) and *Ischnura elegans* (Vander L.) was followed by a period of 11 years in which eight more species became established in some or all the ponds most years. These were, in order of colonisation, *Libellula quadrimaculata* L., *Coenagrion puella* (L.), *Aeshna cyanea* (Müll.), *Pyrrhosoma nymphula* (Sulz.), *Lestes sponsa* (Hans.), *Sympetrum sanguineum* (Müll.), *Aeshna grandis* (L.) and *Brachytron pratense* (Müll.). Of these species *P. nymphula* and *B. pratense* were not recorded after 1972 and 1973 respectively. *I. elegans, S. striolatum, L. quadrimaculata, C. puella* and *L. sponsa* bred on most ponds most years; *A. cyanea* and *S. sanguineum* bred on a few ponds every year; *A. grandis* bred on a few ponds most years. It appeared that the five most abundant species were normally autochthonous and that the other three species were more dependent on recolonisation from more suitable habitats adjacent to the ponds. The close relationship between the populations of the ponds and those of adjacent habitats was shown when all the species returned to the ponds in 1977 following the drought of 1976 which caused 18 of the ponds to dry out.

During the period 1989 to 2000 further ad hoc occasional visits were made to the Woodwalton ponds. Only in 2000 were they organised to cover the flying seasons of all the species present. Despite the fragmentary nature of the observations they are presented here because they provide new information about the effects of shading the ponds by scrub and about the status of *Pyrrhosoma nymphula* and *Brachytron pratense*. They extend an unusually long period of observations from 27 to 39 years. This makes it possible to record the establishment, development, decline and extinction of dragonfly populations on several ponds.

METHODS

As in the 27 year study observations on dragonflies were made as near as possible to solar noon on fine days. Numbers of adults and tenerals were recorded while walking round each pond. Notes were made on oviposition and on exuviae found. Some records were also made on pond depths, on aquatic plants and the extent to which ponds were shaded by invasive Hawthorn (*Crataegus*) and other scrub species.

The records made from 1989 to 1996 were irregular. No observations were made in 1998 and 1999. In 2000 records were made to cover the flying seasons of all the dragonflies present and are equivalent with those made from 1962 to 1988.

In making comparisons between the 1989–2000 period and the 1962–1988 one, use is made both of published material (MOORE, 1991) and of unpublished records made in the 1962–1988 study.

RESULTS

POND DEPTHS

The depths of the ponds continued to vary seasonally and between years. In the

1962–1988 period none of the ponds ever dried out completely except in 1976 when 18 of them did so. In the 1989–2000 period six ponds dried out in 1990, two in 1991 and 1995 and three in 2000. Some ponds may well have dried out in other years especially in 1997 and 1998 but were unrecorded. Generally ponds filled up in winter, but in 1997 one pond was still dry on May 30th. The ponds that dried out were those in the southern part of the site and those that were completely shaded by bushes.

AQUATIC PLANTS

Four of the 11 plants recorded in 1988 had disappeared by 2000. Most species occurred in fewer ponds than in 1988: *Typha* occurred in 11 ponds in 1988 but in only four in 2000; *Polygonum* in 16 in 1988 but only three in 2000; *Chara* in seven ponds in 1988, in two in 2000. The only plant to increase was *Lemna* which had never occurred in more than five ponds between 1962 and 1988 but was in 14 ponds in 2000. It mainly occurred in shaded ponds and was the only aquatic plant to survive in completely shaded ones (see Tab. II). The decrease in other aquatic species was clearly caused by the growth of bushes round the perimeter of many ponds.

BUSH GROWTH ON EDGES OF PONDS

Soon after construction the edges of many of the ponds began to be colonised by woody plants. By 1980 all but one pond had small bushes growing round their edges. At that date the amount of edge covered varied from 10% to 90%. By 2000 14 of the ponds were shaded by more than 50%, and of these seven were completely shaded.

Desultory control of scrub was practised on many of the ponds throughout the periods of observations for conservation reasons. However five ponds (1, 3, 6, 11 and 14) were deliberately left unmanaged in order to support studies on the effects of scrub cover on newts (COOKE et al., 1994) and on dragonflies.

CHANGES IN SPECIES DIVERSITY

The suitability of the ponds for dragonflies was measured by recording the number of species observed on the different ponds. The results are tabulated in Table I. They show that after the pioneer stage the development and climax stages showed a similar pattern in all years although the number of ponds with more species tended to increase. The pattern is what can be expected when ponds differ slightly in their attractiveness to dragonflies. This pattern still existed in 1988, the last year of the 27 year study, although there are signs of a decline in the number of species on several ponds and one pond ceased to contain any dragonflies at all. By 2000 the pattern had changed completely: a few ponds still retained as high a number of species as the best ponds in

Table I
Changes in species diversity on the Twenty Ponds 1962-2000

Stage	Year	Season	Number of ponds with the number of species indicated									
			0	1	2	3	4	5	6	7	8	9
Pioneer	1962	1st	1	4	15							
Development	1964	3rd			3	6	8	2	1			
Development	1968	7th		1		4	8	6	1			
Development	1971	10th				1	3	10	6			
Climax*	1977	16th			1	4	4	7	4			
Climax	1983	22nd			1	2	3	6	6	2		
Climax	1986	25th				1	1	3	4	7	4	
Senescence starting	1987	26th		3		3	3	7	3	1		
Senescence starting	1988	27th	1		1	3	5	4	5	1		
Senescent	2000	39th	7	2	3	2		1		3	1	1

* Numbers were probably reduced by the drought in the preceding year

previous years, but most ponds had many fewer than in the 1980s, seven having none at all. An adverse factor must have operated between 1988 and 2000 which was causing the ponds to lose species progressively. The decline was clearly associated with the growth of scrub round an increasing number of ponds.

The data in Table II show the relationship between shading by scrub and aquatic plants and dragonflies. They show that the ponds retained their dragonflies until 50% of the length of their edges were shaded out by bushes. Below 50% fewer species were present. The Anisoptera disappeared first, leaving only the zygopteran species *C. puella, P. nymphula* and *I. elegans* to disappear later. The ponds which were completely shaded had no dragonflies at all.

The data suggest that the direct effects of shading affected the dragonflies more than the change of the aquatic flora to a monoculture of *Lemna*.

THE DEVELOPMENT OF THE DRAGONFLY COMMUNITIES OVER TIME

The complete sequence of dragonfly communities related to seral vegetation changes could only be observed accurately on those ponds which had never been cleared of scrub. In the other ponds the duration of populations had been extended in time by varying amounts of scrub clearance. The data on the number of species present on the five unmanaged ponds are shown in Table III. They show that after the initial pioneer stage the pattern of species noted above for the whole series of ponds existed until 1986. The only exception was in 1976 when most of the ponds dried out in the course of the summer. In 1987 there are indications of a change and by 2000 four ponds had lost their dragonflies. The last dragonflies were observed on pond 1 in 1987, on pond 3 in 1990, on pond 14 in 1991 and on pond 6 in 1992. All ponds were completely shaded within one or two years after the last dragonfly

was observed. These records show that the dragonfly communities on these unmanaged, ungrazed ponds lasted from 26 to at least 39 years.

CHANGES IN THE SPECIES PRESENT FROM 1989 TO 2000

The records of dragonflies made in this period are summarised in Table IV. The data for all years except 2000 are very incomplete, but for that year they are equivalent to those obtained in the 1962–1988 period. In the years with incomplete data the table distinguishes between negative records of each species in its flying season and those made outside it, when the species was most unlikely to be observed. Negative records in 2000 can be taken as very strong evidence that the species was not present on the ponds that year. In all years, except for 2000, the number of ponds

Table II

The relation between shading by bushes around ponds and aquatic vegetation and the number of species of dragonflies present in 2000

Amount of bush cover in 2000	Pond (See MOORE, 1991)	Aquatic vegetation August 24th, 2000	Number of dragonfly species present in 1988	Number of dragonfly species present in 2000
No bushes	12	AV	7	9
	13	AV	6	7
	16	AV	5	7
	17	AV	7	7
Less than 50% covered	4	AV	6	5
	8	AV	4	8
More than 50% covered	2	AV	4	2+
	5	AV	4	2+
	7	*Lemna* only	5	3
	9	*Lemna* only	4	2+
	10	*Lemna* only	3	1+
	11*	*Lemna* only	4	1+
	18	pond dry	4	3
Circumference of ponds completely covered	1*	*Lemna* only	0	0
	3*	*Lemna* only	2+	0
	6*	*Lemna* only	4	0
	14*	pond dry	2	0
	15	*Lemna* only	5	0
	19	pond dry	4	0
	20	none	4	0

AV: Two or more species of aquatic vegetation; – +: zygopteran species only; – *: ponds which had no scrub control (see p. 291)

Table III

The development of the dragonfly communities on five unmanaged ponds at Woodwalton from 1962 to 2000

Pond	Numer of species observed in the year indicated																											
	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	00
1	0	2	3	3	5	4	4	3	5	5		5	5	4	2	5	7	6	4	6	7	6	5	3	3	1	0	0
3	1	1	4	4	4	3	4	3	5	6		4	4	4	3	5	6	5	4	5	6	7	7	6	8	4	2	0
6	2	2	3	3	7	6	5	4	5	5		5	5	4	2	6	6	4	5	5	6	6	7	5	5	1	4	0
11	2	2	5	2	6	4	5	5	4	5		3	4	4	1	6	4	4	4	7	7	6	6	7	7	3	4	2
14	2	3	4	2	7	4	5	5	4	5		3	6	4	2	4	6	4	4	4	6	6	7	5	6	2	3	0

Records for 1972 were incomplete and are not included. – The last record of a dragonfly on pond 3 was 1990, on pond 6 1992 and on pond 14 1991

observed to be supporting different numbers of species are minimal values; the actual number may have been higher. In Table IV the status of each species in the 1962–1988 period and records for 1988 are included so that comparisons can be made between 1988 and 2000. Despite the incomplete nature of the records the following conclusions about changes in the dragonfly fauna of the whole site can be drawn:

(1) *C. puella, I. elegans, A. cyanea, L. quadrimaculata, S. sanguineum* and *S. striolatum*, the six species characteristic of the climax situation within the 1962–1988 period, continued to inhabit some of the ponds up to and including 2000. All were proved to have bred.

(2) *L. sponsa*, which was a regular breeding species from 1963 to 1988, continued to breed until 1994 at least, but was absent in 2000 for the first recorded season since 1963.

(3) *A. grandis*, which had occurred in 19 seasons between 1966 and 1988, continued to inhabit the ponds at least occasionally. In 2000 a female was observed ovipositing.

(4) *P. nymphula*, which had bred from 1964 to 1972 and then disappeared, recolonised the ponds in 1992 (possibly in 1991) and was well established by 2000. *B. pratense*, which had bred from 1968 to 1973, returned to the ponds in 1993 and 1996, and was observed close to them in 1989 and 2000.

(5) Casual visitors continued to visit the ponds: *Aeshna mixta* Latr., which was observed in nine seasons between 1962 and 1988, was

observed in 1995 and 2000. *Enallagma cyathigerum* (Charp.), which was observed in six seasons between 1964 and 1988, was seen in 1996 and 1997. *Libellula depressa*, which had occurred twice in the earlier period, was observed ovipositing in 1996.

(6) Two species not recorded from 1962 to 1988 were observed in the 1989–2000 period: *Anax imperator* Leach was observed ovipositing in 2000 and *Libellula fulva* Müll. was seen flying over a pond the same year. It did not settle.

(7) *Calopteryx splendens* (Harr.), *Coenagrion pulchellum* (Vander L.), *Erythromma najas* (Hans.) *Aeshna juncea* (L.) and *Orthetrum cancellatum* (L.), which were recorded on very rare occasions in the 1962–1988 period were not recorded in the 1989 to 2000 one.

As shown above the growth of scrub caused the loss of anisopteran species and then zygopteran ones. Partly shaded ponds did not provide a new habitat for species which had not occurred on the ponds before they were shaded.

DISCUSSION

THE CAUSES OF CHANGES IN THE COMPOSITION OF DRAGONFLY COMMUNITIES ON THE TWENTY PONDS

Apart from the straightforward changes caused by the growth of scrub outlined above there were others whose causes were less obvious:

(1) The reappearance of *P. nymphula* in 1992 after a 20 year gap and its continued presence since then.

(2) The reappearance of *B. pratense* after a 20 year gap.

(3) The appearance of *A. imperator* and *L. fulva* for the first time in 2000.

(4) The absence of *L. sponsa* in 2000.

P. nymphula reached a peak in 1966 and was not seen after 1972 except for one female, which was observed on June 9th 1984. The decline of this species may have been initiated by the exceptionally wet spring of 1968 when much of the pond area was flooded. 1972, 1973, 1974 and notably 1976 were very dry years but other species returned to the ponds successfully. However *P. nymphula* remained a very scarce species at the Woodwalton Fen reserve. It was virtually confined to ditches ca 1600 m and more to the north of the Twenty Ponds. Later it began to expand its numbers and range and by 1992 was present 1300 m from the ponds. In 1993 it occurred for the first time on one of the Heath ponds 1000 m to the east of the Twenty Ponds. It appears that when *P. nymphula* died out on the Twenty Ponds the species was so rare at Woodwalton Fen that potential colonists did not reach the ponds until the numbers and range of the species had increased considerably. Like some of the rarer species its populations on the ponds depended on being supplemented from neighbouring habitats. A similar explanation may apply to *B. pratense*, which not only increased notably at Woodwalton but in Cambridgeshire as a whole in recent

Table IV

Records of dragonfly species at the Woodwalton Twenty Ponds 1988-2000

Species	Breeding status 1962-1988	Number of ponds in which the species were observed												
	Years present on ponds	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
I. elegans	regular 1962-1988	13	X	X	2	6	2	2	X	1	1	X	X	6
C. puella	regular 1962-1988	19	1	1	4	12	16	13	X	13	5	X	X	13
L. quadrimaculata	regular 1962-1988	11	2	6	3	10	15	5	X	3	X	X	X	3
S. striolatum	regular 1962-1988	14	X	1	2	X	X	X	4	X	X	X	X	7
A. cyanea	regular 1963-1988	2	X	0	0	0	X	1	0	X	X	X	X	2
L. sponsa	regular 1963-1988	14	X	3	4	1	X	1	X	X	X	X	X	0
S. sanguineum	irregular 1964-1973													
	regular 1974-1986	6	X	1	1	2	X	X	X	X	X	X	X	6
A. grandis	most years 1966-1988	3	X	0	1	0	X	X	X	X	X	X	X	2
P. nymphula	1964-1972 only	0	0	0	X	2	4	12	X	6	4	X	X	9
B. pratense	1968-1973 only	0	0	0	X	0	1	0	X	1	0	X	X	0
A. mixta	not breeding; appeared in 9 years	0	X	0	X	X	X	X	1	X	X	X	X	2
E. cyathigerum	not breeding; appeared in 6 years	1	X	0	0	0	0	0	X	1	1	X	X	0
L. depressa	not breeding; appeared in 2 years	0	X	X	X	0	0	0	X	1	0	X	X	0
A. imperator	not observed	0	X	X	0	0	0	0	X	0	X	X	X	1
L. fulva	not observed	0	X	X	X	0	0	X	X	0	0	X	X	1

X Visits to the ponds in the year indicated were not made in the flying season of the species indicated

years. Similarly it is not surprising that *A. imperator* and *L. fulva* – hitherto unreported from the ponds – were seen at them in 2000, for both species had increased elsewhere at Woodwalton Fen since 1988.

The disappearance of *L. sponsa* in or just before 2000 is extremely difficult to explain. It had been present on the ponds since 1964 generally in considerable numbers. Most unusually the species was absent from the Heathfield ponds and from ditches in the southern two thirds of the reserve in 2000. That year it was only present in ditches at the northern end of the reserve 1800 m away. One can only speculate that it might have been exterminated by unrecorded freak weather conditions, localised pollution or disease following a decline since 1988.

APPLICABILITY OF OBSERVATIONS AT WOODWALTON TO OTHER PONDS

To what extent are the results obtained at Woodwalton applicable to other ponds in lowland England? The Twenty Ponds were smaller (circumference 16 m) than most farm ponds, and unlike most farm ponds their edges were not grazed by cattle. This meant that scrub developed more quickly, and once it reached a height of about two metres on the south side of a pond, it prevented all direct sunlight from penetrating to the surface of the water and the northern shores of the ponds. The effect was accentuated because the ponds are steep-sided and so when water levels go down the water edge remains near the edge of the surrounding grassland. For these reasons the dragonfly fauna was exterminated sooner than it would be on larger ponds under similar conditions.

The Twenty Ponds are also unusual in that they are all within 20 m of each other and are surrounded by ditches supporting many species of dragonfly. Therefore if a species dies out on a pond it can be quickly replaced by colonists from adjacent habitats. It is suggested that ponds constructed on farms and in large gardens in lowland England will go through similar changes to those observed at Woodwalton, and will cease to support dragonflies after a number of years if they are left unmanaged. The length of time will depend on the rate of colonisation and growth of invading scrub species and on the size of the pond. Observations elsewhere show that large ponds surrounded by bushes or trees can continue to support aquatic plants and dragonflies for many years.

CONSERVATION IMPLICATIONS

The history of *P. nymphula* and *B. pratense* on the Twenty Ponds gives further support to the concept that small populations of dragonflies in small habitats, even if apparently stable, are at risk unless supported by strong populations nearby. Nature reserves should be as large as possible to support such populations.

This paper re-emphasises the value of long term observations. Not only do they enable one to record the growth and decline of dragonfly populations in transient

habitats, but they pick up rare events, such as the recent disappearance of *L. sponsa* from the Twenty Ponds. Such events often require further study. Long term studies can never be too long.

ACKNOWLEDGEMENT

I am grateful to my wife, Dr JANET MOORE, for helpful criticisms of the manuscript.

REFERENCES

COOKE, S.D., A.S. COOKE & T.H. SPARKS, 1994. Effects of scrub cover of ponds on Great Crested Newts' breeding performance. In: A. Gent & R. Bray, [Eds], *Conservation and management of the Great Crested Newt.* [English Nature Science, No 20] English Nature, Peterborough.

MOORE, N.W., 1991. The development of dragonfly communities and the consequences of territorial behaviour: a 27 year study on small ponds at Woodwalton Fen, Cambridgeshire, United Kingdom. *Odonatologica* 20(2): 203–231.