Fen Raft Spider Recovery Project:
2007 Summary Report for Redgrave and Lopham Fen

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Summary

1 This report describes the results from the seventeenth year of systematic monitoring of the nationally endangered Fen Raft Spider *Dolomedes plantarius* at Redgrave and Lopham Fen National Nature Reserve, Norfolk. This work was undertaken as part of Natural England's Species Recovery and BAP programmes in 2007. Habitat management work and measurements of surface water levels are also documented and discussed in relation to spider population trends.

2 Throughout the 17-year census the population was very small and its range restricted to two small and spatially separated areas, on Little Fen and Middle Fen.

3 Desiccation of the fen by artesian abstraction, thought to be responsible for the decline in this essentially aquatic species, ended in 1999 with relocation a borehole that had drained the fen. This, in combination with higher than average rainfall in the following two years, resulted in rapid hydrological recovery.

4 An annual index of population size that allowed statistical comparison between years showed that the census data were best described by a model in which population size varied substantially and sometimes significantly between years, with no evidence of a sustained upward or downward trend.

5 Modelling of the data sets for both the Little and Middle Fen sub-populations showed that there was a significant difference between them in the pattern of annual variation.

6 The range occupied by *D. plantarius* on Middle Fen increased in 2007 beyond the area in which it had been recorded over the past fifteen years. A nursery web found 75m beyond the previous most westerly record introduces the possibility that an area of ponds *ca* 35m further west, on which *D. plantarius* was last recorded in the mid-1980s, may be recolonised.

7 Numbers of breeding females on both Little and Middle Fen were amongst the highest recorded during the July counts. Previous high counts have been followed by high numbers of immatures the following year, although these increases have never been sustained.

8 Rotational mowing of *Cladium mariscus,* which dominated the core areas for *D. plantarius*, was abandoned in favour of extensive grazing in summer 2002. Failure of the stock to graze much of the area occupied by *D. plantarius* on Little Fen necessitated supplementary mowing of stands of tall fen vegetation from 2004 onwards. In 2007 the stand that was cut was just outside the census area. On Middle Fen, mowing of mature stands of *C. mariscus* that were left ungrazed by stock was resumed in 2006 and continued in 2007. The area into which the population extended in 2007 is managed effectively by grazing: *Cladium mariscus* is largely confined to the pond margins.

9 High rainfall in May and June sustained high summer water levels in the core spider areas. On Great Fen, where levels are monitored in ponds that may be used as a focus for founding a new sub-population by translocation, summer water levels were sustained proportionally better than in previous years. This may be attributable to the first year of effective operation of a new sluice on the river immediately downstream from this part of the fen.

10 Although there is still no evidence of sustained or significant recovery of *D. plantarius* at Redgrave and Lopham Fen, both the small expansion in range and the relatively high numbers of adult females recorded in 2007 give the potential for recovery. Effective population monitoring remains imperative, not only because of the small size and intrinsic vulnerability of the population, but also for the information that it provides on the influence of vegetation management and water level on demography. Analyses of these aspects of the data are beyond the scope of this report but will be published in the scientific literature together with the results of recently completed PhD studies of the autecology and genetics of *D. plantarius*. This information will help to explain the failure of Redgrave and Lopham Fen population to recover, and to inform conservation management decisions, including the proposed establishment of new populations.

1 Introduction

This report summarises monitoring and management work undertaken as part of the Fen Raft Spider *Dolomedes plantarius* Recovery Project at Redgrave and Lopham Fen National Nature Reserve (NNR) in 2007. This was the seventeenth year of monitoring and targeted management for *D. plantarius* at this site, which remains one of only three UK locations for this Schedule 5 species. The recovery project was initiated in 1991 (under English Nature's Species Recovery Programme) to prevent extinction of this population, which had been reduced to very low levels by desiccation as a result of artesian abstraction since 1960 (Harding 2000), compounded by droughts in the 1980s and 1990s (Smith 2000). By the late 1980s, the remnant population had become restricted to turf ponds on two separate parts of the NNR. Throughout the 1990s, despite targeted habitat management, monitoring showed not only that there was no significant increase in the size of the population, but also that its range had continued to contract. Between 1991 and 1999, irrigation of the ponds inhabited by the spiders appeared to be the key factor in their persistence (Smith 2000).

Rapid hydrological recovery of the fen, following closure of an adjacent public water supply borehole in 1999, was expected to result in a rapid increase in *D. plantarius*, which has very high potential fecundity. This expectation was encapsulated in the original *D. plantarius* Species Action Plan targets for this site (U.K. Biodiversity Steering Group 1999), of a sustained increase in density per pond to the maximum recorded during the 1990s, and a ten-fold increase in range.

By the time of the 2005 review of the Action Plans, the Redgrave and Lopham Fen *D. plantarius* population showed no sign of sustained or significant recovery. It was clear both any recovery would be slow, and that the wetness of the fen was not the only factor required to trigger it. New targets were set to take account of this situation. These included both an increase in range on Redgrave and Lopham Fen (to 13 Ha in three years out of every five by 2010, and to 65 Ha by 2020) and reduction in the risk of stochastic extinction by the establishment of six more sustainable populations by 2010. By 2020 the total number of sites with sustainable populations should be increased to 12.

In this report the 2007 results from a highly standardised annual census are used to assess progress towards these targets and are discussed in the context of the previous 16 years' data. This report also describes the results of monthly monitoring of water levels in the census ponds and documents management tasks carried out by the Suffolk Wildlife Trust (SWT), the NNR managers, on the fen vegetation in the areas occupied by *D. plantarius.* The census results are discussed in the context vegetation and water level management.

More detailed analysis of the census data, to examine the effects of water levels and vegetation management on the long-term trends in numbers, are beyond the scope of this report but will be published in the scientific literature. This, together with the completion of autecological research by Phil Pearson at the University of East Anglia (Pearson 2008) and publication of genetic research by Marija Vugdelic (Vugdelic 2006), should provide much greater insight into the requirements for recovery of *D. plantarius*.

Further background to the project, and details of previous years' work, are given by Duffey (1991) and Smith (1992, 1993, 1994, 1995, 1996, 1997, 1998, 2000, 2001, 2006, 2007).

2 Methods

2.1 Annual census

The annual census of *D. plantarius* followed the methodology adopted in 1993 and described by Smith (1993, 2000, 2006). The three replicate counts were made at 29 turf ponds on Little Fen (Fig. 1) and 30 on Middle Fen (Fig. 2) in late July and early August. Whenever consistent and favourable weather conditions allow, the counts for each fen were made on three consecutive days. In 2007, poor weather made the census more protracted than usual (Table 1).

In 2000 and 2001 very high water levels made it impossible to census Little Fen during the summer. From 2002 onwards, two Little Fen ponds included in the original scheme had to be excluded from the census because they had been substantially infilled with spoil during the fen restoration

Table 1 Census dates for 1994-2007

Year	July (& /Aug.) Census dates	
	Little Fen	Middle Fen
1994	26-29	9-18/08
1995	20-25	27-1/08
1996	18-21	22-26
1997	24-21	22-26
1998	18-21	21-24
1999	17-19	21-26
2000	-	17-20
2001	-	17-20
2002	14-18	19-21
2003	18-22	23-27
2004	21-27	12-24
2005	21-05/08	18-21
2006	13-17	17-20
2007	31-11/08	19-31

operations (Harding 2000). Counts at two other Little Fen ponds were made from the bank because the depth of sediment made work in the water unsafe. By 2004 two of the three replicate counts at a further pond were also made from the bank because of the depth of soft sediment; in 2005 and 2006 all counts at this pond had to be made from the bank.

2.2 Analyses of annual census data

The annual census data are expressed as an index derived from analyses of population trends carried out using generalised linear models, with the maximum count for each pond in July as the response variable (Smith 1995, 2000). Log-linear Poisson regression models were fitted to the systematic data collected since 1991 (excluding Little Fen in 2000 and 2001, when it was deeply flooded)**,** as implemented in program TRIM (Pannekoek & van Strien, 1998). TRIM allows the data to be split into different strata; in this context Little and Middle Fens form separate co-variate strata. The model also allows sites to be censused in some years and not others and so the data from the set of ponds censused at the outset of the project (1991-1995), and those from the set of ponds censused from 1993 onwards, could be utilised (see Smith 1995).

The program fits five standard models: (i) no time (year) effects; (ii) linear trend (in log numbers); (iii) linear trends within covariate strata (linear trends differ between Little and Middle Fen); (iv) time effects (separate effects for each year); (v) time-effects within covariate strata (year effects differ between Little and Middle Fen.

2.3 Breeding indicators

Very limited but comparable quantitative information on breeding success each year is derived from the counts of adult females and of nursery webs during the annual census (above). Additional information is derived from casual records and from sedge-cutting management but this cannot be used for quantitative comparison between years.

2.4 Water levels

Routine water level measurements against permanent posts in the census ponds on Little and Middle Fens, and in the ponds dug on Great Fen in 1998 (Smith 2000, 1998), were carried out at approximately monthly intervals. The levels in the Little and Middle Fen ponds are expressed relative to an arbitrary datum established in April 1992. The heights of the measuring posts in the Great Fen ponds were levelled and so the measurements are expressed relative to Ordnance Datum.

Ground water levels on the fen have been monitored by the Suffolk Wildlife Trust (SWT) since 1976 using a network of 54 piezometer tubes (Smith 2000). Most of these monitor near-surface hydrology: eight are sunk into the underlying chalk. The data presented in this report are the highest monthly mean recorded from all of these tubes between November and April (winter maximum) and the lowest monthly mean recorded between May and September (summer minimum) each year. Although this is a coarse measure, it gives a useful picture of differences between years over the 31-year recording period. Monthly rainfall data measured by SWT at a gauge on the fen since 2001 are also presented.

3 Results

3.1 Distribution

On **Little Fen**, since closure of the artesian borehole in 1999, *D. plantarius* has been found predominantly in the south-western part of the census area (Fig. 3). This area also held the core of the population during the 1990s when it was irrigated with a piped water supply to maintain summer water levels in the ponds. In most years spiders have also occurred on a band of ponds stretching north-east from this core area. Records of spiders on ponds outside this zone are sporadic. 2007 saw a small reduction in the number of ponds on which spiders were recorded (Table 2), with the losses in the south east of area.

On **Middle Fen**, since closure of the bore-hole, *D. plantarius* has similarly been largely restricted to the area of ponds that benefited from irrigation between 1991 and 1999 (Fig. 4, Table 2). Throughout the 17-year census, spiders have been recorded on ponds to the west of this area only in some years. After a two year absence, they re-appeared in this area in 2006, when three half-grown spiders were found on pond 26 (Fig. 4), right at the western end of their range recorded since 1993 and *ca* 75m from the core area of ponds. In 2007, a nursery web was found on pond 26 and another further west, on pond 32. This find extends westwards the range recorded since 1993 by around 75m. Pond 32 is only 35m east of the north/south chain of ponds along the former boardwalk path (Fig. 4), from which spiders have been absent since the mid-1980s.

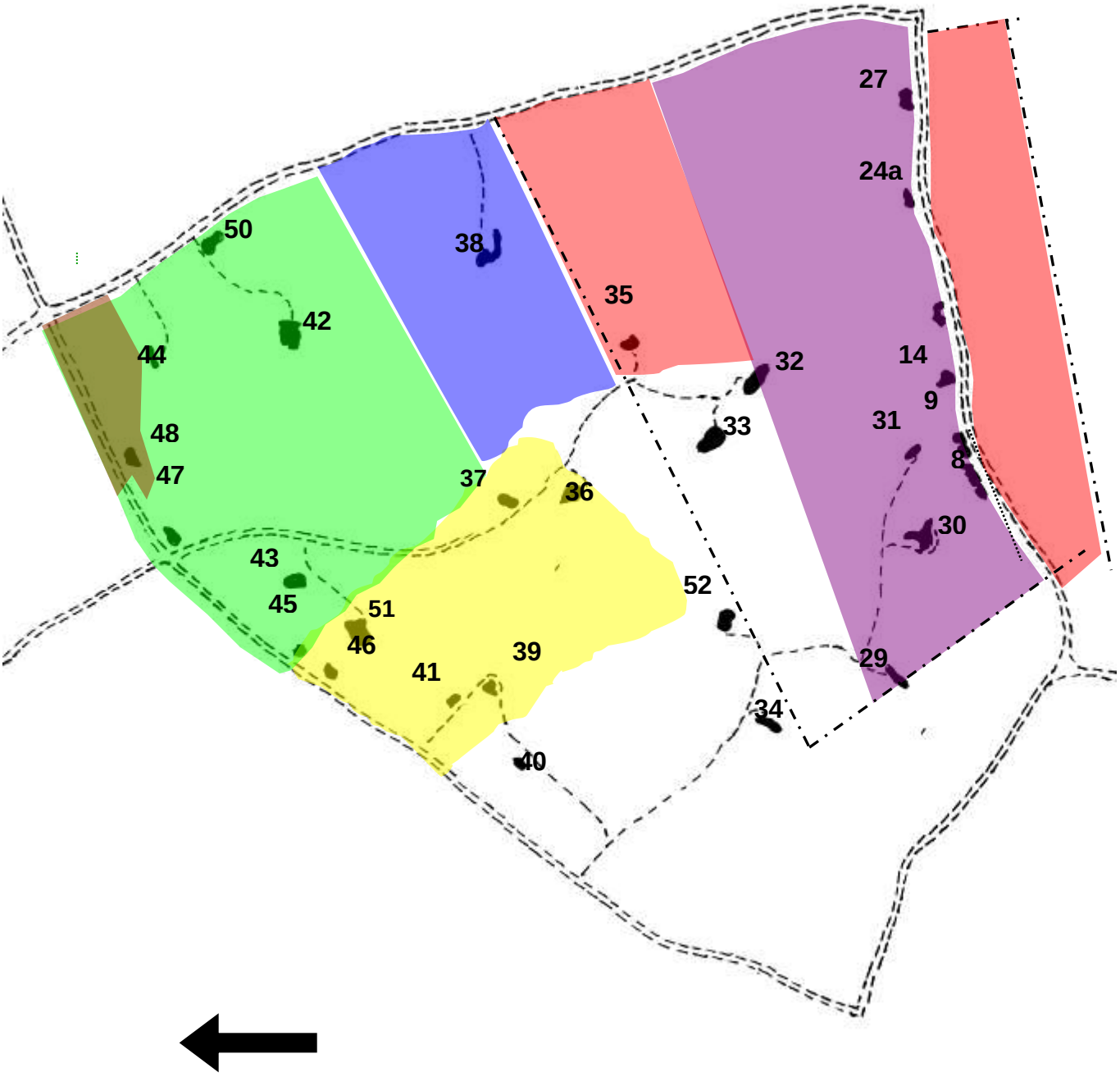
3.2 Abundance

Since census work began in 1991, the size of the *D. plantarius* sub-populations on both Little and Middle Fens has varied substantially, and in some cases significantly, between the years but at no time has there been any evidence of sustained or significant recovery (Table 3, Fig. 5). In 2007 numbers were slightly, but not significantly, higher than those in the previous two years on both Middle and Little Fen.

Separate analysis of the 17 year data set for the Little and the Middle Fen sub-populations shows that, in both cases, the annual time effects models gave a better description of the data (lowest AIC values) than either the linear-trend or no-time-effects models. For Little Fen this model had an AIC value of –162.0 (Wald test for significance of deviation from linear trend: 97.7, p<0.001, df=13). Linear-trend and no-time-effects models had AIC values of 8.7 and 39.5 respectively. For Middle Fen this model had an AIC value of –32.5 (Wald test for significance of deviation from linear trend: 155.2, p<0.001, df=15). Linear-trend and no-time-effects models had AIC values of 283.0 and 282.0 respectively.

Inclusion of the data for both fens in the population models showed that, as in previous years when such comparison was possible, there was a highly significant difference in the annual pattern of variation between Little and Middle Fen (analysis of data for 1991-'99 and 2002-'06: Wald test for difference between fens: 81.3, p<0.001, df=14).

Figure 1 The Little fen census area showing ponds included in the census. Shading shows areas where vegetation was cut and removed in July/August each year: - 2001, - 2002, - 2003, - 2004, 2005 and 2006 - . Broken black line: -------- shows boundary of area from which stock were excluded until 2004.



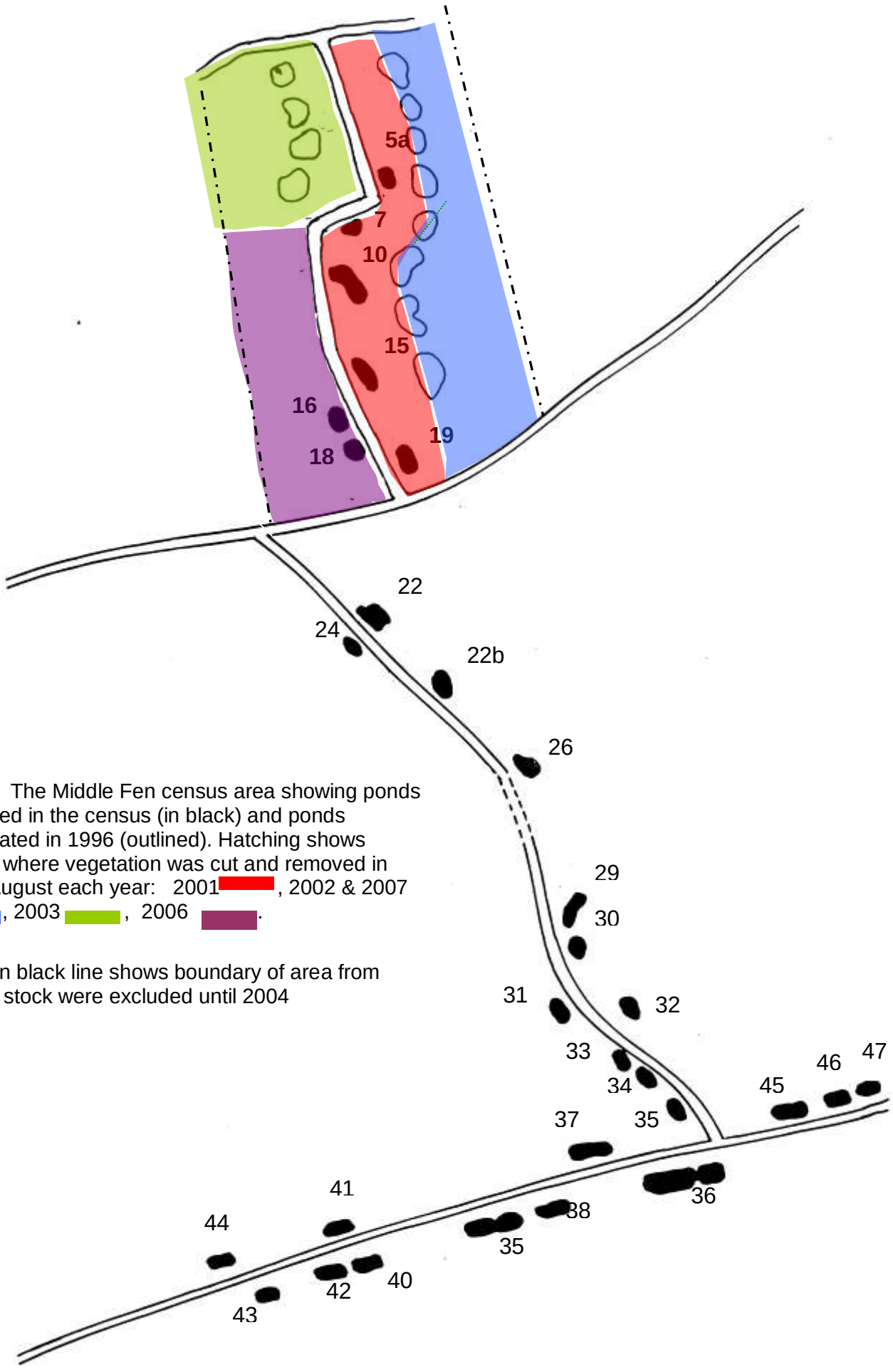


Fig. 2 The Middle Fen census area showing ponds included in the census (in black) and ponds excavated in 1996 (outlined). Hatching shows areas where vegetation was cut and removed in July/August each year: 2001, 2002 & 2007, 2003, 2006.

Broken black line shows boundary of area from which stock were excluded until 2004

Table 2 Numbers of census ponds on which *D. plantarius* was recorded in July each year. Numbers are given separately for ponds that were and were not influenced by the irrigation supplied between 1993 and 1999. The 2000 data for Little Fen are based on two, rather than three replicate counts, made in September rather than July: no data were collected on Little Fen in 2001 (see Smith 2005)

Year	**'93**	**'94**	**'95**	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**	**'02**	**'03**	**'04**	**'05**	**'06**	**'07**
Little Fen															
'Irrigated' n=15[1] ponds	8	8	12	9	12	14	11	-	-	12	6	12	11	9	8
'Unirrigated' n=14[1] Ponds	2	2	4	0	1	6	4	-	-	2	1	2	0	4	2
Total	**10**	**10**	**12**	**9**	**13**	**20**	**15**	**(11)`**	**-**	**14**	**7**	**15**	**11**	**13**	**10**
Middle Fen															
'Irrigated' n=7 ponds	6	7	7	5	6	7	6	7	6	7	7	7	7	7	6
'Unirrigated' n=23 pond	2	3	0	0	0	0	1	2	0	2	1	0	0	1	2
Total	**8**	**10**	**7**	**5**	**6**	**7**	**7**	**9**	**6**	**9**	**8**	**7**	**7**	**8**	**8**

[1] Prior to 2003, n=16 irrigated and 15 unirrigated ponds respectively

Table 3. Proportions of *D. plantarius* in different size classes, and maximum counts of all individuals, adult females and nursery webs, in the standard annual census ponds on Little and Middle Fen at the July census from 1993 to 2007. * The number of adult females given is based on identification of individuals and may be a higher figure than the maximum count.

	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Little Fen															
% Large	36	21	20	65	30	5	8	-	-	9	29	4	10	14	18
% Medium	57	37	66	15	41	50	53	-	-	57	43	68	88	45	73
% Small	7	42	15	20	29	45	39	-	-	34	28	28	2	41	9
Max. spider count	**14**	**19**	**41**	**20**	**66**	**94**	**62**	**-**	**-**	**53**	**7**	**68**	**40**	**42**	**66**
Adult females*	0	1	6	6	16	4	4	-	-	4	2	3	4	7	10
Nursery web count	0	2	0	0	9	0	4	-	-	0	0	1	2	4	4
Middle Fen															
% Large	29	30	3	17	47	5	15	6	20	6	10	5	13	10	19
% Medium	33	48	62	34	53	32	46	49	30	55	48	50	45	63	50
% Small	38	22	35	49	0	63	39	45	50	39	42	45	42	27	31
Max.spider count	**21**	**44**	**102**	**41**	**15**	**99**	**52**	**112**	**20**	**72**	**29**	**42**	**31**	**30**	**54**
Adult females*	0	8	1	5	6	5	7	7	0	2	2	1	4	3	8
Nursery web count	1	3	1	0	0	0	7	0	0	0	0	0	3	1	2

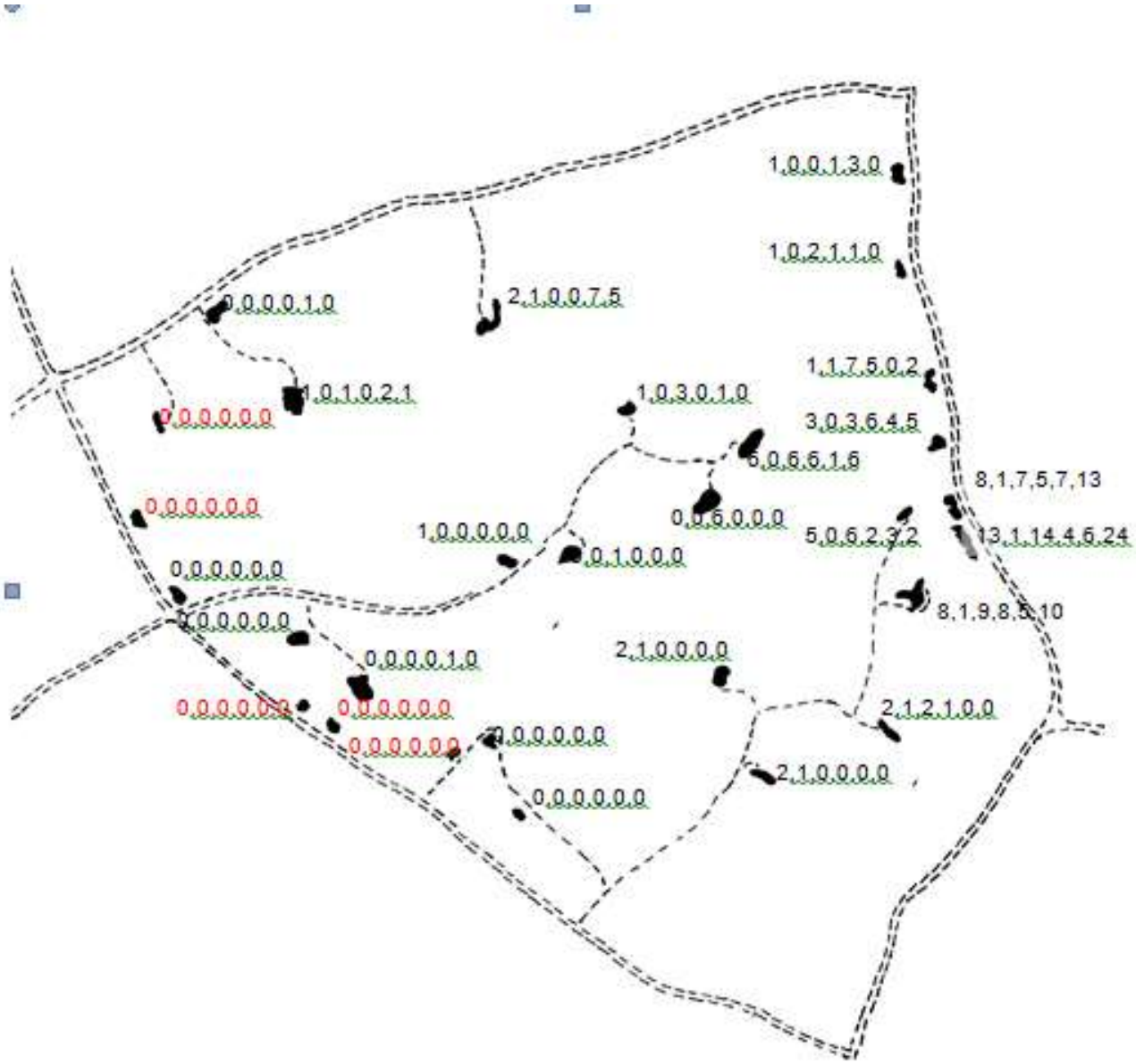


Fig. 3 Numbers of spiders recorded at each of the Little Fen census ponds in late July between 2002 and 2007 (no July data were collected in 2000 and 2001: see text). Numbers represent maximum count for consecutive years. Red numbers denote ponds on which *D. plantarius* has not been recorded at any time in the last 17 years.

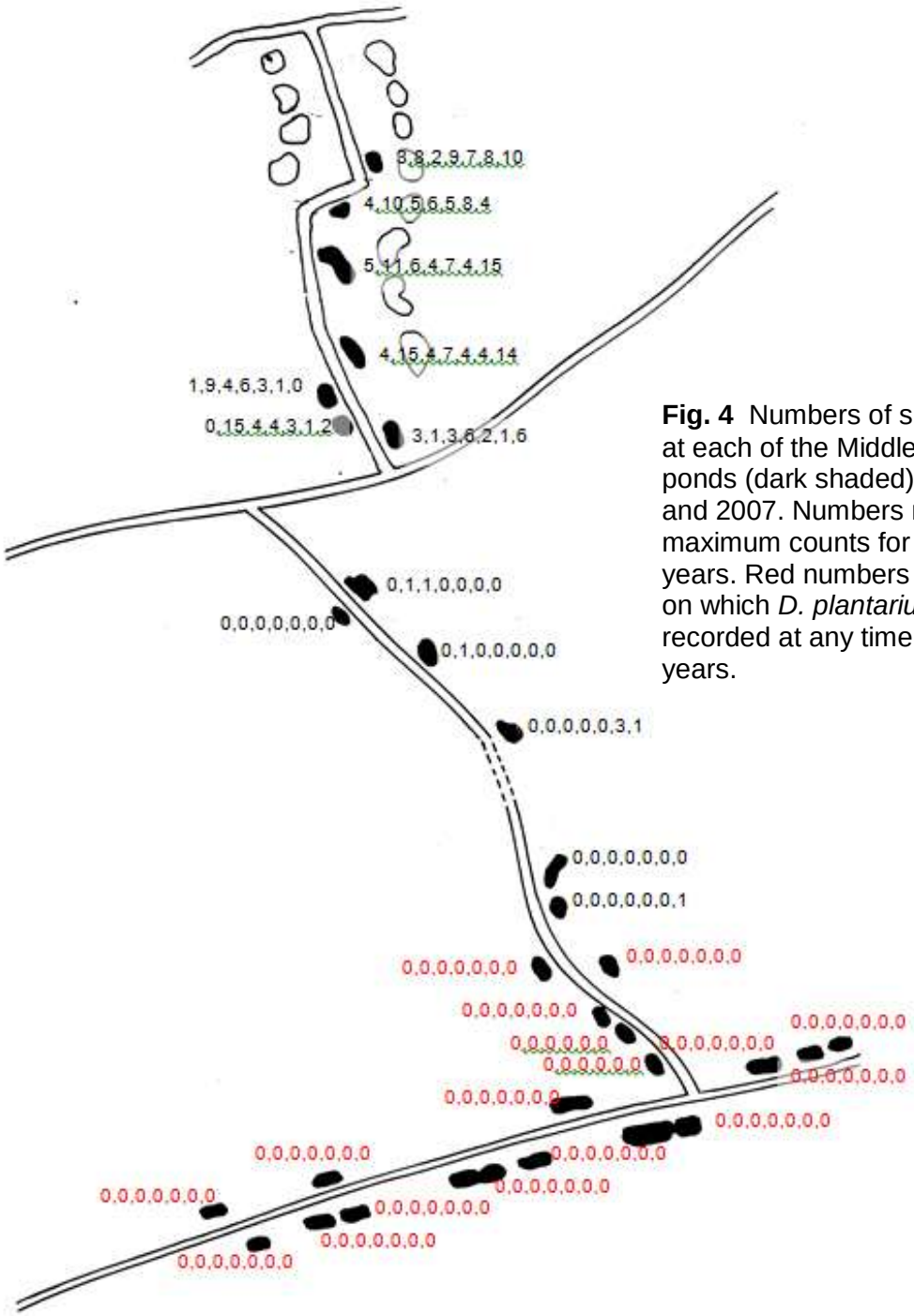


Fig. 4 Numbers of spiders recorded at each of the Middle Fen census ponds (dark shaded) between 2001 and 2007. Numbers represent maximum counts for consecutive years. Red numbers denote ponds on which *D. plantarius* has not been recorded at any time in the last 17 years.

2.3 Breeding indicators

On **Little Fen** a small but progressive increase in the numbers of adult females encountered during the July census continued for a sixth year. Numbers were second only to those recorded in the peak year of 1997 (Table 3). Sedge cutting operations in August revealed a further three nurseries within the core area but immediately south of the track defining the boundary of the census area (on pond 13 and near to ponds 1 and 2 from the 1991 and 1993 censuses: see Smith 1995).

On **Middle Fen** the 2007 census also saw an increase in the numbers of adult females in the census ponds, to equal that in the previous peak year of 1994 (Table 2).

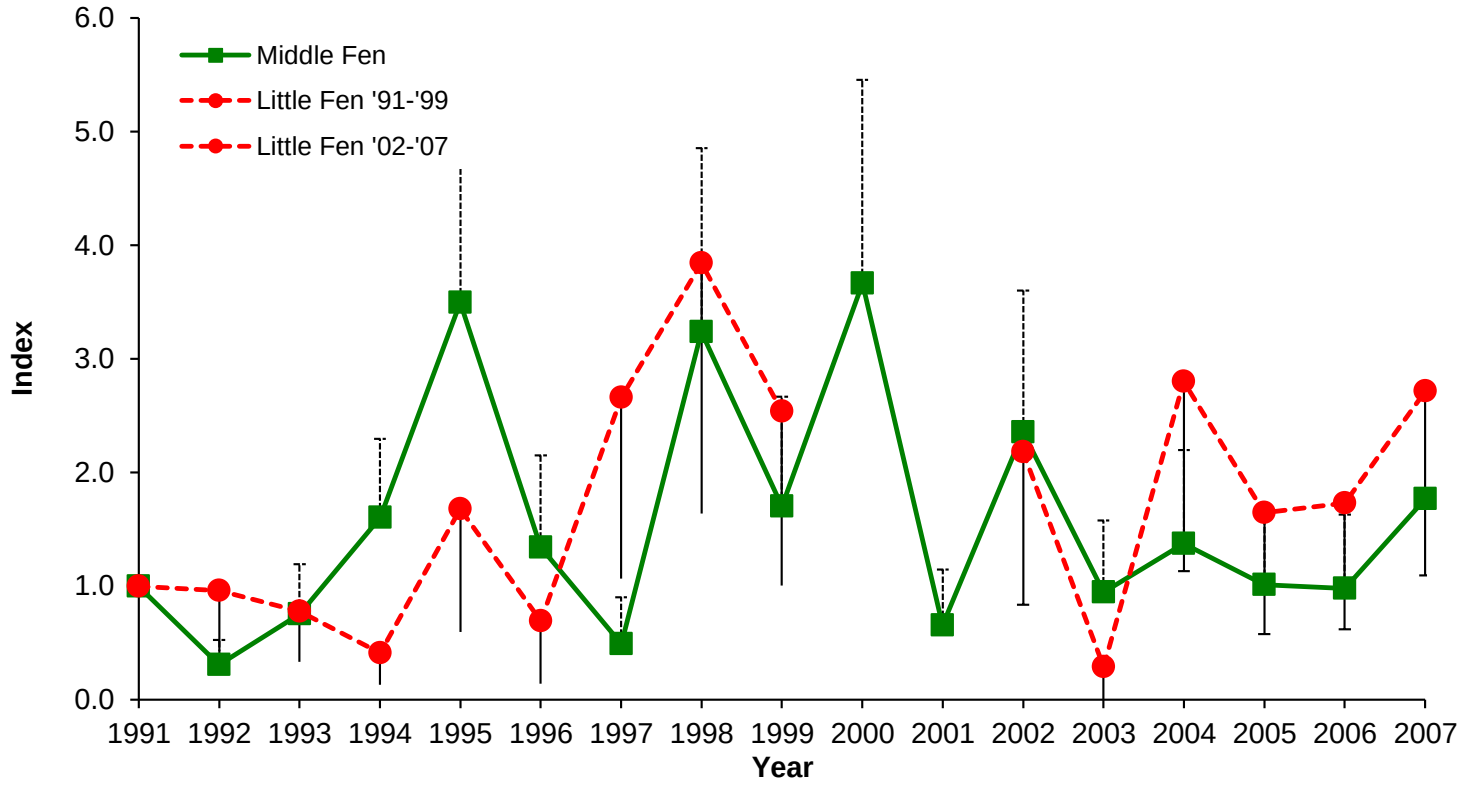


Fig. 5 Annual population indices for *D. plantarius* on Middle and Little Fens in July 1991-2007, generated by a log-linear Poisson regression model and plotted on a linear scale. See text for missing data on Little Fen. 2SEs shown by positive vertical bars for Middle Fen and negative bars for Little Fen.

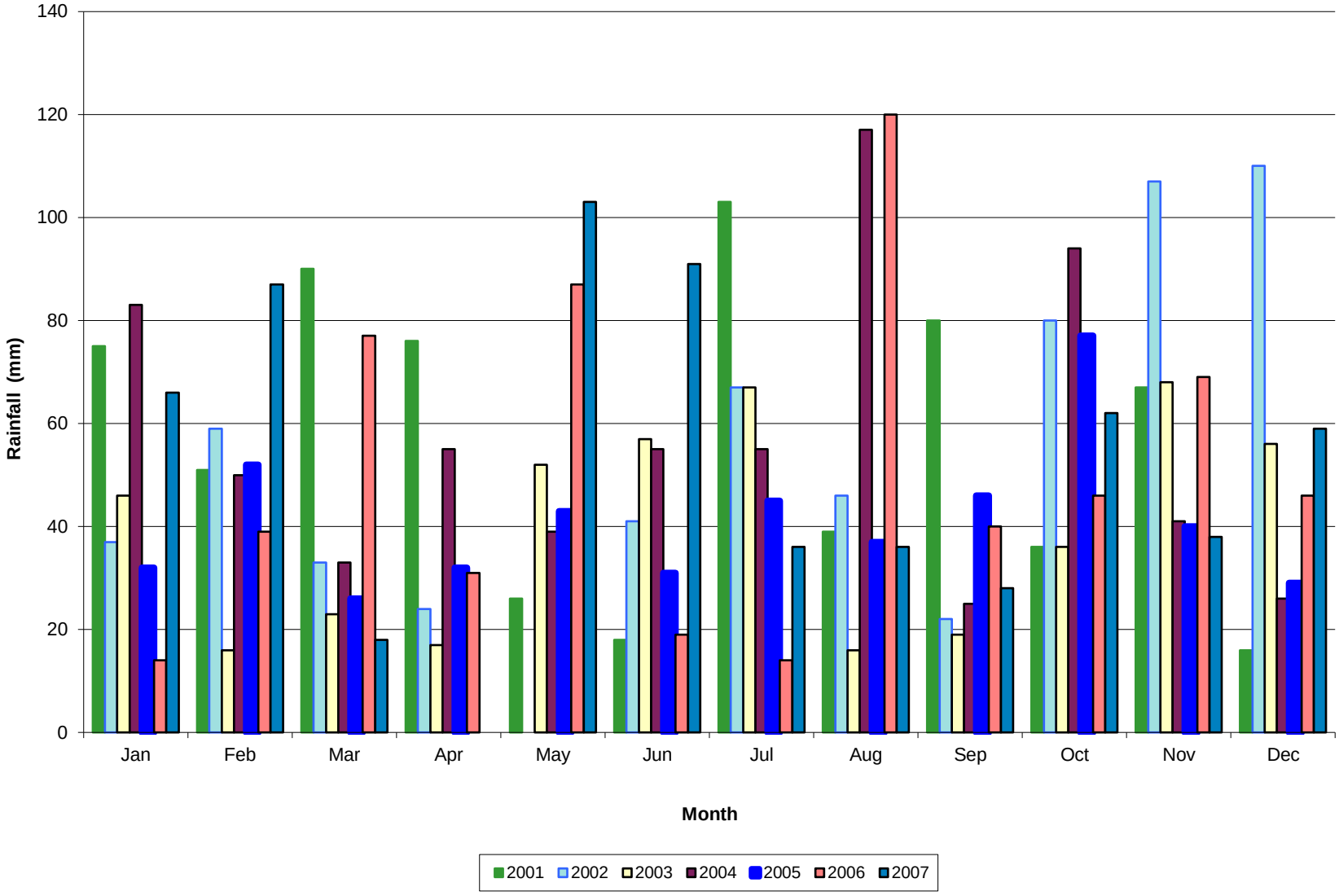


Fig. 6 Monthly rainfall totals for Redgrave and Lopham Fen NNR 2001-2007

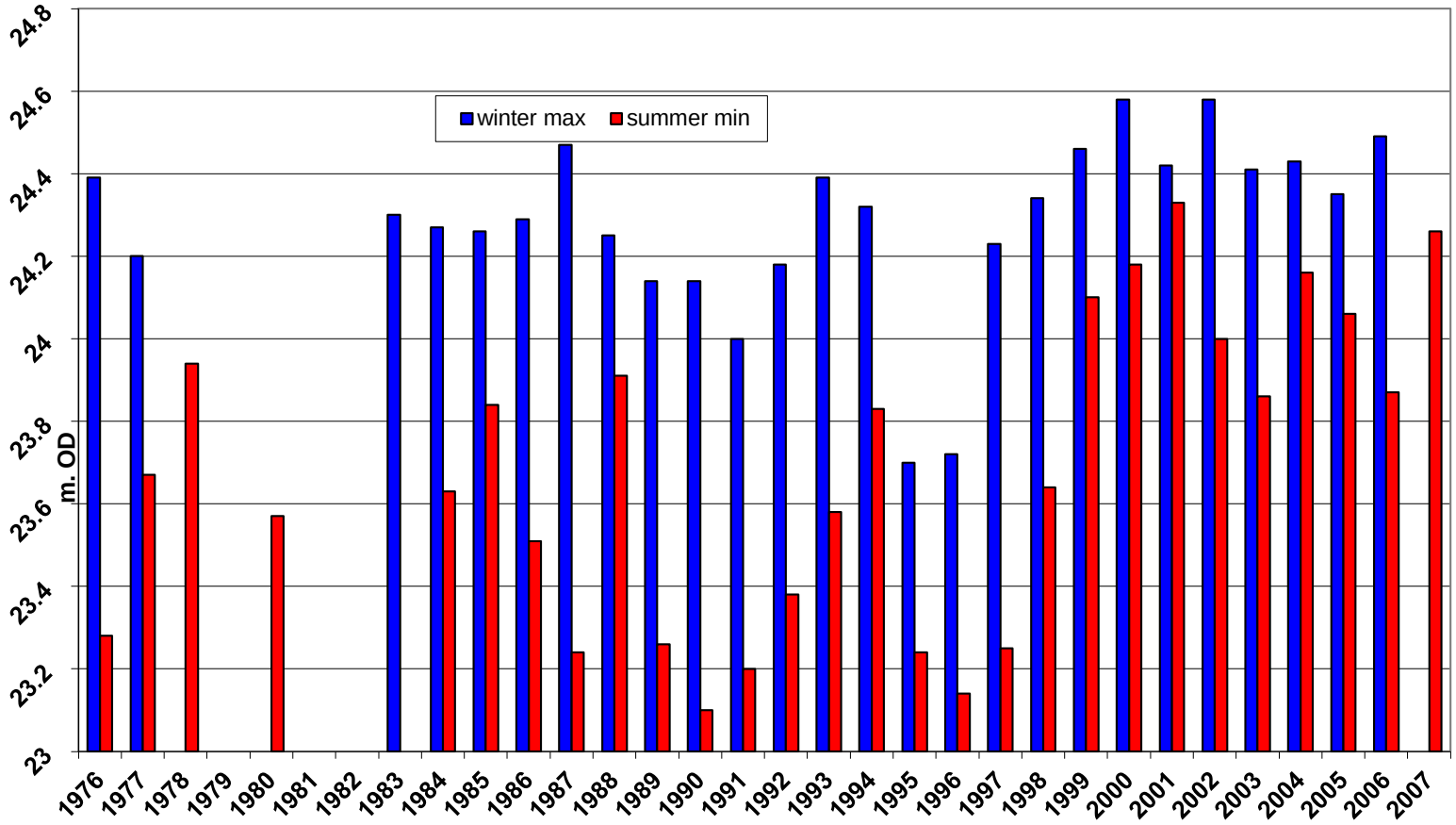


Fig. 7 Mean winter maximum and summer minimum water levels in piezometers on Redgrave and Lopham Fen NNR

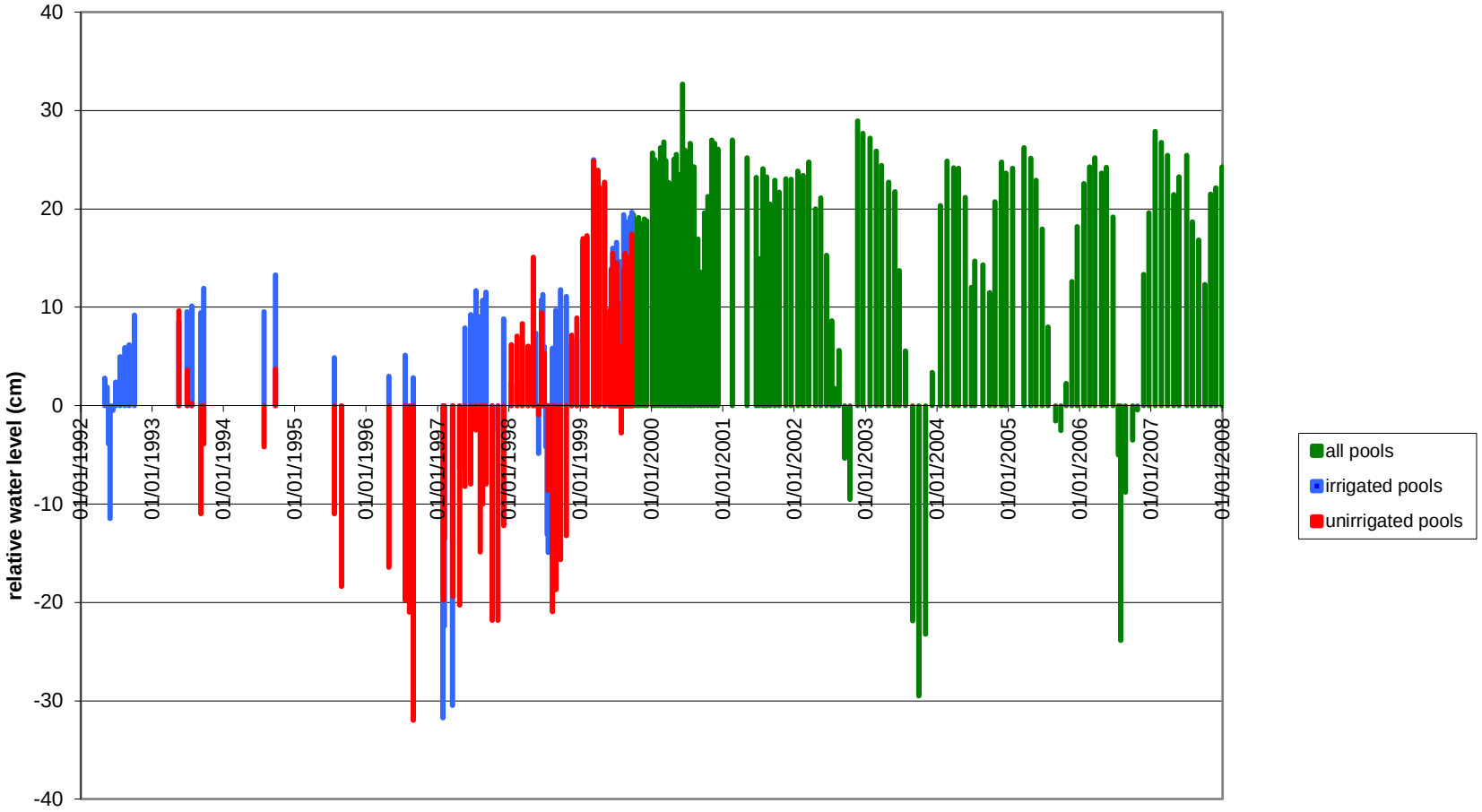


Fig. 8 Water levels in Little Fen ponds 1992-2007. Horizontal line represents the April 1992 datum. Blue and red lines represent mean levels in irrigated and unirrigated ponds respectively : summer irrigation stopped in 1999 (see text).

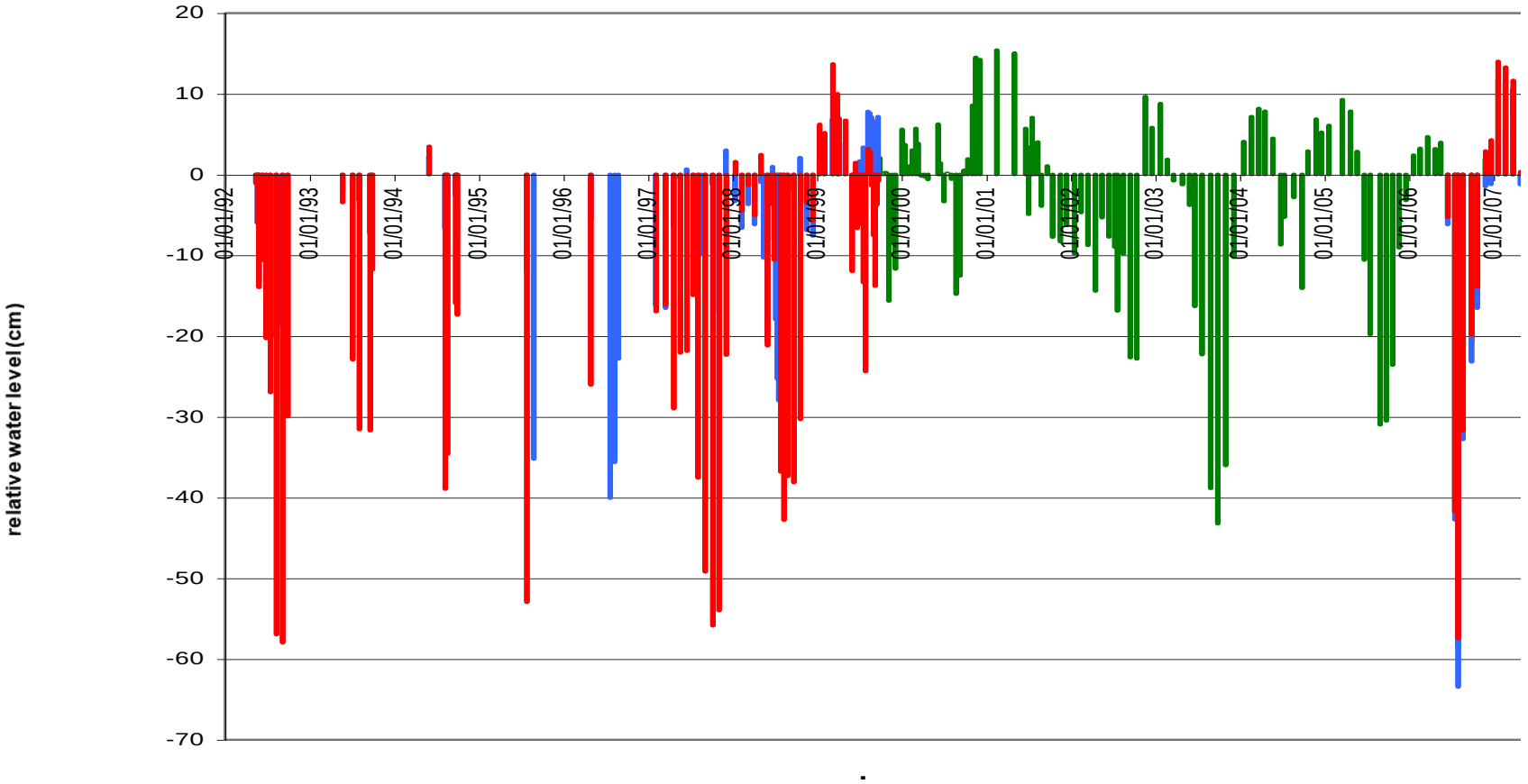


Fig. 9 Water levels in Middle Fen ponds 1992-2007. Horizontal line represents the April 1992 datum. Blue and red lines represent mean levels in irrigated and unirrigated ponds respectively : summer irrigation stopped in 1999 but differences between the two sets of pools are shown again for 2006 (see text).

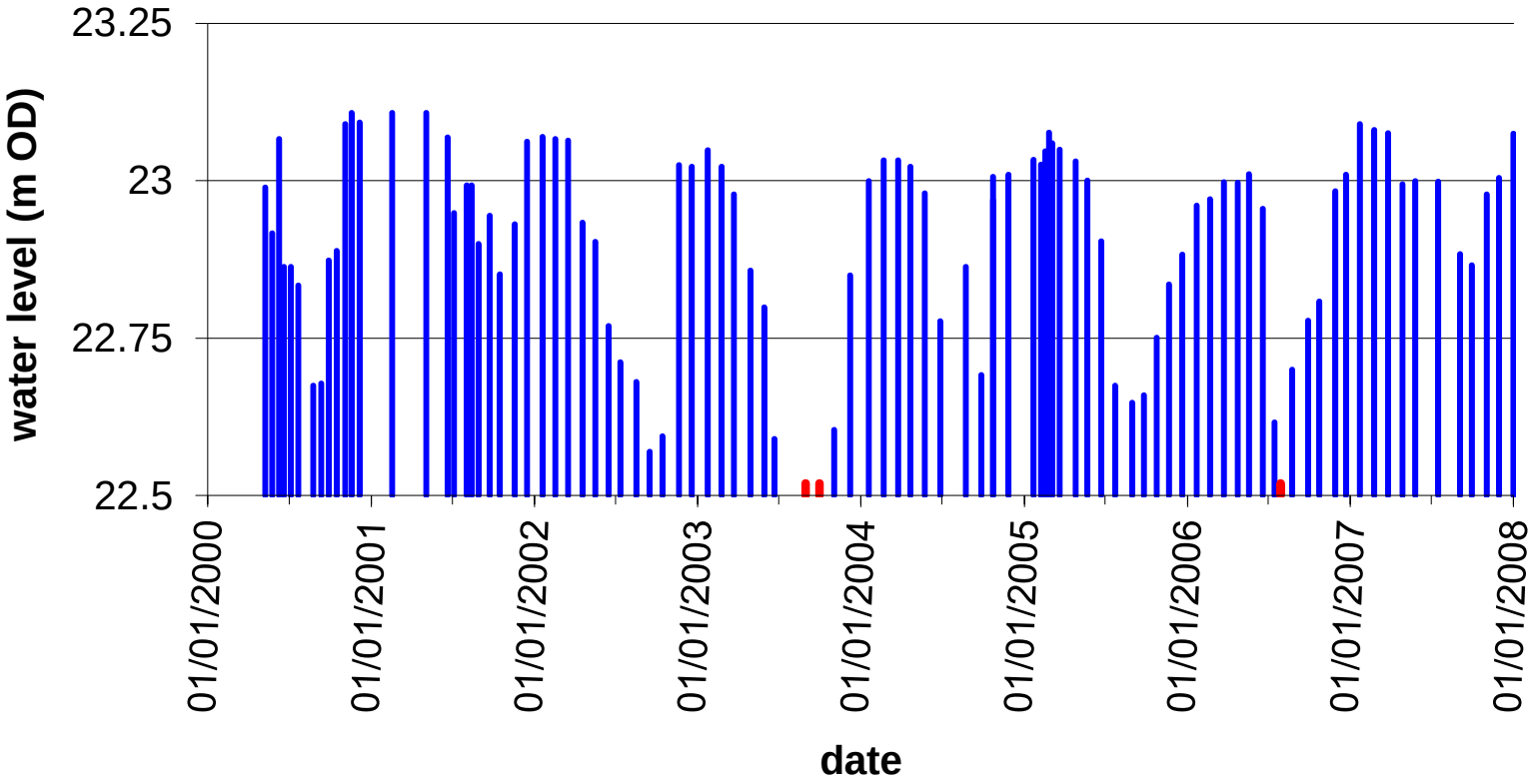


Fig. 10 Water levels in ponds excavated on Great Fen in 1998. Broken line denotes level below which most ponds are dry. Red indicates dates on which all ponds were completely dry (other 'blank' months are missing data).

3.4 Water Levels

2007 saw heavy rainfall in early spring and again in May and June when levels were higher than in any of the previous six years (Fig. 6). This is reflected in both a high winter maximum in the dip wells across then fen and the second highest summer minimum ever recorded (Fig. 7). Water levels in the turf ponds show a similar pattern. On Little Fen summer water levels were much higher than in the previous four years (Fig. 8) although not as high as in the extremely wet years of 2000 and 2001, when the drainage of this part of the fen was impeded. The lowest monthly mean was 36cm higher than in the drought of 2006. On Middle Fen the summer 'low' was short-lived and conspicuously higher than in the previous two years (Fig. 9), with the lowest monthly mean 48cm higher than that in 2006.

In contrast to Little and Middle Fens, the summer water levels in the ponds dug on Great Fen in 1988 (Smith 1988) were the highest since recording began in 2000 (Fig. 10). Water levels in the 2006/07 winter were high but not as high as those in the 2000/01 winter.

4 Habitat management

4.1 Rotational mowing of *Cladium mariscus*

The *C. mariscus* cutting rotation initiated in 1998 (Smith 1998) in stands surrounding the ponds that supported the highest density of *D. plantarius* on both Little and Middle Fen (Figs. 1 and 2) was abandoned after 2003. In 2004 the fences around these areas were removed to allow stock to enter (Smith 2005). However, because of failure of the stock to graze much of the wetter fen, from 2004 onwards SWT initiated limited cutting of stands judged to be in most need of management.

On Little Fen none of the vegetation within the census area was cut although an area immediately to its south, dominated by *Phragmites australis* but with a strong element of *C. mariscus,* was cut in August (Fig.1). On Middle Fen, for the second successive year, an area of dense, mature *C. mariscus* was cut within the core of the *D. plantarius* census area. The rotational blocks correspond with those of the rotation practiced from 1999 (Smith 1998) to 2003 although, as a result of an error, a five year old block, rather than the six year old block to the north, was cut in 2007 (Fig.2).

4.2 Grazing

In 2007, as in previous years, the grazing management of areas occupied by *D. plantarius* was more successful on **Middle Fen** than on Little Fen (full records of stock types, rates and movements are maintained by SWT). However, stock rarely entered areas of tall, dense mature sedge unless they were recently cut (Fig.2). In the western part of the census area, away from the core range for *D. plantarius* amongst the dense *C. mariscus* beds, the grazing regime initiated in 2001 continued to have a substantial impact on the vegetation in 2007. Tall dense reed, which resulted in deep shading of many of the ponds in the late 1990s, has been largely replaced by more mixed associations and *C. mariscus* stem densities appear to have improved in some areas (Stone *et al*. 2004).

On **Little Fen,** as in previous years (Smith 2006), the stock made few incursions into the areas occupied by *D. plantarius* and had a negligible effect on the vegetation. They appeared to be deterred by the much wetter conditions than on Middle Fen.

5 Discussion

The annual population indices for both the Little and Middle Fen populations of *D. plantarius* on Redgrave and Lopham Fen NNR were well below the maximum recorded over the 17 years since monitoring began, although this difference was not significant. Modelling showed that fluctuations in numbers between years continued to differ significantly between the two sub-populations, suggesting that the factors controlling them are complex. However, both the relatively high numbers of adult females, and the extension in the range of the Middle Fen population in 2007, suggest that there is potential for the population to expand in 2008 if conditions remain favourable.

The numbers of adult females recorded during the census on both Little Fen and Middle Fens were amongst the highest since the census began in 1993. There was also evidence that most of these animals bred, giving the potential for a substantial increase population size in 2008. Of those found on Little Fen, one was carrying an egg sac, four had nurseries and five were clearly post-partum, suggesting that they had completed their first breeding attempt of the year. During the slightly earlier survey on Middle Fen, five were found with egg sacs, two with nurseries and one was gravid. During the 15 year census period, 1997 saw the highest recorded number of adult females on Little Fen. This was followed in 1998 by the highest count of immature spiders although the population decreased again in 1989. The previous peaks in adult female numbers of Middle Fen were also followed by years with high numbers of juveniles but the increases were not sustained.

Concern was expressed in 2006 that the summer drought that resulted in drying out of many of the ponds might adversely affect both survival and the potential for successful breeding of *D. plantarius* in 2007 (Smith 2007). Pearson's (2008) study of marked animals in a sub-set of the Middle Fen ponds showed that, although immature spiders disappeared from the ponds as they dried up, most re-appeared when the ponds re-wetted. However, a substantial number of adult females were lost during the drought and were assumed to have died. Fifty per cent of breeding attempts during this period were also thought to have failed due to loss of egg sacs, which require frequent wetting. Immature spiders appeared to respond to drought by a reduction in growth rate; captive-reared *D. plantarius* also exhibited phenotypic plasticity in response to adverse conditions. In 2007 some adult females on Middle Fen were conspicuously smaller than average (post-partum body lengths of 13-15mm cf. *ca* 18-20mm) and had smaller egg sacs. It seems likely that that this was a delayed effect of the drought and would have reduced potential productivity in 2007. Thus, in 2007, the population of adults and of juveniles hatched in both 2006 and 2007 was almost certainly smaller as a result of the 2006 drought.

Although these observations on the impact of the 2006 drought, together with the persistence of *D. plantarius* at Redgrave and Lopham Fen through the droughts between the 1970s and 1990s, show that this species is relatively robust to intermittent dry summers, the current trend towards a rapidly increasing frequency of hotter and drier summers, together with continuing small population size, remains of great concern. A rolling programme of re-profiling of existing ponds as they infill, creation of new ponds, and continual exploration of the potential of sluices to maximise winter recharge and retard summer losses, are all required to help to ensure a summer water supply.

The expansion in range of *D. plantarius* recorded in July 2007 was 75m beyond the western limit previously recorded during the census. To allow detection of any expansion in range, ponds to the west of the core range were included the census area established on Middle Fen in 1993. The discovery of two nursery webs in this area followed that of three half grown juveniles, identical in size and colouration, on a pond at the previous western limit of the population, in 2006. This, together with a failure to find any spiders on the ponds between the core area and the newly colonised ponds, raises the possibility that the range expansion resulted from a single colonising step or 'jump' rather than by gradual progression on a broad front. The absence of spiders from the ponds censused in this area over the past 15 years suggests that such colonising events are rare. However, Pearson (2008) has shown that *D. plantarius* spiderlings have the potential to disperse at

least moderate distances from the nurseries by ballooning, although they much are more likely to disperse by rigging over very short distances. DNA fingerprinting of spiders at the limit of the range in 2008 will help to determine whether they originated from a single colonising event, probably by ballooning from a single nursery, or from a more general expansion of the population. Understanding the mechanism of range expansion will give an important insight into the potential for isolated or newly founded populations to disperse and occupy available habitat. This information will help to inform plans for the introduction of *D. plantarius* to new sites in the UK proposed in the 2005 revision of the Action Plan for this species.

The extension in range of the Middle Fen *D. plantarius* population opens the possibility that it may recolonise an area of ponds only 35m further west, where *D. plantarius* was recorded regularly until the mid-1980s. Their loss from this area was likely to have resulted from deterioration in habitat quality as a result of increasing frequency of desiccation of the ponds in summer. The ponds became heavily shaded by scrub and, although much of this was removed during the restoration of the fen in the late 1990s, invasion by tall *Phragmites australis* perpetuated the shading. Since 2002, however, grazing has been increasingly effective in controlling *P. australis* and reducing shading of these ponds (Smith 2006), most of which retain some fringing *C. mariscus*, the favoured species for nursery web construction at Redgrave and Lopham Fen. The reduction in height and dominance *P. australis* between the ponds, together with poaching of a surface that has been on average much wetter than in the 1990s, has resulted in much more suitable conditions for supporting *D. plantarius*.

While the *D. plantarius* population at Redgrave and Lopham Fen remains very small, and restricted in its distribution, there is a clear need to continue consistent monitoring of its size and range, and of the water levels in the parts of the fen that it occupies. The regular measurement of water levels in the ponds included in the *D. plantarius* census continues to provide data essential to understanding the relationship between water levels and the spiders' abundance and distribution. This relationship is likely to be a key element in elucidating the causes of decline and informing the changes in management that may be required to promote recovery. Regular monitoring of water levels in the ponds dug on Great Fen in 1998 remains essential for evaluating the effectiveness of the new sluice in maintaining sufficiently reliable summer levels to support the proposed future introduction of *D. plantarius*. The collection and analysis of these data is currently carried out by volunteers and is a very important element in the *D. plantarius* recovery programme for this site.

Detailed analyses of the impact of vegetation management and water levels on the population dynamics of *D. plantarius* are beyond the scope of this report but will be published in the scientific literature together with the results of recently completed PhD theses on both the genetics and autecology of this species (Vugdelic 2006 and Pearson 2008 respectively). This information will increase understanding of the reasons why the spider population at Redgrave and Lopham Fen remains so precarious, and will inform future management of both the fen vegetation and hydrology and possible genetic manipulation of the population. It will also contribute substantially towards planning the proposed translocations of *D. plantarius* to new sites and ensuring that these plans can fulfil the JNCC and IUCN criteria for introductions (Soorae & Seddon 1998, Maclean 2003). Reduction in the acute risk of extinction of *D. plantarius* by establishing new populations is a major element of the Action Plan for this species.

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