Fen Raft Spider Recovery Project:
2012 Summary Report for Redgrave and Lopham Fen

Dr Helen Smith

helen.smith@wavcott.org.uk

February 2013

Contents

Summary

1 This report describes the results from the twenty-second year of systematic monitoring of the nationally endangered Fen Raft Spider *Dolomedes plantarius* at Redgrave and Lopham Fen National Nature Reserve (NNR), Norfolk. Habitat management work and measurements of surface water levels are also documented and discussed in relation to spider population trends and to re-introductions of the spiders to other parts of the fen complex.

2 The Biological Action Plan target for *D. plantarius* at this site is for 65ha of habitat occupied in 3 years out of 5 by 2020.

3 Throughout the 22-year census period, the population on the reserve has been small and its range restricted to two small and spatially separated areas, constituting a maximum of *ca* 5ha, on Little Fen and Middle Fen.

4 Desiccation of the fen by artesian abstraction, and thought to be responsible for the decline in this semi-aquatic species, ended in 1999 with relocation of a borehole that had drained the fen. Subsequent hydrological recovery was rapid.

5 An annual index of the size of the *D. plantarius* population, 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.

6 Modelling of 22 years of census data for both the Little and Middle Fen sub-populations showed that there was a significant difference between them in the pattern of annual variation. In 2012, high water levels, resulting from the wettest summer for 100 years, prevented monitoring on Little Fen for the first time since 2001. This made it impossible to assess whether the significant increase seen in the population index in 2010 and 2011 was maintained. The index for Middle Fen was slightly lower than in 2011 but atypically high water levels there may have biased the data.

7 Numbers of both breeding females and nursery webs on Middle Fen were much lower than in 2011, when they were the highest ever recorded. They could not be assessed on Little Fen.

8 Although relative abundance was difficult to assess in 2012, there was evidence of an expansion of the spider's range on the Fen. On Middle Fen, a westward expansion in the spider's range that began in 2006 was maintained although only small numbers of spiders were found. The spiders were also recorded for the first time on turf ponds excavated to the east of the core area in 2009.

9 Range expansion on Little Fen included two adult spiders were found on the upper stretch of the river Waveney, nearly 200m from the core Little Fen population. These changes in range may have resulted from greater mobility of the spiders over the flooded fen surface.

10 Habitat management by mowing was confined to a belt of reed-dominated fen on the northern edge of core area for *D. plantarius* on Little Fen. No *Cladium mariscus* was cut on Middle Fen for the fourth successive year. Grazing stock had access to both areas but, as in all previous years, made more impact on Middle Fen than on Little Fen.

11 The changes in range on Little and Middle Fens, together with completion of a two-year programme of translocations to restored areas on Great Fen and Middle Fen, require a new monitoring strategy for *D. plantarius* on Redgrave and Lopham Fen. However, the current census method, which gives robust data for small populations, should be retained for the core areas until there is clear evidence of sustained recovery within the fen complex as a whole.

1 Introduction

This report summarises monitoring and management work undertaken in 2012 as part of the Fen Raft Spider *Dolomedes plantarius* Recovery Programme at Redgrave and Lopham Fen National Nature Reserve (NNR) on the Norfolk/Suffolk border in East Anglia. This Schedule 5 species was first discovered in the UK at this site in 1956 (Duffey 1958) and this remains one of only three natural populations where it occurs in the wild. Since 2010 a translocation programme designed to reduce vulnerability to stochastic extinction has started to establish populations at other sites in East Anglia and Southern England (Smith 2011a, 2012a and 2013).

Systematic monitoring and targeted management for *D. plantarius* began at this site in 1991 (under English Nature's Species Recovery Programme) to prevent extinction of the population. Desiccation of the fen, resulting from artesian abstraction since 1960 and compounded by droughts in the 1980s and 1990s, reduced the spider population to very low levels (Smith 2000). By the late 1980s, the remnant population had become restricted to turf ponds on two separate parts of the NNR. Targeted habitat management in the 1990s, including the irrigation of the ponds inhabited by the spiders, probably prevented extinction of the spiders but systematic monitoring showed that there was no significant increase in the size of the population and that its range was continuing to contract (Smith 2000).

Artesian abstraction ended in 1999 and hydrological recovery was rapid (Harding 2000). But despite both the very high potential fecundity of *D. plantarius* and the wetness of the fen, the spider population showed no sign of significant or sustained recovery during the following decade. It was clear that any recovery would be slow and that the wetness of the fen was not the only required trigger. Even with a downward revision in 2005 (BARS 2011), the 2010 BAP targets for the Redgrave and Lopham Fen population were not met; the population still showed no evidence of sustained or significant recovery (Smith 2011b). The most positive development during this period was an increase in range of the Middle Fen population, which began in 2006, eight years after restoration of the fen's hydrology. Although this appeared to involve small numbers of spiders over a modest distance, it was the first indication that habitat conditions beyond the core range of this sub-population were becoming suitable. On Little Fen, a positive indication was provided by a significant increase in the population index in both 2010 and 2011 (Smith 2011b).

The extremely slow recolonization of the recovering habitat at Redgrave and Lopham Fen is consistent with recent research that shows that *D. plantarius* at this site has very limited tendency to disperse (Pearson 2008). A 2009 survey of the extent of suitable vegetation types on the Fen, and of standing water in summer (Smith 2009), showed that a lack of continuity of summer-wet habitat was also likely to be impeding dispersal and recolonization of restored areas. These problems were addressed in two ways. First, a rolling programme of excavation of chains of new turf ponds started to provide links between existing population centres and larger scrapes created during the restoration operation of the 1990s (Smith 2010, 2011b). Secondly, as part of national translocation programme to reduce this species vulnerability, *D. plantarius* of local provenance were introduced to suitable areas of restored habitat within the Redgrave and Lopham Fen complex. The first phase of the translocation programme was completed in 2012, with introductions having been made in two successive years to two areas of the fen from which the spider was absent (Smith 2011a, 2012a, 2013).

This report presents the results from the standardised annual census of the natural population of *D. plantarius* at Redgrave and Lopham Fen and from casual recording throughout the fen complex. It also summarises ground water and rainfall data collected by the Suffolk Wildlife Trust (SWT), the NNR managers. All of these results are discussed in the context of the previous 21 years of monitoring data. The next steps required to progress the BAP targets for this site, in terms of monitoring, further translocations and both habitat and hydrological management, are considered.

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, 2008, 2009, 2010, 2011a & b, Smith 2012a &b).

2 Methods

2.1 Annual census

The annual census of *D. plantarius* followed the methodology adopted in 1993 and described by Smith (1993, 2000, 2012b). 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. Whenever consistent and favourable weather conditions allowed, the counts for each fen were made on three consecutive days (Table 1).

Table 1 Census dates for 1994-2012

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
2008	24-28	21-23
2009	13-20	23-28
2010	19-26	26-30
2011	25-31/07	1-3/08
2012	-	1-8/08

In 2000, 2001 and 2012, very high water levels made it physically impossible to census Little Fen during the summer. Sustained, very high water levels that result in establishment of submergent aquatic plants and development of aquatic invertebrate populations over extensive areas of the fen surface appear to result in dispersion of *D. plantarius* away from the turf ponds and are likely to bias the data.

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 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 (ponds 31 and 33: Fig. 1). By 2004 two of the three replicate counts at a further pond (36) also had to be made from the bank and in subsequent years all counts at this pond were made from the bank.

In 1991 and 1992 ponds were censused in much more restricted areas of both Little and Middle Fen. The methodology was changed in 1993 to include a wider area and allow detection of changes in range (Smith 1993) although the two methods were run in parallel until 1995 (Smith 1995). There was sufficient overlap in the sets of ponds sampled to allow formal analysis of population trends for the entire period, since 1991.

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 inundated), as implemented in program TRIM (Pannekoek & van Strien, 1998). In years when data from both Little and Middle Fen are available, TRIM allows the data to be split into different strata: 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 both 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 (Section 2.1 and 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.

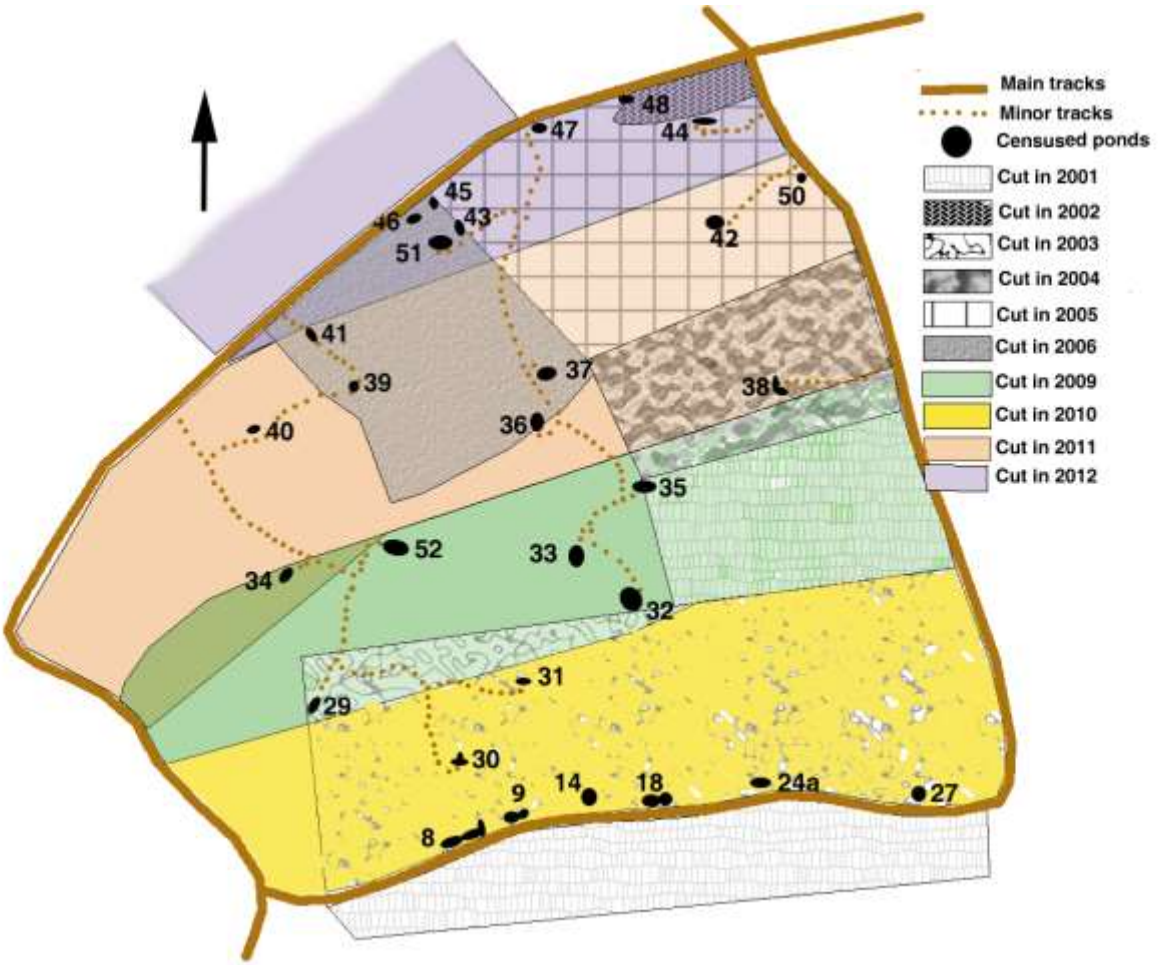


Fig. 1 The Little Fen census area showing ponds included in the census. Shading shows areas where vegetation was cut and removed in July/August each year

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. Additional information comes from casual records, including observations made during sedge-cutting management, but this cannot be used for quantitative comparison between years.

2.4 Water levels

In most years routine water level measurements have been made at approximately monthly intervals 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). This regular monitoring has not been possible since March 2010; measurements have since been taken during the July census periods (Little and Middle Fens only), and in November 2011 and March 2012. In 2012 the very high summer water levels on Little Fen in July delayed collection of water level data until early August. The levels in the Little and Middle Fen ponds are expressed relative to an arbitrary datum established in April 1992 and the levels in the Great Fen ponds relative to Ordnance Datum.

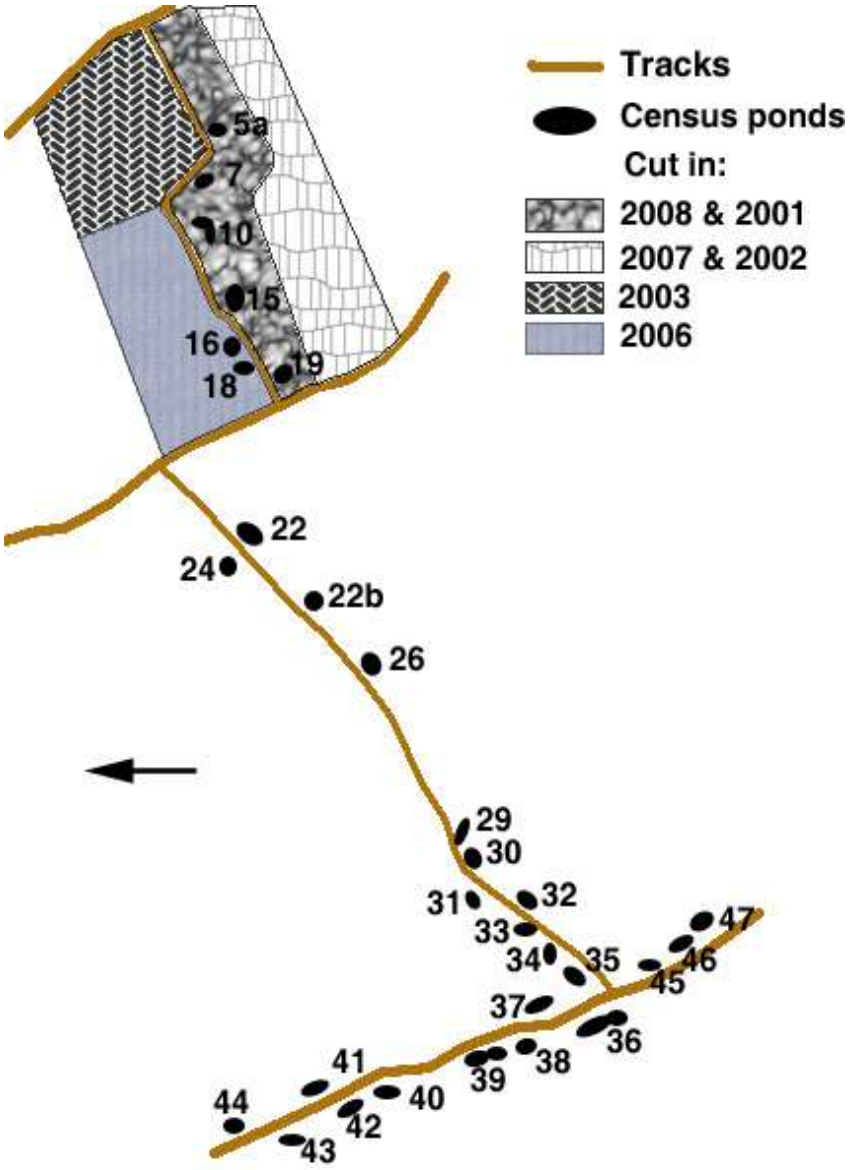


Fig. 2 The Middle Fen census area showing ponds included in the census. Shading shows areas where vegetation was cut and removed in July/August each year.

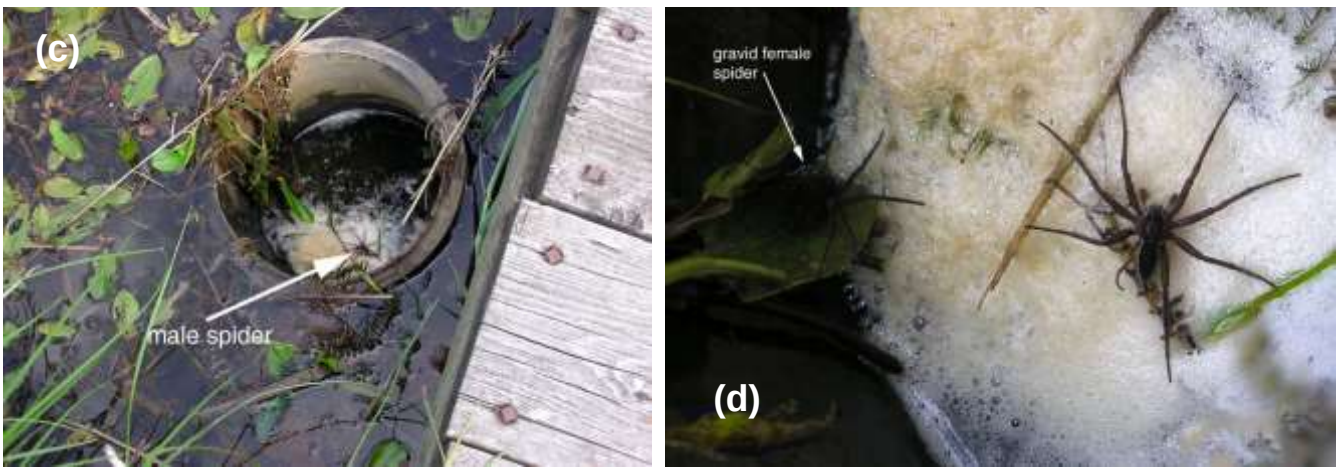
Ground water levels on the Fen have been monitored by SWT since 1976 using a network of 54 piezometer tubes (Smith 2000). Most of these monitor near-surface hydrology; eight are sunk into the underlying chalk. The data presented in this report are the highest monthly mean recorded from all of these tubes 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 36-year recording period. Monthly rainfall data measured on the Fen since 2001 are also presented.

3 Results

3.1 Distribution

On **Little Fen** exceptionally high water levels prevented the collection of any systematic monitoring data. In the July/early August census period, water levels in the turf ponds were very similar to those at the same time in 2000 and 2001 when monitoring last had to be abandoned.

Fig. 3 *Dolomedes plantarius* on the Upper Waveney in May 2012 showing (a) the location in relation to the Little and Middle Fen populations (b) the pipe sluices and (c) and (d), within the sluice



Although distribution within the census are could not be assessed, a casual record on 28th May showed spiders well beyond their recent known area of occupancy on Little Fen. In the last week of May, a

gravid female and courting male were seen inside the collar of a pipe sluice on the downstream end of the upper section the river Waveney on the eastern edge of Little Fen, bordering Redgrave Fen (Fig. 3). This site is nearly 200m from the main centre of population on Little Fen. Neither spiders nor any evidence of a nursery web was found during many subsequent visits. The pipe sluices are subject to very rapid increases in flow rate; if the female had been lost down the pipe she would be extremely unlikely to have survived since they are very vulnerable to drowning in turbulent water.

On **Middle Fen** the numbers of ponds occupied by *D. plantarius* matched the previous peak, reached two years ago (Table 2). All of the sampled ponds in the formerly irrigated, core area of the population were occupied and spiders were found on more ponds at the western extreme of the census area than in 2011. Since these ponds were recolonised, from 2006 onwards (Fig. 4), the spiders found there have been either all immature or all adult in alternate years. The likelihood of encounter is likely to be greater in years when the more numerous juveniles are present and this may, at least in part, account for the higher numbers recorded this year.

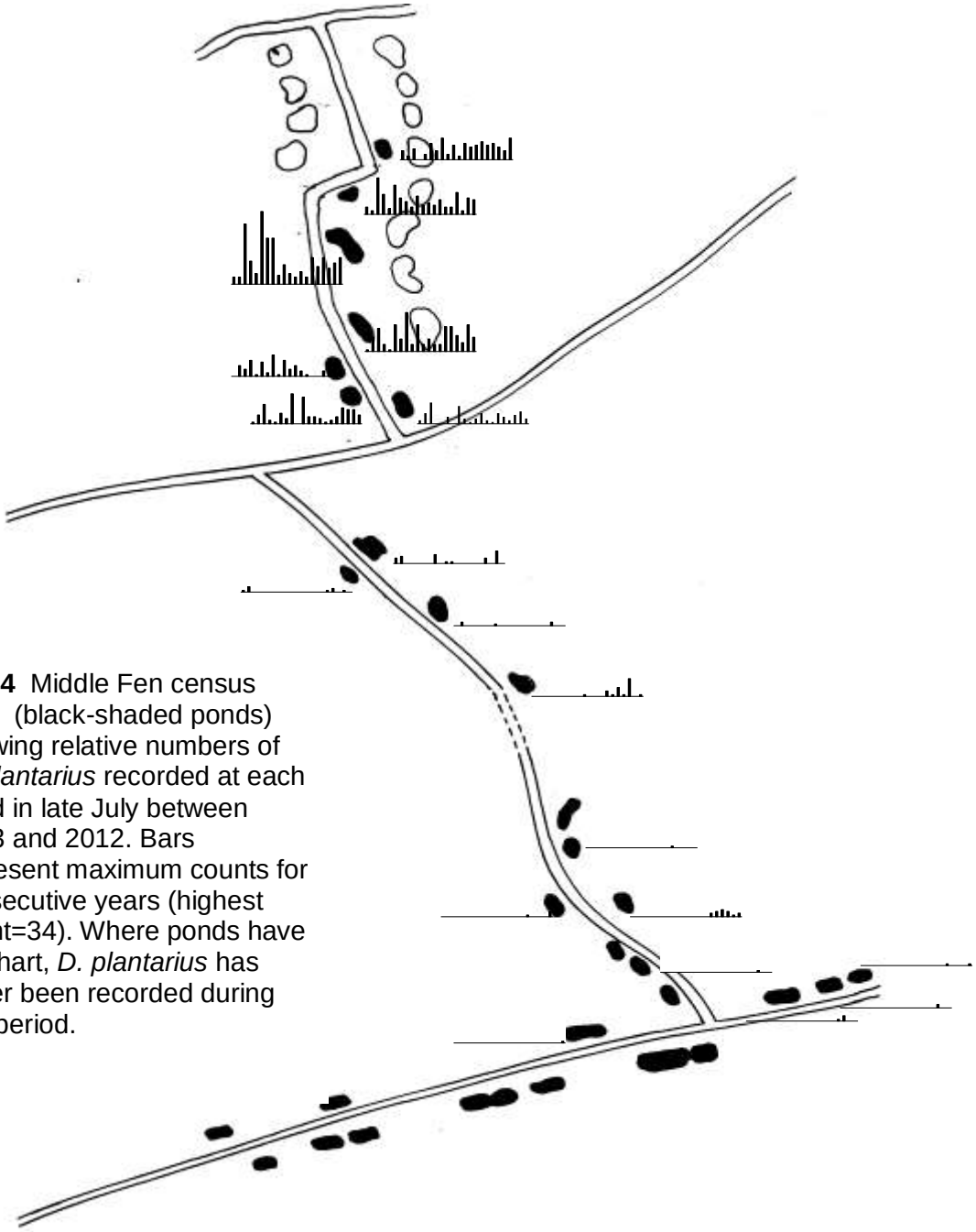


Fig. 4 Middle Fen census area (black-shaded ponds) showing relative numbers of *D. plantarius* recorded at each pond in late July between 1993 and 2012. Bars represent maximum counts for consecutive years (highest count=34). Where ponds have no chart, *D. plantarius* has never been recorded during this period.

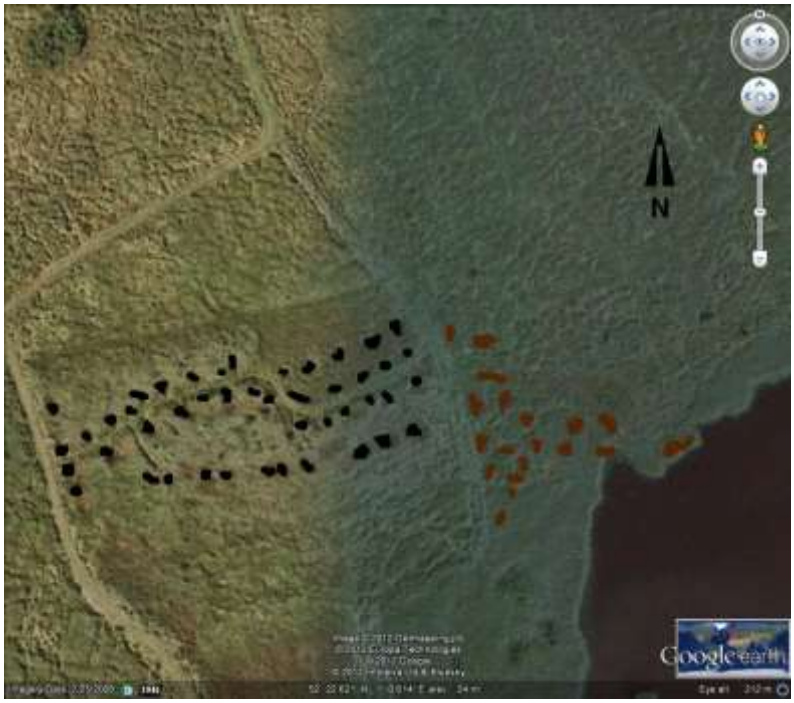
Table 2 Number of census ponds on which *D. plantarius* was recorded in July each year. Numbers are given separately for ponds that were and were not influenced by the irrigation supplied between 1993 and 1999. The 2000 data for Little Fen are based on two, rather than three replicate counts, made in September rather than July: no data were collected on Little Fen in 2001 (see Smith 2005) or 2012 (see text).

Year	**'93**	**'94**	**'95**	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**	**'02**	**'03**	**'04**	**'05**	**'06**	**'07**	**'08**	**'09**	**'10**	**'11**	**'12**
Little Fen																				
'Irrigated' n=15[1]	8	8	12	9	12	14	11	-	-	12	6	12	11	9	8	12	11	15	15	-
'Unirrigated' n=14[1]	2	2	4	0	1	6	4	-	-	2	1	2	0	4	2	4	3	8	9	-
Total	**10**	**10**	**12**	**9**	**13**	**20**	**15**	**(11)`**	**-**	**14**	**7**	**15**	**11**	**13**	**10**	**16**	**14**	**23**	**24**	**-**
Middle Fen																				
'Irrigated' n=7	6	7	7	5	6	7	6	7	6	7	7	7	7	7	6	6	7	7	7	7
'Unirrigated' n=23	2	3	0	0	0	0	1	2	0	2	1	0	0	1	2	6	5	6	3	6
Total	**8**	**10**	**7**	**5**	**6**	**7**	**7**	**9**	**6**	**9**	**8**	**7**	**7**	**8**	**8**	**12**	**12**	**13**	**10**	**13**

[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 2012. * The number of adult females given is based on identification of individuals and may be a higher figure than the maximum count of spiders in the large size category.

	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Little Fen																				
% Large	36	21	20	65	30	5	8	-	-	9	29	4	10	14	18	11	45	27	13	-
% Medium	57	37	66	15	41	50	53	-	-	57	43	68	88	45	73	68	34	67	70	-
% Small	7	42	15	20	29	45	39	-	-	34	28	28	2	41	9	21	21	6	17	-
Max. spider count	**14**	**19**	**41**	**20**	**66**	**94**	**62**	**-**	**-**	**53**	**7**	**68**	**40**	**42**	**66**	**75**	**47**	**124**	**150**	**-**
Adult females*	0	1	6	6	16	4	4	-	-	4	2	3	4	7	10	10	15	20	12	-
Nursery web count	0	2	0	0	9	0	4	-	-	0	0	1	2	4	4	0	3	14	4	-
Middle Fen																				
% Large	29	30	3	17	47	5	15	6	20	6	10	5	13	10	19	12	16	30	25	11.1
% Medium	33	48	62	34	53	32	46	49	30	55	48	50	45	63	50	46	58	54	62	57.1
% Small	38	22	35	49	0	63	39	45	50	39	42	45	42	27	31	40	26	16	13	31.8
Max.spider count	**21**	**44**	**102**	**41**	**15**	**99**	**52**	**112**	**20**	**72**	**29**	**42**	**31**	**30**	**54**	**56**	**70**	**63**	**73**	**63**
Adult females*	0	8	1	5	6	5	7	7	0	2	2	1	4	3	8	5	9	1	19	2
Nursery web count	1	3	1	0	0	0	7	0	0	0	0	0	3	1	2	1	2	0	11	3



Casual recording on Middle Fen showed that *D. plantarius* had colonised the turf ponds excavated immediately east of the core area of population in 2009 (Smith 2010); small numbers of immature spiders were seen on three of the ponds closest to core area (Fig. 5).

Fig. 5 New ponds excavated on Middle Fen in September 2009 (brown). Ponds marked in black are those at the eastern end of the standard census area

3.2 Abundance

It was not possible to assess abundance on Little Fen in 2012 because of the exceptionally high water levels.

On Middle Fen *D. plantarius* numbers were slightly lower than in 2011 but well within the range of variation since 1993 (Fig. 6). The annual population index for Middle Fen shows that, as in previous years, 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. The annual time effects model had an AIC value of –223.35 (Wald test for significance of deviation from linear trend: 175.71, $p<0.001$, df=20). Linear-trend and no-time-effects models had AIC values of 88.48 and 102.08 respectively.

3.3 Breeding indicators

On **Little Fen**, although it was not possible to assess breeding success in relation to previous years, casual recording showed that, in July, there were nursery webs well away from the turf ponds in the extensive flooded areas of the *Cladium mariscus* beds. No nurseries were found by the sedge cutters working in early August but the block cut (Fig. 1) was at the northern and usually least populated end of the core area (Smith 2012b).

After a record breeding season on **Middle Fen** in 2011, 2012 was more typical of previous years, with very much lower numbers of both adult females and nurseries (Table 3).

Fig. 6 Annual population indices for *D. plantarius* on Middle and Little Fens in July 1991-2012, generated by a log-linear Poisson regression model and plotted on a linear scale. No data were collected on Little Fen in 2000, 2001 and 2012 (see text). 2SEs shown by positive vertical bars for Middle Fen and negative bars for Little Fen.

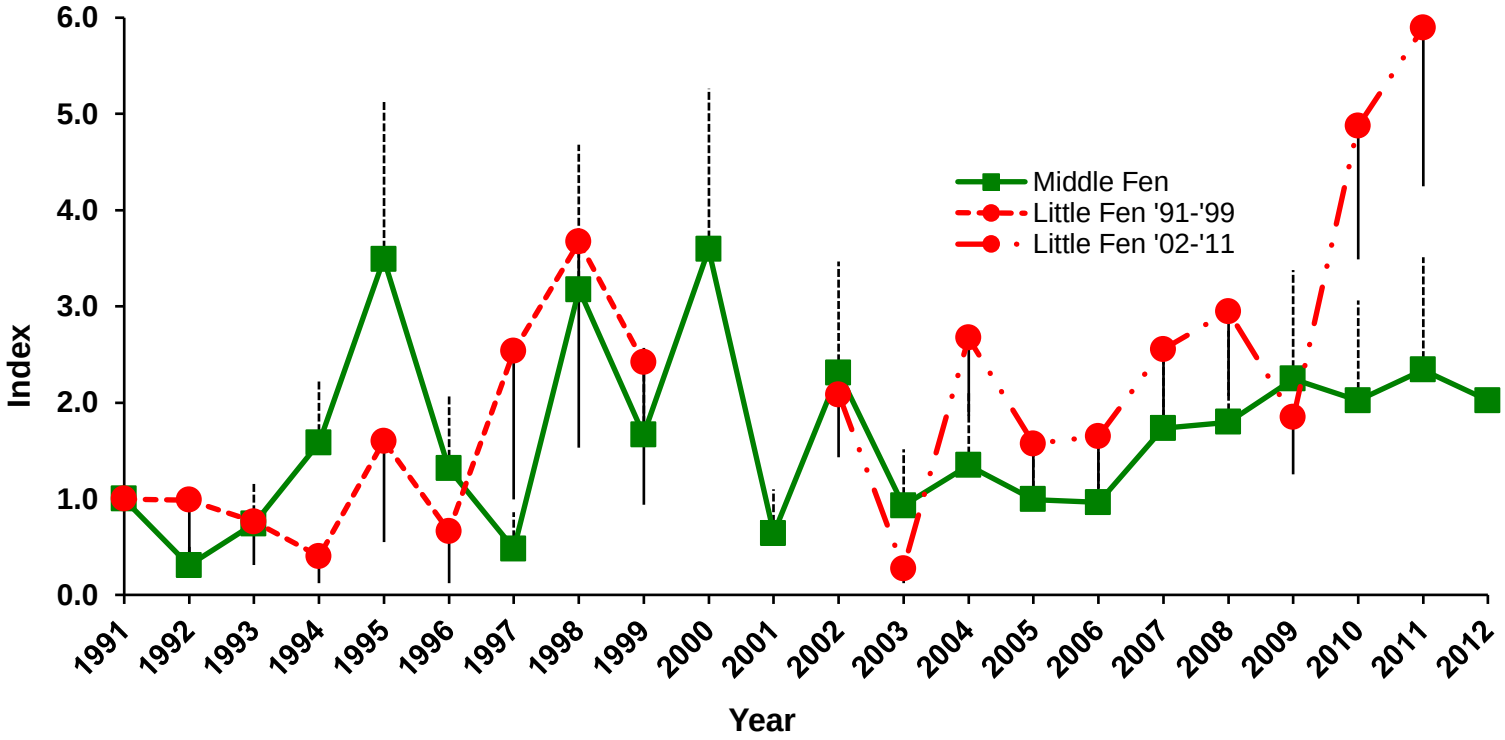
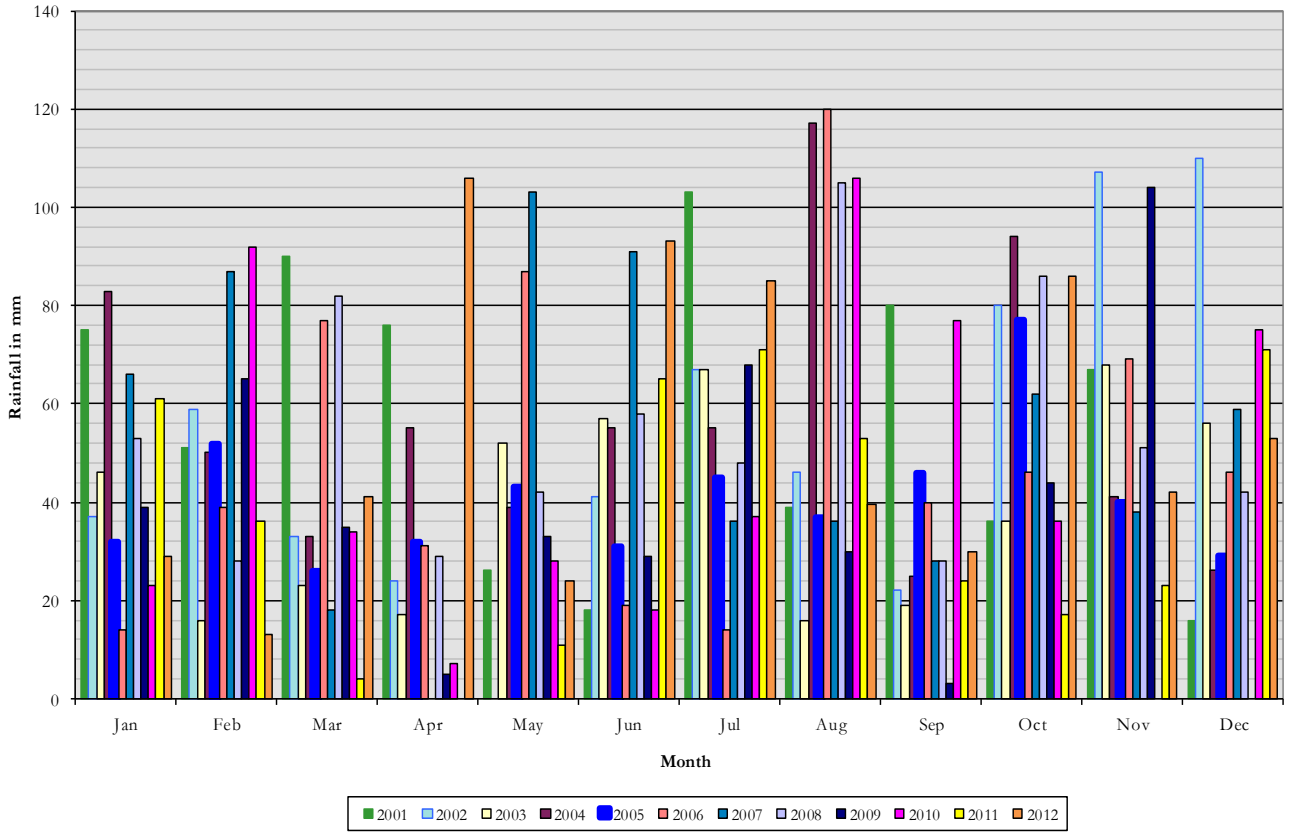


Fig. 7 Monthly rainfall totals for Redgrave and Lopham Fen NNR 2001- 2012 (Suffolk Wildlife Trust data)

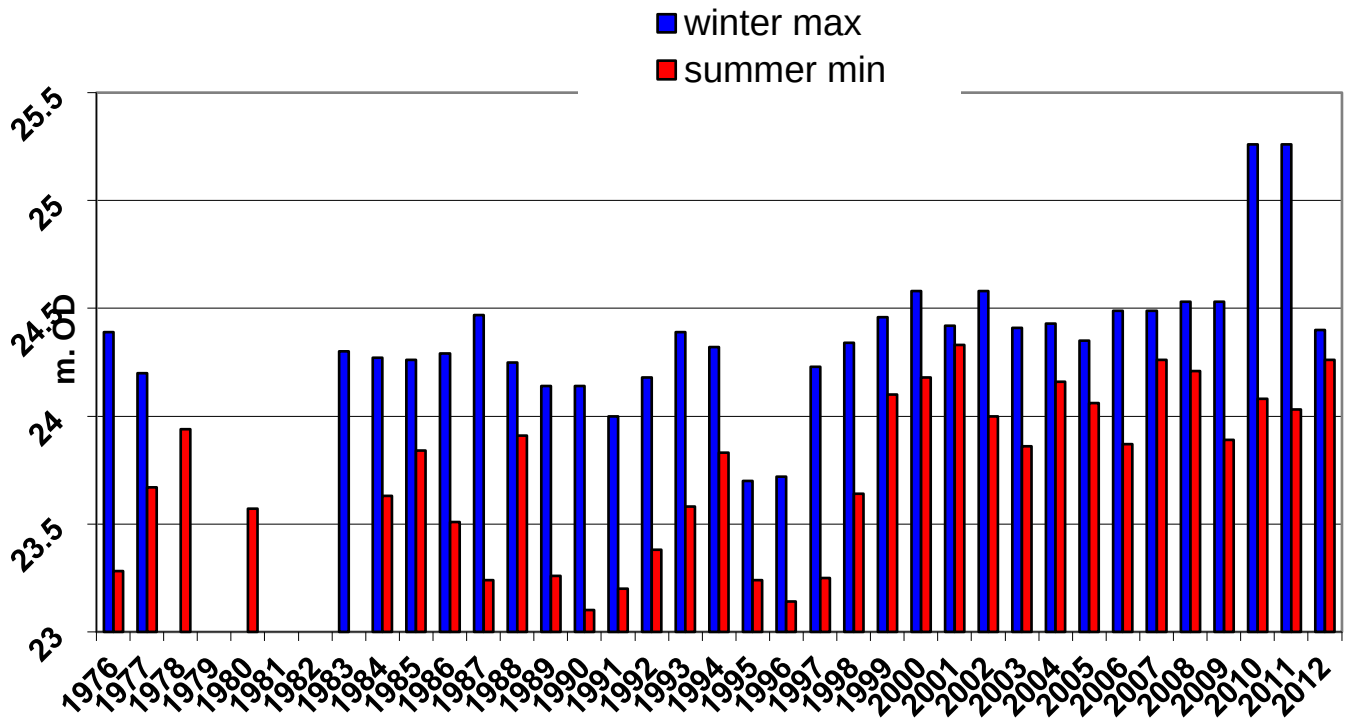


3.4 Water Levels

2012 was an exceptional year for weather, with severe drought and relatively warm conditions in January to March contrasting with an extremely wet summer. The April and June period was the wettest in the England and Wales in data collected since from 1766, while the summer months (June, July, August) were the wettest since 1912. Rainfall totals for autumn and December remained well above average.

Rainfall figures from the Fen from 2001 onwards reflect this national pattern with February having the lowest total while the April and June totals were the highest in the series and the July total second only to the exceptionally wet summer of 2001 – the last time that high water levels precluded census work in the Little Fen ponds (Fig. 7). Mean water levels measured in the piezometers across the fen show the highest summer minimum since 2001 (Fig. 8).

Fig. 8 Mean winter maximum and summer minimum water levels in piezometers on Redgrave and Lopham Fen NNR, 1976-2012 (Suffolk Wildlife Trust data)



4 Habitat management

4.1 Rotational mowing of *Cladium mariscus*

In 2004 SWT changed from a programme of rotational cutting of *C. mariscus* stands to one of cutting those judged to be most in need of management, both within and beyond the core area for *D. plantarius* (see Smith 2004). This need varies according to the wetness of the season and the effectiveness of stock grazing. In practice, on Little Fen, this has resulted in a return to an informal rotation within the core are for *D. plantarius* (Fig.1).

In 2012, on Little Fen, an east-west strip of *C. mariscus,* at the northern end of the census area, was cut during the first week of August. This incorporated, and extended to the west, parts of the blocks last cut in 2005-2006 (Fig.1). As in previous years, occasional clumps of emergent and marginal *C. mariscus* were left uncut around the turf ponds to provide shelter for the spiders and support for nursery webs.

On Middle Fen no *C. mariscus* was cut for the fourth successive year (Fig. 2).

4.2 Grazing

In the western part of the **Middle Fen** census area, away from the dense *C. mariscus* beds that dominate the core range for *D. plantarius,* the grazing regime initiated in 2001 continued to have a substantial impact on the vegetation. Although the grazing pressure in this area in 2011 had started to destroy the tussocky vegetation structure that had developed between the turf ponds and replace it by shortly-grazed 'lawns', the reduced grazing intensity in 2012 resulted in a return to a more varied structure. Grazing around the turf pond margins has resulted in a progressive reduction in shading from *Phragmites australis* and more open, sunny water surfaces.

On **Little Fen**, as in previous years, the stock made relatively few incursions into the areas occupied by *D. plantarius* and had relatively little effect on the vegetation (e.g. Smith 2007).

Full records of stock types, rates and movements are maintained by SWT.

4.3 Turf Ponds

Planned removal of infilling sediment from turf ponds adjacent to the bunds on Little Fen, that were not cleaned in 2009 and 2010 (Smith 2010, 2011b), had to be postponed until 2013 because of the access difficulties created by high water levels.

5 Discussion

The exceptional weather in 2012, and resulting failure to collect systematic monitoring data on Little Fen, made it impossible to assess the relative size of the *D. plantarius* population on Redgrave and Lopham Fen. On Middle Fen, where monitoring was possible, **the census data suggested an average year, with no evidence of the substantial increase in breeding success in 2011 being sustained** or reflected in an increase numbers of immature spiders. The very cold, exceptionally dry winter may have affected survival but the very protracted flooding of the fen surface (Fig. 9) may also have resulted in some downward bias in the numbers of spiders encountered on the ponds included during the census.

Fig. 9 Redgrave and Lopham Little Fen in early August 2012, showing continuity of water between the turf ponds

Despite the difficulty of assessing the population in the core areas, **2012 saw positive changes in the spider's range on the Fen**. Although in 2011 only one adult female was encountered on the census ponds in the recent westward extension of the Middle Fen population, small numbers of immatures were encountered on several ponds in 2012. The apparent alternation of years when only either adults or juveniles have been encountered continues to suggest that the spiders arrived in this area in a single colonising event. Although this species appears to have a low propensity to disperse by ballooning (Pearson 2008), it has the capacity to do so and rare ballooning events are a possibility. Analysis of DNA from exuviae collected over the last six years from this extension of the Middle Fen population should help to elucidate its origin.

The discovery for the first time of *D. plantarius* beyond the census areas, on the river on Little Fen and in newly excavated ponds on Middle Fen, may be attributable to the greater mobility afforded to the spiders by the extensive and protracted flooding of the fen surface. **This expansion in range**, together with the requirement for systematic monitoring of the areas to which spiders have been introduced as part of the translocation programme (Fig. 10 & Smith 2013), **requires the introduction of a new, systematic monitoring programme for the Redgrave and Lopham Fen**.

Fig. 10 Locations of the 2010-2012 *D. plantarius* release areas on Redgrave and Lopham Fen NNR (blue) and the existing sub-populations on Little Fen and Middle Fen (red). The inset shows the ponds around which the Great Fen releases were made (shaded red).

A new monitoring programme should be run in parallel with the existing long-term monitoring of the Little and Middle Fen populations until adequate cross-calibration is possible. Previous trialling of monitoring methods that do not involve working in deep water, including point counts of spiders and counts of nursery webs, yielded much poorer quality data than the existing data (Smith 2001, 2002). In years when spider densities were particularly low, these data were considered inadequate for assessing such a vulnerable population.

Monitoring low density *D. plantarius* populations is difficult even in the grazing marsh ditch systems of the Pevensey Levels and Lower Waveney. The much more restricted visibility in the dense sedge beds and around the turf ponds at Redgrave and Lopham Fen presents very challenging conditions for extensive monitoring. **Fixed transects, with a combination of timed counts of spiders at fixed points and continuous counts of nurseries, are likely to be the most effective possibility**. These should be centred on the existing census areas and the areas where spiders were introduced in 2010-2012, and radiate out to include areas of potentially suitable habitat. Annual changes in the field of view from these transects, resulting from often substantial changes in the height of the fen vegetation between years, is likely to be a significant source of noise in the data unless sample sizes are relative large. **It is recommended that a new monitoring programme is introduced in 2013 and is assessed in relation to the existing scheme for several years before consideration is given to abandoning the latter.**

The changes in range of the *D. plantarius* population on the Fen in 2012 represent some progress towards the BAP target for this site of 65ha of habitat occupied in 3 years out of 5 by 2020. Since increased mobility over the flooded fen surface may have facilitated this expansion, extensive monitoring will reveal whether new areas have been colonised in sufficient numbers to sustain populations in dry summers when they are much more isolated.

If successful, the introductions of *D. plantarius* to new areas on Great Fen and Middle Fen will also help to achieve the BAP target for the reserve. Initial monitoring results from Great Fen suggested that the population density is low but effective monitoring in the dense *C. mariscus* there is challenging (Smith 2013). Monitoring of the Middle Fen translocation, completed in 2012, will help to inform decisions on the need for augmentation of the new population centres.

In 2009 and 2010, chains of new turf ponds were excavated to the east and west of the core areas on Middle Fen to provide better continuity of summer wet conditions across the Fen (Smith 2010, 2011b). The colonisation of some of these new ponds in 2012 is a promising indication that this strategy may be successful. **Evidence of continuing colonisation of the new ponds in 2013 would justify further extending this network of new turf ponds**. **This should be an important element in a sustained programme to ensure the creation of summer-wet links between the *D. plantarius* subpopulations on the fen**. Such a programme is vital in defending the spiders against summer drought and in facilitating reestablishment of a sustainable, functional metapopulation. This programme also need to encompass continued work to maintain adequate depth in the older turf ponds, deeper water near the *C. mariscus*-fringed margins of the larger scrapes (Smith 2010), and the best possible hydrological outcomes via the sluice system. These measures to maintain suitable conditions for *D. plantarius* are also likely to benefit a high proportion of the Redgrave and Lopham Fen's many rare aquatic plant and animal species.

Acknowledgements

I am grateful to the staff of the Suffolk Wildlife Trust at Redgrave and Lopham Fen for accommodating this work and for allowing publication of their piezometer and rainfall data. Natural England funded the monitoring programme and Stephen Baillie provided invaluable statistical advice.

References

BARS 2009. National Action Plan – *Dolomedes plantarius* (Fen Raft Spider) Url: http:// https://www.ukbap-reporting.org.uk/plans/

Duffey E. 1958**.** *Dolomedes plantarius* Clerk, a spider new to Britain, found in the upper Waveney Valley, *Transactions of the Norfolk and Norwich Naturalist's Society*: **18**, 1-5.

Duffey, E. 1991. *The Status of Dolomedes plantarius on Redgrave and Lopham Fens in 1991*. Unpublished report to English Nature.

Harding, M. 2000. *The Restoration of Redgrave and Lopham Fen*. Unpublished Report, Suffolk Wildlife Trust, Ashboking.

JNCC 2020. BAP Priority Species https://jncc.gov.uk/our-work/uk-bap-priority-species/ (Downloaded on 10 February 2020).

Pannekoek, J. & van Strien, A. 1998. *Trim 2.0 for Windows (TRends & Indices from Monitoring data).* Research paper 9807, Statistics Netherlands, Voorburg.

Pearson, P. 2008. *The ecology and conservation of the fen raft spider (*Dolomedes plantarius*) in the UK*. Unpublished PhD thesis, University of East Anglia.

Smith, H. 1992. *The status and autecology of* Dolomedes plantarius *on Lopham and Redgrave Fen nature reserve in 1992*. Unpublished report, English Nature, Peterborough.

Smith, H. 1993. *The status and management of* Dolomedes plantarius *on Lopham and Redgrave Fen National Nature Reserve in 1993*. Unpublished report, English Nature, Peterborough.

Smith, H., 1994*. The status and management of* Dolomedes plantarius *on Lopham and Redgrave Fen National Nature Reserve in 1994*. Unpublished report, English Nature, Peterborough.

Smith, H. 1995. *The status and management of* Dolomedes plantarius *on Redgrave and Lopham Fen National Nature Reserve in 1995*. English Nature Research Reports, No. 168, Peterborough.
Smith, H. 1996. *The status and management of* Dolomedes plantarius *on Redgrave and Lopham Fen National Nature Reserve in 1996*. English Nature Research Reports, No. 214, Peterborough.
Smith, H. 1997. *Fen Raft Spider Project: interim summary report for 1997*. English Nature Research Reports, No. 258, Peterborough.
Smith, H., 1998. *Fen Raft Spider Project: interim summary report for 1998*. English Nature Research Reports, No. 258, Peterborough.
Smith, H. 2000. The status and conservation of the fen raft spider (*Dolomedes plantarius*) at Redgrave and Lopham Fen National Nature Reserve, England. *Biological Conservation*, *95*, 153-164.
Smith, H. 2001. *Fen raft spider recovery project: a decade of monitoring*. English Nature Research Reports, No.358. Peterborough.
Smith, H. 2006. *Fen Raft Spider Recovery Project: Report for Redgrave and Lopham Fen 2001-2005.* Unpublished Report to English Nature, Peterborough.
Smith, H. 2007. *Fen Raft Spider Recovery Project: 2006 Summary Report for Redgrave and Lopham Fen*. Unpublished Report to Natural England, Peterborough
Smith, H. 2008. *Fen Raft Spider Recovery Project: 2007 Summary Report for Redgrave and Lopham Fen*. Unpublished Report to Natural England, Peterborough.
Smith, H. 2009. *Fen Raft Spider Recovery Project: 2008 Summary Report for Redgrave and Lopham Fen*. Unpublished Report to Natural England, Peterborough
Smith, H. 2010. *Fen Raft Spider Recovery Project: 2009 Summary Report for Redgrave and Lopham Fen*. Unpublished Report to Natural England, Peterborough.
Smith, H. 2011a. *Fen Raft Spider Translocation Project Report 2010*. Unpublished Suffolk Wildlife Trust Report to the BBC Wildlife Fund.
Smith, H. 2011b. *Fen Raft Spider Recovery Project Report 2010.* Unpublished Report to Natural England.
Smith, H. 2012a. *Report on the Fen Raft Spider* Dolomedes plantarius *translocation project in East Anglia in 2011*. Unpublished Report to the Translocation Project Partners.
Smith, H. 2012b. *Fen Raft Spider Recovery Project: 2011 Summary Report for Redgrave and Lopham Fen*. Unpublished report to Natural England
Smith, H. 2013. *Fen Raft Spider Translocation Project Report 2012*. Unpublished Report to Natural England and the Broads Authority.