Hymettus

Survey for the BAP flies *Dolichopus laticola* and *D. nigripes* (Diptera: Dolichopodidae) in Norfolk fens

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Summary

- Sixteen Norfolk fens were surveyed for *Dolichopus laticola* and *D. nigripes* between 16 and 23 June 2011 using timed 10 minute sweep-net samples. 124 samples were taken altogether. All larger Dolichopodidae were also collected. Variables recorded were soil wetness, management and habitat type.

- *Dolichopus laticola* was recorded at six fens, five of which were new sites for the species. These records slightly increased the known range which extends along the Ant valley from Broad Fen in the north to Hulver Ground near its confluence with the Bure, and along the Bure from Ebb & Flow to Woodbastwick Fen. Outlying populations were found at Burgh Common in the south and Ormesby Broad in the east.

- *Dolichopus nigripes* was recorded only at Reedham Fen in the Ant valley, and this represents the first good population in this valley; it was previously known only from a single specimen from Catfield Great Fen in 2010. This species is otherwise restricted to the Bure valley fens.

- *D. laticola* was more frequent than expected in samples taken at 'old cut' fen vegetation and next to ditches. It was under-represented in grazed fen and apparently absent in fen next to ponds or swampy areas. It was scarce in sedge beds (*Cladium*) and scrub or carr. Samples with *D. laticola* were from land that was slightly drier than where it was absent.

- There was only a weak correlation between the occurrence of *D. laticola* and the value of fens measured using an index of vegetation quality. It was more likely to be present at fens of exceptional quality and absent from those of particularly poor quality, but there was no consistent pattern for areas of intermediate quality. Dolichopus laticola occurred more often at sites with high numbers of other species of dolichopodids.

- Ordination using DCA of 36 species of dolichopodids in 94 samples showed that *D. laticola* was associated with other mire species, some of which were fen specialists. *Dolichopus nigripes* was also associated with other fenland specialists.

Introduction

Two species of flies, *Dolichopus laticola* Verrall and *D. nigripes* Fallén (Diptera, Dolichopodidae), were included in the list of priority species in the Biodiversity Action Plan (www.jncc.gov.uk, accessed October 2010). Their distribution is almost confined to the fens of the Norfolk Broads. The only records away from this area are a 19th century record of *D. nigripes* from a Dorset fen, and the discovery in 2010 of a thriving population of *D. laticola* at Walberswick NNR, Suffolk (Vincent, 2011).

In 2010, an intensive survey was undertaken at six fens in the Norfolk Broads to determine the broad ecological requirements of these two flies (Drake, 2010). One conclusion from this work was that both species could be found readily along tracks and paths in open fen, so that surveying for them does not require searching for a specific microhabitat. Using this information, a search was undertaken in 2011 of fens from which the species had not been recorded recently. There were two reasons for this survey. Firstly, although the intensive study in 2010 had indicated broad habitat preferences, it was not clear what factors may influence wider distribution, for example why the species were, with rare exceptions, confined to the Norfolk fens. Surveying a range of fens was likely to suggest factors that influenced their geographic range. Secondly, the recent discovery of *D. laticola* at reedbeds in Suffolk suggested that the range of this species may be rather wider than previously thought, so fens throughout Broadland needed to be investigated. In contrast to the range of *D. laticola*, *D. nigripes* has been found only in the Bure fens, with the exception of a single female from Catfield Great Fen in 2010. This tiny range seemed unlikely to be real, given the relatively high connectivity between the fens in Broadland. The project contributed to an action point in the Biodiversity Action Plan for more survey of both species.

Methods

The distribution of fen within Broadland is given in George (1992), from which sites were selected for survey. The selection was based on:

- fens not surveyed in 2010
- ease of gaining access permission. This was necessary since no organisation provided logistic support for the project. The emphasis was on sites managed by the Broads Authority, Norfolk Wildlife Trust and Natural England.
- sites widely spaced and at the extremity of the distribution of fenland in the river valleys of Broadland.

The sites were visited between 16 and 23 June 2011, the same time of year as the 2010 survey was undertaken. It was also approaching the peak flight period shown by Vincent (2011) for the population at Walberswick. In 2011, this period followed an exceptionally dry and warm spring that resulted in many adult insects being active earlier than normal (for instance, swallowtail butterflies were about two weeks earlier). It also resulted in drought conditions, with the official drought being declared on 10 June in eastern England. To further confound conditions, the survey period coincided with the onset of very unsettled weather, with rain falling for long periods or in heavy frequent showers on every day of the survey. The effects of this weather on the logistics of the survey were to reduce the number of sites and samples per site that could be surveyed, and made it difficult to assess the wetness of the ground since previously parched sites were now saturated. The 16 sites that were finally visited are given in Table 1 and Figure 1, together with the number of samples taken at each.

Table 1. Number of samples and dates of visits to each site.

Site	Number of samples	Day of June, 2011
Alderfen Broad	8	16, 20
Broad Fen	10	22
Burgh Common	11	18, 20
East Ruston Allotments	6	20
Hickling Broad	8	17
Hulver Ground	7	23
Martham Broad	6	17
Ormesby Broad	8	21
Reedham Marsh	13	16
Smallburgh Fen	10	18, 20
Stanley Carrs	3	22
Strumpshaw Fen	7	19
Surlingham Church Marsh	7	19
Surlingham Marsh	5	23
Sutton Fen	4	21
Upton Fen	11	18, 19
Total	124	

Most of these sites had not been visited by the author in surveys between 2007 and 2010. The exceptions were Hulver Ground and Sutton Fen, which were sampled opportunistically in 2011 when visited for another purpose and had been surveyed in all years between 2007 and 2010.

Sampling

The method was the same as used in 2010. Samples were obtained using a standard 10 minute sweep-net sample which consisted of sweeping vegetation for about 25 sweeps and inspecting the net contents, and repeating this for 10 minutes. All obvious dolichopodids were removed using a pooter, but tiny species such as those in the genera *Teuchophorus*, *Achalcus* and *Micromorphus* were probably often overlooked although this was not important because their collection was not directly relevant to the study. As the aim of the 2011 survey was to locate the two BAP species, the sampled area was as large as could be fitted into the 10 minute period, but without straying into markedly different habitat from where sampling began. No effort was made to randomise the samples as this was irrelevant to the project's aim. The distance walked during a sample varied widely but was usually in the order of 100m. In the previous year, it had been established that both species could be found frequently at paths and tracks rather than at any more specific microhabitat, so there was no need to search other than the most easily accessible places.

A few environmental variables were noted at each sample point:

- soil wetness, measured on an arbitrary scale of 1 (dry), 2 (soft and damp), 3 (saturated), 4 (free water)
- management: recent cut, old cut (clearly managed but perhaps several years ago), neglected, grazed
- habitat: ditch, pond or swamp, mixed fen, reedbed, sedge-bed (*Cladium*), grass, track or path, scrub or carr.

Sometimes more than one of these variables was included in a single sample since the vegetation often varied in the distances covered during one sample.

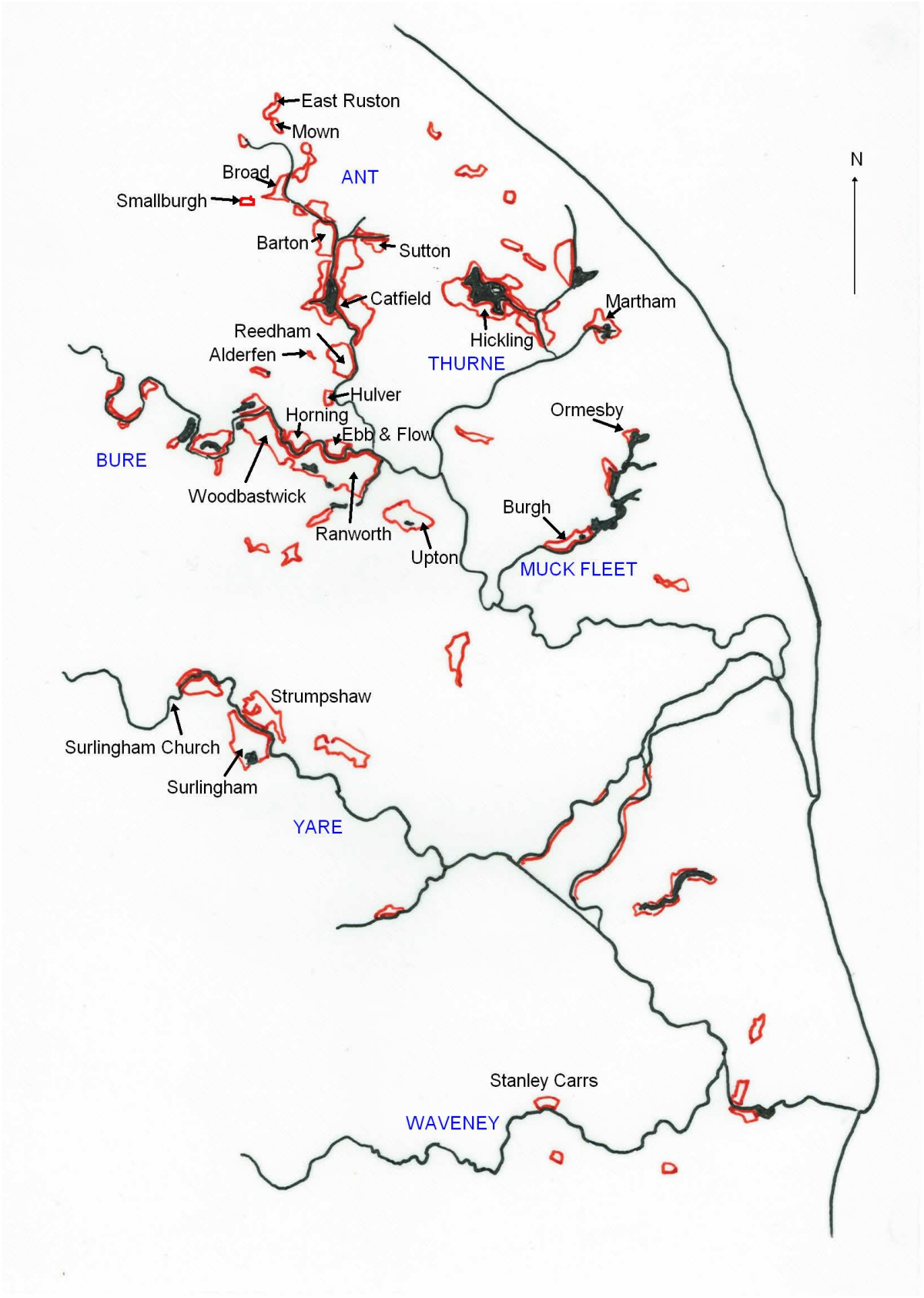


Figure 1. Norfolk Broadland. Rivers and broads are shown in black and their names in blue capitals; fen is shown in red, and named when mentioned in the text. Adapted from George (1992).

Results

Dolichopodids were present in 120 of the 123 samples taken. *Dolichopus laticola* was present in about 14% of samples and was ranked 18th in order of frequency of all 68 species recorded, and was the 9th most frequent of the 21 species of *Dolichopus* in the samples. *Dolichopus nigripes* was present in only about 4% of samples and ranked 35th of all dolichopodids and was the 17th most frequent species of *Dolichopus*.

Dolichopus laticola was present at six fens, of which five were sites where it had not been previously recorded by NCC in 1988 or by the author since 2007. The fens and number of samples with *D. laticola* were Broad Fen (4), Sutton Fen (2), Reedham Marsh (5) and Hulver Ground (1) in the Ant valley, and Burgh Common (4) and Ormesby Broad (1) on the Ormesby and Muck Fleet tributary of the Bure. These records extended the known range slightly within Broadland, although were restricted to the Ant and Bure catchments. Within this range, *D. laticola* occupied blocks of fen that were more-or-less connected along these rivers. Intervening blocks with grazing marsh, although not being inhospitable, probably represented a small barrier to movement. The outlying northern fens (East Ruston Allotments, Smallburgh Fen), may have been occupied as they are close to large populations.

Of greater interest was the occurrence of *D. laticola* at the south-eastern sites of Ormesby Broad and Burgh Common. The species was described new to science by Verrall (1904) from Ormesby Broad where he collected it on 28 June 1888, and he says "If my memory serves me true they were taken in marshy rushy ground near the north-west of the Broad." So the population recorded in the present survey may represent descendents of the original specimens, perhaps collected close to Verrall's site. This area was not typical fen in 2011, being instead composed of wide wet rides with fen or swamp vegetation within deciduous woodland. Burgh Common was traditional fen with cattle grazing tall reed-dominated fen or shorter mixed fen herb vegetation.

The absence of *D. laticola* in the Thurne catchment may be real. Not much ground was covered at Hickling or Martham broads in the present survey but many samples were taken between 2007-9 at sites around the broad and at adjacent sites along the Meadow Dyke to Heigham Sound and Horsey Mere. The area is slightly brackish and this may be one reason for the fly's absence here. This cluster of wetlands is also isolated by grazing marsh from the Ant and Bure populations. However, there remains a considerable area of fen not surveyed in this catchment, notably between Martham Broad and Brayden Marshes.

Dolichopus laticola has strong populations along the Bure between Woodbastwick Fen and Ebb & Flow, and was recorded at Mills Marsh within Ranworth Marshes in the 1988 NCC survey. Its absence from Upton Fen is therefore remarkable since it is separated only by about 3km of fen, carr and grazing marsh from the nearest population at Ranworth Marshes.

No *D. laticola* was found on the Yare or Waveney sites although surveys of these were marred by showers and wet vegetation, so that few samples were taken in relation to the available habitat.

The number of individuals in each sample was usually just one or two, and a maximum of seven was found at Broad Fen and five at Reedham Marsh.

Dolichopus nigripes was found only at Reedham Marsh, where it was present in five of the 13 samples. This represented a moderately large population, almost comparable with that at Woodbastwick Fen where, in 2010, the species was found in 60% of the 45 samples taken. A single female was found outside the Bure marshes in 2010 at Catfield Great Fen so the Reedham population confirmed that its range extends into the Ant valley, even if only a few kilometres from the Bure population.

Only one or two individuals were recorded in any sample.

Relationship with environmental variables

The combination of numerous zero cells, non-random sampling and scoring of more than one variable in some classes precluded anything but a simple analysis. The percentage of samples with or without *D. laticola* was calculated for each variable. As the species was apparently absent from many sites, the analysis was done for all 16 fens and then for the six fens where *D. laticola* was present to avoid false negatives in the ten fens where the species may have been genuinely absent. Owing to the wide area covered in each sample, some variables were scored for more than one factor, for example both new and old cut could have been included in one sample. This did not affect the comparisons for individual factors except for wetness which, if scored for more than class was converted to the mean of these individual values for the sample, for example, a site that included damp (2) and saturated (3) ground scored 2.5. The mean of these values was then calculated for all sites with or without *D. laticola*. If the species showed no preference for a variable then its percentage occurrence would be similar to that for all samples (the 'total' column in Table 3). Over-representation was therefore indicated by percentages well above or below 14% for all fens or 32% for just the six fens where it was found. This analysis had not been undertaken for the previous year's data (2010) and so is presented here (Table 3).

The results for the two years of data did not coincide well although there were no cases of complete disagreement. Combining both years' results, *D. laticola* showed possible preference for 'old cut' vegetation and possible avoidance of 'new cut' and 'neglected' stands. Its response to 'grazed' was complicated by this category being superimposed on varied heights and densities of vegetation, since some grazed sites were short vegetation (similar to 'new cut') and other was exceedingly dense old reed, but this difference in structure was not scored consistently so disentangling the effect of grazing could not be made using these data.

The low representation in sedge beds (*Cladium*) and scrub or carr may have been an artefact of the low sample size, although avoidance of both these habitats was noted in the 2010 survey. Samples with *D. laticola* were slightly drier than where it was absent, although the difference was less pronounced when just the occupied fens were compared.

Table 2. Environmental variables in relation to the presence of *Dolichopus laticola*. The wetness score is the average, and all other variables are the number of samples with or without *D. laticola* in 2011.

	Management				Habitat features								Wetness	Total
	new cut	old cut	neglected	grazed	ditch	pond, swamp	fen	reed	sedge	grass	track	scrub, carr	wet score	
All fens														
laticola present	6	8	6	2	6	0	14	2	0	3	4	2	1.97	17*
laticola absent	34	31	37	22	23	18	88	16	5	21	32	14	2.40	107
% with *laticola*	15	21	14	8	21	0	14	11	0	13	11	13		14
Fens where *laticola* was found														
laticola absent	11	12	15	6	8	8	29	5	1	6	11	6	2.21	36
% with *laticola*	35	40	29	25	43	0	33	29	0	33	27	25		32

* Some variables were scored for more than one factor, e.g. both new and old cut could have been included in one sample, so the totals for each variable often exceed the total number of samples in the last column.

Table 3. Management variables for 2010 data for six fens, equivalent to the first columns in Table 2.

	new cut	old cut	neglected	grazed	Total
laticola present	1	27	2	24	84
laticola absent	12	31	7	24	99
% with *laticola*	8	47	22	50	46

Relationship with botanical quality

The imprecision in the conclusions about what factors influence the occurrence of the two *Dolichopus* species may be partly caused by not taking account of the overall habitat quality at a site scale rather than at a sample scale. One measure of quality can be found in the conservation value of the vegetation. An index of the botanical value is the Rarity Weighted Principal Fen Species Score (RWPFSS) of Wheeler (1988). The following extract is taken from Harding *et al*. (2010). "A Principal Fen Species is one which is closely associated with fen vegetation. Although not all are restricted to fens (many are), all are largely dependent on fens for their conservation. It is a similar concept to ancient woodland indicators. A score is derived for each sample based on the number of principle fen species it includes. A weighting is applied to rare species, this weighting being derived by Wheeler from the frequency of occurrence of each species recorded in his fen data set. The higher the score, the more important the sample is for botanical conservation." The RWPFSS is only one measure of the conservation value of a fen.

Harding *et al*. (2010) undertook an extensive survey of Broadland fen between 2005 and 2009, and for RWPFSS. They divided the RWPFSS into five classes, and presented their results as maps with each class represented by different coloured points. Within each area that had been surveyed recently for Diptera, the numbers of each RWPFSS class were counted from the maps. The entomological surveys were those undertaken by the author in the present *Dolichopus* project in 2010 – 2011 and those undertaken for the Broads Authority in 2007-2009 and for the RSPB at Sutton Fen in 2007 (Drake, 2008; Lott *et al*., 2009, 2010). Entomological sampling was limited on many of the fens, so the area within which RWPFSS scores were counted was restricted to compartments around the entomological survey points, rather than the whole area of a fen; so, for example, scores were counted in only about half the area of Catfield Fen. There was probably some under-counting of points since they sometimes overlapped and could not always be differentiated. Appendix 2 gives the counts for each area.

Dolichopus records were expressed as the proportion of total samples taken on each fen, and the botanical value was treated in three ways. Firstly an average score was calculated as

(number of samples in each class) x (class value) / total samples

The classes were 0-2, 2.01-4, 4.01-6, 6.01-8, >8, and the class value was the average of the scores in the raw dataset. These were close to the median values:

RWPFSS classes	Mean of raw scores
0 - 2	0.98
2.01 - 4	2.90
4.01 - 6	4.79
6.01-8	6.72
8.01-12	9.23

The botanical value was also expressed as the proportion of samples in different RWPFSS classes in an area of fen. The classes used were the proportion of the poorest samples (RWPFSS less than 2), the proportion of better samples (RWPFSS 4 or more) and of the best classes (RWPFSS 6 or more). Few fens had more than a handful of scores greater than 6 so the last group highlighted areas of exceptional botanical value.

There was no relationship with the average RWPFSS score for either *D. laticola* or *D. nigripes* (Figure 2). A lack of correlation was expected for *D. nigripes* since it was absent from most of the Ant valley fens that were of highest botanical value.

When the more widespread *D. laticola* records were plotted against the RWPFSS value for fens at either extreme of the spectrum, it could be seen that poor fens (with high proportion of the poorest botanical class) rarely supported any *D. laticola* (Figure 3, left-hand graph). The single exception was Reedham Fen, and this was notable since this was the only site where *D. nigripes* was found in good numbers in the Ant valley. Conversely, fens that included a high proportion of the best two classes were more likely to support *D. laticola* (Figure 3, right-hand graph). The four fens with outstanding flora where *D. laticola* occurred were Broad Fen, Sutton Fen, Catfield Great Fen and Burgh Common; the three botanically outstanding sites where it was not found were Smallbugh Fen, Little Reedham Fen and Upton Fen. The intermediate condition, represented by areas with a high proportion of the three best classes,

did not reveal any useful pattern: *D. laticola* was as likely to be present as absent across fens with fairly high botanical value, and similarly present or absent from fens of relatively low botanical value (Figure 3, centre). So it appeared that only the extremes of botanically poor or excellent provided an indication of whether *D. laticola* would be present.

Figure 2. Proportion of samples with *Dolichopus laticola* or *D. nigripes* plotted against the average Rarity Weighted Principal Fen Species Score for each fen.

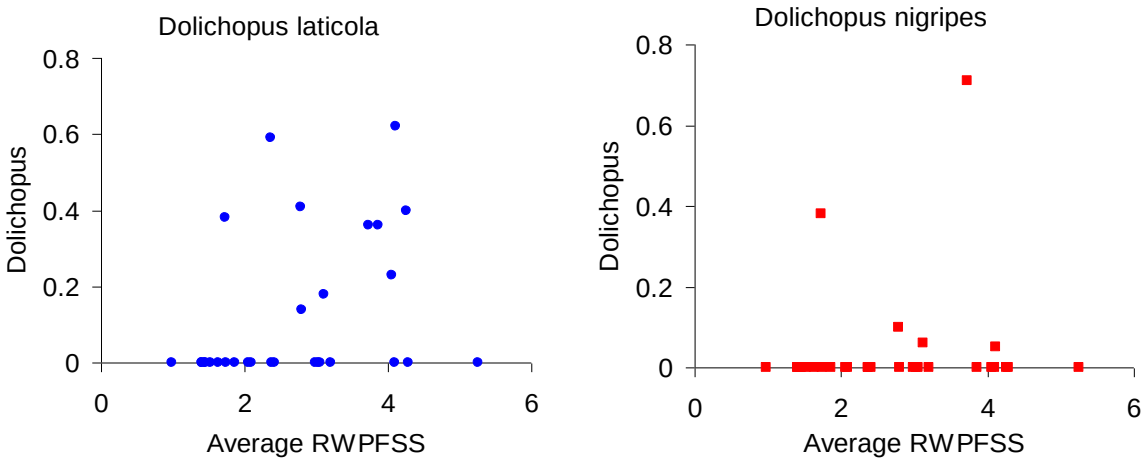
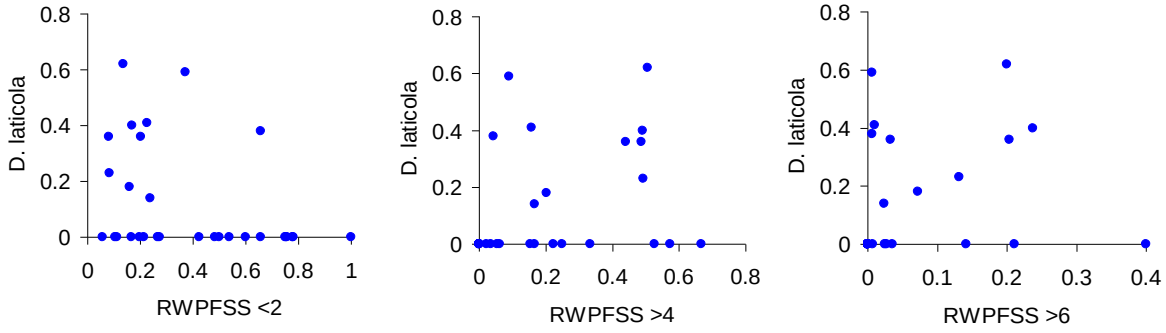


Figure 3. Proportion of samples with *Dolichopus laticola* plotted against the proportion of samples in different classes of Rarity Weighted Principal Fen Species Score for each fen.



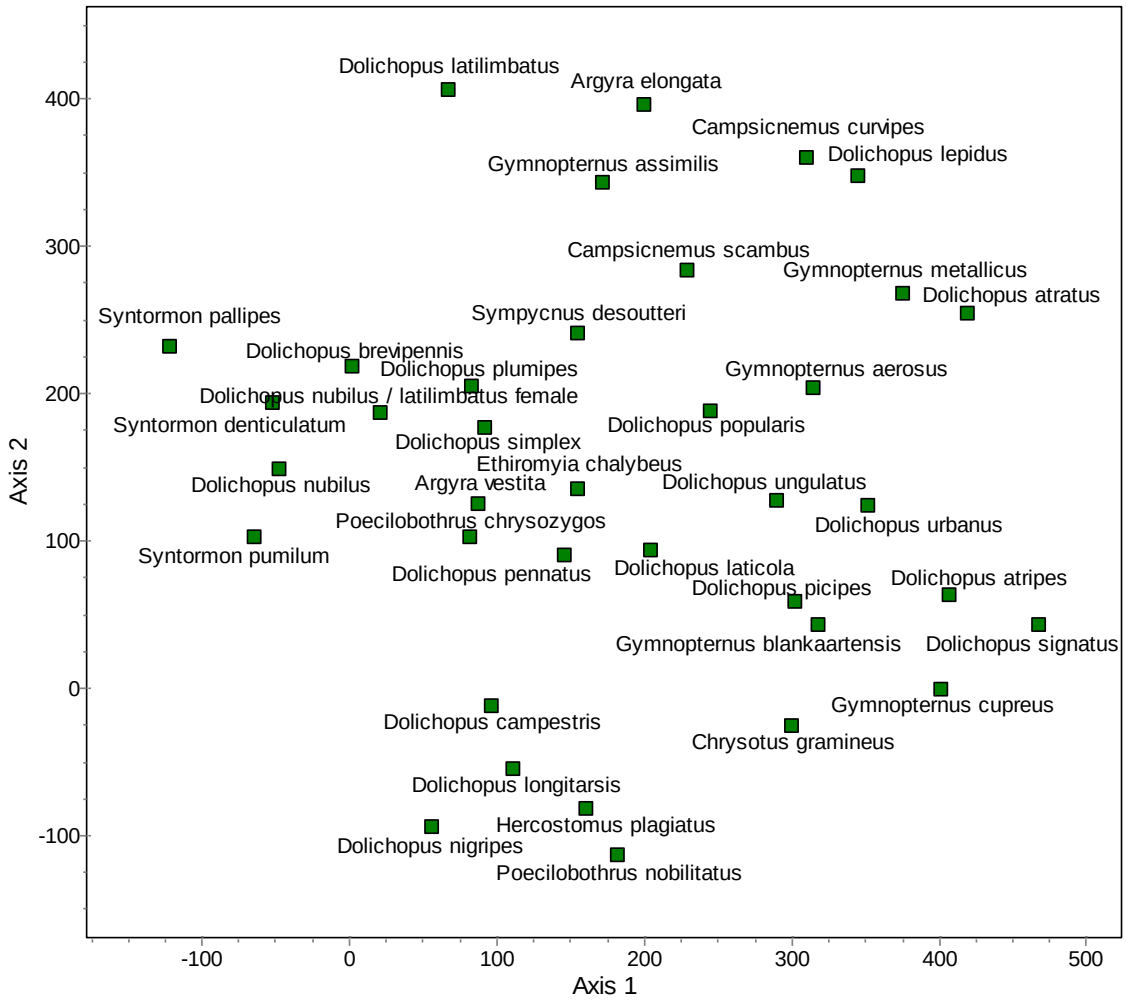
Ordination

Thirty-six species of dolichopodids present in at least five samples were ordinated using correspondence analysis (DECORANA). The small *Teuchophorus spinigerellus* was excluded as it and other small species were probably overlooked in the sweep-net. Females of *Dolichopus nubilus* and *D. latilimbatus* were not differentiated and were included as a separate taxon, although males of both species were often recorded in the same samples. Samples with fewer than five species were removed, leaving 94 samples.

The length of the gradient of the first axis was 3.04, which was shorter than recommended for DCA analysis, but this was considered a small source of error for the present purposes. The eigenvalue for the first axis was 0.387, which represented a large proportion of the variance in the data.

Dolichopus laticola was close to the centre of the ordination plot, which could suggest that it belonged to a relatively unspecialised group of species, but it was also part of a group of fen-associated species in the lower half of the plot (Figure 4). These were *D. nigripes*, *Gymnopternus blankaartensis*, *Hercostomus plagiatu),* and mire species with wider tolerance to pH, such *D. atripes*, *D. picipes* and *D. campestris*. Other fen-associated species were more widely scattered, for example, *Argyra vestita* close to the centre, and *A. elongata* and *G. assimilis* near the top. Generalist species of wet habitats, such as *D. simplex, D. plumipes*, *Campsicnemus scambus* and *Sympycnus desoutteri*, tended to fall in the upper half of the plot, whereas very common species with wide ecological preferences, such as *Poecilobothrus nobilitatus* and *Chrysotus gramineus*, were in the bottom half. The axes probably reflected trends from an assemblage associated with more nutrient-rich or mineral wetlands at the top left to mires on the bottom, although with considerable 'confusion' introduced by the scattered position of some species with known specialist requirements.

Figure 4. DECORANA Ordination plot of axes 1 and 2 for the more frequently occurring dolichopodids.



Effect of weather on catches

Both BAP *Dolichopus* were scarcer in 2011 than in 2010 when *D. laticola* was the 5th most frequent dolichopodid (18th in 2011) and the second most frequent *Dolichopus* (9th in 2011). The occurrence of *D. nigripes* was even sparser by comparison with 2010 samples. Much of this difference could be explained by having targeted sites in the 2010 survey where the species were known to have occurred in recent years, whereas the aim of the present survey was to establish their occurrence in a wider range of fens. However, spring and early summer of 2011 were exceptionally dry, and continued a trend from 2007 for increasingly dry springs. Despite heavy rain falling during the 2011 survey, the impression was that catches were lower than in previous years, especially the apparent absence of small species of many families of flies. Lower returns for the two BAP *Dolichopus* and other species could therefore have been partly due to the unusual weather pattern. To check whether this was true, the mean and maximum number of species and individuals of dolichopodids were calculated for each fen sampled in 2010 and 2011. The same method was used in both years, although in 2010 the sample was confined to a small patch of apparently homogenous habitat whereas in 2011 the distance covered was larger and sometimes included a variety of habitat features.

Table 4. Mean and maximum number of species and individuals of dolichopodids per site in 2010 and 2011.

Year	Site	Species		Individuals	
		mean	maximum	mean	maximum
2010	Barton Fen	6.5	14	29	113
	Catfield Great Fen	6.4	14	21	105
	Ebb & Flow	9.2	17	31	80
	Horning Marsh Farm	6.7	17	28	151
	Sutton Fen	7.5	16	38	186
	Woodbastwick Fen	8.3	16	42	205
2011	Alderfen Broad	5.5	8	10	14
	Broad Fen	11.3	23	51	206
	Burgh Common	11.5	18	53	135
	East Ruston	4.3	7	21	33
	Hickling Broad	8.0	14	26	51
	Hulver Ground	10.0	15	34	55
	Martham Broad	5.0	7	11	19
	Ormesby Broad	7.9	12	22	60
	Reedham Marshes	9.5	14	31	85
	Smallburgh Fen	8.0	14	27	103
	Stanley Carrs	6.7	9	12	16
	Strumpshaw Fen	3.8	5	8	13
	Surlingham Church	5.0	8	13	24
	Surlingham Marsh	7.2	9	19	27
	Sutton Fen	9.3	12	23	30
	Upton Fen	5.6	10	16	30

There was no pronounced difference between the catches in the two years. The total number of species of dolichopodids was almost identical (70 species in 2010, 68 in 2011), and numbers of *Dolichopus* itself, which were less likely to have been over-looked than small species, was the same – 21 species, with small differences in species composition (Table 4). There were marked site-to-site differences in mean and maximum numbers of dolichopodids, some of which could be explained by poor weather (for instance, at Stanley Carrs and Strumpshaw Fen) and others by the generally lower quality of the fenland habitat (for instance, at Alderfen Broad and East Ruston Allotments) but other low catches were less easy to explain at fens of apparently high quality (Upton Fen, Smallburgh Fen). However, species richness at the sites with most dolichopodids in 2011 (Broad Fen, Burgh Common) exceeded the values found at sites of equal quality in 2010. The difference in sampling method (area covered) may explain part of this difference.

Discussion

Recent surveys now allow a fairly detailed distribution to be presented for both *Dolichopus* species. Records of *D. laticola* and *D. nigripes* were obtained from surveys undertaken by the author from 2007, and from the NCC Fen Survey in 1988. These are shown together with the location of 300 samples where dolichopodids were recorded but neither BAP species was found (Figure 5). Records on the NBN Gateway are from Natural England's Invertebrate Site Register, and they include those of the NCC 1988 survey, Verrall (1904) for which the grid references will be estimates based on locality names, and three unattributable records between 1953 and 1979. The estimated grid references lie within the range established more recently. There may be more records but these have not been submitted to the national

recording scheme for Empididae and Dolichopodidae. No others are listed in the national review of Empidoidea (Falk & Crossley, 2005).

Dolichopus laticola is more widespread in Broadland than previously thought (Figure 5). Its distribution extends along the Bure and Ant valleys, with outlying eastern populations on the Ormesby tributary of the River Bure. The highest density is centred on the Ant valley fens. The discovery in 2010 of a large population at Walberswick Marshes in Suffolk suggests that the species may occur at other fens of high quality between here and the Bure catchment, but it was not found on the Yare in recent surveys. There is relatively little old fen on the Waveney but perhaps more intensive survey in this valley may locate some small populations. Other intervening fens that would deserve attention are the Benacre NNR and Minsmere RSPB Reserve on the Suffolk coast.

In contrast, the distribution of *D. nigripes* remains small although not confined entirely to the Bure Marshes as previously thought. A thriving population was located at Reedham Marshes, and a single female recorded from Catfield Great Fen in 2010 suggested a sparse population along some of the River Ant fens. However, intensive surveys in 2007-2009 of Catfield Great Fen, Sutton Fen and Barton Fen revealed no *D. nigripes* so any populations here must have been tiny. It is not clear why this species does not occur on these exceptional fens north of Catfield, despite there being more-or-less continuous wetland habitat along the River Ant.

The oddly patchy distribution of both species suggested that barriers that appear trivial may hinder movement. Upton Fen is separated from the nearest record of *D. laticola* at Ranworth Marshes by about 1km of grazing marsh, and this may explain the apparent absence of the fly here. This grazing marsh may have been more intensively farmed and perhaps even converted to arable land in the past although the ditches now have a moderately high quality for aquatic invertebrates (Drake *et al*., 2010). At the north of the Ant valley, there is a slight barrier of a main road and the hamlet of Smallburgh separating the northern-most population at Broad Fen from the high-quality Smallburgh Fen. North of Broad Fen the quality of the fens deteriorates, markedly so at Mown Fen that was not investigated but is essentially derelict fen and carr, and East Ruston Allotments may be more acidic than the other areas and has a swampy rather than fenny aspect which perhaps provides unfavourable conditions for *D. laticola*. The possibly century-old population at Ormesby Broad may indicate that small, isolated populations of *D. laticola* can survive long periods.

It was not intended that the 2011 survey would yield useful information on the relationship of the BAP species with environmental features since this had been examined using 2010 data (Drake 2010, 2011). However, the few features that were scored did confirm that *D. laticola* preferred 'old cut' vegetation, and this corresponded with the results obtained in 2010 for a preference for vegetation with a high proportion of tall herbs among the reed and a high cover of leaf litter. It avoided sedge beds and carr, which again concurred with the results obtained in 2010. One difference between the two year's results was the preference for wetter ground soil in 2010 and for drier than average ground in 2011. However, the difficulty of assessing soil wetness in 2011 makes this an unreliable conclusion.

There are clearly factors operating on the distribution of these two flies that cannot be simply explained in terms of management or hydrology. Good populations of *D. laticola* were present at some fens that are widely recognised as having exceptional value, for example Sutton Fen and Catfield Great Fen, but the flies were apparently absent from other fens with

outstanding vegetation, for example Smallburgh and Upton. However, *D. laticola* showed a weak association with fens of high botanical value, and an absence at fens of particularly poor value. The association was not well substantiated but may be useful for targeting further areas for survey to fill in the gaps in the local distribution of *D. laticola* in Norfolk where maps of botanical interest are now available for almost the entire fen resource in Broadland (Harding *et al*., 2010).

The relationship between *D. laticola* and sites of high botanical value appeared to have a counterpart in entomological value. It was notable that *D. laticola* was found only at sites with high numbers of dolichopodid species. This presumably reflected some aspect of quality that was also beneficial for *D. laticola*. Related to this association of *D. laticola* with the more dolichopodid-rich fens was the association with other fenland species, revealed by DECORANA ordination. Plots using 2010 and 2011 data produced similarities in assemblages. Both *D. laticola* and *D. nigripes* appeared to belong to an assemblage that included other dolichopodids that are known to be specialists on fens, such as *Gymnopternus assimilis*, *G. blankaartensis* and *Thrypticus smaragdinus* in 2010 and with *G. blankaartensis* and *Hercostomus plagiatus* in 2011. Although there was disparity between the two years' plots, the two BAP species were more closely related to this group than to the suite of species that are more often associated with mineral-rich wetlands such as seepages and water margins. Small sample size may be responsible for the inconclusive result.

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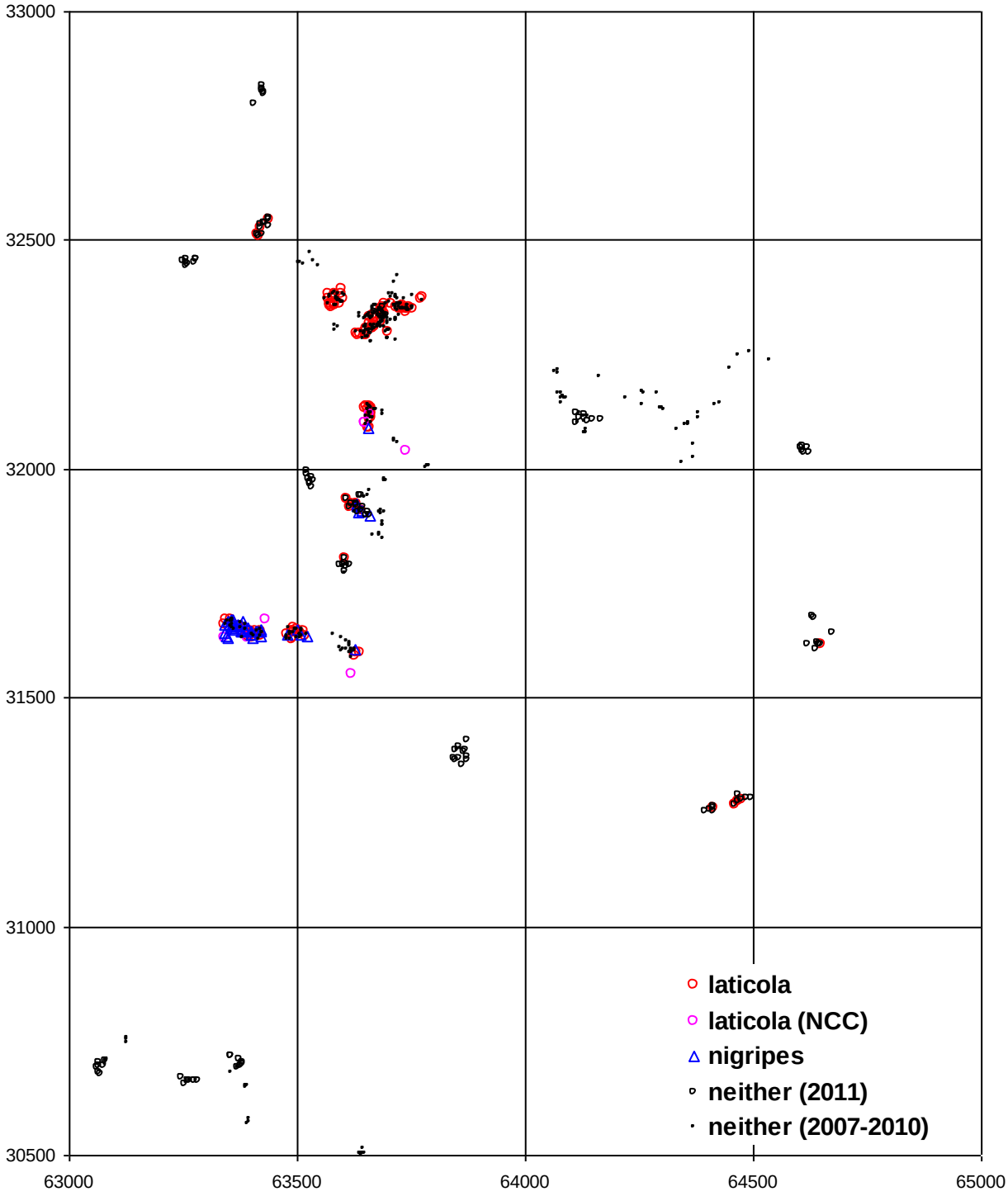
Figure 5. Distribution of *Dolichopus laticola* (red or pink circles) and *D. nigripes* (blue triangle) recorded between 1988 (NCC survey) and 2007-2011 (Drake), and all sites where neither species was recorded sampled by Drake between 2007 and 2011 (black dots and circles). Eastings and northings include the 100km square. Samples from Stanley Carrs on the Waveney (in the south) are not shown.



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Appendix 1. Environmental data and presence of *Dolichopus laticola* and *D. nigripes* in 2011.

Site	Sample	eastings	northings	Date	wetness	wet score	new cut	old cut	neglected	grazed	ditch	pond	fen	reed	sedge	grass	track	scrub	laticola	nigripes
Alderfen	1	63533	31961	16-Jun-11	2	2	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Alderfen	2	63530	31970	16-Jun-11	2	2	1	0	1	0	1	0	1	0	0	0	1	0	0	0
Alderfen	3	63530	31967	20-Jun-11	2	2	0	0	1	0	0	0	1	0	0	0	0	1	0	0
Alderfen	4	63537	31975	20-Jun-11	2	2	0	0	1	0	0	0	1	0	0	0	1	1	0	0
Alderfen	5	63532	31981	20-Jun-11	2	2	0	0	1	0	0	0	1	0	0	0	0	1	0	0
Alderfen	6	63522	31990	20-Jun-11	1 4	2.5	1	0	0	0	1	0	1	0	0	0	1	0	0	0
Alderfen	7	63520	31996	20-Jun-11	1 4	2.5	1	0	0	0	1	0	1	0	0	0	1	0	0	0
Alderfen	8	63524	31977	20-Jun-11	1	1	0	0	1	0	0	0	1	0	0	1	0	1	0	0
Broad	1	63439	32550	22-Jun-11	2	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Broad	2	63440	32543	22-Jun-11	2	2	1	0	0	0	1	0	1	0	0	0	0	0	1	0
Broad	3	63422	32535	22-Jun-11	2	2	0	1	1	0	0	0	1	1	0	0	0	0	0	0
Broad	4	63428	32539	22-Jun-11	2 3	2.5	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Broad	5	63440	32529	22-Jun-11	2 3	2.5	1	0	0	1	1	0	0	0	0	1	0	0	0	0
Broad	6	63432	32539	22-Jun-11	2 3	2.5	0	1	0	1	0	0	1	0	0	1	0	0	0	0
Broad	7	63421	32528	22-Jun-11	2	2	0	1	0	1	0	0	1	0	0	1	0	0	1	0
Broad	8	63423	32512	22-Jun-11	3	3	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Broad	9	63418	32507	22-Jun-11	3 4	3.5	0	0	1	0	0	0	1	0	0	0	0	0	1	0
Broad	10	63414	32512	22-Jun-11	3	3	1	0	0	0	0	0	1	0	0	0	0	1	1	0
Burgh	1	64413	31261	18-Jun-11	3	3	0	1	0	0	0	0	1	0	0	0	1	0	0	0
Burgh	2	64413	31250	18-Jun-11	2	2	0	0	1	0	0	1	1	0	0	0	1	0	0	0
Burgh	3	64405	31255	18-Jun-11	2	2	0	0	1	0	0	0	1	0	0	0	1	0	0	0
Burgh	4	64394	31252	18-Jun-11	2 3	2.5	0	0	1	0	0	0	1	0	0	0	1	0	0	0
Burgh	5	64466	31287	20-Jun-11	2	2	0	0	1	1	1	0	1	0	0	0	0	0	0	0
Burgh	6	64474	31277	20-Jun-11	2 3	2.5	0	0	1	1	0	0	1	0	0	0	0	0	1	0
Burgh	7	64487	31282	20-Jun-11	2 3	2.5	0	0	1	1	0	0	1	0	0	0	0	0	0	0
Burgh	8	64496	31282	20-Jun-11	2 3	2.5	0	0	1	1	0	0	1	0	0	0	0	0	0	0
Burgh	9	64466	31273	20-Jun-11	2	2	0	1	0	0	0	0	1	0	0	0	0	0	1	0
Burgh	10	64461	31266	20-Jun-11	2	2	0	1	0	0	0	0	1	0	0	0	0	0	1	0
Burgh	11	64413	31259	20-Jun-11	2	2	0	1	0	0	0	0	1	0	0	0	0	0	1	0
East Ruston	1	63405	32797	20-Jun-11	2	2	0	0	1	0	0	1	1	0	0	1	0	0	0	0
East Ruston	2	63426	32819	20-Jun-11	3	3	0	0	1	1	0	1	1	0	0	0	0	0	0	0
East Ruston	3	63423	32827	20-Jun-11	3 4	3.5	0	0	1	0	0	0	1	0	0	0	1	0	0	0
East Ruston	4	63424	32832	20-Jun-11	3 4	3.5	0	0	1	0	0	0	1	0	0	0	0	0	0	0
East Ruston	5	63423	32839	20-Jun-11	2	2	0	0	1	0	0	1	1	0	0	0	0	0	0	0
East Ruston	6	63428	32822	20-Jun-11	2 3	2.5	0	0	1	0	0	0	1	0	0	0	0	1	0	0
Hickling	1	64113	32102	17-Jun-11	2	2	1	1	0	0	0	0	0	1	0	0	1	0	0	0
Hickling	2	64138	32103	17-Jun-11	3	3	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Hickling	3	64150	32107	17-Jun-11	3 4	3.5	0	1	0	0	0	0	1	0	0	0	1	0	0	0
Hickling	4	64165	32108	17-Jun-11	2 3	2.5	0	1	0	0	0	0	1	0	0	1	1	0	0	0
Hickling	5	64131	32113	17-Jun-11	2 3	2.5	0	1	1	0	0	0	1	0	0	0	1	0	0	0
Hickling	6	64132	32120	17-Jun-11	2	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Hickling	7	64121	32112	17-Jun-11	2 3	2.5	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Hickling	8	64111	32121	17-Jun-11	1 2 4	2.33	0	0	0	1	1	0	0	1	0	1	0	0	0	0
Hulver	1	63605	31774	23-Jun-11	2	2	0	1	0	0	0	0	1	0	0	0	0	0	0	0

Site	Sample	eastings	northings	Date	wetness	wet score	new cut	old cut	neglected	grazed	ditch	pond	fen	reed	sedge	grass	track	scrub	laticola	nigripes
Hulver	2	63607	31786	23-Jun-11	2 3	2.5	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Hulver	3	63616	31789	23-Jun-11	2 3	2.5	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Hulver	4	63601	31788	23-Jun-11	2	2	1	0	0	0	0	0	1	0	1	0	0	0	0	0
Hulver	5	63594	31789	23-Jun-11	2	2	1	0	0	0	0	0	1	0	0	0	0	1	0	0
Hulver	6	63605	31794	23-Jun-11	2	2	0	1	0	0	0	1	1	0	0	1	0	0	0	0
Hulver	7	63606	31803	23-Jun-11	2	2	0	0	1	0	0	0	1	0	0	0	0	0	1	0
Martham	1	64622	32037	17-Jun-11	2	2	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Martham	2	64619	32046	17-Jun-11	3 4	3.5	1	1	0	0	0	0	0	1	1	0	0	0	0	0
Martham	3	64609	32039	17-Jun-11	3	3	1	0	0	0	0	0	1	1	1	0	0	0	0	0
Martham	4	64606	32046	17-Jun-11	2 3	2.5	1	0	0	0	0	0	1	1	1	0	0	0	0	0
Martham	5	64607	32050	17-Jun-11	3	3	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Martham	6	64611	32037	17-Jun-11	3	3	1	0	1	0	0	0	0	1	1	0	0	0	0	0
Ormesby	1	64650	31616	21-Jun-11	1	1	0	0	1	0	1	0	0	0	0	1	0	0	1	0
Ormesby	2	64640	31621	21-Jun-11	2 3	2.5	0	0	1	0	0	1	1	0	0	0	0	1	0	0
Ormesby	3	64621	31617	21-Jun-11	2 3	2.5	0	0	1	0	0	0	0	0	0	1	0	1	0	0
Ormesby	4	64639	31605	21-Jun-11	2	2	0	1	1	0	0	0	1	0	0	1	0	0	0	0
Ormesby	5	64646	31618	21-Jun-11	2 3	2.5	0	0	1	0	1	1	1	0	0	0	0	1	0	0
Ormesby	6	64674	31640	21-Jun-11	3	3	0	0	1	0	0	1	0	1	0	0	0	1	0	0
Ormesby	7	64629	31677	21-Jun-11	2	2	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Ormesby	8	64635	31675	21-Jun-11	1	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0
Reedham	1	63615	31915	16-Jun-11	1	1	0	1	0	0	1	0	0	1	0	0	1	0	1	0
Reedham	2	63620	31924	16-Jun-11	1 2	1.5	0	1	0	0	1	0	0	1	0	0	1	0	1	0
Reedham	3	63634	31906	16-Jun-11	1 2	1.5	0	1	0	0	1	0	1	1	0	0	1	0	0	1
Reedham	4	63651	31898	16-Jun-11	1	1	0	1	0	0	1	0	0	1	0	0	1	0	0	0
Reedham	5	63659	31899	16-Jun-11	2 3 4	3	0	1	0	0	0	1	1	0	0	0	0	0	0	1
Reedham	6	63656	31906	16-Jun-11	2 3	2.5	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Reedham	7	63643	31910	16-Jun-11	2	2	1	0	1	0	0	0	1	0	0	0	0	1	1	1
Reedham	8	63646	31915	16-Jun-11	2 3 4	3	1	0	0	0	0	1	1	0	0	0	0	0	0	0
Reedham	9	63632	31922	16-Jun-11	2	2	1	1	0	0	0	0	1	0	0	0	0	0	1	1
Reedham	10	63630	31920	16-Jun-11	2	2	1	0	0	0	1	0	1	0	0	0	1	0	0	1
Reedham	11	63610	31933	16-Jun-11	2	2	1	0	1	0	1	0	1	0	0	0	1	0	1	0
Reedham	12	63639	31942	16-Jun-11	1	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0
Reedham	13	63641	31942	16-Jun-11	2	2	1	1	0	0	1	0	1	0	0	0	1	0	0	0
Smallburgh	1	63259	32442	18-Jun-11	2	2	0	1	0	0	0	0	1	0	0	0	1	0	0	0
Smallburgh	2	63262	32448	18-Jun-11	3 4	3.5	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Smallburgh	3	63275	32452	18-Jun-11	3	3	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Smallburgh	4	63280	32459	18-Jun-11	3 4	3.5	0	1	0	0	1	0	1	0	0	0	1	1	0	0
Smallburgh	5	63257	32451	20-Jun-11	3 4	3.5	1	0	0	0	0	0	1	0	0	0	1	0	0	0
Smallburgh	6	63251	32454	20-Jun-11	3 4	3.5	0	1	0	0	0	0	1	0	0	0	0	1	0	0
Smallburgh	7	63259	32457	20-Jun-11	3 4	3.5	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Smallburgh	8	63271	32457	20-Jun-11	3	3	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Smallburgh	9	63278	32457	20-Jun-11	3	3	0	1	0	0	0	0	1	0	0	0	0	1	0	0
Smallburgh	10	63268	32453	20-Jun-11	3	3	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Stanley	1	64367	29304	22-Jun-11	2 3	2.5	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Stanley	2	64373	29309	22-Jun-11	2	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Stanley	3	64356	29310	22-Jun-11	2	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0
Strumpshaw	1	63381	30704	19-Jun-11	2	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Strumpshaw	2	63381	30698	19-Jun-11	3	3	0	1	0	0	0	0	1	0	0	0	0	0	0	0
Strumpshaw	3	63378	30694	19-Jun-11	2	2	0	0	1	0	0	0	1	0	0	0	0	0	0	0

Site	Sample	eastings	northings	Date	wetness	wet score	new cut	old cut	neglected	grazed	ditch	pond	fen	reed	sedge	grass	track	scrub	laticola	nigripes
Strumpshaw	4	63368	30690	19-Jun-11	2	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Strumpshaw	5	63372	30710	19-Jun-11	1	1	0	0	1	0	1	0	1	0	0	0	1	0	0	0
Strumpshaw	6	63374	30714	19-Jun-11	3	3	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Strumpshaw	7	63356	30715	19-Jun-11	3	3	0	1	0	0	0	0	0	1	0	0	0	0	0	0
Surlingham Church	1	63070	30677	19-Jun-11	1	1	0	0	0	1	1	1	0	0	0	1	0	0	0	0
Surlingham Church	2	63064	30680	19-Jun-11	2	2	0	0	0	1	1	1	0	0	0	1	0	0	0	0
Surlingham Church	3	63062	30692	19-Jun-11	2	2	0	0	0	1	0	1	0	0	0	1	0	0	0	0
Surlingham Church	4	63066	30696	19-Jun-11	2	2	0	0	0	1	0	1	1	0	0	1	0	0	0	0
Surlingham Church	5	63065	30702	19-Jun-11	2 3	2.5	0	0	0	1	0	1	1	0	0	0	0	0	0	0
Surlingham Church	6	63075	30696	19-Jun-11	2 3	2.5	0	0	0	1	0	0	1	0	0	0	0	0	0	0
Surlingham Church	7	63078	30707	19-Jun-11	2 3	2.5	0	0	0	1	1	0	1	0	0	0	0	0	0	0
Surlingham Marsh	1	63248	30668	23-Jun-11	2 3	2.5	0	0	0	1	0	0	1	0	0	1	0	0	0	0
Surlingham Marsh	2	63266	30664	23-Jun-11	2	2	0	0	0	1	0	0	1	0	0	1	0	0	0	0
Surlingham Marsh	3	63253	30655	23-Jun-11	2	2	0	0	0	1	0	0	1	0	0	1	0	0	0	0
Surlingham Marsh	4	63274	30662	23-Jun-11	2	2	0	0	0	1	0	0	1	0	0	1	0	0	0	0
Surlingham Marsh	5	63284	30662	23-Jun-11	2	2	0	0	0	1	0	0	1	0	0	1	0	0	0	0
Sutton	1	63696	32335	21-Jun-11	2	2	0	1	0	0	0	0	1	0	0	0	1	0	0	0
Sutton	2	63686	32343	21-Jun-11	1	1	0	1	0	0	1	0	1	0	0	1	1	0	1	0
Sutton	3	63688	32352	21-Jun-11	2	2	1	0	0	0	0	0	1	0	0	0	0	0	1	0
Sutton	4	63671	32341	21-Jun-11	2	2	1	0	0	0	0	0	1	0	0	0	1	0	0	0
Upton	1	63846	31367	18-Jun-11	2 3 4	3	1	0	0	0	0	0	1	0	0	0	1	0	0	0
Upton	2	63849	31364	18-Jun-11	2 4	3	1	0	0	0	1	0	1	0	0	0	0	0	0	0
Upton	3	63855	31366	18-Jun-11	2	2	1	0	1	0	0	0	1	0	0	0	0	0	0	0
Upton	4	63863	31352	18-Jun-11	2 3	2.5	0	1	1	0	1	0	1	0	0	0	1	0	0	0
Upton	5	63872	31363	18-Jun-11	3 4	3.5	0	1	0	0	1	1	1	0	0	0	0	0	0	0
Upton	6	63847	31384	19-Jun-11	2	2	1	0	0	0	0	0	1	0	0	0	1	0	0	0
Upton	7	63856	31394	19-Jun-11	2	2	0	1	0	0	1	1	1	0	0	1	1	0	0	0
Upton	8	63872	31406	19-Jun-11	2	2	0	0	1	0	0	0	1	0	0	0	1	0	0	0
Upton	9	63870	31384	19-Jun-11	2	2	1	0	0	0	1	0	1	0	0	0	1	0	0	0
Upton	10	63872	31370	19-Jun-11	3	3	0	1	0	0	1	0	1	0	0	0	1	0	0	0
Upton	11	63865	31383	19-Jun-11	3	3	1	1	0	0	0	0	1	0	0	1	1	0	0	0

Appendix 2. Counts of botanical RWPFSS classes and records of *Dolichopus* in each area of fen.

ELP map title	Fen area	Counts of each RWPFSS class						Proportion of each class			Total records of *Dolichopus*				No. of samples
		0-2	2-4	4-6	6-8	>8	total	average score	>6	>4	<2	Number		Proportion		
												laticola	*nigripes*	*laticola*	*nigripes*	
Upper Yare	Strumpshaw	47	47	17	0	0	111	2.375	0.000	0.153	0.423	0	0	0	0	7
	Rockland	7	6	0	0	0	13	1.865	0.000	0.000	0.538	0	0	0	0	6
	Surlingham Marsh	12	31	1	0	0	44	2.417	0.000	0.023	0.273	0	0	0	0	3
	Surlingham Broad	5	0	0	0	0	5	0.983	0.000	0.000	1.000	0	0	0	0	3
	Surlingham Church	4	26	5	1	0	36	3.052	0.028	0.167	0.111	0	0	0	0	3
	Hassingham	21	11	0	0	0	32	1.640	0.000	0.000	0.656	0	0	0	0	6
Upper Bure	Woodbastwick	10	53	56	4	0	123	3.725	0.033	0.488	0.081	16	32	0.36	0.71	45
	Horning Marsh Farm	23	63	15	1	0	102	2.780	0.010	0.157	0.225	12	3	0.41	0.1	29
	Ebb & Flow	11	44	9	5	0	69	3.114	0.072	0.203	0.159	3	1	0.18	0.06	17
	Hulver Ground	10	25	6	1	0	42	2.801	0.024	0.167	0.238	1	0	0.14	0	7
Lower Bure	Upton	9	57	67	13	9	155	4.290	0.142	0.574	0.058	0	0	0	0	11
	Burgh Common	12	21	14	9	3	59	3.860	0.203	0.441	0.203	4	0	0.36	0	11
Thurne	Martham	18	6	0	0	0	24	1.461	0.000	0.000	0.750	0	0	0	0	6
	Horsey Mere	83	23	4	0	0	110	1.521	0.000	0.036	0.755	0	0	0	0	4
	Hickling (saline survey)	64	18	0	0	0	82	1.403	0.000	0.000	0.780	0	0	0	0	6
	Skoyles	28	8	0	0	0	36	1.408	0.000	0.000	0.778	0	0	0	0	7
	Lings Mill area	70	67	7	1	0	145	2.090	0.007	0.055	0.483	0	0	0	0	8
	Mrs Myles	6	4	0	0	0	10	1.748	0.000	0.000	0.600	0	0	0	0	3
Ant	Little Reedham	2	7	6	4	0	19	4.096	0.211	0.526	0.105	0	0	0	0	3
	Reedham	107	49	6	1	0	163	1.733	0.006	0.043	0.656	5	5	0.38	0.38	13
	Snipe	8	7	1	0	0	16	2.057	0.000	0.063	0.500	0	0	0	0	6
	Sharp	6	15	6	1	0	28	3.027	0.036	0.250	0.214	0	0	0	0	3
	Catfield	16	47	16	2	0	81	2.985	0.025	0.222	0.198	0	0	0	0	18
	Catfield Great	13	34	29	14	5	95	4.108	0.200	0.505	0.137	13	1	0.62	0.05	21
	Sutton	22	113	96	21	14	266	4.055	0.132	0.492	0.083	44	0	0.23	0	c. 190
	Barton	62	90	14	1	0	167	2.367	0.006	0.090	0.371	19	0	0.59	0	32
	Common	2	6	4	0	0	12	3.207	0.000	0.333	0.167	0	0	0	0	3
	Smallburgh	4	1	4	1	5	15	5.255	0.400	0.667	0.267	0	0	0	0	9
	Broad	10	20	15	7	7	59	4.257	0.237	0.492	0.169	4	0	0.4	0	10
	East Ruston	25	8	0	0	0	33	1.446	0.000	0.000	0.758	0	0	0	0	6