Interim report on the BAP flies *Dolichopus laticola* and *D. nigripes* (Diptera, Dolichopodidae) in theBroadland fens of Norfolk

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Summary

Dolichopodidae were sampled at six fens in Norfolk's Broadland using timed sweep-net samples. *Dolichopus laticola* was found at all six fens and was one of the more frequent dolichopodids. *Dolichopus nigripes* was found at three fens but was frequent only at Woodbastwick Fen. *Dolichopus laticola* showed a preference for reed-dominated fen vegetation and was also frequent at the short open vegetation of paths and tracks. *Dolichopus nigripes* showed a preference for the short open vegetation of paths and apparent avoidance of reed-dominated vegetation. Both species avoided sedge, carr and old tall scrub. Both species were associated with other dolichopodids that are known to be fenland specialist.

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Introduction

Dolichopodids are a family of small to medium-sized slender flies, often dark metallic green and sometimes with modified legs in the males. The are about 285 British species, and the *Dolichopus* is the largest genus with 54 species (Chandler, 1998). They are predators as larvae and adults (except for one genus) but very little is known about the taxonomy or behaviour of the larvae. Most are associated with wetlands. They are moderately popular with amateur dipterists and a long-established recording scheme is in the process of being rejuvenated. The rarity status if the family was revised in the last decade (Falk & Crossley, 2005).

In 2007 a revised list of species was issued for inclusion in the UK Biodiversity Action Plan (www.jncc.gov.uk, accessed October 2010). It included two Dolichopodidae flies, *Dolichopus laticola* Verrall, 1904 and *D. nigripes* Fallén, 1823. They are among the few British Dolichopodidae with Endangered status (Falk & Crossley, 2005) and share the same habitat of high quality fenland in Norfolk. They are moderately large dolichopodids and are easy to identify so are unlikely to have been overlooked in recent years when Diptera recording has been intense. They therefore made good candidates for inclusion in the BAP, where they were listed under the criterion that allows for likely strong decline in the UK.

The plan for *D. laticola* states:

> It is estimated that the population will decline by at least 25 % during the next 25 years if the threats to the habitat have not been eliminated during this time. A decline is estimated due to the restricted distribution in the Norfolk broads where lack of management and woodland encroachment has decreased the available habitat for this species in recent years. The species has a restricted distribution, being known only from England, Denmark and Belgium, therefore there is likely to be a high percentage of the world population in the UK.

The plan for *D. nigripes* states:

> The species occurs at only a single site in the UK and is under a demonstrable threat. Apparently restricted in the UK to one relatively small fenland area where it occurs in small numbers (in the Bure Valley).This species is likely to become extinct in the next 25 years if the management of the site changes.

Dolichopus laticola was, until 2010, known only from the fens of the Norfolk Broads (Falk & Crossley, 2005). Here it was known from several fens in the Ant and Bure catchments, including Ormsby Broad where Verrall (1904) first caught and described it new to science. The JNCC BAP page refers unattributed and undated records from Kent, Surrey and Sussex although the origin of the statement cannot be traced and may be an error. However, it was found to be moderately frequent at Walberswick, a large reedbed in Suffolk, in summer 2010 (Peter Vincent, pers. comm.).

Dolichopus nigripes has a more restricted distribution in Norfolk where it was known for some time only from the Bure Marshes NNR. However, it was added to the British list on the basis of a single male caught by Dale (presumably the father, J.C. Dale) on 2 August 1839, labelled from Glanvilles Wootton, Dorset (c. ST6708) which is the village where Dale lived, although the fly was presumably caught at one of the valley fens in this area. The species is not mentioned in C.W. Dale's *History of Glanville's Wootton* (Dale, 1851). This isolated and old record remains the only one outside Norfolk, but is likely to be correct as the specimen was seen and its identify verified by Verrall (1904) under its synonym *D. falleni* Loew. Both species were recorded in a project undertaken for the Broads Authority in which invertebrates were surveyed at many fenlands in Broadland.

The aim of the present project was to link the occurrence of the species to environmental variables in an attempt to understand the reason for their limited distribution.

Methods

Sampling

Samples were obtained using a standard 10 minute sweep-net sample which consisted of repeatedly sweeping vegetation for about 25 sweeps and inspecting the net. 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. Large dark *Dolichopus* were often noted flying rapidly out of the net away from the light so the net had to be entered carefully. Some *D. nigripes* or *D. laticola* may have been under-recorded in the first day or two before this unusual behaviour had been noticed.

The patch of sampled vegetation that was swept was usually about 30-40m in diameter when in the centre of a stand, or 50-80m length of ditch margin. It was noticeable that repeatedly sweeping the same patch of vegetation caught many fewer larger dolichopodids after the initial sweeps, and sweeping for 10 minutes in a small area caused too much disturbance so there was no point in reducing the patch size or sweeping for much longer than 10 minutes.

A suction sampler was tried out but was abandoned since almost no large species of flies were caught. The only reason for using it was to tackle 'difficult' vegetation such as dense old saw sedge *Cladium mariscus* but it was no better or worse than sweeping in such net-unfriendly vegetation. Support for this choice came from the results of the Fen Project (Lott *et al*., 2009) in which the number of samples containing any of the 25 species of *Dolichopus* taken by sweep-netting was nearly always greater than the number taken by vacuum sampling.

The sampling strategy had initially intended to be randomly positioned transects passing across many types of vegetation, along which samples would be taken at regular intervals. However, this was abandoned after trying it at Sutton Fen on the first day of fieldwork. It was impossible to walk far in these fens without encountering impenetrable vegetation (usually old reed *Phragmites australis* with bog myrtle *Myrica gale* or saw sedge), or ditches. The approach was therefore changed to sampling 'features' with distinct characteristics (Table 1). Within a discrete vegetation type, a sample was taken after walking a randomly selected number of paces in the direction of some conspicuous object, such as a bush or tree on the horizon, to mark the starting point. This was the nearest rapid approach that could be made to taking a random sample within each stratum (in the statistical sense). The samples

were therefore not strictly random but were probably indistinguishable from random, and this method had the advantage of being rapid, safe and workable in difficult terrain. Sometimes this failed such as when the only way through the fen was to follow the tracks made by red deer or vehicles. Some features, such as ponds, were sampled when they were found and clearly these were not selected in any random manner.

Environmental variables were measured at each sampling point (Table 2). These were based loosely on those used by Lott *et al*. (2009) in a project to investigate the relationship between invertebrate assemblages and fen management undertaken for the Broads Authority. Vegetation structure was scored using the DAFOR scale for each 'layer' in the sense used for Natural England's Common Standards Monitoring of invertebrates (Heaver *et al*., 2008). Some layers were subdivided. Soil wetness was scored on a subjective 1-4 scale. Tussocks were scored using DAFOR but were rarely found to be a measurable feature. The approximate time since a ditch had been cleaned was estimated from its successional stage as early, mid or late, and its fringing vegetation was scored as short, rush-dominated or reed-dominated. Management of fen vegetation was measured as cut recently, a while ago, neglected or grazed. A very brief description was given. A grid reference was taken using Garmin GPS, and the time of the sample noted. Only a few photographs were taken as it is difficult to usefully show the key features of fen vegetation – one bit of fen vegetation looks much like the next.

Sampling took place on 10 consecutive days 20-29 June 2010 when the weather was almost constantly fine. There was rare drizzle and showers on a few days. The period was chosen as both BAP *Dolichopus* had been recorded between these dates in 2007-2009 during the Broads Authority's fenland invertebrates project (Lott *et al*., 2009).

Sites

Six fens were visited (Table 1). These were where either of the BAP *Dolichopus* had been recorded in 2007-2009. Three are at the north end of the Ant valley (Barton, Sutton, Catfield Great Fen) and three on the Bure (Woodbastwick, Horning Marsh Farm, Ebb & Flow).

Identification

Dolichopodids were identified using the standard British work (Assis-Fonseca, 1978). Two European works (Parent, 1938; Stackelberg, 1930, 1933) were referred to for other species of *Dolichopus* that could be confused with either BAP species.

These identification guides divide *Dolichopus* into groups based on the colour (dark or pale) of the femora, which has phylogenetic significance (Bernasconi *et al*., 2007). There are 17 species of dark-legged *Dolichopus* in Britain, including the two BAP species, and of these nine have been recorded by the author in Norfolk fens between 2007-2010. Males of some species may be separated in the field, ofttten with some difficulty, but females of most species are not separable without a microscope. It was therefore necessary to collect all specimens.

Analysis

Ordination was run using detrended correspondence analysis (DECORANA) in the version by Pisces Conservation (2007).

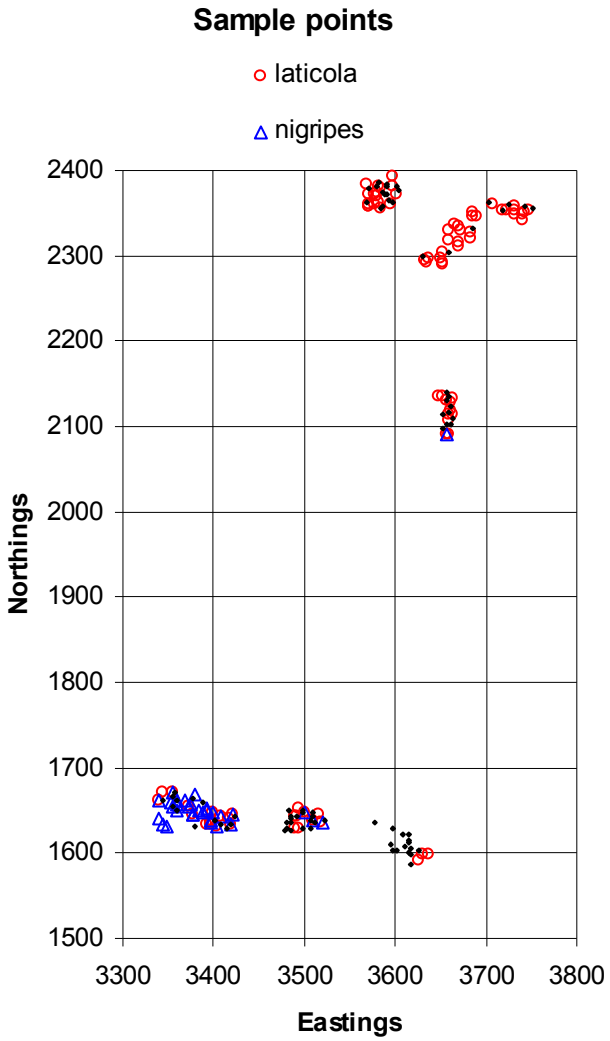
Table 1. Sites visited and number of samples taken of each main feature.

Feature	Site						Total
	Barton	Catfield	Ebb & Flow	Horning	Sutton	Woodbastwick	
Ditch	6	4	4	9	7	10	40
Grass/rush, ± grazing	1	1	1			9	12
Pond, swamp				1	3	1	5
Reed	5	5	10	12	22	7	61
Sedge	6	7		2	2	2	19
Track/path	13	1		2		11	27
Wood (scrub, carr)	1	3	2	3	5	5	19
Total	**32**	**21**	**17**	**29**	**39**	**45**	**183**

Table 2. Environmental variables recorded.

Feature	Measure	Variables	Notes
Vegetation structure (based on natural England's CSM for invertebrates)	DAFOR	open water	
		peat, litter or moss	scored separately
		short sward	
		tall grass / herb	
		reed, sedge or mixed	scored separately; sedge = *Cladium*
		new scrub/bushes	included larger *Myrica* bushes
		old scrub, carr	
Wetness	1 – dry		
	2 - soft		
	3 - saturated		
	4 - water		
Tussocks	DAFOR		rarely measured
Ditch 'age'	1 - early		
	2 - mid		
	3 - late		
Ditch edge vegetation	1 - short		not used in analysis
	2 - rush		
	3 - reed		
Management	1 - cut		analysed as four nominal variables
	2 - old cut		
	3 - neglected		
	4 - grazed		

Figure 1. Sites sampled.



Results

Four samples, including the one vacuum sample, contained no dolichopodids. Seventy species of dolichopodids were recorded from 179 samples. *Dolichopus laticola* was the fifth most frequent species of dolichopodid and the second most frequent of 21 species of *Dolichopus* recorded. *Dolichopus nigripes* was the 13th most frequent species in the family and seventh most frequent species of *Dolichopus*. Both BAP species were therefore important constituents of the family in the fens.

Distribution

Dolichopus laticola was recorded from all six fens (Figure 1). It was more frequent in the Ant fens (found in about half to three-quarters of samples) than in the Bure fens (found in a third or fewer samples) (Table 3). The numbers per sample were highest at Sutton and Barton, much lower at Horning and Ebb & Flow, and with an intermediate value at Catfield and Woodbastwick (Table 3). These averages included samples made up from from different proportions of habitat types so were not directly equivalent, but they did give an indication of the greatest and poorest populations.

Dolichopus nigripes was found widely at Woodbastwick and was scarce at Horning. A single female was found at Catfield, which represented an extension of its range away from the Bure marshes into the Ant valley. *Dolichopus nigripes* was not found elsewhere.

Table 3. Records of each BAP *Dolichopus*: number of samples with each species, number of individuals and the number per sample.

Site (total samples in brackets)	***D. laticola*** samples	individuals	flies/sample	***D. nigripes*** samples	individuals	flies/sample
Ant catchment						
Barton (32)	17	40	1.25	0	0	0
Sutton (39)	29	72	1.85	0	0	0
Catfield (21)	11	20	0.95	1	1	0.05
Bure catchment						
Woodbastwick (45)	15	37	0.82	27	88	1.96
Horning (29)	9	10	0.34	3	6	0.21
Ebb & Flow (17)	3	4	0.24	0	0	0
Total (183)	84	183		31	95	

Relationship with habitat features

Sampling effort was uneven across the seven habitat types but was approximately in proportion to each feature's extent. *Dolichopus laticola* showed only small differences in its occurrence at each feature but a slightly larger proportion of samples were from the short vegetation of tracks and paths (=track in Figure 2, top and bottom graphs), and a smaller proportion were from carr or scrub (=wood in Figure 2). The apparently large proportion of samples with *laticola* from pools was likely to be an artefact of the small number pools found, and these samples could legitimately have been re-classified as 'ditch' or 'reed' which dominated the pools' shores. *Dolichopus nigripes* was found almost exclusively in the Bure so the analysis was restricted to these fens. Like *D. laticola*, it was more frequent on the shorter vegetation of tracks and paths and on the grassy fens that were currently grazed or probably grazed in the recent past.

When the numbers of individuals were examined, rather than just occurrence, *D. laticola* was clearly more abundant at reed (the normal fen vegetation) and along tracks and paths compared to its abundance in the sedge or ditch-fringing vegetation (Figure 3).
D. nigripes was more abundant in the short vegetation of tracks and paths, less frequent on the medium-length grassy vegetation (usually grazed) or at ditch margins, and much less abundant in reed-dominated vegetation. Few individuals of either species were found in carr or old tall scrub (=wood in Fig. 3), or in sedge beds. The preferrence for the tracks was significant, as judged from the nearly non-overlapping 95% confidence limits with the next apparent preference for ditch margins and grassy-rushy fen 'meadow' (probably not meadow in the sense of being mown but grazed or neglected grazed fen-pasture).

Figure 2. Number of all samples with *Dolichopus laticola* compared with all samples taken (top), number of samples with *D. nigripes* on the Bure marshes only (middle), and these numbers as percentages for both species (bottom).

Features are ordered left to right by the number of samples in both catchments.

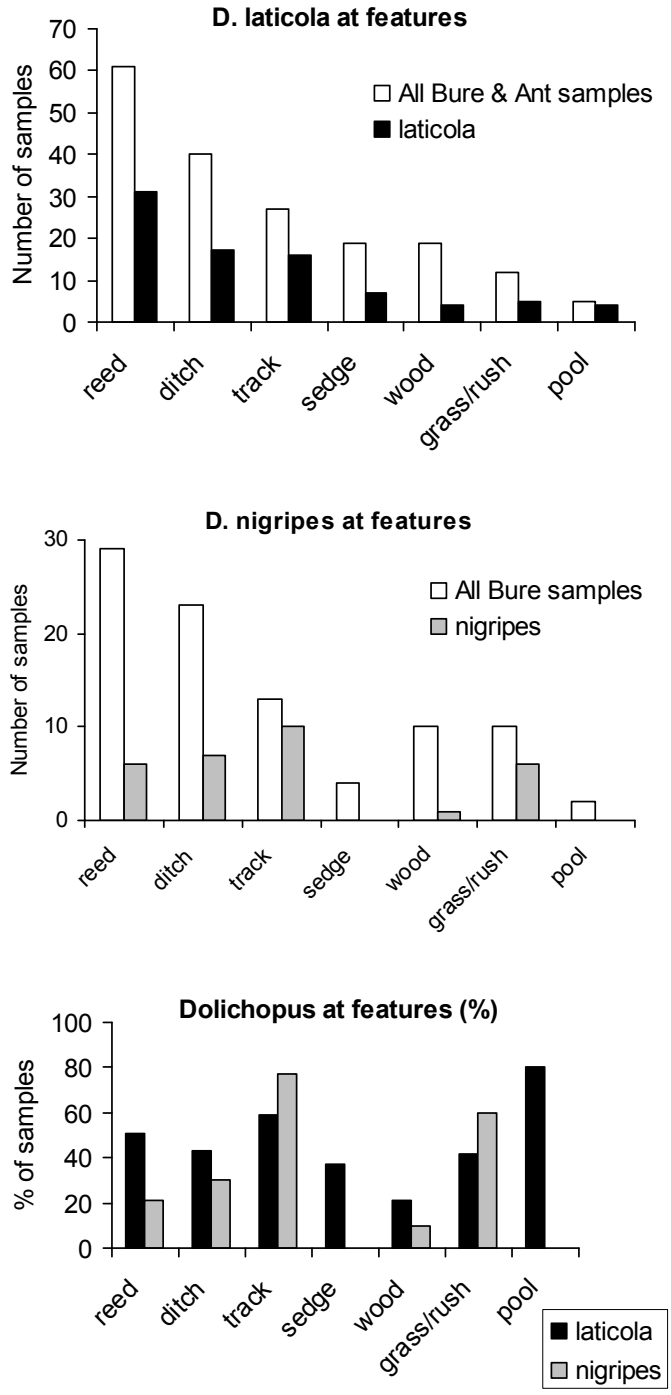
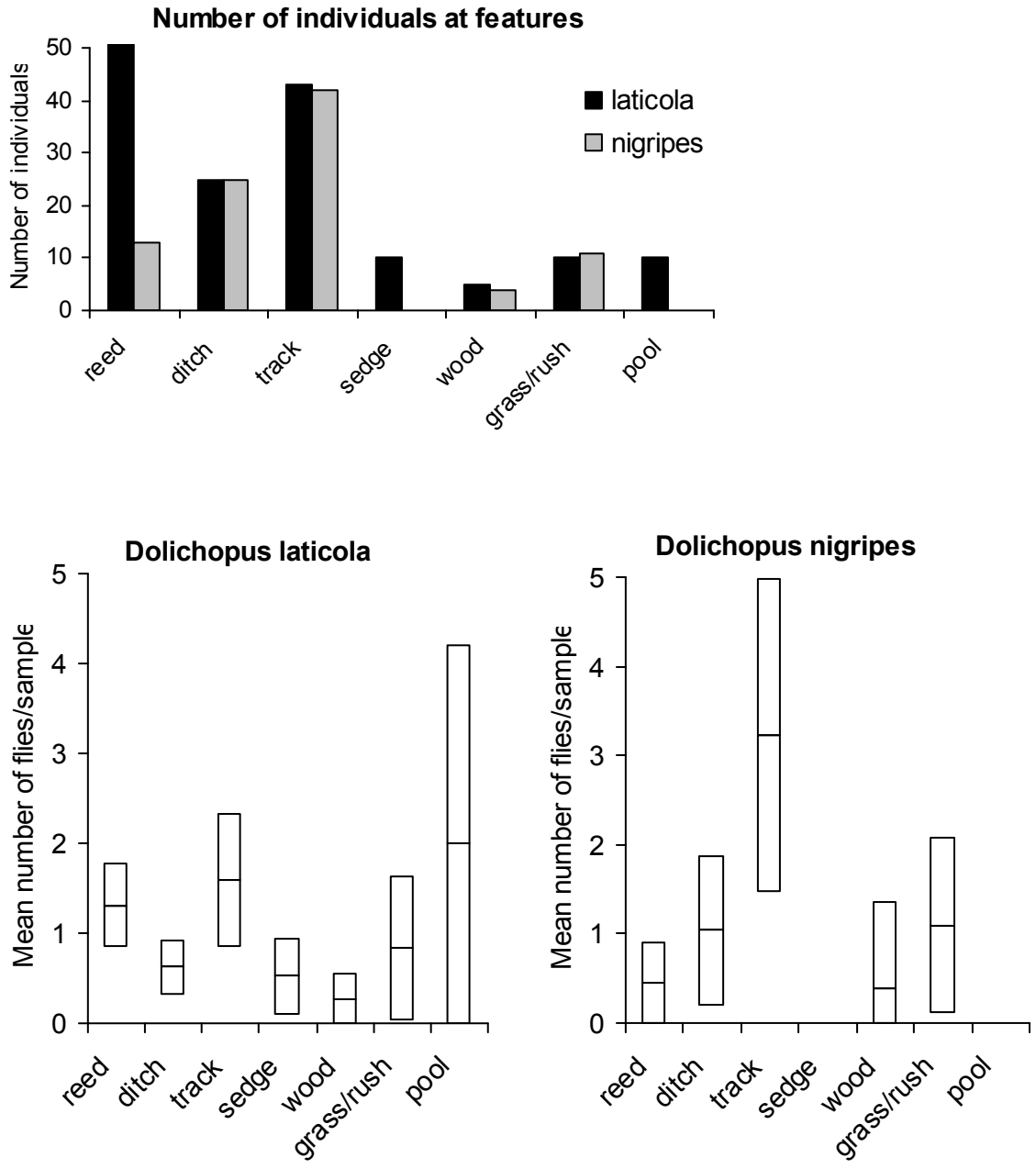


Figure 3. Total number of individuals at each habitat feature (above) and these numbers expressed as the average per sample with 95% confidence limits (below).



Ordination

The relationship between the two BAP *Dolichopus* and other species was examined using DECORANA. An initial run gave a large eigenvalue (0.393) and a gradient length of 3.96 for the first axis. This indicated a high turnover of species, and therefore this method, rather than PCA, was admissible (Lepš & Šmilauer, 2003). The second axis also had a large eigenvalue (0.257).

The 34 most frequent large species that were present in at least six samples were included. One sample with none of these species was also removed. The tiny species in *Micromorphus*, *Teuchophorus* and *Telmaturgus*, which were present in at least nine samples, were excluded since they were likely to have been under-recorded. The data were transformed by log+1 to reduce the extremes of abundances. No downweighting was applied for species scarce in the data.

Dolichopus laticola fell at the centre of the species ordination together with the other most frequent species, *D. longitarsis*, *Ethiromyia chalybea*, *Gymnopternus aerosus*, *G. assimilis* and *Campsicnemus scambus* (Figure 4). This was in contrast to the more outlying position of *D. nigripes* whose only close neighbour in the ordination was *D. picipes*.

A few patterns were discernable. The lower half of the ordination included the fen specialists *Gymnopternus assimilis*, *G. blankaartensis*, *Thrypticus smaragdinus* and *Argyra elongata*, along with *D. laticola* and *D. nigripes*, and it seemed likely that this suite of species were responding to similar conditions. Among species at the top of the ordination were those most often associated with particularly wet conditions, and included *Argyra vestita*, *Dolichopus nubilus*, *D. latilimbatus* and *Hydrophorus bipunctatus*. Some very common generalist dolichopodids that are found in a wide range of damp to wet habitats also occurred towards the top of the ordination (*D. pennatus*, *D. simplex*, *D. ungulatus*, *Chrysotus gramineus*), so this more crowded sector of the ordination appeared to include a more varied suite of species that may well have separated out on the third axis.

Samples were grouped by their feature and shown in ordination space (Figure 5). Assemblages did not separate particularly clearly in relation to features, as shown by the large overlap in many of the more frequently sampled features. For instance, reed, ditch edge, ponds and most sedge samples fell in the same broad ordination space. Shorter grass or rush-dominated vegetation were more clearly bunched to the left, but the most distinct of all was the samples from carr or scrub which fell in a clear group on the lower right of the ordination. The position of samples did not appear to relate to the apparent assemblage preferences of the species, with the exception of the shade associated *Dolichopus urbanus* and *G. metallicus* whose position corresponded with the wooded samples.

Figure 4. DECORANA ordination of the more frequently occurring larger dolichopodids.

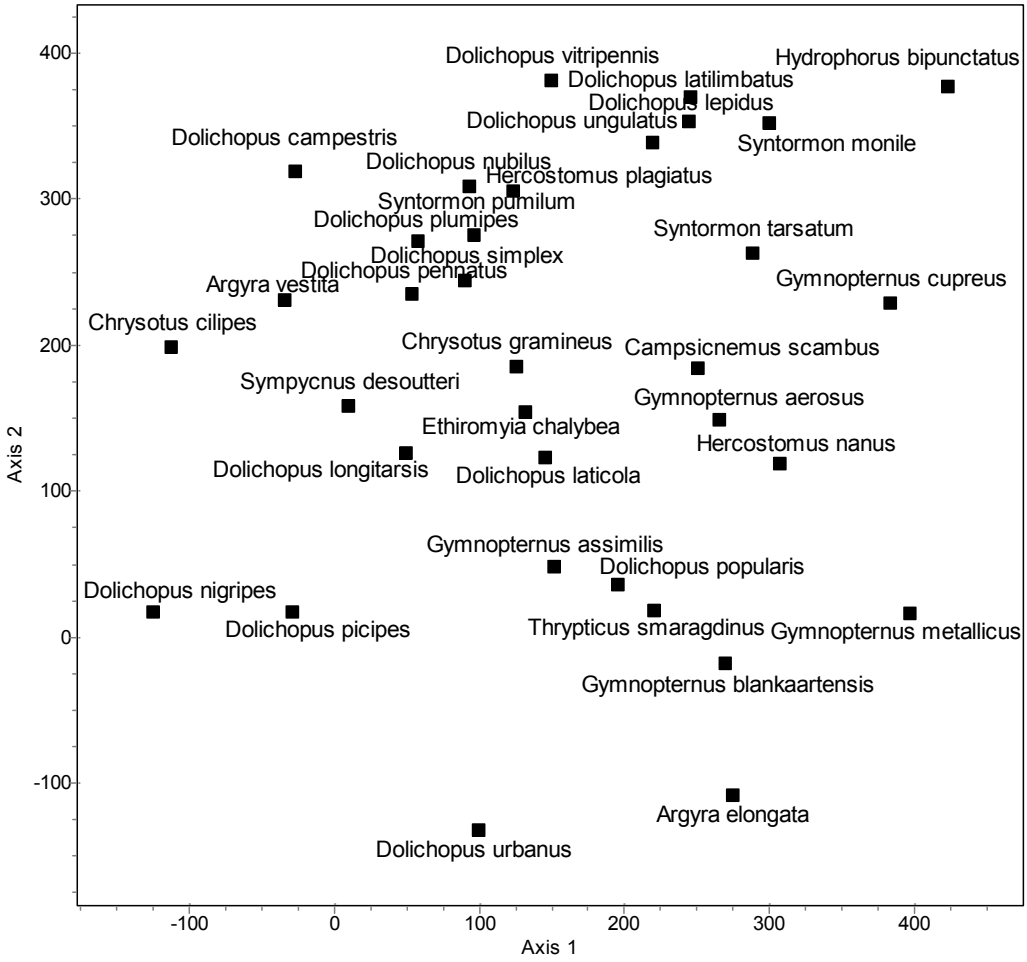
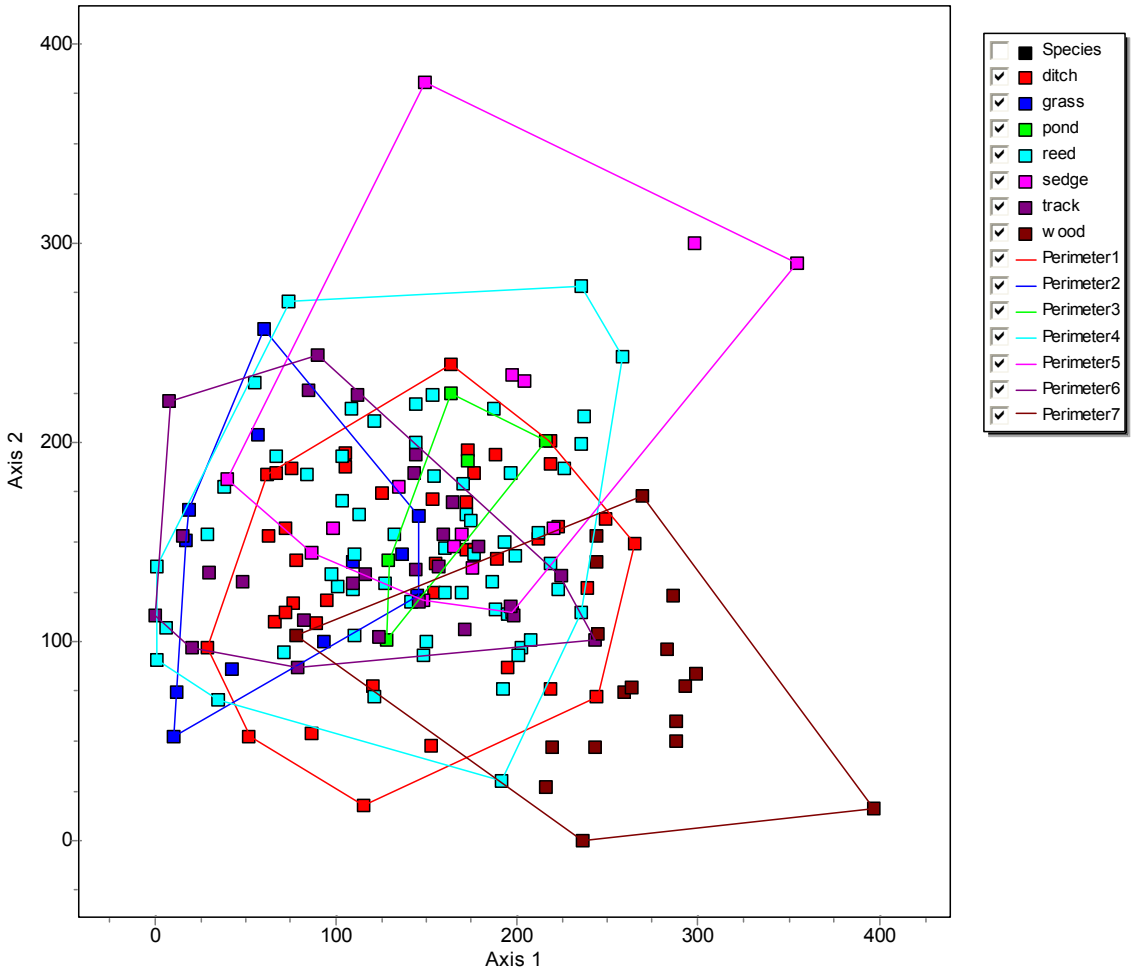


Figure 5. DECORANA ordination axes 1 and 2 showing samples grouped by the habitat features from which they were taken.



Discussion

Dolichopus laticola has strong populations on all six fens surveyed, particularly those in the Ant catchment. This result agrees with evidence from past records for *D. laticola* that show that it is widespread in the Broadland fens. As it was clearly one of the more frequent *Dolichopus* in true wet fen habitat away from drier margins, it is likely that more survey will show it to be present across more of the higher quality fenland in Norfolk. In contrast, *D. nigripes* was frequent only at its previously known site of Woodbastick Fen in the Bure catchment, although a single record from Catfield represented an extension of its range into the Ant catchment. In 2009 it had been recorded from all three of the Bure fens resurveyed in 2010 but was not found again at Ebb & Flow in 2010.

Dolichopus laticola was found in a larger proportion of samples from more open habitat features (tracks, grazed areas, reed-dominated fen) than in more shaded habitat features (old sedge, carr). This may be an artefact of sampling as it is easier to sweep the more open habitats, but there is no reason to think that it is not also a genuine preference since many

commoner *Dolichopus* species are also found frequently in more open-structured habitats. The apparent preference for 'reed' vegetation was particularly clear for this species.

Dolichopus nigripes was also found more frequently in open features, but appeared to prefer more grassy sites to those in which reed was more prevalent. The small number of captures in reed-dominated vegetation did appear to be pronounced. This may hint at the reason for its more restricted distribution compared to that of *D. laticola* since such grassy vegetation was frequent at Woodbastwick but is relatively uncommon in many Norfolk fens.

Both species are part of the association of dolichopodids associated with high quality fen, many of which have a restricted distribution in Britain. Even if no environmental information had been collected, this result in itself points to both species being specialised and requiring habitat that is uncommon. The likely features of such habitat are a high water table, botanically diverse vegetation and unshaded conditions.

More analysis will be undertaken using the environmental variables, and for this generalised additive modelling is considered most appropriate since the statistical distribution of the data preclude parametric methods such as linear regression. It is thought that soil wetness and perhaps the abundance of reed may well be show a good correlation with the distribution of *D. laticola*, but the limited geographic spread of records for *D. nigripes* may make it impossible to discern any trends with the variables.

Both species clearly avoided carr or old scrub that cast considerable shade. This result is useful confirmation of the BAP action to 'Maintain a high quality fen habitat and prevent succession to damp woodland [*nigripes*]', and the similar action to 'Prevent woodland encroachment on known sites [*laticola*]'. However, the action for *D. laticola* to 'Promote importance of fen meadow / fen carr system for this and other species and publish management advice in sources available to managers.' appears to be inappropriate for this species since is clearly avoided fen carr and, unlike *D. nigripes*, showed no clear preference for fen meadow, unless 'fen meadow' is meant to include rich-fen vegetation often dominated by reed and includes a wide range of other plants. This action may be more appropriate for *D. nigripes* which was frequent in grassy fen vegetation. These comments are not meant to detract from the need to make known the importance of fen meadow and especially fen carr to other invertebrates.

Another BAP action for *D. laticola* is 'Appropriate management of fen meadow / fen carr system e.g. water level management, cutting/mowing, eutrophication etc.' The results of the present survey suggest that maintenance of reed-dominated rather than sedge-dominated vegetation may be important for *D. laticola*, but, until the relationship between environmental variables and the presence of either species of *Dolichopus* is undertaken, there is insufficient information to tell how this is best achieved.

Further work

- Analyse the presence of each species in relation to the environmental variables using GAM.
- Survey more fens in Norfolk and Suffolk of different quality (Action 6 for *D. laticola*, Action 2 for *D. nigripes*). As both species were found easily and quickly on paths, tracks and more open-structured fen vegetation, these can be targeted for rapid survey of large dark *Dolichopus*. As part of this survey, it would be useful to revise the descriptions of habitat features so that this information can be collected quickly and

meaningfully at new sites. Among the measurements should be an estimate of soil wetness. As both species were found to be moderately frequent in late June, this would seem to be the most appropriate time for more survey work, although previous records include earlier and later dates that suggest that window of opportunity may be wider.

Acknowledgments

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