Folia Zool. – 54(3): 293–300 (2005)

The bird assemblage of coastal borrowdykes in relation to habitat features

Christopher F. MASON and Sheila M. MACDONALD

Department of Biological Sciences, University of Essex, Colchester CO4 3SQ, UK; e-mail: masoc@essex.ac.uk

Received 26 April 2005; Accepted 13 September 2005

A b s t r a c t . The birds along twenty 500 m lengths of coastal borrowdyke (water-filled ditches left when clay is extracted to make a sea wall) in eastern England were counted in spring 2004 and occurrence related to features of habitat. A total of 45 species was recorded with species richness ranging from 5–21. The most widespread species were little grebe *Tachybaptus ruficollis*, mute swan *Cygnus olor*, mallard *Anas platyrhynchos*, moorhen *Gallinula chloropus*, coot *Fulica atra*, sedge warbler *Acrocephalus schoenobaenus*, reed warbler *Acrocephalus scirpaceus* and reed bunting *Emberiza schoeniclus*, all typical wetland birds. Of 20 habitat variables measured, six (open water, narrow and broad marginal *Scirpus*, width, and low and tall thick scrub) were significant in describing species abundance data in a Canoco analysis. The linear coastal habitat of borrowdykes is regionally important for the conservation of some wetland species and current rotational management for land drainage purposes maintains the variety of habitats to retain a diversity of bird species.

Key words: borrowdyke, wetland, wetland birds, reedbed, conservation

Introduction

The majority of coastal agricultural land in eastern and southeast England is protected from the sea by sea walls, many dating back to the Middle Ages or earlier. The county of Essex alone has several hundred kilometres of sea wall. On the inside of the sea wall is the borrowdyke from which the clay was excavated to make the wall. Some borrowdykes receive drainage water from the surrounding agricultural land prior to its discharge via sluices to the sea, while there is some ingress and seepage of seawater. The water of borrowdykes therefore has variable salinity, influencing the vegetation. The dominant emergent vegetation consists of *Phragmites australis* and *Scirpus maritimus.* As many dykes serve a drainage function they are cleared every seven to ten years, creating broad, deep linear waterbodies which fill with emergent vegetation over time. Borrowdykes receiving no management are generally much narrower and develop dense scrub and trees along the bank. Some borrowdykes dry out in summer.

Receiving drainage from agricultural land, the water of borrowdykes is often very eutrophic. While there has been some limited work on the water quality and plankton of borrowdykes (S a m u e l s & M a s o n 1997), and some studies of invertebrates (e.g. D a v i d s o n et al. 1991, G i l l i l a n d & S a n d e r s o n 2000), there appears to be no published study of the bird assemblage of this habitat. Presented here are the results of a pilot study describing the bird assemblage of borrowdykes in spring and relating distribution to features of the habitat.

Methods

Surveys were conducted along borrowdykes adjacent to the estuaries of the rivers Deben, Orwell, Stour and Colne, and Hamford Water in the counties of Suffolk and Essex, eastern

England. Twenty stretches of length 500 m were selected randomly. Each site was surveyed twice in spring, between late April and mid May and from late May to mid June 2004. All surveys were conducted in the morning. The length of each site was walked slowly and all adult birds seen and heard within the borrowdyke or on the immediate banks were recorded. Any new species observed on the return journey were added.

A number of habitat features was assessed for each consecutive 50 m (Table 1). Mid-way along each site a water sample was taken and salinity measured with a salinity meter (Hanna Instruments – HI98130). The total length of coastal borrowdykes within the counties of Essex and Suffolk was estimated using a map measurer from 1:25,000 Ordnance Survey maps.

Table 1. Habitat features assessed at 50 m intervals along 500 m lengths of coastal borrowdykes (codes used in analyses given in brackets).

Habitat Feature	Description
Low thin scrub < 1m high (LTNS) Low thick scrub < 1m high (LTKS) Tall thin scrub > 1m high (TTNS) Tall thick scrub > 1m high (TTKS)	Each recorded on a 0 (absent) -5 (continuous cover) scale, both banks, summed to give maximum score 100 for each
Number of trees (TREE)	
Marginal *Phragmites* < 50 cm broad (MPHN Marginal *Phragmites* > 50 cm broad (MPHB) Marginal *Scirpus* < 50 cm broad (MSCN) Marginal *Scirpus* > 50 cm broad (MSCB)	Each recorded on a 0-5 scale (as above), both banks, summed to give maximum score 100 for each
Phragmites growing within water (AQPH) *Scirpus* growing within water (AQSC)	Each recorded on a 0-5 scale, summed to give a maximum score of 50 for each
Floating macrophytes (FLOA) Submerged macrophytes (SUBM) Filamentous algae (FALG) Algal bloom (ALBL)	Each recorded as present to give a maximum score of 10 each
Open water (OPEN)	Recorded on a 0-5 scale to give a maximum score of 100
Adjacent hinterland -arable (ARAB) Adjacent hinterland -grass (GRAS)	Recorded as present to give a maximum score of 10
Width m (WIDT)	Estimated by eye, average taken
Salinity (SALI)	

The highest count of each species recorded on the two surveys of each transect was used in the analysis. Bird abundances were log (y+1) transformed prior to analysis. Assemblages and sites were classified using TWINSPAN (Hill, 1979), with pseudo-species cut-off levels based on abundances in the data (0, 0.2, 0.4, 0.6, 1.0), with equal weighting. Eigenvalue cut-off levels were set at an arbitrary level of 0.25, so that division was halted at level 4.

Canonical Correspondence Analysis (CCA, Canoco for Windows 4.5) was employed to relate the species abundance data to the environmental variables (ter B r a a k 1986). For these ordinations, the full species data set (pool of all replicates) and the measured environmental variables from each site were used initially. The number of environmental variables was then reduced using the automatic forward selection option in the Canoco programme. This allows for the step-wise building of a model for the species data, starting with the variable that explains most of the variance. Subsequent environmental variables were included only if they significantly improved the explained variance (based on Monte-Carlo permutation tests).

Plots are species-conditional, based on Hill's scaling ($L^a/(1-L)$). Intra-set correlation coefficients between ordination axes and environmental variables are reported, rather than canonical coefficients, to infer the importance of each parameter in predicting the species composition. Correlation coefficients have the advantage of not being affected if environmental variables are mutually correlated, as is frequently the case in field data (ter B r a a k 1995).

Results

A total of 45 species was recorded along the 10 km of borrowdykes surveyed (Table 2). Species richness per site ranged from 5 to 21. The most frequent species were little grebe *Tachybaptus ruficollis*, mute swan *Cygnus olor*, mallard *Anas platyrhynchos*, moorhen *Gallinula chloropus*, coot *Fulica atra*, sedge warbler *Acrocephalus schoenobaenus*, reed warbler *Acrocephalus scirpaceus* and reed bunting *Emberiza schoeniclus*, all typical wetland birds.

Table 2. Bird species recorded in 20 stretches of 500 m of coastal borrowdyke in eastern England.

Species	Code	Species	Code
little grebe *Tachybaptus ruficollis*	LG	house martin *Delichon urbica*	HM
grey heron *Ardea cinerea*	H.	meadow pipit *Anthus pratensis*	MP
mute swan *Cygnus olor*	MS	yellow wagtail *Motacilla flava*	YW
greylag goose *Anser anser*	GJ	wren *Troglodytes troglodytes*	WR
Canada goose *Branta canadensis*	CG	dunnock *Prunella modularis*	D.
shelduck *Tadorna tadorna*	SU	robin *Erithacus rubecula*	R.
gadwall *Anas strepera*	GA	blackbird *Turdus merula*	B.
mallard *Anas platyrhynchos*	MA	sedge warbler *Acrocephalus schoenobaenus*	SW
shoveler *Anas clypeata*	SV	reed warbler *Acrocephalus scirpaceus*	RW
tufted duck *Aythea fuligula*	TU	lesser whitethroat *Sylvia curruca*	LW
ruddy duck *Oxyura jamaicensis*	RY	whitethroat *Sylvia communis*	WH
marsh harrier *Circus aeruginosus*	MR	willow warbler *Phylloscopus trochilus*	WW
kestrel *Falco tinunculus*	K.	long-tailed tit *Aegithalos caudatus*	LT
grey partridge *Perdix perdix*	P.	blue tit *Parus caeruleus*	BT
pheasant *Phasianus colchicus*	PH	great tit *Parus major*	GT
moorhen *Gallinula chloropus*	MH	carrion crow *Corvus corone*	C.
coot *Fulica atra*	CO	house sparrow *Passer domesticus*	HS
oystercatcher *Haematopus ostralegus*	OC	chaffinch *Fringilla coelebs*	CH
redshank *Tringa totanus*	RK	greenfinch *Carduelis chloris*	GR
black-headed gull *Larus ridibundus*	BH	linnet *Carduelis cannabina*	LI
woodpigeon *Columba palumbus*	WP	reed bunting *Emberiza schoeniclus*	RB
cuckoo *Cuculus canorus*	CK	corn bunting *Miliaria calandra*	CB
green woodpecker *Picus viridis*	G.		

The TWINSPAN classification was concluded at level 4 with the production of seven site groups (Fig. 1). The first division appeared largely to be due to the amount of open water at the sites with groups V, VI and VII mostly having greater than 50% open water, with coot as the indicator species. Wren *Troglodytes troglodytes* and blackbird *Turdus merula* were indicators of the more vegetated sites. Within the open water groups, Group VII had extensive thick beds of *Phragmites*, whereas in Group V the *Phragmites* beds were thin. A thin mixture of *Phragmites* and *Scirpus* characterized Group V1. Group I (sites 19 & 20) had high salinity (5.5,

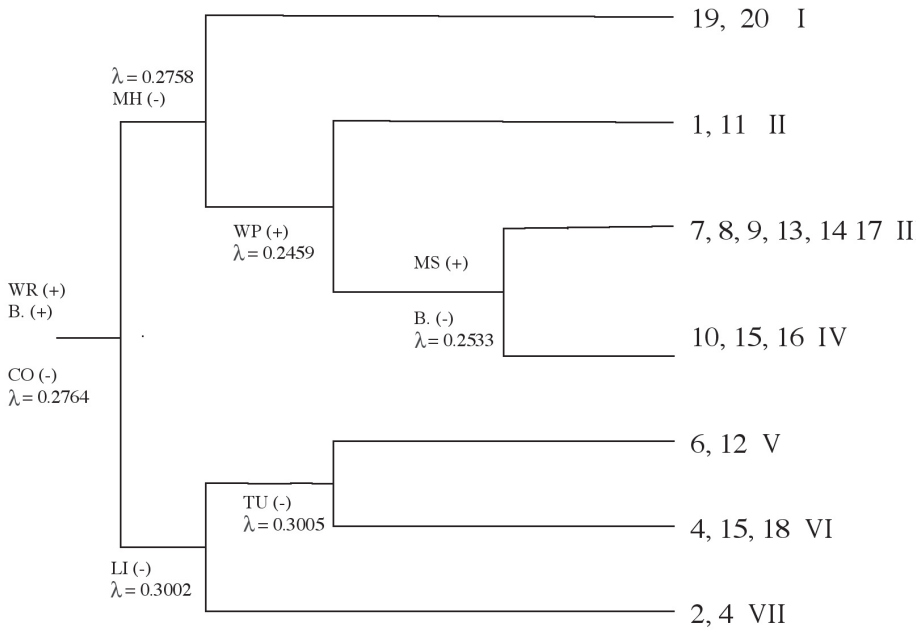

Fig. 1. Dendrogram of TWINSPAN classification of 20 sites based on their bird species composition, arrested after four levels of division giving seven groups (I–VII). Eigenvalues (λ) and indicator species (see Table 2 for codes) are indicated for each dichotomy.

22.8 ‰, respectively) and thick, broad marginal vegetation of *Phragmites* and especially *Scirpus*, with little scrub: moorhen *Gallinula chloropus* was the indicator species separating Groups I from Groups II – IV and was absent from Group I. Groups II – IV were primarily sites with low or tall thick scrub.

In the CCA analysis the amount of open water was the most important environmental factor explaining the patterns of distribution of birds, followed by marginal *Scirpus* (> 50 cm broad), width, tall and low thick scrub, and marginal *Scirpus* (< 50cm broad). These environmental variables in conjunction with the species points accounted for a total of 94.4% of the variance in weighted averages of the species using CCA (Fig. 2). The ordination identified a group of species associated with more open borrowdykes – mute swan *Cygnus olor*, greylag *Anser anser* and Canada goose *Branta canadensis*, tufted duck *Aythya fuligula*, coot and little grebe. Species associated with marginal vegetation include mallard and reed bunting. Unsurprisingly a suite of woodland and scrub species are associated with the scrub variables. Three of the commonest species, moorhen, reed and sedge warbler show some association with low thick scrub.

The total of all canonical eigenvalues was 1.142. The extracted gradients based on all canonical axes with reference to species weighted averages were significant (Monte Carlo permutation test, $F = 2.59$, $P < 0.01$). Intraset correlations of environmental variables with the first two axes of CCA and significance levels based on step-wise addition of the respective variables to the ordination (conditional effect) are given in Table 3. The ordination achieved good separation of the species assemblages classified by TWINSPAN (Fig. 3).

It was determined that there are 70 km of coastal borrowdyke in Suffolk and 282 km in Essex. An estimate of the number of the most common species (with 95% confidence limits, calculated from log (x + 1) counts) associated with borrowdykes is given in Table 4.

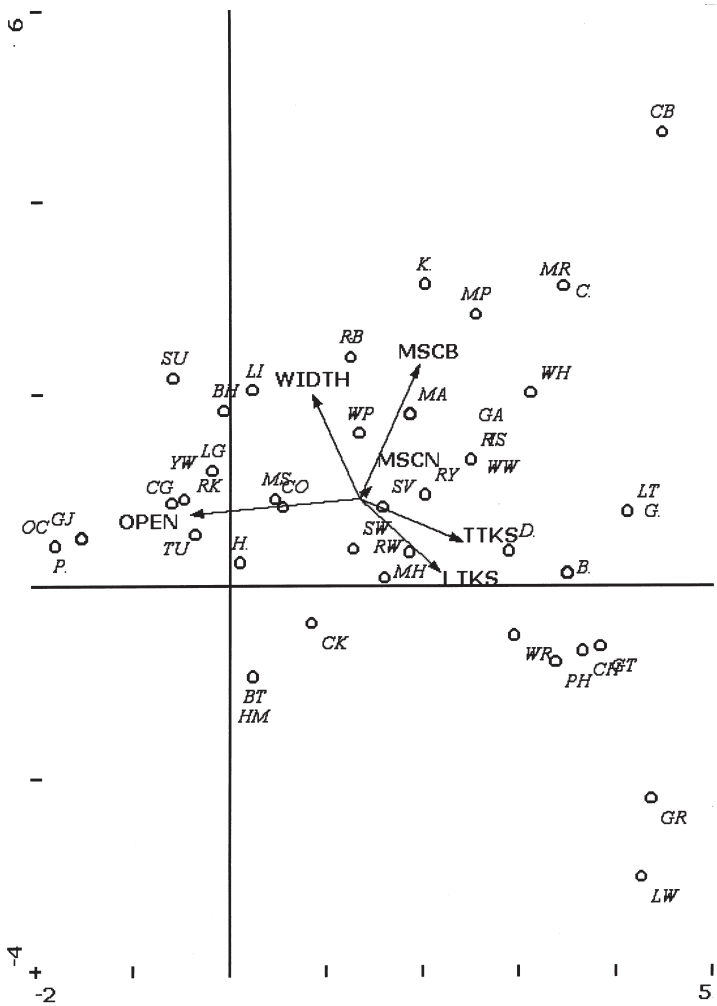

Fig. 2. Canonical Correspondence Analysis ordination diagram with bird species (o), and environmental variables (arrows). Eigenvalues (λ): axis 1, λ = 0..293; axis 2, λ = 0.188. See Table 1. for environmental codes.

Table 3. Intraset correlations of environmental variables with the first two axes of CCA of bird species data. The statistical significance of the effect of each variable was estimated by a Monte Carlo permutation test as each variable was added to the model.

Variable	Correlation Coefficient		Significance (F)
	Axis 1	Axis 2	
Open water (OPEN)	-0.8168	0.0953	2.375**
Marginal *Scirpus* > 50 cm broad (MSCB)	0.1998	0.6737	1.718
Width (WIDTH)	-0.2992	0.6299	1.833**
Tall thick scrub > 1m tall (TTKS)	0.5336	-0.3464	1.606*
Low thick scrub < 1m tall (LTKS)	0.4448	-0.4925	1.310
Marginal *Scirpus* < 50 cm broad (MSCN)	0.0511	0.0543	1.518

** P < 0.01; * P < 0.05

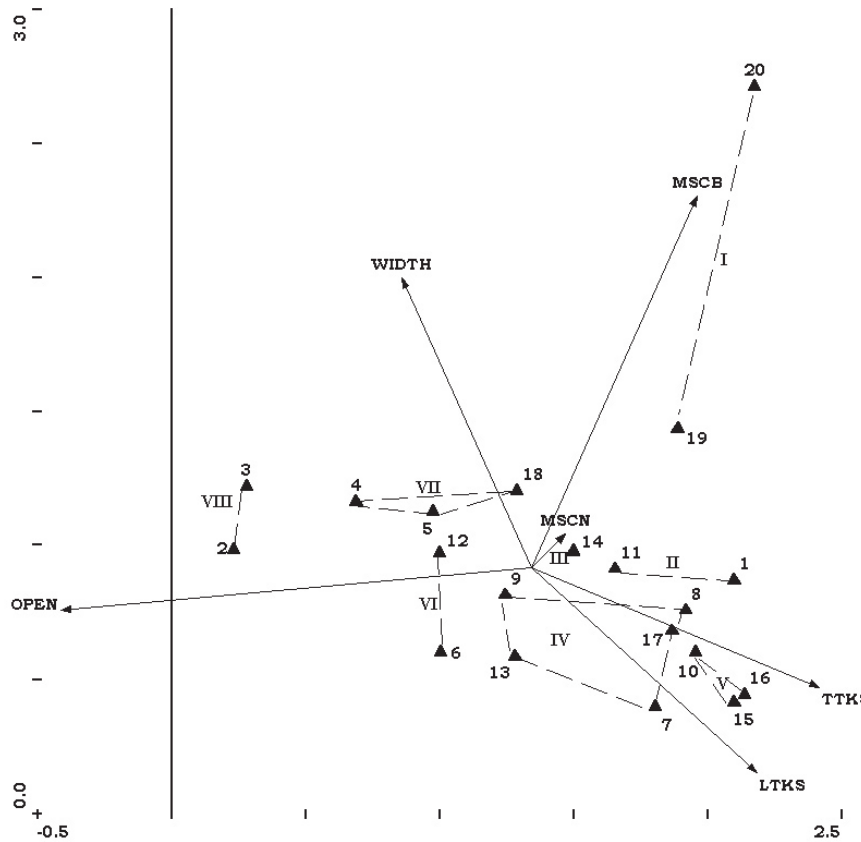

Fig. 3. Canonical Correspondence Analysis ordination diagram with 20 sites (▲) and environmental variables (arrows). Polygons illustrate TWINSPAN groups I-VII.

Table 4. An estimate of the population of eight species of wetland birds in 352 km of coastal borrowdyke in eastern England.

Species	% Frequency	Geometric Mean	Population Estimate	95% Confidence Limits
little grebe *Tachybaptus ruficollis*	35	1.35	950	725 -1176
mute swan *Cygnus olor*	50	1.73	1218	922-1605
mallard *Anas platyrhynchos*	95	3.46	2436	1830-3133
moorhen *Gallinula chloropus*	90	3.31	2330	1837-2950
coot *Fulica atra*	75	3.11	2189	1549-3076
sedge warbler *Acrocephalus schoenobaenus*	85	3.32	2337	1732-3168
reed warbler *Acrocephalus scirpaceus*	90	5.37	3780	2753-5188
reed bunting *Emberiza schoeniclus*	75	2.68	1887	1373-2584

Discussion

The dominant emergent vegetation in borrowdykes, *Phragmites australis*, did not feature in the environmental factors explaining distribution patterns of birds, presumably because of its

ubiquity. Two species associated with emergent vegetation, sedge warbler and reed warbler, similarly showed little separation on the CANOCO axes, though both species showed some association with low, thick scrub which provides habitat for nesting (sedge warbler) and feeding (both species) (F u l l e r 1982). Scrub also provides cover for moorhens.

The ordination identified a community of aquatic birds associated with open water on the wider borrowdykes, with mute swan, coot and little grebe amongst others. Width was also found to influence numbers of these species in winter on rivers (M a s o n & M a c d o n a l d 2000a). Mallard was associated with borrowdykes with dense emergent *Scirpus*; it has been found to be associated with thick emergent vegetation on lowland rivers (M a s o n & M a c d o n a l d 2000a). Those borrowdykes with scrub supported a range of birds typical of woodland or woodland edge. Scrub would have provided secure nesting sites for wetland species such as moorhen and additional feeding opportunities for insectivorous wetland warblers (F u l l e r 1982).

The borrowdyke habitat is clearly important for a number of birds associated with wetlands. As all individual adult birds seen or heard were counted, the population estimates given in Table 4 should not be taken as the number of pairs. With conspicuous birds like mute swan both members of a pair would have been seen at most sites. Five swans were sitting on nests during the survey, giving an estimate of 176 pairs for the borrowdyke system as a whole. With a total estimate for Essex and Suffolk of some 300 pairs (D e n n i s 1996, P i o t r o w s k i 2003), the population utilizing borrowdykes is clearly significant and most probably underestimated in the past. With passerines, the majority of observations would have been of singing males so the estimates given here are likely to be closer to the number of nesting pairs. The numbers of both reed warblers and reed buntings are of especial significance, the latter species in particular having declined markedly over the last decades B r o w n & G r i c e 2005), with a very low population density within farmland in this region (M a s o n & M a c d o n a l d 2000b).

In terms of the conservation of borrowdyke habitats, the wetland species are most important, wider borrowdykes with open water and broad swathes of emergent vegetation supporting the bigger populations. The presence of scrub increases the diversity of the bird community. The current management of a cycle of dredging and clearance of those borrowdykes essential to efficient land drainage, along with benign neglect of those with little drainage function, is probably close to the ideal for maintaining this diversity.

A c k n o w l e d g e m e n t s

We thank Tanja A. H o f m a n n for assistance with the multivariate analyses.

LITERATURE

DAVIDSON N.C., LAFFOLEY D.A., DOODY J.P., WAY L.S., GORDON J., KEY, R., PIENKOWSKI M.W., MITCHELL R. & DUFF K.L. 1991: Nature Conservation and Estuaries in Great Britain. *Nature Conservancy Council Peterborough.*

BROWN A. & GRICE P. 2005: Birds in England. *Poyser, London.*

DENNIS M.K. 1996: Breeding Birds of Essex. *The Essex Birdwatching Society, Colchester.*

FULLER R.J. 1982: Bird Habitats in Britain. *Poyser, Calton.*

GILLILAND P.M. & SANDERSON W.G. 2000: Re-evaluation of marine benthic species of nature conservation importance: a new perspective on certain 'lagoonal specialists' with particular emphasis on *Alkmaria rominji* Horst (Polychaeta: Ampharetidae). *Aquat. Conserv. 10: 1–12*.

HILL M. O. 1979: TWINSPAN – A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. *Cornell University, New York*.

MASON C.F. & MACDONALD S.M. 2000a: Numbers of wintering waterbirds on rivers in eastern England. *Wildfowl 51: 215–219.*

MASON C.F. & MACDONALD S.M. 2000b: Influence of landscape and land-use on the distribution of breeding birds in farmland in eastern England. *J. Zool. 251: 339–348*.

PIOTROWSKI S. 2003: The Birds of Suffolk. *Christopher Helm, London*.

SAMUELS A.J. & MASON C.F. 1997: Ecology of eutrophic waterbodies in a coastal grazing marsh. *Hydrobiologia 346: 203–214*.

TER BRAAK C. J. F. 1986: Canonical Correspondence Analysis: A new eigenvector technique for multivariate direct gradient analysis. *Ecology 67: 1167–1179.*

TER BRAAK C. J. F. 1995: Ordination. In: Jongman R. H. G., ter Braak, C. J. F. & van Tongeren O. F. R. (eds), Data Analysis in Community and Landscape Ecology. *Cambridge University Press, Cambridge: 91–173.*