The ecology of the invertebrate community of Borough Fen Decoy pond

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Introduction

Borough Fen is the oldest surviving Duck Decoy in Britain. It was constructed 4 miles north of Peterborough about 1640 for commercial duck-catching and continued in that use until the Wildfowl Trust converted it to a ringing station (Cook, 1960). The $2\frac{1}{2}$-acre pond and the $14\frac{1}{2}$ acres of mixed woodland in which it lies have thus formed an isolated, managed ecological unit for well over three centuries. With the drainage of the Fens it was one of the few permanent bodies of water remaining, until the relatively recent excavation of ballast and gravel pits. Woods are unusual in the Fen country too, often marking the sites of disused decoys.

The pond water is replenished in the summer, and other times of shortage, through a drain connecting it with the River Welland. Indeed the first written record of the Decoy's existence is an application made by the Earl of Lincoln to the Bedford Level Commissioners, in 1670, for permission to pierce the embankment of that river. In 1972 such topping-up took place on 5 days—28, 29 June, 24 August and 28, 29 September.

The water in the pond and its eight curved 'pipes' is clear and shallow. Nowhere is it more than 2 ft deep, in most places only a few inches. The bottom of fine gravel is overlaid by a thick layer of black mud. In 1947 it was cleaned out by dragline, and each year a different area is pumped clear of mud.

There are patches of algae on the mud, but apart from an island of reeds there are no rooted plants of duckweeds growing in the central part of the pond. Around the margins *Carex acuta*, *Glyceria maxima* and *Phragmites communis* flourish, and the encroaching vegetation is periodically dug out, as are the edges of the reed island. Aquatic plants grow readily in the pipes, which have to be cleared annually (Figure 1). This vegetation consists of *Glyceria maxima*, *Lemna minor*, *Callitriche stagnalis*, *Rorippa nasturtium-aquaticum* and filamentous algae including *Spirogyra*.

The pond often has a roosting population of up to 1,500 duck during the autumn, the birds flighting out in the evening to feed in

Figure 1. Borough Fen Decoy. The mouth of the North Pipe; a general impression of the vegetation round the pond.

the surrounding arable land, sometimes as far as the coast 20 miles away. In the winter the roosting population falls to 400–500. Few of the duck stay to nest. In 1972 one pair of Mute Swans, about ten pairs of Mallard and several pairs of Moorhen nested around the pond.

Water analysis

A water sample taken in June had approximately 90 parts per million (ppm) of calcium.

Two samples of water were taken on a sunny afternoon in July from the central area of the pond, where the water was 4 in deep, over 10 in of mud, with a water temperature of 21°C. Oxygen saturation was 135%/122% and the pH 7·98/8·02. The compounds in solution were, in ppm: oxygen 11·7/10·6; ammonia (as nitrogen) 9·2/10·2; nitrate (as nitrogen) 1·2/1·2; nitrite not detectable; phosphate (as PO_4) 2·1/2·1; total hardness (as $CaCO_3$) 250/250.

Animal survey

This was carried out between March and July 1972. Both *Pygosteus pungitius* (ten-spined stickleback) and *Gasterosteus aculeatus* (three-spined stickleback) were present in the pond. *Rana temporaria* (common frog) returned in 1972, after some years' absence from Borough Fen, but no tadpoles were seen. Some fifty species of invertebrates were found, half of them insects (Table 1).

Table 1. Invertebrates found in Borough Fen Decoy pond

Tricladida	
Dendrocoelum lacteum (Müller)	***
Polycelis nigra (Müller)	.
Nematoda	
Mermithidae	.
Annelida	
Oligochaeta	
Tubificadae	***
Nais sp.	**
Hirudinea	.
Erpobdella testacea (Savigny)	
Helobdella stagnalis (L.)	***
Mollusca	
Gastropoda	
Lymnaea peregra (Müller)	**
Lymnaea stagnalis (L.)	**
Planorbis planorbis (L.)	.
Planorbis contortus (L.)	.
Lamellibranchiata	
Anodonta cygnea	*
Crustacea	
Cladocera	
Simnocephalus vetulus (Müller)	
Daphnia pulex (De Geer)	****
Daphnia obtusa (Kurs.)	*
Daphnia magna (Straus)	*****
Scapholeberis aurita (Fischer)	*
Leydigia leydigi (Schodler)	***
Copepoda	
Cyclops agilis (Koch. Sars)	****
Cyclops vicinus (*uljanna*)	***
Isopoda	
Asellus meridianus (Racovitza)	.
Amphipoda	
Crangonyx pseudogracilis (Bousfield)	***
Insecta	
Hemiptera	
Gerris lacustris (L.)	.
Notonecta glauca (L.)	**
Callicorixa praeusta (Fieber)	.
Corixa punctata (Illiger)	*
Hesperocorixa sahlbergi (Fieber)	.
Sigara dorsalis (Leach)	*
Sigara falleni (Fieber)	.
Sigara lateralis (Leach)	****
Trichoptera	
Limnephilidae	.
Coleoptera	
Haliplus lineatocollis (Marsham)	*
Haliplus ruficollis (Degeer)	*
Hygrotus inaequalis (Fab.)	.
Ostracoda	****
Hydroporus granularis (L.)	.
Hydroporus palustris (L.)	.
Hydroporus pubescens (Gyllenhal.)	.
Diptera	
Ptychoptera contaminata (L.)	.
Ptychoptera minuta (Tonnoir)	.
Anopheles maculipennis (Meigen)	*
Paradixa aestivalis (Mg.)	.
Chironomidae	****
Ceratopogonidae	**
Pericoma sp.	.
Acarina	*

., Scarce; *, fairly frequent; **, frequent; ***, very frequent; ****, abundant; *****, very abundant.

Notes on the ecology of the invertebrates

Tricladida

Dendrocoelum lacteum is a flatworm, found in productive waters where the calcium content is at least 10 ppm (Reynoldson, 1967). It feeds on arthropods, and its distribution is closely linked with that of *Asellus*, one item of its diet. *Polycellis nigra* is a widespread species, which feeds on oligochaetes and arthropods.

Nematoda

Mermithidae (rainworms) are relatively large roundworms, several centimetres in length, parasitic in their early stages in insect larvae.

Hirudinea

Helobdella stagnalis is a very common leech, typical of still waters rich in calcium. *Erpobdella testacea*, a less common species, is found in emergent vegetation, eutrophic ponds and organically polluted waters. Both species feed on invertebrates such as chironomid larvae and oligochaete worms, and *Erpobdella testacea* also takes water fleas.

Mollusca

Lymnaea peregra is the most widespread and abundant British freshwater snail. *L. stagnalis* is common in hard-water ponds. Similarly, *Planorbis contortus* is a widespread ramshorn snail, whereas *P. planorbis* is restricted to hard water. Shells of *Anodonta cygnea* found at Borough Fen measured up to 5½ in. in length. Sticklebacks here would be the hosts for the parasitic larvae of the swan mussel.

Crustacea

The pond teems with Cladocera. *Daphnia pulex* is typical of polluted ponds, as it feeds on unicellular algae with hard cuticles, which abound in these conditions. It can tolerate low oxygen concentrations, and its feeding limbs are not clogged by bacteria. *Daphnia obtusa* is associated with 'duck ponds'. *D. magna* is rather rare, occurring in hard waters in south and east England. *Simnocephalus vetulus*, which flourishes in hard, weedy waters, was restricted to the thick vegetation in the pipe ends. *Scapholeberis aurita*, a rare species, crawls on the underside of the surface film of the water. Before this survey it had only been recorded from Norfolk and Hampton Court (Scourfield & Harding, 1967). *Leydigia leydigi*, a widespread species, lives on the surface of the mud.

The Copepoda found at Borough Fen are common species. *Cyclops vicinus* is usually associated in ponds with *Daphnia pulex*.

Asellus meridianus was not as plentiful in this pond as might have been expected, as it is an abundant water skater in the Peterborough district, and can stand fairly low oxygen concentrations. *Crangonyx pseudogracilis* is a freshwater shrimp which was introduced from North America in the 1930s and is now fairly widespread. It appears to be able to stand pollution better than the common freshwater shrimp, *Gammarus pulex*, which was not found at Borough Fen.

Hemiptera

Gerris lacustris is probably the commonest species of pond skater in the Peterborough district, and *Notonecta glauca* is by far the commonest of the back-swimming water boatmen.

Macan (1954, 1963, 1965) has shown that each species of corixid has precise requirements, including the calcium content of the water and the amount of organic matter on the bottom. Of the six species of corixid found at Borough Fen, the only numerous one was *Sigara lateralis*. This water boatman is often abundant in ponds fouled by animals (in this case the waterfowl). *Callicorixa praeusta* is common in rich waters, often where there is some degree of organic pollution. *Sigara falleni* and *Corixa punctata* are common in calcium-rich waters. *Hesperocorixa sahlbergi* is typical of ponds with black mud on the bottom, where the water is not base-deficient. *Sigara dorsalis* is typical of waters with less organic matter than is present at Borough Fen.

Trichoptera

The two limnephilid caddis larvae found amongst *Carex* stems had constructed their cases from plant material.

Coleoptera

All the beetles found at Borough Fen are very common pond species.

Diptera

Anopheles maculipennis is a very common mosquito, and *Paradixa aestivalis* is a very widespread midge. The grub-like larvae of the Ptychopteridae (phantom craneflies) live in mud beneath shallow water, and breathe air at the surface by means of a long abdominal respiratory process. *Ptychoptera contaminata* is a common species, frequenting especially woodland pools. *P. minuta* is local in distribution, and has not previously been recorded from this vice-country (Stubbs, 1972).

Acarina

Parasitic mite larvae were found attached to the cuticle of *Callicorixa praeusta*.

Discussion

Apart from Cladocera, Copepoda and Ostracoda, only a very few species of animal were at all numerous in the areas of the pond free of rooted vegetation. These were *Dendrocoelum lacteum*, *Helobdella stagnalis*, *Crangonyx pseudogracilis*, *Sigara lateralis*, oligochaete worms, and ceratopogonid and chironomid midge larvae. In addition, the small, temporary areas of aquatic vegetation in the pipes accommodated numbers of *Lymnaea peregra*, *Lymnaea stagnalis*, *Notonecta glauca*, haliplid beetles and mites.

Three important factors influencing the composition of the invertebrate fauna of Borough Fen Decoy Pond are: (a) the high concentration of organic material; (b) the high calcium concentration; (c) the absence from most of the pond of aquatic plants other than algae.

(a) The concentration of ammonia was very high, about double the average for the effluent from Peterborough Sewage Works. The source of most of this ammonia is undoubtedly the excreta of the very large wildfowl population harboured by the pond from August to March. Leaves drifting in from surrounding trees augment this supply of organic material. The high calcium concentration of the water encourages rapid decomposition, resulting in the formation of the thick layer of black mud.

Water samples collected on a sunny summer day contained abundant oxygen. Most of this must have been derived from the photosynthetic activity of unicellular and filamentous algae. Under these conditions, oxygen production was outstripping the consumption of dissolved oxygen by the plants and animals in the pond, notably the bacteria and other micro-organisms breaking down organic compounds. The presence of nitrate indicates activity by aerobic bacteria utilizing ammonia. However, at night, especially when the temperature remains high, the water must rapidly become deoxygenated, and anaerobic breakdown processes must dominate. The aquatic animals must therefore be adapted to cope with wildly fluctuating oxygen levels, unless they breathe air at the surface.

The Trent River Board has worked out a classification of freshwater, using invertebrate organisms as indicators of the degree of organic pollution. The oxygen requirement of the members of the invertebrate community is one of the principal criteria upon which this Biotic Index is ultimately based. The Biotic Index ranges from 0 for foully polluted to 10 for thoroughly clean. The rating for Borough Fen Decoy Pond works out at approximately 6. Many species in the pond are typical of mildly polluted water, in particular *Erpobdella testacea*, *Daphnis pulex*, *Asellus meridianus*, *Sigara lateralis*, and *Callicorixa praeusta*. Tubificid worms and red chironomid larvae are extremely tolerant of pollution, but their presence does not necessarily indicate gross pollution unless all other species requiring dissolved oxygen are absent. Plecoptera (stoneflies), Ephemeroptera (mayflies) and most species of Trichoptera have aquatic stages unable to stand pollution, and, as would be expected, are absent from the pond.

Adult Coleoptera and Hemiptera, and the larvae of some Coleoptera and Diptera (including *Anopheles*, *Paradixa* and *Ptychoptera*) obtain gaseous oxygen at the surface, and so are independent of dissolved oxygen. Snails like *Lymnaea* use dissolved oxygen unless the concentration is low, when they come to the surface and breathe by means of a lung. Some adaptations to low oxygen concentrations of those aquatic invertebrates dependent upon dissolved oxygen are obvious. One such is the presence of haemoglobin in the mud-dwelling chironomid larvae and tubificid worms. The possession of haemoglobin makes possible the uptake of oxygen at very low concentrations. Some chironomid larvae produce it only in situations where oxygen is scarce. Chironomid larvae are able to respire anaerobically if necessary. Both chironomids and tubificids make respiratory movements. Chironomids build U-shaped tubes of salivary secretion in the mud, and undulate their abdomens to create a current through the tubes. Tubificids protrude their tails from the mud and undulate them. The scarcer the oxygen, the greater the length of tail which is protruded.

Other adaptations are less obvious. For instance, in dragonflies, the bottom-dwelling species of nymph appear to have lower metabolic rates, lower growth rates, and to move more slowly than those which live among water plants near the surface, where oxygen concentration, temperature and light intensity are higher (Corbett, Longfield &

Moore, 1960). Amongst the leeches, *Erpobdella octoculata* is widespread, but is replaced by the less common *E. testacea* in anaerobic situations such as emergent vegetation or waters otherwise rich in organic material. Mann (1965) has carried out experiments on the oxygen consumption of these and other leeches, and has shown that *E. testacea* is physiologically better adapted to life in low oxygen concentrations than is *E. octoculata.* The oxygen consumption of *E. octoculata* is dependent upon the concentration of dissolved oxygen, whereas, at low levels, the oxygen consumption of *E. testacea* is independent of oxygen concentration. Mann (1961) also points out that whereas *E. octoculata* breed in summer and lives for 2 years, *E. testacea* dies after breeding early in the year, so that in the warmest months, when oxygen is likely to be scarcest, it is small or in the egg stage. It is significant that *E. testacea* is present at Borough Fen, but *E. octoculata* was not found.

(b) Amongst freshwater invertebrates there are some groups in which the presence of calcium appears to favour all the species, and with decreasing amounts of calcium below a certain level the number of species decreases. For instance Boycott (1936) has shown that some species of Mollusca (e.g. *Lymnaea peregra* and *Planorbis contortus*) can live in hard and soft waters, whereas other species (e.g. *Lymnaea stagnalis* and *Planorbis planorbis*) are only present where there is at least 20 ppm of calcium. One reason for this may be that, as calcium encourages decomposition of organic material, hard waters are more productive than calcium-deficient ones.

In other groups, for instance the Corixidae, some species are characteristic of hard waters, while others are confined to soft waters (Macan, 1954, 1963, 1965). By invertebrate standards the water at Borough Fen is extremely rich in calcium. *Dendrocoelum lacteum, Helobdella stagnalis, Lynmaea stagnalis, Planorbis planorbis, Simnocephalus vetulus, Corixa punctata, Callicorixa praeusta. Sigara falleni, S. lateralis* and *Hesperocorixa sahlbergi* are all species confined to or favoured by hard water, and present at Borough Fen.

(c) The scarcity of vegetation in the pond limits the number of animals, especially snails and insects. Gastropods, Coleoptera and some Hemiptera (e.g. *Notonecta*) were nearly all confined to the temporarily uncleared ends of the pipes. The notable absence of dragonflies is due at least in part to this factor, as many species lay their eggs in aquatic plants, and most nymphs are weed-dwellers. The thick, soft mud does not provide a suitable substrate for some plants, but conditions are favourable for duckweed. This is eaten by the ducks as quickly as it grows. If left undisturbed, the pond would support a greater variety of invertebrates, but obviously plants would quickly engulf the pond if vegetation was left uncleared.

Lack of food probably contributes to the high mortality rate amongst the young of the resident wildfowl population of Borough Fen. In 1972 only three Mallard ducklings survived, and all the cygnets died. Olney (1967) has found in the stomachs of adult Mallard, seeds, aquatic plants, and many of the invertebrate species present in the Decoy pond. An examination was made of the stomacn contents of three Mallard killed at Borough Fen in October 1972 as a contribution to another programme of research. These birds may not have been feeding exclusively at Borough Fen, but the food items found were all present in the pond. Much of the food consisted of 'seeds', predominantly grain scattered on the pond to attract the ducks. However, one stomach contained only about sixty 'seeds' and a large number of insects. These were one land beetle, one larva of *Pericoma*, four larvae of *Ptychoptera*, ten chironomid pupae, and about 300 chironomid larvae.

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Summary

The invertebrate fauna of the pond, which has existed for over 300 years, is listed. The ecological requirements of the different species are described, and the ways in which they are adapted to the particular conditions of Borough Fen discussed.

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