Orton Pit

Examination of the effects of rotenone treatment on the invertebrates of ponds
Autumn/Winter 2005-6

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Report to
Froglife
February 2006

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Introduction

In November and December 2005, rotenone was applied to some of the ponds in Orton Pit SSSI in order to kill fish which would otherwise predate the early stages of great crested-newt *Triturus cristatus*. Rotenone is also known to kill invertebrates, and is used as a general insecticide. Aquatic invertebrates are generally less sensitive to rotenone than fish, but some studies of the impacts of rotenone application for fish control have demonstrated significant collateral damage to invertebrate populations and assemblages. Since the ponds of Orton Pit SSSI support an important assemblage of invertebrates, there is inevitably concern that rotenone treatment which kills all the fish in a pond may also cause significant damage to the invertebrate populations.

Rotenone works by interfering with the basic mechanism of cellular respiration, and is in principle capable of killing any invertebrate. However, experimental studies suggest great variation in susceptibility to rotenone poisoning, not only between organisms but also between different studies on the same organism. It seems likely from existing information that rotenone application sufficient to kill fish at Orton Pit SSSI would also kill some invertebrates, but that only specific survey could determine how many of which invertebrates were affected.

From the point of view of practical conservation, limited mortality even over a quite wide range of invertebrate species is not a matter of great concern: unless rotenone treatment were sufficiently frequent that small-scale mortality from individual applications might have a cumulative effect on invertebrate populations, there is every chance of rapid recovery. Mass mortality of one or more common species could have a more profound short-term effect through alteration of food chains. Loss of all or a large proportion of one or more rare species would be a more profound consequence, especially if that species were a poor colonist; complete or substantial loss of invertebrates over a wide taxonomic range would have the most profound consequences.

This report presents the findings of survey work to examine the impacts of rotenone application in 2005 on the invertebrates of selected ponds in Orton Pit SSSI. Investigation has taken the form of sampling the aquatic invertebrate fauna before and after treatment. Even such a simple basic method, however, leaves many possible combinations of methods and ponds which might be used for the work. It was considered best to examine a small number of ponds closely rather than a larger number superficially; and to restrict observations to two occasions: shortly before treatment, and sufficiently long after treatment for any impact to have been felt, and for any affected individuals to have died, or to have recovered. Rotenone is broken down rapidly in the environment, and a period of a week was considered sufficient to ensure that any impacts of treatment were fully felt. Reasons for this general approach are:

- The more complete the information on the fauna of a pond prior to treatment, the more likely it is that any effect can be detected, and that data gathered after treatment can be interpreted.
- The great variety of the ponds at Orton, in area, depth, vegetation and immediate surroundings, means that it is certain that there will be great variation in the fauna prior to treatment, and likely that there will be

considerable variation in the impacts of rotenone. Any measure of impact averaged over a substantial number of ponds would be likely to show great variation and any conclusions which might be drawn would be very generic. It is desirable, if possible, to gather sufficiently detailed data that impacts on individual ponds can be estimated.

- The important information to be gathered from a management and conservation viewpoint is whether there are significant overall losses as a result of treatment; it should not be the purpose of this study to add directly to the information on rotenone toxicity.
- There is no question of the potential effects of rotenone, or doubt that in principle it could kill any and all of the invertebrates in a pond. It can be regarded as more or less certain that there will be some invertebrate mortality as a result of applying rotenone to a pond at a concentration sufficient to kill fish. There is little to be gained by confirming this as a general point.
- It would be impossible from ordinary field techniques to get an accurate estimate of the proportion of any given species affected in the immediate aftermath of treatment: dead and moribund individuals will be captured at a different frequency from healthy individuals of the same species; it will not be possible to distinguish between individuals which will die and those affected but destined to survive; and dead individuals may be rapidly scavenged.
- Aquatic invertebrate populations are relatively stable at the time of year that treatment is proposed. Though adult insects may move between ponds in good weather, movement is probably fairly slight except in exceptionally warm conditions. Records made from a pond several days after treatment with rotenone should therefore be almost entirely of individuals which have survived the treatment. Certainly, in isolated ponds, any individuals unable to actively disperse by leaving the water must be survivors.
- Given that Rotenone treatment will be happening in subsequent years and there is therefore scope for altering and refining sampling in subsequent years in the light of the 2005 findings, it is desirable that work in 2005/6 gave a good feeling for the “natural history” of rotenone treatment, rather than merely statistics.

In practice, six ponds were examined: five which were treated with rotenone (24H, 24I, 36B, 40A, 41A), and one untreated pond (17F) which was used as a control.

A single pond can absorb a surprising amount of survey time if detailed information is sought. The amount of information gathered must be a compromise between the desire for data and the need to gather it in a reasonable time. The best option under the circumstances was considered to be to aim for:

- as complete as possible an inventory of the readily identifiable macroscopic aquatic fauna of the pond;
- a quantitative samples of the fauna that may enable estimates of any population change for at least the more numerous species.

Though any major change in the invertebrate assemblage in ponds of conservation importance is a matter of concern, impacts on uncommon species are greater significance than those on relatively common and widely distributed species, whose long-term recovery from any short-term impacts is reasonably certain. It is therefore desirable that groups of known conservation significance are particularly closely investigated. The most important single group of aquatic invertebrates currently known from the Orton ponds is the water beetles. Dragonflies form another significant group mentioned in the SSSI schedule, but there is no single species of very high importance; rather, it is the size of the assemblage which is important. The scarcest of the recorded species, the variable damselfly *Coenagrion pulchellum*, unfortunately cannot be confidently identified as a larva, so monitoring of impacts on this species would be difficult.

Before the ponds could be treated with rotenone, tall emergent and marginal vegetation was cut, and any substantial amounts of cut material in the ponds was dragged out onto the bank. Since this management could influence the distribution of the aquatic fauna and would certainly, at least in the more densely vegetated ponds, affect sampling, the "before" samples were taken after vegetation had been cut.

Methods

Inventory sampling

No sampling of any pond with a rich fauna will produce a complete species list. As a definable and reasonably achievable target for the preparation of an inventory for each pond, recording was as far as possible exhaustive for water beetles (i.e. recording continued until capture of new species has apparently ceased, and involved sampling of all habitat components within and at the margins of the pond) with all other readily identifiable invertebrates captured during the sampling also identified. The sampling method was as follows:

- each station for aquatic survey was sampled using a standard pond net of side twenty-four centimetres and mesh size one millimetre;
- water margins and dense vegetation in shallow water were sampled using a plastic sieve of seventeen centimetres diameter, with a mesh size of two millimetres (giving holes of approximately one millimetre);
- fine bare and thinly vegetated sediments were sampled using a small sieve, eight centimetres in diameter and with a mesh size of less than one millimetre;
- representative bulk samples obtained by the larger pond net were examined in the net and large and obvious animals extracted immediately;
- net samples from representative areas were spread on metal grids of mesh size 5 millimetres suspended over plastic trays, and active animals allowed to make their own way through the grid for approximately 15 minutes;
- material remaining in the sieve was then sorted for less active invertebrates, such as molluscs, and additional larger individuals unable to fit through the mesh of the grid;
- representative portions of the material from both the larger net and the sieve were immersed in water to encourage activity in those taxa, such as caddisflies, which are infrequent in sieve-sorted samples.

Sampling was continued until new discoveries had apparently ceased. Large and very distinctive taxa were noted in the field. Other field-sorted animals were preserved in

70% iso-propyl alcohol for later examination. Material extracted via the sieve was preserved in the field as a bulk sample for later sorting and identification.

No precise length of pond margin was used for sampling; sub-samples were taken from a number of points chosen both to reflect the character of the pond and to include the areas which seemed likely to hold the richest fauna.

The following invertebrate groups have been identified:

- Mollusca (water snails and mussels);
- Hirudinea (leeches);
- Larger Crustacea;
- Coleoptera (beetles);
- Diptera (flies – to family or genus only, except for Dixidae, Stratiomyidae, and a single distinctive species of Tipulidae);
- Ephemeroptera (mayflies);
- Hemiptera (bugs);
- Lepidoptera (moths);
- Megaloptera (alder-flies);
- Odonata (dragonflies);
- Trichoptera (caddisflies).

Note was also be made of the presence of Oligochaeta (and would have been for Hydracarina, had any been captured).

An estimate was made of the frequency of each recorded taxon in the sample from each pond. If only one or two individuals of a species were captured, the actual number was recorded. A three-point scale was used beyond this: occasional (3 - 10); frequent (11 – 100); common (more than one hundred). It would be useful in principle to add a further level of "abundant" for particularly numerous species, since the "common" category includes a very wide range of frequencies, but estimating numbers in the hundreds in the field was found to be effectively impossible.

Estimates of numbers are inevitably somewhat approximate, especially at the borderline between "frequent" and "common". Potential difficulty is posed by groups whose members are not readily distinguishable in the field, and one or more species of which is common in the samples. As far as possible, this problem was addressed by noting the overall number of the group seen, and taking for identification a sufficiently large sample that all or most of the contained species would be likely to be included, and their relative proportions in the sample give a good idea of the number of each present in the catch as a whole. There were, in practice, not very many cases where this occurred. Almost certainly, the greatest source of error in estimating abundance at the lower levels of the scale is simply failing to notice some individuals of some species, and at the higher levels making poor estimates of numbers of individual taxa amongst the general mass of material; under-estimates of frequencies are likelier than over-estimates. The abundance codes are intended to give only a general impression of relative frequency of the different species.

Quantitative sampling

Separate quantitative samples have been taken from the marginal area of each pond and from areas of deeper water. In each case the sample has been taken either from a precisely defined place or from a substantial area of homogenous character, selected as characteristic of the pond as a whole. Since the "before" and after" samples were taken by the same person with only a short period of time between the two, no significant difficulty was experienced in sampling from comparable areas in any given pond.

In deeper water, samples were taken by ten two-metre net sweeps taken while standing at a single point at the edge of the pond. The first sweep was taken at the maximum reach of the net, and successive sweeps were taken progressively closer to the bank until the last sweep approached, but did not reach, the marginal fringe. Each sweep was taken low in the vegetation, but as far as possible without dragging large volumes of vegetation out of the pond and always without digging into the substrate.

Marginal samples were taken over a two-metre stretch of margin. Twenty one-metre passes of the sieve were used to take each sample, ten over each of two adjoining metre lengths of the water's edge. Sampling extended from the extreme edge to 25 centimetres from the margin or a depth of approximately ten centimetres, whichever came first.

Each sample was emptied into a plastic tray. If a large volume of water was included, excess was decanted through a fine sieve. Any very large pieces of vegetation were rinsed, checked for attached invertebrates, and removed, as were any hard or sharp pieces of debris which might puncture polythene bags. The remaining material was placed in a self-sealing polythene bag, together with a label on waterproof paper, and preserved immediately.

The selection of ponds for sampling

It was considered desirable at the outset to examine as wide a range of ponds as possible. The available range was very large. However, two categories of ponds were avoided: large, and especially very deep, ponds were avoided because of the relative difficulty of gathering a meaningful sample of the fauna for inventory purposes; the densely vegetated ponds of Area H1 were avoided because the extent of change and disturbance produced by management of the marginal and emergent vegetation was sufficiently great that it was considered possible that this management alone might significantly affect the aquatic fauna. The treated ponds finally selected are all in Area H2; the control pond (17F) is in H3. The treated ponds selected for survey are: 24H, 24I (adjoining ponds, but very different in character, the former rather deep and steeply shelving with local shallow shelves, the later shallow and with dense emergent vegetation); 36B, a pond with both a shallow area with considerable emergent growth and a deeper area with a more restricted marginal fringe; 40A, a narrow well-vegetated basin with an associated area of flooded grassy vegetation; 41A, a pond with dense submerged macrophytes, especially *Potamogeton coloratus*, but little emergent growth. These ponds have been selected for variation in density and character of vegetation, and in depth. In these respects they offer a considerable range of character. They are recognisably similar to one another in general character, but no more so than most of the pools in the SSSI.

Survey timetable

"Before" samples

1 November: 26H, 26I, 40A, 41A
16 November: 17F, 36B

"After" samples"

31 December: 36B, 40A, 41A
1 January: 17F, 26H, 26I

Constraints and limitations of the survey work

Any work undertaken over the period from late autumn to winter runs the risk, whatever the timescale, that changing weather conditions will affect the fauna. The temperature inevitably affects the behaviour, and hence the recordability, of species, especially if they enter hibernation or retreat to hiding places in periods of particular cold. The distribution of cold weather over the survey period was particularly inconvenient. There were two brief periods of particularly cold weather: the first coincided exactly with the beginning of Rotenone treatment; the second almost immediately followed the end of the treatment. Thus all "before" samples were taken before there had been any very cold weather. The "after" samples were taken after either one or two periods of intense cold. Both cold periods were relatively brief, but they were sufficiently intense to produce thin ice. There are inevitably impacts from this, and the inevitable changes make the interpretation of the results more difficult than would otherwise have been the case.

The survey work has examined only the immediate impact of rotenone application on the invertebrates of the ponds. There are other possible impacts, of uncertain significance. The preparation of the ponds for Rotenone application involved cutting emergent and marginal vegetation. In shallow and densely vegetated ponds, such management has a considerable effect on the habitat structure, light penetration and shelter. There are possible impacts on many elements of the fauna. In particular:

- cutting the plants will affect the fauna associated with the emergent vegetation itself, especially any species spending the winter months on or within the plant stems;
- cut material spread on the ground close to the pond margin may greatly increase the amount of plant litter, and affect the ground-dwelling and near ground-dwelling fauna in the area;
- cut material in the ponds can accumulate, especially floating material drifting into parts of the margins, and may affect the habitat in these areas sufficiently to alter the fauna;
- diminished shelter over the winter and into the spring, until the vegetation regenerates, may affect species overwintering in the shallow water or marginal fringe;
- increased light penetration in the spring may affect the species of both aquatic and marginal wetland species which survive or colonise.

Impacts on those elements of the aquatic fauna sampled during this survey are likely to be transitory for the ponds examined: vegetation is likely to recover quickly and plant debris will probably decay quite rapidly, and is of a kind always present in the ponds. Sampling in 2005/6 avoided the ponds where vegetation structure was most profoundly affected by preparation work, because the extent of disturbance involved seemed likely to be sufficient to directly affect the fauna. In some of these ponds, recovery may be slower and the faunal change greater.

Survey work covered only the aquatic fauna (more precisely, the fauna collected by pond-net: there is no actual separation between aquatic and non-aquatic invertebrates, and the division is usually made according to the methods used to collect them). However, rotenone also has the potential to affect terrestrial and semi-terrestrial species in the marginal fringe, and management of the vegetation prior to Rotenone treatment certainly will. The reasons for not examining the terrestrial fauna are first, the considerable additional time and effort that would be needed to do so, but overwhelmingly the fact that in autumn there is rather little of this fauna present to sample. This lack of marginal invertebrates may reduce the impact: some species are hibernating in terrestrial situations some way from their summer breeding grounds. Other species, however, overwinter as larvae or eggs in the marginal sediments, in plant litter, or in plant tissues, and these could be affected. These immature stages are mostly not readily collectable or not readily identified. If the marginal wetland fauna were to be investigated, survey would have to compare the fauna in the summers before and after rotenone application.

Identification of aquatic groups has been somewhat selective. This has been in part forced: some of the groups captured cannot at present be identified to species in the stages captured. Some groups could certainly, in principle, be identified further, but are taxonomically difficult and would require specialist identification. It is likely that, after the water beetles, the most important group of invertebrates potentially affected by water-borne toxins will be flies whose larvae develop in aquatic conditions, often the sediments and plant litter in the shallows and margins. Some interest is already known amongst such flies, and much more is likely, to judge from other brickpit sites. However, most such flies cannot be identified to species as larvae, many not beyond family; and conventional aquatic sampling methods are generally inefficient in capturing them. Collectively, these considerations mean that it is likely to be impossible to be certain of impacts based on aquatic sampling, though a major change in the numbers of Diptera larvae may be detectable. Sampling of adult flies, again in the summers before and after treatment, would be needed to investigate impacts in more detail. Because adult flies may readily colonise ponds, survey of adults would not necessarily be very informative as to mortality caused by rotenone. Emergence traps set over marginal vegetation and sediments in the summers preceding and following rotenone treatment could gather informative data, but present technical and methodological problems.

Survey work has covered only macroscopic invertebrates. These include the groups of known conservation concern in the reserve, and restriction to such groups is conventional in general surveys of aquatic invertebrates for conservation purposes, at least in Britain. However, rotenone is known to kill zooplankton, and the effects on populations of Cladocera, in particular, can be fairly long-lasting. It is possible that uncommon species of micro-Crustacea and other small organisms occur in the ponds and might be adversely affected by rotenone treatment. Considerable specialist baseline survey of the ponds would, however, be needed to address this issue. Of more immediate concern is that major impacts on micro-organisms might have a delayed effect on the macro-organisms of conservation concern. Such effects would be detectable only later in the year.

Invertebrates, as well as amphibians, are affected by fish predation. There are potential benefits to invertebrates in the longer-term from removal of fish by rotenone treatment. Admittedly, rich and important invertebrate assemblages often co-exist with sizeable populations of sticklebacks, and it is clear that the numbers of sticklebacks in the ponds surveyed at Orton in 2005/6 were not preventing the presence of a substantial number of species of invertebrates. Additionally, amphibians may also be significant predators of invertebrates. There is thus no strong reason to assume very great benefits. Nonetheless, only survey in future years would be able to determine the long-term effects of fish removal.

Survey findings

Presentation of records

The detailed findings are presented in Appendix 1 (inventory samples) and Appendix 2 (quantitative samples). These appendices include complete species lists for all samples, estimates of abundances of species from inventory sampling, and counts from quantitative sampling. Several summary figures are also included.

For the inventory survey, these are: the total number of taxa recorded in each sample, and the percentage change in number of taxa between the two samples from each pond; the total number of water beetle species recorded in each sample, and the percentage change between the two samples from each pond; the total number of taxa, excluding adult water beetles, recorded in each sample, and the percentage change between the two samples from each pond; and for each sample a faunal quality score and faunal quality index intended to provide a measure of the conservation value of the assemblage recorded on each occasion. Each of these statistics is also provided for the total lists summed over all the treated ponds.

For the quantitative samples, figures calculated are: the number of taxa in each sample, and the percentage change between the two samples from each sample station; the number of taxa, excluding adult water beetles, from each sample, and the change between samples; the number of individual invertebrates captured in each sample, and the percentage change between samples from each sample station. The methods of calculating the faunal quality score and faunal quality index are given in Appendix 4.

The character and quality of the aquatic invertebrate fauna of the ponds

The ponds proved to contain a good and representative section of the Orton Pit SSSI aquatic invertebrate fauna. A total of 123 mutually exclusive taxa were recorded. These include five Red Data Book and seventeen Nationally Scarce species, collectively comprising 17.9% of the total taxa recorded and 20.9% of those identified to species. This is a high value, consistent with the known high quality of the Orton Pit invertebrate fauna. Notes on the Red Data Book and Nationally Scarce species recorded are given in Appendix 5.

The greatest richness of species is amongst water beetles, of which 57 species were recorded in all, but mostly in small numbers. Numerically, the samples are variously dominated by water-lice (*Asellus aquaticus*), freshwater shrimps (*Crangonyx pseudogracilis*), mayflies (mostly *Cloeon dipterum*) and fly larvae (especially Chironomidae, Limoniidae and Psychodidae). In deeper and more open water water-boatmen (especially *Hesperocorixa linnaei*) are sometimes very common, and the surface layers of the sediment often contain large numbers of pea mussels (*Pisidium* sp(p)). Water snails are interestingly scarce in the samples. Only four species in all were recorded, two of these from only a single pond each. None was found in large numbers in any sample, and no ramshorns (Planorbidae) or bithynias (Bithyniidae) were recorded. Other interesting absences are flatworms, of which none were seen, and leeches, of which only one individual (*Theromyzon tessulatum*) was captured.

The control pond, 17F, was chosen because it appeared to be of high invertebrate potential, showed a wide range of conditions, and was thought likely to support a rich fauna, similar in character to that of the treated ponds and including a large proportion of the species recorded elsewhere. In practice, it has proved to be amongst the more species-poor of the ponds sampled, and to be something of a curiosity in that it is the only pond examined in which no water snails of any species have been captured. The absence of snails is essentially an extension of the generally snail-poor condition of the other ponds, but it is unfortunate that the control pond should be the most extreme example. It remains possible that some are present, but at very low density. Despite these reservations, it was an appropriate control pond inasmuch as of the 60 taxa recorded from it, only one, the water beetle *Enochrus melanocephalus*, was definitively absent from samples from the treated ponds.

Despite being selected for variety, all the ponds supported assemblages of invertebrates recognisably of broadly similar character and with wide overlaps in the more numerous species found. Nonetheless, of the 122 taxa recorded from the treated ponds, only 26 (21.3%) were recorded from all five ponds, and these include several very broad taxonomic categories; 41 taxa were recorded from only a single one of the treated ponds.

Differences between the "before" and "after" samples

There is a general decline in all measures of invertebrate diversity and interest in sampled invertebrates in the treated ponds between the two visits. Amongst inventory samples, those taken on the second visit recorded an average of 32.6% fewer taxa than those on the first, with reductions in individual ponds ranging from 25.4% to 39.5%. The reduction in number of taxa was noticeably great amongst water beetles, where the reduction averaged 49.8%, with a range of 37.9% to 63%. The Faunal Quality Scores for individual samples fell roughly in line with the reduction in taxa. The Faunal Quality Indices are all less on the second visit than the first, but the differences are sometimes small. Quality Scores for beetles alone also show, not surprisingly, a substantial and invariable decline between visits, but though the Quality Index for water beetles shows a general decline, in Pond 36B it is slightly higher on the second visit than the first. Quantitative samples show the difference in the fauna between the two visits to be greater in the marginal fringe than in deeper water. The number of taxa recorded declined by 44.4% in the marginal samples, and by only 26.7% in samples from deeper water. The difference in the number of individuals recorded varied considerably between ponds, but in the deeper water samples from the treated ponds, three of the five samples recorded a greater number of individuals on the second visit than on the first, the average change being a decline in numbers of 1.9%. In the marginal samples, however, only one pond (24I) showed an increase in numbers between the two visits, and this appears to be the result of an anomalously low number of individuals recorded in the first sample. The small catch on the first visit probably reflected the real situation, since it was noted while collecting material for the inventory survey that the margins were very unproductive. This pond had the greatest density of emergent vegetation, and was therefore the one most likely to be affected by vegetation management prior to treatment. It may be that the marginal fauna was genuinely rather poorly developed because of the extent of marginal shade and the widespread presence of swamp conditions prior to management, and that the increased number of individuals recorded on the second visit reflects a shift in the distribution of the fauna in response to changed vegetation structure. Whatever the cause, the increased in abundance is not a great one, and even with this sample included in the figures, the average change in the number of invertebrates recorded in the marginal samples is 56.4%.

Examination of the summed results from the treated ponds shows that a total of 42 mutually exclusive taxa were recorded on the first visit but not the second. This compares with only six taxa recorded on the second visit, but not the first. A substantial proportion of these taxa were only ever recorded in small numbers: twenty were only recorded from a single pond; 28 were recorded as no more than two individuals in any given sample. Twenty-five of the 41 taxa are water beetles.

Though these changes are substantial, they are mirrored in changes in the control pond, 17F. This pond, too, shows a reduction in the numbers of taxa recorded overall, and in numbers both of taxa and individuals in deep and shallow water, with particularly great losses in the marginal fauna and amongst water beetles. In quantitative samples, the changes in the number of taxa recorded (-12.0% in deep water samples, -38.9% in marginal samples) and in the number of individuals recorded (-30.3% in deep water samples, -69.5% in marginal samples) falls within the range recorded for the treated ponds. In inventory samples, however, the declines in the total number of taxa recorded (21.3%) and in number of water beetle species recorded (32.1%) are less than in any of the treated ponds, and though the Faunal Quality Score is substantially lower for the sample on the second visit, the Quality Index is somewhat higher, a phenomenon seen in only one of the treated ponds. The differences between the figures from the control pond and the lowest figures for change in the treated ponds are, however, quite small.

Data from the samples thus suggests that there was a general decline in the number of taxa of invertebrates in the ponds, and in the abundance of invertebrates in the marginal fringe, between the two visits, irrespective of whether the ponds were treated with rotenone. The figures suggest that the effect may have been greater in the treated ponds than in the control, but the variation in the results from the treated ponds, coupled with the small difference between the figures from the control pond and some figures from the treated ponds, this is uncertain. Except in a small number of respects, discussed below, the changes in the treated ponds are similar in type to those seen in the control.

The possible effects of cold weather

A significant proportion of aquatic and semi-aquatic invertebrates spend the winter away from the water. This especially applies to semi-aquatic bugs and many water beetles. For some species the removal to hibernation sites is invariable. All pond-skaters (Gerridae), for example, disappear from the water surface in the autumn. For others, the situation is less clear-cut. Amongst various species of water beetles, some individuals leave the water in the winter, while others remain. Overwintering insects may simply walk to the nearest good cover, or may fly longer distances. Lists obtained in late autumn or winter are therefore always incomplete, and the numbers of individuals of particular species captured at these times may not accurately reflect their abundance in the preceding or following summers.

The first samples in this survey were taken late in the year, when temperatures were consistently low, the pond faunas would be expected to have largely settled into a winter mode, and dispersal by flight would be out of the question. Nonetheless, it appears that a proportion of the hibernating fauna had not yet left the ponds. The pondskaters *Gerris lacustris* and *G. odontogaster*, for example, were each recorded in small numbers, each from a single pond. In summer, one or both of these species would be expected to occur on every pond on the site containing a significant area of open water. Most must therefore have left, but a few remained. The same applies, to a less certain extent, to the water beetles. Certainly, many individuals remained of species which could hibernate out of the water. Some of those recorded were almost certainly, like the pondskaters, the few remaining individuals of species which had mostly already left the water – the few individuals captured of the common *Helophorus minutus*, for example.

It seems certain that more individuals, and the entire remaining populations of some species, left the ponds between the first and second sampling visits. The rather sudden cold snap experienced in late November was sufficiently abrupt that it may have killed some individuals remaining in, and closely tied to, the water margins. For those – probably most – which survived, this may have been the final trigger to leave the water. In the treated ponds, such voluntary departures and cold-related mortalities cannot be distinguished from mortality due to rotenone treatment. The greater loss of water beetles from treated ponds than from the control pond suggests the possibility that the treated ponds may have experienced additional loss as a result of rotenone treatment. However, not only is the evidence far from conclusive, but it must also be borne in mind that even if losses from the sampled fauna did occur as a result of rotenone treatment, they are not necessarily the result of mortality. A facultative hibernator may respond to respiratory stress induced by rotenone treatment by leaving the water, and may then seek a terrestrial hibernation site. Assuming they find successful hibernation sites, such individuals are likely to return to the pond in the spring.

Evidence for facultative terrestrial hibernators affected by rotenone treatment can only be sought by comparing treated ponds with the control. In practice, the only species for which there is any indication of a possible impact is *Ilybius quadriguttatus*. This beetle was recorded from three of the five treated ponds on the first sampling occasion, and from the control pond. It was found again in the control pond on the second visit, but in none of the treated ponds. The numbers involved are small, with a maximum of two individuals recorded from any sample, so the results are far from unambiguous.

This is, however, a species which regularly hibernates well away from its breeding sites, but, at least in southern counties, can usually be found throughout the winter in water in sites which have not deeply frozen.

The onset of very cold weather is also likely to be responsible for the disproportionate loss of invertebrates from the pond margins. The November cold period was sufficiently intense to produce shallow freezing, and this would be expected to impinge particularly on the marginal fringe and very shallow water. A large proportion of the lost water beetles are predominantly marginal and shallow water species. Many active invertebrates are likely to have descended into deeper water in response to cold surface conditions.

Do these considerations and uncertainties leave any species for which the records might be examined for the impact of rotenone application? If we remove from consideration those species which may have left the water but survived, and those species recorded from only one or two individuals, which must be considered sufficiently scarce that they might be missed by sampling even if still present, there are very few indeed. Only three taxa call for closer examination: the caddisflies *Agrypnia varia* and *Limnephilus* sp(p). (possibly all *L. marmoratus*) and larvae of the water beetle genus *Ilybius*. Of these, *Agrypnia varia* stands out as being of particular significance because of the exceptional nature of the evidence for the impact of rotenone.

The caddisfly Agrypnia varia

Agrypnia varia larvae were captured in all ponds prior to rotenone treatment, and were judged to be frequent or common in three of the treated ponds and in the control pond. On the second visit, healthy larvae were found to be still frequent in the control pond, but the treated ponds contained only dead larvae. These were conspicuous in the samples because the majority of larvae were large and had left their cases (a common response to environmental stress), exposing the white abdomens. Though a week or more had passed since rotenone treatment, and though some had brown areas indicative of bacterial decay or were invaded by fungal hyphae, a large proportion of the larvae were, on superficial examination, unaffected by decay and showed no sign of attack by scavengers. This was surprising, because these soft-bodied insects usually decay quite rapidly after death. Dead sticklebacks, captured incidentally in the ponds during sampling, were conspicuously more decayed than the *Agrypnia* larvae. The condition of these larvae was so good that it seemed possible that they were not in fact dead, but merely immobilised. It remains possible that this was so, but a number of larvae taken away for further examination and placed in clean water at ambient outside temperatures began to decay within a day or two, so it seems likely that, if they were indeed merely immobilised, this was an immobilisation leading to eventual death. Another possibility is that death in these insects was delayed, so that they were freshly dead at the time of survey even though some days had elapsed since the application of rotenone. More likely is that the cold water simply delayed decay in definitively dead insects, but why it should have done so with such effectiveness in this particular species is not clear.

The mortality of *A. varia* appeared complete. A considerable number of larvae were examined overall, and none were found to be alive. Of course, only a small proportion of the total population of any pond was examined, and no doubt dead larvae are easier to catch than live ones, so the possibility of survivors cannot be ruled out. Any such survivors are perhaps most likely to be amongst smaller larvae, a greater proportion of which will have been missed during examination of the samples, especially if they remained within their cases. Even if some larvae survived, a large proportion of the population was certainly killed.

The good condition of the dead *A. varia* larvae has necessitated the making of assumptions in recording the contents of the quantitative samples. Because these were preserved without prior examination of the catch, it is impossible to distinguish between animals which were fresh and undecayed at the time of capture and those which were still alive. It was precisely to avoid such ambiguities as this that the second samples were taken a significant period after rotenone treatment. The assumption has been made that all *A. varia* larvae found in the quantitative samples were in fact dead when captured, but there can be no guarantee that this is so. Equally, it is possible that the assumption that individuals of all other species in the quantitative samples which were reasonably intact and undecayed when examined were alive at the time of capture. This is based on extrapolation from observations made during inventory survey, which found no dead individuals of any of these species, but live individuals of most of them.

The possibility of significant impacts on other species

In light of the large and unambiguous mortality of *Agrypnia varia* after exposure to rotenone, the most obvious place to look for other indications of significant impacts is amongst other caddisflies. Only four species are certainly identified from the samples. Of these, the caseless caddis *Holocentropus picicornis* was captured in small numbers in a single pond; some at least survived treatment. The leptocerid *Athripsodes aterrimus* was found in all but one of the ponds in consistently small numbers and the records show no evidence of a decline. Small larvae of a species of *Limnephilus* were recorded in four of the treated ponds and in the control pond on the first visit. These small larvae were not identifiable to species, but a small number of large larvae belong to the same species-group, from ponds 17F and 36B, were identified as *L. marmoratus*. All the larvae may well be of the same species, but other members of the species-group are common and could be present. In the control pond larvae were common on the second visit as well as the first, and in quantified samples the numbers of individuals captured was higher on the second than on the first visit, both in deep water and, surprisingly, at the margins (though in the latter case the numbers were small and the difference between the first and second samples only a single individual). In all the treated ponds, estimated frequency from the inventory survey was lower on the second visit than on the first. Larvae were captured at six sample stations on the first visit. On the second visit, sampling recorded no larvae at all at four of these sample stations, a considerably reduced number at one (from 14 to 8), and an increase at another (from 3 to 5). Empty cases were found on the second visit, but were also found on the first visit; because empty cases tend either to fall to the sediments or float and drift, depending on their construction materials and age, recording of the numbers of empty cases is not likely to be very informative. The overall general decline in numbers captured in the treated ponds, and the contrasting situation on the control pond, suggest probable decline. It is worth noting that though some individuals of *Limnephilus* sp. certainly survived treatment, inventory survey recorded only a single live larva from the treated ponds on the second visit. It is conceivable that some of the larvae found in quantitative samples were dead before capture.

A single additional taxon may be singled out for further discussion: *Ilybius* sp. larvae (Coleoptera, Dytiscidae). The quantitative samples give no strong indication of decline. The numbers captured in quantitative samples were small, and though six were captured before treatment as compared with three after this difference in not numerically great. However, this taxon was captured in all of the ponds prior to treatment, and was assessed as frequent in four of them. After treatment, the assessed abundance in the control pond had increased (from occasional to frequent) whereas in all the treated ponds in which it was formerly recorded as frequent it had either declined to one or two captured individuals or was not found at all. This was also the only taxon, apart from *Agrypnia varia*, in which recently dead individuals in the early stages of decay were found (though only a single larva, in the quantitative sample from 36B). Again, this consistent decline in the treated ponds, contrasted with an apparently thriving population in the control pond, suggests the possibility of a significant mortality due to rotenone.

It is possible that other significant mortalities are undetectable amongst the species for which there are few records, hidden in groups not identified to species, or included amongst the species currently presumed to have taken refuge beyond the reach of the sample net, and more likely that limited mortality has taken place amongst other taxa. Overall, however, the impression gained from the figures, and from sampling in the field, is of high rates of survival and limited impacts. The numerically dominant species in the pools have survived, if not necessarily unscathed, then at least in sufficient numbers that any losses are not immediately apparent and to ensure that there should be rapid recovery from any losses. The general character of the invertebrate fauna of the pools remains largely unchanged.

Conclusions

A starting point in considering the survey work in 2005 was that some invertebrate mortality was probably inevitable as a result of rotenone treatment, but that this would be a matter of practical concern only if it were very large, had a serious effect on uncommon species, or were likely to disrupt the usual functioning of the invertebrate communities. The evidence from the 2005/6 survey suggests that mortality has been selective, most severely felt by common species, and generally of a sufficiently limited extent as to leave the basic character of the invertebrate assemblages of the ponds unchanged. Most of the commoner species either appear unaffected or remain in sufficiently large numbers that any losses should be rapidly made up. There is a suggestion of complete or almost complete loss for only a single species, and this is a common one, probably present in a large proportion of pools on the reserve, which should rapidly re-colonise.

Despite these generally optimistic conclusions, there remain ambiguities and uncertainties. There is an untested assumption of the survival of many adult water beetles; uninvestigated impacts on the planktonic and microscopic fauna might be important in themselves, but could also have significant longer-term effects on the macroscopic fauna; and there could be hidden impacts on groups which were not identified to species or which live beyond the reach of the sampling methods employed. Some of these unknowns can be investigated by follow-up surveys of the treated ponds. Spring survey would determine whether the “lost” species of water beetles return and would provide an opportunity to look for survivors of the most severely depleted taxa. In the case of water beetles it will not be possible to distinguish survivors from new colonists, but if the assemblage returns to its former state without even an intervening breeding season to boost numbers, this is arguably not a matter of great concern. Autumn survey would enable detection of any major changes over the course of a year which might be caused by unseen changes in the microscopic components of the fauna, and if possible impacts were found, follow-up surveys in subsequent years could be used to track recovery time. The possibility of impacts on species and habitats not specifically examined in 2005 can only be investigated by additional, and different, surveys.

Finally, there must be a caveat on the conclusion of limited demonstrated impact. If, as seems possible, rotenone use in the Orton Pit ponds has a particularly severe effect on cased caddises of the Phryganeidae and Limnephilidae, this is potentially a concern if the ponds support scarce species of these groups. It should be emphasised that this is an entirely hypothetical concern. There is no evidence at present that any caddisflies of significant conservation concern occur on the reserve, or indeed in the brickpits generally, and no obvious reason to think it likely that such species occur. The caddisfly fauna of the ponds investigated for the present study seem rather poor. However, this is not an especially well-surveyed group in the area, and a possibility of interest remains.

Implications for future survey work

The timing of the survey was based around the time of treatment of the ponds. This seems logical: it makes it possible to investigate the immediate consequences of treatment. However, the time selected for treatment is a relatively poor time for survey of invertebrates, and the findings have proved liable to be affected and confused by weather. It might be better to undertake survey work at peak times for survey work (spring or early autumn), even if this is far removed from the times of rotenone treatment. The disadvantages of sampling at these more distant times are that: the samples will be taken before vegetation management, and any impact this has will not be separable from the effects of rotenone; the fauna could change for reasons other than rotenone treatment, and such changes will not be separable; and that if the “after” samples are delayed until the following spring, it will not be possible to distinguish survivors of rotenone treatment from new arrivals.

The first of these concerns could be addressed to a significant effect by careful selection of ponds for survey. For a large proportion of the ponds treated in 2005 the changes in vegetation would be unlikely to affect the aquatic invertebrate fauna. Where vegetation management is likely to have a significant impact, this is arguably worthy of separate and specific investigation anyway (see below), but if vegetation management is an integral part of rotenone treatment, then there is nothing fundamentally wrong in looking at the combined impacts of vegetation cutting and rotenone treatment. Clearly, though, it would be more satisfactory if the impacts of the two could be separated.

The possibility of faunal change between sampling and treatment is a real one. It is most likely to occur as a result of weather – either unusually wet conditions or unusually dry conditions would be likely to affect the ponds and their fauna. The effects of such phenomena will be widespread, however, and it should be possible to address them through the use of control ponds. Though there remains a possibility of change for other reasons, it may be no greater than the danger of change for reasons of temperature and weather in samples taken in the late autumn and winter. The problem posed by colonisation cannot be solved in any simple way. Arguably, though, from a practical point of view it is of slight importance where the fauna comes from, so long as it is established. If the invertebrate fauna of a pond is able to demonstrate, by the late spring following the year of treatment, a fauna similar in composition to that held in the spring prior to treatment, exactly where the elements of that fauna came from is of little consequence.

The quantitative samples have been of value chiefly for providing well-preserved material of small and inconspicuous invertebrates which might otherwise be missed or under-estimated. It is clear from examination of the estimates of abundance in the inventory lists and the numbers of individuals captured in the quantitative samples that the abundances of some species were significantly under-estimated in the field. Though they provide an interesting overall indication of overall relative frequencies of different species and of changes in the numbers of some, it is apparent that the numbers are prone to be seriously affected by anomalous figures resulting either from concentrations of particular species or from vagaries of sampling. The taking of samples of this type is considered useful in aiding the generation of good inventory samples, and should continue as a subsidiary sampling method, but it should not be hoped that these samples will provide useful data for analysis in their own right.

Some currently uninvestigated aspects of the possible impacts of rotenone treatment are arguably worthy of examination. Of particular interest are the effects on the marginal fauna, both ground-dwelling and on vegetation, of vegetation cutting, rotenone poisoning of the sediment/plant infauna, and raking of cut material onto marginal areas. It seems likely, by implication from the finding of limited impacts of rotenone treatment on the aquatic invertebrate fauna, that in heavily vegetated ponds the effects of cutting and raking will be greater than those of chemical treatment. These aspects could be simply investigated by sweep-netting, suction sampling and pitfalling to investigate the fauna in the summers before and after treatment. A thorough examination of the fauna and any impacts would be time-consuming and expensive, but the areas involved are small, and by selection of groups to be examined, restriction of survey to a limited period, and emphasis on active collecting methods rather than trapping (which can involve rather time-consuming sorting of catches), it should be possible to generate at least a broad indication of the effects and possible implications on one or two selected ponds.

There is potential value in follow-up surveys of treated ponds. Some aspects of this, essentially to tie up loose ends from the existing survey data, have been considered in the Conclusions section, above. Continued survey beyond the first year after treatment might enable detection of longer-term changes in the aquatic invertebrate fauna resulting from the removal of predatory fish.

Appendix 1 Inventory samples

17F is the control site; the remainder of sample ponds were treated with rotenone

b before rotenone application
a after rotenone application
For the control pond, these refer to samples before and after application of rotenone to all treated ponds

Taxa recorded from treated ponds only before rotenone application
Taxa recorded from treated ponds only after rotenone application

Definitions of the status categories used are given in Appendix 3.

Frequency codings:
1,2 actual numbers captured
o 3 – 10
f 11-100
c 101+
+ recorded in quantitative samples
* recorded only as dead individuals (or individuals believed to have been dead)

Taxon	**Status**	**17F**		**24H**		**24I**		**36B**		**40A**		**41A**		**Total hits**	
		b	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**
Mollusca															
Hydrobiidae															
Potamopyrgus antipodarum	c					1	+	f	o	1	1			**3**	**3**
Lymnaeidae															
Galba truncatula	c											1	2	**1**	**1**
Lymnaea stagnalis	c					o	1							**1**	**1**

Taxon	Status	17F		24H		24I		36B		40A		41A		Total hits	
		b	a	b	a	b	a	b	a	b	a	b	a	b	a
Radix peregra	c			o	o	f	f	o	f	o	c	o	o	**5**	**5**
Sphaeriidae															
Musculinum lacustre	c	1		2	+									**1**	**1**
Pisidium sp.		c	f	f	f	c	f	c	f	f	f	o	o	**5**	**5**
Hirudinea															
Glossiphoniidae															
Theromyzon tessulatum	c	1										1		**1**	**0**
Oligochaeta				+									1	**1**	**1**
Crustacea															
Asellidae															
Asellus aquaticus	c	c	f	c	f	c	c	c	c	c	c	c	c	**5**	**5**
Crangonyctidae															
Crangonyx pseudogracilis	c	f	f	f	o	c	c	f	c	c	c	c	c	**5**	**5**
Gammaridae															
Gammarus pulex	c	f	o					o	f					**1**	**1**
Araneae															
Cybaeidae															
Argyroneta aquatica	l	c	f	f	f	c	f	f	f	f	f	o	o	**5**	**5**
Coleoptera															
Curculionidae															
Stenopelmus rufinasus	l					1								**1**	**0**
Dryopidae															
Dryops luridus	c	o	1	o	o	f	1	o	1	+		o		**5**	**3**
Dryops sp. female		o	+	o	2	f	o	o	1	+	1	o	2	**5**	**5**
Dytiscidae															
Agabus didymus	l	1													
Agabus nebulosus	c		1							1	1			**1**	**1**
Colymbetes fuscus	c					o	1	1					1	**2**	**2**

Taxon	Status	17F		24H		24I		36B		40A		41A		Total hits	
		b	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**
Copelatus haemorrhoidalis	I					o			1	f	o	1		**3**	**2**
Graptodytes granularis	LRnsB			2	o	2						o	2	**3**	**2**
Graptodytes pictus	I	f	2	f	o	f	2	f	f			f	o	**4**	**4**
Hydroglyphus geminus	LRnsB	1								2		1		**2**	**0**
Hydroporus angustatus	c			1										**1**	**0**
Hydroporus memnonius	c									1				**1**	**0**
Hydroporus palustris	c							+					1	**1**	**1**
Hydroporus planus	c	2				o				o		1		**3**	**0**
Hygrotus impressopunctatus	I	1				2		1		o	1	1		**4**	**1**
Hygrotus inaequalis	c	o	2	o	2	o	o	f	f	o	o	o		**5**	**4**
Hyphydrus ovatus	c		1	o		1	2	o	2			+		**4**	**2**
Ilybius quadriguttatus	c	2	2	2		2				1				**3**	**0**
Ilybius sp. larvae		o	f	f	2	f	2	f	*	1	1	f		**5**	**4**
Laccophilus minutus	c										+	2		**1**	**1**
Porhydrus lineatus	I	1		2		f	2	1	1					**3**	**2**
Rhantus grapii	LRnsB									+				**1**	**0**
Rhantus suturalis	LRnsB	1	2	1	1								+	**1**	**2**
Rhantus sp. larvae			2											**0**	**0**
Gyrinidae															
Gyrinus distinctus	LRnt			o										**1**	**0**
Gyrinus paykulli	LRnsA			o		1								**2**	**0**
Haliplidae															
Haliplus confinis	c	o	1	1	o	f			o					**3**	**1**
Haliplus immaculatus	c			o				1				1		**3**	**0**
Haliplus lineatocollis	c	1		1						f				**2**	**0**
Haliplus obliquus	I	o	2	o	1	f	2	f	o	o			1	**4**	**4**

Taxon	Status	17F		24H		24I		36B		40A		41A		Total hits	
		b	a	b	a	b	a	b	a	b	a	b	a	b	a
Haliplus ruficollis	c			f	1	o	o	o	1	f	o	o		**5**	**4**
Haliplus ruficollis grp. ▯		+	o	f	2	+		o		o	+			**4**	**2**
Haliplus sp. larvae		2	2	2	1	+		+	1	2	+			**4**	**3**
Hydraenidae															
Hydraena riparia	I	1						o						**1**	**0**
Hydraena testacea	LRnsB			o				2						**2**	**0**
Limnebius nitidus	LRnsB	o	1	o	+	o	o			o		o		**4**	**2**
Limnebius papposus	LRnsB	o		o	1	1				f				**3**	**1**
Ochthebius dilatatus	I							o		1		1		**3**	**0**
Ochthebius minimus	c	o		1		f		1		f		o		**4**	**0**
Ochthebius pusillus	LRnt									1				**1**	**0**
Hydrochidae															
Hydrochus carinatus	VU											1		**1**	**0**
Hydrochus ignicollis	VU			1		1						2		**3**	**0**
Hydrophilidae															
Anacaena bipustulata	LRnsB	o	+	1	1	o		2		1		o		**5**	**1**
Anacaena globulus	c									2	+			**1**	**1**
Anacaena limbata	c	2		o	2	o		o		o		o		**5**	**1**
Berosus affinis	LRnsB	1	+				2	o				o		**2**	**1**
Berosus luridus	LRnt					o	2	o	+					**2**	**2**
Berosus signaticollis	LRnsB										1			**0**	**1**
Cymbiodyta marginella	I					+								**1**	**0**
Enochrus coarctatus	I	1	2	o	o	1		2	o	o		1		**5**	**2**
Enochrus halophilus	LRnsA	o								2				**1**	**0**
Enochrus melanocephalus	LRnsB		1											**0**	**0**
Enochrus testaceus	c	o	1	2	o	o	f	o	o	o	2	o	1	**5**	**5**
Helochares lividus	I					o						f		**2**	**0**

Taxon	Status	17F		24H		24I		36B		40A		41A		Total hits	
		b	a	b	a	b	a	b	a	b	a	b	a	b	a
Helophorus minutus	c	1				o				o				**2**	**0**
Hydrobius fuscipes	c	o				1				o				**2**	**0**
Laccobius biguttatus	I	+	1	1										**1**	**0**
Laccobius bipunctatus	c			o	2	f	1			f	1	o		**4**	**3**
Laccobius minutus	c					+								**1**	**0**
Noteridae															
Noterus clavicornis	c	f	o	f	f	c	f	f	f	f	f	c	f	**5**	**5**
Noterus sp. larvae				+					+	+	1			**2**	**2**
Scirtidae															
Cyphon sp.		f	o	o	1	o	o	o	o	o	o	f	2	**5**	**5**
Diptera															
Ceratopogonidae						1								**1**	**0**
Chaoboridae															
Chaoborus crystallinus	c	1	o						1		1			**0**	**2**
Chironomidae		f	f	f	o	c	o	f	f	f	f	f	o	**5**	**5**
Culicidae															
Coquilletidia richiardii	c					+	+				1			**1**	**2**
Dixidae															
Dixella autumnalis	c	c	f	o	o	f	o	f	o	f	o	o	o	**5**	**5**
Limoniidae		o	o	1	o	+	o	o	f	+	o	+	o	**5**	**5**
Psychodidae		o	o	o	o	f	o	o	o	o	o	f	o	**5**	**5**
Ptychopteridae															
Ptychoptera sp.		o	o	f	o	o		o	f	+				**4**	**2**
Stratiomyidae															
Oplodontha viridula	I	1	+			1	+	1	1	+		1		**4**	**2**
Oxycera trilineata	I					+				+	1			**2**	**1**
Stratiomys singularior	N									1	+			**1**	**1**

Taxon	Status	17F		24H		24I		36B		40A		41A		Total hits	
		b	a	b	a	b	a	b	a	b	a	b	a	b	a
Tabanidae															
Chrysops sp.				1										**1**	**0**
Tipulidae															
Phalacrocera replicata	N				2			o	o	1	o			**2**	**3**
Indet. larvae				1	1									**1**	**1**
Ephemeroptera															
Baetidae															
Cloeon dipterum	c	c	c	c	f	f	f	o	f	f	o	f	f	**5**	**5**
Caenidae															
Caenis horaria	c		1	f	o	o						o	1	**3**	**2**
Caenis luctuosa	c	f	f	f	o	o	o	1	1	+	+	o	o	**5**	**5**
Hemiptera															
Corixidae															
Corixa panzeri	l			o	f									**1**	**1**
Corixa punctata	c			1				1	+					**2**	**1**
Cymatia bonsdorffi	l				1									**0**	**1**
Cymatia coleoptrata	l							o	f					**1**	**1**
Hesperocorixa linnaei	c	o	2	f	c	c	c	c	c	o	o	f	f	**5**	**5**
Hesperocorixa moesta	l	o	o	f	o	f	o	f	o	o	o	f	o	**5**	**5**
Hesperocorixa sahlbergi	c									2				**1**	**0**
Sigara distincta	c				1									**0**	**1**
Sigara dorsalis	c											o	2	**1**	**1**
Sigara fossarum	c			f	c			2		o	2			**3**	**2**
Gerridae															
Gerris lacustris	c							o						**1**	**0**
Gerris odontogaster	c			o										**1**	**0**
Hebridae															

Taxon	Status	17F		24H		24I		36B		40A		41A		Total hits	
		b	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**
Hebrus ruficeps	l							1		1				**2**	**0**
Hydrometridae															
Hydrometra stagnorum	c			o				1						**2**	**0**
Naucoridae															
Ilyocoris cimicoides	c			o	f	o	1	f	o			+	1	**4**	**4**
Nepidae															
Nepa cinerea	c					o								**1**	**0**
Ranatra linearis	l			1							1			**1**	**1**
Notonectidae															
Notonecta glauca	c	o	2			o	1	o	2			o	1	**3**	**3**
Notonecta marmorea	l	o				o		o	o			o	o	**3**	**2**
Notonecta obliqua	l	1	1							1				**1**	**0**
Pleidae															
Plea minutissima	l	f	f	o	2	o	o	f	f			1	1	**4**	**4**
Veliidae															
Microvelia reticulata	c	f		o		f	2	f		o				**4**	**1**
Lepidoptera															
Pyralidae															
Cataclysta lemnata	c											+	+	**1**	**1**
Parapoynx stratiotata	c			2				1						**2**	**0**
Megaloptera															
Sialidae															
Sialis lutaria	c	f	f	o	o	o	o	o	o			f	o	**4**	**4**
Odonata															
Aeshnidae															
Aeshna sp.						o								**1**	**0**
Anax imperator	l	o	f	o	2	o	o	1	2			f	1	**4**	**4**

Taxon	Status	17F		24H		24I		36B		40A		41A		Total hits	
		b	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**
Brachytron pratense	Nb	o	1				2		2		+			**0**	**3**
Coenagriidae															
Coenagrion sp.		o	f	o	f	f	f	f	f	o	f	f	f	**5**	**5**
Ischnura elegans	c	2	o	o	2	+		o	f	f	f	o	o	**5**	**4**
Pyrrhosoma nymphula	c											1		**1**	**0**
Indet. nymphs		o	o	+	o	f	o	f	f	o	o	f	f	**5**	**5**
Libellulidae															
Libellula quadrimaculata	I									2				**1**	**0**
Libellula sp.				2										**1**	**0**
Sympetrum sp.		1	o	2		o	2	+		o	+	o	1	**5**	**3**
Trichoptera															
Leptoceridae															
Athripsodes aterrimus	c	o	o	o	o	o	1	o	1			o	o	**4**	**4**
Triaenodes bicolor	c					1								**1**	**0**
Limnephilidae															
Limnephilus marmoratus	c	2	1						+					**0**	**1**
Limnephilus sp.	c	c	c	o				f	+	o	1	f		**4**	**2**
Phryganeidae															
Agrypnia varia	c	f	f	f	*	o		c	*	o	*	c	*	**5**	*
Polycentropidae															
Holocentropus picicornis	c							o	1					**1**	**1**
Total taxa		**61**	**48**	**67**	**47**	**71**	**43**	**63**	**47**	**61**	**40**	**59**	**39**	**117**	**81**
% change		**-21.3**		**-29.9**		**-39.5**		**-25.4**		**-34.4**		**-33.9**		**-30.8**	
Total water beetles		**28**	**19**	**29**	**18**	**33**	**15**	**24**	**14**	**29**	**14**	**27**	**10**	**53**	**30**
% change water beetles		**-32.1**		**-37.9**		**-54.5**		**-41.7**		**-51.7**		**-63.0**		**-43.4**	

Taxon	Status	17F		24H		24I		36B		40A		41A		Total hits	
		b	a	b	a	b	a	b	a	b	a	b	a	b	a
Total without adult beetles		34	32	41	31	40	29	41	36	34	28	34	30	65	51
% change without beetles		-5.9		-24.4		-27.5		-12.2		-17.6		-12.1		-21.5	
SQS whole fauna		123	96	152	99	148	80	120	90	143	74	130	63	293	171
SQI whole fauna		2.05	2.00	2.27	2.11	2.08	1.86	1.90	1.88	2.34	1.85	2.20	1.62	2.50	2.11
SQS water beetles		74	52	102	51	99	40	57	34	86	25	84	25	53	30
SQI water beetles		2.64	2.84	3.52	2.83	3.00	2.67	2.38	2.43	2.97	1.79	3.11	2.50	3.53	2.83

Notes

Limnephilus marmoratus is identifiable as a larva only when large, and even then not with absolute confidence; all *Limnephilus* larvae examined belong to the same species-group as *L. marmoratus*, and may all be the same species.

Agrypnia varia is confidently identifiable to species only as large larvae. Some smaller larvae could be *A. obsoleta*. All identifiable members of the genus were *A. varia*, however, and all *Agrypnia* larvae recorded have been listed as *A. varia* for current purposes.

Agrypnia varia in the “after” samples are listed as present but dead in all but the control pond. This was true for all *A. varia* seen in inventory samples. However, since the qualitative samples were preserved without prior examination, and many of the corpses found were still in good condition, it is impossible to be certain that the quantitative samples do not include some individuals which were alive when captured.

Counts in the totals rows are of mutually exclusive taxa. Thus, for example, unidentified specimens of *Haliplus* larvae have not been counted as a separate taxon if identified adults of any species of *Haliplus* were recorded in the same sample, but have been counted if no identified *Haliplus* species were recorded.

Appendix 2 Quantitative samples

17F is the control site; remainder of sample ponds rotenone-treated

b before rotenone application
a after rotenone application
For the control pond, these refer to samples before and after application of rotenone to all treated ponds

(Shaded box) Taxa either recorded from treated ponds only before rotenone application, or recorded in consistently lower numbers after treatment

Taxa present but considered to be recently dead are placed in italics. This has been done only for an *Ilybius* larva in the deep water "after" sample from 36B, which though fresh in appearance was invaded by fungal hyphae, and *Agrypnia varia* in all after samples except the control site. This is in part supposition. Some larvae were certainly dead, since they too supported fungal hyphae. Others appeared in good condition. All *A. varia* examined in inventory samples from these ponds were dead, even though a large proportion were intact and undecayed. The assumption has therefore been made that those captured in qualitative sampling were also dead. However, since these samples were preserved without prior examination it is impossible to be certain of this. If any were alive when captured, it is likely that they were the smaller larvae. A larger proportion of these were still within their cases when examined, and it is more likely that small living individuals would be overlooked during inventory sampling.

Taxon	**17F**				**24H**				**24I**				**36B**				**40A**				**41A**			
	deep		**edge**		**deep**		**edge**		**deep**		**edge**		**deep**		**edge**		**deep**		**edge**		**deep**		**edge**	
	b	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**
Mollusca																								
Hydrobiidae																								
Potamopyrgus antipodarum												1	19	3	8	1								
Lymnaeidae																								

Taxon	**17F**				**24H**				**24I**				**36B**				**40A**				**41A**			
	deep		**edge**		**deep**		**edge**		**deep**		**edge**		**deep**		**edge**		**deep**		**edge**		**deep**		**edge**	
	b	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**
Radix peregra					19	2	4		13	8	1	1		2			10	27	1	1				
Lymnaea stagnalis									2															
Sphaeriidae																								
Musculinum lacustre						2																		
Pisidium sp.	50	14	25	2	8	198	18	6			8	3	65	8	8	2	22	45	2					
Oligochaeta							1						8			2			2					
Crustacea																								
Asellidae																								
Asellus aquaticus	2				4	22	2	1	6	8			14	20	5	2	9	31	3		89	132	31	11
Crangonyctidae																								
Crangonyx pseudogracilis	2	7	8	2	2	10	5		2		3		79	10	27	10	7	37	52	6	22	18	10	10
Gammaridae																								
Gammarus pulex																2								
Araneae																								
Cybaeidae																								
Argyroneta aquatica		4		2	3	1	6	2	11	4	6	1		1	2	3	8	1	6	2	4		4	
Coleoptera																								
Dryopidae																								
Dryops luridus										1					2	1			1					
Dryops sp. female		2					2		1		2		1							1				
Dytiscidae																								
Copelatus haemorrhoidalis																	2							
Graptodytes pictus	2																							
Hydroporus palustris															1									
Hygrotus impressopunctatus																	1							
Hygrotus inaequalis	1								1							2								

Taxon	17F				24H				24I				36B				40A				41A			
	deep		edge		deep		edge		deep		edge		deep		edge		deep		edge		deep		edge	
	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a
Hyphydrus ovatus																					1			
Ilybius sp. larvae	1						1		1					*1*		1	1			1			3	
Laccophilus minutus																				1				
Porhydrus lineatus									1															
Rhantus grapii																	1							
Rhantus suturalis																								1
Gyrinidae																								
Gyrinus distinctus					1																			
Gyrinus paykulli					1																			
Haliplidae																								
Haliplus immaculatus															1									
Haliplus obliquus									7					3										
Haliplus ruficollis					1												1						1	
Haliplus sp. larvae	1	1					8		5		2				1		1	1	2					
Haliplus sp. female										1					2									
Hydraenidae																								
Limnebius nitidus			1			1						1							1					
Ochthebius dilatatus																			1					
Ochthebius minimus	1								1		2								1					
Hydrochidae																								
Hydrochus ignicollis									1															
Hydrophilidae																								
Anacaena bipustulata		1	1																					
Anacaena globulus																				2				
Anacaena limbata													1		1		1		4					
Berosus affinis	1	1																						
Berosus luridus										1						1								
Cymbiodyta marginella											1													
Enochrus coarctatus						1			1				1				2		2					

Taxon	**17F**				**24H**				**24I**				**36B**				**40A**				**41A**			
	deep		**edge**		**deep**		**edge**		**deep**		**edge**		**deep**		**edge**		**deep**		**edge**		**deep**		**edge**	
	b	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**	**b**	**a**
Enochrus testaceus									3		1			1						1				
Helochares lividus																							10	
Laccobius bipunctatus											4								2	1			3	
Laccobius biguttatus			1																					
Laccobius minutus											2													
Noteridae																								
Noterus clavicornis	1	1					1		8	4	1	4	1	1	2	1	1		3				3	1
Noterus sp. larvae							1									2	1							
Scirtidae																								
Cyphon sp.					1		1								1		15	5	11					
Diptera																								
Ceratopogonidae									3															
Chaoboridae																								
Chaoborus crystallinus	1	11																						
Chironomidae	130	55	13		10	18	3		55	31	3	8	33	36	1		10	13			10	8	5	4
Culicidae																								
Coquilletidia richiardii									1	1														
Dixidae																								
Dixella autumnalis	23	13	6	4	4				3	2		1					1		1		2		3	
Limoniidae	2	1	3	2			5		20	12		5	2	3	2	1	6	1	8	2	2	1	4	1
Psychodidae	13	14	27	15	2	2	10	8	22	11	10	37	22	2	4	9	5	2	1		2	2	17	2
Ptychopteridae																								
Ptychoptera sp.													3		1				2					
Stratiomyidae																								
Oplodontha viridula	2	1							3		2	1					1							
Oxycera trilineata											1						2		9	1				
Stratiomys singularior																			1					
Tipulidae							1	1																

Taxon	17F				24H				24I				36B				40A				41A			
	deep		edge		deep		edge		deep		edge		deep		edge		deep		edge		deep		edge	
	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a
Phalacrocera replicata																		1						
Ephemeroptera																								
Baetidae																								
Cloeon dipterum	185	142	15		183	63	47	1	13	8			88	115	17	3	9	1	1		94	163	34	4
Caenidae																								
Caenis horaria						1	3																	
Caenis luctuosa	18	22	15	2	23	20	28		1		1		5	3			1	2			6	13		
Hemiptera																								
Corixidae																								
Corixa panzeri						3																		
Corixa punctata														1	1									
Cymatia coleoptrata														3										
Hesperocorixa linnaei		1			14	20	1		16	22			36	59	1	1	3				5	4		
Hesperocorixa moesta					1	1			1				2				1				2	4		
Sigara fossarum					7	18																		
Naucoridae																								
Ilyocoris cimicoides					8		1				1										1	1		
Nepidae																								
Nepa cinerea									1															
Notonectidae																								
Notonecta glauca																					1	1		
Notonecta marmorea																					1	2		
Pleidae																								
Plea minutissima	1	1	4	3	3																			
Veliidae																								
Microvelia reticulata	3						1												1					
Lepidoptera																								
Pyralidae																								

Taxon	17F				24H				24I				36B				40A				41A			
	deep		edge		deep		edge		deep		edge		deep		edge		deep		edge		deep		edge	
	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a
Cataclysta lemnata																					2			1
Megaloptera																								
Sialidae																								
Sialis lutaria	1		1	1		1																		
Odonata																								
Aeshnidae																								
Anax imperator	1																				9	3		
Brachytron pratense																		1						
Coenagriidae																								
Coenagrion sp.	2	3	2	2	4				2	2			7	6			2	2	3	1	28	48	3	2
Ischnura elegans					2				1				3	4				1	1		3			
Indet. larvae	12	11			12	2	1		2	2			5	2		1	3	5	1		65	52	1	1
Libellulidae																								
Sympetrum sp.		1	1						1	1			1				1	2			2	2	1	1
Trichoptera																								
Leptoceridae																								
Athripsodes aterrimus		2				4	5		1		1		1	1								2		
Limnephilidae																								
Limnephilus marmoratus														1										
Limnephilus sp.	7	15	3	4	15								14	8	1		3	5	1	1	1		16	
Phryganeidae																								
Agrypnia varia	1	*2*	1		6	*2*	9		1		1		7	*38*		*1*		*9*			9	*31*	26	*5*
Polycentropidae																								
Holocentropus picicornis														1										
No. taxa	**25**	**22**	**18**	**11**	**23**	**21**	**24**	**6**	**30**	**15**	**20**	**11**	**24**	**22**	**20**	**17**	**28**	**18**	**27**	**13**	**22**	**16**	**17**	**11**
% change	**-12.0**		**-38.9**		**-8.7**		**-75.0**		**-41.7**		**-45.0**		**-8.3**		**-15.0**		**-35.7**		**-51.9**		**-27.3**		**-35.3**	

Taxon	17F				24H				24I				36B				40A				41A			
	deep		edge		deep		edge		deep		edge		deep		edge		deep		edge		deep		edge	
	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a
No. individuals	465	324	128	39	334	390	165	16	211	119	53	63	418	294	89	45	131	183	123	20	361	456	175	39
% change	-30.3		-69.5		+16.7		-90.3		-43.6		+18.9		-29.7		-49.4		+39.7		-83.7		+26.3		-77.7	
No. taxa without adult beetles	20	18	15	11	20	19	22	6	21	11	13	9	20	19	15	13	21	18	19	8	21	16	13	9
% change without beetles	-10.0		-26.7		-5.0		-72.7		-42.9		30.8		-5.0		-13.3		-14.3		-57.9		-23.8		-30.8	

Appendix 3 Statuses and definitions

Each species recorded during the invertebrate survey, and listed in the tables of results, has been assigned a status. Status categories higher than local are the most recent published statuses applied by the Nature Conservancy Council and the Joint Nature Conservation Committee, obtained as follows:

Coleoptera	Foster 2000
Diptera	Falk 1991
Odonata	NCC 1989

Of the groups identified in the present survey work, only water beetles have been assessed, in a published document, against the most recent IUCN criteria for Red List categories (Foster 2000). The statuses applied to other invertebrate groups recorded in this survey employ an earlier set of status definitions. Formal status categories derived from the older system which are used in this report are as follows:

Nationally Scarce category B (Nb)
Taxa which do not fall within RDB categories but which are nonetheless uncommon in Great Britain and are thought to occur in between 31 and 100 10km squares of the National Grid or, for less well-recorded groups, between eight and twenty vice-counties.

Nationally Scarce (N)
For some less well-recorded groups and species, it has not been possible to determine which of the Notable categories (A or B) is most appropriate for scarce species. These species are assigned to an undivided Nationally Scarce category.

The following status categories included in the more recent IUCN definitions apply to water beetles recorded by this survey:

Vulnerable (VU)
A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a very high risk of extinction in the wild in the medium-term future, as defined by any of the following criteria [C and D1 omitted]:

A. Population reduction in the form of either of the following:

1. An observed, estimated, inferred or suspected reduction of at least 20% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
   - (a) direct observation
   - (b) an index of abundance appropriate for the taxon
   - (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   - (d) actual or potential levels of exploitation
   - (e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2. A reduction of at least 20%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

B. Extent of occurrence estimated to be less than 20,000 km² or area of occupancy estimated to be less than 2000 km², and estimates indicating any two of the following:

1. Severely fragmented or known to exist at no more than five locations.
2. Continuing decline, observed, inferred or projected, in any of the following:
    - (a) extent of occurrence
    - (b) area of occupancy
    - (c) area, extent and/or quality of habitat
    - (d) number of locations or subpopulations
    - (e) number of mature individuals.
3. Extreme fluctuations in any of the following
    - (a) extent of occurrence
    - (b) area of occupancy
    - (c) number of locations or subpopulations
    - (d) number of mature individuals

C. Population very small or restricted in the form of either of the following [only 2 relevant]:

2. Population is characterised by an acute distribution in its area of occupancy (typically less than 100 km²) or in the number of locations (typically less than 5). Such a taxon would thus be prone to the effects of human activities (or stochastic events whose impact is increased by human activities) within a very short period of time in an unforeseeable future, and is thus capable of becoming Critically Endangered or even Extinct in a very short period.

D. Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

Lower Risk (LR). A taxon is Lower Risk where it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the LR category can be separated into four subcategories.

Conservation Dependent (LRcd). Taxa, which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.

Near Threatened (LRnt). Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable - in Britain, defined as occurring in 15 or fewer hectads but not CR, EN or VU. The absolute count of hectads is, in this review, considered subordinate to evidence of decline on an extent not qualifying the species for CR, EN or VU.

Nationally Scarce (LRns). Taxa which do not qualify for Conservation Dependent or Near Threatened - in Britain defined as species occurring in 16 to 100 hectads but not CR, EN or VU. Nationally Scarce species are usually divided into lists A (LRnsA 16-30 hectads) and B (LRnsB 31-100 hectads) as in the previous system. This subcategory associates a level of threat with rarity status, whereas the previous National Scarcity listings were based solely on rarity. Those species, the populations of which occasionally occupy more than 30 or 100 hectads as LRnsA and LRnsB respectively, can still be listed if it is thought that their baseline populations frequently fall below these thresholds, or if the habitats occupied are considered under threat.

Least Concern (LRlc). Taxa, which do not qualify for Conservation Dependent, Near Threatened or National Scarce subcategories - in Britain, this covers all species found on evaluation not to fit into any of the other categories.

Species in the “Least Concern” category, and others not falling into any of the conservation categories listed above are, for the purposes of this report, described as local (l) or common (c). Neither of these terms has a precise definition, and they are used only to distinguish between species of wide distribution and either broad or very commonly met habitat requirements, and those which, because of more specialised habitat requirements, lesser mobility, or other cause, are of less frequent occurrence. These categories have been applied according to personal experience and the opinions of standard texts, and must be considered in part subjective.

References

Falk, S. 1991b. A review of the scarce and threatened flies of Great Britain (part 1). Peterborough:
Nature Conservancy Council. (Research and Survey in Nature Conservation, no. 39).

Foster, G.N. 2000. A review of the scarce and threatened Coleoptera of Great Britain. Part 3: Aquatic Coleoptera. Peterborough: Joint Nature Conservation Committee (Species Status, no. 1)

Nature Conservancy Council. 1989. Guidelines for the selection of biological SSSIs. Peterborough: Nature Conservancy Council.

Appendix 4 Faunal Quality Scores

It has become fairly conventional in recent years to assess invertebrate assemblages by use of quality scores and indices. Typically, such assessment methods assign scores to individual taxa on a geometrically rising scale according to rarity. A total score is obtained by summing the individual scores of species obtained from a sample or site, and a Quality Index is obtained by dividing this total score by the number of taxa recorded. It is common, but not universal, practice to base the scores of individual species on their formal status, if they have one.

In assigning scores for species recorded in this survey, the initial basis was such a geometrically rising system of scores: common 1; local 2; very local 4; Nationally Scarce 8; Red Data Book 16. In practice, it was felt necessary to adjust these scores considerably. In some cases, there must be doubt about the validity of the formal conservation status currently applied; in others, the local status of the species is somewhat at odds with its national status, and adopting the simple scoring system outlined above would give such species too much or too little prominence.

In the course of adjusting the statuses, some species have been given scores intermediate between those on the geometric scale. Such intermediate scores are arguably the result of indecisiveness rather than a reflection of the actual status or significance of the animal in question. It may be desirable to adjust the scoring system in the future if it is used in future years.

The table below gives the final scores used in the calculation of Quality Indices for the samples taken in 2005/6, with brief notes where justification is considered necessary, or where it is felt doubt must be expressed.

Taxon	Status	Score	Notes
Mollusca			
Hydrobiidae			
Potamopyrgus antipodarum	c	1	
Lymnaeidae			
Galba truncatula	c	1	
Lymnaea stagnalis	c	1	
Radix peregra	c	1	
Sphaeriidae			
Musculinum lacustre	c	1	
Pisidium sp.		1	
Hirudinea			
Glossiphoniidae			
Theromyzon tessulatum	c	1	
Oligochaeta			
Crustacea			
Asellidae			
Asellus aquaticus	c	1	
Crangonyctidae			
Crangonyx pseudogracilis	c	1	

Taxon	Status	Score	Notes
Gammaridae			
Gammarus pulex	c	2	A very common running water species and frequent in larger lakes, but sufficiently uncommon in smaller pools to be worthy of a slightly higher score than its overall status might suggest
Araneae			
Cybaeidae			
Argyroneta aquatica	l	2	
Coleoptera			
Curculionidae			
Stenopelmus rufinasus	l	1	Though a somewhat local species, this weevil feeds on water-fern *Azolla filiculoides*, and can be assigned only the lowest possible score for assessment of conservation interest
Dryopidae			
Dryops luridus	c	1	
Dryops sp. female		1	
Dytiscidae			
Agabus didymus	l	2	Though apparently a common species in some parts of its British range, *A. didymus* is decidedly infrequent in the Peterborough area
Agabus nebulosus	c	2	An erratic species prone to transitory appearances, but far less frequently seen in brickpit pools than other species of water beetles given a "common" status
Colymbetes fuscus	c	1	
Copelatus haemorrhoidalis	l	2	
Graptodytes granularis	LRnsB	8	
Graptodytes pictus	l	2	
Hydroglyphus geminus	LRnsB	4	Quite frequent in the Peterborough area, and sufficiently prone to transitory appearances in ponds to reduce its value
Hydroporus angustatus	c	1	
Hydroporus memnonius	c	1	
Hydroporus palustris	c	1	
Hydroporus planus	c	1	
Hygrotus impressopunctatus	l	2	A borderline candidate for a score of 2; frequent in the Peterborough area, though often in low numbers
Hygrotus inaequalis	c	1	
Hyphydrus ovatus	c	1	
Ilybius quadriguttatus	c	2	A borderline candidate for a score of 2;

Taxon	Status	Score	Notes
			generally fairly common, and a frequent species in ditches, but less common in brickpit pools than most of the species given common status
Ilybius sp. larvae		2	
Laccophilus minutus	c	2	A borderline candidate for a score of 2; generally fairly frequent in ditches and ponds, but less common in brickpit pools than most of the species given common status
Porhydrus lineatus	l	2	
Rhantus grapii	LRnsB	8	A quite frequent species in ditches around Peterborough, but uncommon in brickpit ponds
Rhantus suturalis	LRnsB	4	Frequent in the Peterborough area, and more widely, and not unduly exacting in its requirements; the score is, if anything, possibly set too high
Rhantus sp. larvae		4	
Gyrinidae			
Gyrinus distinctus	LRnt	12	Well-established in the Peterborough area
Gyrinus paykulli	LRnsA	8	A characteristic and not unduly uncommon species of larger water bodies in the Peterborough area
Haliplidae			
Haliplus confinis	c	2	The higher score given to this generally common species is open to question, but it appears at lest substantially less common than the other *Haliplus* species given formally common status
Haliplus immaculatus	c	1	
Haliplus lineatocollis	c	1	
Haliplus obliquus	l	4	Associated with beds of stoneworts
Haliplus ruficollis	c	1	
Haliplus ruficollis grp. ♀		1	
Haliplus sp. larvae		1	
Hydraenidae			
Hydraena riparia	l	2	
Hydraena testacea	LRnsB	6	Possibly over-scored; a quite frequent species in the Peterborough area, the score is selected to reflect that it is commoner than its formal status indicates, but nonetheless local; a reduction to 4 could be justified
Limnebius nitidus	LRnsB	6	Possibly over-scored; a quite frequent species in the Peterborough area, the score is selected to reflect that it is

Taxon	Status	Score	Notes
			commoner than its formal status indicates, but nonetheless local; a reduction to 4 could be justified
Limnebius papposus	LRnsB	6	Possibly over-scored; a quite frequent species in the Peterborough area, the score is selected to reflect that it is commoner than its formal status indicates, but nonetheless local; a reduction to 4 could be justified
Ochthebius dilatatus	l	2	
Ochthebius minimus	c	1	
Ochthebius pusillus	LRnt	16	Though well-established at Orton Pits, this species does not seem to occur in other pits in the area. It is a small species, and may prove to occur more widely, but for the moment is given a relatively high score to reflect its localisation
Hydrochidae			
Hydrochus carinatus	VU	8	Despite its formal status, this is a quite frequent species in the Peterborough area, in brickpits, gravel pits and ditches
Hydrochus ignicollis	VU	16	*H. ignicollis* appears well-established at Orton Pit, but does not appear to occur in other pits in the area, where the two expected *Hydrochus* species are carinatus and elongatus. *H. ignicollis* is often regarded as a relict fen species, and certainly seems a less efficient colonist than the other two
Hydrophilidae			
Anacaena bipustulata	LRnsB	4	A rather frequent species in the Peterborough area
Anacaena globulus	c	1	
Anacaena limbata	c	1	
Berosus affinis	LRnsB	6	Possibly over-scored; it is a frequent species in the Peterborough area, and a characteristic member of the brickpit assemblage
Berosus luridus	LRnt	8	The least common of the three *Berosus* in the Peterborough area, at least in brickpit pools; it is possibly more frequent in ditches
Berosus signaticollis	LRnsB	6	Possibly over-scored; it is a frequent species in the Peterborough area, and a characteristic member of the brickpit assemblage
Cymbiodyta marginella	l	2	

Taxon	Status	Score	Notes
Enochrus coarctatus	l	4	Possibly over-scored; it is local in the Peterborough area and less frequently found than some Nationally Scarce species, but is not rare and seems to be well-established in Orton Pit
Enochrus halophilus	LRnsA	8	A difficult species to score. Nationally, the formal status overstates its actual rarity. However, it is a predominantly coastal species; inland records are few, and the colonies in the Peterborough brickpits are significant. However, it has been recorded in the Peterborough area outside the brickpits, and may be increasing.
Enochrus melanocephalus	LRnsB	6	Possibly over-scored; a quite frequent species in the Peterborough area, the score reflects that it is commoner than its formal status indicates, but nonetheless local; a reduction to 4 could be justified
Enochrus testaceus	c	2	On the borderline of common and local, the contradictory score and status applied to this species are redolent of indecision
Helochares lividus	l	4	
Helophorus minutus	c	1	
Hydrobius fuscipes	c	1	
Laccobius biguttatus	l	2	
Laccobius bipunctatus	c	1	
Laccobius minutus	c	1	
Noteridae			
Noterus clavicornis	c	1	
Noterus sp. larvae		1	
Scirtidae			
Cyphon sp.		1	
Diptera			
Ceratopogonidae		1	
Chaoboridae			
Chaoborus crystallinus	c	1	
Chironomidae		1	
Culicidae			
Coquilletidia richiardii	c	1	
Dixidae			
Dixella autumnalis	c	1	
Limoniidae		1	
Psychodidae		1	
Ptychopteridae			
Ptychoptera sp.		1	

Taxon	Status	Score	Notes
Stratiomyidae			
Oplodontha viridula	l	2	
Oxycera trilineata	l	4	
Stratiomys singularior	N	6	A decidedly local species, but too frequent and widespread to be considered truly Nationally Scarce
Tabanidae			
Chrysops sp.		1	
Tipulidae			
Phalacrocera replicata	N	8	
Indet. larvae		1	
Ephemeroptera			
Baetidae			
Cloeon dipterum	c	1	
Caenidae			
Caenis horaria	c	1	
Caenis luctuosa	c	1	
Hemiptera			
Corixidae			
Corixa panzeri	l	2	
Corixa punctata	c	1	
Cymatia bonsdorffi	l	4	
Cymatia coleoptrata	l	2	
Hesperocorixa linnaei	c	1	
Hesperocorixa moesta	l	4	
Hesperocorixa sahlbergi	c	1	
Sigara distincta	c	1	
Sigara dorsalis	c	1	
Sigara fossarum	c	1	
Gerridae			
Gerris lacustris	c	1	
Gerris odontogaster	c	1	
Hebridae			
Hebrus ruficeps	l	4	
Hydrometridae			
Hydrometra stagnorum	c	1	
Naucoridae			
Ilyocoris cimicoides	c	1	
Nepidae			
Nepa cinerea	c	1	
Ranatra linearis	l	2	
Notonectidae			
Notonecta glauca	c	1	
Notonecta marmorea	l	2	
Notonecta obliqua	l	4	A relatively frequent species in some parts of Britain in lowland acid waters, but very local in the Peterborough area
Pleidae			

Taxon	**Status**	**Score**	**Notes**
Plea minutissima	l	2	
Veliidae			
Microvelia reticulata	c	1	
Lepidoptera			
Pyralidae			
Cataclysta lemnata	c	1	
Parapoynx stratiotata	c	2	
Megaloptera			
Sialidae			
Sialis lutaria	c	1	
Odonata			
Aeshnidae			
Aeshna sp.		1	
Anax imperator	l	4	
Brachytron pratense	Nb	4	Greatly increased in recent years, and now a frequent species in the Peterborough area
Coenagriidae			
Coenagrion sp.		1	
Ischnura elegans	c	1	
Pyrrhosoma nymphula	c	4	Though a common species nationally, *P. nymphula* is decidedly scarce in the Peterborough area.
Indet. nymphs		1	
Libellulidae			
Libellula quadrimaculata	l	2	
Libellula sp.		2	
Sympetrum sp.		1	
Trichoptera			
Leptoceridae			
Athripsodes aterrimus	c	1	
Triaenodes bicolor	c	1	
Limnephilidae			
Limnephilus marmoratus	c	1	
Limnephilus sp.	c	1	
Phryganeidae			
Phryganea bipunctata	c	1	
Polycentropidae			
Holocentropus picicornis	c	2	This caddisfly is given a higher score than its status suggests appropriate because it is relatively infrequent in smaller ponds

Appendix 5 Notes on Nationally Scarce and Red Data Book species

Coleoptera

Anacaena bipustulata (Hydrophilidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
A. bipustulata is found mainly in ditches and ponds in former fenland, though also occasionally inland in small streams in the Weald. Anacaena adults and larvae are semiaquatic. Adults deposit long-masted egg-cases on debris, and larvae hatch in 8-10 days, taking possibly as long as two months to complete development. Larvae are predaceous. Recent published records are for South and North Somerset, Dorset, East Sussex, East and West Kent, Oxfordshire, East and West Norfolk, Bedfordshire, Huntingdonshire, Monmouth, Carmarthen, South Lincolnshire, Leicestershire, and Derbyshire. This species is not under threat.

Berosus affinis (Hydrophilidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
B. affinis is mainly associated with slow flowing drains and ponds on coastal levels, with some vegetation over mud or silt. The larvae of Berosus spp. are unusual among Hydrophilidae in that they are apneustic, obtaining oxygen from water by the use of pseudobranchiae; in consequence they can live in mud at the bottoms of ponds. Evidence of its colonising ability includes finds on Ashdown Forest following the hot summer of 1995; this species had never before been recorded from this intensively studied area. It has been recorded in flight in Spain. There are recent published records for South and North Somerset, Dorset, South Hampshire, East Sussex, East and West Kent, West Norfolk, Cambridgeshire, Bedfordshire, Huntingdonshire, and Monmouth. There are no modern records from the former northern part of its range in the Isle of Man, the Wirral, Yorkshire, North Lincolnshire and Derbyshire, nor from the west of Wales or south-west England other than Braunton Burrows. This species is still abundant in coastal levels; losses in the north and west presumably reflect climatic deterioration but they may owe to records during brief periods of successful migration and colonisation.

Berosus luridus (Coleoptera, Hydrophilidae)
IUCN Lower Risk (near threatened)
Formerly Nationally Scarce category B
B. luridus lives in lowland ponds and slow drains with a peaty substratum. It is not, however, confined to acid water as, for example, it occurs in marl lakes in the Republic of Ireland. Adult numbers of this species peaked in May and July in a study on a German heath. The larvae of Berosus spp. are unusual among Hydrophilidae in that they are apneustic, obtaining oxygen from water by the use of pseudobranchiae; in consequence they can live in mud at the bottoms of ponds. There are recent published records for South and North Somerset, East Sussex, East and West Kent, Surrey, West Norfolk, Huntingdonshire, Leicestershire, South-west Yorkshire, and Moray. The distribution is thus highly disjunct, with an isolated Scottish population in

Speyside and around the Moray Firth. There is evidence of loss of range, with no modern records from Wales, the Wirral, Dorset, London, the Broads, and much of Kent and Cambridgeshire. A few of these records may have been based on misidentification of B. affinis. Drainage of fenland and loss of heathland are the two main causes of habitat loss.

Berosus signaticollis (Coleoptera, Hydrophilidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
B. signaticollis is tolerant of a quite wide range of conditions than B. luridus, occurring in lowland drains and ponds, but with a particular association with shallow, rainwater-filled, temporary pools. Adult numbers of this species peaked in April and September in a study on a German heath. The larvae of Berosus spp. are unusual among Hydrophilidae in that they are apneustic, obtaining oxygen from water by the use of pseudobranchiae; in consequence they can live in mud at the bottoms of ponds. B. signaticollis flies readily. There are recent published records for North Somerset, Dorset, North Hampshire, East and West Kent, Surrey, West Norfolk, Huntingdonshire, Northamptonshire, South Lincolnshire, and Leicestershire. Loss of heathland habitats has caused the contraction in range of this species, which is otherwise resilient, being capable of living in highly disturbed pools.

Enochrus halophilus (Coleoptera, Hydrophilidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category A
E. halophilus is found in brackish pools on the coast and inland in areas receiving saline seepage. The life history details of Enochrus species appear to vary considerably from one species to another and the life history of individual British species has not been described. An egg-case is produced, sometimes under water, and larval development may last between one and two months. Adults feed on algae and decaying plants whereas the larvae are predaceous. There are recent published records for South and North Somerset, East Sussex, East and West Kent, West Norfolk, Cambridgeshire, Carmarthen, Anglesey, North Lincolnshire, and North-east Yorkshire. Loss of coastal habitats through development must pose a risk, as does rubbish infill and other developments associated with old brickpits in the Peterborough area.

Enochrus melanocephalus (Coleoptera, Hydrophilidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
This species has been described as "developing in the algal bloom of shallow stagnant waters that are fully exposed to the sun." In England, it is found in exposed, base-rich sites including coastal pools and ditches with a brackish influence. In 1993, following the drought of 1992, this species appeared for the first time in well surveyed pools of the West Norfolk pingo fens. It also colonises new ponds created by extractive industries. The life history details of Enochrus species appear to vary considerably from one species to another and the life history of individual British species has not been described. An egg-case is produced, sometimes under water, and larval development may last between one and two months. Adults feed on algae and decaying plants whereas the larvae are predaceous. E. melanocephalus is a pioneer species that will benefit from the creation of new pools. There are recent published records for South and North Somerset, East Sussex, East and West Kent, East and West Norfolk,

Cambridgeshire, Bedfordshire, Huntingdonshire, Northamptonshire, Monmouth, Anglesey, North Lincolnshire, Leicestershire, Nottinghamshire, Derbyshire, Cheshire, South-west Yorkshire and Durham.

Gyrinus distinctus (Coleoptera, Gyrinidae)
IUCN Lower Risk (near threatened)
Formerly Red Data Book category 3 (Rare)
G. distinctus is a lowland species occurring in the edges of lakes, ponds and slow-moving sections of rivers, usually in association with thin emergent vegetation and a small amount of submerged vegetation. Although little is known about the life-cycles of individual species of whirligig beetle, the occurrence of teneral adults of most species in July and August indicates breeding in the early summer by overwintered adults, some of which may survive for more than one season. Fully grown larvae are to be found later in the season and sometimes in early March, the latter indicating the possibility that they too can overwinter. The larvae have filamentous abdominal gills and live as predators on the bottom. Larvae have been found to spin a tough cocoon, secured to plant structures just above the water. Recent published records are for East Kent, Northamptonshire (old brickpits near Peterborough), Cheshire (Hatchmere), Derbyshire (River Trent), South-west Yorkshire (Catcliffe Flash), Kirkcudbrightshire (Loch Kindar), Argyll (Loch Ederline), Kintyre (Loch Barnluasgan), Islay (Loch Còrr) and Mull (Loch Poit na h-I). Further, unpublished records for South Lancashire and Westmorland contribute to a narrow distribution band from Mull to East Kent, with outlying records in Monmouthshire. Despite its association with pristine, "Atlantic" lochs, the occurrence of G. distinctus in man-made habitats further south makes it difficult to claim that the species is at risk from disturbance and enrichment. It is reasonable to assume that its larvae have a requirement for highly oxygenated water, such as is available along wave-washed shores of exposed lakes, and that any polluting event that reduces oxygen content is likely to cause harm. Deep, still water habitats created by man are suitable for this species, e.g. the brick pits around Peterborough. Such sites provide the most stable habitats available in the southern parts of its range.

Gyrinus paykulli (Coleoptera, Gyrinidae)
IUCN Lower Risk (Nationally Scarce List A)
Formerly Nationally Scarce category A
This species usually occurs in deep, still water amongst reeds (Phragmites australis), either in the edges of lakes or in fenland ditches, and often in man-made habitats. It is often overlooked because it is active on the surface only amongst reeds rather than in open water. Oviposition has been observed in late spring, and development to the adult has been completed in about 56 days under laboratory conditions. The larvae have filamentous abdominal gills and live as predators on the bottom. Larvae have been found to spin a tough cocoon, secured to plant structures just above the water. Recent published records are for East Sussex, East Kent, East and West Norfolk, Cambridgeshire, Northamptonshire, Anglesey (Llyn Cerrig Bach), North Lincolnshire, Cheshire, East Perth (Loch of the Lowes) and Fife (Lindores Loch). The distribution is mainly associated with primary fenland areas. On the basis of association with deep, still water and the larval method of respiration, it may be assumed that this species is at risk from any polluting event that reduces the level of oxygenation. It is also associated with permanent water, so it may be assumed that fluctuations in water table are also damaging.

Hydraena testacea (Coleoptera, Hydraenidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
This species is found in stagnant water in association with a well-developed marginal vegetation line, but it also occurs in slow-moving water in canals and streams, being found in the moist zone just above the main water line. The seasonal occurrence of adults is strongly bimodal, with peaks in June and September. There are recent published records for East Cornwall, North Somerset, West and East Sussex, East and West Kent, Surrey, East Suffolk, East and West Norfolk, Huntingdonshire, Northamptonshire, East Gloucester, Monmouth, Pembroke, Leicestershire, Derbyshire, South-west Yorkshire, Westmorland, and Ayrshire. Despite some evidence of contraction in range, this species is not under threat.

Hydrochus carinatus (Coleoptera, Hydrochidae)
IUCN Vulnerable
Formerly Red Data Book category 3 (Rare)
H. carinatus occurs mainly in mossy edges of fluctuating ponds and in rich fens. The life-cycle of this species is unknown but adults are commonest in the spring and autumn. Hydrochus species are aquatic as adults and larvae, but do not swim. They are slow in their movements, and feign death when disturbed. Adults are believed to feed on algae but the larval diet is unknown. Recent published records are for West Norfolk, Cambridgeshire, Huntingdonshire, Northamptonshire, South and North Lincolnshire. Loss of fenland habitats have reduced the distribution of this species but excessive abstraction of groundwater in Breckland poses the greatest threat, as this will alter the hydrology of the fluctuating water bodies.

Hydrochus ignicollis (Coleoptera, Hydrochidae)
IUCN Vulnerable
Formerly Red Data Book category 3 (Rare)
This species occurs in stagnant, well vegetated pools, often in association with mosses in the margins of pools that dry out. This species is associated chiefly with ancient fenland, for example in the Breckland pingo fens. Hydrochus species are aquatic as adults and larvae, but do not swim. They are slow in their movements, and feign death when disturbed. Adults are believed to feed on algae but the larval diet is unknown. A review in 1977 gave the following distribution based on an examination of a considerable amount of museum material: South and North Somerset, East Sussex, East Kent, Oxfordshire, East Norfolk, Cambridgeshire, Bedfordshire, and Wales. There are modern, additional records for East Kent, East Sussex, West Norfolk, Northamptonshire, Anglesey, and South Lincolnshire. Loss of fenland habitats has resulted in a contraction in the range of this species, which is perhaps most at risk from excessive water abstraction in Breckland.

Hydroglyphus geminus (Coleoptera, Dytiscidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
This species is most characteristic of recently created still water sites with a clay or mud substratum, but it is also typical of the shallow rhyne systems of the Somerset Levels, and will occur amongst shallowly flooded moss. It is often recorded in flight and can occur in atypical sites in years of abundance. There are recent published records for

North Somerset, South Wiltshire, Dorset, North Hampshire, East Sussex, East and West Kent, Berkshire, Huntingdonshire, Northamptonshire, East Gloucester, Monmouth, Warwickshire, Glamorgan, Radnor, Leicestershire, and Derbyshire. The northernmost record is for Gosforth, South Northumberland, where the species no longer occurs despite an abundance of apparently suitable habitats provided by subsidence ponds. Dispersal in hot summers accounts for the widespread occurrence of this species. It is not under threat, but its British population probably contracts to pockets in southern England when there is a succession of severe winters.

Limnebius nitidus (Coleoptera, Hydraenidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
L. nitidus lives on moist clay or silt beds at the edges of ponds, ditches, slow streams, canals and rivers. In the west of Scotland, it appears to be narrowly confined to the coast, occurring in small streams and in small springfed mires. There are recent published records for South and North Somerset, South Wiltshire, East Sussex, East and West Kent, Surrey, East Suffolk, Huntingdonshire, Monmouth, Leicestershire, Derbyshire, South-west Yorkshire, Durham, Cumberland, South and North Northumberland. There is evidence of decline in west Wales and south-west England. L. nitidus cannot be considered under threat.

Limnebius papposus (Coleoptera, Hydraenidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
L. papposus is largely confined to lowland fen areas in drains and ponds, usually with rich vegetation and detritus. This species flies. The distribution map indicates a stronghold in the Somerset Levels and a major cluster of old records around another stronghold around the Wash. This species is not under threat. There are recent published records for South and North Somerset, East Kent, East Suffolk, East and West Norfolk, Cambridgeshire, Huntingdonshire, Brecon, and Leicestershire. There are no reliable records from northern Britain. The strong association of L. papposus with the Somerset Levels and the fens draining into the Wash indicates that this species benefits from a regular cycle of ditch clearing such as is provided by Internal Drainage Boards.

Ochthebius pusillus (Coleoptera, Hydraenidae)
IUCN Lower Risk (near threatened)
Formerly Red Data Book category 3 (Rare)
O. pusillus is associated with exposed, muddy edges of ponds, including a recently created dewpond on downland. Its scarcity indicates that it is a specialist pioneer species rather than an opportunist. This species is at the extremity of its largely Central European distribution, and, as a pioneer species, might be expected to fluctuate considerably. There are recent published records for East Sussex, East Kent, East Suffolk, Huntingdonshire, and Glamorgan. It cannot be considered under risk despite its rarity in England. Construction of new ponds, including isolated ones lined with butyl plastic, is beneficial for this species.

Rhantus grapii (Coleoptera, Dytiscidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
R. grapii lives in lowland stagnant water, usually in partly shaded fen conditions among dense vegetation. Some sites, such as the mosses over limestone in Anglesey and the Norfolk pingo fens, are extremely base-rich. It is known to move into temporary pools in bogs and fens, presumably for reproduction. The life cycle is probably univoltine with adults overwintering out of water and with larvae in summer. Gut contents analysed included copepods, Chaoborus and dytiscid larvae and plant remains. Flight capacity is unknown. Recent published records are for East Cornwall, South and North Somerset, Dorset, East Sussex, East and West Kent, East Suffolk, East and West Norfolk, Cambridgeshire, Huntingdonshire, Northamptonshire, Monmouth, Carmarthen, Pembroke, Anglesey, Derbyshire and South-west Yorkshire. The species is not known north of Askham Bog. There is little evidence of a modern contraction in range of this species other than loss from some London sites and from Askham Bog

Rhantus suturalis (Coleoptera, Dytiscidae)
IUCN Lower Risk (Nationally Scarce list B)
Formerly Nationally Scarce category B
R. suturalis occurs in exposed lowland ponds and ditches amongst vegetation. It overwinters as an adult.. The development time of 33 days at ca 20°C from egg laying to adult eclosion is short compared to 52 days for the common Agabus bipustulatus under similar conditions. This species is often attracted to light at night and readily takes to flight. Creation of new ponds will be beneficial to this species. Recent published records are for South and North Somerset, Dorset, East Sussex, East and West Kent, Hertfordshire, East and West Norfolk, Huntingdonshire, Northamptonshire, Monmouth, Leicestershire, Derbyshire, Cheshire, Durham, and South Northumberland.

Diptera

Phalacrocera replicata (Diptera, Cylindrotomidae)
Nationally Scarce
A fairly large brown cranefly found in wetlands and at the margins of water bodies. The aquatic larvae are cryptically coloured and shaped and feed amongst mosses. It breeds in pools and ditches, and in both fens and bogs. Records are widely scattered through England, Wales and Scotland, but it appears particularly frequent in northern England.

Stratiomys singularior (Diptera, Stratiomyidae)
Nationally Scarce
A large black and yellow soldier-fly which breeds in wetlands, especially brackish coastal marshes and ditches, though also inland. The tough-skinned larvae, which take several years to mature, are able to withstand considerable desiccation. This species is most frequent in coastal areas, especially in the south-east, and has a reputation for a close association with brackish water. However, it also occurs regularly inland, especially where there are mineral-bedded shallow standing water and seepages, for example in chalk-pits, clay-pits, and recently or regularly cleared shallow silty ditches

and drains. Though predominantly a south-eastern species, scattered records extend the species' range west to South Wales and north to Edinburgh.

Odonata

Brachytron pratense (Odonata, Aeshnidae)
Nationally Scarce category B
The hairy dragonfly. A medium-sized dragonfly particularly associated with ditches and drains in grazing levels but also found in ponds, well-vegetated gravel pits and other habitats. Its sites usually have extensive growth of emergent vegetation over open water, and the adults fly low over the water, weaving between emergent stems. Historically very local and predominantly southern in distribution, this species has increased in both distribution and abundance in recent years.