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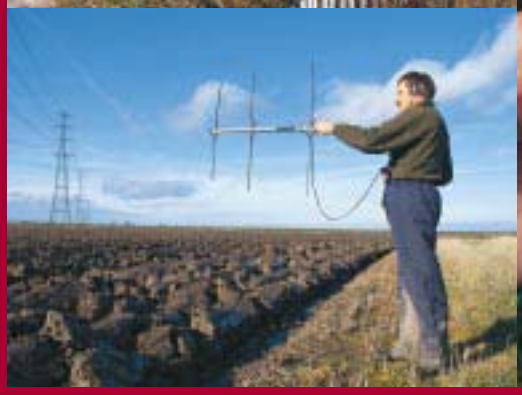

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A study of the distribution and ecology of the lesser silver water beetle *Hydrochara caraboides* on the Somerset Levels

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1. Introduction

1.1 Status

The lesser silver water-beetle *Hydrochara caraboides* is a rare species in Britain, and has its largest population on the peat moors of the Somerset Levels. For many years this was the only known site for the species in Britain, but in 1990 a second population was discovered in Cheshire (Biggs and others 1991).

The highly restricted British distribution of *Hydrochara* has resulted in its inclusion on Schedule 5 of The Wildlife and Countryside Act, which prohibits its collection. It was included in the British Red Data Book (RDB) for insects as RDB1 – Endangered (Shirt, D.B., ed. 1987), with this status having subsequently been altered to Vulnerable using the new International Union for the Conservation of Nature RDB criteria (Foster, in press).

Figure 1 – adult lesser silver water beetle

The extreme rarity of *Hydrochara*, and the threats posed to its survival in Britain by continuing loss and inappropriate management of its wetland habitats, resulted in its inclusion as a priority species in the UK Biodiversity Action Plan (BAP) (UK Biodiversity Group 1999). The UK BAP aims to maintain and enhance its status through a set of actions that are laid out in the plan for the species. A copy of the Action Plan for *Hydrochara* is included at Appendix 1 of this report.

Our knowledge of the distribution of *H caraboides* within its two extant population centres is still far from complete. In recognition of this, action 5.5.1 in the UK BAP for this species identifies the need to carry out further surveys in both Somerset and Cheshire. Similarly, our knowledge of the autecology of the beetle is still very fragmented, and action 5.5.3 of the UK BAP states that autecological studies should be carried out in order to develop an informed conservation management strategy for *Hydrochara*.

1.2 The Somerset *Hydrochara* project

This project was set up by English Nature in order to address the actions laid out in the UK BAP, and with particular emphasis on the gathering of information on the distribution and autecology of *H caraboides* on the Somerset Levels. The project ran for the four years

2000-01 to 2003-04, commencing in May 2000, and finishing in March 2004. The aims of the project as stated in English Nature's Project Brief were as follows:

- Survey for the beetle (larvae, cocoons and adults) in ditches on the Levels within its known range. Part of this survey will be to identify a series of ditches where more intensive autecological work can be undertaken. Environmental conditions at each sampling point will be measured in detail, noting especially the structural conditions and vegetation that are thought to most influence the beetle (since structure can be altered through management).
- Investigate oviposition and pupation sites, and describe the management that leads to the most satisfactory conditions.
- Identify beneficial and adverse management practices, particularly the timing of operations that coincide with sensitive life stages.
- Write a detailed action plan to conserve the species in Somerset or, if this is inappropriate because insufficient information has been gained from the work, provide advice that can be used in modifying prescriptions for agri-environment schemes.

During the four years over which this project has run, the author has restricted his ecological studies and survey work to sites within the known range of the beetle on the Somerset Levels. The majority of effort has been aimed at four sites: Shapwick Heath National Nature Reserve (NNR), Westhay Moor Site of Special Scientific Interest (SSSI), Catcott, Edington and Chilton Moors SSSI and Tealham and Tadham Moors SSSI. All these sites lie within the known range of the beetle, and the great majority of records of the species emanate from them.

Shapwick Heath is owned and managed by English Nature. During 2001, when it was not possible to visit other sites on the Levels because of the foot and mouth outbreak, the author was permitted to carry on working on the eastern section of the NNR, which is ungrazed by stock. For this reason, Shapwick was selected as the main study site for the species during this project, and much of the autecological research has been undertaken here. Westhay Moor Site of Special Scientific Interest (SSSI) is partially privately owned and part-owned by the Somerset Wildlife Trust (SWT), who manage their area as a NNR. Catcott Heath is also owned and managed by the SWT and Tealham and Tadham Moors SSSI are mostly in private ownership.

Unfortunately, the first year of the study did not begin until the end of May, by which time the species' main activity period was well advanced. During 2001, the foot-and-mouth epidemic prevented access to all study areas except Shapwick throughout the beetle's main activity period in spring and early summer. Despite these setbacks, it has been possible to build a good understanding of the distribution and ecology of the lesser silver water beetle on the Somerset Levels.

1.3 Description of adult *Hydrochara caraboides*

H caraboides belongs to the family Hydrophilidae, within the super-family Hydrophiloidea. The Hydrophiloidea are predominantly aquatic, and are characterised by their short antennae and long maxillary palpi, with the palps generally being longer than the antennae (Hansen 1987 and Friday 1988).

Figure 2 – adult lesser silver water beetle

Within the British water beetle fauna, *H caraboides* is a large species, with adults ranging from 14 to 18mm in length. The body is dark brown-black in colour, usually with a slight greenish tinge. The dorsal surface (see Figure 1) is very smooth looking, with only faint puncturation. Antennae are reddish-yellow with a black-brown four-segmented club. The maxillary palps are considerably longer than the antennae and are uniformly reddish-brown in colour. The beetle's ventral surface has a pronounced mid-line keel that runs back as far as the tip of the hind coxae. Much of the underside of the abdomen is coated in dense, "felty" pubescence, which is used to store a film of air, used for respiration whilst the beetle is underwater. This air store gives the underside of the submerged beetle the silvery appearance that has resulted in its common name (see Figure 2).

Adult *Hydrochara* possess well-developed swimming hairs on the hind two pairs of legs. There is little sexual dimorphism, with the best character being provided by the protarsi – which are strongly curved basally, then straightened distally in the male, while in the female they are less abruptly, but more evenly curved from base to apex. Figure 3 illustrates this character in both the male and female beetle.

The diet of the adult is poorly known, though it seems likely that it is a vegetarian, as is its close relative *Hydrophilus piceus* (Hansen 1987). The adults appear to be long-lived, in captivity at least, with specimens having been kept alive in the aquarium for over a year. *H piceus* is known to live for 2-3 years (Hansen 1987), and it seems likely that *H caraboides* may also live and breed over more than one season.

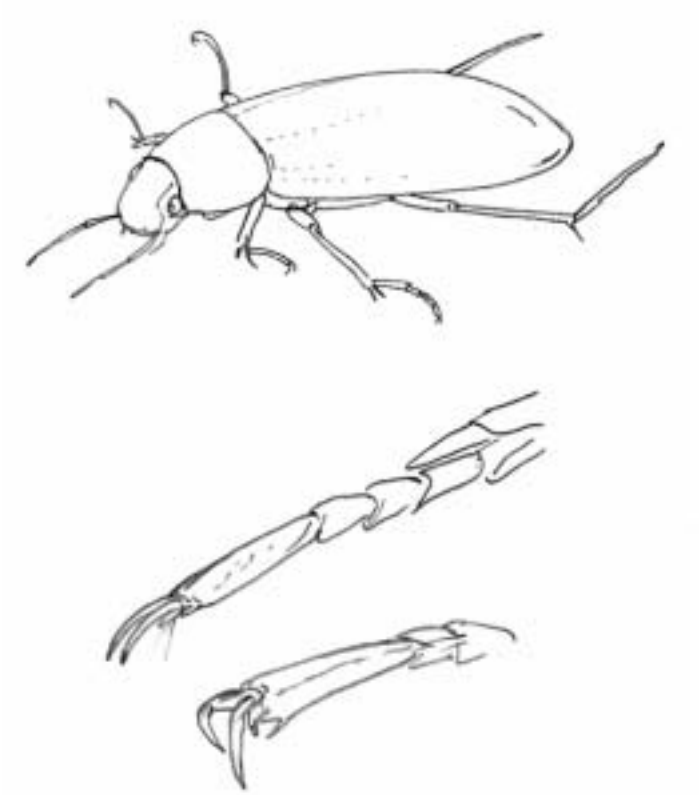


Figure 3 – adult lesser silver water beetle (top) – protarsus of female (middle) and male (below)

It would be difficult to mistake the adult of *H caraboides* for any other British beetle. It is perhaps most similar to its closest British relative, the great silver water beetle, but the latter is, as its name suggests, considerably larger (34-48mm), and with the ventral mid-line keel extending well beyond the tip of the abdomen and terminating in a sharp point.

1.4 Description of early stages of *Hydrochara caraboides*

The egg cocoon is made of white silk and is tent-shaped, with a long silken mast (see Figure 4). It is extremely cryptic, as it is wrapped in a leaf, usually a dead tree leaf, though dead or green leaves of other plants will also be used on occasion. The egg cocoon is free-floating and it looks very much like a dead, floating leaf, with the mast looking like the upturned leaf stem. An exhaustive account of the egg cocoon and its construction is provided by Maillard (1970).

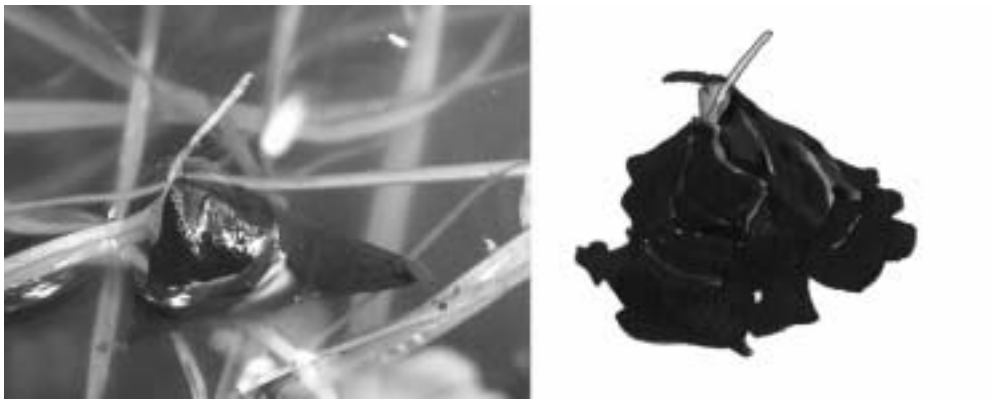


Figure 4 –Lesser silver water beetle egg cocoons

The larva of *H caraboides* (Figure 5) is quite unlike that of any other British beetle, and should be instantly recognisable. It is of a formidable appearance, with the large head being surmounted by a pair of strongly developed, two-toothed mandibles. In life the mandibles are characteristically held open, and the head is also furnished with long and prominent antennae and maxillary palps. The larva has three instars. After the final moult, larvae have a well-marked dark stripe running along the centre of the head and pronotum. The most notable feature of the abdomen is the long processes running along its sides, with each of these bearing a number of long filaments.

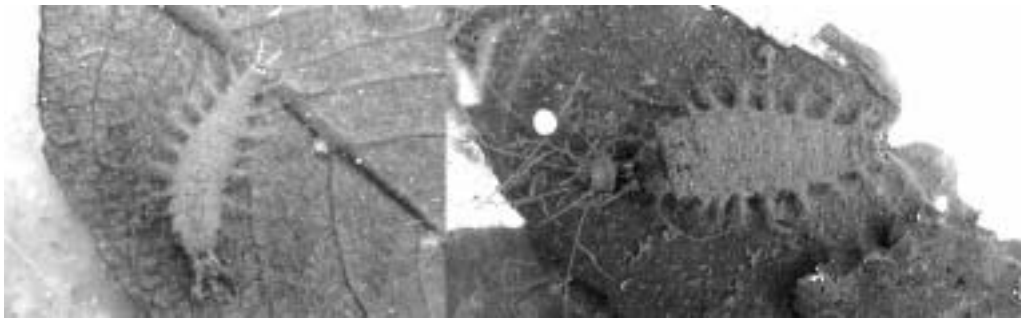


Figure 5 –Lesser silver water beetle young larva (left) and full grown larva (right)

Each of the abdominal segments has a pair of these processes borne laterally. These processes are not gills, as might be supposed. However, it is noticeable that final instar larvae tend to become coated in mud, and the filaments may be a means of catching sediment in order to camouflage the larva from predators. Certainly, the filaments on the side of the larvae are effective in breaking up its outline when at rest. The dorsal surface of the abdomen is also furnished with a number of short, dark pubescent tubercles. The upper surface of the eight and ninth abdominal segments are modified to form a "breathing pocket", which the larva breaks the water film with in order to breathe. A very detailed description of the larva is given by B∴ving and Henriksen (1938).

The most striking feature of the pupa (Figure 6) is the long bristles with which the sides of the abdomen are furnished. To begin with, it is white in colour, but towards eclosion, the pupa changes to a striking pale green. This colour is also noticeable on the abdomen and elytrae of the newly emerged adult, with the colour darkening gradually over one to two days. The pupa is described in detail in B∴ving and Henriksen (1938).

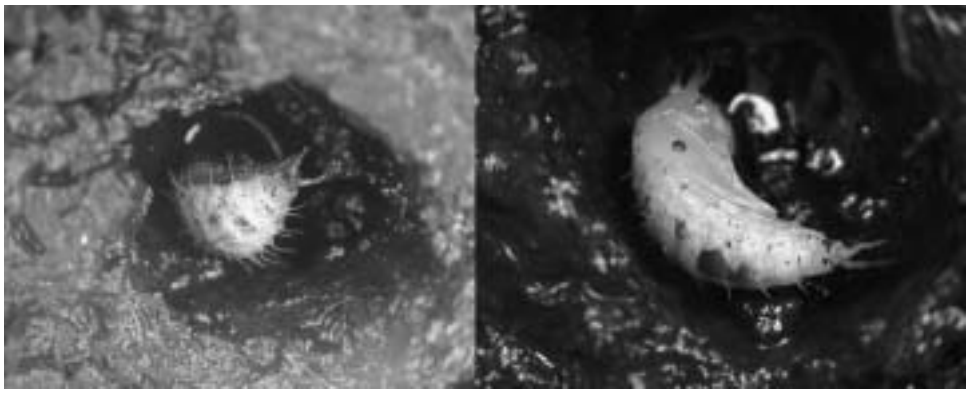
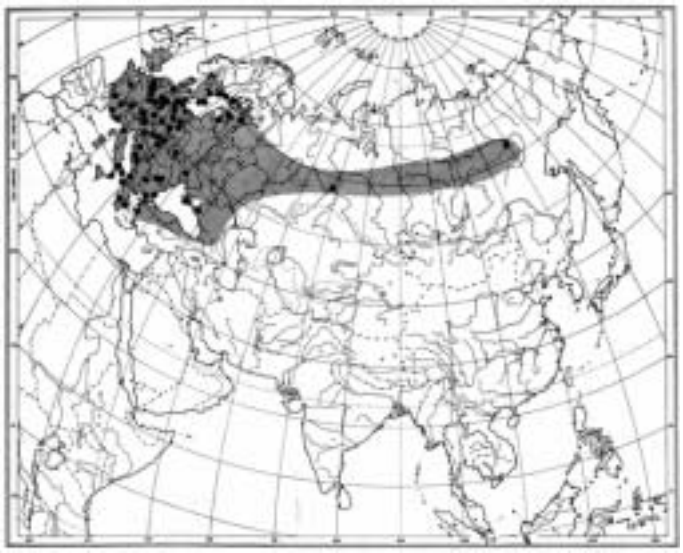


Figure 6 –Lesser silver water beetle pupae

2. The distribution of *Hydrochara caraboides*

2.1 World distribution of *Hydrochara caraboides*

Worldwide, the genus *Hydrochara* contains 21 species, with these being found in the Palaearctic, Nearctic, Ethiopian and Oriental Regions (Smetana 1980). Within the Western Palaearctic, only two species, *H caraboides* (Linnaeus) and *H flavipes* (Steven) are known to occur. *H caraboides* has a wide distribution in the West Palaearctic, and extends east as far as the Lena river basin in Siberia. *H flavipes* has a more restricted Mediterranean distribution stretching from the Iberian peninsula in the west as far east as north west China and Afghanistan (Smetana 1980). The two species occur together in parts of the Mediterranean, but *H caraboides* is absent from the Iberian peninsula, north Africa and the eastern Mediterranean. It is the only species of its genus to occur in Britain. The approximate world distribution of *H caraboides* is shown in Map 1.



Map 1 – World distribution of lesser silver water beetle (from Smetana 1980)

2.2 UK distribution of *Hydrochara caraboides* to 1950

This section briefly summarises the historic distribution of *H caraboides* in Britain, drawing heavily on the account of this species in Balfour-Browne (1958). In this work, he uses Watsonian vice counties as a basis for recording water beetle distributions, and this system is followed here, with the vice county number (vc) given in parentheses after the vice county name.

Map 2 – UK distribution of *Hydrochara caraboides* by vice county. Stippled areas indicate vice counties with pre-1950 records, black areas are those with post-1950 records.

H caraboides has always had a rather restricted distribution in Britain. Nonetheless, it was once considerably more widespread than it is now. *H caraboides* has been known in Britain since at least the early nineteenth century. At this time it was recorded from Glamorgan (vc 41) in south Wales by Dillwyn, Askham Bog, mid west Yorkshire. (vc 64) by Wright and Cook, Whittlesea Mere, Cambridgeshire. (vc 29) by Stephens and from various sites around the London area in west Kent (vc 16), Surrey (vc 17), Middlesex (vc 21) and south Essex (vc 18) by various coleopterists. These are the only British records of the beetle from Glamorgan and Askham Bog, but the London area and Whittlesea Mere must both have once supported large breeding populations, with the species being recorded from these areas on a number of occasions. For example, J Curtis writing in 1862 describes *H caraboides* as being "exceedingly abundant in the ponds and ditches round London."

In the second half of the nineteenth century, there was a record of the species by E B Wrigglesworth from south west Yorkshire (vc 63), and in 1903 a single specimen was found in south Lancashire (vc 59) by GW Chaster and Burgess Sopp. In 1926 and 1927 further single records were made respectively from west Sussex (vc 13) (Foster, in press) and, somewhat dubiously, from Cardiganshire (vc 46) by Miss Carpenter. During the early twentieth century, another important breeding colony was discovered by F Balfour-Browne at Woodwalton Fen, Huntingdonshire (vc 31) and the species was also discovered at a second Cambridgeshire site, at Wicken Fen.

In north Somerset (vc 6), all known historic records of *H caraboides* are listed by Duff (1993). The first occurrence of the beetle here was at Brent Knoll in 1897, recorded by B G Rye. It was not until the extensive surveys of the Somerset Levels by F Balfour-Browne during the 1920s and 1930s that it was appreciated that the Brue valley area supported the main breeding population of the beetle, with Shapwick, Ashcott, Catcott, Westhay and Tealham-Tadham all being mentioned as localities here where he recorded it (Balfour-Browne 1936). Since that period there have been a number of other casual records from the Brue valley, though all have been within the same limited area in which Balfour-Browne had originally found the beetle. A list of recent and historic records of *Hydrochara caraboides* in Somerset is given in Table 1 below. Map 2 shows the distribution of all British records of the species by vice-county.

There is, however, one intriguing 1915 record from the "north Somerset coastal marshes" in Balfour-Browne (1936). A map in his paper roughly marks the position of these sites, which are all within approximately 5km of Weston-super Mare. The three individual areas he marks on his map appear to represent the following: 1) the coastal grazing marsh c. 5km north of Weston-super Mare (approximate centre ST380670), which lies immediately to the north of the Congresbury Yeo's outflow into the Bristol Channel; 2) the grazing marshes inland of Sand Bay (approximate centre ST350650), lying 3km north of Weston-super Mare and 3) the area of grazing marshes around Lympsham (approximate centre ST320540), inland from Brean and Berrow, bounded to the south by Brent Knoll and to the north by the lower reaches of the Lox Yeo river, and lying approximately 5km south of Weston-super Mare. It is interesting that Rye's original Somerset record for *Hydrochara* ties in so closely with this latter area. These remain the only two old Somerset records of *Hydrochara* away from its stronghold in the Brue valley. It is not possible to say with certainty from which of the three areas of coastal marsh Balfour-Browne's record came, but it seems possible that *Hydrochara* was once well established in this part of Somerset, and might still be rediscovered here.

Little detail is given of the habitat in which the species was found at its historic British localities, but it seems to have occurred in both swampy fenland and man-made habitats such as ditches and ponds. Its two nineteenth century strongholds, at Whittlesea Mere and in the London marshes have both been completely destroyed. The former site had been drained by as early as 1850, whilst around London, a combination of agricultural drainage and relentless urban and industrial expansion had led to its extinction some time after 1907, when it was last seen at Hanwell brick-ponds in Middlesex (Balfour-Browne 1958). Elsewhere, though historic sites such as Wicken and Woodwalton Fens and Askham Bog have survived, drainage of surrounding land, pollution and cessation of traditional management practices such as ditch clearance, sedge cutting and grazing have resulted in a decline in the quality of their aquatic habitats.

2.3 UK distribution of *Hydrochara caraboides*, 1950-2000

Away from the Somerset Levels, *H caraboides* has not been seen at any of its historic sites for over half a century, with the last record from elsewhere probably being at Woodwalton Fen, where Balfour-Browne recorded it in 1938. The range contraction evident in Map 2 is striking, and reflects the loss of both habitat quality and quantity through much of the beetles' historic range in Britain.

In the Somerset Levels *Hydrochara* has continued to be recorded in the Brue valley, in the same sites it was found in during the 1920s and 1930s, when Balfour-Browne carried out a detailed survey of the water beetle fauna of the area (Balfour-Browne 1936). This area of the Levels is mantled with deep accumulations of peat. It is striking that on the southern Levels, where the underlying clay is not mantled with peat, the beetle has never been recorded.

Many of the more recent records of *Hydrochara* on the Somerset Levels are derived from the surveys of aquatic invertebrates carried out by the Nature Conservancy Council (NCC) in 1983 (Drake and others 1984). This also found the species to be confined to the small area of the Somerset Moors in the Brue valley. There are a number of other casual recent records from this area, which are derived from a variety of sources. All of these records are collated in Table 1 below.

In 1990, a single adult *Hydrochara caraboides* was found in a pond in Cheshire (vc 58) (Biggs and others 1991), and this has been followed by a number of other records from this county. The area of the county in which *Hydrochara* has been found is on the Cheshire Plain, a flat expanse of pasture land on clay soils that is dotted with thousands of field ponds. This landscape also runs westwards into Denbighshire (vc50), and it is not therefore surprising that the beetle should also have been found in this county in 2003. The latter represents the first modern record of the beetle in Wales. There are now records of *Hydrochara* from eight 10 km squares in the county, and good breeding colonies have been found, with egg cocoons and larvae present (Guest 1996a and 1996b).

3. The Somerset distribution of *Hydrochara caraboides*

Table 1 below lists all of the known records of *Hydrochara caraboides* from Somerset up until the beginning of the current survey in 2000. Table 2 following this lists all of the records of the species on the Somerset Levels since 2000. Maps 3, 4, 5 and 6 show the distribution of the species based on those records for which there are six-figure grid references given by the recorder. This means that all of the older records of the species from Somerset have had to be omitted from the maps, with the first properly grid-referenced data being that of Peter Hodge from Mudgley in 1981, and Trevor Beebee from the early 1980s.

Table 1 – Records of *Hydrochara caraboides* from the Somerset Levels to end of 1999

Date	Site	Grid Ref	Recorder	Source
No date	Catcott Heath	*ST44	KW Miller	Duff (1993)
1897	Brent Knoll	*ST35	BG Rye	Duff, (1993)
1915	Coastal marshes in N Somerset	-	F Balfour-Browne	Balfour-Browne (1936)
8/1924	Shapwick Heath	*ST43/44	J Barrington	Duff (1993)
1925-35	Shapwick Heath	*ST43/44	F Balfour-Browne	Balfour-Browne (1936)
1931-35	Westhay	*ST44	F Balfour Browne	Balfour-Browne (1936)
1931	Westhay	*ST44	CE Tottenham	Duff (1993)
c1940	Ashcott Heath	*ST43	GA Walton	Duff (1993)
1960-62	Shapwick Heath	*ST43/44	A Eve	English Nature Taunton files
7/1967	Shapwick Heath	*ST43/44	GL Frewin	Duff (1993)
3/1975	Shapwick Heath	ST44	JA Owen	Duff (1993)
4/1976	Shapwick Heath	*ST43/44	JA Owen	Duff (1993)
7/1977	Catcott Heath	*ST44	GL Frewin	Duff (1993)
3/1978	Street Heath	ST43	RS Cropper	Duff (1993)
6/1979	Shapwick Heath	ST44	RS Cropper	Duff (1993)
6/1979	Westhay Moor	ST44	J Cooter	Duff (1993)
6/1979	Westhay Moor	ST44	RS Cropper	Duff (1993)
6/1979	Westhay Moor	ST44	NCC	English Nature Taunton files
6/1979	Shapwick Heath	ST43	NCC	English Nature Taunton files
1980s	Tealham Moor	ST408451	T Beebee	English Nature Taunton files
1980s	Tadham Moor	ST440448	T Beebee	English Nature Taunton files
1980s	Westhay Moor	ST452446	T Beebee	English Nature Taunton files
1980s	Westhay Moor	ST452447	T Beebee	English Nature Taunton files
1980s	Westhay Moor	ST453450	T Beebee	English Nature Taunton files
1980s	Ashcott Corner	ST453400	-	English Nature Taunton files
4/1981	Mudgley	ST44	PJ Hodge	Duff (1993)
4-5/1983	Westhay Moor	ST445450	Drake and others	Drake and others (1984)
4-5/1983	Westhay Moor	ST447448	Drake and others	Drake and others (1984)
4-5/1983	Westhay Moor	ST447446	Drake and others	Drake and others (1984)
4-5/1983	Westhay Moor	ST444443	Drake and others	Drake and others (1984)
4-5/1983	Westhay Moor	ST458446	Drake and others	Drake and others (1984)
4-5/1983	Tealham Moor	ST403461	Drake and others	Drake and others (1984)
1983	Tadham Moor	ST435447	Drake and others	Drake and others (1984)

Date	Site	Grid Ref	Recorder	Source
4-5/1983	Queen's Sedgemoor	ST532420	Drake and others	Drake and others (1984)
1985	Catcott Heath 3 larvae	ST44	P Hill-Cottingham	Hill-Cottingham (1993)
9/1985	Westhay Moor	ST44	RS Cropper	Duff (1993)
1986	Catcott Heath Adults in 4 ditches	ST44	P Hill-Cottingham	Hill-Cottingham (1993)
1987	Catcott Heath 1 larva	ST44		
1987	Westhay Moor	ST464453	D Sheppard	English Nature Taunton files
1987	Westhay Moor	ST464452	D Sheppard	English Nature Taunton files
20/10/87	Westhay Moor	ST444437	CM Drake	CM Drake
1988	Catcott Heath 1 larva	ST405413	P Hill-Cottingham	English Nature Taunton files
9/1988	Westhay Moor	ST44	AJ Parsons	Duff (1993)
5/1990	Ashcott Heath	ST43	PJ Hodge/IS Menzies	Duff (1993)
5/1990	Ham Wall	ST44	MJ Collier	Duff (1993)
1991	Catcott Heath	ST405412	T Beebee	English Nature Taunton files
27.10.92	Catcott Grounds	ST405432	R Angus	P Chapman
10/92	Tealham Moor	ST413456	STNC/RS Cropper	Hill-Cottingham (1993)/Duff (1993)
1994	Catcott Moor	ST409424	D Gibbs	English Nature, Taunton files
1994	Tealham Moor	ST398461	D Gibbs	English Nature Taunton files
1994	Tealham Moor	ST403458	D Gibbs	English Nature Taunton files
1994	Tadham Moor	ST436439	D Gibbs	English Nature Taunton files
1994	Tadham Moor	ST438440	D Gibbs	English Nature Taunton files
1995	Catcott Heath	ST413426	P Hill-Cottingham	English Nature Taunton files
1995	Catcott Heath	ST413427	P Hill-Cottingham	English Nature Taunton files
1995	Westhay Moor	ST447446	NRA/P Hill-Cottingham	English Nature Taunton files
17/5/96	Shapwick Heath	ST426406	CR Turner	CR Turner
10/6/96	Shapwick Heath	ST424407	CR Turner	CR Turner
12/6/96	Shapwick Heath	ST424403	CR Turner	CR Turner
24/10/96	Shapwick Heath	ST424407	CR Turner	CR Turner

Notes: An asterisk after the grid reference indicates that no grid reference was given by the original recorder, the grid reference given being a best guess given by the author, or Duff (1993).

Table 2 – Records of *Hydrochara caraboides* from the Somerset Levels 2000-2003

Date	Site	Grid Ref	Recorder	Reference
5/00	Shapwick Heath, 1ad.	ST425409	CM Drake	
24/5/00	Shapwick Heath, 1ad.	ST424409	DC Boyce	
6/00	Shapwick Heath, 1ad.	ST424408	M Yeandle	
10/6/00	Westhay Heath 1ad, 2lv.	ST425419	A Smith	
30/6/00	Shapwick Heath, 5ad.	ST424409	DC Boyce	
28/9/00	Catcott Heath, 2ad.	ST406414	DC Boyce	
18/10/00	Westhay Moor, 5ad.	ST445442	DC Boyce	
18/10/00	Westhay Moor 1ad.	ST448450	DC Boyce	
26/10/00	Westhay Moor 2ad.	ST453438	DC Boyce	
174/01	Shapwick Heath, 1ad.	ST424409	DC Boyce	
20/4/01	Shapwick Heath, 1ad.	ST424408	DC Boyce	
20/4/01	Shapwick Heath, 1ad.	ST424406	DC Boyce	
20/4/01	Shapwick Heath, 2ad.	ST421405	DC Boyce	
24/04/01	Shapwick Heath, 1ad.	ST423403	DC Boyce	
24/04/01	Shapwick Heath, 5ad.	ST425404	DC Boyce	
25/04/01	Shapwick Heath, 3ad.	ST425404	DC Boyce	
16/05/01	Shapwick Heath, 10ad.	ST425404	DC Boyce	
16/05/01	Shapwick Heath, 4ad.	ST425404	DC Boyce	
18/05/01	Shapwick Heath, 12ad.	ST425404	DC Boyce	
18/05/01	Shapwick Heath, 1ad.	ST421405	DC Boyce	
21/05/01	Shapwick Heath, 6ad.	ST425404	DC Boyce	
21/05/01	Shapwick Heath, 9ad.	ST425404	DC Boyce	
22/05/01	Shapwick Heath, 1ad.	ST424406	DC Boyce	
23/05/01	Shapwick Heath, 1ec.	ST424409	DC Boyce	
30/05/01	Shapwick Heath, 21ec.	ST425404	DC Boyce	
04/06/01	Shapwick Heath, 20ec.	ST425404	DC Boyce	
07/06/01	Shapwick Heath, 5ec.	ST424406	DC Boyce	
07/06/01	Shapwick Heath, 6ec.	ST425404	DC Boyce	
27/06/01	Shapwick Heath, 1lv.	ST425404	DC Boyce	
19/02/02	Shapwick Heath, 3ad.	ST425404	DC Boyce, JM Walters	-
16/03/02	Shapwick Heath, 7ad.	ST425404	DC Boyce, D Bilton, C Turner, JM Walters	-
16/03/02	Westhay Moor, 1ad.	ST453433	DC Boyce, D Bilton, C Turner, JM Walters	-
26/04/02	Shapwick Heath SH1, 1m.	ST424409	DC Boyce	-
26/04/02	Shapwick Heath SH3, 1f.	ST424406	DC Boyce	
26/04/02	Shapwick Heath SH5, 1m.	ST424408	DC Boyce	-
27/04/02	Shapwick Heath SH8, 1m.	ST425404	DC Boyce	-
27/04/02	Shapwick Heath SH9, 1m.	ST423403	DC Boyce	-
27/04/02	Shapwick Heath SH17, 1m, 1f.	ST425404	DC Boyce	
27/04/02	Shapwick Heath SH18, 2m	ST423403	DC Boyce	-
06/05/02	Shapwick Heath SH20, 3m, 1f.	ST417405	DC Boyce	-
06/05/02	Shapwick Heath SH22, 1m	ST419404	DC Boyce	-
07/05/02	Shapwick Heath SH6, 1m.	ST421405	DC Boyce	-
07/05/02	Westhay Moor WM5, 1m, 1f.	ST456436	DC Boyce	-
27/05/02	Shapwick Heath, 3m.	ST423403	DC Boyce	-
29/05/02	Shapwick Heath SH3, 1cc.	ST424406	DC Boyce	-
04/06/02	Shapwick Heath SH18, 9ec.	ST423403	DC Boyce	-
05/06/02	Shapwick Heath SH20, 4ec.	ST417405	DC Boyce	-
14/06/02	Westhay Moor WM4, 7ec.	ST454438	DC Boyce	-
10/07/02	Westhay Moor 1f, 4lv.	ST454438	DC Boyce	-
12/07/02	Westhay Moor 14lv.	ST454438	DC Boyce	-

Date	Site	Grid Ref	Recorder	Reference
22/07/02	Westhay Moor 6lv.	ST454438	DC Boyce, JM Walters	-
19/02/03	Shapwick Heath 2m	ST425404	DC Boyce	
20/03/03	Catcott Burtle 1m, 1f	ST405433	DC Boyce, J Webb, M Jones	
29/04/03	Shapwick Heath 11ec, 2cc	ST425404	DC Boyce	
30/04/03	Shapwick Heath 17ec, 3cc	ST425404	DC Boyce	
01/05/03	Shapwick Heath 5ec, 1cc	ST423403	DC Boyce	
13/05/03	Shapwick Heath T1 10ec	ST425404	DC Boyce	
14/05/03	Shapwick Heath T2&3 11ec	ST423403	DC Boyce	
16/05/03	Shapwick Heath T3&4 8ec	ST425404	DC Boyce	
16/05/03	Shapwick Heath 12ec	ST424408	DC Boyce	
18/05/03	Catcott Burtle 2m, 3ec	ST405433	DC Boyce	
20/05/03	Westhay Moor	ST454438	DC Boyce	
02/06/03	Shapwick Heath 4ec	ST424406	DC Boyce	
10/06/03	Shapwick Heath 1ec	ST424408	DC Boyce	

Notes: For all of these records, the number of *Hydrochara caraboides* seen during each visit is recorded after the site name. Abbreviations are as follows: ad = adult, f = adult female, m = adult male, cc = female constructing egg cocoon, ec = egg cocoon, lv = larva. SH or WM after the site name denotes a record from one of the sample plots established in 2002. T after the site name denotes a record from one of the transects set up in 2003.

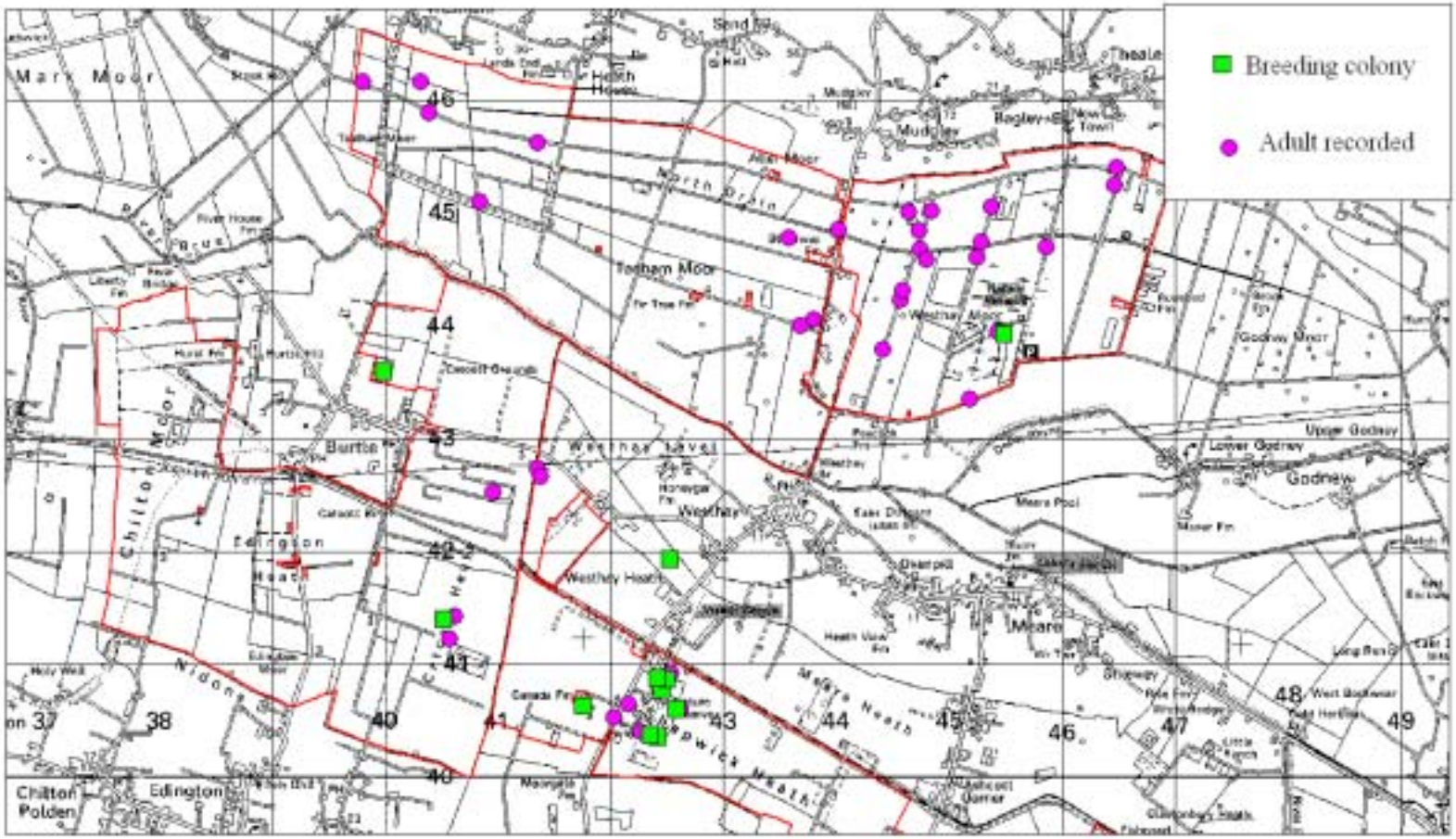
Table 2 summarises all of the known records of *Hydrochara* in Somerset since the beginning of this project. All of the records collected during the current project have come from the peat moors in the Brue valley. Shapwick Heath NNR, has been much the most intensively studied site, and has produced the majority of records, with breeding proved to occur in seven discrete sites within the reserve. The best cluster of breeding sites for *Hydrochara* occurs in and around the Roughet, to the east of the minor road crossing the reserve. To the west of the road, near Canada Farm, one further breeding colony has been found, but the habitat in this block of the reserve seems much less favourable for *Hydrochara*. Though less well studied, *Hydrochara* appears to be much less abundant at Catcott Heath and Westhay Moor. These are generally more open, disturbed wetlands than the central area of Shapwick Heath, and the late-successional habitats favoured by *Hydrochara* are much more scattered in their occurrence. Only one breeding population was recorded from either of these sites, this being at Westhay, where a small colony was found in 2002, in a ditch on the fringes of the remnant raised mire. Additionally, a good new breeding site has been found in 2003 in a wooded swamp at Catcott Burtle, immediately to the north of Catcott Heath (see Table 2). The breeding colony here was found in a wooded swamp very similar in character to *Hydrochara*'s prime breeding areas on Shapwick.

No evidence of breeding was recorded from Tealham and Tadham Moors, and only a single adult was recorded during preliminary surveys in 2000. Though this was much the least intensively surveyed site in the Brue valley, it is again, a much more open site, and suitable breeding habitat appears much more patchy. The coastal marshes around Weston-super-Mare, from where there are two old records (see section 2.2, page 8) of *Hydrochara* were surveyed in 2003. Unfortunately, the beetle was not re-discovered here, though there was certainly some potentially good habitat for it. The Gordano NNR was also visited twice, and though the habitat quality here looked very good, no evidence of *Hydrochara* was found.

ENGLISH NATURE

Hydrochara caraboides distribution within the Brue Valley Somerset Levels and Moors

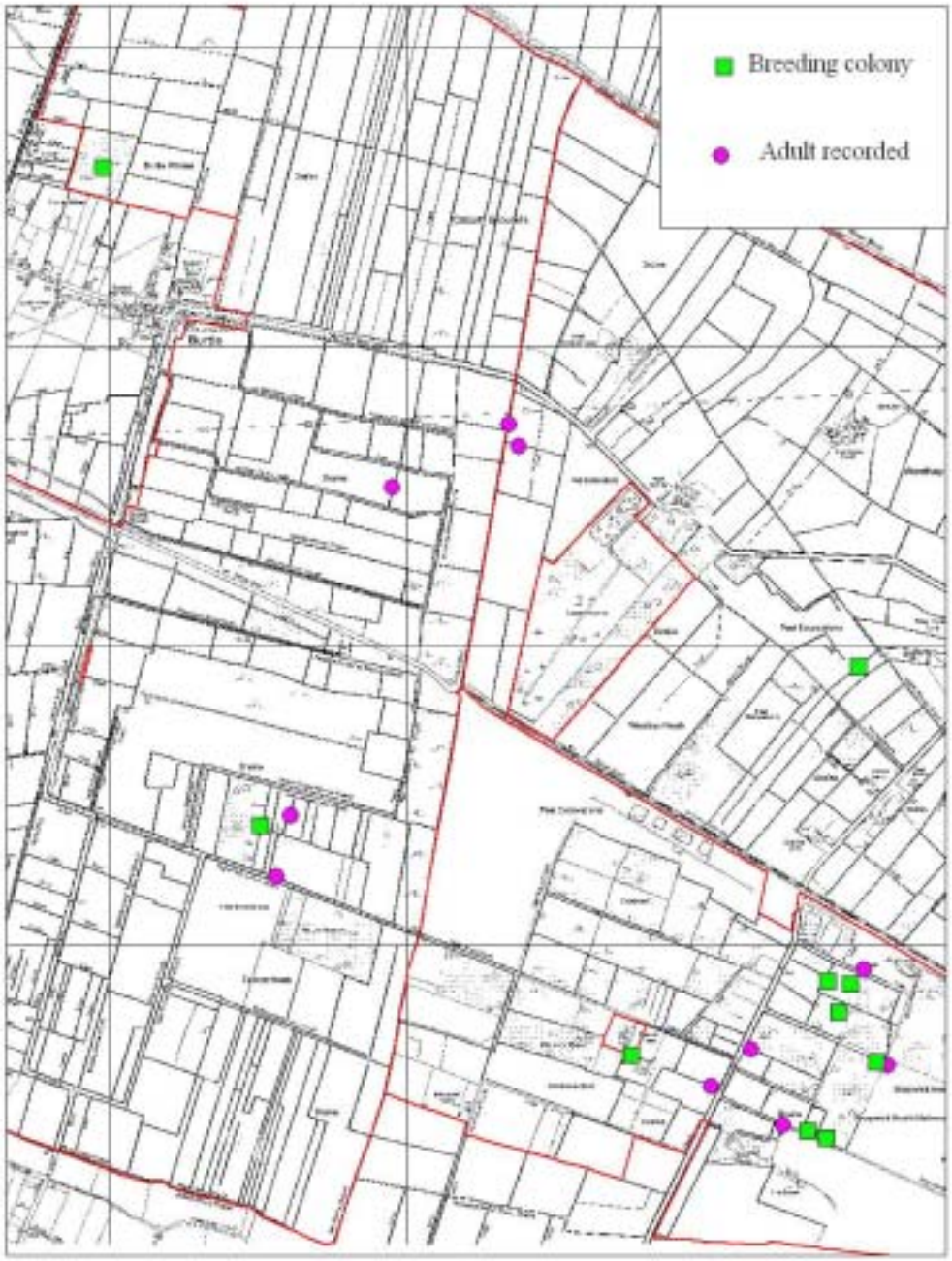
Map 3



ENGLISH NATURE

Hydrochara caraboides distribution on Shapwick Heath, Westhay Heath and Catcott Heath

Map 4

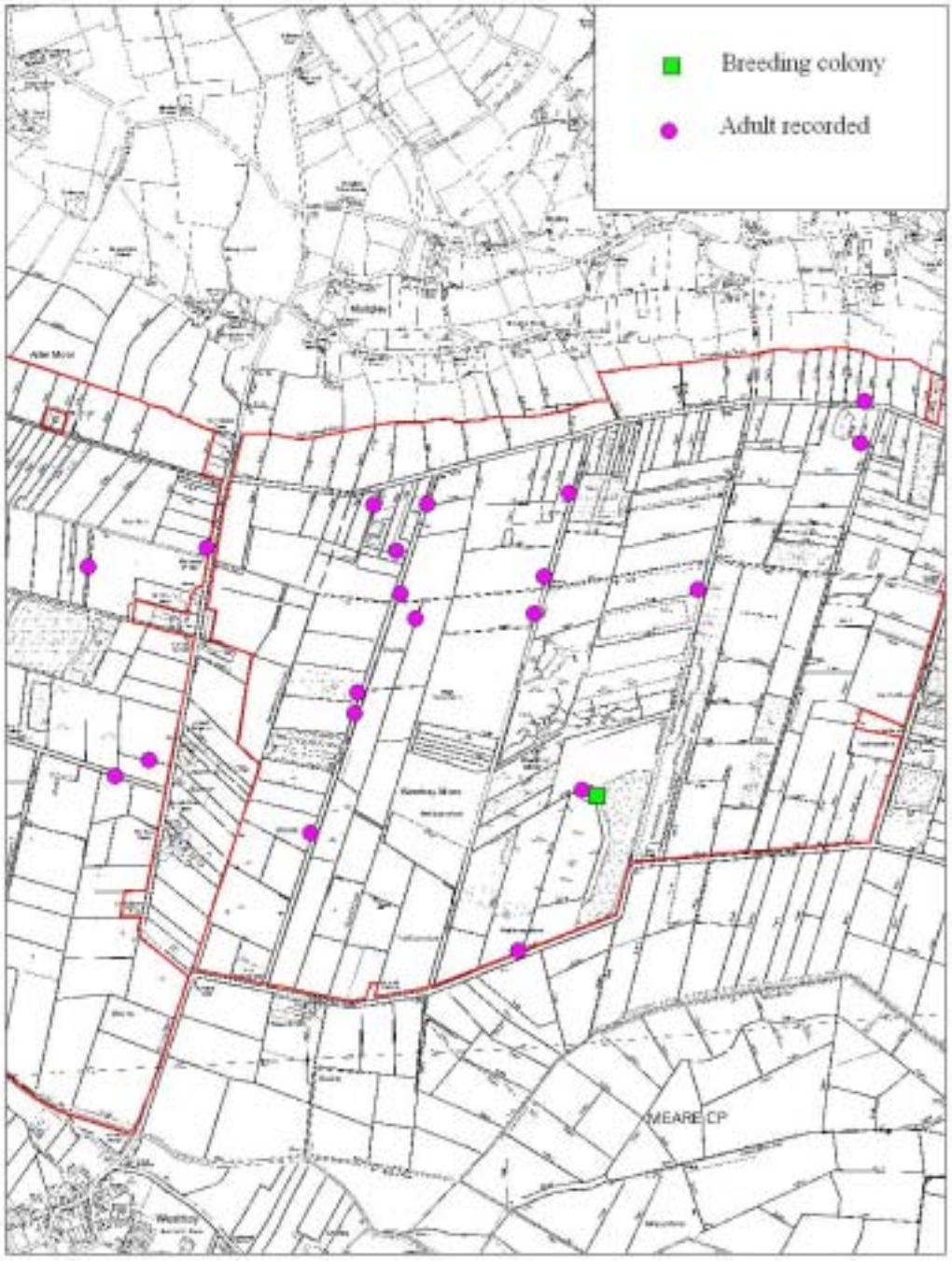


Template: C:\rg\Appl\Template\enetd1oo.wor. Compiled by Mark Jones on 19 February 2003. Somerset Team, Roughmoor, Bishops Hull, Taunton TA1 5AA

ENGLISH NATURE

Hydrochara caraboides distribution on Westhay Moor

Map 5

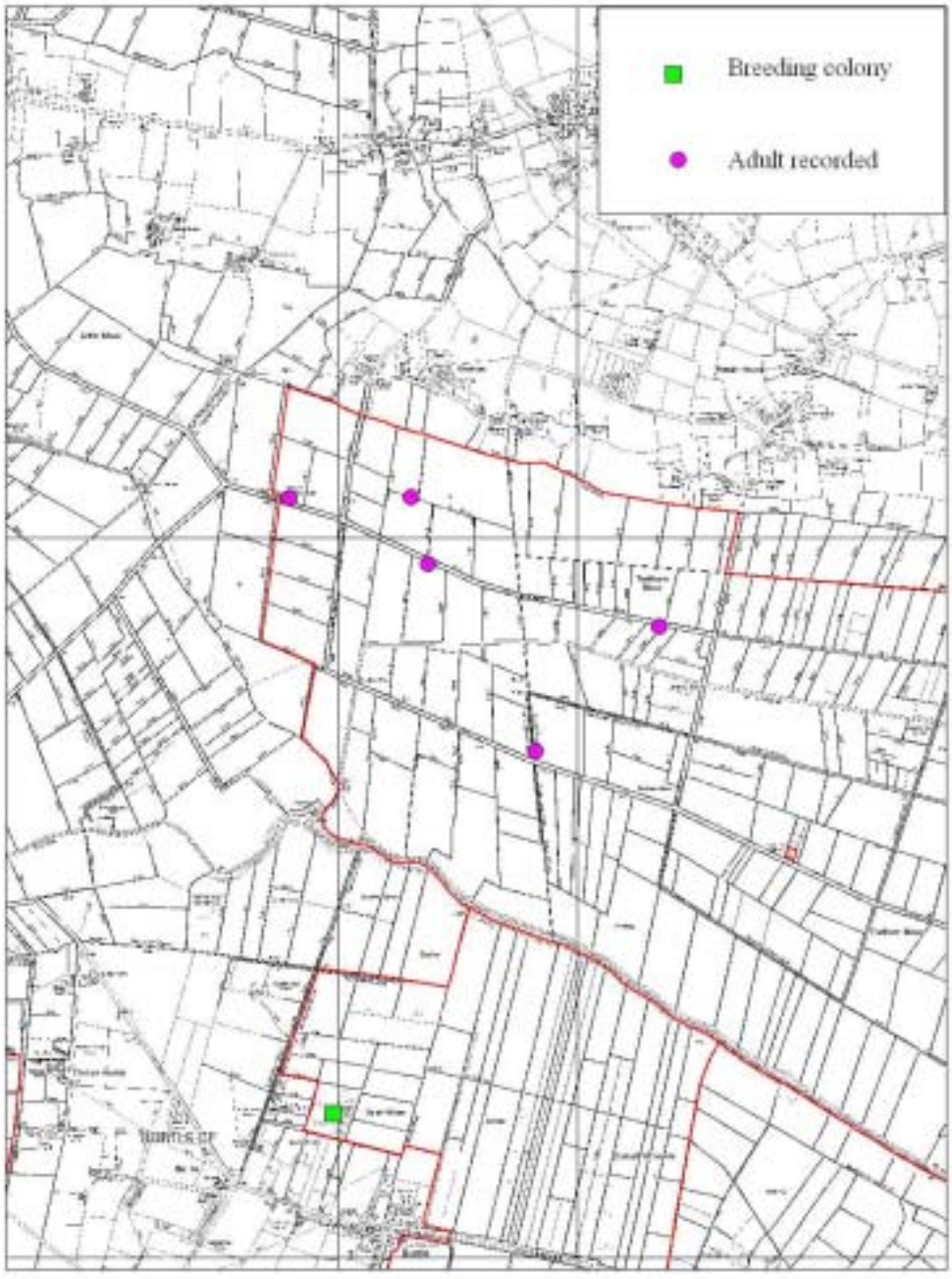


Template: C:\ngApps\Template\enmb11co.wor. Compiled by Mark Jones on 19 February 2003. Somerset Team, Roughmoor, Bishops Hull, Taunton TA1 5AA

ENGLISH NATURE

Hydrochara caraboides distribution on Tealham Moor

Map 6

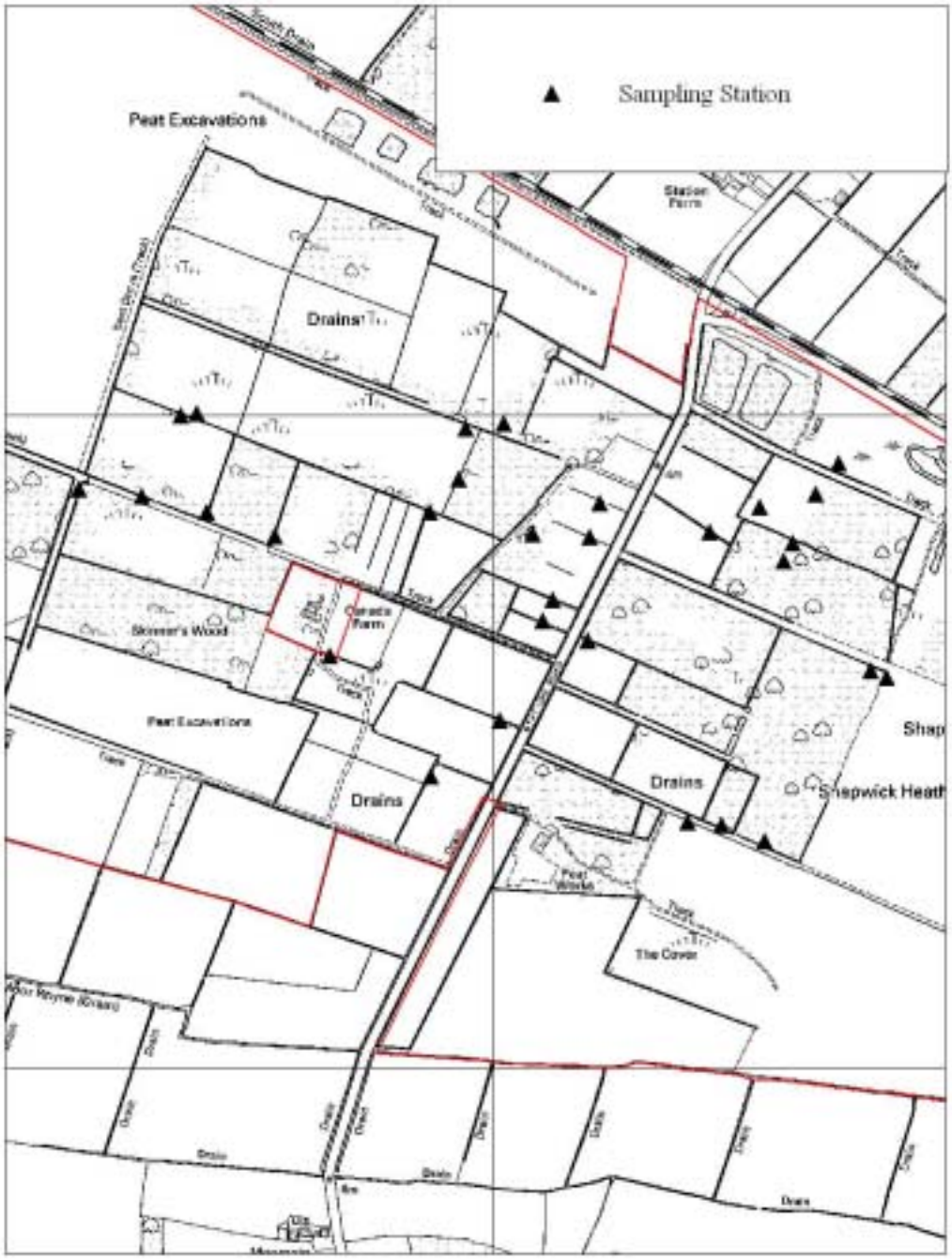


Template: C:\tgApp\Templates\enabdt.co.wor. Compiled by Mark Jones on 19 February 2003. Somerset Team, Roughmoor, Bishops Hull, Taunton TA1 5AA

ENGLISH NATURE

Location of sampling stations at Shapwick Heath

Map 7

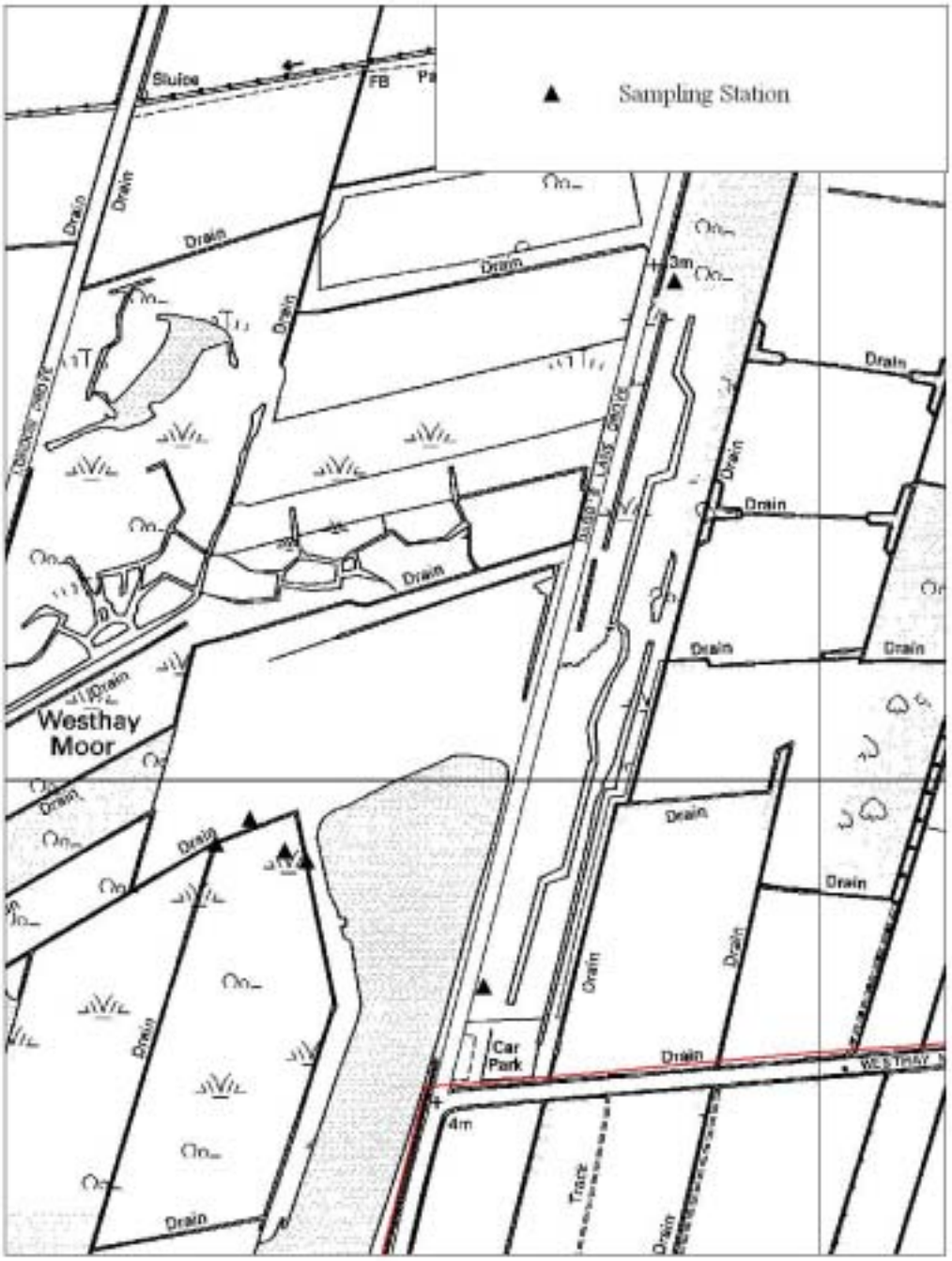


Template: C:\mpApps\Templates\enstd1 co wor . Compiled by Mark Jones on 19 February 2003 . Somerset Team, Roughmoor, Bishops Hull, Taunton TA1 5AA

ENGLISH NATURE

Location of sampling stations at Westhay Moor

Map 8



Template: C:\sgApps\Template\enstd1co.wor. Compiled by Mark Jones on 19 February 2003. Somerset Team, Roughmoor, Bishops Hull, Taunton TA1 5AA.

4. Habitat requirements of *Hydrochara caraboides* on the Somerset Levels

During April-June 2002, 37 sampling plots were set up at sites on Shapwick Heath NNR, Westhay Moor, Catcott Heath and Westhay Heath. These aimed to cover the range of variation in aquatic habitats found at these two sites. All sites at which *Hydrochara* adults, egg cocoons or larvae had been found in 2000 or 2001 were included in the sampling programme, with the remainder of sites being picked to sample the full range of habitats present on this reserve. Each sample plot was allotted a code, consisting of two letters (SH for Shapwick Heath and WM for Westhay Moor, followed by an unique number). Where adults or egg cocoons of *Hydrochara* were recorded during the 2002 habitat survey, this is recorded in Table 2 above, with these records being differentiated from other "casual" observations by the addition in the "Site" column of the site code. In all cases, sampling stations covered an area of approximately 25 square metres. So for example, in a ditch of 1 metre width, a 25 metre length was sampled, whilst in an area of swamp, a square of 5x5 metres was sampled. The location of the sampling stations on Shapwick Heath NNR and Westhay Moor is plotted on Maps 6 and 7 respectively.

In May 2003, this initial sampling exercise was used to carry out a more detailed and rigorous sampling programme that aimed to assess more exactly the nature of the habitat in which *Hydrochara* egg cocoons occur. Five transects were set up across the wooded swamp at Shapwick Heath (SH17 and SH18), the location of these also being shown on Map 6. Each transect was split into two metre sections, with a two metre square quadrat recorded to the south of the transect line in all of these. The percentage of the quadrat covered by water was recorded, and where this figure was less than 50%, no further information was collected. Otherwise, the area of the quadrat with water cover was then sub-divided into four categories: open water, water dominated by duckweeds, water with stands of dense emergents (usually *Phragmites australis*, *Typha latifolia*, *Iris pseudacorus* or tall *Carex* species) and water dominated by mats of Floating Sweet-grass *Glyceria fluitans*. At each quadrat the number of egg cocoons present was recorded, and the plant species from which each cocoon was made, and the depth of water under each cocoon were also noted. Percentage shade was also noted for each quadrat, and a water depth measurement was taken from the centre point of the water-covered area.

The various data fields recorded during the 2002 and 2003 sampling exercises are discussed below, with a description of when and how they were measured, and an assessment of their importance for *Hydrochara*. This discussion is widened to include reference to other information collected by the author during the three years of the study, plus any other information on the habitat preferences of the species found in either the British or continental literature. A full record of all the data collected in 2002 from each of the sampling stations is given in Appendix 2, and the spreadsheets from the 2003 egg cocoon transects can be found at Appendix 3.

4.1 Distribution and abundance of adult *Hydrochara caraboides*

At each sampling plot, one 15-minute sample for adult *Hydrochara* was carried out. These visits took place on 26 April, 27 April, 6 May and 7 May 2002, before egg cocoon construction began. A pond net was used to sample throughout the sample plot, and an

attempt was made to sample all microhabitats present within the plot. The samples were emptied into a white tray, and all adult *Hydrochara* were recorded and sexed, the latter being achieved through examination of the protarsi with a hand lens (see Figure 3 above). Sampling stations in which *Hydrochara* was recorded are listed in Table 2 above.

In all, adult *Hydrochara* were recorded at 12 of the 37 sampling plots. Ditches favoured by adults varied widely, from very shallow, shaded detritus ditches of the type favoured by the species for breeding (see below), through to open, deep, clay-bottomed pits on the site of former peat workings. As an adult, *Hydrochara* appears to be indifferent to the presence of a peat or clay substratum.

Widening the net to include all the post-2000 records of adults listed in Table 2, the picture is the same, with the adult being found across almost the entire spectrum of habitat types present on the Somerset peat moors. *Hydrochara* adults are known to fly readily at night, and this has been witnessed on one occasion during the current study (see section 5.2 below).

In April and May 2001, large numbers of adult *Hydrochara* were found in shallow water at the edge of the old peat workings in the area that includes sample plot SH8. By the end of May, the wooded swamp immediately to the west of here was full of *Hydrochara* egg cocoons. No egg cocoons or adults were to be found in the former area by this time. It seems that adult *Hydrochara* are able to utilise a range of habitat types into which they disperse freely by flight, but their breeding habitat is much more specific. Given the catholic habits of the adults, it is not surprising that past studies of the adult distribution using multivariate analyses have failed to find strong patterns in the distribution of the adult on the Somerset Levels (Drake and others 1984).

Figure 7 – wooded swamp at Shapwick NNR

4.2 Competition with other large water beetles

At the same time that *Hydrochara* was collected in 2002, a note was made of other large water beetles (of the genera *Hydrophilus*, *Dytiscus*, *Acilius* and *Colymbetes*) recorded, as these were deemed to be the species most likely to predate on, or compete with *Hydrochara*. Only the great diving beetle, *Dytiscus marginalis* occurred with any frequency in sites in which *Hydrochara* was recorded, and this species was equally frequent in sites from which *Hydrochara* was absent. It is encouraging that adults of its Red Data Book relative, *Dytiscus dimidiatus* were recorded at three of the sampling plots (SH8, SH17, CH1).

Hydrochara's closest relative, the great silver water beetle *Hydrophilus piceus* was also found at three sample plots (SH8, SH9 and CH2). All three of these ditches are open, with abundant emergent and/or submerged vegetation. Like *Hydrochara*, *Hydrophilus* is found in a wide range of aquatic environments on the Levels. However, it has never been found in the shallow, shaded ditches favoured by breeding *Hydrochara*. Rather, it shows a strong preference for permanent ditches with abundant submerged vegetation. Studies on the continent have shown larval *Hydrophilus* to be a generalist predator of other aquatic invertebrates, though in Britain, a specialism as a predator of large aquatic molluscs has been proposed.

In summary, adult *Hydrochara* are frequently found in company with other large water beetles. However, the egg cocoons and larvae tend to occur in areas of very shallow and ephemeral aquatic habitats from which other large water beetles (even the virtually ubiquitous *Dytiscus marginalis*) are absent. Larvae of *Hydrophilus* and *Dytiscus* are extremely aggressive generalist predators, and *Hydrochara* larvae may be preyed upon, or outcompeted by other large water beetle larvae.

4.3 Competition with aquatic vertebrates

A note was made of the presence/absence of any aquatic vertebrates (amphibians or fish) netted whilst sampling for adult *Hydrochara* in 2002, as these were thought to be possible competitiors/predators of *Hydrochara* larvae.

Only three aquatic vertebrates were recorded from the sampling plots, these being the ten-spined stickleback *Pungitius pungitius*, the palmate newt *Triturus helveticus* and the Smooth Newt *Triturus vulgaris*. Adult *Hydrochara* appear to be indifferent to the presence of these species, though none were present in the four sample plots from which egg cocoons were recorded (see 4.4 below). However, in 2001 numbers of palmate newt efts had been found in the same area of wooded swamp from which over 50 egg cocoons were recorded. It is possible that the absence of vertebrate predators is an important factor in determining the distribution of breeding *Hydrochara*, but we currently have insufficient data to arrive at firm conclusions.

4.4 Distribution and abundance of egg cocoons

In 2001, 53 egg cocoons were recorded overall, with 47 in the extensive area of wooded swamp that includes sample plots SH17 and SH18. A further five had been recorded from the ditch including sample plot SH3 and a singleton in the ditch including sample plot SH1. Of these, 45 were wrapped in dead silver birch leaves, seven were in dead pedunculate oak *Quercus robur* leaves and one was in a dead leaf fragment of common reedmace *Typha latifolia*. The choice of vegetation in which the cocoon is wrapped by the female is chiefly dictated by the most abundant tree species local to the breeding site. Herbaceous plants seem to be less popular, but are occasionally selected. In Danish studies, dead beech leaves were most frequently used, though living leaves of herbaceous species such as forget-me-nots *Myosotis* spp. and sweet-grasses *Glyceria* spp. were occasionally used (B∴ving & Henriksen 1938). The detailed studies of Maillard (1970) in France cite the use of various herbaceous species such as frogbit *Hydrocharis morsus-ranae*, water-plantain *Alisma plantago-aquatica*, pondweeds *Potamogeton* spp. and great yellow-cress *Rorippa amphibia*. This author also mentions the use of dead leaves of trees such as Sallow *Salix caprea* and of dead leaf fragments of common reed *Phragmites australis*. In 2001, the 47 egg cocoons recorded in

the wooded swamp at Shapwick Heath had all been in water depths ranging from 3-22cm. The six others in ditches on Shapwick Heath had been in water ranging in depth from 5-14cm.

On 29 May, 4 June, 5 June, and 14 June 2002, all sample plots were visited to search for egg cocoons, with 15 minutes being spent at each sampling station. The type of vegetation in which the egg cocoon was wrapped was noted, and the depth of the water column at the location in which the egg cocoon was found was also recorded. Egg cocoons were much more restricted in their distribution than were the adult beetles, with a total of 21 egg cocoons being found in 2002, in just four of the sample plots: one in SH3, nine in SH18, four in SH20 and seven in WM4. Of the 21 egg cocoons, 14 were wrapped in dead silver birch *Betula pendula* leaves, this being the dominant tree species at sample plots SH18 and WM4. At SH20 however, the ditch is shaded by alder *Alnus glutinosa*, and all five egg cocoons here were wrapped in dead leaves of this species. Of the remaining two cocoons, one was wrapped in a dead hawthorn *Crataegus monogyna* leaf, and the other in a fresh green leaf of enchanter's-nightshade *Circaea lutetiana*. The sampling in 2003 showed silver birch to be much the most favoured species used to wrap the cocoon in SH17 and SH18, though common reedmace and common reed had also been used.

A new breeding site was discovered at Shapwick in 2003, with 12 egg cocoons found along the shallow, mossy ditch in the Roughet (SH5). Six of these cocoons were constructed using a silver birch leaf, two using grey willow and the remaining four were constructed using yellow flag *Iris pseudacorus*.

4.5 Width of watercourse

Measured in 2002. This measurement could only be recorded for ditch habitats, in swamps it was obviously not applicable. In ditches, it was measured from bank to bank to the nearest 10cm. There appears to be no relationship between the width of the watercourse and presence of breeding *Hydrochara*.

4.6 Depth of water column

The depth of the water column was measured during the June 2002 visit to each sample plot. A graduated pole was used to measure the water column at its deepest point. . This measure is not very useful in interpreting the pattern of *Hydrochara* distribution, as it only measures a single point in the deepest area of water present in each sample plot. In almost all cases, water depth varied considerably in the sample plots, with shallow areas usually occurring on the bank edges. *Hydrochara* certainly favours shallow water, and in sample plots in areas with deep water, adult *Hydrochara* could sometimes still be found, provided that the ditch sides had shallow shelving areas. A good example of this was in the flooded peat workings at SH8, cited in sub-section 4.1 above. Despite the deep water, large numbers of adult *Hydrochara* could be found in shallow fringes with mats of *Glyceria fluitans* near the bank.

There is a strong relationship between the presence of egg cocoons and water depth. The measure of water depth given with the location of each egg cocoon found during 2001 and 2002 reveals that of the 74 egg cocoons recorded during the two years, 70 have been in water less than 20cm deep, most being in water much shallower than this. Water depth was also measured along the transects on Shapwick in 2003. These results also demonstrate a link

between water depth and the presence of egg cocoons, with all of the 29 cocoons found during this study being in water depths of between 2 and 14 cm.

Figure 8 – ditch at Westhay

Indeed, *Hydrochara* seems to tolerate, and may even favour areas of water that dry up over the summer months. The breeding ditch on Westhay Heath, discovered in June 2000 by Tony Smith, had completely dried up by July. Similarly, the wooded swamp at Shapwick Heath, which was the most important *Hydrochara* breeding site discovered during this study, had completely dried out by July 2001, though in the previous month large numbers of egg cocoons had been present here. By 7 June 2001, the water level had already started to drop rapidly, and two egg cocoons were found "beached" on the substrate. The ditches including sampling plots SH3 and SH20 had also dried up by late summer in both 2001 and 2002. Of the breeding areas for *Hydrochara* discovered during this study, only the ditches including sampling plots SH1 and WM4 seemed to be permanently filled with water, and even at these, there was a considerable drop in the water level over the summer months. The very hot, dry summer of 2003 demonstrated this phenomenon even more strikingly, with all of the main breeding areas drying up completely by July. All of the egg cocoons found in SH5 and many of those on the fringes of SH17 were "beached" as water receded much earlier than it had done in the previous years of the study.

The contrast with 2002 could not be stronger, when egg cocoons were absent from SH17, though this area had also been a prolific breeding area (47 egg cocoons recorded) in 2001. This sample plot forms part of an area of wooded swamp that had first been flooded in 1998. During 2001 and 2003, SH17 was only shallowly flooded, with water depths mostly being less than 20cm. In 2002, the area was much more deeply flooded with water, with maximum depth in the sampling plot now being in excess of 1 metre. Shallow, temporarily inundated swamp woodland of the type favoured by breeding *Hydrochara* in 2001 was now to be found to the west of SH17 in what had been unflooded woodland in 2001. This habitat was sampled in 2002 at sample plot SH18, and nine egg cocoons were recorded. It therefore seems clear that in this area of Shapwick Heath, the breeding population of *Hydrochara* has migrated south west in response to increasing water levels in 2002, but has then re-occupied its former breeding grounds during the drought of 2003.

4.7 The sediment layer

This was measured during the June visit in 2002. A graduated pole was sunk into the sediment until it could no longer be pushed in easily. Sediment depth was recorded to the nearest 10cm. Four of the sites where *Hydrochara* egg cocoons occurred were late-successional ditches with a thick layer of detritus on the bottom, though as has been shown above, the most prolific breeding areas were recently flooded areas of swamp woodland. Adults were found quite widely across a range of sediment depths.

4.8 Shading by trees and shrubs

An estimate of the % shade in each sample plot was made during both the 2002 and 2003 visits. Degree of shading was estimated to the nearest 10%. All plots in which egg cocoons were found were at least 50% shaded by overhanging trees. Of the 74 egg cocoons found during 2001 and 2002, and listed in Table 2, only 2 were found in areas with less than 25% shade from overhanging trees. It is possible that the preference for shaded areas shown during this study reflects the fact that these are less prone to being clogged with a thick mat of duckweed (see sub-section below). Obviously, shaded areas also provide an abundant supply of floating dead leaves with which the female can construct the egg cocoon, but other studies have shown herbaceous species are frequently used elsewhere (Maillard 1970), and it is considered unlikely that abundant dead tree leaves are an obligate requirement for breeding populations of *Hydrochara*. Some of the sites at which it has been found in Cheshire are partially shaded by willows *Salix* spp, though it also occurs commonly in open ponds in this area (Guest 1996a & 1996b). The 2003 survey failed to show a clear link between the presence of *Hydrochara* egg cocoons and the degree of shading by trees and shrubs.

4.9 Aquatic vegetation

4.9.1 Frogbit *Hydrocharis morsus-ranae*

The limited literature on the habitat of *Hydrochara* in the Somerset Levels initially suggested an association with well-vegetated species-rich ditches with a community referable to the A3 greater duckweed *Spirodela polyrhiza* - frogbit *Hydrocharis morsus-ranae* community of the National Vegetation Community (NVC). Accordingly, during 2000, 16 ditches with vegetation referable to the A3 community were surveyed on Catcott Heath and Tealham/Tadham Moors. *Hydrochara* was not found in any of these. Some authors suggest a strong association between *Hydrochara* and frogbit (Hill-Cottingham 1993), and for this reason, presence/absence of this plant was recorded during the systematic sampling programme in 1992. Frogbit was only found in one of the 2002 sample plots (SH3). It has become much scarcer on Shapwick Heath NNR in recent years (M Yeandle pers comm.).

Past studies of the invertebrate fauna of the Somerset Levels suggest that *Hydrochara* used to occur most frequently in open ditches with abundant macrophytes (Drake and others 1984), with definite breeding being reported from this habitat (Hill-Cottingham 1993). Its virtual absence from such sites now is puzzling, and led to much fruitless survey work in the first year of the study. There appears to be no correlation between the presence of either adults or breeding colonies of *Hydrochara* and this plant.

4.9.2 Duckweeds

Casual sampling carried out in 2001 and 2002 had suggested a strong correlation between distribution of egg cocoons and low levels of duckweed growth. Cover of floating duckweeds was recorded in the 2002 sample plots to the nearest 10%. Of the four sample plots in which egg cocoons were found during 2002, three were in areas with <25% cover of duckweed and the other was in an area with approximately 50% cover. All bar one of the 74 egg cocoons found in 2001 and 2002, and listed in Table 2 above were found in areas of open water with no duckweed growth. Quite often, these would be located within small open patches of water within areas that were otherwise covered with mats of floating duckweeds. Patterns in the data collected in 2003 were less clear-cut. It was not possible to discern a definite relationship between open water, duckweed abundance and the presence of egg cocoons. As outlined above, this may be because the females only require very small patches of open water in areas that are otherwise dominated by duckweeds. This would certainly appear to be the case from the 2003 samples, where egg cocoons were invariably found in open water, even where duckweed densities in the quadrat were otherwise high.

Construction of the egg cocoon by the female takes place on the surface of the water, and it is possible that floating duckweed would prevent the female from being able to carry out this delicate operation. It is also possible that its presence would make the egg cocoon more susceptible to predation, with predators able to reach the egg cocoon across the thick duckweed mat.

Though no research has been done, there has certainly been an increase in cover of duckweeds on the Somerset Levels, especially of the common duckweed *Lemna minor*. Since the early 1980s, the alien north American species *Lemna minuta* has also been increasing its distribution and abundance on the Somerset Levels (O Mountford pers. comm.). All of the native duckweeds are recorded from the Somerset Levels. The small floating species common duckweed *Lemna minor* and fat duckweed *Lemna gibba* are most frequent, with the former in particular being very abundant throughout the Levels. Duckweeds require still, sheltered waterbodies in order to thrive – very much the general habitats required by *Hydrochara*. The abundance of *L minor* and *L gibba* has been shown to be strongly linked to nutrient levels in the water, with both species having proliferated on the Levels in response to increased eutrophication. The primary agent of nutrient enrichment is thought to be agricultural, though airborne pollutants may also be significant. Eutrophication has resulted in an uncompromising dominance of Lemnetum communities on the Somerset Levels, especially in permanently inundated, open ditches, where there is no shade from trees and/or periodic dessication, to limit duckweed growth.

The remaining species of duckweed, ivy-leaved duckweed *Lemna trisulca*, greater duckweed *Spirodela polyrhiza* and rootless duckweed *Wolffia arrhiza* are scarcer, much less competitive species that are not thought to impact so strongly on the habitat of H*ydrochara*.

4.9.3 Floating sweet-grass *Glyceria fluitans*

During this study, approximately 75% of the records of adult *Hydrochara* have been of specimens netted amongst floating mats of *G. fluitans*. A similarly strong relationship has been found between these two species in ponds on the Cheshire Plain (Guest 1996a and 1996b). The 2003 transects showed a strong relationship between presence of egg cocoons and occurrence of floating sweet-grass in the quadrat. Despite this, the relationship is not

thought to be obligate, and a number of egg cocoons have been found away from floating sweet-grass during the course of the study. The exact nature of the relationship between the beetle and this plant has not been determined.

5. Summary of habitat and management requirements

Using the information in section 4, it is possible for us to set out a series of habitat requirements for *Hydrochara caraboides*. These can be summarised as follows:

- ∉ still, or very slow-flowing water;
- ∉ shallow, often seasonally inundated waterbodies;
- ∉ leafy or detritus-rich substrates;
- ∉ clear water, without excessive growth of floating duckweeds;
- ∉ abundant invertebrate prey, especially small Crustacea and *Asellus aquaticus;*
- ∉ mats of floating sweet-grass *Glyceria fluitans;*

On the Somerset Levels, the above combination of habitat requirements are most often met with in seasonally inundated, late-successional ditches with at least some shading from trees, or in areas of wooded swamp. It appears that *Hydrochara* occurred more widely on the Somerset Levels in the past in open ditches. Eutrophication and the concomitant increase in floating duckweeds are the most likely cause of its disappearance from such areas. The following summary aims to pick up the habitat requirements of *Hydrochara* and translate them into management recommendations that will maintain and enhance the breeding colonies of the beetle at its Somerset sites.

- ∉ Ensure that the ditch clearing rotation allows for the development of late-successional ditches with shallow water and a deep detritus layer.
- ∉ Maintain at least partial tree cover along late-successional ditches within breeding areas.
- ∉ Manage water levels to ensure that there is suitable shallow water (less than half a metre) within breeding areas from March through to July.
- ∉ Maintain areas of seasonally flooded swamp woodland within the Somerset peat moors. Create new areas of habitat by raising water levels to depths of less than half a metre in woodland between March and July.
- ∉ Avoid clearance of ditches within breeding areas between May and August inclusive, when egg cocoons and larvae are in the water, or when pupae are present in ditch banks.
- ∉ Investigate means of controlling the growth of *Lemna minuta* and other floating duckweeds in waterbodies that would otherwise provide suitable breeding habitat for *Hydrochara*.

6. Other aspects of the ecology and behaviour of *Hydrochara caraboides*

6.1 Adult behaviour and ecology

The adult can be found throughout the year, though there is a marked peak in records in the spring, from March through to June. Breeding probably takes place during this period, with construction of the egg cocoon in 2001 and 2002 seemingly concentrated into a relatively short period from late-May through to the middle of June. By contrast, between 29 April and 1 May 2003, egg cocoons were present on Shapwick Heath in abundance, with five recorded whilst actively being constructed by the female. However, though this was the peak period of egg cocoon production by *Hydrochara*, unhatched cocoons continued to be found throughout May, with the latest record being of four in ditch SH3 on 2 June. By 10 June just one remained unhatched and floating. One of the other three was still afloat, but had a clear larval emergence hole below the waterline. The other two had become waterlogged, but had no unhatched eggs within the cocoon, suggesting successful larval emergence. Clearly, the period of egg cocoon production peaked a month earlier in 2003 than in the previous two years. However, lower numbers of cocoons were still found right through into early June in those areas where the water table remained sufficiently high. The much earlier peak in cocoon production is presumably linked to the very warm, dry weather in March and April that were enjoyed by Britain in 2003. It was noticeable that in the main breeding areas occupied by *Hydrochara* on Shapwick Heath, water levels were already receding by the end of April, and a number of egg cocoons were found "beached" during May.

There follows a period through July and August when the adults become very hard to find. As the autumn rains begin to raise the water table again, adults (presumably mostly from the newly emerged generation) increase in numbers, and there is a second, much smaller peak in records during October. In cold weather over the winter, the adults vanish, but during milder spells they can still occasionally be found in the water.

Adults are capable swimmers by the standards of the Hydrophilidae, being possessed of long yellow swimming hairs on the tarsi of the two posterior pairs of legs. However, swimming seems to generally take place as an escape mechanism, when the beetle is disturbed, and in captivity at least, the species moves about by clambering through submerged detritus and mats of floating sweet-grass.

Studies of *Hydrochara* on the continent have established that it flies readily, and it has frequently been taken at light traps, sometimes in considerable numbers. During the current project, a single observation of a flying adult was made. This was in June 2000 at Shapwick Heath (SH5), when an individual was seen to crawl out of the water onto a *Glyceria* mat before flying off (M Yeandle, pers. comm.). The weather at the time was hot and sunny. On the continent, adults are quite often attracted to light at night (Smetana 1980), and it is likely that most dispersal takes place after dark. It would be interesting to run mercury vapour light traps within breeding areas for the species. The distribution of adult *Hydrochara* on the Somerset Levels is very much wider than that of egg cocoons and larvae, which suggests that the adult does disperse readily.

Despite a number of observations of captive adults being made, no adult feeding has been observed. The great silver water beetle feeds on vegetation, and it seems likely that

Hydrochara may also be herbivorous, with Floating Sweet-grass being a possible candidate given the predilection of the adults for this plant.

Possible mating behaviour has only been observed on two occasions during the current study. On 16/05/01 a male and female were netted in tandem in the wooded swamp near sample plot SH17. On 30/04/03 a female *Hydrochara* in the early stages of egg cocoon production was found in tandem with a male. In both cases, the pair did not appear to be *in copula*, and quickly separated when they were inadvertently disturbed.

The adult female had only been observed once in the act of cocoon construction up till 2003. In this case, a female was observed on 29 May 2002. A dead floating birch leaf was the starting point, with this being coated on its submerged surface with a layer of silk which bent the leaf into a ridged roof shape. Observations were broken off at this point, and by the following morning, the cocoon had been completed. All of the five females found constructing cocoons between 29 April and 30 May were at an early stage of construction, and all were using silver birch leaves. A detailed description of cocoon construction in this species is given by Maillard (1970). In captivity, four egg cocoons produced 24, 30, 32 and 35 larvae respectively, though Maillard (1970) estimates each cocoon to contain on average 50 to 60 eggs.

6.2 Larval behaviour and ecology

Egg cocoons have been taken and put into tanks in order to study the behaviour of the larvae. Larvae have also been netted in the field and taken back for captive studies to be carried out. The young larvae exit through a hole in the flat masted end of the cocoon, this hole usually being at or just below the waterline. From the moment they emerge from the cocoon, the larvae are voracious predators, and need to be separated from each other quickly as they will readily resort to cannibalism given the opportunity.

The first instar larvae are pale yellow-white in colour, with the head and thorax a rather richer orange-brown. They are quite mobile, spending much time moving about among submerged vegetation, or free-floating and swimming in the water column. They will take almost any invertebrate prey that comes within their reach. Touch seems to be very important in alerting the larva to the presence of prey, and the head is very mobile and can be swivelled to the side rapidly to capture prey in the formidable jaws. A range of prey items, collected at the same time as the larvae, were introduced into the aquarium. The aim being to replicate as closely as possible the range of prey items that would be available to the larva in the wild. In captivity, in addition to feeding on each other, first instar larvae have been observed to take juvenile water lice *Asellus aquaticus*, Diptera larvae and particularly, small Crustacea such as water fleas (Crustacea: Cladocera) and Cyclopoid Copepoda. These findings agree quite well with the range of prey items listed by B.ving and Henriksen (1938) from their studies of the larva in Denmark.

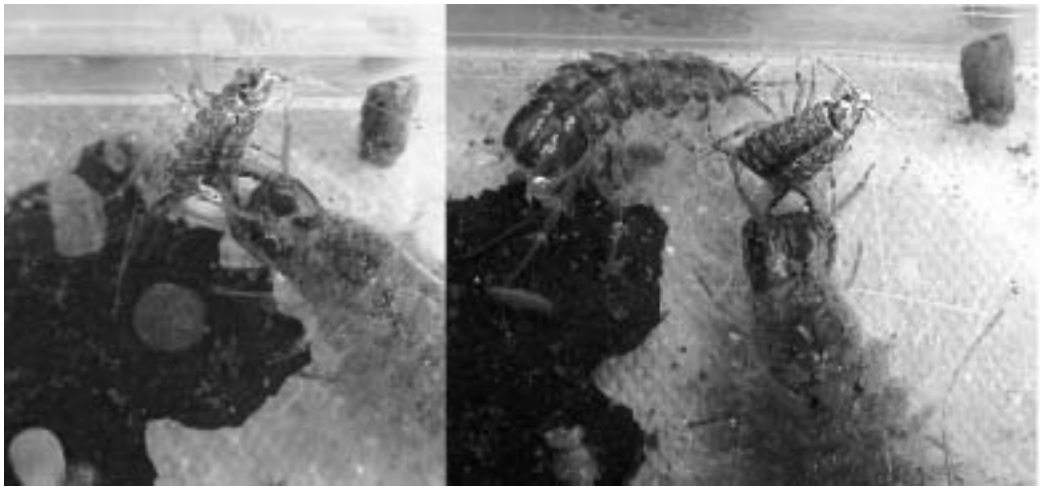


Figure 9 – Third instar lesser silver water beetle larva feeding on waterlouse

In the second and third instars the larva darkens in colour with the head and prontum a light orange-brown colour, with a strong, black, central stripe. The abdomen is a dark brown colour, and increasingly the larva becomes covered with a muddy encrustation. Changes in the appearance of the larva are matched by changes in its behaviour. It becomes much more sedentary, not swimming in the water column, but rather crawling through the bottom detritus. In captivity, it particularly favours sitting on dead leaves. At this stage, much the most important prey items are water lice *Asellus aquaticus*, which are ambushed as they pass near to the larva. Water lice are detritivores, and are the most abundant large prey items amongst the leaf litter and detritus on the bottom. The darker colouration and encrustation with sediment affords the mature larva excellent camouflage, this being heightened by the long, filamentous structures on the sides of the abdomen, which are very effective in breaking up the outline of the larva as it rests on dead leaves. It seems likely that the changes in colour and behaviour seen in the developing larva may help to camouflage the species from predators in the different microhabitats it occupies through its development, with paler first instar larvae inhabiting the upper water column, whilst the darker second and third instars spend much of their time amongst the bottom detritus. They may also enhance its effectiveness as a predator.

Once prey has been captured, the larva takes it to the water surface and the head is thrust up out of the water. This behaviour is well known in *Hydrochara*, and is also exhibited by a number of other hydrophilid species. Most hydrophilids feed by repeatedly puncturing their prey with the mandibles and regurgitating digestive juices onto the escaping body fluids of the prey, then sucking this up (B∴ving and Henriksen 1938, Balfour-Browne 1958). Such a mode of feeding would be impossible underwater, and this is presumably what necessitates this peculiar feeding behaviour.

Hydrochara's closest British relative, the great silver water beetle, *Hydrophilus piceus*, is thought to be a specialist predator of large planorbid snails (Foster, in press), making characteristic holes in the shells of its victims. A similar specialism as a snail predator has frequently been stated for *Hydrochara*. Whilst it is possible that snails may be taken in the wild, these have never accepted in captivity, though the aquaria in which the larvae have been kept were always stocked with a range of water snails (small planorbids, *Lymnaea peregra* and *Aplexa hypnorum*). Jonathan Guest has concluded from his studies in Cheshire that *Hydrochara* is unlikely to be a specialist snail predator, as it seems to be well adapted to

snatch fast-moving prey such as water lice and mayfly nymphs (Guest, 2000). The work of B.:ving and Henriksen (1938) also shows *Hydrochara* larvae to be predators of a range of mobile invertebrates. Captive studies strongly suggest that *Hydrochara* is a generalist ambush predator, whose choice of prey is largely dictated by the range of suitable prey species within its preferred size range that are most abundant in the microhabitats it occupies through its development.

Maturation rates seem to vary greatly depending upon the availability of prey. In captive situations, where larvae were continually provided with prey items they could mature within three weeks. However, in natural situations, larvae were found over a much longer period. For example, at sample plot WM4 on Westhay Moor, larvae were found from early June through to the end of July, with some of the latter still not being fully grown.

Figure 10 –Lesser silver water beetle full grown larva (left) and larva in cell prior to pupation (right)

In captivity, the mature larvae become very dark-coloured and sluggish in the few days prior to pupation. At this stage, captive larvae were moved to a plastic tub with shallow water and a bank of peat at one end. Larvae emerged from the water and made a shallow cell just below the surface of the peat by wriggling their body and head. Once the cell was completed, the larvae pupated. Pupae were quite active and rested on their side, back, or in one case stood on their head within the pupal chamber.

Figure 11 – newly emerged adult lesser silver water beetle

In 2001, all larvae died before pupating, and in 2002, though five larvae successfully pupated, only two adults successfully completed their development, with a third adult emerging crippled. In the latter case, the pupal chamber was very wet, and it is likely that a moist, but not waterlogged microclimate is required in order to ensure successful pupation. The three adults emerged after being in the pupal state for one to one and a half weeks.

No instances of *Hydrochara* adults or larvae being predated have been recorded in the field. Habitats occupied by the larvae are free of most large vertebrate predators such as fish, though newts were found in one breeding site, and may predate the larvae. Adults and larvae of the great diving beetle *Dytiscus marginalis* were frequently found in *Hydrochara* breeding areas, and on one occasion its rare relative, *Dytiscus dimidiatus* was also present. These may also predate *Hydrochara* larvae in the wild, though the microhabitat occupied by the larva tended to be in shallower water than that in which newts or these large predaceous beetles were found. In captivity, larvae readily resort to cannibalism in their first instar, and self-predation may be an important mechanism for controlling the density of the species within an area.

7. Other rare water beetles on the Somerset Levels

Whilst sampling for *Hydrochara*, notes have been kept on other water beetles encountered, particularly the other rare species that are known to occur on the Somerset Levels. Duff (1993) lists species of water beetle from the Somerset Levels that have Red Data Book status (Foster, in press), and have been recorded since 1980. These are listed below, with brief notes on their occurrence during the current survey, habitat and conservation status.

Great silver water beetle *Hydrophilus piceus* (Linnaeus). **LRnt. RDB3**

Recorded from all of the main study areas on the Somerset Levels, with adults found on many occasions. As with *Hydrochara*, the adults were to be found in a wide range of habitats, from densely vegetated ditches to recently excavated peat workings with little aquatic vegetation. The immature stages were not recorded, but this species is known to be a predator of large water snails in the larval stage, and it is therefore most likely to be found in richly vegetated open ditches, where populations of large planorbids reach their maximum abundance.

Figure 12 – Great silver water beetle

Hydaticus transversalis (Pontoppidan). **LRnt. RDB3**

Despite its very restricted national distribution, the species is still abundant on the Somerset Levels, and seems able to thrive in a very wide range of aquatic habitats, ranging from recently excavated peat workings with little aquatic vegetation, to densely vegetated ditches and shaded detritus-filled ditches with no aquatic vegetation. It is likely that as with many water beetles, the adults disperse into a range of habitats, but the larvae are much more restricted in their habitat choice.

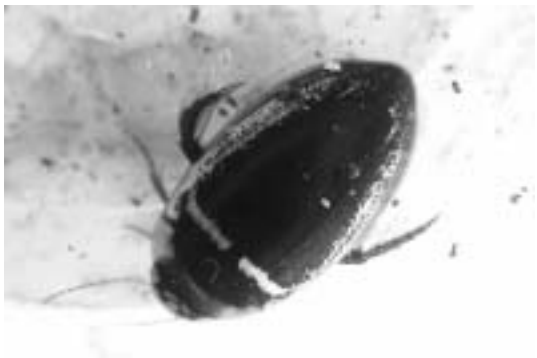


Figure 13 – *Hydaticus transversalis*

Laccornis oblongus (Stephens) **LRnt. RDB3**

There are recent records of this diving beetle from Shapwick Heath, Westhay Moor, Mudgley, Beckery and the Gordano Valley (Duff 1993). During the current study a small population was found on Shapwick Heath. The habitat in which the species formerly occurred at Westhay Moor has been lost as a result of peat extraction (D Bilton pers. comm.). This species requires areas of shallow, seasonally flooded mossy fen. The area it occurs in at Shapwick was formerly grazed and since this ceased the site has become dominated by tall tussocks of purple moor-grass *Molinia caerulea*, and the areas of saturated mossy lawn where Laccornis has been found are now very small in extent. It is imperative that the dominance of tall vegetation, especially *Molinia* tussocks should be reduced. Ideally cattle grazing should be re-introduced to the site, but failing this regular cutting of the vegetation may help to reduce the dominance of tall monocotyledons. The management of water levels at this site should ensure that it is flooded with shallow water during the spring and early summer.

Figure 14 – *Laccornis oblongus*

Dytiscus dimidiatus Bergsträsser **EN. RDB3**

This is the largest British diving beetle. It has a reasonably wide distribution on the Somerset Levels, being found away from the peat moors on sites such as West Sedgemoor. During the current study, it has been found on Shapwick Heath, Catcott Heath and Westhay Moor. At Shapwick it has been encountered regularly, often occurring in the same shallow, swampy ditches as Hydrochara. Within the peat moors of the Brue valley at least, this beetle appears to be holding its own, and is not thought to be threatened currently, though further studies of its ecological requirements are needed.

Figure 15 – *Dytiscus dimidiatus*

Although not found during the current study, *Haliplus variegatus*, is also worthy of brief discussion. It is a decreasing species, listed as RDB3 by Hyman & Parsons (1992), but now "upgraded" to Vulnerable (Foster, in press). It was formerly known from a number of sites on the Somerset Levels (Balfour-Browne 1936), but was last seen on Tealham Moor by PD Orton in 1988. Holmen (1987) suggests that this species favours clear water with abundant vegetation. This species is thought to specialise in feeding on stoneworts, which generally favour calcareous, but relatively nutrient poor water. He postulates that in Denmark, pollution may be resulting in the observed decline in this species. This may also be the case on the Somerset Levels, where nutrient levels in the watercourses are known to have increased as a result of agricultural intensification in the catchment over the last century. Indirectly, increased eutrophication has also resulted in an increase in the cover of duckweeds in the Levels, and this may prevent sufficient light from reaching submerged stonewort communities.

Four other Red Data Book water beetles have been recorded recently on the Somerset Levels. These are; *Limnebius aluta* Bedel **VU RDB3**, *Hydrochus elongatus* (Schaller) **LRnt RDB3**, *Hydrochus ignicollis* Motschulsky **VU RDB3** and *Cercyon granarius* Erichson **LRnt RDB3**. none of these species were recorded during the current study.

8. Future studies

Though considerable progress has been made in increasing our understanding of the distribution and ecology of *Hydrochara caraboides*, there are still a number of areas of work that need to be pursued.

Studies during the first four years of the project have primarily aimed to elucidate the distribution and ecology of the beetle in Somerset. Inevitably, there are still areas where our knowledge in both these fields needs to be improved, and they continue to merit further study. In the following section, a prioritised list of work items is suggested that will help to further our understanding of *Hydrochara* on the Somerset Levels.

1 Continue to study the breeding population of *Hydrochara* in the area of flooded swamp woodland on Shapwick Heath (SH17). This area was first flooded in 2000, and the breeding colony that was discovered in 2001 seems to have subsequently moved around the area in response to changes in water depth and possibly other factors. Further monitoring of the breeding distribution of the species in this area should help us to better understand the physical, chemical and biological factors that are required by the beetle.

2.. In addition to this, it is suggested that a further area of potential breeding habitat at Shapwick should be created. A similar monitoring programme to that undertaken at Shapwick Heath (SH17 & SH18) in 2003 (see section 4) should be carried out in order to assess the success of the experimental management work in creating new habitat for *Hydrochara*. The most likely means of establishing new areas of breeding habitat would be through the flooding of wet woodland to a depth where shallow areas of water (<0.5 metres) were present in May-June. It is suggested that this should be a high priority for funding, given the objectives of the BAP, and the opportunities for positive management afforded by the Somerset Levels and Moors ESA.

3.. Encourage studies to be carried out on the distribution, abundance and ecology of the Lemnaceae on the Somerset Levels. Of particular importance for *Hydrochara* would be the examination of management techniques that aim to reduce the dominance of Lemnaceae in unshaded ditches during the period when egg cocoons are present, in May. It is suggested that the contractor should clear sample 1 metre plots of floating duckweeds along ditch SH3 on Shapwick Heath. Small open areas of water along this ditch have been used by breeding *Hydrochara* in both 2001 and 2002, but much of the length of the ditch is matted with duckweeds. By recording the number of egg cocoons in both duckweed present and absent plots, it may be possible to develop our understanding of the importance of duckweeds as a factor influencing the distribution of breeding *Hydrochara* on the Somerset Levels.

4.. Expand distributional studies of *H caraboides*. There are still a number of sites on the peat moors that have not been surveyed for presence/absence of adult *H caraboides*. In particular, there are further areas of Tealham and Tadham Moors that have not yet been thoroughly searched for the species.

5.. Continue programme of publicity/dissemination of information on *H caraboides* and its conservation. A talk to landowners and conservation bodies will be given in

March 2003. It is proposed that an article should be prepared for publication in the conservation/entomological press during 2003.

6.. Carry out an adult mark-recapture programme to study dispersal and longevity of *H caraboides* through the year.

7.. Study and photograph egg cocoon construction by female *H caraboides*. Thus far this process has only been partially observed. Inability to construct egg cocoons in areas with a dense mat of duckweeds on the water surface may be a major factor limiting the distribution of the beetle on the Somerset Levels.

8.. Attempt to locate pupation sites in the wild. A difficult task, but not impossible with the knowledge of the breeding habitat we now have.

Of the above list, items 1 and 2 are of key importance, as they should help to firm up our understanding of the ecology of the species, and the management techniques that will benefit it. More indirectly, study of the ecology of the Lemnaceae may also be very important in ensuring the long-term survival of *Hydrochara*.

9. Acknowledgements

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Appendix 1: Species Action Plan for *Hydrochara caraboides*

Lesser silver water-beetle (*Hydrochara caraboides)* action plan

1. Current status

1.1 The lesser silver water-beetle is found in exposed, richly vegetated ditches and ponds. In the Somerset Moors, this species is confined to peat areas and is frequent only on the turbary peats of Tadham and Westhay Moors. The species benefits from piecemeal, periodic ditch clearing and high water levels that reduce peat wastage on the Somerset Moors. The Cheshire sites include some relatively undisturbed ponds. The egg cocoon's construction necessitates the use of floating debris and, therefore large floating plants, such as frogbit and flote-grass, are thought to be beneficial. However, access to ponds and ditches by grazing animals may be required in order to maintain an open structure. Eggs are laid in spring or early summer, and larvae occur, often floating just below the surface, from May to July. The larvae are predators of water snails. Adults emerge during the summer and overwinter, though it is not clear whether this occurs in the water or on the bank. Adults are occasionally found attracted to light or to glass, and fly readily at dusk if kept in captivity.

1.2 In Britain this species is known from 11 ten km squares since 1970. It was much more widely distributed in the 19th century, being particularly well recorded from the Hammersmith marshes, the Cambridgeshire fens and Askham Bog. Until recently it was thought to have become confined to the deeper turbary peats of the Somerset Moors, but the discovery in 1990 of an adult in a pond on the Cheshire Plain has been followed by the discovery of more colonies, some with egg cocoons and larvae. By 1997, it had been recorded from seven ten km squares here.

1.3 In Great Britain, this species is classified as Endangered. It is given full protection under Schedule 5 of the Wildlife and Countryside Act 1981.

2. Current factors causing loss or decline

2.1 Inappropriate ditch management.

2.2 Conversion of grazing marsh to arable land, resulting in steeper ditch profiles and overgrowth of ditches in the absence of grazing.

2.3 Infilling of ponds.

2.4 Agricultural improvement.

2.5 Loss of ponds to urban development.

3. Current action

3.1 Ponds on the Cheshire Plain have been the subject of the Pond Life survey since 1995.

3.2 Through English Nature's Species Recovery Programme, additional survey has been undertaken and some ponds have been managed to improve them for this species.

3.3 Surveys for this species were undertaken in 1993 and 1994 on the Somerset Moors.

3.4 The species is present in the Somerset Levels and Moors SPA.

4. Action plan objectives and targets

4.1 Maintain viable populations within the Somerset Moors and the Cheshire Plain.

5. Proposed action with lead agencies

The priorities for the lesser silver water-beetle are to implement appropriate habitat management at existing sites, and to undertake research to elucidate relevant aspects of the species' ecology. In addition, further surveys should be carried out to establish the distribution of the beetle.

5.1 Policy and legislation

5.1.1 Where appropriate include the requirements of the species when preparing or revising prescriptions for agri-environment schemes.
(ACTION: ENGLISH NATURE, MAFF).

5.1.2 Take account of this species' requirements in response to applications for water abstraction licences.
(ACTION: EA).

5.1.3 Address the requirements of this species in the LEAP process and in relevant WLMPs.
(ACTION: EA, IDBs, LAs, MAFF).

5.2 Site safeguard and management

5.2.1 Where possible, ensure that all occupied habitat is appropriately managed, including periodic ditch cleaning on the Somerset Moors, by 2008. This may be through SSSI or agri-environment scheme management agreements.
(ACTION: ENGLISH NATURE, LAs).

5.2.2 Ensure that the habitat requirements of *Hydrochara caraboides* are taken into account in any relevant development policies, plans and proposals.
(ACTION: ENGLISH NATURE, LAs).

5.2.3 Ensure that the species is included in site management documents for all relevant SSSIs.
(ACTION: ENGLISH NATURE).

5.2.4 Consider notifying as SSSIs sites holding key populations of the species, where this is necessary to secure their long-term protection and appropriate management.
(ACTION: ENGLISH NATURE).

5.3 Species management and protection

5.3.1 None proposed.

5.4 Advisory

5.4.1 Advise landowners and managers of the presence of this species and the importance of beneficial management for its conservation.
(ACTION: EA, ENGLISH NATURE, MAFF).

5.4.2 As far as possible, ensure that all relevant agri-environment project officers, and members of regional agri-environment consultation groups, are advised of locations of this species, its importance, and the management needed for its conservation.
(ACTION: ENGLISH NATURE, MAFF).

5.5 Future research and monitoring

5.5.1 Undertake further surveys to determine the status of this species.
(ACTION: ENGLISH NATURE).

5.5.2 Establish a regular monitoring programme for this species.
(ACTION: ENGLISH NATURE).

5.5.3 Conduct targeted autecological research to inform habitat management.
(ACTION: ENGLISH NATURE).

5.5.4 Pass information gathered during survey and monitoring of this species to a central database for incorporation in national and international databases.
(ACTION: ENGLISH NATURE).

5.6 Communications and publicity

5.6.1 Promote opportunities for the appreciation of the species and the conservation issues associated with its habitat. This should be achieved through articles within appropriate journals, as well as by a publicity leaflet.
(ACTION: ENGLISH NATURE).

5.7 Links with other action plans

5.7.1 Implementation of this action plan could benefit other species other species of grazing marsh, including the shining ram's-horn snail *Segmentina nitida*.

5.7.2 This plan should be considered in conjunction with that for coastal and floodplain grazing marsh.

Appendix 2: Sampling plots on Westhay Moor and Shapwick Heath

Site/Code: WM1	**Grid ref:** ST456436		**Width of watercourse:**
Dates visited:	07/05/02	14/06/02	n/a
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	0.7m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
10-spined stickleback	-		0.1m
Smooth newt			
			% shade: 0
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 0
			% Lemna: 10.

Site/Code: WM2	**Grid ref:** ST458446		**Width of watercourse:**
Dates visited:	07/05/02	14/06/02	5.0m
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	0.3m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
Palmate newt	*Dytiscus marginalis*		0.1m
			% shade: 90%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 10%
			% Lemna: 5%

Site/Code: WM3	**Grid ref:** ST459447		**Width of watercourse:**
Dates visited:	07/05/02	14/06/02	5.0m
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	0.4m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
Palmate newt	-		0.1m
			% shade: 100%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 0
			% Lemna: 5%

Site/Code: WM4	**Grid ref:** ST454438		**Width of watercourse:**
Dates visited:	07/05/02	14/06/02	1.5m
Adult Hydrochara: **Egg cocoons:**	- -	1f 7	**Depth of water column:** 0.4m (P)
Aquatic vertebrates: Palmate newt	**Other water beetles:** *Dytiscus marginalis*		**Depth of sediment layer:** 0.8m
			% shade: 50%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 15%
			% Lemna: 30%

Site/Code: WM5	**Grid ref:** ST454439		**Width of watercourse:**
Dates visited:	07/05/02	14/06/02	1.5m
Adult Hydrochara: **Egg cocoons:**	1m, 1f -	- -	**Depth of water column:** 0.2m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 0.9m
			% shade: 50%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 10%
			% Lemna: 30%

Site/Code: WM6	**Grid ref:** ST454439		**Width of watercourse:**
Dates visited:	07/05/02	14/06/02	1.2m
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 1.0m (P)
Aquatic vertebrates: -	**Other water beetles:** -		**Depth of sediment layer:** 0.2m
			% shade: 0
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 0
			% Lemna: 0

Site/Code: WM7	**Grid ref:** ST454438		**Width of watercourse:**
Dates visited:	07/05/02	14/06/02	n/a
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	1.0m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
Palmate newt	*Dytiscus marginalis*		0.3m
			% shade: 50%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 20%
			% Lemna: 0

Site/Code: SH1	**Grid ref:** ST424409		**Width of watercourse:**
Dates visited:	26/04/02	29/05/02	1.7m
Adult Hydrochara:	1m	-	**Depth of water column:**
Egg cocoons:	-	-	0.2m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
Palmate newt	*Dytiscus marginalis*		1.5m
			% shade: 10%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 20%
			% Lemna: 90%

Site/Code: SH2	**Grid ref:** ST425409		**Width of watercourse:**
Dates visited:	26/04/02	29/05/02	n/a
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	1.5m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
Ten-spined stickleback	*Dytiscus marginalis*		0.2m
			% shade: 0
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 0
			% Lemna: 100%

Site/Code: SH3	**Grid ref:** ST424406		**Width of watercourse:**
Dates visited:	26/04/02	29/05/02	0.7m
Adult Hydrochara: **Egg cocoons:**	1f -	1ov 1	**Depth of water column:** 0.2m (T)
Aquatic vertebrates: -	**Other water beetles:** -		**Depth of sediment layer:** 0.6m
			% shade: 20%
			***Hydrocharis*:** Y
			***Glyceria fluitans*:** 10%
			% Lemna: 75%

Site/Code: SH4	**Grid ref:** ST424407		**Width of watercourse:**
Dates visited:	26/04/02	29/05/02	1.3m
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.2m (P)
Aquatic vertebrates: -	**Other water beetles:** -		**Depth of sediment layer:** 1.0m
			% shade: 100%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 20%
			% Lemna: 30%

Site/Code: SH5	**Grid ref:** ST424408		**Width of watercourse:**
Dates visited:	26/04/02	29/05/02	2.0m
Adult Hydrochara: **Egg cocoons:**	1m -	- -	**Depth of water column:** 0.1m (T)
Aquatic vertebrates: -	**Other water beetles:** -		**Depth of sediment layer:** 0.1m
			% shade: 0
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 15%
			% Lemna: 80%

Site/Code: SH6	**Grid ref:** ST421405		**Width of watercourse:**
Dates visited:	07/05/02	14/06/02	1.5m
Adult Hydrochara:	1m	-	**Depth of water column:**
Egg cocoons:	-	-	1.4m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
Ten-spined stickleback	*Dytiscus marginalis*		1.2m
			% shade: 30%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 20%
			% Lemna: 90%

Site/Code: SH7	**Grid ref:** ST423408		**Width of watercourse:**
Dates visited:	26/04/02	29/05/02	0.7m
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	0.1m
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
-	*Dytiscus marginalis*		0.6m
			% shade: 20%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 5%
			% Lemna: 100%

Site/Code: SH8	**Grid ref:** ST425404		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	n/a
Adult Hydrochara:	1m	-	**Depth of water column:**
Egg cocoons:	-	-	1.6m
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
Ten-spined stickleback	*Dytiscus dimidiatus* *D marginalis* *Hydrophilus piceus*		0.3m
			% shade: 0
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 5%
			% Lemna: 100%

Site/Code: SH9	**Grid ref:** ST423403		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	n/a
Adult Hydrochara:	1m	-	**Depth of water column:**
Egg cocoons:	-	-	1.3m
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
Ten-spined stickleback	*Hydrophilus piceus*		0.1m
Smooth newt			
			% shade: 0
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 0
			% Lemna: 90%

Site/Code: SH10	**Grid ref:** ST421406		**Width of watercourse:**
Dates visited:	06/05/02	05/06/02	1.0m
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	0.1m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
-	-		0.4m
			% shade: 50%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 15%
			% Lemna: 0

Site/Code: SH11	**Grid ref:** ST421407		**Width of watercourse:**
Dates visited:	06/05/02	05/06/02	1.5m
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	0.3m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
-	-		1.0m
			% shade: 80%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 5%
			% Lemna: 100%

Site/Code: SH12	**Grid ref:** ST416408		**Width of watercourse:** 1.6m
Dates visited:	06/05/02	05/06/02	
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.3m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 0.5
			% shade: 100%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 0
			% Lemna: 100%

Site/Code: SH13	**Grid ref:** ST415408		**Width of watercourse:** 1.7m
Dates visited:	06/05/02	05//06/02	
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.3m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 0.5m
			% shade: 100%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 0
			% Lemna: 100%

Site/Code: SH14	**Grid ref:** ST415409		**Width of watercourse:** 1.7m
Dates visited:	06/05/02	05/06/02	
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.2m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 1.5m
			% shade: 90%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 10%
			% Lemna: 20%

Site/Code: SH15	**Grid ref:** ST414409		**Width of watercourse:** 1.5m
Dates visited:	06/05/02	05//06/02	
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.3m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 0.5m
			% shade: 10%
			***Hydrocharis*:**0
			***Glyceria fluitans*:** 0
			% Lemna: 0

Site/Code: SH16	**Grid ref:** ST415408		**Width of watercourse:** 1.7m
Dates visited:	06/05/02	05/06/02	
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.3m (P)
Aquatic vertebrates:	**Other water beetles:** *Dytiscus marginalis*		**Depth of sediment layer:** 0.5m
			% shade: 100%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 0
			% Lemna: 100%

Site/Code: SH17	**Grid ref:** ST425404		**Width of watercourse:** n/a
Dates visited:	27/04/02	04/06/02	
Adult Hydrochara: **Egg cocoons:**	1m, 1f -	- -	**Depth of water column:** 1.2m (P)
Aquatic vertebrates: Palmate newt	**Other water beetles:** *Dytiscus dimidiatus* *Dytiscus marginalis*		**Depth of sediment layer:** 0.1m
			% shade: 90%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 15%
			% Lemna: 40%

Site/Code: SH18	**Grid ref:** ST423403		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	n/a
Adult Hydrochara:	2m	-	**Depth of water column:**
Egg cocoons:	-	9	0.2m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
-	-		0.1m
			% shade: 100%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 10%
			% Lemna: 10%

Site/Code: SH19	**Grid ref:** ST422403		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	2.0m
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	1	1.0m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
-	-		0.2m
			% shade: 90%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 15%
			% Lemna: 40%

Site/Code: SH20	**Grid ref:** ST417405		**Width of watercourse:**
Dates visited:	06/05/02	05/06/02	1.1m
Adult Hydrochara:	3m, 1f.	-	**Depth of water column:**
Egg cocoons:	-	4	0.1m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
-	*Acilius sulcatus*		1.5m
			% shade: 70%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 15%
			% Lemna: 30%

Site/Code: SH21	**Grid ref:** ST418404		**Width of watercourse:**
Dates visited:	06/05/02	05/06/02	1.0m
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	0.1m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
Newt efts	*Dytiscus marginalis*		0.2m
			% shade: 20%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 80%
			% Lemna: 0

Site/Code: SH22	**Grid ref:** ST419405		**Width of watercourse:**
Dates visited:	06/05/02	05/06/02	1.0m
Adult Hydrochara:	1m	-	**Depth of water column:**
Egg cocoons:	-	-	0.1m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
-	-		1.2m
			% shade: 60%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 0
			% Lemna: 20%

Site/Code: SH23	**Grid ref:** ST416409		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	1.0m
Adult Hydrochara:	-	-	**Depth of water column:**
Egg cocoons:	-	-	0.1m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:**
			1.1m
			% shade: 70%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 30%
			% Lemna: 80%

Site/Code: SH24	**Grid ref:** ST418407		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	2.0m
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.1m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 1.5m
			% shade: 90%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 5%
			% Lemna: 10%

Site/Code: SH25	**Grid ref:** ST419408		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	2.0m
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.1m (P)
Aquatic vertebrates: Newt efts	**Other water beetles:**		**Depth of sediment layer:** 1.5m
			% shade: 0
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 30%
			% Lemna: 100%

Site/Code: SH26	**Grid ref:** ST419409		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	1.8m
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.2m (P)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 0.7m
			% shade: 90%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 20%
			% Lemna: 80%

Site/Code: SH27	**Grid ref:** ST420409		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	n/a
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.1m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 0.2m
			% shade: 100%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 80%
			% Lemna: 20%

Site/Code: SH28	**Grid ref:** ST421408		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	2.0m
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.2m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 0.1m
			% shade: 10%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 30%
			% Lemna: 0

Site/Code: SH29	**Grid ref:** ST421407		**Width of watercourse:**
Dates visited:	27/04/02	04/06/02	1.2m
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.1m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 0.1m
			% shade: 80%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 20%
			% Lemna: 0

Site/Code: SH30	**Grid ref:** ST420408		**Width of watercourse:** n/a
Dates visited:	27/04/02	04/06/02	
Adult Hydrochara: **Egg cocoons:**	- -	- -	**Depth of water column:** 0.2m (T)
Aquatic vertebrates:	**Other water beetles:**		**Depth of sediment layer:** 0.1m
			% shade: 100%
			***Hydrocharis*:** 0
			***Glyceria fluitans*:** 15%
			% Lemna: 0

Notes on Appendix 2:

The letters P and T in parentheses in the depth of water column field indicate whether the sample plot was permanently or temporarily filled with water.

In the dates visited/adult *Hydrochara* fields, f=female, m=male & ov=ovipositing female.

Appendix 3: Quadrats recorded along transects at Shapwick Heath NNR, May 2003

Sample No	Egg cocoons	Water	Open	Duckweed	Emergents	*G fluitans*	Shade	Depth	Notes
1a	0	90	10	50	40	0	10	6	
1b	0	100	20	30	50	0	10	5	
1c	0	50	40	10	50	0	20	4	
1d	2	50	20	0	0	80	50	2	Bp5. Pc4
1e	2	100	20	0	0	80	50	6	Pc8. Bp5
1f	2	90	40	0	20	40	80	3	Bp4. Bp8.
1g	1	50	40	0	10	50	100	2	Bp3
1h	2	90	70	0	0	30	90	3	Bp3. Bp2.
1i	1	100	20	0	0	80	100	10	Bp12
1j	0	40	60	0	10	30	100	6	
1k	0	10	50	50	0	0	100	3	
1l	0	80	90	10	0	0	100	14	
1m	0	50	90	10	0	0	100	14	
1n									
1o	0	100	80	20	0	0	100	22	
1p	0	100	70	30	0	0	100	12	
2a	0	100	100	0	0	0	100	24	
2b	0	70	100	0	0	0	100	6	
2c	0	70	100	0	0	0	100	2	
2d	1	80	90	10	0	0	100	5	Bp7
2e	0	100	90	10	0	0	100	5	
2f	0	100	90	10	0	0	100	6	
2g	0	100	90	10	0	0	100	10	
2h	0	100	80	20	0	0	90	13	
2i	0	100	70	30	0	0	90	26	
2j	0	100	90	10	0	0	100	12	
2k	0	100	70	20	10	0	100	14	
2l	0	100	70	30	0	0	80	13	
2m	0	100	80	20	0	0	100	15	
2n	0	100	60	30	0	10	90	34	

Sample No	Egg cocoons	Water	Open	Duckweed	Emergents	*G fluitans*	Shade	Depth	Notes
2o	0	100	20	30	30	20	50	17	
2p	0	100	10	90	0	20	90	9	
2q	2	100	20	50	0	30	90	13	Bp14. Bp13
2r	2	100	30	30	30	10	90	11	Bp9. Bp12
2s	0	100	10	10	80	0	20	7	Cp tussocks
2t	0	100	60	0	40	0	0	11	
2u	0	90	80	0	20	0	0	14	
2v	0	100	70	0	30	0	0	12	
2w	0	100	90	0	10	0	80	10	
2x	0	100	70	0	20	10	90	11	
2y									
2z	0	80	80	10	10	0	80	3	
2A	0	100	80	10	10	0	100	8	
2B	0	100	80	10	10	0	100	9	
2C	0	100	90	10	0	0	100	8	
2D	1	90	60	30	10	0	100	6	Bp2
2E	0	100	90	10	0	0	90	34	
2F									
2G	1	100	90	0	0	10	100	4	Bp2(C)
2H	0	100	90	0	0	10	100	5	
2I									
2J									
2K									
2L									
2M									
2N									
2O									
2P									
2Q									
2R	0	100	90	0	10	0	90	8	
2S	1	100	80	0	20	0	100	4	Bp7
3a	0	100	0	70	30	10	0	33	

Sample No	Egg cocoons	Water	Open	Duckweed	Emergents	*G fluitans*	Shade	Depth	Notes
3b	0	100	30	20	50	0	70	10	
3c	0	80	0	10	100	0	90	6	
3d									
3e	2	100	20	0	10	70	80	2	Bp2. Bp4
3f	1	90	50	0	40	10	10	5	Bp4
3g	0	100	40	10	0	50	20	12	
3h	0	100	20	10	0	70	30	17	
3i	0	100	20	30	0	60	70	20	
3j	1	100	10	20	0	70	80	7	Bp6
3k	0	90	20	30	0	50	80	10	
3l	0	50	10	30	0	60	50	14	
3m	0	70	40	10	50	0	60	24	
3n	0	70	90	10	0	0	80	29	
3o	0	100	70	10	20	0	100	18	
4a	0	100	0	90	20	10	0	35	
4b	0	100	20	40	40	0	20	25	
4c	0	100	10	20	70	0	70	12	
4d	0	60	10	10	80	0	70	8	
4e	0	80	40	0	40	20	90	4	
4f	0	100	20	0	70	10	70	5	
4g	2	100	60	0	20	20	10	8	Tl3. Tl4
4h	0	100	10	10	80	0	30	15	
4i	0	100	100	0	0	0	20	17	
4j	0	100	50	0	50	0	40	14	
4k	0	50	80	0	20	0	100	7	
4l	0	100	100	0	0	0	100	21	
4m	0	100	30	0	0	70	80	6	Gal pal. not Gf
4n	0	100	80	0	0	20	100	6	Gal pal. not Gf
4o	0	100	100	0	0	0	100	10	
5a	0	100	0	80	20	0	0	40	
5b	0	100	30	50	20	0	20	22	
5c	0	100	20	40	30	10	50	17	

Sample No	Egg cocoons	Water	Open	Duckweed	Emergents	*G fluitans*	Shade	Depth	Notes
5d	0	80	20	40	20	20	80	12	
5e	2	70	30	0	20	50	80	10	Bp6, Bp5
5f	1	100	40	10	0	50	90	8	Bp4
5g	1	100	70	0	10	20	40	13	Tl5
5h	0	100	80	0	10	10	70	20	
5i	0	100	100	0	0	0	100	16	
5j	0	100	60	0	40	0	50	15	
5k	0	60	80	0	20	0	80	12	
5l	0	90	100	0	0	0	100	25	
5m	1	100	60	0	0	30	70	8	Bp3
5n	0	100	100	0	0	0	100	15	
5o	0	100	100	0	0	0	100	10	
5p	0	100	100	0	0	0	100	10	
5q	0	50	100	0	0	0	100	7	

Note: This table includes data collected on 13/05/03 (transect 1) 14/05/03 (2 & part of 3) and 16/05/03 (part of 3 & 4)

ENGLISH NATURE

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Front cover photographs:
Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888

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