Surveys for the Depressed River Mussel *Pseudanodonta complanata* at selected locations in Staffordshire (July 2011)

Fig. 1 *Pseudanodonta complanata* from the Llangollen Canal

Dr. M. J. Willing

A report for The Staffordshire Wildlife Trust

Nick Mott (Project Officer)

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1. SUMMARY

- Seven Staffordshire canal and river sites were visited on 5th and 6th July 2011 to try to locate populations of depressed river mussels *Pseudanodonta complanata*.
- The surveys provided opportunities to provide training to Staffordshire Wildlife Trust and Environment Agency staff in identifying and sampling potentially suitable *P. complanata* habitat.
- No *P. complanata* were located although low numbers of two other unionid mussels, *Anodonta anatina* and *Unio pictorum* were recorded at most sites.
- Large numbers of the non-native Asian clam *Corbicula fluminea* were located at two sites on the Trent and Mersey Canal. These are new records for Vice-county 39: Staffordshire and the first finds of this species in the Midlands.
- Suggestions are made for further work on *P. complanata* and *C. fluminea* in Staffordshire.
- A unioid mussel identification key is attached to link with the laboratory based *Pseudanodonta complanata* training day.

2. INTRODUCTION

The depressed (compressed) river mussel *Pseudanodonta complanata* inhabits medium to slow flowing hard water, lowland rivers and occasionally canals. It is locally distributed throughout England (Kerney 1999) where it has been recorded from at least 65 ten kilometre squares, whilst in Wales it is only known from a stretch of the lower River Wye (Willing 2009a). In Europe the species is widespread, occurring in the lowlands between south Scandinavia and the Alps. Throughout this range it is considered to be local (Kerney 1999) or regionally rare (McIvor & Aldridge 2007). Wells and Chatfield (1992) catalogued possible problems for the species in Austria, Germany, Poland, Sweden and Switzerland. In Germany the mussel is considered to be 'threatened by extinction' and has a high degree of legal protection (Der Bundesminister für Umwelt, Naturschutz und Reaktorsicherheit, 1996), although in the Netherlands, Gittenberger *et al* (1998) show a 50% increase in the number of known populations between 1970 – 1997 compared to pre-1970. On the IUCN Red List of Threatened Species (IUCN 2008) the species is placed at 'Lower Risk – Near Threatened'. *P. complanata* was made a UK Biodiversity Steering Group (BAP) Priority Species in 1995 (Anon 1995) and an action plan for the mussel published in 1997 (Willing 1997). The Environment Agency has a statutory duty to promote the conservation of flora and flora dependent on aquatic habitats, and is the lead partner for the depressed river mussel SPA (species action plan in the UK. As part of the UK Biodiversity Action Plan (UKBAP), the main objective for the depressed river mussel is to maintain the present geographical distribution of the species.

The Conchological Society has three records of *P. complanata* for Vice-county 39: Staffordshire (10:2 Table 3) the most recent from Leek in 1933. In March 2010 N. Mott (freshwater ecologist with the Staffordshire Wildlife Trust) undertook a programme of *P. complanata* surveys at nine river and canal sites throughout the Canock Chase AONB (Mott 2010). Unfortunately no sites produced *P. complanata,* although several localities appeared to offer potentially suitable habitats for the mussel.

The specific aims of this project were twofold. Firstly to survey a number of potentially suitable *P. complanata* sites on the rivers Tame, Mease, Trent and Dove and also the Coventry and Trent & Mersey canals. The second aim was to train a number of Staffordshire Wildlife Trust and Environment Agency staff to gain proficiency in field survey techniques for this and other large freshwater unionid mussels and also to be able separate and identify this group of mussels.

3. METHODS

Pseudanodonta complanata can be surveyed in rivers and canals by a series of methods. No single approach is usually suitable in all parts of a river or canal and where one method fails to recover mussels then, on many occasions, another strategy is successful. The four main sampling options are with:

1. a long handled net (with a coarse mesh);
2. various dredges;
3. a hand collecting technique at river/canal margins whilst wading in the water;
4. the use of a 'glass bottom bucket' to visually search for mussels.

Further details of these various sampling methods are discussed in Appendix 10.3.

During these surveys the first technique was adopted as most sediments consisted of gravel deposits in only moderate water depths. The use of glass-bottomed buckets was trialled at sites 1a and 2a, but water turbidity and low mussel densities made this technique less useful than the use of a hand net.

Sites were visited on 5th and 6th July 2011. Sites were also photographed using a digital camera and images are included in section 5. Survey locations were logged using a GPS device.

4. RESULTS

Appendix 10.1 gives unionid mussel survey results including some records of other species). Molluscan naming throughout follows Anderson (2005) and site locations are displayed on Figs. 2 and 3.

No live or dead *Pseudanodonta complanata* were found during the survey although two other unionid mussels, *Anodonta anatina* and *Unio pictorum* were recovered, the former species at all sites and the latter at four sites. A single dead *Anodonta cygnea* was also found at site 2a on the River Dove.The Asian clam *Corbicula fluminea* was found at two sites on the Trent

and Mersey Canal. Sampling in the canal at Newbold Quarry produced 73 individuals, whilst that at Stretton, 77 clams were recovered. *Corbicula fluminea* shell measurements are recorded in Table 2 (10.1)

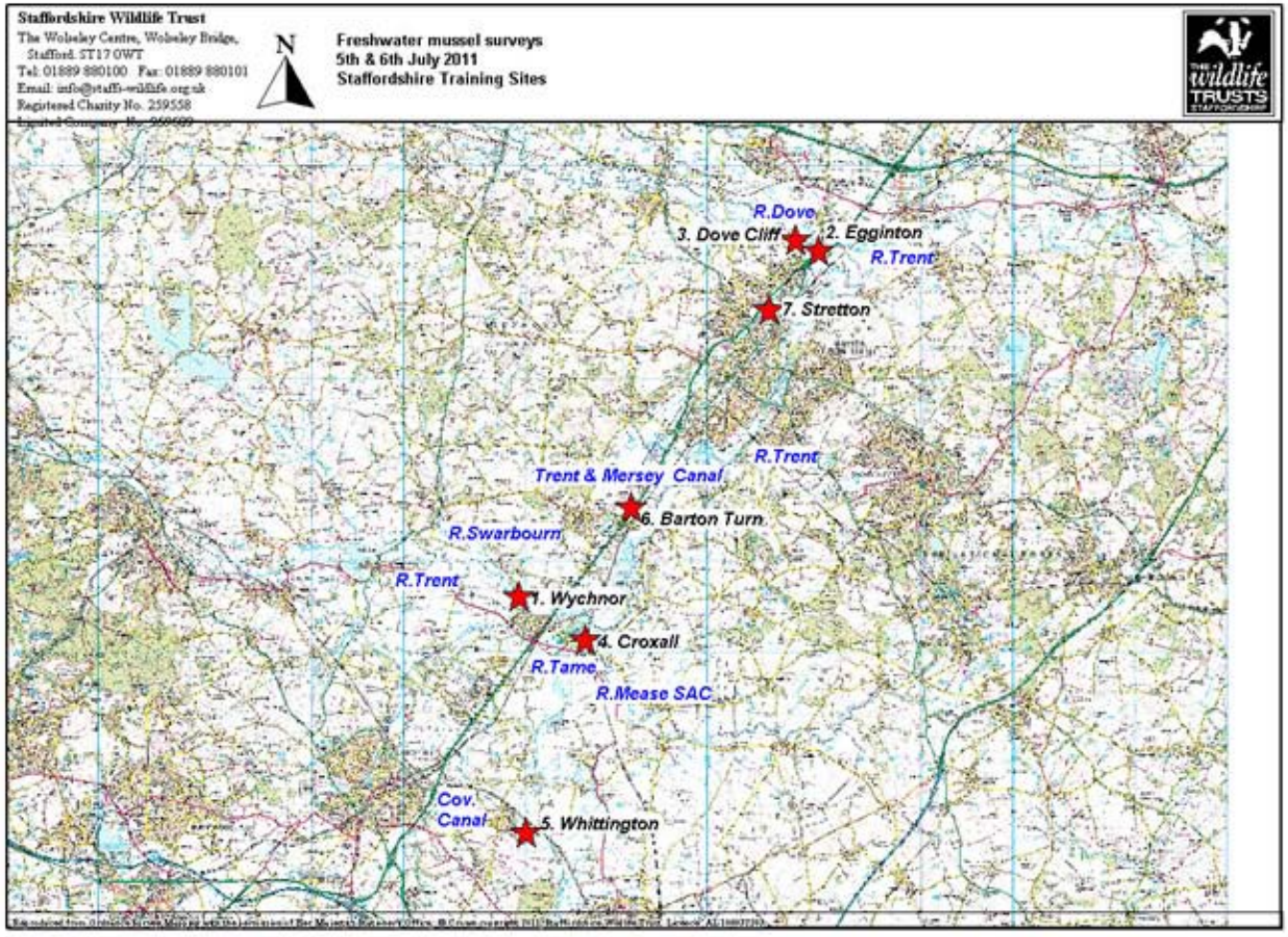

Fig. 2 Survey sites 5th – 6th July 2011

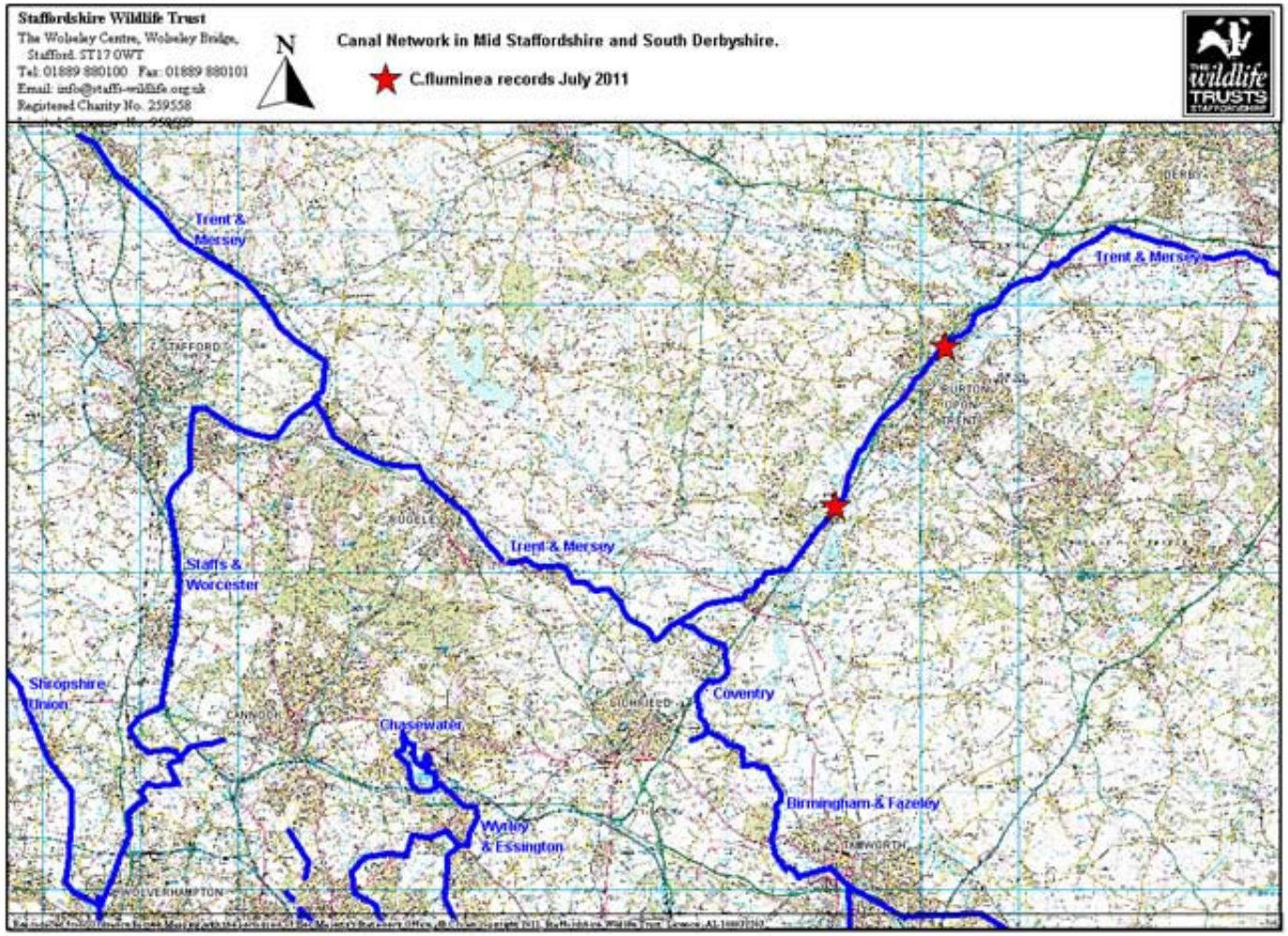

Fig. 3 Survey locations on the Trent & Mersey Canal, 6th July 2011

5. SITE ASSESSMENT SUMMARIES & DISCUSSION

Site 1 Wychnor:
Two sites were visited. Site 1a lay in the Trent & Mersey Canal about 150m below a junction with the River Trent (Fig. 4). Small quantities of gravel at river margins gave way to loosely consolidated mud and silt. A search effort by 5 people totalling approximately 3 'man-hours' only produced a low number of the two common unionid species *Anodonta anatina* and *Unio pictorum* (Fig. 5). The site appeared potentially suitable for *Pseudanodonta complanata*.

Fig. 4 Wychnor: Site 1a

Fig. 5 Mussels from site 1a: *Unio pictorum* (left) & *Anodonta anatina* on (right)

Site 1b lay immediately downstream the lock gates where the River Trent flows into the Trent & Mersey Canal (Fig 6). Loosely consolidated organic silt deposits produced the same two unionid species as site 1a (Fig. 7).

Fig. 6 Wychnor: Site 1b

Fig. 7 Mussels from site 1a: *Unio pictorum:* two specimens to upper right & *Anodonta anatina* on right – specimen on lower left has two *Dreissena polymorpha* attached

Site 2 River Dove:

Two sites were visited on the River Dove. The lower site 2a consisted of a stretch of fast water flow over a predominantly gravel bed with no fine marginal sediments. Large numbers of dead *Anodonta anatina* and a single *A. cygnea* (living at some point further upstream) were collected on exposed gravel bars amongst flood debris. Mussel sampling in this fast flowing stretch presented a few challenges. The use of a 'glass-bottomed bucket' was rendered difficult due to the part algal covering whilst the tightly packed gravel made the use of a net problematic. About 80m downstream the river widens to produce a slower water flow and a 'bay' where fine muddy sediments have accumulated grading into muddy-gravel nearer to the central channel. Hand netting by four surveyors produced about 30 – 40 live *A. anatina,* mostly juveniles. This site is potentially suitable for *Pseudanodonta complanata* although fine sediments are possibly rather too loosely consolidated to produce 'ideal' conditions for the mussel.

Fig. 8 River Dove Site 2a

About 300m upstream Site 2b lies at a weir in the river (fig. 9). A few live *A. anatina* were located in marginal shingle and finer sediments about 40m downstream of the weir. No live mussels were found amongst the boulders and cobbles lining the river bottom immediately upstream of the weir.

Fig. 9 River Dove Site 2b

Fig. 10 Site 2b: *Anodonta anatina* recovered about 40m below the weir

Site 3 Croxall: Rivers Tame, Mease and Trent

Site 3a: The River Tame was sampled about 100m upstream of its confluence with the River Trent (Fig. 11). Water turbidity prevented the use of a 'glass-bottomed bucket' and sampling was undertaken with hand nets. No live mussels were located although a few dead *Anodonta anatina* were found on the river margins. The predominantly gravel river channel was largely covered with a matt of filamentous algae and this would act to smother any large unionid mussels beneath[1]. One find of note was of a juvenile white-clawed crayfish *Austropotamobius pallipes* (Fig. 14).

[1] M.J.W. observed similar unionid mortality assumed to be associated with algal mats blanketing river sediments in the New Bedford River in 2005 (Willing 2007)

Fig. 11 River Tame Site 3a

Site 3b: The small River Mease (Fig. 12) lay further downstream from Site 3a. The predominance of muddy sediments produced a few live *Anodonta anatina* from fine muddy sediments; this is really a rather small river to support *Pseudanodonta complanata*. Finds of note included the unusual presence together of both white-clawed *Austropotamobius pallipes* and invasive signal crayfish *Pacifastacus leniusculus*.

Fig. 12 Site 3b: River Mease

Site 3c: The River Trent was sampled just beyond the confluence of the inflowing River Mease. Gravel, in places set into finer clay sediments, was largely free of the algal blanket present at site 3a and potentially suitable for *Pseudanodonta complanata*. Sampling produced a number of live *Anodonta anatina* (Fig. 13).

Fig. 13 *Anodonta anatina* from Site 3C

Fig. 14 *Austropotamobius pallipes* from Site 3a

Site 4 Coventry Canal at Fisherwick

Two surveyors spent about 1 ‘man-hour’ sampling the Coventry Canal at Fisherwick (Fig. 15). Virtually no fine marginal sediments, potentially suitable for *Pseudanodonta complanata* were present. The consoliated hard gravel bottom of the canal produced a single live *Anodonta anatina* (Fig. 16).

Fig. 15 Site 4: Coventry Canal at Fisherwick

Fig. 16 *Anodonta anatina* from Site 4

Site 5 Trent & Mersey Canal: Newbold Quarry / Barton Turn

Two sites were surveyed on the Trent and Mersey Canal. Site 5 (fig. 17) adjacent to Newbold Quarry (Barton Turn) was sampled by two surveyors for a total of approximately 1.5 'man-hours'. There were no significant deposits of fine marginal sediments (potentially suitable for *Pseudanodonta complanata)* with the canal sediments chiefly consisting of gravel embedded within sand and silt. No *P. complanata* were found, but a low numbers of the two common unioid species *Anodonta anatina* and *Unio pictorum* were recovered (Fig. 18). Of additional interest were occasional *Sphaerium rivicola,* a relatively deep waters species typical of relatively clean and well oxygenated hard water in canals and larger rivers, especially in the 'canal basin' of central England. A worrying find were large numbers of the invasive Asian clam *Corbicula fluminea* (Fig. 19). Further discussion on this species appears in Section 6.

Fig. 17 Site 5: Newbold Quarry

Fig. 18 Mussels from Site 5: Two *Unio pictorum* with *Anodonta anatina* between on left; seven *Sphaerium rivicola* on right

Fig. 19 A mixed age part sample of *Corbicula fluminea* collected at Site 5

Site 6 Trent & Mersey Canal: Stretton

Site 6 was a further survey point on the Trent and Mersey Canal (Fig. 20) lying about 6 miles to the north east of Site 5 (Fig. 3). Canal sediments and molluscan fauna (Figs 21, 22) were very similar to that found at Site 5 including the presence again of abundant of *Corbicula fluminea. Sphaerium rivicola* was present in much higher numbers than at site 5 (Fig 22).

Fig. 20 Site 6: Trent & Mersey Canal

Fig. 21 Unionid mussels from Site 6: *Unio pictorum* on left with *Anodonta anatina* on the right

Fig. 22 *Sphaerium rivicola* from Site 6

6. ASIAN CLAMS *CORBICULA FLUMINEA* IN THE TRENT & MERSEY CANAL

Large numbers of Asian clams *Corbicula fluminea* were found at two sites on the Trent Mersey Canal (Site 5: Newbold Quarry; Site 6 Stretton). These finds are of major significance as *C. fluminea* is an alien invasive species with the potential to spread to other waterways in Staffordshire and beyond) to the likely detriment of native species including any populations of depressed river mussels *Pseudanodonta complanata* present in the county.

C. fluminea was first recorded in the UK in 1998 from the River Chet, Norfolk (Baker *et al* 1999). Within only a few years the mussel had colonised many of the Broadland rivers (Aldridge & Müller 2001 & Aldridge personal communication). The species was first found in the tidal Thames in 2004 by Oliver Whalley in 2004 (Davison 2006) and has spread downstream as far as Battersea. The first Fenland record came in 2005 when the clam was recorded along a 10km stretch of the New Bedford River in Cambridgeshire (Willing 2007). The discovery of *C. fluminea* at two sites (about 6 miles apart) on the Trent and Mersey Canal is a new vice-county record[2] for Staffordshire (V.C. 39). It is likely that the mussel occupies the canal between these two locations, but currently it is unknown how widely spread it is in this and other connected canals. Measurement of the mussels from the two sites (Fig. 25) shows no significant difference in mean shell width ($p = 0.05$). The bimodal distribution of the two samples, with a predominance of juvenile mussels, (Figs 23 & 24) suggests that the canal may have only been recently colonised with only a few years of major recruitment. It is not possible to give an accurate figure for population density (as the sediment surface area was not

[2] Confirmed by Adrian Norris, Non-marine Recorder, The Conchological Society.

measured), but it is estimated that population densities at the two sites may lie in the range 130 – 509 individuals m^{-2} measured at some Norfolk Broads sites (Müller 2003). The 'aggressive' colonisation ability of *C. fluminea* in many parts of the world is well documented (e.g. McMahon 1983; Elliott & zu Ermgassen 2008). The potential impact of the arrival of this clam is likely to cause significant impacts to invaded freshwater ecosystems. The high densities that can occur (hundreds of thousands of individuals per m^2) combined with their very efficient water filtering capability, may therefore impact on levels of phytoplankton; as a consequence they are likely to compete with other native freshwater bivalves including *Pseudanodonta complanata* and increase water clarity. It has been stated that *C. fluminea* is a more efficient competitor to native unionid bivalves such as *P. complanata* as a result of their higher mass-specific filtration rates (Beaver *et al* 1991). There are other potentially damaging economic effects if mussels obstruct water intakes to industrial facilities and power stations (Müller 2003, Elliott & zu Ermgassen 2008). If *C. fluminea* is now present and well established in at least a 6 mile stretch of the Trent and Mersey canal then it is highly likely to spread, possibly quite rapidly, throughout the 'canal basin' of central England as well as many associated rivers systems (e.g. the Trent, Dee, Severn, Mersey, Humber, Great Ouse and Avon). Colonisation is likely to be greatly assisted by canal boat traffic, both directly due to water flow, but also, as suggested by Müller (2003) potentially by mud attached to anchor chains. The discovery of *C. fluminea* also provides research opportunities (discussed section 7).

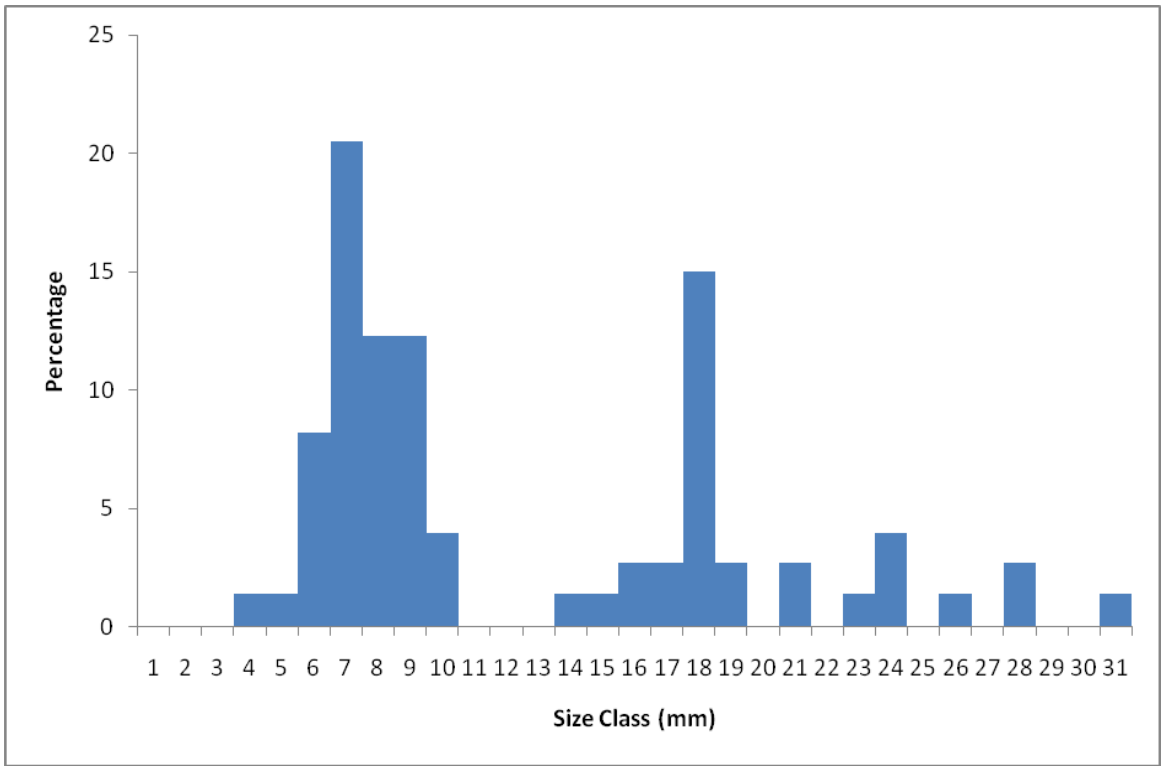

Fig 23: *Corbicula fluminea* shell width distribution at Site 5 Trent & Mersey Canal

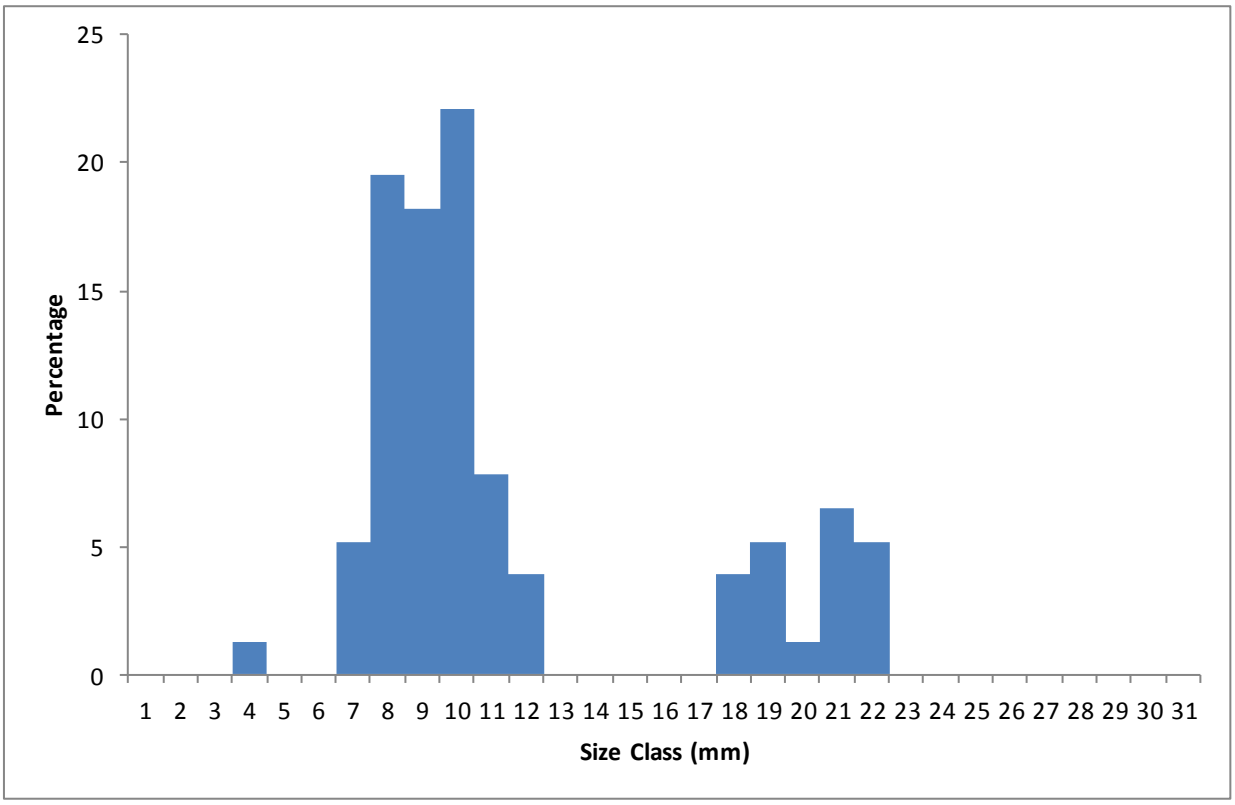

Fig 24: *Corbicula fluminea* shell width distribution at Site 6 Trent & Mersey Canal

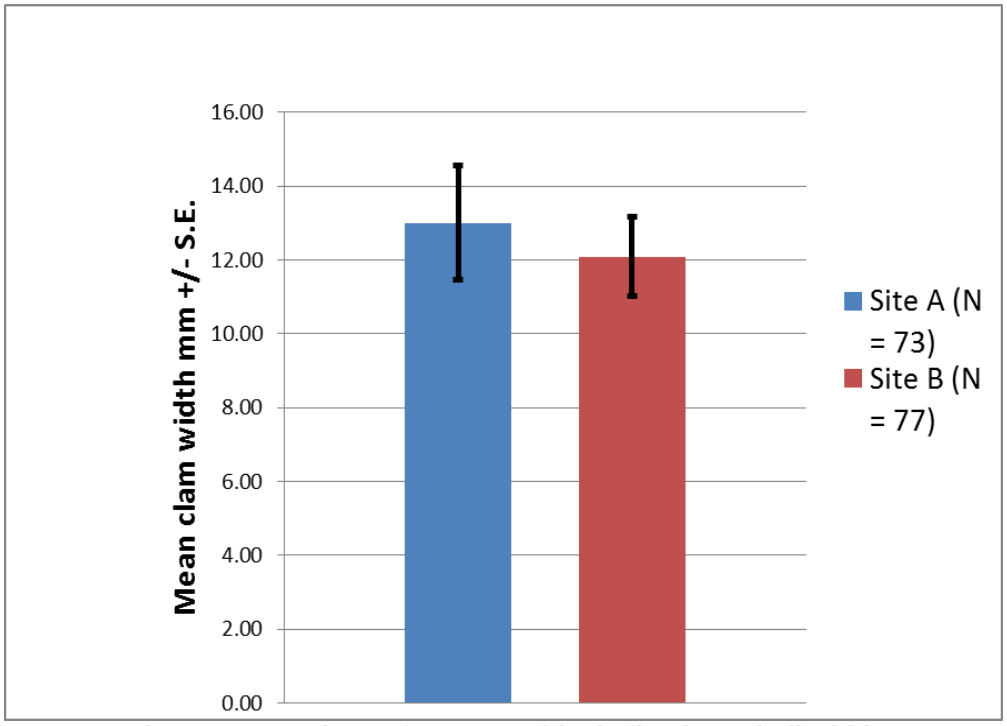

Fig 25: Comparison of mean *Corbicula fluminea* shell width from complete samples taken sites 5 (A) & 6 (B) on the Trent & Mersey Canal

7. FURTHER WORK

7.1 *Pseudanodonta complanata*: Although *P. complanata* was not found during these surveys, there is a reasonable possibility that the species is living somewhere in the county, most probably within the extensive canal network. There are records from both of the adjoining counties of Cheshire and Shropshire. Recent work in the Llangollen Canal in Cheshire has located many new records for the species (Willing 2009b) documented in Table 3. Initially it would be useful to check the three historical *P. complanata* sites held by the Conchological Society sited at Little Hayward, Leek and Walsall (Table 3). On the Llangollen Canal *P. complanata* populations were found by locating suitable areas of habitat where banks of fine, consolidated marginal sediment had accumulated. These were often present where the canals displayed an irregular margin, vegetated by a variety of emergent and marginal plants such as *Glyceria*, *Typha*, *Sparganium*, *Phragmites* and *Phalaris.* An example of such a margin is shown in Fig. 26.

Fig. 26 Looking downstream towards the lock gates at Swanley Bridge on the Llangollen Canal
(note the irregular left hand bank vegetated by *Glyceria maxima* growing on the muddy marginal sediments that extended into the canal and produced many unionid mussels including live *Pseudanodonta complanata*)

7.2 *Corbicula fluminea*: The discovery of two populations of *Corbicula fluminea* new to Staffordshire and the Midlands provides a valuable opportunity to undertake studies on this potentially damaging invasive species. Initially it is important to plot the current distribution of the clam in the Trent and Mersey Canal (and possibly beyond). Once this base-line data is established the rate and direction of colonisation could be monitored as could its impact upon a selection of native species where interspecific competition is

likely such a the unionid mussels and other sensitive (and easily sampled and identified) species such as *Sphaerium rivicola*

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9. ACKNOWLEDGEMENTS

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10. APPENDICES

Appendix 10.1 Results

Table 1: Survey Results & Notes

Survey Site (in order of survey date):	**Grid. Ref.**	*Anodonta anatina*	*Unio pictorum*	**Site description (& other notes)**
1. Wychnor (5.7.2011)	(a) (canal downstream of river junction) SK 17356 15661	2	3	(a) canal margins grading into silty gravel (about 20%); occasional patches of firmer fine sediment potentially suitable for *Pseudanadonta complanata*. Search effort: 4 surveyors operating for about 45m each (therefore total search time: approximately 3 'man-hours')
	(b) (At canal/river junction immediately below canal gates	4	2	(b) Lightly compressed silt and clay with some firmer compacted clay, Search effort: 3 surveyors operating for about 20m (therefore total search time: approximately 1 'man-hour')

2. River Dove (5.7.2011)	(a) Dove Cliff (SK 26513 27307)	Numerous dead In faster flowing stretch 150+ collected in 20m - occasional live in gravel; 80m downstream; slower flow 30 – 40 live (mostly juveniles).	-	(a) Moderate to fast flow with gravel and cobble sediments; grading approximately 80m downstream into slower flow and pool with fine muddy/silty marginal sediments. A single dead *Anodonta cygnea* was found amongst several hundred dead *Anodonta anatina* Search effort: 4 people undertaking visual and hand net search – approximately 3 man-hours
	(b) Egginton (SK 26650 27350)	4 (3 adult; 1 juvenile)	-	Gravel, cobbles and boulders above weir; gravel and cobbles below weir. All mussels collected in fine gravel and silt margins about 40m below weir. Search effort: 4 people undertaking visual and hand net search – approximately 2 man-hours total
3. Croxall (5.7.2011)	(a) River Tame about 100m upstream from confluence with River Trent – SK 19107 14868	A few dead specimens	-	(a) Sediments chiefly gravels with a matted coat of filamentous algae Search effort: 4 persons - approximately 2 man-hours total search effort with nets. Figs: Several juvenile white-clawed crayfish *Austropotamobius pallipes* found in samples
	(b) Lower River Mease SK 19467 14719	2 live	-	(b) Some gravel but mostly fine silt/clay sediments. Numerous signal crayfish *P. leniusculus* and a few white clawed crayfish *A. pallipes* taken in samples Search effort: 4 persons - approximately 3 man-hours total search
	(c) River Trent channel immediately adjacent to	5 live		(c) Chiefly gravel.

	confluence with R. Mease			Search effort: 1 person - approximately 0.75 man-hours total search
4. Fisherwick (6.7.2011)	Coventry Canal SK 17056 08157	1	-	Chiefly gravel sediments to margins of canal with no significant deposits of fine marginal sediment
5 Newbold Quarry, Barton Turn (6.7.2011)	Trent & Mersey Canal SK 20668 18844	1	2	Gravel embedded within sand and silt, some finer marginal sediments. About 12 *Sphaerium rivicola* and 73 *Corbicula fluminea* recovered Search effort: 2 person - approximately 1 man-hours total search
6. Stretton (6.7.2011)	Trent & Mersey Canal SK 25029 25459	4	7	Sediments similar to Site 5, Newbold Quarry 100+ *Sphaerium rivicola* and 77 *Corbicula fluminea* recovered Search effort: 2 persons - approximately 1.5 man-hours total search

Table 2: *Corbicula fluminea* from sites on the Trent & Mersey Canal

Size classes	Site 5: Newbold Quarry		Site 6: Stretton	
Shell width (mm)	**N**	**%**	**N**	**%**
3	0	0	0	0
4	1	1.4	1	1.3
5	1	1.4	0	0
6	6	8.2	0	0
7	15	20.5	4	5.2
8	9	12.3	15	19.5
9	9	12.3	14	18.2
10	3	4	17	22.1
11	0	0	6	7.8
12	0	0	3	3.9
13	0	0	0	0
14	1	1.4	0	0
15	1	1.4	0	0
16	2	2.7	0	0
17	2	2.7	0	0
18	11	15	3	3.9
19	2	2.7	4	5.2
20	0	0	1	1.3
21	2	2.7	5	6.5
22	0	0	4	5.2
23	1	1.4	0	0
24	3	4	0	0
25	0	0	0	0
26	1	1.4	0	0
27	0	0	0	0
28	2	2.7	0	0
29	0	0	0	0
30	0	0	0	0
31	1	1.4	0	0
TOTALS	**73**	**-**	**77**	**-**

Appendix 10.2 Historic sites for *Pseudanodonta complanata* in Staffordshire and neighbourring Vice-counties

Table 3: *P. complanata* records Staffordshire, Shropshire, Derbyshire & Cheshire:

Site Location (& approximate habitat type)	Vice-county	Approx Grid Ref	Recorder	Verified by	Record date
Trent & Mersey Canal, Little Haywood	**Staffordshire & Dudley (VC 39)**	**SK02**	**P.T. Deakin**	**J.W. Taylor**	**27.08.1916**
Rushall Canal, Walsall (canal)	**Staffordshire & Dudley (VC 39)**	**SP09**	**P.T. Deakin**	**J.W. Taylor**	**28.05.1883**
Leek (canal)	**Staffordshire & Dudley (VC 39)**	**SJ95**	**W. Hill**	**G.C. Slawson**	**8.1933**
Preston Montford Field Centre Estate, Shrewsbury (Pond)	Shropshire (VC 40)	SJ432143	R.A.D. Cameron	M.P. Kerney	1973
Shropshire Union Canal, Rednal (canal)	Shropshire (VC 40)	SJ32	C. Oldham	C. Oldham	25.02.1936
R. Severn, west bank between Arley & Dowles (River)	Shropshire (VC 40)	SO77	C. Oldham	A.S. Kennard	14.04.1933
No known records	Derbyshire 57	-	-	-	-
Shropshire Union Canal, Swanley Bridge nr Nantwich (canal)	Cheshire (VC 58)	SJ65	C. Oldham * Reconfirmed by M.J. Willing & Sharon Weaver	A.S. Kennard	01.04.1936 *February 2009
Union Canal, Wharton's Lock nr Beeston Castle (canal)	Cheshire (VC 58)	SJ56	N.F. McMillan * Re-surveyed by M.J. Willing & Sharron Weaver	F.R. Woodward	30.06.1965 * In February 2009 could not be relocated at this site
Llangollen Canal, Stoneley Green (canal)	Cheshire (VC 58)	SJ6151	Rev. G. Long	June Chatfield	23.08.1986
Shropshire Union Canal, Beeston (canal)	Cheshire (VC 58)	SJ5559	Garry Whitfield	Garry Whitfield	28.06.1968
Llangollen Canal, Whilleymoor Lock	Cheshire (VC 58)	SJ 53499 45221	Sharon Weaver	Martin Willing	March 2009
Llangollen Canal, Quoisley Lock	Cheshire (VC 58)	SJ 53903 46318	Sharon Weaver	Martin Willing	March 2009
Llangollen Canal, Marbury Lock	Cheshire (VC 58)	SJ 56262 46480	Sharon Weaver	Martin Willing	March 2009
Llangollen Canal, Wrenbury Bridge	Cheshire (VC 58)	SJ 60716 48851	Sharon Weaver	Martin Willing	March 2009
Llangollen Canal, Baddiley No. 1 Lock	Cheshire (VC 58)	SJ 60746 49296	Sharon Weaver	Martin Willing	March 2009
Llangollen Canal, Bachehouse Bridge	Cheshire (VC 58)	SJ 61703 54809	Sharon Weaver	Martin Willing	March 2009

Appendix 10.3 Methods available for the survey of unionid mussels including *Pseudanodonta complanata*

The main survey options for the survey of *Pseudanodonta complanata* (and other unionid) populations are:

1. In deeper waters, sediment samples can be removed, using either a standard E.A. approved FBA-pattern, long-handled aquatic-sampling net extendable to 4.5m (and fitted with a 3mm woven mesh bag of 25cm depth; these holes let fine mud and clay sediments pass through with ease but are small enough to retain most juvenile unionid mussels). Sediment samples are then sieved in shallow water using a 0.5m diameter 1cm mesh sieve or examined by hand on the bank.

2. A hand-thrown dredge either light weight (1.5 kg) or EA specification (5kg) 'naturalists' or 'heavy' dredge (Fig.27), both fitted with a 3mm mesh bag (to assist passage of fine sediment through the net). As with sediments recovered with the hand net, the sediment samples are then sieved in shallow water using a 0.5m diameter 1cm mesh sieve or examined by hand on the bank.

Fig. 27 The 'heavy dredge' used to collected unionid mussels on the Shropshire Union & Llangollen Canals

3. In shallow water depths (<1m) with soft sediments, it is sometimes easier and more efficient to search for large unionid mussels (but not juveniles) by hand collecting at river/canal margins, whilst wearing a dry suit than it is by the use of a hand net or sieve.

4. The use of a ‘glass bottom bucket’ to visually search for mussels in clear water at depths <1.5m although the turbidity of most canal and many river waters makes this a technique unsuitable.

Appendix 10.4: Unionid mussel identification guide (©M.J. Willing)

Fig. 28 *Unio tumidus* (Llangollen Canal)

Fig. 29 ***Unio pictorum*** **(Llangollen Canal)**

Fig. 30 ***Anodonta anatina*** **(Llangollen Canal)**

Fig. 31 ***Pseudanodonta complanata*** **(Llangollen Canal)**

Fig. 32 ***Anodonta cygnea*** **(River Wye)**

Mussel identification: notes to aid in ID of the large unionid mussel likely to be encountered in Cheshire Canals. The key ID guide referred to below is Killeen *et al* (2004) cited as 'KAO'

Key steps:

1. It is important to become familiarised with key shell features - see p. 18 'KAO'.

2. The 5 large unioid mussels that are or might be present in Cheshire canals are *Unio pictorum U. tumidus, Anodonta anatina*, *A, cygnea* and *Pseudanodonta complanata*. All except the last species are also likely to be present in the Cheshire meres.

3. It is important to consider a range of shell characteristics **together** in order to reliably separate these mussels. Thus certain key features might be missing from a specimen (e.g. corrosion of umbonal rugae on P. complanata) and so other shell features then need to be considered.

4. It is convenient to deal with the *Unio pictorum* and *U. tumidus* separately as these two species are unlikely to be confused with the other three large unionids.

5. In order to develop ID competence it is vital to examine a range of individuals from each species; **a reference shell collection** of voucher material is very useful including a number of specimens displaying the range of variability in each species.

Key distinguishing features of *Unio* species:

Features:	***Unio pictorum***	***Unio tumidus***
Hinge:	Unlike *Anodonta* & *Pseudanodonta,* both species have hinge teeth inside shell below umbos	
Size:	Considerable overlap in size (both can reach ca, 100mm in length) and so not a useful ID feature	
External shell shape:	The dorsal & ventral surfaces are approximately parallel to each other; When viewed from above (down onto the umbos) the shell valves are rather compressed. See KAO p. 24 & fig. 24 in this report	The dorsal & ventral surfaces are both rather convex; When viewed from above (down onto the umbos) the shell valves are rather tumid. See KAO p. 24 & fig. 23 in this report
Rugae (on umbonal area):	If not corroded are sometimes seen as two radiating rows;	If not corroded are sometimes seen as irregular wavy ridges;

	See KAO p. 28	See KAO p. 28
Shell colour:	Often rather uniformly yellow; fig. 24 in this report	Often yellow-green to brown; often with radiating green rays; fig. 23 in this report

Key distinguishing features separating *Anodonta* species from *Pseudanodonta*:

Features:	***Anodonta anatina***	***Anodonta cygnea***	***Pseudanodonta complanata***
Hinge:	No hinge teeth present		
Size (length across valves):	The middle sized mussel typically up to 100mm but considerable size overlap with *P. complanata*	Reaches the greatest size, typically up to 140mm	The smallest of the three typically up to 75mm but considerable size overlap with *A. anatina*
External shell shape:	Broadly wedge shaped with the ventral margin more noticeably more convex (curved) than *P. complanata;* When viewed from above (down onto the umbos) the shell valves are rather tumid ('bulge' outwards). See KAO p. 25 & fig. 25 in this report	The dorsal & ventral surfaces are approximately parallel to each other; When viewed from above (down onto the umbos) the shell valves are rather compressed. See KAO p. 25 & fig. 27 in this report	Broadly wedge shaped with the ventral margin more noticeably straight than *A. anatina* When viewed from above (down onto the umbos) the shell valves are rather compressed. See KAO p. 25 & figs. 26 & 28 – 34 in this report
Rugae (on umbonal area):	In younger, uncorroded shells as continuous wavy lines. See KAO p. 25	In younger, uncorroded shells as rather indistinct continuous wavy lines. See KAO p. 25	In younger, uncorroded shells often as <u>two separated, staggered rows</u>. See KAO p. 25
Shell colour:	In younger specimens yellow to very light bluey-green	Often rather evenly coloured olive-green; darker brown in older specimens.	In younger to middle-sized specimens darker olive-green than *A. anatina*
Other distinguishing	Shell <u>sometimes</u> seen to be thicker	Shell typically thin shelled - of even	Shell typically of even thickness

features:	(more opaque when single valve held against the light) in the anterior ventral area; In some specimens a ‘crimped’ lines seen along the posterior-dorsal area of the shell (not always easy to see) See KAO p. 25	thickness (evenly transluscent) when single valve held against the light.	acroos the valve; Sometimes the valves do not meet (when shell valves are shut) in the ventral-anterior region.

Further images of *Pseudanodonta complanata* (all from the Llangollen Canal)

Fig. 33 *Pseudanodonta complanata* (Braddiley No. 1 Lock, Llangollen Canal)

Fig. 34 ***Pseudanodonta complanata*** **(Bachehouse Bridge, Llangollen Canal)**

Fig. 35 ***Pseudanodonta complanata*** **(Bachehouse Bridge, Llangollen Canal)**

Fig. 36 ***Pseudanodonta complanata*** **(Marbury Lock, Llangollen Canal)**

Fig. 37 ***Pseudanodonta complanata*** **(Quoisley Lock, Llangollen Canal)**

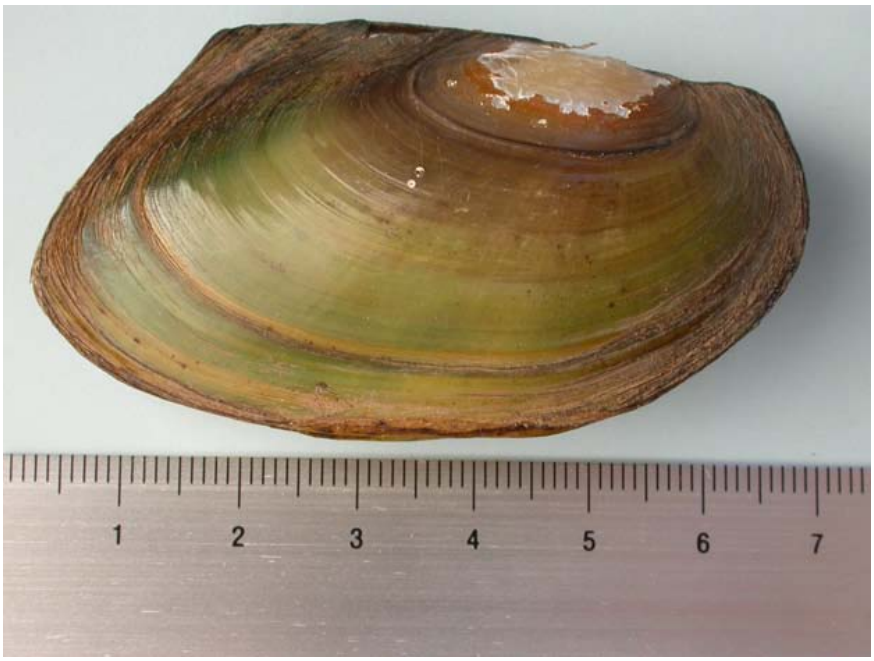

Fig. 38 ***Pseudanodonta complanata*** **(Quoisley Lock, Llangollen Canal)**

Fig. 39 ***Pseudanodonta complanata*** **(Whilleymoor Lock, Llangollen Canal)**

 # End of Report #