Freshwater Mussels:
Novel Biofilters?

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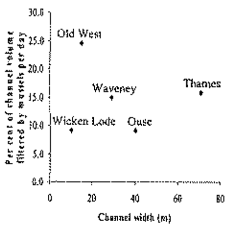
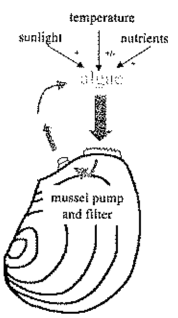
Freshwater mussels occur at high densities in many freshwater ecosystems. Although the impacts of invasive mussels on freshwater ecosystems are well recognised, little is known about the effects of native freshwater mussels. Potentially they could be playing an important rôle in nutrient cycling and reducing turbidity. In my PhD I hope to study the effect of freshwater mussels on river ecosystems, and to assess the feasibility of using mussels as biofilters of algal blooms in rivers and ditches.

How much water can a mussel bed filter?

Freshwater mussels may filter a significant proportion of a river's discharge: Strayer *et al.* (1994) calculate that the mussels of the Hudson River filter a volume of water which is roughly equivalent to the river discharge. Using available data on the densities of unionid mussels in some British rivers (Negus, 1962; Aldridge, 1997; Muller, 1999; McIvor, 1999; and unpub. data) and equations describing mussel filtration rates (Kryger and Risgåard, 1988), I have estimated the proportion of the channel volume filtered by mussels. These calculations suggest that mussels may filter between 9 and 25% of river volume per day, so that in the summer it may only take 4 to 7 days *for the mussels to filter out half the suspended matter* in a river. With a knowledge of the rates of algal increase within the water column and the river flow, it may be possible to estimate the algal depression that mussels are causing in the river.



How many mussels will we need?



In order to control algal blooms, the rate of algal clearance by mussels must exceed algal production. Algal production will depend on water chemistry (particularly nitrate and phosphate), temperature, light intensity and photoperiod. Mussel clearance rates will also be temperature dependent, but the clearance of individual algal species by mussels may vary according to the size and shape of the algal cells. Different species of mussel and different-sized mussels may be able to selectively filter different algal species. I hope to study some of these factors this winter, using cultured algae in tanks with mussels.

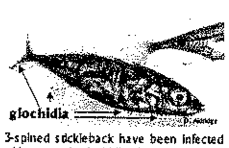
In the meanwhile it seems reasonable to assume that large numbers of mussels will be needed, at least equivalent to dense natural populations of native unionids (50 - 200/m^2). Invasive species, such as *Dreissena polymorpha* and *Corbicula fluminea*, are often present at densities of >1000/m^2.

So we're going to need a lot of mussels...

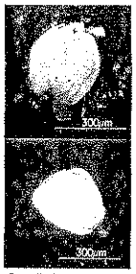
Where will all these mussels come from?

The only way to get such large numbers of mussels is by **breeding** them. Mussel larvae, or glochidia, naturally parasitize fish where they metamorphose into juvenile mussels. The *in vitro* method of Isom and Hudson (1982) to rear juvenile mussels was tried initially without success. Attempts to rear mussels have been continued using fish infection followed by rearing in tanks (see below). We still have a long way to go before we can rear large enough numbers of mussels for use as biofilters.

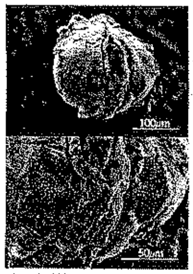
In the meanwhile, however, we can also work towards rearing rare and endangered mussel species for reintroduction. A possible candidate is the Depressed River Mussel, *Pseudanodonta complanata*, which has become extremely rare in many European rivers in the last decades.



3-spined stickleback have been infected with mussel glochidia (*Pseudanodonta complanata* and *Unio pictorum*). The juvenile mussels were collected as they excysted from the fish. They were transferred to small dishes in a well-mixed aerated tank, and fed a mixture of algae and fine sediment. So far juveniles have been reared for 3 weeks in this way. Attempts to rear mussels will continue with all native freshwater mussel species.



Juvenile *Psuedanodonta complanata* with feet out

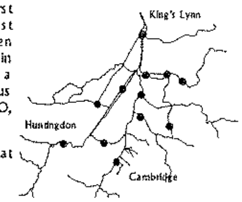


1-week-old juvenile *Unio pictorum* showing new shell growth

Can mussels survive poor water quality?

If mussels are to act as biofilters in eutrophic water, the first requirement is that they can survive in eutrophic conditions. To test this, 12 sites with varying levels of eutrophication were chosen throughout the Ouse catchment, and labelled mussels were placed in cages at each site. Their survival and growth will be measured after a year, and compared with Environment Agency data covering various water chemistry parameters (chlorophyll a, nitrate, phosphate, DO, amongst many others).

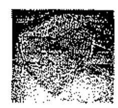
In addition mussels have been placed at different densities in cages at one site, to look at optimal densities for mussel survival.



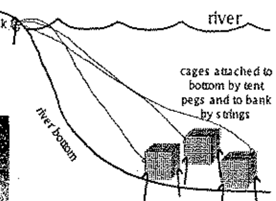
Map of Ouse Catchment showing translocation sites

Engraving mussels to label them

12 mussels per cage



Cage 23cm square



Arrangement of cages at each site

Large scale trials

The Ouse Washes, in East Anglia, consist of a system of ditches separating pasture. In winter the whole area floods, while in summer the area becomes an important wildfowl reserve, and also supports rare plants. Recently the ditches have become clogged up with filamentous algal growth, due to high nitrate and phosphate levels in the inflowing water.

As part of a project by Rob Cathcart looking at eutrophication control in the ditches (see **Rob Cathcart's poster**), this year we have translocated 6000 mussels into 3 ditches (2000 mussels per ditch, 40 per metre length of ditch). The levels of nitrate, phosphate and chlorophyll a are being monitored at biweekly intervals throughout the summer, and we hope that the mussels may be able to reduce the algal levels.

An initial observation that filamentous algal growth was significantly reduced in one ditch in the proximity of the mussels is very promising!

The survival and growth of the mussels is also being monitored using a subsample of labelled and measured mussels. The mussels will be taken out of the ditches in late September before the ditches reflood for the winter.

Moving 6000 mussels from river to ditch in carrot bags: a. collecting mussels at Aldreth; b. mussels collected from 10m stretch of river; c. putting 40 mussels into each carrot bag; d. moving mussels to ditches in a quadbike-trailer; e. putting mussels into ditch at 1m intervals; f. ditch with 50 carrot bags (2000 mussels).

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The Asian clam, *Corbicula fluminea*, in Great Britain

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Introduction

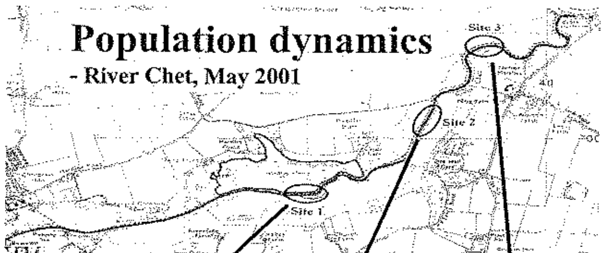
The Asian clam, *Corbicula fluminea,* arrived in Britain approximately four years ago and has rapidly gained a foothold in the Norfolk Broads, one of the largest and most important wetland areas in Europe (Aldridge & Müller, 2001). It threatens to be of immense ecological and economic importance in Britain. Research in the United States and Europe suggests that *C. fluminea* has the capacity for rapidly establishing large, dense populations (up to 130,000 ind.m^{-2}), spreading through waterways at a rate of hundreds of miles within a few years. It has caused serious industrial damage in the United States (e.g. by blocking power station cooling pipes) and has had huge impacts on riverine and lacustrine ecosystems (Phelps, 1994) (see McMahon 1983 for a comprehensive review).

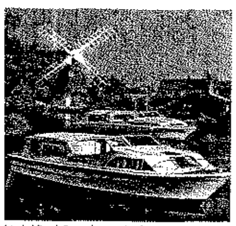
Population dynamics

- River Chet, May 2001

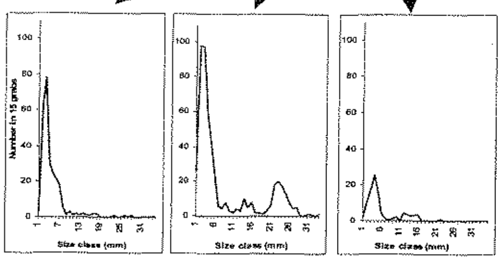
The River Chet

First UK record for the Asian clam





A typical Broads Scene - boats are implicated as vectors and may have transported *Corbicula* to the Chet.



Site 1) Very low numbers of adults of any size, but high numbers of juveniles - possibly transported there from other sites and then unable to grow to adult size. Growth studies are under way.

Site 2) Highest densities, large numbers of juveniles, with higher proportions of medium sized adults and large, older individuals. This site may act as source of juveniles.

Site 3) Most recently colonised. No large, older adults, but some medium-sized individuals which probably arrived as juveniles the year before. Some juveniles beginning to appear in the population.

Clams found on the grab after sampling - this is how mud-anchors might spread *Corbicula*! And no, I didn't put them there for the picture myself!

Research objectives

To predict the spread and potential impacts of *C. fluminea* in the Norfolk Broads and the rest of the UK.

This includes, among others, the following studies:

- **Population source determination**
- **Population dynamics and distribution changes**
- **Wildfowl diet**
- **Fish diet**
- **Dredging effects**

Ecosystem effects

Fish stomach content analysis

- **fish killed as a pilot study**
- **fish stomach-flushed for quantitative assessment of calorific gain from *C. fluminea***

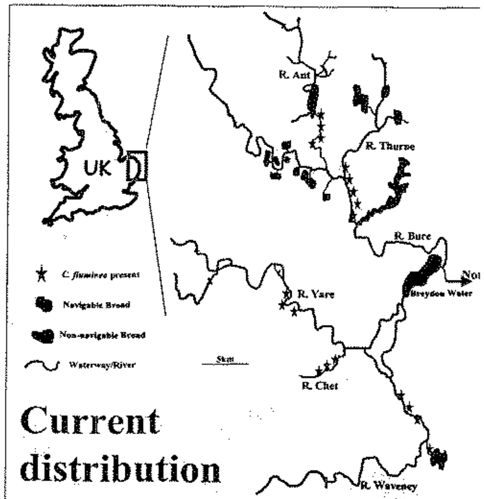
Roach *Rutilus rutilus*

Duck stomach content analysis

During wildfowling season (1st September to 30th Jan) duck carcasses were obtained from various locations and examined for *C.fluminea* remains. So far 25 individuals of various species examined, but no clams found. Efforts will now concentrate on areas with the highest clam densities and on obtaining diving ducks.

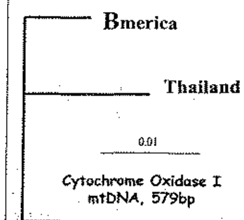
Predator exclusion studies

Six 1x1m cages have been placed at each of 4 locations in the River Chet to exclude predators from reaching the sediment. The effects of this on clam densities and size-frequency distribution will be assessed after 12 months



Current distribution

Population genetics



Specimens from Norfolk and Germany were sequenced and compared with sequences from the main American (America), a smaller American (Bmerica), Argentinian and Thai populations gathered from the literature.
The Norfolk population is virtually identical to the main American population and represents, together with the other European and South American populations, a part of the recent rapid range expansion originating probably from North America.

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Our workboat on the Norfolk Broads