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**Research article**

# The Asian clam (*Corbicula fluminea*) in the River Thames, London, England

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## Abstract

The Asian Clam, *Corbicula fluminea* (Müller, 1774) invaded British waters in 1998. It remained confined to an isolated network or rivers in Eastern Britain until 2004, when it was discovered in low densities in the River Thames, London. We report that *C. fluminea* has now been discovered at three more sites on the tidal River Thames. Surveys indicate that the clam has now established dense populations of up to 648±352 $m^{-2}$ at Ham on the River Thames, with evidence of annual recruitment. Given the substantial connectedness of the Thames to many of Britain's other rivers, it is likely that *C. fluminea* will now continue to spread through Britain's waterways.

*Key words*: Asian Clam, *Corbicula fluminea*, invasive species, bioinvasion

## Introduction

The Asian clam *Corbicula fluminea* (Müller, 1774) (Figure 1) is one of the world's most notorious and widespread invasive organisms (Park and O'Foighil 2000). It has undergone a massive global range expansion since the 1940s, spreading from its native range in southeast Asia to South America, North America and then to Europe (McMahon 1999). By the 1970's *Corbicula* had colonised thousands of miles of waterways in the United States, including the Great Lakes (McMahon 1983). The clam reached Germany in the late 1980s (Hasloop 1992), and has since spread through most of the major watersheds on the European mainland including the Rhine (Bij de Vaate 1991) and Rhone (Mouthon 2001). This rapid dispersal across the world has been facilitated by humans which have helped the clam cross the continental divide (McMahon 1983).

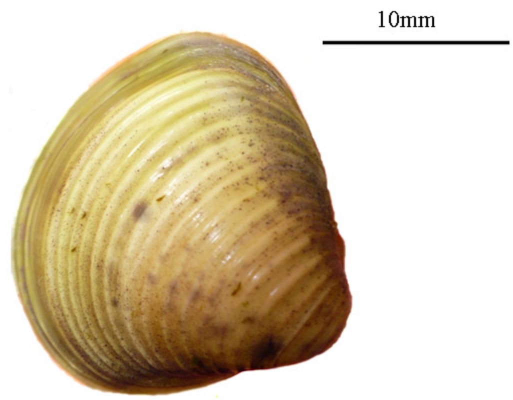


**Figure 1.** *Corbicula fluminea* from Ham on the River Thames, London (Author: Philine S.E. zu Ermgassen)

It had substantial economic impacts while spreading through North America: macro-fouling of the raw water service systems of nuclear power stations was estimated to have cost the US $2.2 billion annually in the early 1980s (OTA 1993). *C. fluminea* also caused changes in invaded ecosystems through its considerable filtration capabilities. Asian clams can filter up to one litre of water per individual per hour (Way et al. 1990; Silverman et al. 1995) and reach densities of hundreds of thousands of individuals per square metre, making them important consumers of phytoplankton. The increased water clarity caused by their filtration can lead to increases in light penetration, enhanced macrophyte growth, and alteration of fish stocks. Further, the clam may also alter the benthic substrate (Sickel 1986; Beaver et al. 1991), and may compete with native species for limited resources (Devick 1991).

*C. fluminea* appears to have arrived in Britain in 1998 (Baker et al. 1999). This invasion could be perceived as a post-glacial re-colonisation event; remnants from a member of the *Corbicula* genus from the last interglacial period have been found underneath Trafalgar Square in London (Miller et al. 1979). The recent invasion started in a small waterway, the River Chet, in the Norfolk broads (Baker et al. 1999, Figure 2). The Norfolk broads are an isolated set of inter-

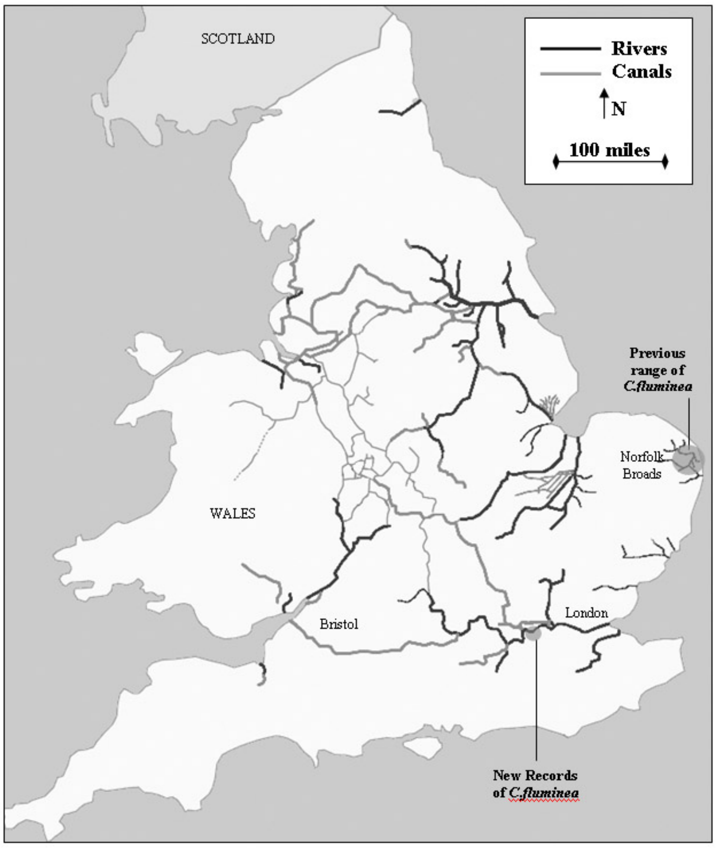


**Figure 2.** The range of *C. fluminea* populations in the Norfolk Broads in 2002 (from Müller, 2003) and the recent location of sightings in the River Thames

connected rivers and lakes on the East of England which drain into the North Sea at Great Yarmouth. This introduction was unlikely to have been via the ballast water of commercial ocean-going vessels; there is a virtual absence of commercial shipping routes into freshwater systems in Britain. Other introductory mechanisms for *Corbicula* include bait buckets, bilge water or the accidental transfer with imported aquaculture species (Counts 1986), but it is unclear if any of these played a role in the introduction. The clam spread rapidly around the drainage system of the Broads, but remained confined there between 1998 and 2004, largely because the Norfolk Broads catchment is comparatively isolated. This is in sharp contrast to all of the other major rivers in southern England which are linked to each other by one or more canals (see Figure 2).

In 2004, the first specimen if *C. fluminea* was noted at Teddington on the River Thames (Whaley 2004). In October 2005, one living juvenile *Corbicula* was collected by the Environment Agency's Mark Davison in a kick-net sample taken from just below Teddington Lock (grid reference TQ 1674 7146). Further individuals measuring 1.9 and 5.4 mm respectively were collected on a subsequent visit to the site in January 2006 (Mark Davison, Environment Agency, pers comm.), while a survey at a nearby site in Isleworth (grid reference TQ 1695 7606) in November 2005 also located one juvenile. The source of the invasion is unknown, but may have originated from the overland transport of infested pleasure craft from the Norfolk Broads to the Thames catchments; Muller (2003) noted that adult clams could potentially be transported in mud attached to the mud anchors of such boats.

The purpose of this study is to present new data on distribution of *C. fluminea* within English waters and to confirm whether it has now established a population the River Thames.

## Methods

To build a broad idea of the current distribution of Asian clams in the River Thames, data was collated from the Environment Agency records regarding the sites at which *Corbicula fluminea* had been found in monthly kick-samples along the bank-side river bottom. All of the detection sites had tidal water levels, although the water quality tended was dominated by the influx of freshwater from upstream reaches (Teddington Lock is the tidal limit; see Figure 3). At the sampling sites, the river tended to have hard embankments, a width of between 10 and 15 metres, and a maximum depth of around 6m at high water.

In late July 2007, the density of *C. fluminea* was assessed at three sites near Ham, Richmond, on the River Thames. This was the site at which most *C. fluminea* had been found by the Environment Agency (n=98 in November 2006). Sample sites were situated at approximately 500 metre intervals, with grid references of: TQ16417301, TQ16417301 and TQ17507337 (moving from the most upstream site to the most downstream site). Samples were collected using an Ekman grab sampler of capture area 468 cm$^2$, which was dropped from the side of a small motor-boat. Samples were collected in triplicate from 5 locations along lateral transects of the river at each site. The samples were collected at evenly spaced intervals, starting and finishing approximately 1m from each bank of the river. All of the clams collected were measured to the nearest millimetre using vernier callipers.

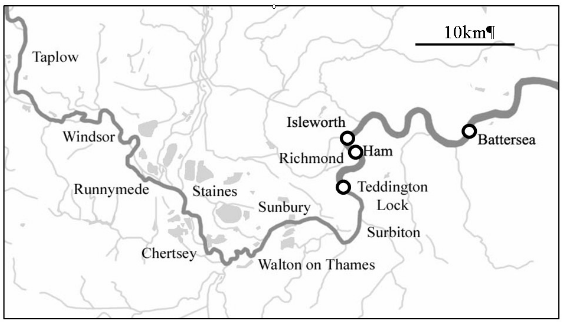


**Figure 3.** Locations where *C. fluminea* has been found on the River Thames to date

## Results

*C. fluminea* has now been found at four sites on the tidal River Thames (Figure 3, Annex 1). The highest densities found in 3-minute kick-samples to date are:

Ham (TQ172733): 98 individuals on 08/11/06
Teddington (TQ165718): 9 individuals on 08/11/06
Isleworth (TQ169760): 1 individual on 08/11/06
Battersea (TQ 267768): 1 individual on 10/08/06

The results of our surveys show that Asian clams are thriving in unprecedented densities in and around Ham on the River Thames, reaching densities as high as 648±352 m$^{-2}$ in the central Ham transect. A two-way ANOVA showed that clams were spread evenly across each transect of the river, but differed in overall density between the sites (Figure 4, Table 1). A size analysis of the samples revealed a clear bimodal distribution (Figure 5).

**Table 1.** The results of a Two-way ANOVA to *why "to" test for the effects of distance of samples along each transact (1m from near bank, 4m from near bank, central channel, 4m from far bank, 1m from far bank) and sample site on the numbers of *C.fluminea* found in bottom-grab samples

| Factor | F | d.f. | p |
|---|---|---|---|
| Position along transect | 0.53 | 4 | 0.711 |
| Site | 5.35 | 2 | 0.010 |
| Position: Site (interaction) | 1.38 | 8 | 0.172 |

## Discussion

A dense population of up to 648 individuals $m^{-2}$ ± 352 SE can be found at Ham, indicating that a *C. fluminea* population has become established as part of the resident fauna of the River Thames. The bimodal size distribution of the clams implies that there have been only a few years of substantial annual recruitment. The current densities are similar to those found in the Norfolk broads, where mean population densities range from 130 to 509 individuals $m^{-2}$ (Müller 2003). Given the early status of this invasion, it is possible that population densities in the Thames will reach unprecedented levels in the UK by the end of the decade. *C.fluminea* has the potential to reach densities of up 18,000 individuals $m^{-2}$, the densities found after the invasion of the New River, USA (Doherty et al. 1987).

It is clear that the *C. fluminea* is predominantly found in the upper reaches of the tidal Thames (Teddington, the most upstream site, is the tidal limit). The three miles of waterway between Teddington and Richmond are only truly tidal for about 2 hours before and 2 hours after high tide, when vertical weir gates at Richmond are raised. At all other times, the weir sluice gates maintain artificially water levels of at least 1.7 m (Gray 2005). This tidal regime is likely to have made these areas very vulnerable to invasion by *C. fluminea*; a new population could seed larvae into large stretches of rivers upstream and downstream by virtue of the reversing currents.

Usually, bivalves like *C. fluminea* depend upon human transport to transfer them upstream from where larvae can spread downstream through currents (Voelz et al. 1998).

The salinity in this stretch of water would also favour the establishment of *C. fluminea*; although the overall salt content does gradually

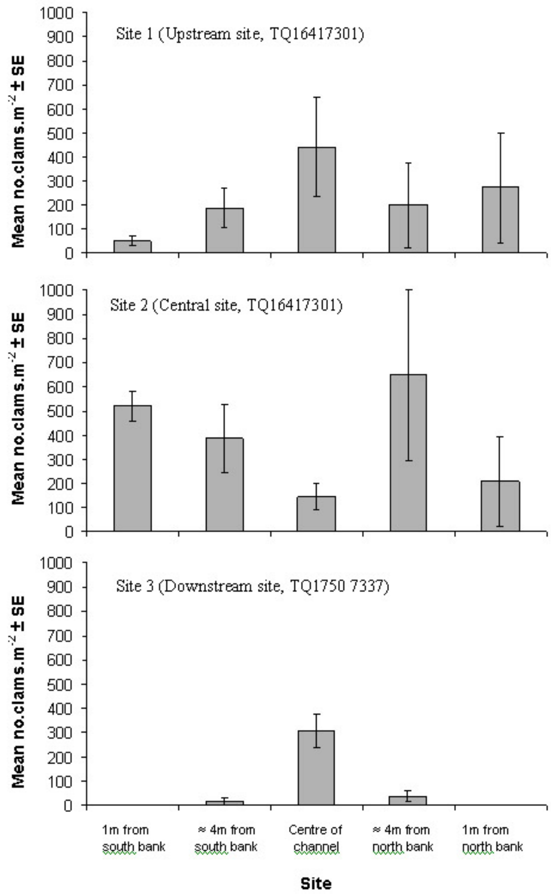


**Figure 4.** Densities of *C.fluminea* at sites near Ham on the River Thames

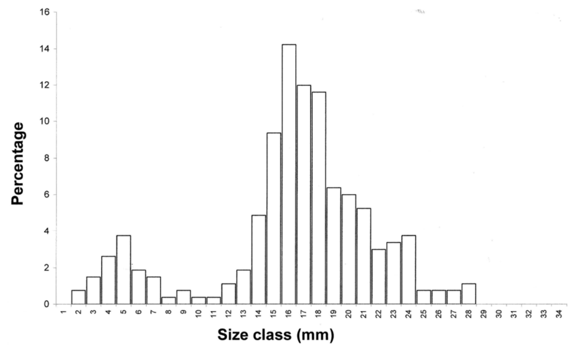


**Figure 5.** The size distribution of *C.fluminea* at Ham on the River Thames

increase towards the sea, the tidal Thames is essentially fresh-water as far downstream as Battersea (the lowest site at which *C. fluminea* has been found). Salinity for the sites under study ranges from 0.16 ppt to 0.84 ppt (Lars Atkesson, Environment Agency, pers. comm.), which falls well below *Corbicula*'s upper tolerance level of 24 ppt (Evans et al. 1979).

It is unclear as to why the invasion and establishment of *C. fluminea* in the River Thames has happened recently, but it may coincide with the recovery of the Thames as an ecosystem. Only 40-50 years ago, it was considered biologically "dead", but because of recent improvements in the treatment of effluent sewage, it is now thought to be one of the cleanest rivers flowing through a European city (Gray 2005). Between 1990 and 2007, the Environment Agency has recorded a general increase in the chemical water quality of English rivers (www.environment-agency.gov.uk), and many invasive (and native) species have been increasing in density in the Thames, including the Chinese Mitten Crab (Rainbow 2003) and zebra mussel (Aldridge et al. 2004).

Regarding the future spread of the clam, calcium, pH and, temperature values are suitable for *C. fluminea* growth and reproduction across most of England (Müller 2003). England has an extensive, interconnected waterway network through which clam larvae could spread via diffusive upstream and downstream locomotion (Voelz et al. 1998). Further, thousands of motorised pleasure vessels commute along England's waterways each year, which could potentially facilitate the dispersal of *C. fluminea* larvae (or adults) in association with mud-anchors, outboard engines, or attached aquatic vegetation. It is therefore likely that *C. fluminea* will colonise many other waterbodies around the country. Precedents have already been set; *C. fluminea* colonized most of the River Rhine and many of its tributaries within 10 years of being discovered near its estuary in the Netherlands (Bij de Vaate 1991; Den Hartog et al. 1992).

Should *C. fluminea* continue to spread around the UK, it could have major economic impacts through the macrofouling of industrial facilities which draw water from infested waterways. It could potentially affect around 12 inland power stations, each of which is located on waterways currently suitable for the survival and reproduction of *C. fluminea* (Müller 2003). In a worst case scenario, this could cost the British power generating industry around £2.5 million per annum (Müller 2003). Effects on water treatment facilities could be even greater. For example, a recent increase in the densities of zebra mussels in the UK has cost millions of pounds in mitigation (Elliott et al. 2005).

More worryingly, *C. fluminea* could have substantial effects on the native biota of the UK, exacerbating the problems already being caused by *Dreissena polymorpha* (Aldridge et al. 2004). It has been reported that *C. fluminea* is a superior competitor to native unionids because of their higher mass-specific filtration rates (Beaver et al. 1991), and because *C. fluminea* can displace or uproot native mussels (Fuller and Richardson 1977). If this is true, this causes particular concern for the future of the BAP species *Pseudanadonta complanata* which can also be found at Ham (Mark Davison, Environment Agency, pers. comm.). The high densities of Asian clams will have numerous other ecological impacts in the River Thames, most notably through their substantial filtration capabilities. Further studies are required to elucidate the full extent of clam infestation of the Thames catchment and to assess their current and future ecological impacts.

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**Annex 1**
Recent records of *Corbicula fluminea* in the UK

| Location (River/site name) | Record coordinates | | Record date | Number collected | Collector/reference |
|---|---|---|---|---|---|
| | Longitude | Latitude | | | |
| R. Chet, Norfolk | 1°31.6'E | 52°32.7'N | October 1998 | 1st | Baker et al. 1999 |
| R. Waveney, Norfolk | 1°40.6'E | 52°30.1'N | April 1999 | 2 | Muller 1999 |
| R. Chet, Norfolk | 1°40.6'E | 52°30.1'N | Spring 2003 | 1089 ind.m$^{-2}$ | Muller 2003 |
| R. Bure, Norfolk | 1°35.0'E | 52°38.2'N | Spring 2003 | 339 ind.m$^{-2}$ | Muller 2003 |
| R. Yare, Norfolk | 1°29.4'E | 52°34.8'N | Spring 2003 | 1394 ind.m$^{-2}$ | Muller 2003 |
| R. Waveney, Norfolk | 1°38.2'E | 52°31.0'N | Spring 2003 | 472 ind.m$^{-2}$ | Muller 2003 |
| R. Thames, Teddington, London | 0°19.3'W | 51°25.7'N | October 2005 | 1 | Mark Davison |
| R. Thames, Isleworth, London | 0°19.0'W | 51°28.2'N | November 2006 | 1 | Mark Davison |
| R. Thames, Battersea, London | 0°10.5'W | 51°28.5'N | August 2006 | 1 | Mark Davison |
| R. Thames, Ham, London | 0°18.8'W | 51°26.8'N | August 2006 | 98 | Mark Davison |
| R. Thames, Ham, London | 0°19.5'W | 51°26.6'N | July 2007 | 648 ind.m$^{-2}$ | This study |