Database of association with habitat and environmental variables for non-shelled slugs and bivalves of Britain and Ireland

Irish Wildlife Manuals No. 41

Comhshaol, Oidhreacht agus Rialtas Áitiúil
Environment, Heritage and Local Government

Database of association with habitat and environmental variables for non-shelled slugs and bivalves of Britain and Ireland

Evelyn A. Moorkens & Ian J. Killeen

Citation:

Moorkens, E. A. & Killeen, I. J. (2009) Database of association with habitat and environmental variables for non-shelled slugs and bivalves of Britain and Ireland. *Irish Wildlife Manuals*, No. 41. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Cover photos (clockwise from top left): *Margaritifera margaritifera* © National Museum of Wales; *Arion occultus* © Roy Anderson; *Arion owenii* © Adrian Sumner; *Sphaerium solidum* © National Museum of Wales.

Irish Wildlife Manuals Series Editors: N. Kingston & F. Marnell

ISSN 1393 – 6670

CONTENTS

ACKNOWLEDGEMENTS

We are indebted to Gerhard Falkner, Petr Obrdlík, Emmanuel Castella and Martin Speight for their original database and their encouragement to extend it with the slug and bivalve species. We are particularly grateful to Martin Speight for many interesting discussions that have opened up the new world of habitat and predictive databasing to us.

Thanks are given to the many authors and researchers that sent reprints and discussed aspects of molluscan ecology with us during this study. Particular thanks go to Roy Anderson, Jose Castillejo, Peter Glöer, Ben Rowson and Jacques Mouthon.

Final thanks go to the photographers whose work appears in these texts, Roy Anderson, Michal Maňas, Ben Rowson, Adrian Sumner, the staff of the National Museum of Wales, and the great molluscan photographer Derek Rands, who has sadly recently passed away.

INTRODUCTION

The maintenance of biodiversity requires ecosystems that effectively function from the gross scale to the narrowest scale. Loss of biodiversity will occur if individual species can no longer successfully fulfil their life cycles due to management changes that negatively affect their specific ecological needs, or, on a larger scale, interfere with the dynamics needed to support a meta-population.

Digitised databases are a familiar form of maintaining biological records. The FAEWE (Functional Analysis of European Wetland Ecosystems) project, initiated under the EU STEP programme (Science and Technology for Environmental Protection), initiated the compilation of database information on ecological features (Maltby *et al*., 1996). Three groups of invertebrates (Gastropods, Syrphids and Carabids) were categorised for a wide variety of life history traits and habitat preferences, and tested for their contribution to the assessment of habitat quality at a range of sites. As invertebrate habitat requirements have often been overlooked in the past, databasing this information has been a major step forward in invertebrate conservation (Speight, 1997; Speight & Good, 2003). The Syrphid database in particular, has gone from strength to strength and now includes detailed species accounts, with regular revisions being made as further knowledge comes to light (Speight, 1997; 1999; 2008; Speight *et al.,* 2003a, b; Speight & Castella, 2003; Burgio & Sommaggio, 2007). Using the database, Syrphid species lists can be predicted from accurate habitat assessment, and species lists can equally provide information on the level of function of habitats. The usefulness of this system is reflected in its adaptation as a formal means of conservation assessment in a number of European countries.

The ambitious molluscan database of habitat preferences and life history traits was published in 2001 (Falkner *et al.,* 2001), providing opportunities for malacologists to carry out similar ecological assessment. As with the Syrphid system, the molluscan database is based on a fuzzy coding system, which assigns a 0 (no association), 1 (minor association), 2 (Moderate association) or 3 (maximum association) category with each variable assessed. Categories of 0 in the database have been kept blank in order to read the spreadsheets with ease.

The non-shelled slugs and bivalve molluscs have not been included to date in the Molluscan Database of Falkner *et al.* (2001), although the three species of *Testacella* that live in Britain and Ireland, with remnant external shells, and the semi-slugs with larger shells were all included at the time. The purpose of this study is to assess each of the non-shelled slugs and bivalve molluscs of Britain and Ireland and include them in the database categories following the definitions from the glossary of Falkner *et al.* (2001). As this was carried out in the context of the ecology of the species in Britain and Ireland, categories may not reflect how the species behaves at other areas in their range. The information therefore should not be unduly extrapolated for their habitats across their range. This is particularly important for introduced species, which may behave very differently in their exotic habitats compared with in their natural habitats. Definitions of the habitats and the traits follow those presented in the glossaries of Falkner *et al.* (2001), which should be referred to when required.

The spreadsheets of macrohabitats, microhabitats and traits were completed following a literature search and based on the research from the literature and the best judgement of the authors. A

species account was compiled for all 64 species assessed. The spreadsheets are available for download – see Appendix 1-6.

Needless to say these database additions should be used in conjunction with those species assessed in Falkner *et al.* (2001) for a complete assessment of any Irish or British habitat or species list.

A recent checklist was produced by Anderson (2005), which updated the nomenclature of the British and Irish species in line with international usage and the nomenclature used in this assessment follows that checklist. For the slugs, Anderson introduced new names and taxa which arose from taxonomic separations of species that were already present. The recent increased understanding of species taxonomy, particularly through the use of molecular techniques, is likely to result in further expansions to the national lists in the near future. For the bivalves, we have included an additional species, *Pisidium globulare*, which was recognised only as a form of *P. casertanum* in Killeen, Aldridge & Oliver (2004).

The species accounts are not intended to be used for identification, but rather a summary and guide to further information that is available on identification and life history. For bivalve identification, the Field Studies Council guide is recommended (Killeen *et al*., 2004). An identification guide to slugs is urgently needed, and is being prepared by Anderson (Roy Anderson, pers. comm.).

Bivalves

A total of 32 species were assessed in this study as shown in Table 1.

Freshwater habitats are under considerable threat from a wide range of sources such as river (or canal) modification, river and canal management (dredging and weed cutting), destruction or over-dredging of ponds and lakes, water quality decline, tourism & development pressure (e.g. angling activities, marinas), competition and the effect of alien invasive species. As a result, there are several species of bivalve mollusc that are already showing evidence of decline, and many others which are potentially threatened. These are summarised in the above table.

General features of the bivalve shell with terms used in the species accounts are shown in Plate 1.

Table 1: Bivalve species assessed in this study.

	Conservation Interest	
	Ireland	**Britain**
MARGARITIFERIDAE Haas, 1940		
Margaritifera margaritifera (L., 1758)	High priority	High priority
UNIONIDAE, Rafinesque, 1820		
Unio pictorum (L., 1758)		Potential CI
Unio tumidus Philipsson, 1788		Potential CI
Anodonta cygnea (L., 1758)	Potential CI	Potential CI
Anodonta anatina (L., 1758)	Potential CI	Potential CI
Pseudanodonta complanata (Rossmässler, 1835)		Priority
CORBICULIDAE Gray, 1847		
Corbicula fluminea (Müller, 1774)		Pest
SPHAERIIDAE Deshayes, 1854		
Sphaerium corneum (L., 1758)	Low	Low
Sphaerium nucleus (Studer, 1820)	Potential CI	Potential CI
Sphaerium rivicola (Lamarck, 1818)		
Sphaerium solidum (Normand, 1844)		High priority
Musculium lacustre (Müller, 1774)	Low	Low
Musculium transversum (Say, 1829)		Potential CI
Pisidium amnicum (Müller, 1774)	Low	Low
Pisidium casertanum (Poli, 1791)	Low	Low
Pisidium conventus Clessin, 1877	Potential CI	Potential CI
Pisidium globulare Clessin, 1873		Potential CI
Pisidium henslowanum (Sheppard, 1823)	Low	Low
Pisidium hibernicum Westerlund, 1894	Low	Low
Pisidium lilljeborgii Clessin, 1886	Low	Potential CI
Pisidium milium Held, 1836	Low	Low
Pisidium moitessierianum Paladilhe, 1866	Conservation interest	Potential CI
Pisidium nitidum Jenyns, 1832	Low	Low
Pisidium obtusale (Lamarck, 1818)	Low	Low
Pisidium personatum Malm, 1855	Low	Low
Pisidium pseudosphaerium Schlesch, 1947	Conservation interest	Conservation interest
Pisidium pulchellum Jenyns, 1832	Low	Potential CI
Pisidium subtruncatum Malm, 1855	Low	Low
Pisidium supinum Schmidt, 1851		Potential CI
Pisidium tenuilineatum Stelfox, 1918		Priority
DREISSENIDAE Gray, 1840		
Dreissena polymorpha (Pallas, 1771)	Pest	Pest
Mytilopsis leucophaeata (Conrad, 1831)		Pest

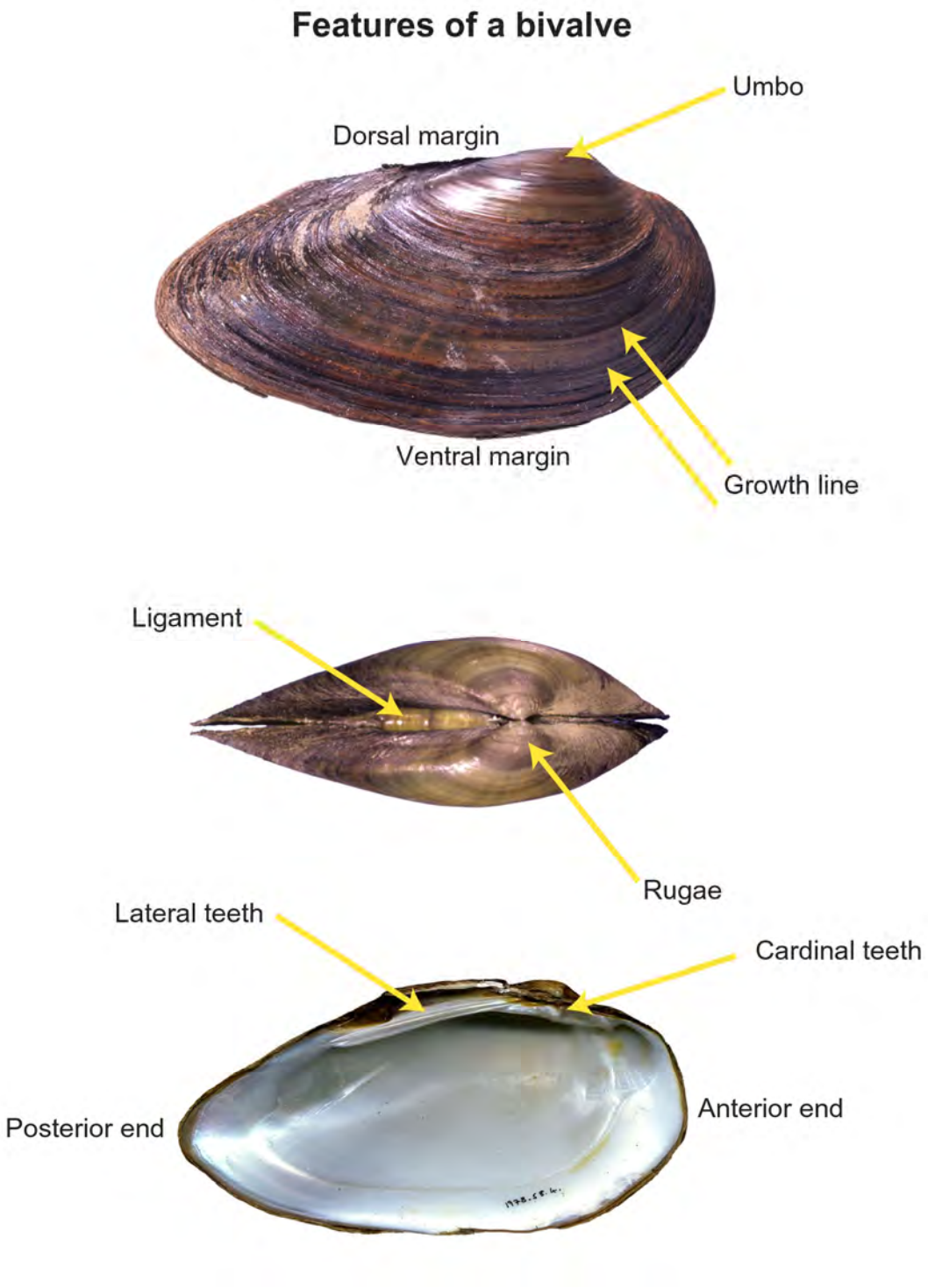


Plate 1: Features of a bivalve

Slugs

A total of 32 non-shelled slugs have been added to the molluscan database (Table 2). The species were considered to be native if they were present in the country before the industrial revolution, as very old introductions are difficult to separate from native species.

Table 2 Slug species assessed in this study.

Species	Native status	Pest status	Conservation priority
Arionidae Gray			
Arion (Arion) ater	Native	Pest	Low
Arion (Arion) flagellus	Native?	Pest	Low
Arion (Arion) rufus	Native?	Pest	Low
Arion (Arion) vulgaris	Introduced?	Pest	Low
Arion (Mesarion) fuscus	Native?	Pest	Low
Arion (Mesarion) subfuscus	Native	Pest	Low
Arion (Carinarion) circumscriptus	Native	Pest	Low
Arion (Carinarion) fasciatus	Native	Sometimes pest	Low
Arion (Carinarion) silvaticus	Native	Sometimes pest	Low
Arion (Kobeltia) distinctus	Native	Pest	Low
Arion (Kobeltia) hortensis	Native	Serious pest	Low
Arion (Kobeltia) intermedius	Native	Sometimes pest	Low
Arion (Kobeltia) occultus	Introduced?	Unknown	Unknown
Arion (Kobeltia) owenii	Native?	Less of a pest	Low
Geomalacus maculosus	Native	Not a pest	High
Boettgerillidae Van Goethem			
Boettgerilla pallens	Introduced	Pest	Low
Agriolimacidae Wagner			
Deroceras (Deroceras) agreste	Native	Pest	Low
Deroceras (Deroceras) laeve	Native	Some damage	Low
Deroceras (Deroceras) panormitanum	Introduced	Pest	Low
Deroceras (Deroceras) reticulatum	Native	Serious pest	Low
Limacidae Lamarck			
Lehmannia marginata	Native	Sometimes pest	Low
Lehmannia nyctelia	Introduced	Sometimes pest	Low
Lehmannia valentiana	Introduced	Sometimes pest	Low
Limacus flavus	Introduced	Sometimes pest	Low
Limacus maculatus	Introduced	Sometimes pest	Low
Limax cinereoniger	Native	Not a pest	High
Limax maximus	Native	Rarely a pest	Low
Malacolimax tenellus	Native	Not a pest	High
Milcidae Ellis			
Milax gagates	Native?	Pest	Low
Tandonia budapestensis	Introduced	Serious pest	Low
Tandonia rustica	Unknown	Not a pest	High
Tandonia sowerbyi	Introduced	Pest	Low

Most slugs are of low conservation priority, and many cause considerable economic damage. Most of the pest species are introduced, or have adapted and spread into economic crops to become pest species. A few are of conservation interest, these are *Geomalacus maculosus*, which has a small world range and is restricted by its habitat requirements. Although not thought to be currently under threat, it is an umbrella species for unimproved mountainous areas on sandstone geology, and old native humid oak woodlands.

The Limacids *Limax cinereoniger* and *Malacolimax tenellus* are also of conservation interest, as they have restricted distributions and are indicators of high quality woodland habitats.

The Milacid *Tandonia rustica* needs further investigation to determine its true distribution and status in Britain and Ireland, but in the meantime it should be treated as of conservation interest.

Most shelled gastropod species can be distinguished by shell characteristics, with a few very similar species requiring confirmation by dissection. Slugs have no external shell; their shell is internal and small in size and of little use in taxonomic identification. The main external means of identifying slugs are body colour, patterning, size, shape, the location of the respiratory pore, mantle, and the presence, absence and situation of a body keel. This is useful in separating slug groups from each other, but is often not enough to separate closely related species, particularly of Arionids. These are very variable in body colour, which itself changes from hatching to maturity, and the added problem of species interbreeding has restricted the casual recorder to using aggregate nomenclature, such as "*Arion subfuscus* agg.", "*Arion hortensis* agg." or "*Arion ater* agg."

In the species accounts, some general descriptions of the external features of slugs are given, the most important features are shown in Plate 2 and in Table 3 below.

Table 3: Key features of slug families.

Family	Keel	Tail	Mantle	Foot fringe	Respiratory pore (Pneumostome)
Arionidae	Absent	Tail blunt, mucus gland present	Granular mantle with no concentric rings	Strong fringe visible	Pore to front half of mantle
Boettgerillidae	Keel from tail to mantle	Tail pointed	Mantle pointed to rear	No obvious fringe	Pore to rear half of mantle
Agrolimacidae	Keel short and truncated	Tail pointed	Fingerprint pattern on mantle	No obvious fringe	Pore to rear half of mantle
Limacidae	Keel present but does not extend to mantle	Tail pointed	Fingerprint pattern on mantle	No obvious fringe	Pore to rear half of mantle
Milacidae	Keel from tail to mantle	Tail pointed	Grooves on mantle	No obvious fringe	Pore to rear half of mantle

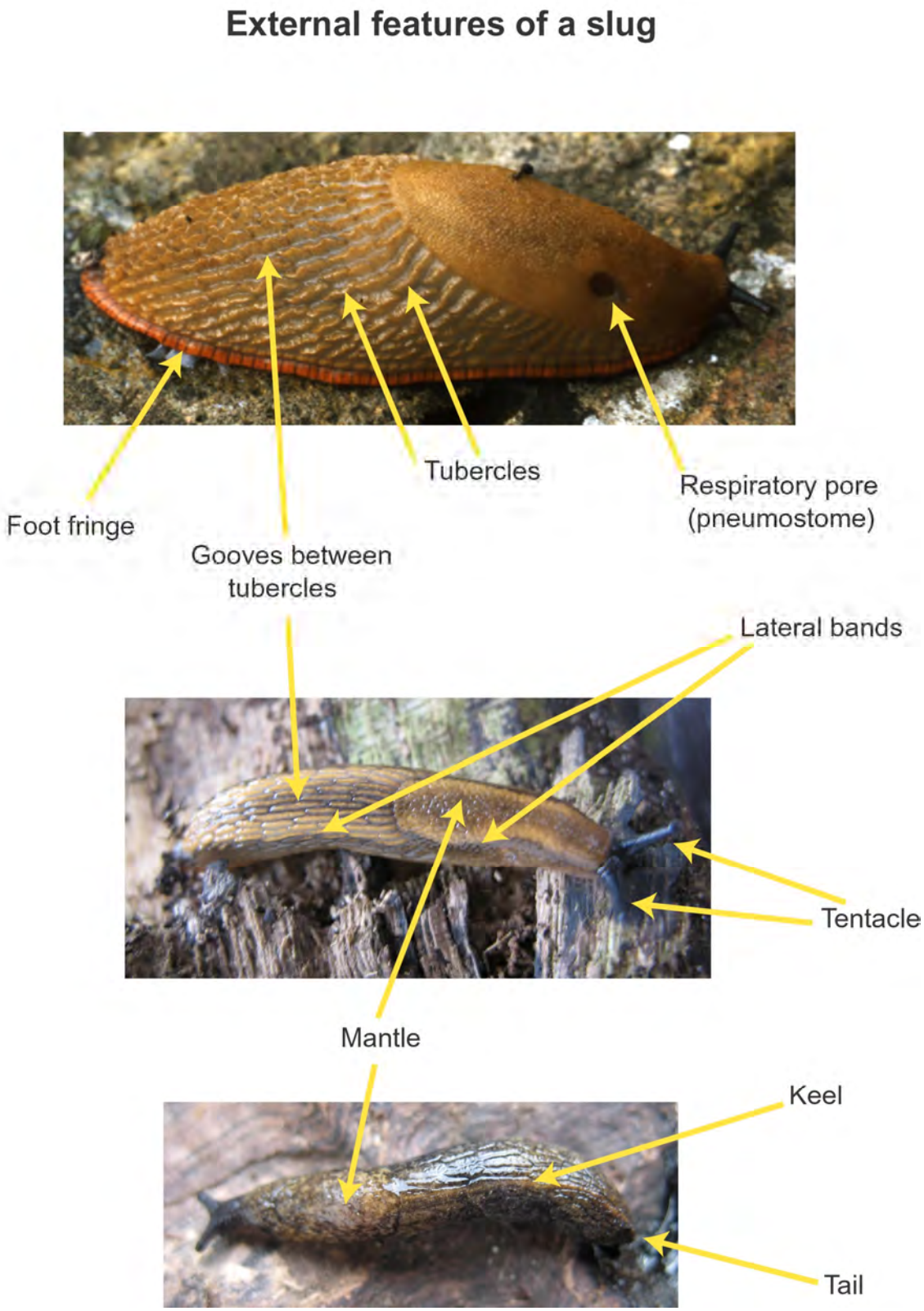


Plate 2: External features of a slug

BIVALVE SPECIES ACCOUNTS

Margaritifera margaritifera (Linnaeus, 1758)

Common name: Freshwater pearl mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

This is a large, solid mussel typically reaching 110mm to 135mm in length (but individuals up to 160mm are known), height 45-50mm, and depth 25-30mm. The outline shape is very variable but the shell is elliptical with arched dorsal margins and usually concave ventral margins. The umbos are well to the anterior end and are usually extensively eroded. The periostracum (or skin) is very thick and coloured brown black to black, but paler brown in younger individuals. Internally the hinge plate is long and is without posterior lateral teeth and only has weak cardinal teeth. Internally the shell is a nacreous bluey white often with a pinkish colour when living or in freshly dead shells.

There is considerable variation in shell shape and many subspecies and varieties have been described (mainly on the basis of shell shape). Another group of forms is found in shells from populations living in waters of moderate to high calcium content. They are thicker, with more prominent teeth and have un-eroded or only slightly eroded umbos. The extreme end of this range is represented by *Margaritifera durrovensis* from the Nore-Suir system in Ireland and which is treated separately here.

Habitats

The freshwater pearl mussel lives principally in oligotrophic streams and rivers with a pH of 5.5 to 7, low calcium and low conductivity. The species also occurs occasionally in oligotrophic lakes, and in a few rivers and streams that have higher calcium and conductivity levels but are either very low in other nutrients or in very large river systems in deep water. Aging adult mussels are still found in rivers where these natural habitats have recently deteriorated and successful reproduction is not possible.

Microhabitats & Habits

Margaritifera margaritifera prefers stable stream-beds of sand, gravel and cobbles into which it buries or where it can become lodged between larger stones. It can be very common in riffle areas living in the gravel patches downstream of rocks and boulders. It will also aggregate into dense beds of over 500 per square metre in moderate to fast flowing stretches, often in deeper water from 0.5 to 2m depth. In some small streams, especially in highland areas, it can also be found in very shallow water where the flow is constant and temperatures low.

Life history

Members of the pearl mussel family, Margaritiferidae, have a complex life cycle - they have great longevity, living to 100 years of age, maturing between 7 and 15 years of age, and can have a prolonged fertile period lasting into old age (Bauer, 1987).

Sexes are normally separate. Sperm is released into the open water via the male's exhalent siphon, is carried to the eggs via the female inhalant siphon, and fertilisation occurs in the brood chambers. These develop into the larval stage, called glochidia, which are temporarily brooded in the female gills from June each year, and are then released into the open water in high numbers in an event lasting 1-2 days between July and September, probably dictated by temperature in the river during development. The average number of glochidia produced per female is between 4 and 17 million (Bauer, 1987; Young & Williams, 1984; Ross, 1988).

A small percentage of glochidia will be inhaled by passing salmonid fish that act as the pearl mussels' temporary hosts. Glochidia are simple organisms with little more than a pair of shells, an adductor muscle to snap them shut, and a layer of cells, which can absorb and digest nutrients (Ziuganov *et al.*, 1994). The valves close on a filament of the salmonid gills, and nourishment is taken from this fish host until the glochidia are large and mature enough to exist independently. During this time they increase to about 6 times their original length. In a study, Young & Williams (1984) found a 95% loss of glochidia while attached to fish.

Those that survive on the fish develop into young mussels. They fall off in early summer (normally June) and bury into gravel, remaining buried for about five years, until large enough to withstand the flow of open water, moving stones, and perhaps trout predation. Young & Williams (1984) estimated from field studies that only about 5% of young mussels falling off fish survive to reach three to six years of age in rivers capable of supporting recruitment.

Dispersal mechanisms and translocation

Margaritifera is dispersed within a river catchment in an upstream and downstream direction by the movement of salmonid fish hosts bearing glochidia. Mussels are also dispersed downstream during flood events by the force of water flow. It is likely that *Margaritifera* was dispersed between catchments during interglacial and early postglacial periods by movement of host fish through estuaries and seas in the reduced saline conditions that would have occurred at the time.

Food

Feeding mechanisms in *Margaritifera* change during their development. On the host fish, the larval mantle cells have a dense felt of microvillus used to take food into storage granules in mantle cells (Wächtler *et al.*, 2000). After dropping off the fish host, very young juvenile mussels pedal feed by moving their foot around the interstices of the gravel in which they are buried. Microfilm bacteria are swept up by cilia through active foot movement until the development of the gills and siphons some months later. The mussels filter feed for the rest of their lives. Food consists mainly of unicellular bacterium, experimental studies showed that clearance rates of small unicellular particle types (4 μm) were high in *Margaritifera*, whereas larger particles of phytoplankton and detritus were rejected to pseudofaeces (Baker & Levington, 2003).

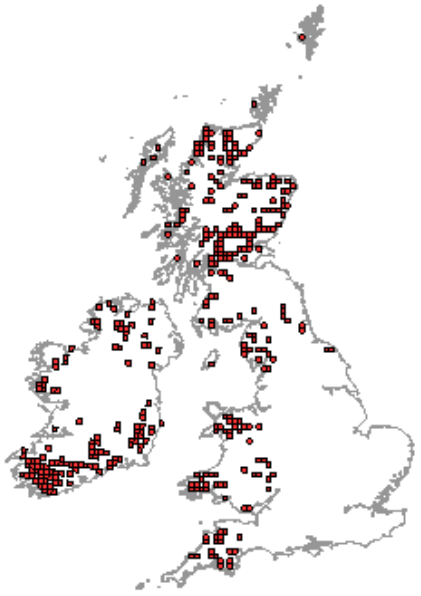
Range

Margaritifera margaritifera is known from North America, northern and central Europe and Russia. The species is declining throughout its range and is listed in the IUCN red data book as endangered worldwide (Baillie & Groombridge, 1996).

Distribution – Ireland

The current range of *Margaritifera margaritifera* in Ireland includes the western sea board from Donegal to Cork and parts of the south east, with some outlying populations in the counties bordering the Republic and Northern Ireland. It is restricted to rivers flowing over granite or sandstone rock, mainly in the western part of Ireland, but also in areas of the south and south east where geological conditions allow.

It is now common only in the west and south-west, Elsewhere, particularly in the southeast and north it has experienced serious decline. There are approximately 142 rivers and lakes with known records.



Map from NBN based on Kerney (1999)

Distribution - Britain

In England, the pearl freshwater mussel was formerly known from a number of rivers from Cornwall and Devon in the south-west to Cumbria and Northumberland in the north (Kerney, 1999). However, it has become extinct in many rivers, and most surviving populations are considered to be 'functionally extinct' in that they consist of a relatively small number of old specimens with no substantial evidence of recent recruitment. The pearl mussel was formerly

widespread in Wales, with several rivers supporting large populations. However, there has been a dramatic decline over the last 30 years such that most of the rivers it formerly inhabited now only support a few aged individuals. In Britain, the stronghold of the species is in Scotland where it is estimated that there are 10 rivers that may support populations with over 100,000 individuals. However, as in England and Wales, there have been a significant number of declines and extinctions.

Conservation Status

Margaritifera is protected under the following:

EU: European Habitats & Species Directive 1992 (Annexes II and V)

Bern Convention 1979 (Annex 3)

Britain: UK Wildlife and Countryside Act 1981 Schedule 5

UK Biodiversity Action Plan priority species

Ireland: Wildlife Act 1976

Wildlife (Amendment) Act 2000

Red listed - CR [A3 c,d,e; A4 c,d,e] Byrne *et al*. (2009)

Threats

There are a number of factors leading to the decline and loss of pearl mussel populations internationally and most of those are evident in Ireland and Britain (Araujo & Ramos, 2001; Moorkens, 1999).

The loss of pearl mussel populations mostly occurs from continuous failure to produce new generations of mussels because of the loss of clean gravel beds, which have become infiltrated by fine sediment and/or over-grown by algae or macrophytes. These block the required levels of oxygen from reaching young mussels which spend their first five to ten years buried within the river bed substrate. Other ways in which mussel populations can decline and be lost is through adult mussel kills, or loss of host fish that are essential to the life cycle of *Margaritifera*.

Activities that lead to the above unsuitable river conditions include: Modification of cultivation practices, especially agricultural intensification, increased use of fertilisers, pesticides, overgrazing, intensive forestry management, stock feeding, leisure salmonid fishing management, pearl fishing, sand and gravel extraction, quarrying, peat extraction, mining, discharges, urbanised areas, human habitation, industrial and commercial areas, disposal of household or industrial waste, road building and maintenance, bridge construction and ongoing operation, drainage, canalisation, modification of hydrographic functioning, management of water levels, dumping, dredging, erosion, competition from non-native species.

Margaritifera durrovensis Phillips, 1928

Common name: Nore pearl mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

The taxonomic status of *M. durrovensis* has been argued ever since Phillips first published his species description. The species and subspecies classification of *M. durrovensis* was dismissed by Chesney *et al.* (1993), who formed their conclusions on the basis of shell, anatomical and enzyme polymorphism comparisons. Subsequently, Moorkens (1996) looked at morphometric taxonomical differences between shell sets from various rivers and different species within the *Margaritifera* genus and showed *M. durrovensis* showed greater morphometric differences to other margaritiferids. The progress in genetic analyses in recent years has allowed the debate to resume. Holmes *et al.* (2001) found good genetic separation between *M. durrovensis* and *M. margaritifera* populations. Machordom *et al*. (2003) found that Ireland had populations linked genetically to two separate lineages. Geist & Kuehn (2005) studied the genetics of 24 European pearl mussel populations. The analyses of nine microsatellite loci with different levels of polymorphism revealed a high degree of fragmented population structure and very different levels of genetic diversity within populations. Early indications from examination of *M. durrovensis* genetic material by Geist (pers. comm.) suggest that this genetic population fits into a fragmented population model.

The taxonomic status of *Margaritifera durrovensis* remains inconclusive but is probably best described as a rare ecophenotype of *M. margaritifera*, a status which concurs with Machordom *et al*. (2003) and Chesney *et al.* (1993), the most recent bivalve guide to the region (Killeen *et al*., 2004), and the most recent published Irish list of molluscs (Anderson, 2005).

Brief description of species

This is a large, solid mussel typically reaching 110mm in length, height 45-50mm, and depth 25-30mm. The shell is elliptical with gently arched dorsal margins and slightly concave ventral margins. The umbos are towards the anterior end and are never eroded. The periostracum (or skin) is very thick and coloured brown black. Internally the hinge plate is long and is without posterior lateral teeth but with obvious cardinal teeth. Internally the shell is a nacreous blue white often with a mauve to pink colour when living or in freshly dead shells.

Habitats

The Nore pearl mussel is currently only known from the lime-rich waters of the River Nore, Ireland where the water chemistry is pH of 8.2, alkalinity of c. 290mg $CaCO_3$/l and conductivity of 600µs/cm.

Microhabitats & Habits

Margaritifera durrovensis prefers stable river-beds of sand, gravel and cobbles into which it buries or where it can become lodged between larger stones. It was once common in riffle areas living in the gravel patches downstream of rocks and boulders. It is now rare and restricted and is close to extinction.

Life history

The life history of *M. durrovensis* is the same as for *M. margaritifera*, but due to the higher levels of Calcium present compared to *M. margaritifera* rivers, growth is faster and mussels may then have a shorter lifespan.

Dispersal mechanisms and translocation

Dispersal mechanisms are likely to be the same as in *M. margaritifera*.

Food

Food and feeding mechanisms are likely to be the same as in *M. margaritifera*.

Range

Margaritifera durrovensis is endemic to the Barrow/Nore/Suir river system in south-east Ireland.

Distribution – Ireland

Margaritifera durrovensis was formerly known from the lime-rich waters of the Rivers Barrow and Nore main channels, but living specimens have not been found outside the Nore since 1993 (Moorkens, 1996). During 1993 one living specimen was found in the River Barrow. Mc Millan & Zeissler (1990) describe dead shells from the Suir main channel as *M. durrovensis*, but Moorkens (1996) found all dead shells in the Suir, including museum specimens, were *M. margaritifera*. Surveys of the River Suir from 1991-1993 led to the discovery of dead shells only (Moorkens,1996).

Distribution - Britain

Forms of *Margaritifera margaritifera* with thicker, less eroded shells are known from a few rivers with water of moderate to high calcium content. However, *Margaritifera durrovensis* is known only from the Nore-Suir system in Ireland.

Conservation Status

Margaritifera durrovensis is protected under the following:

EU: European Habitats & Species Directive 1992 (Annexes II and V)

Bern Convention 1979 (Annex 3)

Ireland: Wildlife Act 1976

Wildlife (Amendment) Act 2000

Red listed - CR [B1 a,b(I-iv)] Byrne *et al*. (2009)

Threats

There are a number of factors leading to the decline and loss of any pearl mussel populations internationally and most of those are evident for the Nore pearl mussel in Ireland (Araujo & Ramos, 2001; Moorkens, 1999).

The decline of the Nore pearl mussel population has occurred from continuous failure to produce new generations of mussels because of the loss of clean gravel beds, which have become infiltrated by fine sediment and/or over-grown by algae or macrophytes. These block the required levels of oxygen from reaching young mussels which spend their first five to ten years buried within the river bed substrate. The type of activities that lead to this decline are the same as for *M. margaritifera*.

Unio pictorum (Linnaeus, 1758)

Common name: Painter's mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Unio pictorum is generally around 75mm in length, 32mm in height and 22mm across the valves. It is a distinctly elongate-shaped mussel with straight, parallel dorsal and ventral margins, a tapered posterior end and a rounded anterior end. The umbos project slightly above the hinge line and there is a distinct shelf on the dorsal margin in front of the umbos. The umbonal rugae are erect, tubercular, and show in two radiating rows. The hinge ligament is long and narrow. The shell is an olive-yellow colour with conspicuous brown growth lines. Internally the hinge plate is long and straight with well-defined lateral and cardinal teeth. The anterior adductor scar lies near the shell margin.

The shell of *Unio pictorum* can be very variable in shape, size and colour. Specimens from lakes and canals for example are often larger, more tumid, darker brown in colour, and thicker shelled than those from large rivers which are generally smaller, more compressed and olive-green in colour.

Habitats

The painter's mussel is a lowland species that lives mostly in calcareous water in large, slow-flowing rivers, canals, lakes and reservoirs, and occasionally in ponds.

Microhabitats & Habits

Unio pictorum populations tend to be concentrated in the marginal zones of large rivers where a firm, muddy substrate is available, but it is found less commonly in sand, fine gravels and soft mud (Aldridge, 1999). The species often occurs in high densities within the stems of tall marginal plants. It frequently occurs with a rich fauna of other bivalve species.

Life history

Growth rates and maximum ages for unionids vary with habitat, food availability and water temperature but a life span of 20-30 years was suggested by Comfort (1957). Studies in a river in Cambridgeshire (England) (Aldridge, 1999) showed a maximum age for *Unio pictorum* of 22 years. Aldridge (1999) also showed growth rates for the Cambridgeshire populations; 3 year old individuals were c. 40mm in length, and 10 year olds approximately 80mm in length.

Unio pictorum releases mature, hooked glochidia on mucous threads each reaching 15cm in length and carrying c. 500 glochidia. Each adult mussel releases between 100,000 and 300,000 glochidia (Piechocki, 1999). Egg masses before release are yellow in colour (Aldridge & McIvor, 2003). The glochidia attach to the fins and gills of a variety of fish species.

Dispersal mechanisms and translocation

Mussels are dispersed as glochidial larvae on their host fish both within their native river catchments but also through artificial stocking for angling.

Food

All unionids are filter feeders using the ctenidia "gills" to sort potential food particles brought into the mantle cavity. Food includes diatoms, algal cells, bacteria and organic material from the water column. There do not appear to be any studies that show particular preferences for *Unio pictorum*.

Range

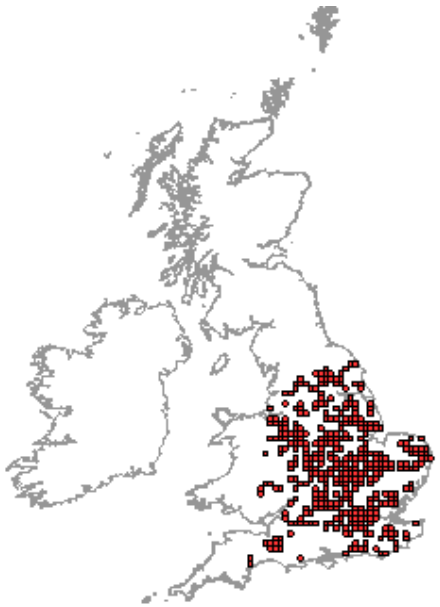
Lowland Europe, mostly the northern part and in southern Scandinavia.

Distribution – Ireland

Unknown in Ireland

Distribution - Britain

The painter's mussel occurs throughout most of lowland England and into east Wales. It is rare in southwest and northern England, and from much of Wales, and is absent from Scotland.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

River (or canal) modification, river and canal management (dredging and weed cutting), destruction or over-dredging of large ponds and lakes, water quality decline, tourism & development pressure (e.g. marinas), competition or direct mortalities due to exotic species.

A population of *Unio pictorum* in Barden Lake, Kent, is being significantly impacted by the recent arrival of zebra mussels and repeated surveys in the River Thames, River Great Ouse and Barden Lake showed that the proportion of unionid mussels infested by zebra mussels had increased significantly in all sites studied during the from 1999-2004 (Aldridge *et al*., 2004)

Studies in the UK (see Killeen *et al*. 2004) have shown that *U. pictorum* is relatively tolerant of polluted waters and can be the sole large mussel species present in waters immediately downstream of sewage outfalls. However, Mouthon (1996) included the species in his list of species with lower tolerance to biodegradable pollution.

Unio tumidus Philipsson, 1788

Common name: Swollen river mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

This species has solid, tumid shell, generally oval in outline shape with a very rounded ventral margin (compared to *Unio pictorum*). Typical dimensions are length 60-65mm (130mm max.), height 30-35mm, and depth 25mm. The umbos are prominently raised above the hinge line, and have irregular rugae with prominent, wavy ridges. The valves are joined by a broad, short ligament. The colour of the shell is usually chestnut to dark brown or green with distinct brown growth lines, often marked with yellow or green rays. Internally, the hinge plate of the shell is short and curved with prominent lateral and cardinal teeth.

Habitats

The swollen river mussel lives principally in large, calcareous lowland rivers and canals, occurring less frequently in lakes and reservoirs.

Microhabitats & Habits

Populations of *Unio tumidus* are concentrated in the marginal zones of large rivers where a firm, muddy substrate is available, although *U. tumidus* can be more abundant in the central channel than other unionid species (Aldridge, 1999; Killeen *et al.*, 2004). The mussel is found less commonly in sand, fine gravels and soft mud. *Unio tumidus* lives in a narrower habitat range than *U. pictorum* being more resticted to larger bodies of good quality, oxygenated water. Although *U. tumidus* may be locally abundant in some large rivers, it generally is found in lower abundance than *U. pictorum* and *Anodonta anatina.*

Life history

Growth rates and maximum ages for unionids vary with habitat, food availability and water temperature but a life span of 20-30 years was suggested by Comfort (1957). Studies in a river in Cambridgeshire (England) (Aldridge, 1999) showed a maximum age for *Unio tumidus* of 21 years. Aldridge (1999) also showed growth rates for the Cambridgeshire populations; 3 year old individuals were c. 40mm in length, and 10 year olds approximately 80mm in length.

Unio tumidus releases mature hooked glochidia on mucous threads each reaching 15cm in length and carrying c. 500 glochidia. Each adult mussel releases between 100,000 and 300,000 glochidia (Piechocki, 1999). Egg masses before release are white in colour (Aldridge & McIvor, 2003). The glochidia attach to the fins and gills of a variety of fish species.

Dispersal mechanisms and translocation

Mussels are dispersed as glochidial larvae on their host fish both within their native river catchments but also through artificial stocking for angling.

Food

All unionids are filter feeders using the ctenidia "gills" to sort potential food particles brought into the mantle cavity. Food includes diatoms, algal cells, bacteria and organic material from the water column. There do not appear to be any studies that show particular food preferences for *Unio tumidus*.

Range

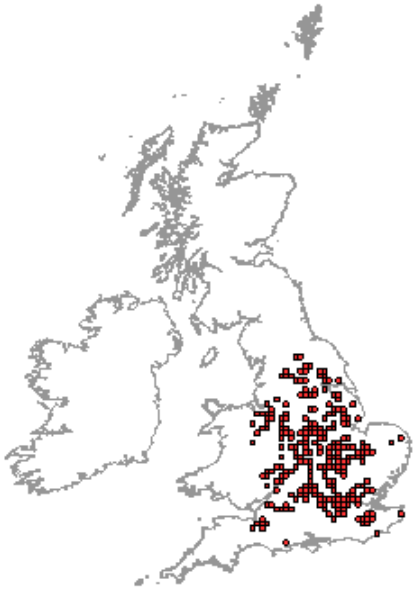
Lowland Europe, mostly the northern part and in southern Scandinavia.

Distribution – Ireland

Unknown in Ireland

Distribution - Britain

In Britain, *Unio tumidus* is found in England and east Wales, principally in the 'canal basin' of lowland, central England. It is absent from Scotland.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

River (or canal) modification, river and canal management (dredging and weed cutting), destruction or over-dredging of large ponds and lakes, water quality decline, tourism & development pressure (e.g. marinas), competition or direct mortalities due to exotic species. Conditions within the sediments seem to be decisive for the survival of juvenile mussels and thus for the age structure of the populations. Repeated surveys in the River Thames, River Great Ouse and Barden Lake showed that the proportion of unionid mussels infested by zebra mussels had increased significantly in all sites studied during the from 1999-2004 (Aldridge *et al*., 2004).

Mouthon (1996) showed *Unio tumidus* to have low tolerance of biodegradable pollution. Weber (2005) showed negative influences from sporadically occurring low oxygen and high ion concentrations in the water.

Anodonta cygnea (Linnaeus, 1758)

Common name: Swan mussel

Synonyms: *Mytilus zellensis* Gmelin, 1791

Anodonta cellensis C. Pfeiffer, 1821

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Anodonta cygnea is the largest freshwater mussel found in Britain and Ireland usually around 140mm (sometimes > 200mm) in length, 68mm in width, and 40mm depth. The shell has an oblong outline shape and the dorsal and ventral margins are more or less parallel. The umbo is broad but not at all prominent and is furnished with indistinct wavy rugae. The shell is thin and of even thickness across the entire shell. The shell colour is usually olive-green or yellowish with distinctive brown growth lines. Internally, the shell hinge is weak and has no teeth.

The swan mussel is very variable in size, outline shape and colour and there are numerous varietal names.

Habitats

The swan mussel prefers standing or very slow-flowing water. It is found mostly in lakes and large ponds, slow-flowing lowland rivers, canals and large drains. It is found in faster-flowing rivers but is confined to sheltered sections. The species has been introduced either accidentally or deliberately into a number of artificial habitats such as reservoirs, flooded gravel pits and ornamental lakes.

Microhabitats & Habits

Anodonta cygnea favours muddy, silty and organic-rich substrates, often amongst tall emergent plants such as common reed, and club rushes. A study by Müller & Patzner (1996) in a lake in Austria showed no significant differences in age structure of *Anodonta cygnea* at different depths. Three and ten years old clams were present at all depths, but in different percentages.

Life history

Growth rates and maximum ages for unionids vary with habitat, food availability and water temperature but a life span of 20-30 years was suggested by Comfort (1957). Studies in a river in Cambridgeshire (England) (Aldridge, 1999) showed a maximum age for *Anodonta anatina* of 37 years and a maximum length of 150mm. Aldridge (1999) also showed growth rates for the Cambridgeshire populations; 3 year old individuals were c. 40mm in length, and 10 year olds approximately 80mm in length. However, Bauer (2001) states that *Anodonta* species grow rapidly and are short-lived, a life span of 15 years is given for *A. cygnea*.

The swan mussel is a long-term brooder with glochidia retained from October through to May. The glochidia are hooked, and large (c. 0.34mm), up to 140,000 are released in small numbers and then attach to the scales, fins and gills of the host (Bauer, 2001). The swan mussel uses a wide range of host fish species.

Dispersal mechanisms and translocation

The species may be dispersed as glochidial larvae on their host fish both within their native river catchments but especially through artificial stocking for angling. In recent years the species has sometimes been sold in aquarists centres as biofilters for garden ponds, and which has subsequently been released into other natural or artificial water bodies.

Food

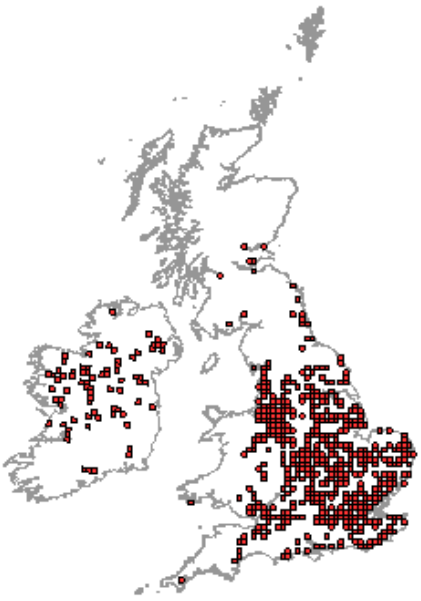
All unionids are filter feeders using the ctenidia "gills" to sort potential food particles brought into the mantle cavity. Food includes diatoms, algal cells, bacteria and organic material from the water column.

Range

Anodonta cygnea is widespread throughout much of lowland Europe becoming much scarcer in southern Europe and in Scandinavia.

Distribution – Ireland

The swan mussel has had a relatively wide distribution in Ireland, although older records may have at times been incorrectly attributed records of *Anodonta anatina* (Kerney, 1999). Over the last ten years this species has suffered from the spread of the zebra mussel *Dreissena polymorpha*, whose spat settles on hard surfaces, including living *Anodonta.* The decline of *Anodonta cygnea* and *A. anatina* in the Shannon-Boyle navigation (Minchen *et al*., 2002), and the decline in these species within the two canal systems in recent years (Moorkens & Killeen, 2005) suggests that the zebra mussel has been the cause of a serious recent decline in both species.



Map from NBN based on Kerney (1999)

Distribution - Britain

The swan mussel is widespread and generally common in lowland England, but is very sparsely distributed in Wales and Scotland. The species' range has been extended by its introductions to ornamental lakes. There is some evidence of decline in river habitats.

Conservation Status

Britain: None

Ireland: None; Listed as VU A3e (Moorkens, 2006). Red listed – VU [A4 c,e] Byrne *et al*. (2009)

Threats

River (or canal) modification, river and canal management (dredging and weed cutting), destruction or over-dredging of ponds and lakes, water quality decline, tourism & development pressure (e.g. angling activities), competition or direct mortalities due to exotic species, collection and resale by aquatic garden centres. A population of *Anodonta cygnea* in Barden Lake, Kent, is being significantly impacted by the recent arrival of zebra mussels and repeated surveys in the River Thames, River Great Ouse and Barden Lake showed that the proportion of unionid mussels infested by zebra mussels had increased significantly in all sites studied during the from 1999-2004 (Aldridge *et al*., 2004)

Anodonta cygnea has been shown by Mouthon (1996) to be one of the species of freshwater bivalve most sensitive to biodegradable pollution.

Anodonta anatina (Linnaeus, 1758)

Common name: Duck mussel

Synonyms: *Anodonta piscinalis* Nilsson, 1823

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

The duck mussel is smaller than the swan mussel and although they can be difficult to separate, they differ particularly in outline shape and shell thickness. *Anodonta anatina* is generally wedge shaped in outline: the dorsal margin is strongly divergent from the mid axis and the ventral margin is rounded. The species is usually 75mm (120mm max.) in length, 46mm in height, and 26mm in depth. The unbonal area does not rise above the dorsal margin but it is distinctly swollen. The umbo has rugae in the form of indistinct wavy ridges. The colour of the shell is greenish, brown or yellow. The thickness of the shell is not even; the ventral part of the front (anterior) end is thickened whereas the rest of the shell is relatively thinner.

The duck mussel is very variable in size, outline shape and colour and there are numerous varietal names.

Habitats

The duck mussel lives in a wide range of mostly calcareous, lowland freshwater habitats from relatively small streams to large lowland rivers. It has a preference for flowing water but it is also found in lakes and canals, but much less often in ponds. It has been introduced to many new sites such as reservoirs and filled gravel pits as a result of stocked fish carrying glochidia larvae.

Microhabitats & Habits

Like all large lowland river mussels, populations of *Anodonta anatina* are concentrated at margins of rivers and canals where sediment is muddy and compact and it is only occasionally found in sand substrates, and even more rarely in silt (Aldridge, 1999). The species can often make up >70% of the large mussel population at a particular site and reach densities in excess of 100/m^2 (Aldridge, 1999; Killeen *et al.*, 2004).

Life history

Growth rates and maximum ages for unionids vary with habitat, food availability and water temperature but a life span of 20-30 years was suggested by Comfort (1957). Studies in a river in Cambridgeshire (England) (Aldridge, 1999) showed a maximum age for *Anodonta anatina* of 28 years and a maximum length of 116mm. Aldridge (1999) also showed growth rates for the Cambridgeshire populations; 3 year old individuals were c. 45mm in length, and 10 year olds approximately 75mm in length. However, Bauer (2001) states that *Anodonta* species grow rapidly and are short-lived, a life span of 20 years is given for *A. anatina*.

The duck mussel is a long-term brooder with glochidia retained from October through to May. The glochidia are hooked, and large (> 0.3mm), up to 140,000 are released in small numbers and then attach to the scales, fins and gills of the host (Bauer, 2001). The duck mussel uses a wide range of host fish species.

Dispersal mechanisms and translocation

The species may be dispersed as glochidial larvae on their host fish both within their native river catchments but especially into other rivers, lakes and ponds through artificial stocking for angling.

Food

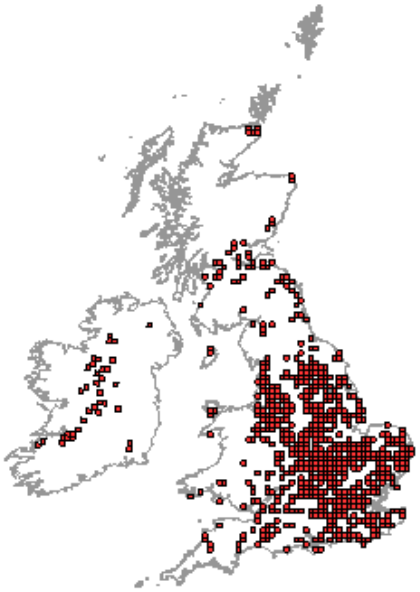
All unionids are filter feeders using the ctenidia "gills" to sort potential food particles brought into the mantle cavity. Food includes diatoms, algal cells, bacteria and organic material from the water column.

Range

This species is widespread throughout much of lowland Europe and southern Scandinavia, and less common in southern Europe.

Distribution – Ireland

The duck mussel has had a relatively wide distribution in Ireland, although older records may have at times been incorrectly attributed records of *Anodonta anatina* (Kerney, 1999). Over the last ten years this species has suffered from the spread of the zebra mussel *Dreissena polymorpha*, whose spat settles on hard surfaces, including living *Anodonta.* The decline of *Anodonta cygnea* and *A. anatina* in the Shannon-Boyle navigation (Minchen *et al*., 2002), and the decline in these species within the two canal systems in recent years (Moorkens & Killeen, 2005) suggests that the zebra mussel has been the cause of a serious recent decline in both species.



Map from NBN based on Kerney (1999)

Distribution - Britain

Anodonta anatina is common and widespread throughout lowland England, but scarcer in southwest and northern England, Wales and Scotland.

Conservation Status

Britain: None

Ireland: None; VU A3e (Moorkens 2006). Red listed – VU [A4 c,e] Byrne *et al*. (2009)

Threats

River (or canal) modification, river and canal management (dredging and weed cutting), destruction or over-dredging of ponds and lakes, water quality decline, tourism & development pressure (e.g. angling activities, marinas), competition or direct mortalities due to exotic species. Repeated surveys in the River Thames, River Great Ouse and Barden Lake showed that the proportion of unionid mussels infested by zebra mussels had increased significantly in all sites studied during the from 1999-2004 (Aldridge *et al*., 2004).

Anodonta anatina has been shown by Mouthon (1996) to be one of the species of freshwater bivalve most sensitive to biodegradable pollution.

Pseudanodonta complanata (Rossmässler, 1835)

Common name Depressed river mussel

Synonyms: *Anodonta elongata* Holandre, 1836

Pseudanodonta rothomagensis Locard, 1890

Pseudanodonta minima Kennard, Salisbury & Woodward, 1925

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Pseudanodonta complanata has a wedge-shaped shell rather similar to that of *Anodonta anatina* but is much more compressed (less tumid) across the 2 valves. Typical dimensions are: length 70-75mm, height 35-40mm and depth 20-25mm. The shell is thin but of even thickness throughout the valve. The umbos are located close to anterior end and have rugae that form a distinct pair of alternating rows of short ridges. A particular characteristic of the species is the gape between the shell valves at the anterior ventral margin (see whn the shell is viewed upside down). The shell surface is generally glossy and frequently a bright mossy green in colour, but also ranging to olive green or brownish.

Habitats

The depressed river mussel lives in calcareous water, in lowland rivers, large drains and canals, and is never in lakes or ponds. Populations are concentrated in the lower stretches of river systems and do not extend into minor tributaries or as far upstream as other mussel species.

Microhabitats & Habits

Populations of the depressed river mussel tend to be found near the margins of rivers and canals where the sediment is muddy and relatively compacted, it is occasionally found in sand substrates, but never in silt (Aldridge, 1999; Killeen *et al.,* 2004). It lives usually lives in association with other large mussel species, but it is normally much less abundant (e.g. making up 2% of the overall mussel population in the River Thames) (Killeen *et al*., 2004).

Life history

Growth rates and maximum ages for unionids vary with habitat, food availability and water temperature but a life span of 20-30 years was suggested by Comfort (1957). Studies in a river in Cambridgeshire (England) (Aldridge, 1999) showed a maximum age for *Pseudanodonta complanata* of 15 years and a maximum length of 85mm. Aldridge (1999) also showed growth rates for the Cambridgeshire populations; 3 year old individuals were c. 35mm in length, and 10 year olds approximately 70mm in length.

Studies on the depressed river mussel at a site in eastern England (McIvor & Aldridge, 2007) showed that the species is sexually mature at c. 4 years old and is gravid with mature glochidia from September through to April. Each adult mussel releases between 5,000 and 50,000 glochidia. The glochidia attach to the fins and gills of a variety of fish species including ruffe, perch, zander and sticklebacks.

Dispersal mechanisms and translocation

Mussels are dispersed as glochidial larvae on their host fish both within their native river catchments but also through artificial stocking for angling.

Food

All unionids are filter feeders using the ctenidia "gills" to sort potential food particles brought into the mantle cavity. Food includes diatoms, algal cells, bacteria and organic material from the water column. There do not appear to be any studies that show particular food preferences for *Pseudanodonta complanata*.

Range

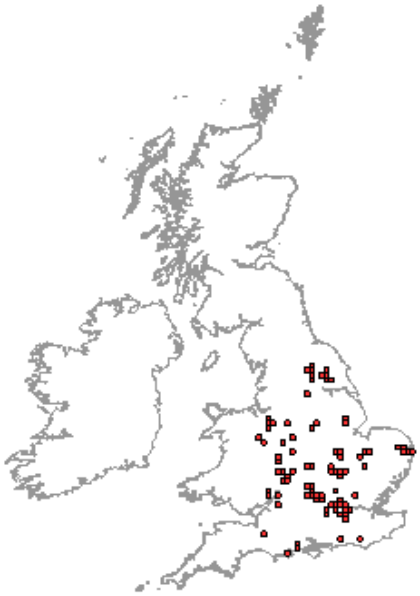
The species ranges across much of Western Europe and into Finland, Sweden, and northern Russia.

Distribution – Ireland

Unknown in Ireland

Distribution - Britain

The depressed river mussel is known from England and Wales, but not Scotland. It ranges from North Yorkshire to Sussex and Norfolk to Monmouthshire. Recent studies show it is more widespread than previously thought, although it has disappeared from approximately 30% of its historical sites. While generally uncommon within its range, large populations are present in the river systems of the Norfolk Broads, the Somerset Levels, the River Arun, West Sussex, and the Old West River, Cambridgeshire (see Killeen *et al*., 2004).



Map from NBN based on Kerney (1999)

Conservation Status

Britain: UK Biodiversity Action Plan priority species.

Ireland: None

Threats

River (or canal) modification, river and canal management (dredging and weed cutting), destruction or over-dredging of large ponds and lakes, water quality decline, tourism & development pressure (e.g. marinas), competition or direct mortalities due to exotic species. Aldridge (2000) and McIvor & Aldridge (2007) particularly highlighted the effects of channel management. Conditions within the sediments seem to be decisive for the survival of juvenile mussels and thus for the age structure of the populations. Repeated surveys in the River Thames, River Great Ouse and Barden Lake showed that the proportion of unionid mussels infested by zebra mussels had increased significantly in all sites studied during the from 1999-2004 (Aldridge *et al*., 2004).

Mouthon (1996) showed *Pseudanodonta complanata* (along with *Unio tumidus*) to be the bivalve species least tolerant of biodegradable pollution.

Corbicula fluminea (Müller, 1774)

Common name: Asiatic clam

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004). There is extensive literature on the biology and invasion of this species.

Brief description of species

Corbicula fluminea is a highly distinctive species. The shell is tumid and solid with a rounded triangular outline shape, prominent, rounded umbos, and a conspicuous raised external ligament. The typical dimensions are length 30mm, height 25mm, and depth 18mm. The surface of the shell is polished, olive to yellow-green in colour, and with a sculpture of prominent, raised, regular concentric ribs. The internal hinge of the shell is very thick with 3 cardinal teeth in each valve and with serrated lateral teeth.

Habitats

In Britain, the Asiatic clam has been found in rivers and associated channels.

Microhabitats & Habits

The species lives in a range of substrates, preferring sand and gravel to mud. This species' ability to produce large quantities of pseudofaeces increases sedimentation, which changes the substrate of their habitat. Studies in eastern England by Aldridge & Müller (2001) showed the species lives in habitats ranging from shallow (<1m) essentially lentic environments to relatively wide (c. 30m), deep (>3m), flowing channels. In the River Chet, Norfolk it was found at highest densities within the central channel. At some locations, densities in excess of 2500 individuals $m/^2$ were recorded. However, in North America densities of >100,000/m^2 have been recorded.

Life history

The Asiatic clam broods its young in brood pouches on the gills, and developed offspring are released directly to the environment. The embryo size is small (<0.4mm) and reproductive output is very high. There appears to be a great deal of variation in the life history of *Corbicula* depending upon climate and habitat, but growth is very rapid and in general maturity of the species is reached one year and the life span ranges from 2-4 years. Some populations have a single reproductive period in the summer whereas others show bimodal reproduction (Hornbach, 1992).

Dispersal mechanisms and translocation

The Asiatic clam has exceptional powers of dispersal and a wide range of mechanisms are involved. These include juveniles carried in ballast water and bait buckets, in sediment attached to anchor chains of boasts, in river gravel transported in barges, and ingestion and excretion by fish and waterfowl.

Food

There is extensive literature on experiments and observations on food preferences of *Corbicula*. However, their diet has been shown to include a wide range of detritus, bacteria and phytoplankton, algae and diatoms. Large densities of *Corbicula* have the ability to significantly affect the levels of phytoplankton in a water body (see references in Aldridge & Müller, 2001) and have a detrimental effect on the rest of the biota.

Range

This species is a native of south-east Asia but has become widely dispersed into Europe and North America.

Distribution – Ireland

Unknown in Ireland

Distribution - Britain

Unknown in Britain before October 1998, but spreading rapidly. It is now known from all of the major river catchments of the Norfolk Broads: Rivers Bure, Ant, Thurne, Yare, Chet and Waveney. It has been recently found living and breeding in the River Thames in west London.

Conservation Status

Britain: None

Ireland: None

Threats

The Asiatic clam is itself a pest species that as a result of its great fecundity, rapid growth rate and exceptional powers of dispersal has become widely spread outside its native Southeast Asia. It can alter the substrate of a river by siltation derived from deposition of pseudofaeces, and thus make the substrate unsuitable for other species of bivalves. It can out-compete other bivalve species and can become a major bio-fouler when large quantities of the animals accumulate in intake pipes to power stations and water treatment works.

Sphaerium rivicola (Lamarck, 1818)

Common name: Nut (or river) orb mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

This is the largest species of *Sphaerium* occurring in Britain. The shell is rounded oval in outline shape and typically reaches 20-25mm in length, 17mm in height, and 13mm in depth. The umbos are centrally located, relatively broad and flattened. The surface of the shell has a sculpture of well-developed, fine but prominently raised concentric striations and stronger growth lines. The umbonal area is rather smooth and the striations increase in prominence with growth. The shell is olive-yellow, horn, grey or brown coloured, sometimes with alternating bands of different colours, and has a glossy or silky texture. The ligament is prominent and is visible externally. Internally, the hinge plate is moderately robust, curved, and with well developed cardinal teeth and small narrow lateral teeth.

Habitats

Sphaerium rivicola lives in a much narrower range of habitats than most sphaeriids. It is principally found in clean, calcareous water in canals and large, slow-flowing rivers, and very occasionally in large canalised drains connected to large rivers. In mainland Europe it is very occasionally found in lakes.

Microhabitats & Habits

The nut orb mussel lives in large, well oxygenated water bodies in association with a rich diversity of other mollusc species such as the large unionoid mussels, *Pisidium supinum* and the gastropod *Viviparus viviparus*. It appears to require deeper water than other *Sphaerium* or *Pisidium* species and is rarely found in marginal habitats less than 0.5m in depth. The species is found in a wide range of soft, fine substrates from mud to sand and grit, usually with a silty element.

Life history

As with all sphaeriids, *Sphaerium and Musculium* species brood their young in brood pouches on the gills, and developed offspring are released directly to the environment. The species within these genera commonly carry multiple brood sacs throughout the year, in various stages of development, and the young within each sac may be of different sizes. Newborn young are released a few at a time (Heard, 1977; Mackie, 1979). The animals live from a few months to four years (usually 18-24 months). In general, the maximum embryo size ranges from 1.8-7mm for *Sphaerium* and 1.2-2.2mm for *Musculium* (Heard, 1977).

There do not appear to be any life history studies specific to *Sphaerium rivicola*.

Dispersal mechanisms and translocation

Sphaerium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Sphaerium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

All species within the genus *Sphaerium* and *Musculium* are filter feeders. Water containing food is drawn in through the inhalant siphon and which is then drawn in by cilia on the gills into the mantle cavity. Filtered water and pseudofaeces are then ejected through the exhalent siphon. The siphons in *Sphaerium* and *Musculium* are fused into a tube which often the same length as the shell. Food includes detritus, green and blue-green algae, rotifers, protozoans, and bacteria. Whilst some studies have shown limited evidence for food preference, most species appear to take in a wide variety of food types (see Dillon, 2000).

Range

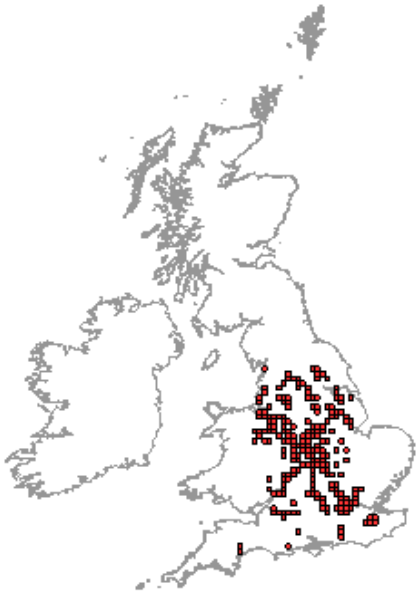
Mostly in the lowland regions of central and eastern Europe.

Distribution – Ireland

Unknown in Ireland

Distribution - Britain

Sphaerium rivicola occurs principally in the 'canal basin' of lowland, central England and the Welsh borders. It is rare in southern England and is unknown in Scotland.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *Sphaerium rivicola* was one of the species of freshwater bivalve most sensitive to biodegradable pollution.

Sphaerium solidum (Normand, 1844)

Common name: ***Witham orb mussel***

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Sphaerium solidum, as its name suggests has a solid shell for its size. It is rounded triangular in outline shape with prominent umbos, which project above the dorsal margin. Typical dimensions of the shell are: length 11mm, height 8mm, and depth 6mm. The surface of the shell is glossy, usually pale yellow in colour and with a sculpture of strong, regular, prominently raised concentric ribs that are coarser on the upper part of the shell and finer towards the margins. The ligament that connects the 2 valves is partially visible but is not prominent. Internally, the hinge plate is robust, broad and strongly curved, with small curved cardinal teeth and strongly developed lateral teeth.

Habitats

In Britain, the species lives in canalised rivers and large, deep drains. In mainland Europe it is also recorded in canals and backwaters of large rivers, and is very occasionally found in lakes (Zettler & Glöer, 2006).

Microhabitats & Habits

Due to the species rarity in Britain, details on the species ecology are sparse. However, the habitats in which it was found in Lincolnshire are generally poor in aquatic vegetation but rich in their associated mollusc fauna, and are generally found in deep water (as for *Sphaerium rivicola*). In the habitats in the recently discovered site on the Great Ouse in Cambridgeshire (Bass *et al*., 2003), *Sphaerium solidum* was found on silt and clay substrate, principally in depths of 1-2m and with little aquatic vegetation. Willing (2005) found that it required moderately clean (although turbidity seems not to cause problems) water and a variety of riverbed sediments ranging from clay, silt,

sandy, silty, and sand. Sites where the channel floor is blanketed with a filamentous algal mat seem to be particularly adversely affected. No population in England has been located where 'large' numbers of individuals are present. Recent work on the Great Ouse indicates that, although the species may be present over at least 20km of river, the population is highly fragmented and occurs in very small population 'pockets' of perhaps less than 100m lengths (Willing, 2005).

Life history

As with all sphaeriids, *Sphaerium* and *Musculium* species brood their young in brood pouches on the gills, and developed offspring are released directly to the environment. The species within these genera commonly carry multiple brood sacs throughout the year, in various stages of development, and the young within each sac may be of different sizes. Newborn young are released a few at a time (Heard, 1977; Mackie, 1979). The animals live from a few months to four years (usually 18-24 months). In general, the maximum embryo size ranges from 1.8-7mm for *Sphaerium* and 1.2-2.2mm for *Musculium* (Heard, 1977).

There do not appear to be any life history studies specific to *Sphaerium solidum*.

Dispersal mechanisms and translocation

Sphaerium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Sphaerium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

All species within the genus *Sphaerium* and *Musculium* are filter feeders. Water containing food is drawn in through the inhalant siphon and which is then drawn in by cilia on the gills into the mantle cavity. Filtered water and pseudofaeces are then ejected through the exhalent siphon. The siphons in *Sphaerium* and *Musculium* are fused into a tube which often the same length as the shell. Food includes detritus, green and blue-green algae, rotifers, protozoans, and bacteria. Whilst some studies have shown limited evidence for food preference, most species appear to take in a wide variety of food types (see Dillon, 2000).

Range

Locally distributed in the lowland regions of central and eastern Europe.

Distribution – Ireland

Unknown in Ireland.

Distribution - Britain

Sphaerium solidum was first discovered living in Britain in 1968 and was recorded only from the River Witham, Lincolnshire and adjoining deep drains. Sampling in 2000-2002 of the known sites yielded no living individuals and only occasional shells suggesting that the population was in decline, possibly as a result of increased eutrophication resulting from fertilizer run-off (Killeen *et al*., 2004). A population was subsequently discovered in the River Great Ouse in Cambridgeshire (Bass *et al*., 2003).

Map from NBN based on Kerney (1999)

Conservation Status

Britain: British Red Data Book RDB1 Endangered; UK Biodiversity Action Plan priority species.

Ireland: None

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *Sphaerium solidum* was one of the species of freshwater bivalve most sensitive to biodegradable pollution. The recent decline and possible extinction from some of its former known sites in England resulted in its addition to the UK Biodiversity Action Plan list of Priority Species in 2006.

Sphaerium corneum (Linnaeus, 1758)

Common name: Horny orb mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Rounded oval, more or less equilateral, tumid, sometimes nearly spherical shell, typical dimensions are: length 11mm, height 8.5mm, and depth 7mm, but specimens up to 16mm are known. The umbos are broad and rounded, relatively prominent, and centrally located. The shell surface is dull to silky, yellow, horn, grey or brown in colour, sometimes with alternating bands of different colours, and with a sculpture of very fine, irregular concentric striations, sometimes with stronger growth lines. The shell surface also has a few, irregularly spaced pores. Internally, *S. corneum* has a very narrow hinge, particularly below the umbo, and has weakly to moderately curved cardinal teeth.

Sphaerium corneum is highly variable in shell outline shape and tumidity and a number of varietal names have been assigned to these forms. The most distinctive, *S. corneum* f. *scaldianum* (Normand, 1854) is more trapezoidal in outline, with marked angles particularly between the dorsal and posterior margins.

Habitats

Sphaerium corneum lives in a wide range of hard and soft, flowing and standing water habitats: rivers, canals, streams, lakes, ponds, marsh drains etc. It is found principally in the lowlands but has occasionally been recorded from highland lochs.

Microhabitats & Habits

Sphaerium corneum is found on a wide range of substrate types from mud through to coarse sand or gravel. It is also be found crawling amongst aquatic vegetation away from the substrate.

Life history

As with all sphaeriids, *Sphaerium* and *Musculium* species brood their young in brood pouches on the gills, and developed offspring are released directly to the environment. The species within these genera commonly carry multiple brood sacs throughout the year, in various stages of development, and the young within each sac may be of different sizes. Newborn young are released a few at a time (Heard, 1977; Mackie, 1979). The animals live from a few months to four years (usually 18-24 months). In general, the maximum embryo size ranges from 1.8-7mm for *Sphaerium* and 1.2-2.2mm for *Musculium* (Heard, 1977).

Dispersal mechanisms and translocation

Sphaerium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Sphaerium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

All species within the genus *Sphaerium* and *Musculium* are filter feeders. Water containing food is drawn in through the inhalant siphon and which is then drawn in by cilia on the gills into the mantle cavity. Filtered water and pseudofaeces are then ejected through the exhalent siphon. The siphons in *Sphaerium* and *Musculium* are fused into a tube which often the same length as the shell. Food includes detritus, green and blue-green algae, rotifers, protozoans, and bacteria. Whilst some studies have shown limited evidence for food preference, most species appear to take in a wide variety of food types (see Dillon, 2000).

Range

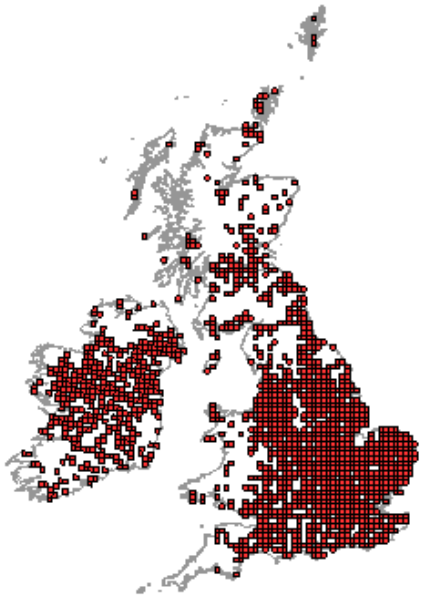
Sphaerium corneum is a Palaearctic species.

Distribution – Ireland

Widespread throughout Ireland, mostly in lowland locations and in a wide range of habitats.

Distribution - Britain

Widespread throughout Britain, mostly in lowland locations. Much scarcer in the less calcareous geology of the southwest, Wales and Scotland.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *S. corneum* was moderately tolerant of biodegradable pollution.

Sphaerium nucleus (Studer, 1820)

Common name: Swamp orb mussel

Identification literature

In the guide to the *Freshwater Bivalves of Britain & Ireland* (Killeen, Aldridge & Oliver, 2004) first recognised *Sphaerium nucleus* (Studer, 1820) as part of the British fauna. It was subsequently recorded from Ireland (Moorkens, 2005).

Recent studies (Killeen, 2008) have raised the question of whether *Sphaerium ovale* (Férussac, 1807) occurs in Britain or Ireland. Whilst *Sphaerium nucleus* is now widely recognized as a distinct taxon and has been recorded from several European countries, the position of *S. ovale* is less clear. It is listed in the CLECOM checklist (Falkner *et al*., 2001a) as occurring in the UK but not Ireland. It is also listed as occurring in other European countries. It is recognized in Germany and has been recorded frequently in the north of the country (Zettler & Glöer, 2006), but the sparsity of any mention in the literature for other countries suggests that it is not widely recognized or accepted.

The characters for distinguishing *S. corneum*, *S. nucleus* and *S. ovale* are shell shape and tumidity, pore density, thickness of the hinge plate, and size/shape of the cardinal teeth (see Korniushin & Hackenberg, 2000).

Brief description of species

Sphaerium nucleus has an obliquely oval, very tumid shell with irregular profile and greatest tumidity near or below the centre of the valves. In size, it is generally smaller than *Sphaerium corneum* with a typical size of length 7-8mm, height 6-7mm, and depth 5.5-6mm. The umbos are rounded, broad and prominent (although narrower and less prominent than for *S. corneum*). The surface of the shell is dull to silky, it is coloured yellow to grey, occasionally brown, sometimes with alternating bands of different colours. A characteristic feature of *S. nucleus* is the dense, regularly-spaced pores in the shell. Internally, *S. nucleus* has a broader hinge plate (than *S. corneum*) and has strongly curved cardinal teeth.

Habitats

All of the material identified as *S. nucleus* from Ireland and England is from lentic habitats, densely and richly vegetated swampy conditions in drainage ditches, and occasionally in lake margins,

including turloughs. In the Czech Republic, Korinkova *et al* (2007) record it from small, often temporary pools, littoral zones of ponds, shallow swamps and drains with stagnant water and dense vegetation.

According to Zettler & Glöer (2006), in north Germany *S. nucleus* "lives predominantly in small, temporary waters, like pools in the woods or reeds; it can also be found in moors, ditches and ponds; it has not been recorded from the "shores" of large lakes or rivers, but in swampy/boggy cut-off meanders.

Microhabitats & Habits

Sphaerium nucleus is found in muddy or silty substrate usually with a high organic content. substrate types from mud through to coarse sand or gravel. According to Zettler & Glöer (2006), in north Germany *S. nucleus* "can be found amongst aquatic vegetation or dead leaves; the preferred substrate is mud over anaerobic substrate. *S. nucleus* is often associated with *Pisidium globulare*, also with *P. personatum* and *P. milium"*. In Britain and Ireland it appears to prefer better quality habitats and lives mostly in densely and richly vegetated swampy places, often with a diverse suite of molluscs and other invertebrates, including rare beetles and rare mollusc species such as *Anisus vorticulus* or *Pisidium pseudosphaerium*. These are often found in old grazing marsh complexes.

Life history

There do not appear appear to be any studies specific to *Sphaerium nucleus*. The life history is likely to be similar to that for *S. corneum*.

Dispersal mechanisms and translocation

Sphaerium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Sphaerium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

All species within the genus *Sphaerium* and *Musculium* are filter feeders. Water containing food is drawn in through the inhalant siphon and which is then drawn in by cilia on the gills into the

mantle cavity. Filtered water and pseudofaeces are then ejected through the exhalent siphon. The siphons in *Sphaerium* and *Musculium* are fused into a tube which often the same length as the shell. Food includes detritus, green and blue-green algae, rotifers, protozoans, and bacteria. Whilst some studies have shown limited evidence for food preference, most species appear to take in a wide variety of food types (see Dillon, 2000).

Range

Probably European

Distribution – Ireland

The swamp orb mussel was first recognized in Ireland in 2004 in the Royal Canal in Co Longford (Moorkens & Killeen, 2005). It has since been recorded from sites in Clare, Westmeath, Roscommon, Monaghan and Wicklow.

Distribution - Britain

Poorly known due to confusion with *Sphaerium corneum*, although it may prove to be widespread. The species has been so far been recognised from grazing marsh complexes in south-east England at Pevensey Levels, Sussex, the lower Waveney valley and the Norfolk Broads in East Anglia, and the Somerset Levels.

Conservation Status

Britain: None

Ireland: None. Red listed – VU [D2] Byrne *et al*. (2009)

Threats

The richly vegetated swampy habitat that *Sphaerium nucleus* is found in is the sort of habitat that is particularly vulnerable to dredging and clearing. The species is also threatened by land drainage and pollution, eutrophication, water abstraction, changes in agricultural practice, destruction and infilling of pools, and so on.

Musculium lacustre (Müller, 1774)

Common name: Lake (or capped) orb mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Musculium lacustre has a very thin, fragile shell, typically 11mm in length, 8mm in height, and 6mm depth. The shell outline is distinctly quadrangular with prominently raised, narrow umbos that are capped by the juvenile shell. The shell is generally grey in colour, with a slightly glossy texture and a sculpture of very faint concentric striations, making the surface appear almost smooth.

Habitats

Musculium lacustre occurs in a wide range of freshwater habitats in hard or soft water, but it is most frequently occurring in swamps, ponds and marsh drains, or in the well-vegetated margins of rivers and canals. The species is tolerant of moderately polluted water or stagnant, poorly oxygenated conditions, or places subject to periods of drought. In poor environments *M. lacustre* may be the only bivalve present.

Microhabitats & Habits

Musculium lacustre occurs on muddy substrates often over anoxic mud, and frequently where there is a dense vegetation cover. It generally occurs crawling amongst weeds and at the substrate/weed interface. It is mostly shallow water, lowland species often occurring in habitats that are subject to some seasonal drying.

Life history

As with all sphaeriids, *Sphaerium* and *Musculium* species brood their young in brood pouches on the gills, and developed offspring are released directly to the environment. The species within these genera commonly carry multiple brood sacs throughout the year, in various stages of development, and the young within each sac may be of different sizes. Newborn young are released a few at a time (Heard, 1977; Mackie, 1979). The animals live from a few months to four years (usually 18-24 months). In general, the maximum embryo size ranges from 1.8-7mm for *Sphaerium* and 1.2-2.2mm for *Musculium* (Heard, 1977).

Studies by O'Toole & Wilson (2001) on a population of *Musculium lacustre* in Citadel Pond in Phoenix Park, Dublin, Ireland found that in spring 1999 no adult *M. lacustre* were found but juveniles of 1-2 mm appeared in high densities. Growth started around April '99 and first larvae were incubated in the beginning of May. The birth period started at the end of June '99 when the first newborn appeared in the habitat. Almost all of the adults bred releasing 1-2 broods (exceptionally 3 or 4) over a period of approximately 4 weeks and dying afterwards. Juveniles did not start growth after birth but went into diapause during the winter. Whereas O'Toole & Wilson (2001) found *M. lacustre* produces just one generation for the next year in Ireland's relatively cool summer, in the hot summers of Hong Kong *M. lacustre* produces two generations in one year Morton (1985).

Dispersal mechanisms and translocation

Musculium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Musculium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

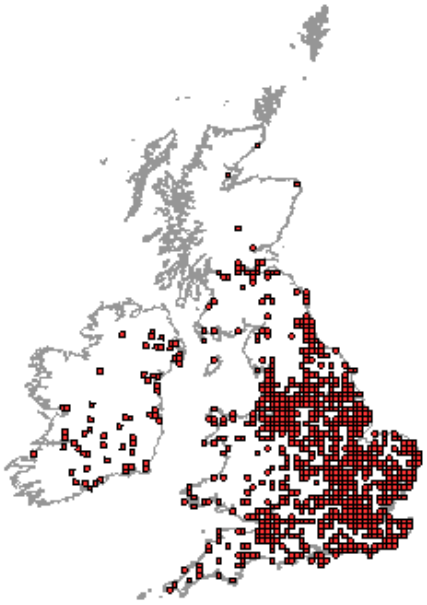
All species within the genus *Sphaerium* and *Musculium* are filter feeders. Water containing food is drawn in through the inhalant siphon and which is then drawn in by cilia on the gills into the mantle cavity. Filtered water and pseudofaeces are then ejected through the exhalent siphon. The siphons in *Sphaerium* and *Musculium* are fused into a tube which often the same length as the shell. Food includes detritus, green and blue-green algae, rotifers, protozoans, and bacteria. Whilst some studies have shown limited evidence for food preference, most species appear to take in a wide variety of food types (see Dillon, 2000).

Range

Palaearctic but probably Holarctic. Occurs principally in Europe, but has been widely spread elsewhere (e.g. China, Hong Kong).

Distribution – Ireland

In Ireland, *M. lacustre* has been found most frequently in the lowlands of the Midlands, south and east. The map in Kerney (1999) shows that there has been a decline over the last 50 years. However, recent surveys (Moorkens & Killeen, 2005) have shown that the species is widely but locally distributed in the Grand and Royal Canals.



Map from NBN based on Kerney (1999)

Distribution - Britain

Musculium lacustre is widely distributed in the lowlands of England, but is much more sparsely distributed in Wales and Scotland. There is some evidence of decline due to habitat loss.

Conservation Status

Britain: None

Ireland: None. Red listed – VU [A2 c] Byrne *et al*. (2009)

Threats

The types of habitat required by the species are frequently considered to have very little conservation value, and thus, they are especially vulnerable to land drainage and pollution, water abstraction, changes in agricultural practice, destruction and infilling of pools, and so on. The major threat in Britain and Ireland is loss of ponds, and dredging and over management of canals and their margins.

Musculium transversum (Say, 1829)

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Musculium transversum has a rather thin oblong, rounded rectangular shell, typically 12mm in length, 8mm in height, and 6mm in depth. Like *M. lacustre*, the umbos are raised but in contrast to *M. lacustre*, they are not usually capped although the margin of the juvenile shell may be well-defined. The shell surface has fine, more or less regularly spaced concentric striations, has a silky texture and yellowish, creamy grey in colour. The ligament joining the 2 valves is long, narrow and visible externally.

Habitats

In England this species has been recorded only from canals and canalised rivers (Kerney, 1999). The records from Europe are also from such habitats. In its native North America the species occurs in a much wider range of freshwater habitats including rivers, creeks, ponds and pools.

Microhabitats & Habits

Kerney (1999) notes that the species prefers a muddy substrate and can tolerate anaerobic bottom conditions. The most recent record from England (Lindley, 2006) records specimens from thick mud in a managed canal in north Yorkshire. Studies in America (e.g. Gale, 1971) showed that individuals of all ages preferred mud over sandy mud, and sandy mud over sand.

Life history

As with all sphaeriids, *Sphaerium* and *Musculium* species brood their young in brood pouches on the gills, and developed offspring are released directly to the environment. The species within

these genera commonly carry multiple brood sacs throughout the year, in various stages of development, and the young within each sac may be of different sizes. Newborn young are released a few at a time (Heard, 1977; Mackie, 1979). The animals live from a few months to four years (usually 18-24 months). In general, the maximum embryo size ranges from 1.8-7mm for *Sphaerium* and 1.2-2.2mm for *Musculium* (Heard, 1977).

Dispersal mechanisms and translocation

Musculium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Musculium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

All species within the genus *Sphaerium* and *Musculium* are filter feeders. Water containing food is drawn in through the inhalant siphon and which is then drawn in by cilia on the gills into the mantle cavity. Filtered water and pseudofaeces are then ejected through the exhalent siphon. The siphons in *Sphaerium* and *Musculium* are fused into a tube which often the same length as the shell. Food includes detritus, green and blue-green algae, rotifers, protozoans, and bacteria. Whilst some studies have shown limited evidence for food preference, most species appear to take in a wide variety of food types (see Dillon, 2000).

Range

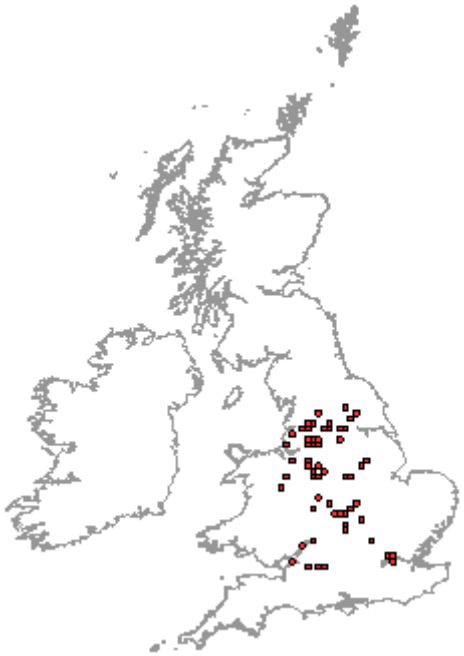
This is a North American species widely introduced to parts of Europe. It was first reported in England in the mid 19th century.

Distribution – Ireland

Unknown in Ireland.

Distribution - Britain

Currently known living only from a few sites in central England as far north as Lancashire and Yorkshire. This is a declining species, which was formerly more common and widespread in the 'canal basin' of lowland England. Kerney (1999) shows records for over 50 x 10km squares but only 14 of these were post-1965. There are very few records from the last 10 years (see Lindley, 2006).



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

The reasons for the sharp decline in the species in England are unclear. However, the principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. It is moderately tolerant of polluted habitats.

Pisidium amnicum (Müller, 1774)

Common name: River (or giant) pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

This is the largest species of *Pisidium* occurring in Europe, with adult shells typically reaching 11mm in length, 8mm in height, and 7mm in depth. The shell is oval in outline shape with rounded ends, and a broad, rounded umbo lying posterior of the mid point. The shell surface is glossy, brownish green or pinky grey with greenish band around ventral margin and has a sculpture that comprises prominent, irregularly spaced concentric ribs.

Habitats

Pisidium amnicum is a lowland species that lives in a wide range of permanent, usually flowing habitats: streams, rivers, canals, large drainage ditches. In Ireland and Britain it is found less often in lakes and large ponds. The species prefers clean, calcareous water.

Microhabitats & Habits

The species is found in soft sediments, mud and silt, sometimes with a sandy or organic element. Toth & Baba (1981) found that in a river in Hingary, *P. amnicum* lived at a much higher density on clay-silt bottoms compared to fine or coarse sand or silt. It is generally found in depths to 5m and is usually associated with several other *Pisidium* species.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and

live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986).

Table 4: Life history data for *Pisidium amnicum* as summarized by Holopainen & Hanski (1986)

		Siilaisenpuro, Finland (2m) Holopainen & Hanski (1986)	**Tadnoll Br, Dorset (1m)** Bass (1979)	**Rhein-Herne, Germany (2m)** Meier-Brook (1977)
Length (mm)	Maximum	8.9	9.0	8.9
	Mature	4.0	4.0	3.5
	At birth	1.8	1.8	1.8
Number of newborn clutch	Average	12	13	13
	Range	1-29	5-37	3-37
Clutches per individual		1	1	1-2
Longevity (months)		24-36	12-24	24
Month of egg laying		Aug	Aug-Dec	Aug-Dec
Month of parturition		July	May-June	May-June
Age at maturity (months)		13	5	3-5

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

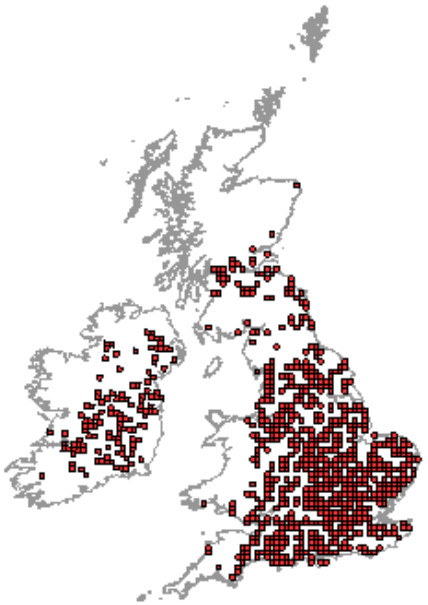
This is a Palaearctic species occurring throughout most of Europe but becoming rarer to the north and in Scandinavia. It has been introduced to eastern North America.

Distribution – Ireland

In Ireland, *Pisidium amnicum* occurs principally in the lowland areas of the Midlands, south and east. It is absent or rare in the south-west, west and north. The species is a particularly characteristic component of the Grand and Royal Canals (Moorkens & Killeen, 2005).

Distribution - Britain

Pisidium amnicum occurs in lowland areas throughout England, the Welsh borders and in lowland Scotland and Ireland. It is much rarer and more sparsely distributed in south-west and northern England. It is absent from western Wales and northern Scotland.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *P. amnicum* was one of the species of *Pisidum* most sensitive to biodegradable pollution.

Pisidium casertanum (Poli, 1791)

Common name: Caserta pea mussel

Synonyms: *P. cinereum* Alder, 1838

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Pisidum casertanum is the most geographically widespread *Pisidium* species and occurs in the widest possible range of freshwater habitats. As a result the species varies considerably in size, shape, shell thickness and hinge features. Many of the forms have been assigned varietal names of which the most distinct are f. *ponderosa*, f. *humeriforme* and f. *globulare*. The latter is now recognised as a distinct species and is treated separately in this study.

The shell is generally oval to slightly triangular in outline shape with typical dimensions of: length 5mm, height 4mm, and depth 3mm. The umbos are broad and rounded but not prominent. The shell surface is cream, white or grey in colour with a dull or silky texture and a sculpture of very faint concentric striations.

Pisidium casertanum form *ponderosa* Stelfox, 1918 is considered by some authors as a distinct species. It differs from 'typical' *P. casertanum* in having a greatly thickened shell, a more rounded triangular outline shape and greater tumidity. Internally the hinge plate is thick, robust and strongly arched, and the cardinal and lateral teeth are more strongly developed.

Habitats

Pisidium casertanum occurs in the widest possible range of freshwater habitats. It is found in virtually every type of habitat from the largest calcareous rivers to the poorest quality flushes, ditches and ponds. *Pisidium casertanum* form *ponderosa* occurs mostly in large rivers and canals.

Microhabitats & Habits

Pisidium casertanum is found in virtually every type of substrate and in organic detritus in tiny upland pools down to over 20m depth in lakes.

Pisidium casertanum form *ponderosa* lives in a narrower range of sediment types from mud through to silty sand and occurs mostly in large rivers and canals where it is typically associated with *P. supinum* and *P. moitessierianum*.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986).

Table 5: Life history data for *Pisidium casertanum* as summarized by Holopainen & Hanski (1986)

		Päärjärvi, Finland (2m) Holopainen (1979)	**Lake Esrom, Denmark(20m)** Holopainen & Jónasson (1983)	**Pond, Ohio, US** Burky *et al*. (1981)	**Pond, Canada** Mackie (1979)
Length (mm)	Maximum	4.2	4.3	4.9	5.0
	Mature	2.2	2.4		2.0
	At birth	0.9	1.0	1.0	1.2
Number of newborn clutch	Average				
	Range	2-27	2-20		1-5
Clutches per individual		3	3-4	1	1
Longevity (months)		36	48-60	30-33	12
Month of egg laying		April-May	April-May		March-April
Month of parturition		July	Nov-Dec	April-June	July
Age at maturity (months)		9-10	17	9	9-10

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a

current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

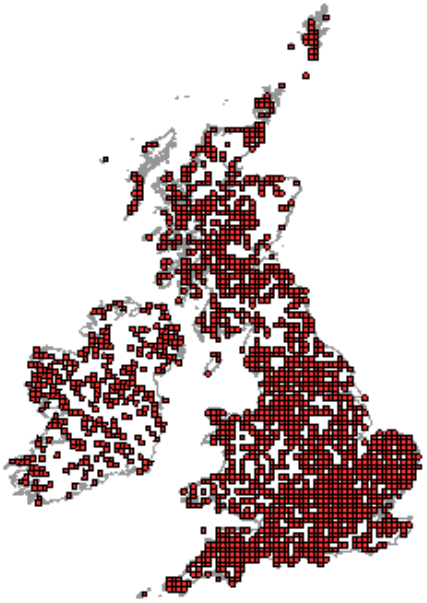
Cosmopolitan – found living on every continent (except Antarctica).

Distribution – Ireland

Widespread and common.

Distribution - Britain

Widespread throughout.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

Given the cosmopolitan distribution and abundance of occurrence there are few perceived threats to this species. Mouthon (1996) found *P. casertanum* to be the *Pisidum* species most tolerant of biodegradable pollution.

Pisidium conventus Clessin, 1877

Common name: Arctic-alpine pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

The shell of *Pisidum conventus* is small, thin, and fragile typically around 2.5mm in length, 2mm in height, and 1.4mm in depth. The shell is more or less oval to slightly quadrangular in outline shape, with a long dorsal margin and angles at the junctions with the posterior and especially the anterior margins. The umbos are broad, almost flattened and located near the mid-point of the dorsal side. The colour of the shell is yellowish with a silky or slightly glossy surface with a sculpture of very fine, irregular concentric striations. Internally, the hinge plate is very long and narrow. The teeth are long and thin, and a diagnostic feature is the curved cardinal tooth in the right valve (C3), which projects below the edge of the hinge plate.

Habitats

Pisidium conventus lives principally in the profundal zone of large lakes. It is an Arctic relict species in Britain and Ireland and it occurs mostly in cold mountain tarns and lakes at altitudes between 300 and 750 metres, but also in deep lochs at lower altitude (e.g. Loch Ness).

Microhabitats & Habits

Pisidium conventus lives in a range of fine substrates where it may occur on its own, with *P. casertanum* or *P. personatum*, or most typically with *P. hibernicum* and *P. lilljeborgii*. It has been recorded at considerable depths, 125 to 300m. It is a stenotopic species and its optimum temperature conditions are 3.86°C-6.85°C.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986).

Table 6: Life history data for *Pisidium conventus* as summarized by Holopainen & Hanski (1986)

		Päärjärvi, Finland (2m) Holopainen (1979)	**Titsee, Germany (13m)** Meier-Brook (1970)	**Titsee, Germany (4-6m)** Meier-Brook (1970)
Length (mm)	Maximum	2.5	3.2	2.8
	Mature	1.4	2.0	1.5
	At birth	1.0	1.0	1.0
Number of newborn clutch	Average	1.3	2.7	2.0
	Range	1-2	1-5	1-6
Clutches per individual		3-4	2	2
Longevity (months)		36		
Month of egg laying		Year round	Year round	
Month of parturition		Year round		
Age at maturity (months)		8-10		

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

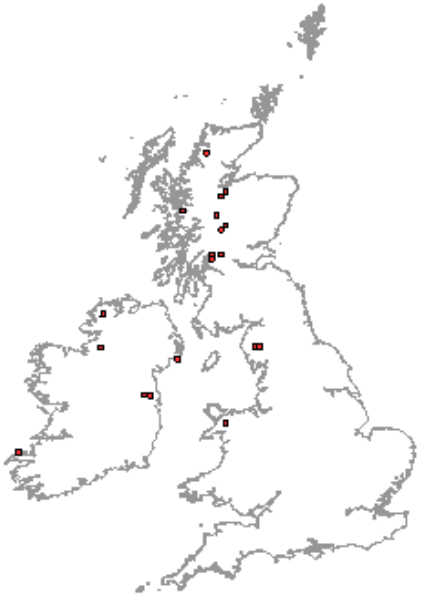
Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

The Arctic-alpine pea mussel *Pisidium conventus* Clessin, 1866 has a Holarctic distribution, but is restricted to cold water, either in circumpolar areas, or at high elevations.

Distribution – Ireland

There have been very few records of this species in Ireland, and these are generally from higher and therefore colder lakes. An old record for Mount Brandon was resurveyed in 2004 (Moorkens, 2005) and a living population was found.



Map from NBN based on Kerney (1999)

Distribution - Britain

Pisidium conventus is a rare species in Britain having been recorded only from Snowdonia in Wales, Helvellyn in the English Lake District, and a few locations in Scotland.

Conservation Status

Britain: None

Ireland: None. Red listed – CR [B2 a,b(i-iv)] Byrne *et al*. (2009)

Threats

The species habitat in lakes and tarns is threatened by conversion of the water bodies into reservoirs, but in general, it is unlikely that the lakes in which this species lives are under threat from pollution or drainage. However, their water temperature may be adversely compromised by future climate change.

Pisidium globulare Clessin, 1873

Common name: Swamp pea-mussel

Synonyms: *Pisidium casertanum f. globulare*

Identification literature

Until relatively recently, *Pisidium globulare* was regarded as a variety of *Pisidum casertanum*. However, Korniushin (1998, 1999) showed that *Pisidium globulare* was a good species based on both shell morphological characters and anatomical features. Killeen, Aldridge & Oliver (2004) included *P. globulare* as a form of *P. casertanum* and they illustrate a single specimen. Colour photographs and descriptions are given by Zettler & Gloer (2006), and morphological characters and illustrations of pore density are given by Horsak & Neumanova (2004). See also Korniushin (1998, 1999).

Brief description of species

Horsak & Neumanova (2004) give typical shell dimensions of 4.2-4.5mm length, 3.5-3.8mm height, and 2.6-2.8mm depth. This species is generally similar in external shell morphology to *Pisidium casertanum*. It differs in having a more tumid, inflated (globular) shell, broader, more prominent umbos, and a high density of shell pores. The lateral teeth of the hinge tend to be shorter than in *P. casertanum*. Anatomically, the gills have a larger outer demibranch.

Habitats

In mainland Europe, *Pisidium globulare* has been recorded from swamps, forest pools, wet meadows, littoral zone of small ponds and lakes, often in the floodplains of large lowland rivers. The habitats are often ephemeral, shallow and naturally high in nutrients.

Microhabitats & Habits

Pisidium globulare appears to favour very shallow habitats with a substrate of mud, fine silt and organic material.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986). No life history data specific to *Pisidium globulare* appears to be available.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

Pisidium globulare is considered to be a Palaearctic species but its full range and distribution is unclear due to its relatively recent recognition as a species distinct from *P. casertanum.*

Distribution – Ireland

Distribution unknown due to confusion with *Pisidium casertanum.*

Distribution - Britain

Distribution unknown due to confusion with *Pisidium casertanum.*

Conservation Status

Britain: None

Ireland: None

Threats

Although the distribution of *Pisidium globulare* is still poorly known, there are indications that the species is rare. The types of habitat required by the species are frequently considered not to have any conservation value, and thus, they are especially vulnerable to land drainage and pollution, water abstraction, changes in agricultural practice, destruction and infilling of pools, and so on.

Pisidium henslowanum (Sheppard, 1823)

Common name: Henslow's pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Henslow's pea mussel is one of the most recognizable species of *Pisidium* due to the raised ridge or crest that lies obliquely on the umbo, a feature it shares only with *P. supinum*. Adult shells typically measure 5mm in length, 4mm in height, and 3mm in depth, are obliquely oval in shape, and have a prominent, narrow umbo (with a raised crest) located posterior of the mid-point. There is a variety (form *inappendiculata*), which lacks the ridge on the umbos, but it appears to be rare in Britain and Ireland.

Habitats

Pisidium henslowanum is a lowland species that occurs in relatively calcareous water. It lives principally in moderate to large, permanent, lotic water bodies such as large streams, rivers, canals, and drainage ditches. It is also found in large lakes but is largely absent from habitats with standing water.

Microhabitats & Habits

The species is found in a wide range of soft, fine substrates from mud to sand and grit, usually with a silty element.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and

live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski 1986). No life history data specific to *Pisidium henslowanum* appears to be available.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

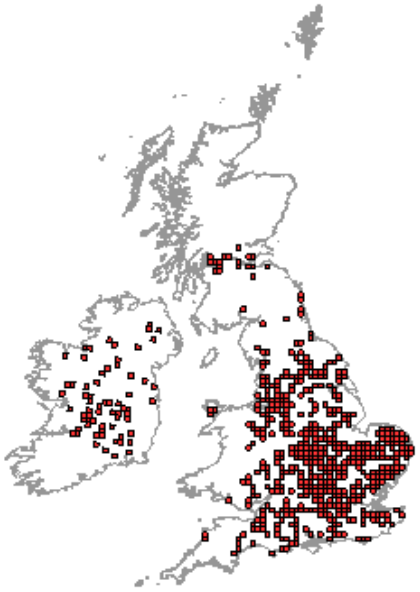
Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

This is a Palaearctic species that is widespread in lowland Europe. Its distribution in more scattered in southern Europe and it becomes much less frequent in northern Scandinavia. *P. henslowanum* also occurs in eastern North America although there is conjecture over its status as a native species.

Distribution – Ireland

In Ireland, *Pisidium henslowanum* occurs principally in the lowland areas of the Midlands, south and east. It is rare or absent in the highland and non-calcareous areas of the country. The species is a particularly characteristic component of the Grand and Royal Canals (Moorkens & Killeen, 2005).



Map from NBN based on Kerney (1999)

Distribution - Britain

Pisidium henslowanum occurs throughout the lowlands areas of England, and the Welsh borders. It occurs sporadically in south-west and northern England and in lowland Scotland. As with Ireland, it is rare in the highland and non-calcareous areas of the country.

Conservation Status

Britain: None

Ireland: None

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *P. henslowanum* was moderately tolerant of biodegradable pollution. Kuiper & Wolff (1970) showed that *P. henslowanum* was very resistant to pollution.

Pisidium hibernicum Westerlund, 1894

Common name Globular pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

The shell of *Pisidium hibernicum* is variable with respect to shell outline and especially surface profile. The shell is small, moderately tumid, with a typical length of 3mm, height of 2.5mm, and depth of 2.2mm. The umbos are prominent and centrally located and the dorsal margins are sloping and straight. The shell surface frequently has an irregular profile giving the appearance of overlapping layers. The surface has a very silky to slightly glossy texture, which is often covered with mud or speckled deposits. The animal is often orange or pink coloured that shows through the shell in living individuals.

Habitats

Pisidium hibernicum occurs in a wide range of aquatic habitats, in both calcareous and soft water. It lives in rivers, canals and large drains through to ponds, lakes and upland tarns.

Microhabitats & Habits

It is a particularly common species in upland lakes and tarns at altitudes up to 700m and may be the only species present. Although widespread in lowland southern England it frequently occurs only in low numbers compared with other *Pisidium* species and is therefore easily missed. *P. hibernicum* generally inhabits muddy and silty sediments often with a high organic content. However, in choice experiments, Meier-Brook (1969) found that the species showed a preference for coarser substrates.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986).

Table 7: Life history data for *Pisidium hibernicum* as summarized by Holopainen & Hanski (1986)

		Titisee, Germany (2-3m)
		Meier-Brook (1970)
Length (mm)	Maximum	3.3
	Mature	1.5
	At birth	1.0
Number of newborn clutch	Average	1.7
	Range	1-2
Clutches per individual		2-4
Longevity (months)		24-48
Month of egg laying		April, July
Month of parturition		July, August
Age at maturity (months)		20

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

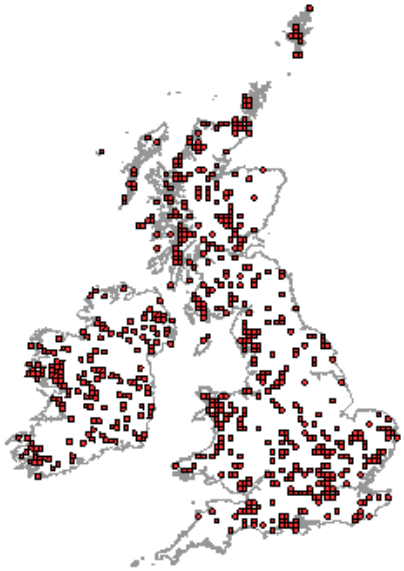
This is a western Palaearctic species that occurs principally in northern Europe to northern Scandinavia. It is rare in southern Europe.

Distribution – Ireland

Pisidium hibernicum is widespread in Ireland in a wide range of habitats and water hardness. It is a characteristic species of the lakes in the west of the country.

Distribution - Britain

The species has a wdespread, but patchy throughout Britain in both the lowlands and uplands. It is generally commoner in northern England, Wales, and Scotland.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None. Red listed – nt [A2 c] Byrne *et al*. (2009)

Threats

In lowland rivers the principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. The species habitat in lakes and tarns is threatened by drainage, pollution from agriculture, forestry and domestic sources, angling activities, and invasive species (e.g. zebra mussels). Mouthon (1996) showed that *P. hibernicum* was moderately tolerant of biodegradable pollution.

Pisidium lilljeborgii Clessin, 1866

Common name: Lilljeborg's pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

This is a moderately large pea mussel with an oval to trapezoidal outline shape and a typical shell size 3.5-4.5mm length, 3-4.4mm height, and 2.5-3.3mm depth. The umbo lies slightly posterior of mid-point, and is prominent, rounded but moderately narrow and projects above the dorsal margins. The sculpture comprises coarse, irregular concentric striae, and the shell has a moderately glossy periostracum.

Habitats

Pisidium lilljeborgii is a boreal relict species found mostly in upland areas from small tarns to very large lakes and lochs, but also occurs occasionally in the sheltered margins of swift-flowing rivers and streams.

Microhabitats & Habits

Pisidium lilljeborgii is tolerant of a wide alkalinity range but occurs more often in soft water. The species lives in a wide range of sediment types but unlike most other *Pisidium* species it also occurs commonly in coarser sandy or gritty substrates. However, in choice experiments, Meier-Brook (1969) found that the species showed a preference for finer substrates. The species has been recorded at altitudes as high as 1230m (Kuiper *et al.,* 1989) and at depths down to 40m. In lakes and tarns it is typically associated with *P. hibernicum*.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and

live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986).

Table 8: Life history data for *Pisidium lilljeborgii* as summarized by Holopainen & Hanski (1986)

		Titisee, Germany (4-6m)
		Meier-Brook (1970)
Length (mm)	Maximum	4.7
	Mature	2.3
	At birth	1.1
Number of newborn clutch	Average	3.2
	Range	1-8
Clutches per individual		2-4
Longevity (months)		24-48
Month of egg laying		April-May
Month of parturition		July-Aug
Age at maturity (months)		20

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

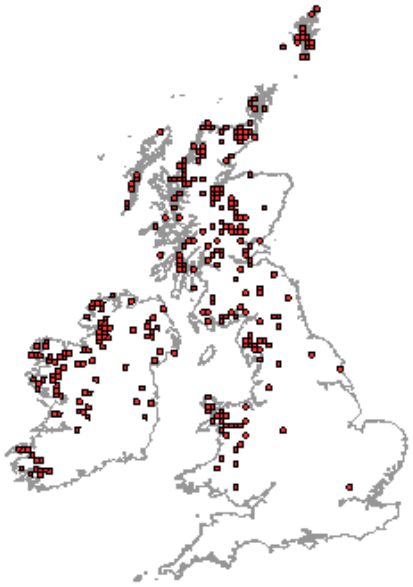
This species has a Holoarctic Range occurring principally in northern latitudes. In Europe it is boreo-alpine.

Distribution – Ireland

Pisidium lilljeborgii is widespread in the west and north of Ireland where it is a characteristic species of lakes. It is uncommon or absent from the Midlands, south and east.

Distribution - Britain

Pisidium lilljeborgii is absent from much of England, occurring only in the north. It is more widely distributed in Wales and Scotland. Some evidence of decline in the latter half of the 20th century (Kerney, 1999).



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None. Red listed – VU [A4 c] Byrne *et al*. (2009)

Threats

In upland rivers the principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, impounding, and changes to flow regimes. The species habitat in lakes and tarns is threatened by drainage, pollution from agriculture, forestry and domestic sources, angling activities, and invasive species (e.g. zebra mussels).

Pisidium milium Held, 1836

Common name: Rosy or quadrangular pea mussel

Synonyms: *P. roseum* Jeffreys, 1862

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Pisidium milium is characterised by its rather rectangular outline shape with its almost straight ventral margin, and the high tumidity across the valves (depth). The typical size is: length 3mm, height 2.4mm, and depth 2.1mm. The umbos are broad, prominent, lie posterior of mid-point and are usually angled towards the posterior end of the shell. The shell surface is yellowish in colour, very glossy, with well-defined, irregular, concentric striations. The animal often has a pinky orange colour that can be seen through the shell.

Habitats

Pisidium milium occurs in a wide variety of aquatic habitats, both calcareous and non-alkaline, particularly in ponds, marshy pools, drainage ditches with swampy conditions. Although it is found in streams, rivers and canals it usually only occurs where there are densely vegetated margins.

Microhabitats & Habits

Lives in mud, silt and organic detritus often in very small or ephemeral bodies of water and usually where there is a rich flora.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but

litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986). No life history data specific to *Pisidium milium* appears to be available.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

Holarctic, Europe, North Africa and North America.

Distribution – Ireland

This is one of the commonest and most widely occurring *Pisidium* species in Ireland.

Distribution - Britain

Pisidium milium is widespread throughout (the principally lowlands) of England, Wales and Scotland.

Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None.

Threats

In lowland rivers the principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. In ponds, swamps, roadside ditches, fens and marshes, the species habitat is threatened by destruction of habitat, drainage, pollution from agriculture, forestry and domestic sources. Mouthon (1996) showed that *P. milium* was relatively tolerant of biodegradable pollution.

Pisidium moitessierianum Paladilhe, 1866

Common name: Pygmy pea mussel

Synonyms: *Pisidium parvulum* Johansen, 1898

Pisidium torquatum Stelfox, 1918

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

The shell of *Pisidium moitessierianum* is wedge-shaped or quadrangular, very small, rarely exceeding 2mm in length and 1.5mm in height. It is robust and tumid for its size with a typical depth across the valves of 1mm. The umbos are prominent and rounded, and bordered by a furrow or collar with raised edges – the diagnostic feature of the species. The shell is greyish in colour with a dull or silky surface and a sculpture of clearly defined concentric striae.

Habitats

Pisidium moitessierianum lives in a relatively narrow range of habitats. It is found principally in canals and large, slow-flowing rivers. It occurs less frequently in smaller rivers, streams, and in large lakes.

Microhabitats & Habits

The species lives in calcareous, generally unpolluted habitats in mud and fine sediments, sometimes in gritty sand. It typically occurs with several other *Pisidium* species, and is especially associated with *Pisidium casertanum* f. *ponderosa* and *P. supinum.*

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but

litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986).

Table 9: The following Life history data for was summarized by Holopainen & Hanski (1986)

		Pääjärvi, Finland (2m)
		Holopainen (1979)
Length (mm)	Maximum	1.8
	Mature	1.0
	At birth	0.6
Number of newborn clutch	Average	2.5
	Range	1-5
Clutches per individual		1
Longevity (months)		24
Month of egg laying		Aug-Sept
Month of parturition		July
Age at maturity (months)		12-13

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

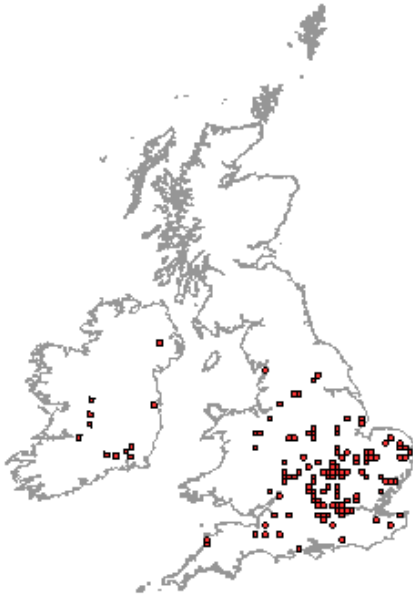
Range

Pisidium moitessierianum is a European and western Palaearctic species. The principal range covers Europe from Ireland to western Russia, and southern Scandinavia. Apart from some places in the

Balkans, it is largely absent from southern Europe. The species is also known from Kazakstan, Israel, Turkey and Syria, and has been introduced into North America (Zettler & Kuiper, 2002).

Distribution – Ireland

Pisidium moitessierianum was considered to be extinct in Ireland (Kerney, 1999) until it was rediscovered in the Grand Canal in 2002 after an absence of records for 78 years (Killeen & Moorkens, 2003). It was previously recorded from 6 ten km squares including the Shannon system and the Suir/Barrow system. In 2003 it was also found in the Royal Canal (Moorkens & Killeen, 2005). It has since been recorded at several sites on the western half of the Grand Canal, and in Lough Cullen.



Map from NBN based on Kerney (1999)

Distribution - Britain

The species is found principally in central, lowland England – the area often referred to as the canal basin. It is absent from Scotland and there are no recent records from Wales.

Conservation Status

Britain: None

Ireland: EN B2ab(iii) (Moorkens 2006). Red listed – EN [B2 a,b(i,iii,iv)] Byrne *et al*. (2009)

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *P. moitessierianum* was one of the species of *Pisidum* most sensitive to biodegradable pollution. Kuiper & Wolff (1970) also showed that *P. moitessierianum* was very sensitive to pollution.

Pisidium nitidum Jenyns, 1832

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Pisidium nitidum has a small, oval, moderately tumid shell, with a rounded anterior end, and slightly truncated posterior end, with typical dimensions: length 3.5mm, height 3mm, and depth 2.3mm. The umbos are broad and rounded, slightly posterior of mid point. The characteristic feature of the species is the smooth umbonal area that is bounded by 3 incised grooves. The shell surface is yellow in colour, very glossy, and has a sculpture of generally prominent, irregularly spaced concentric striae. *Pisidium nitidum* form *crassa* is regarded by some authors as a distinct species. It differs in having a rather more trapezoidal shell outline, coarser striations and a more solid hinge.

Habitats

Pisidium nitidum is one of the commonest *Pisidium* species which occurs in a wide range of moderately clean aquatic habitats, mostly in flowing drainage ditches, streams, rivers and canals, but also in lakes and ponds. The *crassa* form occurs principally in canals and large slow-flowing rivers in association with *P. casertanum* f. *ponderosa, P. supinum* and *P. moitessierianum*.

Microhabitats & Habits

P. nitidum inhabits a wide range of substrate types from muddy and silty sediments to sandier sediments. However, in choice experiments, Meier-Brook (1969) found that the species showed a preference for coarser substrates. It has been recorded at altitudes to 2500m (Kuiper *et al*., 1989).

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986).

Table 10: The following Life history data was summarized by Holopainen & Hanski (1986)

		Lake Esrom, Denmark (2m) Holopainen & Hanski (1986)	**Lake Esrom, Denmark (11m)** Holopainen & Hanski (1986)	**R. Tarrant, Dorset (0.3m)** Ladle & Baron (1969)	**Titisee, Germany (2-3m)** Meier-Brook (1970)
Length (mm)	Maximum	2.6	2.8	3.7	3.0
	Mature	1.6	1.7	2.0	1.6
	At birth	1.0	1.0	1.0	1.0
Number of newborn clutch	Average			6	2.8
	Range	1-11	1-5	3-17	1-5
Clutches per individual		3	1-2		2-3
Longevity (months)		24	12-24	12	24-48
Month of egg laying		Apr-May, July	April-May	May, July	April, July
Month of parturition		July, Sept	July-Sept	June-Nov	July, Sept
Age at maturity (months)		9-10	9	10	20

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

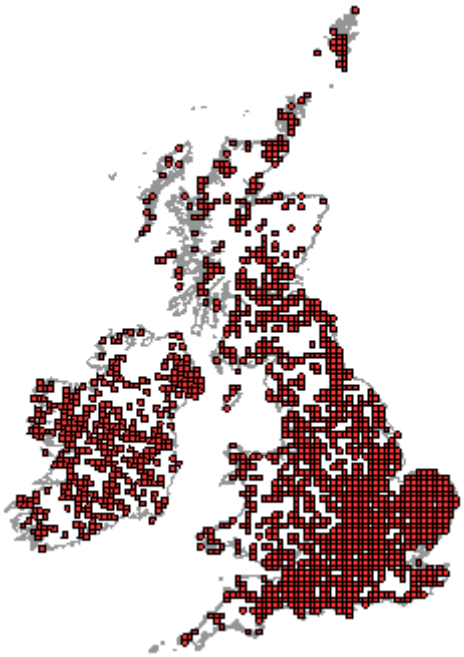
The species has a Holarctic range, mostly Europen, possibly in North Africa, and in North America.

Distribution – Ireland

Widespread throughout.

Distribution - Britain

Widespread throughout.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *P. nitidum* was moderately tolerant of biodegradable pollution. Kuiper & Wolff (1970) also showed that *P. nitidum* was very resistant to pollution.

Pisidium obtusale (Lamarck, 1818)

Common name: Porous-shelled pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Pisidium obtusale has a small, very tumid (almost spherical) shell typically 3.5mm in length, 3mm in height, and 3mm in depth, oval in outline with a very rounded ventral margin. The umbos are prominent, broad and rounded, just posterior of mid-point. The surface of the shell is glossy, creamy coloured with a sculpture of fine, irregularly spaced concentric striae. The shell has numerous pores. Internally the species may be characterised by the very short hinge plate compared to other species, and the pseudocallus (thickening) in the posterior lateral tooth of the right valve.

Habitats

Pisidium obtusale occurs principally in lentic (standing water), swampy habitats, especially ponds, and marsh drains, which usually have very dense aquatic vegetation. It also lives in pools, ditches, fens, marshes and bogs, often in situations that are prone to dessication. The species is tolerant of hard and soft water. *P. obtusale* also occurs in canals, large rivers and lakes but usually only in swampy margins.

Microhabitats & Habits

Pisidium obtusale lives in muddy, silty substrates, usually with a high organic content. It can live in saturated ground (in fens for example) and in deeper lakes and ponds to depths of 5m. It has been recorded at altitudes to 1230m (Kuiper *et al*., 1989). The species frequently occurs on its own, or in poor quality habitat, with *P. personatum* or *P. casertanum*. In swamps and richly vegetated marsh drains it often occurs with *P. milium* and *P. pseudosphaerium*.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986). No life history data specific to *Pisidium obtusale* appears to be available.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

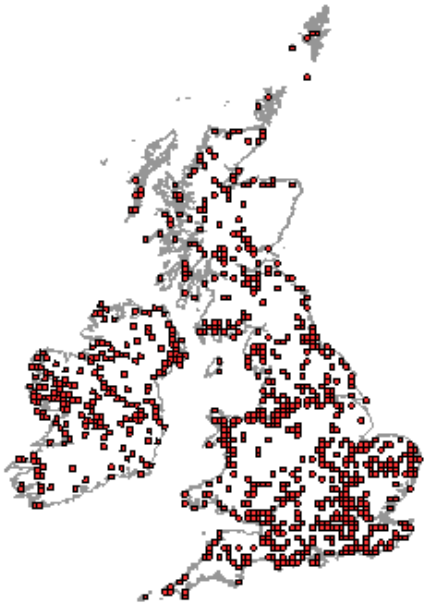
Palaearctic. Mostly Europe to high latitudes within the Arctic Circle.

Distribution – Ireland

Widespread but more frequent in the lowland areas.

Distribution - Britain

Generally widespread throughout but scarcer in east Wales, the English Midlands and east Scotland.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

The types of habitat required by the species are frequently considered not to have any conservation value, and thus they are especially vulnerable to land drainage and pollution, water abstraction, changes in agricultural practice, destruction and infilling of pools, and so on.

Pisidium personatum Malm, 1855

Common name: Red-crusted pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Pisidium personatum has a small, rounded, oval shell, with typical dimensions: length 3.5mm, height 2.8mm, and depth 2.1mm. The umbos are broad and rounded, but not prominent, and are centrally located. The shell surface has a satiny texture, usually greyish colour but it is invariably obscured by a thick reddish brown or black coating, or speckled with deposits. When visible, the shell surface has very fine, irregular concentric striations, and with numerous pores sometimes visible on the surface. The characteristic and most distinctive feature of *P. personatum* is the presence of a raised callus on the hinge plate, lying between the lateral teeth and the ligament pit.

Habitats

Pisidium personatum is characteristic of poor quality habitats such as small streams and trickles, roadside ditches, ponds, pools in fields, upland flushes, pools in woodland, especially in bodies of water subject to desiccation. It lives in both hard and soft water. It is also found in the margins of lowland rivers and large lakes particularly in ephemeral shallows and confluences with ditches.

Microhabitats & Habits

Pisidium personatum lives in muddy, silty substrates, usually with a high organic content. It can live in saturated ground (in flushes, fens and bogs for example) and in pools to depths of a few metres. It has been recorded at altitudes to 2800m (Kuiper *et al*., 1989). The species usually occurs on its own, often in very high abundance (thousands per square metre), or with *P. casertanum*. *P. personatum* is often associated with the gastropods, *Lymnaea truncatula* and *Anisus leucostoma*.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986). No life history data specific to *Pisidium personatum* appears to be available.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

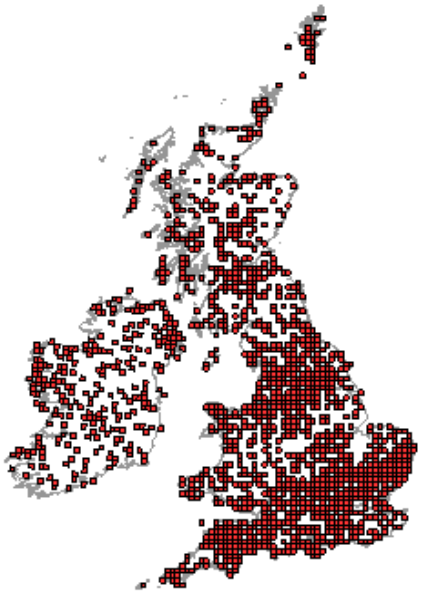
European

Distribution – Ireland

Widely distributed in both upland and lowland regions.

Distribution - Britain

Pisidium personatum occurs throughout Britain, in lowlands and uplands, to altitudes over 900m.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

Given the distribution and abundance of occurrence, and the tolerance of very poor quality habitats, there a few perceived threats to this species.

Pisidium pseudosphaerium Schlesch, 1947

Common name: False orb pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Pisidium pseudosphaerium has a thin, oval, shell, slightly quadrangular in outline shape with broad, flattened umbos located at the mid-point of the dorsal margin. Typical dimensions are length 3mm, height 2.4mm, and depth 1.6mm. The shell surface has a sculpture of very fine, regular concentric striations, cream in colour and with a silky texture.

Habitats

Pisidium pseudosphaerium is a lowland species that is a common component in drains and ditches on grazing marsh complexes, occasionally in larger drains and ponds. In Ireland it is found mainly in overgrowing canal branches and swampy fens.

Microhabitats & Habits

Pisidium pseudosphaerium lives in richly vegetated, swampy habitats with clean, standing water and a muddy substrate. This species is frequently associated with *P. obtusale, P. milium* and *Sphaerium nucleus*, and is rarely found with any other species of *Pisidium*.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but

litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski 1986). No life history data specific to *Pisidium pseudosphaerium* appears to be available.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

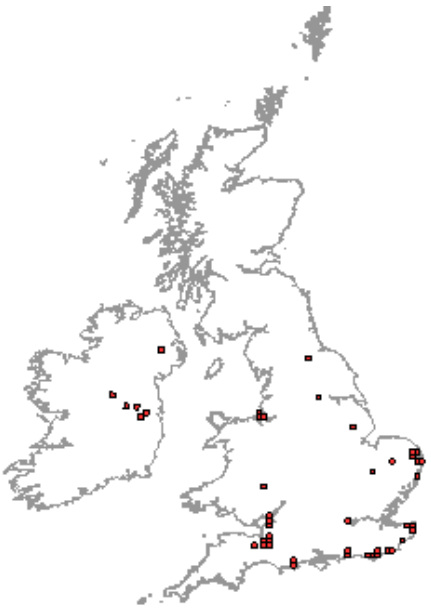
Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

The range of this species is European, mostly in northern Europe as far north as southern Scandinavia.

Distribution – Ireland

There are only a few records of *Pisidium pseudosphaerium* from Ireland, from the 2 main canals and their feeders. Recent records from the main channels of the Grand and Royal Canals and from two swamps in Westmeath (Moorkens & Killeen, 2005; Moorkens, 2004) confirm its continued presence, but both habitats are vulnerable.



Map from NBN based on Kerney (1999)

Distribution - Britain

This is a locally distributed species found principally in southern and eastern England: the Somerset Levels, Pevensey Levels, Romney Marsh, Kent Levels, East Anglian Broads and Marshes, and occasionally elsewhere. Recent surveys targeted at other rare molluscs on grazing marsh complexes have yielded many new records for the species.

Conservation/Red Data Status

Britain: Red Data Book (Bratton 1990) RDB3 Rare

Ireland: Vulnerable B2ab(iii) (Moorkens 2006). Red listed – EN [B2 a, b(i,iii,iv)] Byrne *et al*. (2009)

Threats

The richly vegetated swampy habitat that *Pisidium pseudosphaerium* is found in is the sort of habitat that is particularly vulnerable to dredging and clearing. The species is also threatened by land drainage and pollution, eutrophication, water abstraction, changes in agricultural practice, destruction and infilling of pools, and so on.

Pisidium pulchellum Jenyns, 1832

Common name: Iridescent pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

The shell of *Pisidium pulchellum* is distinctly obliquely oval/rounded shape, tumid (broad across the 2 valves) with a typical size of length 4mm, height 3.5mm, and depth 2.7mm. The umbos are broad and rounded, and lie posterior of mid-point. The shell has a sculpture of prominently raised, regularly spaced concentric striations. The shell surface is glossy with an iridescent appearance, grey or cream in colour, and in living specimens the pinky orange colour of the animal can be seen through the shell

Habitats

Pisidium pulchellum lives in good quality, clean, calcareous water, in small rivers/large streams, small, disused canals, drainage ditches (especially those with a flow). It is also found in lakes and ponds, particularly in the northern and western parts of Britain and Ireland. It occurs much less frequently in large, managed canals and slow-flowing rivers.

Microhabitats & Habits

Pisidium pulchellum lives in a range of substrates from mud through to sandy grit.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but

litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986). No life history data specific to *Pisidium pulchellum* appears to be available.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

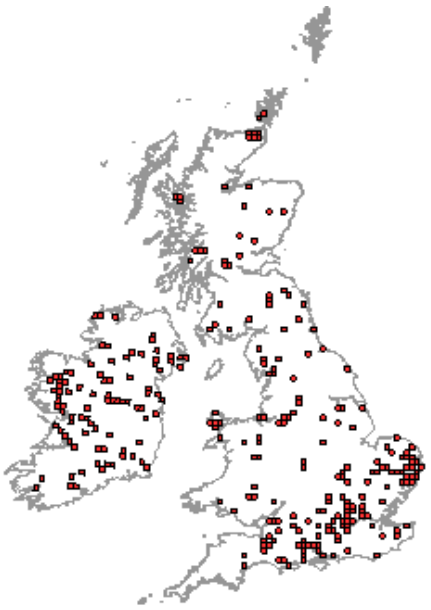
Palaearctic, mostly in lowland northern Europe.

Distribution – Ireland

Pisidium pulchellum is widely distributed in Ireland but is most frequent in the large lakes and loughs in the north and west. It also occurs locally in the Grand and Royal Canals (Moorkens & Killeen, 2005) and in rivers, ponds, lakes and drains elsewhere.

Distribution - Britain

The distribution of *P. pulchellum* in Britain is sporadic. It occurs mostly in southern England from Dorset to NW Norfolk - it is frequent in the Hampshire Basin, localised in Sussex and Kent. It occurs less frequently in Wales, northwest England and Scotland.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None. Red listed – EN [A2c] Byrne *et al*. (2009)

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. *P. pulchellum* is considered to be one of the species of *Pisidum* most sensitive to pollution.

Pisidium subtruncatum Malm, 1855

Common name: Short-ended pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

This pea mussel is highly variable in size, shape, convexity, prominence of the umbos and sculpture. The shell is obliquely shaped with a truncated posterior end, a rounded anterior end, and prominent, rounded umbos that slope towards the posterior end. Typically the shell is 3.5mm in length, 2.8mm in height, and 2.2mm in depth. Larger individuals up to 5mm are known. The shell surface is silky to slightly glossy with fine, irregular striae, and greyish in colour.

Habitats

Pisidium subtruncatum occurs in a wide range of aquatic habitats - streams, rivers, canals, large drains, ponds and lakes. It shows a strong preference for flowing water and it occurs much less often in standing water such as ditches and pools.

Microhabitats & Habits

The species lives in a wide range of fine substrates from mud to grit. *Pisidium subtruncatum* is one of the commonest and often the dominant *Pisidium* species in streams and small rivers where it is frequently associated with *P. nitidum*.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and

live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 10, generally increasing with parent size (Holopainen & Hanski, 1986).

Table 11: Life history data as summarized by Holopainen & Hanski (1986)

		Lake Esrom, Denmark (20m)	**River Tarrant, Dorset (0.3m)**
		Holopainen & Jónasson (1983)	Ladle & Baron (1969)
Length (mm)	Maximum	3.3	4.2
	Mature	1.7	2.2
	At birth	0.9	0.8
Number of newborn clutch	Average	3.7	13
	Range	1-12	3-25
Clutches per individual		3-4	2
Longevity (months)		48-60	12
Month of egg laying		April-May	April, July
Month of parturition		Nov-Dec	June, October
Age at maturity (months)		17	7-10

Mouthon (2005) found in the Saône River at Lyon, France, the life cycle of this bivalve was characterised by the appearance of five cohorts that succeeded each other from May to September–October. The longevity of the two first cohorts was only 3 months, whereas the longevity of the three others, which lived though the winter, reached 11 months. The author attributed these differences from the norm to higher temperatures, and magnitude, duration and timing of flood events.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a

current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

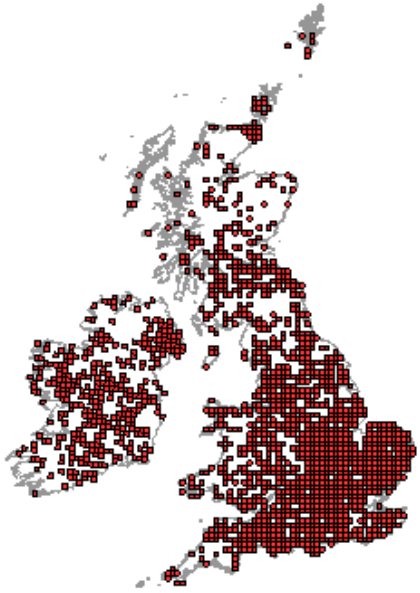
Pisidium subtruncatum has a Holarctic distribution. It is occurs throughout Europe but becomes scarcer to the south.

Distribution – Ireland

Widespread, mainly in lowland sites throughout Ireland.

Distribution - Britain

Widespread, mainly in lowland sites throughout Britain.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *P. subtruncatum* was moderately tolerant of biodegradable pollution. Kuiper & Wolff (1970) also showed that *P. subtruncatum* was very resistant to pollution.

Pisidium supinum A. Schmidt, 1851

Common name: Hump-backed pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

The shell of *Pisidium supinum* is very solid, and moderately tumid, with a rounded triangular outline shape. The dimensions are typically: length 4mm, height 3.7mm, and depth 2.8mm. The umbos are prominent, narrow, almost pointed and lie posterior of the mid point. There is an oblique raised crest high up on the shell. The shell surface is generally grey in colour with a silky surface and a sculpture of well defined, regularly and relatively widely spaced concentric striations. Internally the hinge plate is very solid and strongly arched with well developed cardinal and lateral teeth.

Habitats

Pisidium supinum lives in a relatively narrow range of clean, calcareous habitats. In Britain, it is virtually restricted to canals and large, slow-flowing rivers. In mainland Europe it also occurs (less frequently) in smaller rivers, streams, and in large lakes.

Microhabitats & Habits

Pisidium supinum lives in a range of substrates from mud through to sandy grit. It is often found in deeper water than for many other *Pisidium* species, and is less common in very shallow margins. The species is usually associated with *P. moitessierianum,* and the thick-shelled *ponderosa* form of *P. casertanum*.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and

live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986). No life history data specific to *Pisidium supinum* appears to be available.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

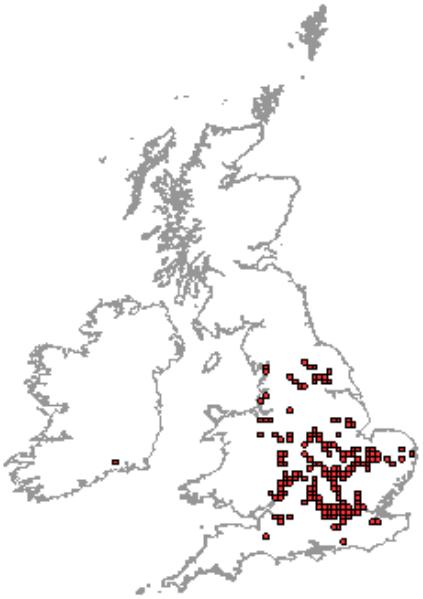
This species has a Palaearctic range, occurring principally in the lowlands of northern Europe and southern Scandinavia. It is generally rare in southern Europe.

Distribution – Ireland

In Ireland, *Pisidium supinum* is known only from shells of an uncertain age from the River Suir at Fiddown, Co, Waterford (Phillips, 1916).

Distribution - Britain

The species is found principally in central, lowland England – the area often referred to as the canal basin, and the large river catchments in Yorkshire. It is absent from Scotland and there are no recent records from the Welsh borders.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *P. supinum* was one of the species of *Pisidum* most sensitive to biodegradable pollution. Kuiper & Wolff (1970) also showed that *P. supinum* was very sensitive to pollution.

Pisidium tenuilineatum Stelfox, 1918

Common name: Fine-lined pea mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004).

Brief description of species

Pisidium tenuilineatum has a small, tumid shell, which is oval to slightly triangular in outline, and which has a rounded ventral margin and a slightly truncated posterior end. The shell length rarely exceeds 2.0mm, with a height of 1.5mm, and a depth of 1.2mm. The umbos are broad, prominent and rounded, and lie posterior of mid point. The shell surface is silky or dull, generally grey in colour and has a very distinctive sculpture of fine, regularly spaced concentric ribs. Internally, the hinge is solid, the cardinal teeth are equidistant from the well-developed lateral teeth.

Habitats

In Britain, *Pisidium tenuilineatum* lives principally in clean, calcareous, unpolluted, lowland rivers, large streams and occasionally in ponds. On the continent it is known various kinds of running and stagnant water; rivers, canals, streams, brooks and in the littoral zone of large lakes, mostly at altitudes less than 500m (Kuiper, 1981; Zettler & Gloer, 2006).

Microhabitats & Habits

The species lives in both swift and slow-flowing water, most often in fine sediments that accumulate at river margins, particularly on the downstream side of tall, emergent macrophytes. In Poland, Piechocki (1989) records that its characteristic habitats are small lowland rivers with fine bottom sediments, in which it is sometimes abundant. Studies in Britain (Killeen & Willing, 2004) have shown that *P. tenuilineatum* frequently occurs in low numbers, rarely comprising more than 10% of all *Pisidium* individuals from a sample, although in some places it has been found in abundances as high as 80% of all individuals in a sample.

Life history

As with all sphaeriids, *Pisidium* species brood their young in brood pouches on the gills (e.g. Mackie, 1979). Most species of *Pisidium* usually produce one or two cohorts of young per year and live from a few months to four years. The maximum embryo size is relatively constant at 1mm but litter size is variable from 1 to 40, generally increasing with parent size (Holopainen & Hanski, 1986). No life history data specific to *Pisidium tenuilineatum* appears to be available.

Dispersal mechanisms and translocation

Pisidium species may be dispersed by a wide variety of natural processes: by water movement (and flood events), through ingestion and ejection by fish, by attachment to limbs of aquatic insects and amphibians, or feathers of water-fowl. Due to their reproductive method of giving birth to live young and also the ability to self-fertilise, *Pisidium* have the capacity to establish populations if moved to new suitable locations. Dispersal is also possible through human activities: intentional stocking programs for fisheries and for biocontrol, release of organisms from the aquarium or horticultural trade, release of organisms along with bait fish by fishermen, release of ballast water, deliberate establishment of exotic food sources for human consumption, and the creation of artificial water channels.

Food

Pisidium species have become adapted to filter waters from within the sediments. They bury beneath the surface and then move through the substrate with umbo downwards, drawing a current of water through the ventral mantle margin and ejecting it along with pseudofaeces through the posterior siphon. It is believed that all *Pisidium* species may feed exclusively on bacteria (Lopez & Holopainen, 1987).

Range

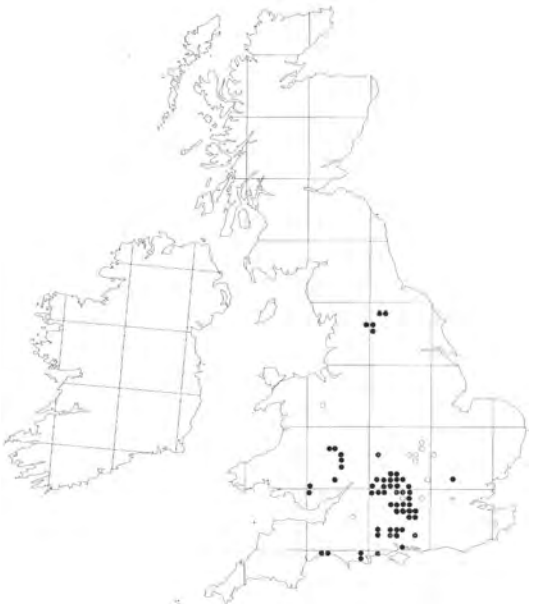
Pisidium tenuilineatum is widely distributed across the western Palaearctic from the Mediterranean to southern Sweden and eastwards to Russia (Kuiper, 1981).

Distribution – Ireland

Unknown in Ireland

Distribution - Britain

The distribution of *Pisidium tenuilineatum* is mainly central southern England, principally the Hampshire and Thames basins. It is also known from south and south-east Wales (Rivers Lugg, Monnow and Usk), Yorkshire (Rivers Wharfe and Ure), River Mimram in Hertfordshire and the River Axe in Devon. It was formerly known from rivers and canals in the Midlands and from ponds in Sussex, and Herefordshire. The species has not been recorded from Scotland.



Map based on Kerney (1999) and Killeen & Willing (2004).

Conservation Status

Britain: UK Biodiversity Action Plan priority species; British Red Data Book RDB3 Rare.

Ireland: None

Threats

The principal threats to the species are pollution of its habitats through eutrophication or other chemical sources, alteration of water courses, changes to flow regimes, over-frequent dredging and the effect of invasive species. Mouthon (1996) showed that *P. tenuilineatum* was the species of *Pisidum* most sensitive to biodegradable pollution. In Poland, Piechocki (1992) highlighted the sensitivity of the species to orthophosphate, and more recently in the UK, studies have shown that the distributional limits within a river are affected by levels of orthophosphate (Killeen & Willing, 2004).

Dreissena polymorpha (Pallas, 1771)

Common name: Zebra mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms are given in Killeen, Aldridge & Oliver (2004). The literature on all aspects of this invasive species is enormous.

Brief description of species

The zebra mussel is a highly variable species in terms of shell shape and colouring. The shell is elongate, rounded-triangular in outline like the marine mussel (*Mytilus*). Typical dimensions length 20mm (40mm max.), height 11mm, and depth 11mm. The surface of the shell normally has a defined ridge running from the rather pointed umbos and the ventral margin is often concave (giving a humped appearance). The surface of the shell is smooth and dull with a grey-brown to yellow colour, often with wavy or zig-zag bands of alternating pale and dark colours (hence the name zebra mussel). It has a byssus of threads that emerge from a small opening on the ventral margin. Internally the shell at the umbo has a small shelf (septum) but not with a tooth as in *Mytilopsis*. The interior shell colour is white tinged with blue/purple.

Habitats

The zebra mussel thrives in slow rivers, canals, docks, reservoirs, power station cooling systems, water treatment facilities, water pipelines and lagoon areas with brackish water. It tolerates salinities of up to around 6% and water temperatures up to about 29°C.

Microhabitats & Habits

Dreissena polymorpha attaches to solid surfaces such as stones, unionid mussels and canal walls using byssus threads. It can colonise soft sediments once dead zebra mussel shells have accumulated to create a suitable substrate. Veliger larvae are sensitive to UV light and so adults are generally found at >1m depth, forming huge densities. This gives the zebra mussel a competitive advantage, and had has resulted in the loss of many species of native mussels in areas of the American Great Lakes and river systems (Ricciardi *et al*., 1995; Schloesser *et al*., 1995; Strayer & Smith, 1996) and in Ireland (Minchin *et al.,* 2002; Moorkens, 2006).

Life history

Annual and geographic variation in temperature has been identified as the primary factor triggering reproduction of *D. polymorpha* where veligers typically appear in the water at temperatures above 12°C. Dreissenidae are sequential spawners, and the duration of larval production in *D. polymorpha* can vary from 6 to 52 weeks. The seasonal flexibility in larval production patterns indicates that adults carry ripe gametes for a very long time. After initial spawning, the exposure to ripe eggs and sperm in the water column often triggers gamete release by other ripe mussels, as such creating variability in recruitment. Zebra mussels usually mature in one year (sometimes two). The time required for larvae to develop to shelled juveniles can range from 8 to 240 days. Typical life spans extend for several years.

As with other aspects on the biology of zebra mussels, the literature on the species' life history is vast. The early life stages of *Dreissena polymorpha* in Lough Key, Co. Roscommon, Ireland during the reproductive season, 1998-2003 were studied by Lucy (2006). Variation existed in seasonal larval densities, larval size distributions and juvenile settlement patterns among sampling weeks, years and monitoring sites from 1998 to 2003. In terms of seasonal appearance, zebra mussel larvae were detected in the plankton as early as February 2000 (7.2 ^{o}C) and March, 1999 (11^{o}C). The first definite seasonal appearance of larvae occurred in May corresponding with site water temperatures greater than 12.5 ^{o}C. Water temperature however, was generally in excess of 15 ^{o}C during the reproductive season. The annual start of significant spawning in the lake was early July, with larvae appearing in samples until the beginning to the middle of October. Peak annual spawning was typically from June week 4 to August week 4.

Recent studies in England (Aldridge *et al.*, 2004) showed that a newly recorded population of zebra mussels in the River Darent, Kent, contained zebra mussels in dense mats of up to 11,000 individuals/ m^2 and up to 20 cm in depth. A fishing lake in Lancashire had experienced increased water clarity and reduced fish biomass coincidental with the arrival of zebra mussels, while a newly recorded population in Barden Lake, Kent, was having a deleterious impact on native unionid mussels, particularly the swan mussel (*Anodonta cygnea*) and, the painter's mussel (*Unio pictorum*).

Dispersal mechanisms and translocation

This species is dispersed with shipping, as a fouling organism or in ballast water. The species also spreads effectively via inland waterways (canals and rivers). As well as on vessels (including recreational craft), the zebra mussel can be transported on floating vegetation and debris. In the United States, the zebra mussel has spread widely as a result of drifting of the larval stage with currents. There are also reports of possible local dispersal of larvae in the wet feathers of waterfowl. In addition, larvae may spread as a result of stocking of fish to an area. They may also end up on scuba divers' wet suits or in scientific sampling equipment, and thus be transferred from one area to another.

Food

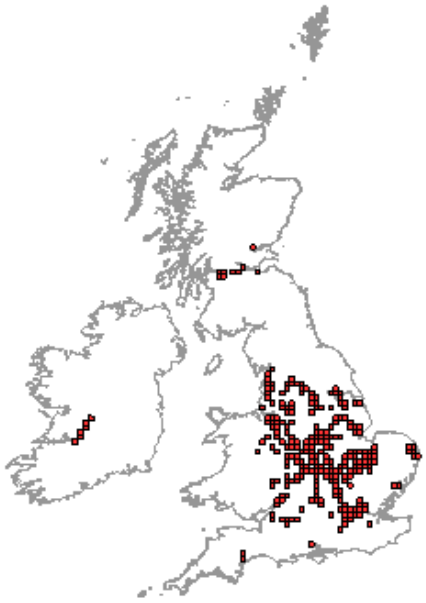
As with all freshwater bivalves *Dreissena polymorpha* is a filter feeders using the gills to sort potential food particles brought into the mantle cavity. Food includes diatoms, algal cells, bacteria and organic material from the water column. There are numerous studies on food types, many indicate preferences and others not. When zebra enter a water body and flourish, they have the ability to rapidly improve the clarity of the water therein.

Range

The species is native to the Black and Caspian Seas. The species probably found its way into the Baltic from the Black Sea via the river Dnieper and the Oginsky Canal, the river Neman, and on into the Curonian Lagoon, but it may also have spread via canals from the Caspian region, using the river Volga and its tributaries. The species now occurs in several western European countries, including Britain and Ireland, eastwards into Poland, as well as countries on the east coast of the Baltic (Estonia, Latvia and Lithuania). The species is also advancing in western Asia and south into Turkey. The zebra mussel has become widespread across the United States and Canada (Great Lakes and all major estuaries east of the Rocky Mountains).

Distribution – Ireland

The zebra mussel first arrived in Ireland in Limerick around 1994 (McCarthy & Fitzgerald, 1997) and has since rapidly spread throughout the Shannon-Boyle system (Minchin *et al*., 2002), into Lough Erne in Northern Ireland and many other isolated lake systems. The map on the right is therefore no longer useful for Ireland but remains reasonably accurate for Britain.



Map from NBN based on Kerney (1999)

Distribution - Britain

The species was first recorded in Britain in the early 1820s from sites in the London Docks and at Wisbech, Cambridgeshire and subsequently at other sites or near ports trading in Baltic timber, which is almost certainly the means of introduction (Kerney & Morton, 1970). By the 1850s had spread throughout the canal basin of England and Wales. The distribution remained relatively static but by the late 1980s there was evidence of decline particularly in the north Midlands and

Lancashire (Kerney, 1999). However, since 1999 there has been a dramatic increase in the abundance of this species throughout much of southern and eastern England, including the lower River Thames and the rivers of the Norfolk Broads (Aldridge *et al.*, 2004).

Conservation Status

Britain: None

Ireland: None

Threats

The zebra mussel is itself a serious threat to native bivalves and other species.

Mytilopsis leucophaeata (Conrad, 1831)

Common name: Dark false mussel

Identification literature

Descriptions, key features and colour photographs of growth series and shell forms given in Killeen, Aldridge & Oliver (2004).

Brief description of species

The dark false mussel has a small, obliquely triangular shaped shell (similar to marine mussels, *Mytilus*) with a typical size (in Britain) of length 13mm, height 7mm, and depth 7mm. The exterior of the shell is characterised by a thick brown periostracum that has dense erect concentric ridges. The most distinctive feature is internal and comprises a small shelf (known as a septum) on the umbos, and which has a triangular plate like tooth arising from it. The inside is coloured bluish-purple.

Habitats

Mytilopsis leucophaeata can withstand wide variations in salinity, but is most commonly found in fresh and brackish-water environments, such as rivers, canals, lagoons and estuaries, with salinities from 0.5 to 5%. However, the species may also be found in coastal waters of higher salinity. In European waters, such as the Wadden Sea, it occurs at salinities of up to just over 12%. It does best in areas with salinities between 1.4 and 12.7%. In Britain it is restricted to brackish lagoons and docks, and more recently in the saline reaches of rivers where salinities range from 0.5 to 15%.

Microhabitats & Habits

Using its foot and strong byssal threads, the dark false mussel can attach to various hard substrates, and it is able to exploit both natural and manmade surfaces. It lives attached to hard substrates such as pilings, walls and loose emergent debris. In western European waters, it coexists on substrates with both common mussels and zebra mussels. Particularly in waters of low salinity, between 0.2 and 3%, mixed populations of dark false and zebra mussels are often found. *M. leucophaeata* can form very large aggregations: up to 28,000 individuals per square metre have been recorded.

Life history

Mytilopsis leucophaeata needs relatively warm water, 18–20°C, to reproduce successfully. Studies on a population at Antwerp, Belgium (Verween *et al*., 2005) showed that in all years spawning began at the end of May/early June and lasted for about five months. Temperature at first detection ranged between 16.2°C and 19.5°C, salinity ranged from 2.6 to 4.9%. In all years, two or more distinct larval peaks could be observed. Their data showed that for *M. leucophaeata*, the threshold temperature for gamete maturation may be 13°C ± 1°C. The densities of larvae showed a high year-to-year variability, with moderate values in 2000-2002 (yearly average densities 2169 ind./m^3) and high values in 2003 (yearly densities 5273 ind./m^3). It has been shown that in cold winters, entire populations can die out.

Dispersal mechanisms and translocation

The dark false mussel has a free-swimming planktonic veliger larva, a byssus for attachment to hard surfaces and is dispersed principally though ballast water in ships or as attached animals.

Food

As with all freshwater bivalves *Mytilopsis leucophaeata* is a filter feeders using the ctenidia "gills" to sort potential food particles brought into the mantle cavity. Food includes diatoms, algal cells, bacteria and organic material from the water column.

Range

Mytilopsis leucophaeata is an eastern North American species that has been spread to many parts of the world, particularly Europe where it is known from Normandy to Denmark.

Distribution – Ireland

Currently unknown in Ireland

Distribution - Britain

The dark false mussel was first recorded in Cardiff in 1996 and subsequently in a lagoon in the Thames estuary in Kent in 1998. Recent surveys have failed to locate living individuals at either of these sites. However, it has recently been recorded at two locations around The Wash.

Conservation Status

Britain: None

Ireland: None

Threats

Mytilopsis leucophaeata is believed to have been introduced into Britain by shipping, probably from the Netherlands. As with the zebra mussel the species has a planktonic veliger larva and a byssus for attachment onto hard substrates and, therefore, it has the potential to spread and become a commercially significant fouling pest in water pipes and culverts.

SLUG SPECIES ACCOUNTS

Arion ater (Linnaeus, 1758)

Common name: Large black slug or Drúchtín (Gaelige)

Synonyms: *Arion empiricorum* Férussac, 1819

Photo: Evelyn Moorkens

Identification literature

Quick (1960) provides internal and external descriptions, and a key is given by Cameron *et al.*, (1983). Other descriptions and illustrations are in Kerney & Cameron (1979) and Kerney (1999).

Brief description of species

Large slug, with extended length reaching 10-15cm, occasionally 20cm. The slug has large, elongate tubercles, large respiratory pore and a robust foot fringe. Colour varies considerably, from completely black specimens to brown to brick red-orange and sometimes black with varying amounts of creamy white. The colours are determined by porphyrin pigments described by Kennedy (1959) and related as far back as 1927 as being related to levels of moisture and the altitude where the individual is living (Barr, 1927). Darker specimens are associated with higher altitudes and northerly parts of the range, lower temperatures and lower humidity (Albonico, 1948). The sole and body mucus is colourless and sticky. When disturbed, this species contracts into a hemispherical shape and rocks gently from side to side.

Habitats

Arion ater is very catholic in its habitat requirements. Unlike most slug species, it is found in acid moorland and bog habitats, but is also happy in lowland agricultural, garden, woodland, coastal and fen habitats.

Microhabitats & Habits

It is mainly nocturnally active, although can be seen during the day after rain. Microhabitats vary enormously, as long as the situation is damp and food is available.

Generation time/longevity

Mating generally occurs in the summer months with a series of 2 to 3 clusters of up to 150 pearly white eggs (5mm wide) laid 2 to 3 weeks after coitus. Hatching of eggs occurs 4 to 6 weeks later, and the pale young slugs are approximately 10mm long. Individuals grow and mature quickly, and have a life span of 12 to 18 months, although the latter information is based on isolated individuals kept in captivity (Comfort, 1957).

Dispersal mechanisms and translocation

High slug density and sparse food supply induce rapid dispersal of *A. ater* (South, 1992). Slugs can travel considerable distance during nocturnal locomotor activity, but other than deliberate movements by individuals, more widespread dispersal is aided by man.

Food

Arion ater is omnivorous, eating rotting vegetation, carrion and dung. It prefers decomposing rather than living plant material, making it less of a pest than most ground dwelling slugs.

Range

The range of *Arion ater* is Northern and Central Europe, Scandinavia, Iceland and Russia.

Distribution – Ireland

Widespread throughout Ireland

Distribution – Britain

Widespread throughout Britain

Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

No immediate threats to this widespread species.

Arion flagellus Collinge, 1893

Photo : Evelyn Moorkens

Common name: Durham slug

Synonyms : *Arion lusitanicus* cf Quick, non Mabille, 1868

Identification literature

Arion flagellus was confused with *A. lusitanicus* (now *A. vulgaris*) in Quick (1960), but the two species were distinguished with external and internal descriptions by Davies (1987).

Brief description of species

There is a wide range of colouring in this slug. Slug body can be black, brown, of purplish tinge, with more lightly pigmented specimens having yellow or greenish tinges. The head and tentacles are usually black, often tinged with purple. The tubercles are prominent and widely spaced, and the sole is pale.

Habitats

Cultivated or waste ground, disturbed habitats, gardens, farmyards and rubbish tips, but also undisturbed woodland.

Microhabitats & Habits

Found in proximity to rotting vegetation and under logs in woodland and disturbed ground.

Generation time/longevity

This species usually lives for one year, maturing later than other slugs and laying eggs of 3mm in diameter in clusters, often adhering to substrates, well into the winter season.

Dispersal mechanisms and translocation

To a large extent this species is dispersed by man, but may remain restricted to isolated areas without spreading if left undisturbed.

Food

Omnivorous feeder but may have a preference for rotting rather than growing plant material.

Range and distribution

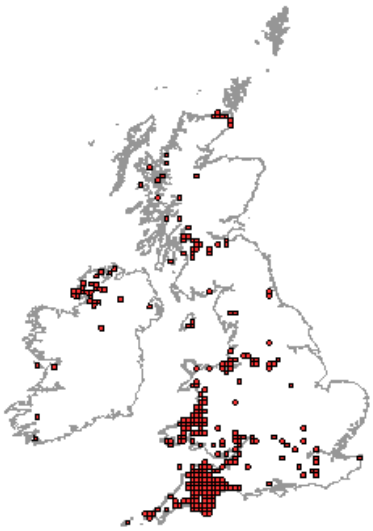
This was considered to be a British and Irish species, but Falkner *et al.* (2001) questioned that it may be present in France and Austria, and was recently reported from Spain (Quintiero *et al.,* 2005). In Britain and Ireland, records are increasing and it is likely to be spreading, although it may also be due to increased observations.

Distribution – Ireland

The original specimens for the description by Collinge were from Schull, Co. Cork, but the slug was not found again for 60 years. Since its rediscovery and separation from *A. lusitanicus*, records of the slug from most parts of Ireland have been made.

Distribution – Britain

This species is called the Durham slug as it was rediscovered in Durham 60 years after the descriptions from Schull (Quick, 1952). Since its separation from *A. lusitanicus*, records from a widespread area of Scotland, England and Wales have been reported.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

No immediate threats to this widespread species.

Arion rufus (Linnaeus, 1758)

Photo: Ian Killeen

Common name Large red slug

Synonyms: *Limax rufus* L., 1758

Arion empiricorum Férussac, 1819

Arion sulcatus Morolet, 1845

Identification literature

Quick (1960) provides the description for the *Arion rufus* found in Britain and Ireland.

Brief description of species

Not distinguishable from *Arion ater* in the field, as both have a range of similar colour forms, although *A. rufus* is usually reddish-brown. The species are distinguishable internally by dissection as per the descriptions in Quick (1960). *Arion rufus* is separated from *Arion ater* in the most recent taxonomic review of British and Irish non-marine molluscs (Anderson 2005), and in CLECOM (Faulkner *et al*., 2001a).

Habitats

Similar to *Arion ater*, but *A. rufus* is in more anthropological habitats than *A. ater*, more often recorded in parks and gardens than wild places and never occurring in peaty moors or bogs (Quick, 1960).

Microhabitats & Habits

Similar to *A. ater*, it is associated with decaying vegetation, carrion and dung, rather than growing seedlings and growing agricultural crops.

Generation time/longevity

Although the genital system is distinguishable from *A. ater*, the egg and hatching development is similar. Mating generally occurs in the summer months with a series of 2 to 3 clusters of up to 150 eggs laid 2 to 3 weeks after coitus. Hatching of eggs occurs 4 to 6 weeks later, and the pale yellow or orange young slugs are approximately 10mm long. The life span is likely to be annual and no longer than 18 months.

Dispersal mechanisms and translocation

Arion rufus tends to inhabit areas in closer association with man than *A. ater*, so it is more likely to be indirectly dispersed by man. However, this large slug can also travel considerable distance during active times.

Food

Similar to *A. ater*, it is omnivorous, eating rotting vegetation, carrion and dung. It prefers decomposing rather than living plant material.

Range

The range of *Arion rufus* is Britain, Ireland and Fennoscandia, with a separate species occurring in continental western Europe (Anderson, 2005).

Distribution – Ireland

Widely distributed across Ireland

Distribution – Britain

Widely distributed across Britain

Conservation Status

Britain: None

Ireland: None

Threats

No immediate threats to this widespread species.

Arion vulgaris Moquin-Tandon, 1855

Common name Lusitanian slug

Synonyms: *Arion lusitanicus* (Mabille, 1868)

Identification literature

Arion vulgaris (then *A. lusitanicus*) was not separated from *A. flagellus* in Quick (1960), but the two species were distinguished with external and internal descriptions by Davies (1987).

Brief description of species

This is a large slug, up to 15cm long, part of the *A. ater* type complex, with very variable colouration, mostly rusty black or brown with a dark underlayer, including the sole. Can be separated by dissection.

Habitats

Damp, sheltered places, disturbed ground, gardens, woodland.

Microhabitats & Habits

It appears to occupy a wide range of disturbed mictohabitats but remains local in distribution, although may be underrecorded.

Generation time/longevity

These slugs are hermaphrodite and mate between July and September. Details are unclear as they are apparently difficult to breed in captivity, and may have poor reproductive capability, a possible reason why they have not spread easily in Britain and Ireland, although they have pest status elsewhere. Animals live for a year to eighteen months.

Dispersal mechanisms and translocation

Arion vulgaris remains localised in Britain and Ireland, but its rapid expansion has been noted in some instances and it appears to be readily dispersed by man in the rest of its occupied range in

Europe. There are reported incidents of juvenile slugs dispersing via attachment to the coats of animals such as foxes and cats (Davies, 1987).

Food

This slug is an omnivore and will eat rotting vegetables and rubbish such as cardboard, but also living plant parts, dung and carrion.

Range

It is native to the southwest of Europe and possibly native to Britain and Ireland, but introduced to large parts of central, southern and northern Europe and the USA.

Distribution – Ireland

The distribution is hampered by its confusion with other species, it is likely to be still localised but spreading.

Distribution - Britain

The distribution is hampered by its confusion with other species, it is likely to be still localised but spreading, particularly in the south west of England.

Conservation Status

Britain: None

Ireland: None

Threats

No immediate threats to this widespread species.

Arion fuscus (Müller, 1774)

Synonyms: There is considerable difficulty in separating *Arion fuscus* in Britain and Ireland with *Arion subfuscus* (Draparnaud, 1805). The latter was considered to be synonomised with *Arion fuscus* for Northern Europe (Falkner *et al*., 2001). However, *Arion subfuscus* remains a good species, and both are considered to be present in Ireland (Anderson, 2005). Based on internal dissection, Anderson concluded that only one Irish specimen conformed to *Arion fuscus,* while the rest of the Irish specimens and the British specimens were of *Arion subfuscus*.

Photo: Michal Maňas

Identification literature

There is no reliable way of distinguishing this species externally from *A. subfuscus*, dissection of the ovotestis is required, and described by Pinceel *et al.* (2004). Genetic analyses have confirmed these distinctions (Jordaens *et al*., 2006).

Brief description of species

Medium sized slug with extended length from 5-7cm. Colour very variable, with a darker longitudinal band on each side of the body, passing above and below the respiratory pore. Tubercles small but elongate. The sole is yellowish in colour but with colourless mucus, but the body mucus is bright yellow to orange in colour. Caution is required as this description also fits *Arion subfuscus*.

Habitats

The only specimen of *Arion fuscus* that Anderson (2005) was able to definitely attribute to the morphotype as accepted by ovotestis attributes was from mountain habitat on Clare Island, Co. Mayo. Elsewhere in its current range the habitats it lives in are very widespread from woods to coastal habitats to gardens and agricultural land.

Microhabitats & Habits

Not described for the Irish site but elsewhere it inhabits damp rotting refugia but feeds indiscriminately on whatever is available.

Generation time/longevity

These slugs are hermaphrodite. Animals live for a year to eighteen months.

Dispersal mechanisms and translocation

This species has spread widely, and likely to be due to inadvertent transportation by man.

Food

This species is omnivorous and opportunistic in its food range.

Range

Widespread distribution in Europe and has been found in the USA as an exotic species.

Distribution – Ireland

Known from one site in county Mayo (Anderson, 2005)

Distribution - Britain

Not listed as present in Britain (Anderson, 2005)

Conservation Status

Britain: None

Ireland: None

Threats

No immediate threats to this widespread species, likely to spread.

Arion subfuscus Draparnaud, 1805

Photo: Derek Rands

Common name: Dusky slug

Synonyms: There is considerable difficulty in separating *Arion subfuscus* in Britain and Ireland with *Arion fuscus* (Müller, 1774). *Arion subfuscus* was considered to be synonomised with *Arion fuscus* for Northern Europe (Falkner *et al*., 2001). However, Anderson (2005) states that most of the Irish and all of the British specimens he studied were *Arion subfuscus.*

Identification literature

There is no reliable way of distinguishing this species externally from *A. fuscus*, dissection of the ovotestis is required, and described by Pinceel *et al*. (2004). Genetic analyses have confirmed these distinctions (Jordaens *et al.,* 2006).

Brief description of species

Medium sized slug with extended length from 5-7cm. Colour very variable, with a darker longitudinal band on each side of the body, passing above and below the respiratory pore. Tubercles small but elongate. The sole is yellowish in colour but with colourless mucus, but the body mucus is bright yellow to orange in colour. Caution is required as this description also fits *Arion fuscus*.

Habitats

The habitats of this species are varied, it is widespread in disturbed habitats, woodland, grasslands, coastal dunes.

Microhabitats & Habits

Arion subfuscus microhabitats are damp shaded areas, but at night it emerges to feed widely.

Generation time/longevity

These slugs are hermaphrodite. Animals live for a year to eighteen months. Mating has been described from March to May, but may extend further into the year. Eggs are opaque and leathery which hatch after 3-5 weeks.

Dispersal mechanisms and translocation

This species has been widely dispersed by man, but is likely to be native to Britain and Ireland. Man is likely to be its most effective form of dispersal.

Food

This is an omnivorous slug that can feed on living and rotting plants and thus can be a pest.

Range

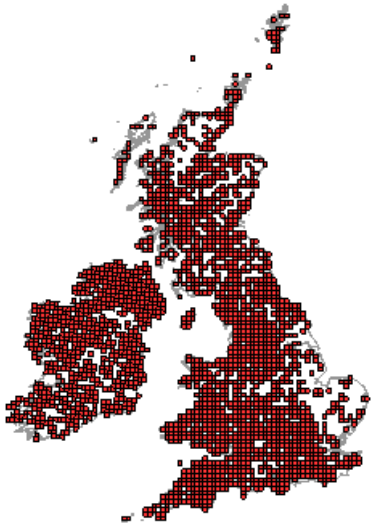
European, but has spread to the USA, although may possibly be native there (Kerney, 1999).

Distribution – Ireland

Widespread throughout

Distribution - Britain

Widespread except for East Anglia, where it lives in old woods.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None, widespread and likely to continue spreading.

Arion circumscriptus Johnston, 1828

Photo: Evelyn Moorkens

Common name: Bourguignat's slug

Synonyms: *Arion fasciatus* Quick, 1960 *non* Nilsson

The three slugs of the subgenus *Carinarion* have been listed as separate species in by CLECOM (Falkner *et al.*, 2001a) and by Anderson (2005), but Geenan *et al.* (2006) have cast doubt on the species differences in the three, *Arion circumscriptus*, *Arion fasciatus* and *Arion silvaticus*.

Identification literature

Kerney & Cameron (1979) provide external descriptions and show differences in the distal genitalia of the three.

Brief description of species

The three *Carinarion* species are small slugs (3-5cm fully extended). *Arion circumscriptus* is distinguished by being dark grey or occasionally brown in colour, with black specks on the mantle, becoming lighter towards the foot fringe. There is one thin dark longitudinal band on each side. The sole is white, and the sole and body mucus is colourless. Internally it has pigmentation specks on the epiphallus.

Habitats

Arion circumscriptus lives in most habitats, wild and cultivated.

Microhabitats & Habits

This slug can be found in damp shaded refugia during the day, mostly under rotting timber.

Generation time/longevity

Reproduction occurs with greater speed in this group than the other Arionids, with less extrusion of the genitalia. Eggs are laid from May to September, and hatch after 4 weeks or more. Animals are annual or may live slightly longer.

Dispersal mechanisms and translocation

Although probably native to Britain and Ireland, this slug has been distributed widely by man.

Food

Mainly rotting plant material in more natural habitats but can carry out considerable damage to living plants in gardens and in agricultural crop fields such as young oilseed rape.

Range

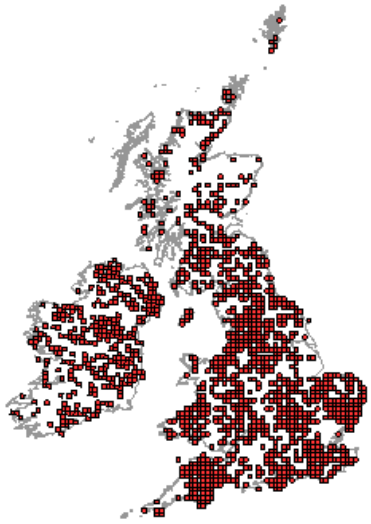
This species is widely spread in the north west of Europe.

Distribution – Ireland

Widespread throughout Ireland except for more acid habitats.

Distribution - Britain

Widespread throughout Britain except for northern Scotland and the more acid habitats elsewhere.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None, widespread and likely to continue spreading.

Arion fasciatus (Nilsson, 1823)

Photo: Evelyn Moorkens

Common name Orange banded Arion

Synonyms: The three slugs of the subgenus *Carinarion* have been listed as separate species in by CLECOM (Falkner *et al.,* 2001a) and by Anderson (2005), but Geenan *et al.* (2006) have cast doubt on the species differences in the three, *Arion circumscriptus*, *Arion fasciatus* and *Arion silvaticus*.

Identification literature

Kerney & Cameron (1979) provide external descriptions and show differences in the distal genitalia of the three.

Brief description of species

Slightly larger than the other two *Carinarion* at 4-5cm fully extended, so this species is still a small to medium slug. It has a greyish tinge, becoming paler at the sides, with a yellow tinge that is most apparent just below the dark lateral bands. The sole is grey-white, and the sole and body mucus is colourless. Internally it has no pigmentation specks on the epiphallus, and the shape of the atrium is a distinguishing feature.

Habitats

Arion fasciatus lives in most habitats, but tends to be more associated with cultivated than wild habitats.

Microhabitats & Habits

This slug can be found in damp shaded refugia during the day, moving about at night to feed on young seedlings and foliage.

Generation time/longevity

Reproduction occurs with greater speed in this group than the other Arionids, with less extrusion of the genitalia. Eggs are laid from May to September, and hatch after 4 weeks or more. Animals are annual or slightly longer.

Dispersal mechanisms and translocation

Although likely to be native to Britain and Ireland it is showing signs of spreading through man's aid to disturbed areas.

Food

This species is happy to eat a wide range of growing and rotting vegetation.

Range

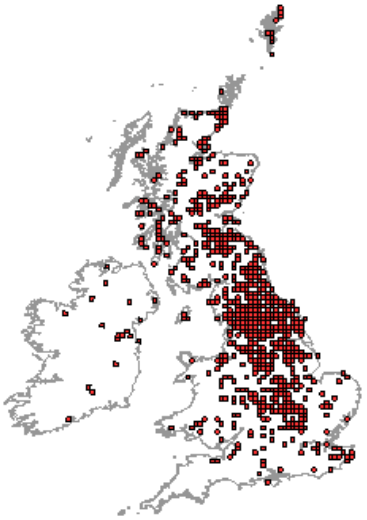
Falkner *et al.* (2001) indicate that it is very widely distributed in Europe.

Distribution – Ireland

The distribution pattern in Ireland is patchy, but it is likely to be underrecorded.

Distribution - Britain

Widely distributed and appears to be still spreading.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None, continuing to spread.

Arion silvaticus Lohmander, 1937

Photo: Roy Anderson

Common name Forest Arion

Synonyms: The three slugs of the subgenus *Carinarion* have been listed as separate species in by CLECOM (Falkner *et al.*, 2001a) and by Anderson (2005), but Geenan *et al.* (2006) have cast doubt on the species differences in the three, *Arion circumscriptus*, *Arion fasciatus* and *Arion silvaticus*.

Identification literature

Kerney & Cameron (1979) provide external descriptions and show differences in the distal genitalia of the three.

Brief description of species

Small to medium slug, with extended length of up to 4cm. The body is normally pale grey in colour, and fades to a pale whitish at the sides, with a dark band on each side. Body and sole mucus are colourless, and the sole colour is white. Internally, the epiphallus has only slight or no pigmentation.

Habitats

This species is mostly found in woodland, moorland, hedge, scrub and heath in moist, sheltered litter and vegetation. It is not dependant on the presence of calcium, and can be found in quite acid environments.

Microhabitats & Habits

This slug can be found in moist shaded vegetation and litter, under logs in wooded environments.

Generation time/longevity

Reproduction occurs with greater speed in this group than the other Arionids, with less extrusion of the genitalia. Eggs are laid from May to September, and hatch after 4 weeks or more. Animals are annual or may live slightly longer.

Dispersal mechanisms and translocation

Native and probably widespread, translocated through plant material and general movement for food at night.

Food

This slug feeds on rotting vegetation and associated detritus.

Range

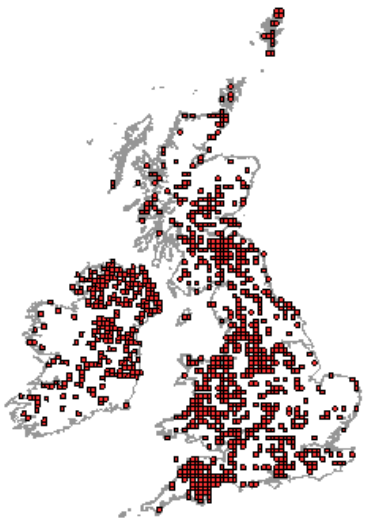
This species has a European range.

Distribution – Ireland

Widespread where it has been surveyed since the species was distinguished from *A. circumscriptus* in the 1960's.

Distribution - Britain

Widespread where it has been surveyed since the species was distinguished from *A. circumscriptus* in the 1960's.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Arion distinctus Mabille, 1868

Photo: Evelyn Moorkens

Common name The darkface Arion

Synonyms: *Arion hortensis* 'species A' Davies, 1977

Identification literature

This species is described in Davies (1977) under the name *Arion hortensis* 'species A'.

Brief description of species

This is a small slug, measuring 2-4cm in adulthood when extended. It is blue-black in colour with darkly pigmented bands on the body and mantle, and variations of yellow and orange pigmentation that changes during the lifetime of the animal, sometimes giving the impression of a dirty brown overall look. The body and sole mucus is orange in colour. The most distinguishing feature is tentacle colour, which in its transparent base shows grey colouring, with a greenish tinge, never a red tinge. Lateral body bands are normally visible when looking at an individual from above. According to Davies (1977), internally the flap covering the termination of the epiphallus within the atrium resembles *Arion intermedius* rather than *A. hortensis*. A useful matrix of character difference separations of the five members of the *Kobeltia* sub-genus currently known from Britain and Ireland is found in Anderson (2004).

Habitats

This is a pest species with a very wide range of habitats and foods. It lives everywhere from natural woodland to gardens to agricultural land.

Microhabitats & Habits

The slug will take refuge in damp places but is otherwise very catholic in its habits.

Generation time/longevity

The life strategy is generally annual, with a wide variation of breeding time, from summer through to winter, laying around 30 eggs which develop quickly in summer (3-4 weeks), and slower in

colder temperatures (10 weeks or more). Winter eggs are robust and survive to mature the following spring, while the adults die off in harsh conditions.

Dispersal mechanisms and translocation

These animals are easily dispersed by movements of garden or agricultural plants, boxes, pots and machinery.

Food

This slug feeds on rotting vegetation, live vegetation, particularly fresh seedlings and seeds.

Range

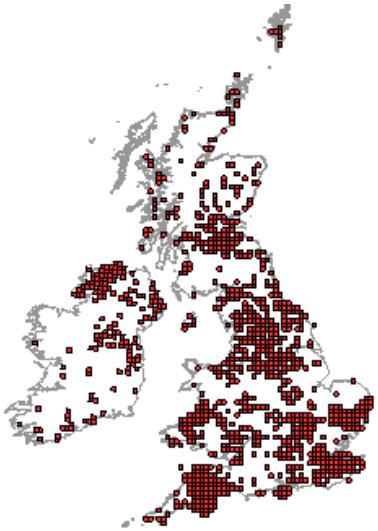
This species is likely to be native to Britain and Ireland and its range is western and southern European. It has spread via man widely across the world.

Distribution – Ireland

This is a very widespread slug where it has been looked for, and likely to be underrecorded, and widely confused with *A. hortensis*.

Distribution - Britain

This is a very widespread slug where it has been looked for, and likely to be underrecorded, and widely confused with *A. hortensis*.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Arion hortensis Férussac, 1819

Common name The small striped slug

Synonyms: *Arion hortensis* 'species R' Davies, 1977

Photo: Evelyn Moorkens

Identification literature

This species is described in Davies (1977) under the name *Arion hortensis* 'species R'.

Brief description of species

This is a small slug, measuring 2-4cm in adulthood when extended, and very similar in appearance to *A. distinctus*. Old descriptions of slugs of this name may include *A. distinctus*. Davies (1977) describes the size and texture of this slug being very similar to *A. distinctus* but with a slightly rougher appearance. It is blue-black in colour, often with red overtones, with darkly pigmented bands on the body and mantle. The body and sole mucus is orange in colour. The most distinguishing feature is tentacle colour, which in its transparent base shows red tinges of colouring. The lateral body bands are often lower on the body than in *A. distinctus*, such as they would not normally be visible if looking at the slug from directly above. According to Davies (1977), pigmentation on internal organs can also include a red tinge, and the ovotestis is often brown to mauve-grey in colour. Internally a stiff flap 1mm in length projects between the terminations of the epiphallus and the spermatheca duct. A useful matrix of character difference separations of the five members of the *Kobeltia* sub-genus currently known from Britain and Ireland is found in Anderson (2004).

Habitats

This is a pest species with a very wide range of habitats and foods. It lives everywhere from natural woodland to gardens to agricultural land.

Microhabitats & Habits

The slug will take refuge in damp places but is otherwise very catholic in its habits.

Generation time/longevity

Adult *A. hortensis* are more conspicuous in autumn and winter, but rather earlier than *A. distinctus*. The breeding season can last from July to well into the winter, with copulation being long, 80-100 minutes. A total of 367 eggs in 16 clusters over 4 months was noted by Davies (1977), and animals live for one year.

Dispersal mechanisms and translocation

They are easily dispersed by movements of garden or agricultural plants, pots and machinery.

Food

This slug feeds on rotting vegetation, live vegetation, particularly fresh seedlings and seeds.

Range

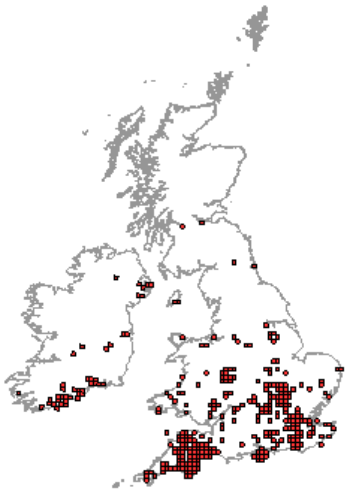
This species is likely to be native to Britain and Ireland and its range is western and southern European. It has spread via man widely across the world.

Distribution – Ireland

This slug has been recorded widely in the past, but there is still confusion as to how widespread it is, as older records are likely to have been *A. distinctus*. Given its pest status, it is likely to be widely spread.

Distribution - Britain

This slug has been recorded widely in the past, but there is still confusion as to how widespread it is, as older records are likely to have been *A. distinctus*. Given its pest status, it is likely to be widely spread.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Arion intermedius Normand, 1852

Photo: Evelyn Moorkens

Common name: The hedgehog slug

Synonyms: *Arion minimus* Simroth

Identification literature

Kerney & Cameron (1979) provide external descriptions and drawings.

Brief description of species

Although this species is a member of the problematic *Kobeltia* sub-genus, it is easily identified on external characteristics. It is a small species, with a maximum extended length of 2cm, pale white to grey with a yellowish tinge, with a darker head and tentacles, and can have faint longitudinal bands. The sole is pale to golden yellow and the mucus is yellow, not the dark orange of the *A. hortensis* group. It contracts into a hump, making the tubercles strong and pointed, giving a hedgehog appearance. This also occurs in other slug species juveniles, particularly *A. owenii*, so care must be taken in using this identifying feature. A useful matrix of character difference separations of the five members of the *Kobeltia* sub-genus currently known from Britain and Ireland is found in Anderson (2004).

Habitats

This species is mostly found in woodland, hedges, scrub and pastures. It is not dependant on the presence of calcium, and can be found in poor soil environments.

Microhabitats & Habits

This slug is commonly found under logs in woodland or fallen branches from trees in fields.

Generation time/longevity

Studies in captivity (Davies, 1977) have shown irregular reproduction patterns but only self-fertilisation. The slug is an annual species, and aestivates for long periods, emerging in cooler weather towards winter.

Dispersal mechanisms and translocation

This slug has spread widely but is likely to be native to Britain and Ireland. It has not shown any distributional changes over time, and appears to remain within relatively natural habitats and is not considered to be a pest.

Food

This species feeds within moist litter. It appears to be happy with relatively low nutrient food, such as dead leaves, rather than seeking out young shoots, and for this reason has not developed into a pest.

Range

The range of this species is native to Western European into Southern Scandinavia, but it has been introduced from Europe to other parts of the world such as New Zealand and Chile.

Distribution – Ireland

Arion intermedius is very widespread in Ireland, across poor acidic areas and relatively high altitudes.

Distribution - Britain

Arion intermedius is very widespread in Britain, across poor acidic areas and relatively high altitudes.

Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Arion occultus Anderson, 2004

Photo: Roy Anderson

Identification literature

Illustrations, colour photographs and descriptions of the animal and its reproductive system are given in Anderson (2004). This is a very newly described species, so all information to date comes from the species description by Anderson (2004).

Brief description of species

This species belongs to the *Arion hortensis* group (subgenus *Kobeltia*), and is similar to *A. hortensis, A. distinctus and A. owenii.* It is a medium sized slug (up to 4cm extended) and forms a bell-shaped appearance at rest. The body is yellowish-grey with some underlying dark brown colouration, with strongly raised tubercles that appear irregularly oblong, and keeled or ridged. It has thick lateral bands and the body pigmentation is paler below these bands. The tentacles are dark and blue grey to blue black in colour. The sole is pale yellow to orange, and the mucus is weak and orange in colour. Internal differences also occur, most notable the lack of serration on the spermatophore. The species is fully described in Anderson (2004), and this paper also includes a useful matrix of character difference separations of the five members of the *Kobeltia* sub-genus currently known from Britain and Ireland.

Habitats

This species is currently known from one site in County Down, from Bank Lodge Woods. It can be found in sandy soil in a plantation of *Acer pseudoplatanus* (Anderson, 2004).

Microhabitats & Habits

It is associated with the herb layer of mature woodland and more disturbed ground nearby. It appears to differ from *A. hortensis* and *A. distinctus* by becoming inactive or hibernating in winter and more active between April and September. The species is largely subterranean.

Generation time/longevity

It is likely to be a mainly annual species like the other members of the sub-genus. There are two main periods of reproduction, in spring and autumn. Animals have been observed mating, with coitus lasting 60-70 minutes. Eggs are laid in batches of 10 to 20 with clutch sizes of up to 50. Hatching takes 4-6 weeks.

Dispersal mechanisms and translocation

Unknown

Food

Unknown, but unlikely to differ from similar species.

Distribution

It is not yet known whether the species is confined to its type locality or under-recorded.

Range

Northern Ireland.

Distribution – Ireland

Known only from a few sites in County Down, Northern Ireland.

Distribution - Britain

Currently unknown from Britain.

Conservation Status

Britain: None

Ireland: None

Threats

None known

Arion owenii Davies, 1979

Photo Adrian Sumner

Common name The warty slug

Synonyms: *Arion hortensis* 'species B' Davies, 1977

Identification literature

This species is another of the *Arion hortensis* aggregates from the subgenus *Kobeltia,* described in Davies (1979) and illustrated in Davies (1977) under the name *Arion hortensis* 'species B'. A useful matrix of character difference separations of the five members of the *Kobeltia* sub-genus currently known from Britain and Ireland is found in Anderson (2004).

Brief description of species

This species has distinctive sharply ridged tubercles, although they are not as strong as those of *A. occultus* and *A. intermedius*, and body colour is typically dark brown with dark bands, greyish sides and a very pale yellow sole. The mantle bands are parallel, not converging towards the anterior end. It has a flattened appearance at rest, like *A. hortensis* and *A. distinctus*, and sole mucus is orange in colour. Internal differences are also diagnostic, particularly the spiral twisting of the spermatophore keel.

Habitats

The type location for this species is Buncrana from the Inisowen peninsula, and the name *A. owenii* comes from the name "Owen" associated with Inishowen and Tyrone. The habitat is described as "tree stumps on long wet grass". It has since been found at a number of sites in Scotland, England and Wales and in the south of Ireland in both wild and disturbed moist, sheltered habitats.

Microhabitats & Habits

Arion owenii has been found under ground litter and within the soil where moist habitat exists.

Generation time/longevity

This species has been kept in captivity for many years by Davies. She found it to be an annual species, mating between September and January. The new generation is half to fully grown by August and reproducing by September to October. This breeding time was also observed by

Davies in the wild. Mating was observed in captivity, with coitus lasting around 45 minutes, and eggs laid in clusters of about 16 with 10 to 30 eggs in each.

Dispersal mechanisms and translocation

Unknown, but unlikely to differ from similar species.

Food

Probably capable of extracting nutrient from a range of living and rotting foods, was fed in captivity on a variety of such foods.

Range

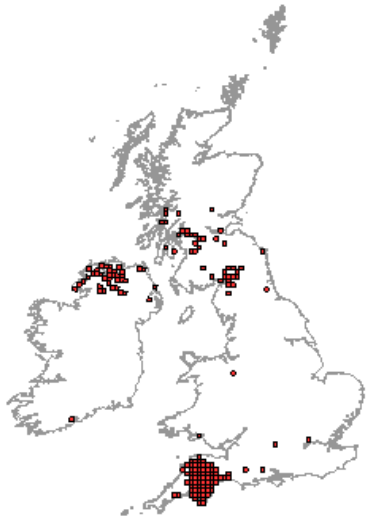
This species has been recorded in Ireland, Britain, Brittany and Norway.

Distribution – Ireland

Northern distribution with records from Cork. This species appears to be locally common where it has been found, and is likely to be under-recorded, although recording effort to date suggests that it is not very widespread.

Distribution - Britain

Common in Devon but with scattered records across a wide area. This species appears to be locally common where it has been found, and is likely to be under-recorded, although recording effort to date suggests that it is not very widespread.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Boetgerilla pallens Simroth, 1912

Common name: Worm slug

Synonyms: *Boettegerilla vermiformis* Wiktor

Photo: Evelyn Moorkens

Identification literature

A description and illustrations of this species can be found in Kerney & Cameron (1979).

Brief description of species

This species is unmistakable due to its narrow, worm-like and pale translucent appearance. It does not resemble any other slug. It is small to medium, with an extended length of 3-4cm. It appears white and ghostly, but its colour is actually a translucent greyish yellow. It has a keel and the head is a darker bluish-grey, with this grey tinge continuing onto the mantle. The sole is pale yellow, and the mucus is colourless.

Habitats

The worm-like characteristics of this slug make it easy to burrow underground or into very narrow crevices, and consequently this species is associated with disturbed ground, rubbish heaps, quarries and roadside verges. It can also be found in woodland habitats, gardens and parks.

Microhabitats & Habits

This slug is often found under cardboard, stones or bricks in moist areas. It is likely to be buried during dry periods and thus fewer observations will be made during these conditions.

Generation time/longevity

This is an annual species with mating from early autumn, egg laying up to late October, and hatching between October and December.

Dispersal mechanisms and translocation

This species has spread widely and rapidly from its native origins, and is likely to disperse easily on a local level through its own movements, and considerable distances through attachment to rubbish that is inadvertently moved over longer distances.

Food

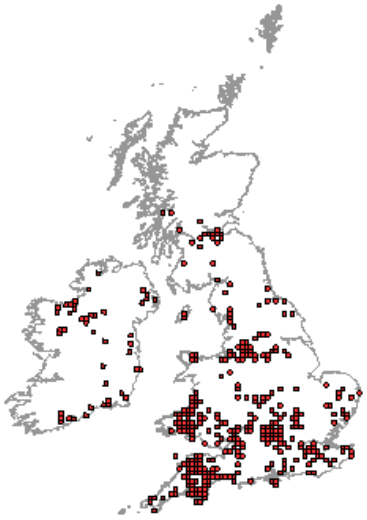
This slug will feed on soil detritus, rotting vegetation, live root plants and carrion. It can cause some damage in greenhouse or market garden situations but is not otherwise considered to be a major agricultural pest.

Range

The native range of *B. pallens* is thought to be the Caucasus of south-east Europe. It has spread widely within Europe and to North America.

Distribution – Ireland

First recorded in Ireland in 1973 (Anderson & Norris, 1974) and since then has spread widely but locally. The distribution of this species is somewhat local, probably through chance movements and then local spreading, making its continuing spread unpredictable and uneven for the short to medium term.



Map from NBN based on Kerney (1999)

Distribution - Britain

First recorded in England and Wales in 1972 (Colville *et al*., 1974), and in Scotland in 1983 (Kerney, 1999). Rapid but uneven spread has taken place since then. The distribution of this species is somewhat local, probably through chance movements and then local spreading, making its continuing spread unpredictable and uneven for the short to medium term.

Conservation Status

Britain: None

Ireland: None

Threats

None

Deroceras agreste (Linnaeus, 1758)

Common name Milky slug

Synonyms: *Agriolimax agrestis* (Linnaeus)

Photo: Roy Anderson

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

A medium slug with extended length normally up to 5cm. It is usually a pale uniform oatmeal colour, unlike speckled appearance of *D. reticulatum*. Tubercles are not pronounced, and the head and tentacles appear darker than the rest of the body. The sole is creamy white and the mucus is colourless to milky white when irritated. The identification can be confirmed by dissection by its very simple, single penial appendage.

Habitats

This species lives in moist, natural and semi-natural grassy habitats and roadside verges of higher altitudes (in Britain, it is mainly found in upland areas of Scotland). It is also known from the Norfolk Broads in marshy habitat.

Microhabitats & Habits

D. agreste retreats under stones when at rest. It emerges in moist conditions and can feed on a wide range of decaying and young living plant material.

Generation time/longevity

Mating occurs in the autumn, but a spring hatch is also common, with eggs laid approximately 10 days after mating. Hatching follows in 2-3 weeks and animals are annual. Self-fertilisation is possible. This slug is an annual species.

Dispersal mechanisms and translocation

Its absence from Ireland suggests that this species is not as easily spread as others, although it is probably spread through man within its current distribution.

Food

This species can tolerate a wide range of food types and likes young living plants in the wild (e.g. meadow flowering plants) and in agricultural situations.

Range

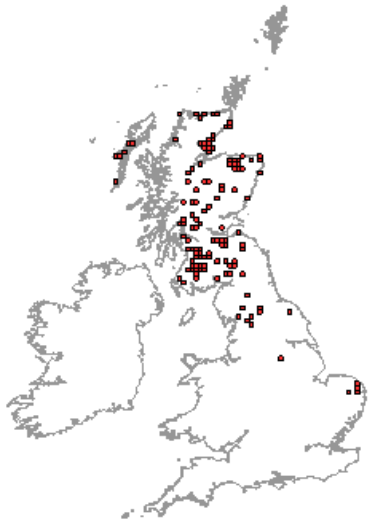
This species has a Western Palaearctic range.

Distribution – Ireland

This species has not been recorded in Ireland

Distribution - Britain

Mainly Scottish distribution and isolated localised areas including the Norfolk Broads.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Deroceras laeve (Müller, 1774)

Common name: Marsh slug

Synonyms: *Agriolimax laevis* (Müller)

Photo: Evelyn Moorkens

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

This is a small slug, with a maximum extended length of 2.5cm. It is chestnut brown in colour, with a lighter coloured mantle and a darker, flecked body. The patterns on the body are fewer and larger than in closely related species, giving a slightly wrinkled appearance to the slug. There is a pale rim around the respiratory pore, and the keel is short and markedly truncated. The sole is pale brown in colour and the mucus is colourless and not as apparent as in other *Deroceras* species. Identification is obvious without dissection, but there are also internal differences from other related species, most notably the presence of a long, sinuous penis with a single appendage. However, many individuals are aphallic and will self-fertilise.

Habitats

Deroceras laeve is a fen and marsh species, and is found towards the wetter profiles of these habitats rather than the drier margins.

Microhabitats & Habits

This species enjoys long periods of activity both day and night thanks to the very moist conditions it lives in, and moves quite fast relative to most slug species. It can be found grazing amongst rotting saturated grass and herb litter.

Generation time/longevity

This species has rather prolonged mating activity, lasting over an hour, with eggs laid singly or in small clusters, hatching after 4-5 weeks. The species is annual, but reproduction is opportunistic rather than seasonal and adults can be found at all times of the year.

Dispersal mechanisms and translocation

The fossil record for this species dates back to the Pleistocene, and the slug has spread throughout its Holarctic range where habitat allows. Probably more isolated in modern times due to disjunctive habitat distribution.

Food

Grazes rotting leaves and roots and presumably micro flora associated with decay.

Range

Holarctic

Distribution – Ireland

Widespread in fen and marsh habitats

Distribution - Britain

Widespread in fen and marsh habitats

Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Deroceras panormitanum Lessona & Pollonera, 1882

Photo: Evelyn Moorkens

Common name: Caruana's slug, Sicilian slug

Synonyms: *Deroceras caruanae* (Pollonera)

Agriolimax caruanae (Pollonera)

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

This is a small to medium slug, with a maximum extended length of 3.5cm. It is pale to medium brown in colour, with a translucent appearance and lighter coloured mantle and a darker, flecked body. There is a very pronounced pale rim around the respiratory pore, and the keel is short and markedly truncated. The sole is grey in colour and the mucus is colourless. An aid to identification is its extreme activity compared with other slug species; it moves very fast and thrashes its tail end quite aggressively when irritated. External features are sufficient for identification, but it also identifiable by internal differences from other related species, most notably its bilobed penis with 4-6 long, serrated appendages.

Habitats

This species is common in gardens and parks, flower-beds and waste ground, and sometimes in hedgerows and fields, often in these latter habitats when near to the coast.

Microhabitats & Habits

This species likes damp habitats with stones or other refugia, with a source of young plant material to graze. It displays aggressive behaviour, attacking nearby animals and at times cannibalism.

Generation time/longevity

This species breeds throughout the year, with small eggs being laid in clusters of up to 50, which hatch in approximately 3 weeks, depending on temperature variation. Some isolated individuals will self-fertilise. Animals generally live for around one year.

Dispersal mechanisms and translocation

It appears that this species can spread locally, but mechanisms and tendencies to spread over a wider area are not well understood, and there are considerable areas within its range where the species has not been recorded.

Food

This species eats a wide range of living and decaying plant species and carrion.

Range

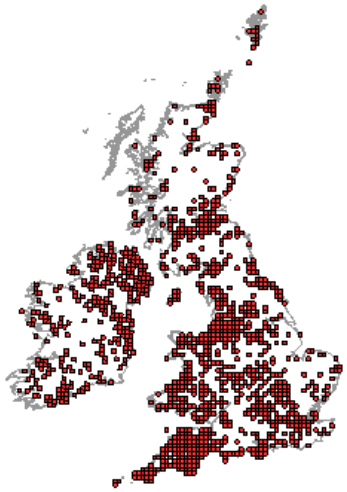
This species has a native south west European range, and has spread to isolated areas elsewhere in Europe and across the world.

Distribution – Ireland

Widespread in places but rarer in midlands.

Distribution - Britain

Widespread in south west and rarer in north and east, except in coastal areas.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Deroceras reticulatum (Müller, 1774)

Photo: Evelyn Moorkens

Common name: Field slug, milky slug

Synonyms: *Agriolimax reticulatus* (Müller)

Agriolimax agrestis (non Linnaeus)

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

This is a medium slug, with a maximum extended length of around 5cm. It is pale cream to medium brown to grey in colour, with a solid rather than translucent appearance, a more uniform coloured mantle and with darker flecks - the dark pattern being most apparent in the grooves between the tubercles, which are strongly distinct. There is a very slight pale rim around the respiratory pore, and the keel is short and truncated. The sole is pale in colour and the mucus is colourless to milky white when irritated and very sticky in nature. External features are sufficient for identification, but it also identifiable by internal differences from other related species, most notably the presence of a rectal caecum and its variable penial appendages, two or more and wider than those of *D. panormitanum*.

Habitats

A very wide variety of habitats are used by this species, form agricultural fields to gardens to hedges and grasslands. It can be found in the centre of very large fields, and is a major pest both to the farmer and gardener.

Microhabitats & Habits

This species takes refuge in soil crevices and under stones and emerges in cool humid conditions and will voraciously eat living and decaying plants.

Generation time/longevity

Mating occurs throughout the year, eggs are laid approximately 10 days later, and hatch in 2 to 3 weeks depending on temperature. Up to 700 eggs can be produced by each individual during a season, and isolated specimens can self-fertilise. This is an annual species.

Dispersal mechanisms and translocation

This species has no difficulty in being transported by man on plants, packaging and rubbish. It is already virtually ubiquitous throughout its European range and has spread to Africa and America, where it is a serious economic pest.

Food

The slug will graze on any source of cellulose, live and rotting vegetation, paper and cardboard, and carrion.

Range

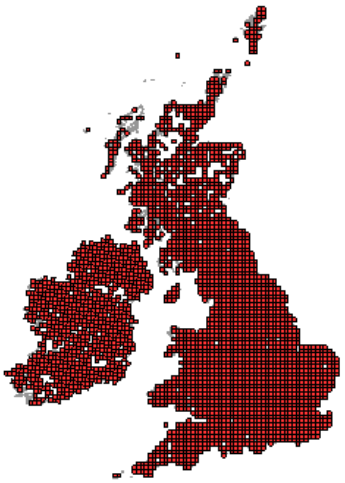
Its natural range is European, but has been carried by man to Africa and America.

Distribution – Ireland

Very widespread throughout Ireland

Distribution - Britain

Very widespread throughout Britain



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Geomalacus maculosus Allman 1843

Common name Kerry Slug, Spotted Slug

Photo: Evelyn Moorkens

Identification literature

Kerney & Cameron (1979), Platts & Speight (1988), Rodriguez *et al*. (1993), Castillejo *et al*. (1994), Castillejo (1997) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

This is a large slug, with a length of around 8cm. It has two main colour forms, a dark greenish grey to black with creamy yellow spots, and a paler medium brown with yellow spots, with spots both on the mantle and body. There are two somewhat darker lateral bands on each side and the tubercles are long and elongated. The sole is pale creamy white and the mucus is colourless to milky when irritated. External features are sufficient for identification, and a particular feature is that it rolls into a ball when disturbed, unlike any other slug species in Ireland. It is also identifiable by internal differences (Quick, 1960), but dissection is unnecessary for identification.

Habitats

In Ireland, the Kerry slug is restricted to the sandstone geology of West Cork and Kerry. Within this range, it lives in two broad habitat types. The first type is oak dominated woodland, or mixed deciduous woodland with a mixture of oak and birch. The habitat is often sloping, with outcropping of rock or with boulders scattered amongst the trees. The second broad habitat is open situations of unimproved oligotrophic open moor or blanket bog with large sandstone boulders.

Microhabitats & Habits

Both trees and rock are in undisturbed, humid conditions and clean air, with a good lichen, or mixture of lichen, liverwort and moss flora. In this habitat, slugs can graze the organic film of the lichen and associated flora of both trees and rocks.

Within the open ground habitat sandstone outcrops and boulders, largely bare of vegetation except for lichens and mosses, provide the same food to graze as in the woodland habitat.

The slugs emerge in humid conditions, during daylight hours after rain, or else during the night. They are notoriously difficult to locate in dry conditions, and can elongate and flatten themselves to take refuge in crevices, and lengths of up to 12cm can be reached during such movements.

Generation time/longevity

Copulation and reproduction details are given by Platts & Speight (1988), with eggs deposited in batches of 18 – 30, between July and October. The slug is capable of self-fertilisation also. Eggs are large, approximately 6 - 8.5mm by 3 - 4.25mm, and take 6 – 8 weeks to hatch. Juveniles take two years to mature, and in total can live for up to seven years.

Dispersal mechanisms and translocation

Little is known about dispersal of this species, but it has spread across most of its possible sandstone range in the humid conditions of south-west Ireland.

Food

While the Kerry slug can be fed in captivity on porridge, carrots and other vegetables, in the wild it has only been observed feeding on lichens, liverworts and mosses growing on rock outcrops in both habitat types, mature trees and timber (Boycott & Oldham, 1930; Platts & Speight, 1988; Rosas *et al*., 1992; Rodriguez *et al.*, 1993; Speight, 1996). This restricted diet appears to have prevented its expansion into wider habitats, thus unlike species from other genera of this family, *Geomalacus* is not a pest species, and remains associated with wild habitats away from the influence of man.

Range

The species has a very restricted world distribution, and can be described as Lusitanian, known only from south-west Ireland, and northern Spain and Portugal. A record for the species from Brittany, France has never been confirmed (Simroth, 1891; Platts & Speight, 1988; Falkner *et al.*, 2002).

Distribution – Ireland

Sandstone geology in Cork and Kerry.

Distribution - Britain

Absent.

Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: Protected under the Irish Wildlife Act, 1976, and the EU Habitats Directive (Annex II, Annex IV); Red list: Least Concern (Moorkens, 2006; Byrne *et al*., 2009)

Threats

Habitat change from natural to intensive usage, include intensification of land use, tourism and general development pressure, expansion of coniferous plantation forestry, and spread of exotic species such as *Rhododendron* into its semi-natural woodland habitat, which would result in losses of the slug. Although it has a restricted world distribution, it is still widespread in Cork and Kerry.

Lehmannia marginata (Müller, 1774)

Common name: Tree slug

Synonyms: *Limax marginatus* Müller

Limax arborum Bouchard-Chantereaux

Photo: Evelyn Moorkens

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions, internal and external drawings.

Brief description of species

This is a medium to large slug with an extended length of up to 8cm. It has a very translucent appearance after rain when moving, less so at rest, but has a gelatinous look following this absorption of water in wet weather. It is grey in colour, but can be considerably paler and have a golden brown appearance in the mantle area, while still retaining a granulated grey pigment. It has two darker body bands on each side, and a pair of mantle bands that form a lyre shape. It has a short keel, which stands out as paler than the body. The sole is greyish white. The mucus is colourless, and very watery and copious when the slug is irritated. It does not need dissection for identification, but can be identified internally by a single pointed flagellum appending the penis.

Habitats

This is a species of both old and relatively new deciduous woodland, including gardens and parks with trees and can also be found in some suitable open habitats, with exposed rocks or old stone walls, in areas of high rainfall.

Microhabitats & Habits

In dry weather *L. marginata* takes refuge in crevices in the bark or roots of trees, but in wet conditions will be found crawling on the trees, at all heights of the tree trunk.

Generation time/longevity

Mating occurs in the winter months, on horizontal, vertical or overhanging surfaces. They can take up to two months to hatch and the 10mm young already show the lyre shaped mantle bands. In contrast to the Arionids and Milacids, the Limacids live for two to three years and can have multiple breeding events.

Dispersal mechanisms and translocation

Although mainly a tree species, the ability of this species to graze old walls is likely to aid its movement into nearby habitat, otherwise it will rely on passive transportation by man.

Food

This species grazes lichens and mosses on trees and walls, but can take a wider range of food if the necessity arises.

Range

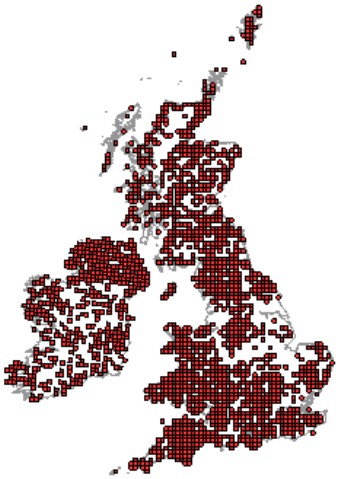
This species has a European range extending to southern Finland and Sweden.

Distribution – Ireland

Native and widespread where habitat is suitable

Distribution - Britain

Native and widespread where habitat is suitable. Possible losses where atmospheric pollution is evident.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

Habitat destruction and air pollution may restrict this species distribution in the future.

Lehmannia nyctelia (Bourguignat, 1861)

Synonyms: *Limax nyctelius* Bourguignat

Photo: Roy Anderson

Identification literature

Identification and genitalia illustration of *Lehmannia nyctelia* are given by Quick (1960) and Kerney & Cameron (1979), but most information on the species is from southern Europe and Australia, where it is a pest.

Brief description of species

This slug is very like *Lehmannia valentiana* but internally separable by the absence of a penile appendage. It is a medium slug with extended length of about 5cm. The body is a pale yellow-grey, translucent in appearance with dark lateral bands high up near the mid-line. It also has lyre shaped bands on the mantle. The respiratory pore has a pale border, and the keel is short. The sole is grey-white and the mucus colourless.

Habitats

The species is only known from greenhouses in Britain, and naturalised in a garden in Devon (Anderson, 2004).

Microhabitats & Habits

The species is not recorded widely enough in Britain to establish habits to establish microhabitats and habits clearly. In its native range, it is mainly a woodland species.

Generation time/longevity

Details of reproduction are not well described, but like other Limacids, it is likely to live for two to three years and have two to three breeding events.

Dispersal mechanisms and translocation

This species has been dispersed by man as a greenhouse alien.

Food

The species is not recorded widely enough in Britain to establish its food requirements. In its native range, it feeds on woodland detritus. In warmer regions where it has been introduced, it has become a crop pest.

Range

This slug is native to North Africa but has been introduced to Britain, elsewhere in Europe, North America, Australia, New Zealand and South Africa.

Distribution – Ireland

Unrecorded in Ireland

Distribution - Britain

Greenhouse alien and naturalised in Devon garden

Conservation Status

Britain: None

Ireland: None

Threats

None

Lehmannia valentiana (Férussac, 1821)

Common name: Greenhouse slug

Synonyms: *Limax valentianus* Férussac

Limax poirieri Mabille

Photo: Derek Rands

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

Difficult to distinguish from *Lehmannia nyctelia,* but is also similar to *Lehmannia marginata*, although the habitats are different. This is a medium slug with an extended length of up to 6cm. It also has a translucent and watery appearance. It is yellowish-grey in colour, with a short, inconspicuous keel. It has two darker body bands quite high up near the mid-dorsal line, and a pair of dark mantle bands that form a lyre shape. The area within the lyre shape can be darker and a mottled brown colour. The sole is uniform and pale, and the mucus is colourless and watery. It can be identified internally by a single bluntly cylindrical flagellum appending the penis.

Habitats

This was a greenhouse alien for over 100 years, but is now found in the open in disturbed habitats and gardens, where it can be a pest.

Microhabitats & Habits

Unlike *L. marginata*, it does not climb trees and can be found crawling on the ground in damp conditions or taking refuge under stones or wood.

Generation time/longevity

This species lives for two to three years with multiple breeding events. Limited information on mating suggests that the species mate in winter, eggs hatch in February and the new generation is full grown by June.

Dispersal mechanisms and translocation

This species is dispersed by man, particularly through commercial nurseries.

Food

This slug is a ground feeder, is not specific in its nutrition needs and will eat growing plants.

Range

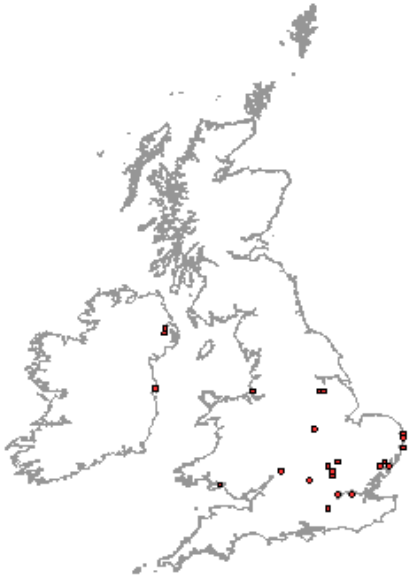
This slug is native to the Iberian Peninsula but is now widely spread across Europe and America.

Distribution – Ireland

Known from greenhouses since 1948, and naturalised in the wild since 1981.

Distribution - Britain

Naturalised in the East Midlands and Merseyside following many years as a greenhouse alien.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Limacus flavus (Linnaeus, 1758)

Photo: Ben Rowson

Common name: Yellow slug

Synonyms: *Limax flavus* (Linnaeus)

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions, internal and external drawings.

Brief description of species

This is a large slug, with a length of up to 10cm. It is a yellow to greenish colour, with darker pigmentation showing through. The mantle has a mottled appearance with yellow blotches. The tentacles have a very characteristic pale steel blue colour. There are no lateral or mantle bands. The respiratory pore has a thin pale rim. The sole is pale yellow in colour, and the mucus is yellow. The slug is identifiable by the above external features, and also differs internally, most notably by a characteristically long and convoluted penis.

Habitats

This slug is found in woodland but is also strongly associated with man and is a common feature of country gardens, cellars, unheated kitchens and sheds. It is often attracted to pet food left in cool places in the evening. In Ireland the slug is rarer and more associated with wild habitats, particularly coastal ones.

Microhabitats & Habits

In woods, it is found under logs and bark, and in gardens it takes refuge in wall crevices and between overlapping wood in fencing. It is nocturnal in habit, and can travel over considerable distances foraging for food. Chelazzi *et al*. (1988) describe airborne odours and trails being useful in bringing individuals together in shared refugia, and presumably this close proximity aids in locating mates.

Generation time/longevity

Mating occurs between August and February and is very fast compared to other species, taking approximately half a minute. Eggs are laid in clusters of up to twenty and are lemon shaped rather

than round. They hatch in three to six weeks and are a pale colour, already with blue tentacles evident. They can live for up to 3 years and reproduce more than once.

Dispersal mechanisms and translocation

This species has moved widely via man's activities.

Food

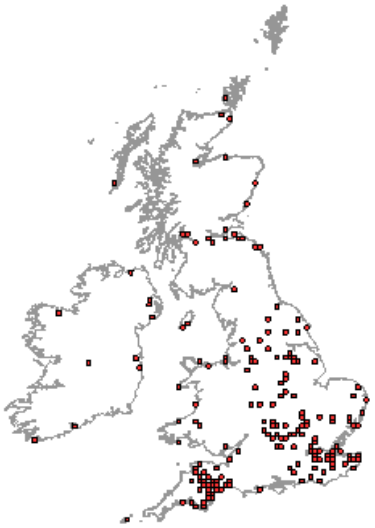
This species eats decaying plant material, fungi and lichens, and can graze algae, mildew and household rubbish.

Range

This slug is native to the Mediterranean and into Western Europe but spread throughout Europe and Africa, Australia and the Americas.

Distribution – Ireland

The distribution of this species in Ireland is not fully understood as this species has been commonly confused with *L. maculatus* and many old records have been discarded by Kerney (1999). It is probably a genuinely local species in Ireland, where *L. maculatus* is the much more common of the two species.



Map from NBN based on Kerney (1999)

Distribution - Britain

Some old records may have been confused with *L. maculatus* but a wide distribution in coastal and lowland areas is evident.

Conservation Status

Britain: None

Ireland: None

Threats

None

Limacus maculatus (Kaleniczenko, 1851)

Photo: Evelyn Moorkens

Synonyms: *Limacus pseudoflavus* (Evans, 1978)

Limax grossui Lupu

Limax maculatus (Kaleniczenko, 1851)

Limax pseudoflavus Evans, 1978

Identification literature

Kerney & Cameron (1979) provides descriptions and internal and external drawings.

Brief description of species

This is a large slug, with a length of up to 13cm. It is a greenish grey colour with mottling, giving an appearance of yellow spots on an olive body. The tentacles are grey in colour, not the characteristic blue of *L. flavus*. There are no lateral or mantle bands. The respiratory pore has a thin pale rim. The sole is cream in colour, and the sole mucus is colourless, and body mucus slightly yellow. The slug is identifiable by the above external features, and also differs internally, most notably by a characteristically short and slightly curved penis.

Habitats

In Ireland, it is found in woodlands, road verges, parks, ruins, and in the sort of proximity to humans that *L. flavus* is found. It is a common night visitor to damp kitchens in Ireland.

Microhabitats & Habits

In woods, it is found under logs and bark, and in gardens it takes refuge in wall crevices and between overlapping wood in fencing. It is nocturnal in habit, and can climb and travel over considerable distances foraging for food.

Generation time/longevity

Mating occurs in the autumn and winter. Egg clusters of up to twenty are laid and hatch in four to six weeks. They can live for up to 3 years and reproduce more than once.

Dispersal mechanisms and translocation

This species has spread widely in Ireland through man and through slow active dispersal by the slug.

Food

This species eats decaying plant material, algae, fungi and lichens, and can graze mildew and household rubbish.

Range

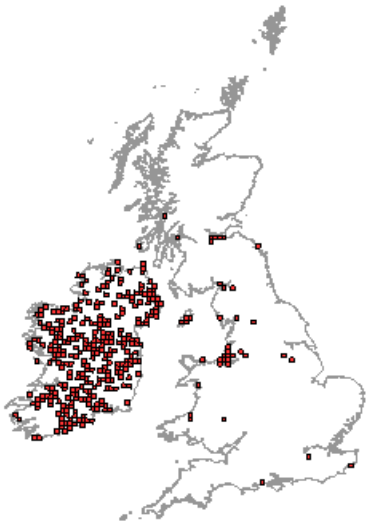
This species is thought to be native to the deciduous forests of the Crimea and the Caucasus. It has been spread widely by man across Europe.

Distribution – Ireland

It is widespread and common except on acid dominated habitats.

Distribution - Britain

It is rare but may be extending its range.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Limax cinereoniger Wolf, 1803

Photo : Evelyn Moorkens

Common name: Ash-black slug

Synonyms: *Limax antiquorum* Férussac (in part)

Limax maximus Grey (in part)

Arion lineatus Dumont

Limax cinereus var. intermedia Brevière

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions, internal and external drawings.

Brief description of species

This is a large slug, with a length of up to 20cm. It is ash black in colour with large coarse tubercles and faint dark black longitudinal body bands. The tentacles are spotted with black. The keel is long and pale. The sole is white in the centre but darker at both edges and the sole and body mucus is colourless. The slug is identifiable by the above external features, and also differs internally, most notably by a very long and coiled penis.

Habitats

This is a species of natural woodlands, often on sloping situations with lichen-covered rocks.

Microhabitats & Habits

Limax cinereoniger finds refuge under fallen timber and in crevices in bark. It is mainly active at night or following heavy rain, and can be seen grazing on trees or rocks when conditions are suitable. It is not considered to be a pest.

Generation time/longevity

An elaborate mating mechanism takes place in mild conditions throughout most of the year, on vertical and overhanging surfaces. The slugs hang from a disc of mucus and intertwine both their bodies and their very long evaginated penes and sperm packets are exchanged. The courtship and mating takes about 20 minutes. Eggs are laid and hatch a month later. The slug can take 2 years to become fully mature and individuals live for 5-6 years.

Dispersal mechanisms and translocation

It is likely that this slug actively dispersed over a long period of time when its habitat was more widespread. It is now likely to be restricted by the isolation of its habitats.

Food

This species feeds on fungi, decaying litter and lichens.

Range

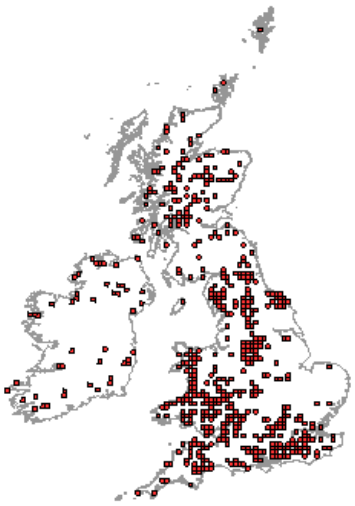
This is a European species that is widespread but local.

Distribution – Ireland

Widespread but rare, as is old native woodland in Ireland. Many of the records shown on the map, particularly from the southern half of the country are from earlier than 1965.

Distribution - Britain

More widespread than in Ireland, reflecting the higher density of old native woodland, but there are some signs of decline.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: Not protected, falls under red list category of VU [A2c] (Moorkens, 2006; Byrne *et al*., 2009)

Threats

Limax cineroniger is a characteristic species of old deciduous woodland. It has a very scattered and fragmented distribution. Threats include over-tidy management of woodlands resulting in the removal of invertebrate habitats such as old logs and rocks.

Limax maximus Linnaeus, 1758

Common name: Great grey slug, Leopard slug

Synonyms: *Limax cinereus* Müller

Limax antiquorum Férussac (in part)

Photo: Derek Rands

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

This is a large slug, with a length of up to 20cm. It is pale brown to grey in colour with small and relatively fine tubercles and two to three dark longitudinal body bands. The tentacles are a dark red brown and not spotted. The keel is short. The sole is white throughout and the sole and body mucus is colourless and quite sticky in nature. The slug is identifiable by the above external features, and also differs internally, most notably by a very long and coiled penis that is thicker towards the proximal end, not uniform as in *L. cineroniger*.

Habitats

This species is much more widespread than *L. cineroniger*, being found in woodlands, hedges, farm margins, outhouses, cellars and large gardens.

Microhabitats & Habits

This slug hides in crevices and under logs during the day, and is active at night, climbing trees and walls to graze and mate.

Generation time/longevity

An elaborate mating mechanism takes place at night from overhanging surfaces. The slugs hang from a mucus filament and intertwine both their bodies and their evaginated penes and sperm packets are exchanged. After exchange, the slugs climb back up the mucus thread. Eggs are laid in spring and autumn and hatch six weeks later. The slug can take 2 years to become fully mature and individuals live for 5-6 years.

Dispersal mechanisms and translocation

This is a large slug and capable of easy active dispersal within macrohabitats. It is likely to be passively distributed by man with ease.

Food

This species feeds on fungi and decaying matter.

Range

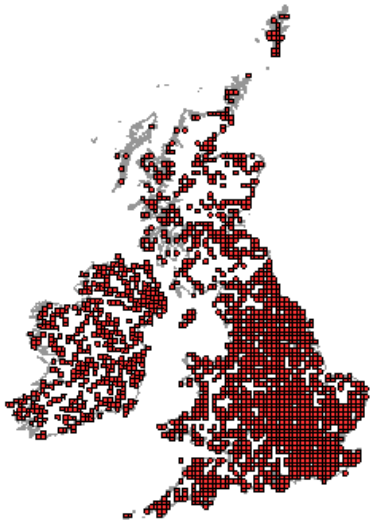
This is a European species originating in southern and western Europe but it has also spread to northern Europe, Africa, America, Australia and New Zealand.

Distribution – Ireland

Widespread and common in suitable habitats

Distribution - Britain

Widespread and common in suitable habitats



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Malacolimax tenellus (Müller, 1774)

Common name: Slender (or tender) slug, lemon slug

Synonyms: *Limax tenellus* Müller

Photo: Roy Anderson

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

This is a small slug, with a length of up to 3.5 to 4cm when extended. It is yellow in colour with a black head and tentacles, small and relatively fine tubercles and faint dark longitudinal body bands. It has a translucent appearance. The keel is short. The sole is yellowish white throughout. The sole mucus is colourless and the body mucus is yellow to orange and quite profuse when the body is irritated. The slug is identifiable by the above external features, and also differs internally, most notably by a short, simple penis with no appendages.

Habitats

This is a very locally distributed species of larger semi-natural old woodland, on a variety of soils from chalk and limestone to neutral and slightly acid. Its habitats include the extensive old English Beech woodlands and the larger remnants of Scot's Pine forest in Scotland.

Microhabitats & Habits

This species is nocturnal, taking refuge under litter by day and emerging at night to feed on fungi.

Generation time/longevity

Mating occurs late in the year and courtship lasts up to an hour and a half. Eggs are laid from November to March in clusters of about 15, and can take up to 4 months to hatch. Young emerging slugs are white with violet tentacles.

Dispersal mechanisms and translocation

It seems that this species has very poor powers of dispersal, as it appears to have been unable to reach isolated woodlands that have now been established for over three hundred years.

Food

This species is a ground feeder of fungi.

Range

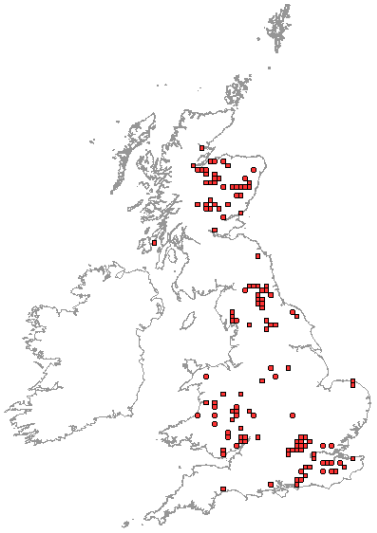
M. tenellus is native to Northern and Central European, but very local throughout its range.

Distribution – Ireland

M. tenellus is not known from Ireland

Distribution - Britain

Locally distributed where habitat is suitable.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

There is some evidence of local losses and no real likelihood of expansion; threats include habitat loss or reduction and poor management of the forest floor habitat. The production of sufficient fungi depends on maintaining a good portion of rotting litter and timber.

Milax gagates (Draparnaud, 1801)

Photo: Adrian Sumner

Common name: Jet slug

Synonyms: *Limax gagates* Draparnaud

Amalia parryi Collinge

Amalia babori Collinge

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

This is a medium slug, with a length of up to 6cm when extended. It is dark grey to black in colour with a black head and tentacles. The tubercles are flat and the slug appears very smooth. There are faint dark longitudinal body bands. The keel strong, with a sharp angle towards the posterior. The sole is white, and sole mucus and body mucus is colourless. The slug is identifiable by the above external features, and also differs internally, most notably by the form of the stimulator in the atrium.

Habitats

This species is found in both wild places, in gardens and close to other human habitation and agriculture, but is most frequently found in coastal areas, particularly damp grasslands.

Microhabitats & Habits

Found in damp and sometimes rotting grassland roots. Can be a pest species in agricultural situations, especially of root crops.

Generation time/longevity

In coastal areas, reproduction can take place at any time of year. This is generally a biennial species, with only one breeding event, either in spring or autumn.

Dispersal mechanisms and translocation

It is transferred by man and by active dispersal within habitats.

Food

Roots and decaying matter, agricultural root crops.

Range

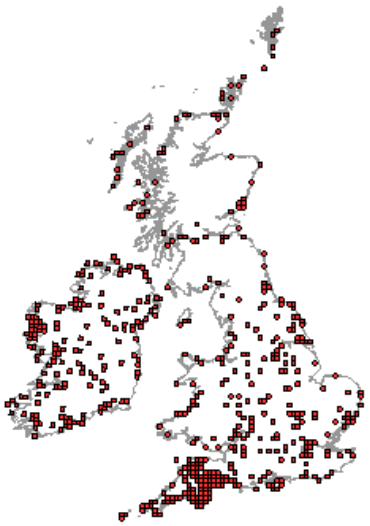
This species is native to West Mediterranean and West European Atlantic regions, but has spread to Northern and Central Europe and has been widely introduced across the world.

Distribution – Ireland

Mainly coastal but with local records widely distributed inland.

Distribution - Britain

Mainly coastal but with local records widely distributed inland.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Tandonia budapestensis (Hazay, 1881)

Photo: Evelyn Moorkens

Common name: Budapest slug

Synonyms:

Milax budapestensis (Hazay)

Amalia budapestensis Hazay

Milax gracilis (Leydig)

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

This is a medium slug, with a length of up to 5cm when extended. It is variably dark in colour, mainly grey brown with a yellowish tinge. The keel is orange in colour. The grooves between the tubercles are darkly pigmented, and a dark rim surrounds the respiratory hole. The sole is a yellowish white colour, and the mucus is generally colourless but becoming yellowish at the mantle when irritated. The slug is particularly identifiable by forming a curved "C" shape at rest rather than hunching like other species. The slug is identifiable by the above external features, and also differs internally, most notably by the absence of a stimulator in the atrium.

Habitats

Tandonia budapestensis is an agricultural pest, a very common species in crop fields and also common in gardens and parks.

Microhabitats & Habits

Frequently found amongst the roots of agricultural crops and under stones and logs in disturbed areas.

Generation time/longevity

This species mates in winter, with a very long courtship lasting all night and well into the following day, under cover of stones or logs. Eggs are laid some weeks after, take up to 3 months to hatch. This species has a biennial life cycle.

Dispersal mechanisms and translocation

This species is easily dispersed by man.

Food

This is a notable pest species and will voraciously eat crops as well as more natural decaying litter and detritus in more natural situations.

Range

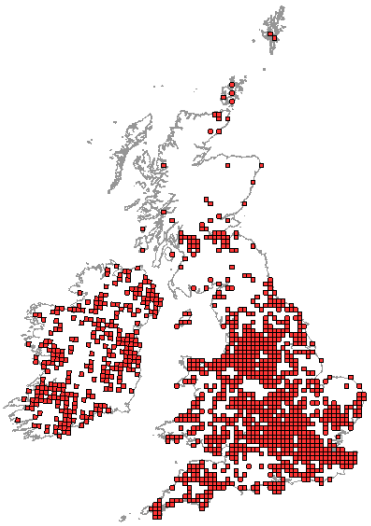
The species is European, but may have been native to a restricted area. It has been spread across Europe and the world by man.

Distribution – Ireland

Widely spread throughout.

Distribution - Britain

Widely spread throughout England and Wales, less so in Scotland, but is probably still spreading.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

Tandonia rustica (Millet, 1843)

Synonyms: *Milax rusticus* (Millet)

Milax marginatus (Draparnaud**)**

Photo: Evelyn Moorkens

Identification literature

Kerney & Cameron (1979) provide descriptions and internal and external drawings.

Brief description of species

This is a large slug, with a length of up to 8-10cm when extended. It is pinkish in colour with black spotting, particularly in the grooves between the tubercles, and the body is much paler below the mid-point of the body. The keel is also pale. There is a pale rim around the respiratory hole, and a pair of black bands in the mantle area. The sole is a yellowish white colour, and the mucus is generally colourless but sometimes becoming whitish. The slug is identifiable by the above external features, and also differs internally, most notably by the accessory glands at the atrium.

Habitats

This species is found in Europe in woodlands and calcareous mountain slopes. It is known from very few places in Britain and Ireland, but notably from large parkland estate grounds, such as Blarney (Cawley, 1996).

Microhabitats & Habits

This species takes refuge during dry conditions, and emerges in humid or nocturnal conditions to graze.

Generation time/longevity

This information is not known for Britain or Ireland, and most information comes from Wiktor (1989).

Dispersal mechanisms and translocation

This species does not appear to be spreading, and could possibly be native to Ireland (a similarly described slug was mentioned by Stelfox (1911).

Food

This species food has not been studied in Britain or Ireland. In Europe, the slug grazes woodland detritus and fungi.

Range

This species is native to Southern and Central Europe

Distribution – Ireland

A few records from the Cork area.

Distribution - Britain

A few records from the Kent area.

Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None. Red listed – VU [D2] Byrne *et al*. (2009)

Threats

Currently restricted and therefore has some vulnerability.

Tandonia sowerbyi (Férussac, 1823)

Photo: Roy Anderson

Common name: Keeled (or Sowerby's) slug

Synonyms: *Milax sowerbyi* (Férussac, 1823)

Identification literature

Kerney & Cameron (1979) and Quick (1960) provide descriptions and internal and external drawings.

Brief description of species

This is a medium to large slug, with a length of up to 7.5cm when extended. It has a brown colour with black blotches, giving a greyish tinge to the slug. The grooves between tubercles are dark. The respiratory pore has a pale orange rim, and the keel is a pronounced orange colour. The sole is white, and the mucus is very sticky and yellowish in colour. The slug is identifiable by the above external features, and also differs internally, most notably by the form of the stimulator in the atrium.

Habitats

This slug can be found in gardens, hedges and agricultural fields, where it can be a serious pest. It can be found in wilder habitats near the coast.

Microhabitats & Habits

Tandonia sowerbyi can burrow underground and take refuge there for considerable periods of time. It can feed underground on roots, and thus is a major pest of root vegetables such as carrots and potatoes.

Generation time/longevity

This species appears to mainly reproduce in the winter, and mating lasts up to 18 hours. Eggs are laid in small clusters of up to 12, and hatch in 4 to 6 weeks.

Dispersal mechanisms and translocation

This species has been very widely spread by man and is likely to be easily dispersed via transportation of vegetables containing the slug.

Food

This species is omnivorous, but most frequently lives on roots and tubers, particularly vegetable crops.

Range

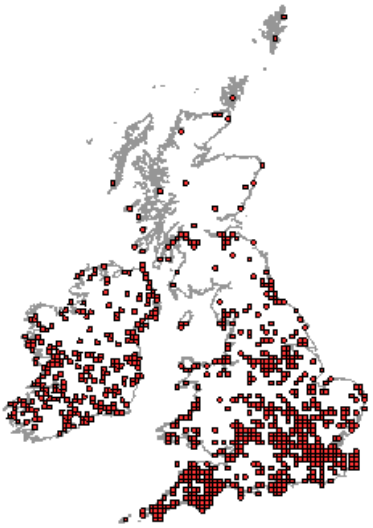
Mostly Mediterranean but widely introduced to Western Europe (Ireland, Britain, France, The Netherlands) and elsewhere across the world.

Distribution – Ireland

A common species, particularly in lowland situations and near the coasts.

Distribution - Britain

A common species, particularly in lowland situations and near the coasts. More localised in Scotland and Wales than in England.



Map from NBN based on Kerney (1999)

Conservation Status

Britain: None

Ireland: None

Threats

None

BIBLIOGRAPHY & RELEVANT LITERATURE

Aldridge, D.C. (1999) The morphology, growth and reproduction of Unionidae (Bivalvia) in a Fenland waterway. *Journal of Molluscan Studies* **65**: 47-60.

Aldridge, D.C. (2000) The impact of dredging and weed cutting on a population of freshwater mussels. *Biological Conservation* **95**, 247-257.

Aldridge, D.C. & Müller, S.J., (2001) The Asiatic clam, *Corbicula fluminea*, in Britain: current status and potential impacts. *Journal of Conchology* **37**: 177-184.

Aldridge, D.C. & McIvor A.L., (2003) Gill evacuation and release of glochidia by *Unio pictorum* and *Unio tumidus* (Bivalvia: Unionidae) under thermal and hypoxic stress. *Journal of Molluscan Studies* **69**: 55-60.

Aldridge, D.C.; Elliott, P. & Moggridge, G., (2004) The recent and rapid spread of the zebra mussel (*Dreissena polymorpha*) in Great Britain. *Biological Conservation* **119**: 253-261.

Altena C. O. & Van Regtfren (1956) Notes sur les limaces, 3. (Avec la collaboration de Mm. D. Aten et A. R. Schouten) Sur la presence en France de'*Arion lusitanicus* Mabille *Journal de Conchyliologie* **95**: 89-99.

Altena C. O. & Van Regteren (1963) Notes sur les limaces. 8. Sur l'état de deux especes nominales du genre *Arion*. *Basteria* **27**: 1-6.

Anderson R. (2004) *Arion occultus* sp. nov., a new slug in *Arion* subgenus *Kobeltia*, from Ireland. *Journal of Conchology* **38**: 13-26.

Anderson R. (2005) An Annotated List of the Non-Marine Mollusca of Britain and Ireland. *Journal of Conchology* **38(**6): 607-637.

Anderson R. & Norris, A. (1974) *Boettgerilla pallens* Simroth, new to Ireland. *Journal of Conchology* **28**: 207-208.

Araujo, R. & Ramos, M.A. (2001) Action plans for *Margaritifera auricularia* and *Margaritifera margaritifera* in Europe. *Nature and Environment*, No. **117**. Council of Europe Publishing, Strasbourg.

Backeljau, T., Baur, A., & Baur, B. (2001) Population and conservation genetics, *in* Barker, G.M. (ed.) *The biology of terrestrial molluscs*, CAB International, Egham.

Baillie, J., & Groombridge, B. (Eds) (1996) *1996 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland and Cambridge, UK.

Baker, S.M. & Levinton, J.S. (2003) Selective feeding by three native North American freshwater mussels implies food competition with zebra mussels. Hydrobiologia **505**: 97-105.

Bamber, R.N. & Taylor, J.D. (2002) The brackish water mussel *Mytilopsis leucophaeta* (Conrad, 1831) (Bivalvia: Dreissenidae) in the River Thames. *Journal of Conchology* **37**: 403-404.

Bank R.A. (2004) Fauna Europaea Project: Mollusca, Gastropoda. http://www.faunaeur.org/ index.php.

Bank R.A., Groh K. & Ripken T. E. J. (2002) Catalogue and bibliography of the non-marine Mollusca of Macaronesia *In*: Falkner, M., Groh, K. & Speight, M. C. D. (eds) Collectanea Malacologica, Festschr für Gerhard Falkner Conchbooks, Hackertheim, pp. 89-235.

Barker, G.M., (2001) *The biology of terrestrial molluscs*. CABI publishing. 558pp.

Barr, R. A. (1927) Some notes on the mucous and skin glands of *Arion ater*. *Quarterly Journal of Microscopical Science* **71**:503-525.

Bass, J. A. B. (1979) Growth and fecundity of *Pisidium amnicum* (Miiller) (Bivalvia: Sphaeriidae) in the Tadnoll Brook, Dorset, England. – *Journal of Conchology* **30**: 129-134.

Bass, J., Blackburn, J. & Giraudy, C., (2003) Range extension of the 'Witham orb mussel' *Sphaerium solidum* (Normand) (Bivalvia: Sphaeriidae) or an overlooked resident of the Great Ouse. *Journal of Conchology* **38**: 60-65.

Bauer, G., (1987) Reproductive strategy of the freshwater pearl mussel *Margaritifera margaritifera*. *Journal of Animal Ecology* **56:** 691-704.

Bauer, G., (2001) Factors affecting naiad occurrence and abundance p.155-162. *In*: Bauer, G. & Wachtler, K. (eds) *Ecology and evolution of the freshwater mussels Unionoida*. (Ecological Studies 145) Springer 394pp.

Bauer, G. & Vogel, C., (1987) The parasitic stage of the freshwater pearl mussel *Margaritifera margaritifera*. I. Host response to Glochidiosis. *Archiv fur Hydrobiologie* **76:** 393-402.

Bauer G & Wächtler K (Eds.) (2000) Ecology and Evolution of the Freshwater Mussels Unionoida. *Ecological Studies, Vol. 145*. Springer, Berlin.

Bilton, D.T., Freeland, J.R. & Okamura, B., (2001) Dispersal in freshwater invertebrates. *Annual Review of Ecological Systems* **32**: 159–81.

Biodiversity Steering Group (1996) *Biodiversity: The UK Steering Group Report. Volume 2 Action Plans*. Her Majesty's Stationery Office, London.

Boycott, A.E. (1936) Habitats of fresh-water Mollusca in Britain. *Journal of Animal Ecology* **5**: 116-186.

Boycott, A. E. & Oldham, C. (1930) The food of *Geomalacus maculosus*. *Journal of Conchology* **19**: 36.

Bratton, J.H. (ed) (1991) *British Red Data Books: 3. Invertebrates other than insects*. Joint Nature Conservation Committee, Peterborough. 253 pp.

Burgio, G. & Sommaggio, D. (2007) Syrphids as landscape bioindicators in Italian agroecosystems. *Agriculture, ecosystems and environment* **120**, 416-422.

Burky, A.J., Hornbach, D.J. & Way, C.M. (1981) Growth of *Pisidium casertanum* (Poli) in west central Ohio. *Ohio Journal of Science* 81: 41-44.

Byrne, A., Moorkens, E.A., Anderson, R., Killeen, I.J. & Regan, E.C. (2009) *Ireland Red List No. 2 – Non-Marine Molluscs*. National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Cameron, R.A.D., Eversham, B. & Jackson, N. (1983). A field key to the slugs of the British Isles. *Field Studies* **5**:807-824.

Castillejo J. (1997) Babosas del Noroeste Ibérico Universidade de Santiago de Compostela, Spain. l9

Castillejo, J., Garrido, C. & Iglesias, J. (1994) The slugs of the genus *Geomalacus* Allman, 1843, from the Iberian peninsula (Gastropoda: Pulmonata: Arionidae) *Basteria* **58**: 15-26.

Cawley, M. (1996) *Tandonia rustica* (Millet) (Mollusca: Gastropoda) new to Ireland. *Irish Naturalists Journal* **25**: 183-185.

Chelazzi, G., Le Voci, G. & Parpagnoli, D. (1988) Relative importance of airborne odours and trails in the group homing of *Limacus flavus* (Linnaeus) (Gastropoda, Pulmonata) *Journal of Molluscan Studies* **54**: 173-180

Chesney H.C.G. & Oliver P.G. (1998) Conservation issues for the Margaritiferidae in the British Isles and western Europe. In: *Molluscan conservation: a strategy for the 21st Century. Journal of Conchology. Special Publication No. 2***.** Eds. IJ Killeen, MB Seddon, & AM Holmes, pp. 231-242. Conchological Society of Great Britain and Ireland.

Chesney H.C.G., Oliver, P.G. & Davis, G.M. (1993) *Margaritifera durrovensis* Phillips, 1928; taxonomic status, ecology and conservation. *Journal of Conchology* **34**: 267-299.

Chevallier H. (1981) Taxonomie des "Limaces rouges" (genre Anon, sous-genre Anon s.s., Mollusca, Pulmonata) *Haliotis* **11**: 87-99.

Clarke, A.H., (1981) The freshwater molluscs of Canada. National Museum of Natural Sciences, S. Ottawa. 446pp.

Claudi, R. & Mackie, G.L. (1993) *Practical Manual for Zebra Mussel Monitoring and Control*. Lewis, Boca Raton, Florida.

Colville, B., Lloyd Evans, L. & Norris, A. (1974) *Boettgerilla pallens* Simroth, a new British species. *Journal of Conchology* **28**: 203-207.

Comfort, A., (1957) The duration of life in molluscs. *Proceedings of the Malacological Society of London* **2**: 219-241.

Cosgrove, P.J., Hastie, L.C. & Young, M.R. (2000) Freshwater pearl mussels in peril. *British Wildlife* **11**: 340-347.

Davies S. M. (1977) The *Arion hortensis* complex, with notes on *A. intermedius* Normand (Pulmonata: Arionidae) *Journal of Conchology* **29**: 173-187.

Davies S. M. (1979) Segregates of the *Arion hortensis* complex (Pulmonata: Arionidae) with the description of a new species, *Arion owenii*. *Journal of Conchology* **30**: 123-128.

Davies S. M. (1987) *Arion flagellus* Collinge and *A. lusitanicus* Mabille in the British Isles: a morphological, biological and taxonomic investigation. *Journal of Conchology* **32**: 339-354.

Davison, M. (2006) *Corbicula fluminea* in the River Thames. *Mollusc World* **10**: 15.

Dillon, R.T. (2000) *The Ecology of Freshwater Molluscs*. Cambridge University Press. 509pp.

Dussart, G.B. (1979) *Sphaerium corneum* (l.) and *Pisidium* spp. Pfeiffer — the ecology of freshwater bivalves in relation to water chemistry. *Journal of* Molluscan *Studies* **45**: 19-34.

Falkner, G. (2000) *Sphaerium (Nucleocyclas) nucleus* (S. Studer, 1820) in Bayern (Bivalvia: Sphaerioidea) *Heldia* **3**: 11-18.

Falkner, G. & Klee, B. (2006) "*Limax cinereoniger* (Gastropoda: Stylommatophora) – eine Sammelart?" Meeting of the German Malacological Society 2006, Giessen, Germany

Falkner, G. & Klee, B. (2007) "Extreme length development of the penis in the terrestrial slug genus Limax: a case of sexual selection? (Gastropoda: Limacidae)"; **9**. World Congress of Malacology, Antwerp, Belgium.

Falkner, G., Bank, R.A. & von Proschwitz, T. (2001a) Check-list of the non-marine molluscan species-group taxa of the states of northern, Atlantic and central Europe (CLECOM 1) *Heldia* **4**: 1-76.

Falkner G., Ripken, T. F. J. & Falkner, M. (2002) Mollusques continentaux de France Liste de Référence annotée et Bibliographie. Patrimoines Naturels, 52, Museum d'Histoire Naturelle, Paris. 350pp.

Falkner G., Obrdlik P, Castella E & Speight M. C. D. (2001b) *Shelled Gastropoda of Western Europe*. Friedrich-Held-Gesselschaft, Münich.

Foltz D. W., Ochman H., Jones, J. S., Evangelisti Sm., & Selander R.K. (1982) Genetic population structure and breeding systems in arionid slugs (Mollusca: Pulmonata) *Biological Journal of the Linnean Society* **17**: 225-241.

Forcart I. (1986) *Limacus maculatus* (Kaleniczenko) und *Limacus flavus* (Linnaeus) *Mitteilungen dei Deutschen Malakozoologischen Gesellschaft* **38**: 21-23.

Gale, W. F. (1971) An experiment to determine the substrate preference of the fingernail clam, *Sphaerium transversum*. *Ecology* **52**: 367-370.

Gale, W. F. (1977) Growth of the fingernail clam, *Sphaerium transversum* (Say) in field and laboratory experiments. *Nautilus* **91**: 8-12.

Gammell, M., (2007) Two new records for *Mytilopsis leucophaeta* in Britain. *Mollusc World* **13**: 11.

Garrido C., Castillejo J, & Iglesias J. (1995) The *Arion subfuscus* complex in the eastern part of the Iberian Peninsula, with redescription of *Arion subfuscus* (Draparnaud, 1805) *Archiv für Molluskenkunde* **124**: 103-118.

Geenen, S., Jordaens, K. & Backeljau, T. (2006) DNA sequences and the systematics of the Carinarion complex (Mollusca: Gastropoda: Pulmonata): A taxonomic riddle caused by a mixed breeding system. *Biological Journal of the Linnean Society*, **89**: 589-604.

Geist, J. & Kuehn, R. (2005) Genetic diversity and differentiation of central European freshwater pearl mussel (*Margaritifera margaritifera* L.) populations: implications for conservation and management. *Molecular Ecology* **14**: 425-439.

Giusti F. (1973) Notulae Malacologicae, XVIII. I molluschi terrestri e salmastri delle Isole Eolie. *Lavori del Societe Italiana di Biogeografica (Nuova Serie)* **3**: 113-306.

Giusti F., Manganelli G. & Schembri P. J. (1995) *Non-marine molluscs of the Maltese Islands*, Monografie di Museo Regionale di Scienze Naturali, Torino, **15**: 1-607.

Guralnick, R., (2004) Life-history patterns in the brooding freshwater bivalve *Pisidium* (Sphaeriidae) *Journal of Molluscan Studies* **70**: 341-351.

Haase M. (1993) The genetic differentiation in three species of the genus Hydrobia and systematic implications (Caenogastropoda, Hydrobiidae) *Malacologia* **35**: 389-398.

Haukioja, E. & Hakala, T., (1974) Vertical distribution of freshwater mussels (Pelecypoda, Unionidae) in southwestern Finland. *Annales Zoologici Fenneci* **11**: 127-130.

Heard, W.H. (1977) Reproduction of fingernail clams (Sphaeriidae: Sphaerium and Musculium). *Malacologia* **16**: 421-455.

Holmes, A., Jones, C., & Noble, L.R. (2001) Conservation genetics of the freshwater pearly mussel *Margaritifera margaritifera* (L., 1758) In: Salvini-Plawen, L., Sattmann, H. & Steiner, G. (Eds.) Abstracts, World Congress of Malacology 2001, Vienna, Austria.

Holopainen I.J., (1979) Population dynamics and production of *Pisidium* species (Bivalvia, Sphaeriidae) in the oligotrophic and mesohumic lake Pääjärvi, southern Finland. *Archive fur Hydrobiologie Supplement* **54**: 466-508.

Holopainen I.J., & Hanski I., (1986) Life history variation in *Pisidium* (Bivalvia : Pisidiidae) *Holarctic Ecology* **9**: 85-98.

Holopainen I.J., & Jónasson P.M., (1983) Long-term population dynamics and production of *Pisidium* (Bivalvia) in the profundal of Lake Esrom, Denmark. *Oikos* **41**: 99-117.

Holopainen I.J., & Jónasson P.M., (1989) Reproduction of *Pisidium* (Bivalvia: Sphaeriidae) at different depths in Lake Esrom, Denmark from 1954 to 1988. *Oikos* **55**: 324-334.

Hornbach, D.J., (1992) Life history traits of a riverine population of the Asian clam *Corbicula fluminea*. *American Midlands Naturalist* **127**: 248-257.

Hornbach, D.J. Way, C.M. & Burky, A.J. (1980) Reproductive Strategies in the Freshwater Sphaeriid Clam, *Musculium partumeium* (Say), from a Permanent and Temporary Pond. *Oecologia* **44**: 164-170.

Horsak, M. & Neumanova, K., (2004) Distribution of *Pisidium globulare* Clessin, 1873 (Mollusca: Bivalvia) in the Czech Republic and Slovakia with notes to its ecology and morphological characters. *Journal of Conchology* **38**: 373-381.

Howlett, D. & Baker, R. (1999) *Corbicula fluminea* (Müller): new to UK. *Journal of Conchology* **36**: 83.

Hyman, I. & Klee, B. (2006): Researching *Limax maximus*: Old literature and new sequences. Molluscan Forum 2006, Natural History Museum London, England.

Hyman, I., Klee, B., Schneppat, U. & Haszprunar, G. (2007): "The widespread slug Limax maximus Linnaeus, 1758 (Gastropoda: Pulmonata): species boundaries and redescription"; 9. World Congress of Malacology, Antwerp, Belgium.

International Commission On Zoological Nomenclature (1985) International code on zoological nomenclature Third edition adopted by the XX general assembly of the International Union of Biological Sciences. Berkeley & Los Angeles. 338 pp.

Jennings, J.J. & Barkham, J.P. (1975) Food of slugs in mixed deciduous woodlands *Oikos* **26**: 211-221.

Jordaens, K., Pinceel, J., Krieckemans, H. & Backeljau, T. (2006) Accurate identification of cryptic slug taxa of the *Arion subfuscus/fuscus* complex by PCR-RFLP (Pulmonata, Arionidae). *Journal of Molluscan Studies*, **72**: 323-325.

Kappes, H. (2006) Relations between forest management and slug assemblages (Gastropoda) of deciduous regrowth forests. *Forest Ecology & Management* **237**: 450-457.

Kennedy, G. Y. (1959) Porphyrin pigment in the integument of *Arion ater*. *Journal of the Marine Biological Association of the United Kingdom*, **38:** 27-32

Klee, B. (2006) Towards a Phylogeny of *Limax* (Gastropoda: Stylommatophora). *Molluscan Forum* **2006**, Natural History Museum London, England.

Klee, B. (2006) Preliminary mitochondrial phylogeny of the genus *Limax*. In: Hyman, I. (2006) The first annual meeting of Task-Force-Limax, Bünder Naturmuseum, Chur, Switzerland. *MalaCo*, **3**: 104-107

Klee, B. & Falkner, G. (2006) *Limax cinereoniger* – eine Sammelart? *Meeting of Friedrich-Held-Gesellschaft* **2006**, Stuttgart, Germany.

Klee, B. & Schneppat, U. (2006): Collecting and transporting living slugs (Pulmonata: Limacidae). *MalaCo*, **3**: 107-108.

Kerney. M.P. (1976) *Atlas of non-marine Mollusca of the British Isles*. Institute of Terrestrial Ecology, Cambridge.

Kerney. M.P. (1999) *Atlas of the Land and Freshwater Molluscs of Britain and Ireland*. Harley Books, Colchester. 264pp.

Kerney M.P. & Cameron R.A.D. (1979): *A field guide to the land snails of Britain and north-west Europe*. 288pp. Collins, London.

Kerney, M.P. & Morton, B.D. (1970) The distribution of *Dreissena polymorpha* (Pallas) in Britain. *Journal of Conchology* **27**: 97-100.

Killeen, I.J., (2008) Notes on the *Sphaerium corneum* group. *Mollusc World* **16**: 21-23.

Killeen, I.J. & Moorkens, E.A. (2003) *Pisidium moitessierianum* Paladilhe, 1866, rediscovered in Ireland. *Journal of Conchology* **38**: 94.

Killeen, I.J. & Williams, S.B. (2000) Status and distribution of *Pisidium tenuilineatum* in the River Wharfe. *The Naturalist,* 124.

Killeen, I.J., & Willing, M.J., (2004) Further surveys to elucidate the distribution of the fine-lined pea mussel *Pisidium tenuilineatum* Stelfox, 1918. Environment Agency Technical Report W1-054/TR, Bristol, 145pp.

Killeen, I.J., Aldridge, D.C. & Oliver, P.G., (2004) *Freshwater bivalves of Britain and Ireland*. Field Studies Occasional Publication **82**. FSC Publications, Shrewsbury. 114pp.

Klee, B. & Hyman, I. (2006) Betaversion of an Access-based database for molecular collection management. In: Hyman, I. (2006) The first annual meeting of Task-Force-Limax. Bünder Naturmuseum, Chur, Switzerland. *MalaCo*, **3**: 104-107.

Klee, B., Heim, R., Hyman, I. & Haszprunar, G. (2007) Species boundaries in *Limax* (Gastropoda: Stylommatophora): extreme colour variations in and between species. World Congress of Malacology, Antwerp, Belgium.

Klee, B., Hyman, I., Wiktor, A. & Haszprunar, G. (2007) Cutting the Gordian Knot of a Taxonomic Impediment: A Plea for MOTU-Numbers (Molecular Operational Taxonomic Units). World Congress of Malacology, Antwerp, Belgium

Klee B., Falkner G. & Haszprunar G. (2005) Endemic radiations of *Limax* (Gastropoda: Stylommatophora) slugs in Corsica – they came twice. In: Burckhardt & Mühlethalter (eds): 8th GfBS Annual Conference Abstracts Basel, Switzerland. Organisms, Diversity Evolution 5, Electronic Supplement **13**:1–109.

Klee, B., Falkner, G. & Haszprunar, G. (2006) *Limax* (Gastropoda: Stylommatophora) in Corsica: a combined morphological-genetic approach. Meeting of the German Malacological Society 2006, Giessen, Germany.

Klee, B., Heim, R., Hyman, I. & Haszprunar, G. (2007) Species boundaries in *Limax* (Gastropoda: Stylommatophora): extreme colour variations in and between species. Jahrestagung der Gesellschaft für Biologische Systematik, Naturhistorisches Museum Wien, Austria.

Koøínková, T., Petrusek, A. & Juøièková, L. (2007) *Sphaerium corneum* / nucleus is a complex of several cryptic species. *The Malacologist* **48**: 10.

Korniushin, A., (1998) On the identity of the anatomically distinct form of *Pisidium casertanum* (Poli) (= *P. roseum* sensu Korniushin 1995) *Heldia* **2** (5/6): 133-135.

Korniushin, A. V. (1999) Anatomical investigation and taxonomic revision of pill clams of the genus *Pisidium* s. l. (Bivalvia: Sphaeriidae) in the Palaeartic Region. *Malacological Review, Suppl.,* **8**.

Korniushin, A.V. & Hackenberg, E. (2000) Verwendung konchologischer und anatomischer Merkmale für die Bestimmung mitteleuropaischer Arten der Familie Sphaeriidae (Bivalvia), mit neuem Bestimmungsschlussel und Diagnosen. *Malakologische Abhandlungen* **20**: 45-72.

Kuiper, J.G.J., (1981) The distribution of *Pisidium tenuilineatum* Stelfox and *Pisidium annandalei* Prashad in the Mediterranean area. *Basteria* **45**: 79-84.

Kuiper, J.G.J. & Wolff, W.J., (1970) The Mollusca of the estuarine region of the rivers, Rhine, Meuse and Scheldt in relation to the hydrography of the area. III The genus *Pisidium.* *Basteria* **34**: 1-42.

Kuiper, J.G.J., Okland, K.A., Knudsen, J., Koli, L. Von Proschwitz, T. & Volovirta, L. (1989) Geographical distribution of the small mussels (Sphaeriidae) in northern Europe (denmark, Faroes, Finland, Iceland, Norway and Sweden). *Annales Zoologici Fennici* **26**: 73-101.

Ladle, M. & Baron, F., (1969) Studies on three species of *Pisidium* (Mollusca: Bivalvia) from a Chalk Stream. *Journal of Animal Ecology* **38**: 407-413.

Lopez, G. & Holopainen, I., (1987) Interstitial suspension feeding by *Pisidium* spp. (Bivalvia: Pisidiidae): A new guide to the lentic benthos? *American Malacological Bulletin* **5**: 21-30.

Lindley, D., (2006) Yorkshire notes. *Mollusc World* **10**: 16-17.

Lister M. (1685) *Appendicis ad Historiae Animalium Angliae Tres Tractatus, &c. Altera Editio, auctior & emendatior.* S. Smith, London. 45

Lucy, F., (2006) Early life stages of *Dreissena polymorpha* (zebra mussel): the importance of long-term datasets in invasion ecology. *Aquatic Invasions* **1**: 171-182

Maltby, E., Hogan, D.V. & McInnes, R.J. (eds.) (1996) *Functional analysis of European wetland ecosystems. Phase 1 (FAEWE)* EC ecosystem research report **18**, EUR 16132: 448pp.

McCarthy, T. & Fitzgerald, J. (1997) The occurrence of the zebra mussel *Dreissena polymorpha* (Pallas, 1771), an introduced befouling freshwater bivalve. *Irish Naturalist* **25**: 413-416.

McIvor, A.L. & Aldridge, A.C., (2007) The reproductive biology of the depressed river mussel, *Pseudanodonta complanata* (Bivalvia: Unionidae), with implications for its conservation. *Journal of Molluscan Studies* **73**: 259-266.

McMahon R.F. (1996) The physiological ecology of the zebra mussel, *Dreissena polymorpha*, in North America and Europe. *American Zoologist* 36: 339-363.

Machordom, A., Araujo, R., Erpenbeck, D. & Ramos, M.-A. (2003) Phylogeography and conservation genetics of endangered European Margaritiferidae (Bivalvia: Unionoidea) *Biological Journal of the Linnean Society* **78**: 235-252.

Mackie, G.L., (1979) Growth dynamics in natural populations of Sphaeriidae clams (*Sphaerium, Musculium, Pisidium*) *Canadian Journal of Zoology* **57**: 441-456.

McMillan, N. & Zeissler, H., (1990) Recent and fossil Mollusca of the Rivers Barrow, Nore and Suir, South-east Ireland. *Bull. Ir. Biogeog. Soc*. **13,** 189-199.

Meier-Brook, C., (1969) Substrate relations in some *Pisidium* species (Eulamellibranchia: Sphaeriidae) *Malacologia* **9**: 121-125.

Meier-Brook C., (1970) Untersuchungen zur Biologie einiger *Pisidium*-Arten (Mollusca. Eulamellibranchiata, Sphaeriidae) *Archive für Hydrobiologie Supplement* **38**: 73-150.

Meier-Brook C., (1977) Intramarsupial suppression of fetal development in Sphaeriid clams. - *Malacological Review* **10**: 53-58.

Minchen, D., Lucy, F. & Sullivan, M., (2002) Monitoring of zebra mussels in the Shannon-Boyle navigation, other navigable regions and principal Irish lakes, 2000 & 2001. *Marine Environment and Health Series* **5**, 17pp.

Minchin, D., Lucy, F. & Sullivan, M. (2005) Ireland: a new frontier for the zebra mussel *Dreissena polymorpha* Pallas. *Oceanological and Hydrobiological Studies* **34**:19-30.

Moorkens, E. A. (1996) *Studies on the Biology and Ecology of* Margaritifera *in Ireland*. Unpublished PhD Thesis, University of Dublin, Trinity College.

Moorkens, E.A. (1999) *Conservation Management of the Freshwater Pearl Mussel* Margaritifera margaritifera. *Part 1: Biology of the species and its present situation in Ireland.* Irish Wildlife Manuals No. 8, National Parks and Wildlife Service,.Ireland.

Moorkens E.A., (2004) Non-marine Mollusca: new and notable records for Ireland. *Bulletin of the Irish Biogeographiocal Society* **28**: 189-198.

Moorkens, E.A., (2005) News from Ireland. *Mollusc World* **7**: 8-9.

Moorkens, E.A. (2006) Irish non-marine molluscs – an evaluation of species threat status. *Bulletin of the Irish Biogeographiocal* Society **30**: 348-371.

Moorkens, E.A. & Costello, M.J. (1994) Imminent extinction of the Nore freshwater pearl mussel *Margaritifera durrovensis* Phillips: a species unique to Ireland. *Aquatic Conservation: Marine and Freshwater Ecosystems* **4**, 363-365.

Moorkens E.A. & Killeen I..J., (2005) The aquatic mollusc fauna of the Grand and Royal Canals, Ireland. *Bulletin of the Irish Biogeographiocal* Society **29**: 143-193.

Moorkens E.A.. & Speight M.C.D. (2001) The CLECOM project list of Irish non-marine Mollusca. *Bulletin of the Irish Biogeographical Society* **25**: 95-104.

Morton, B., (1985) The population dynamics, reproductive strategy and Life history tactics of *Musculium lacustre* (Bivalvia: Pisidiidae) in Hong Kong. *Journal of Zoology* **207**: 581-603.

Mouthon, J., (1996) Molluscs and biodegradable pollution in rivers: proposal for a scale of sensitivity of species. *Hydrobiologia,* **317**: 221-229.

Mouthon, J. (1999) Longitudinal organisation of the mollusc species in a theoretical French river. *Hydrobiologia,* **390**: 117-128.

Mouthon, J., (2005) Life cycle and population dynamics of *Pisidium subtruncatum* MALM (Bivalvia: Sphaeriidae) in the Saône, a large lowland river, at Lyon (France): environmental influences. *Archiv für Hydrobiologie* **163**: 539-554.

Mouthon, J. (2007) Inventaire des mollusques de la rivière Doubs (Franche-Comté, France) *MalaCo* **4**: 158-162.

Müller, D. & Patzner, R.A., (1996) Growth and age structure of the swan mussel *Anodonta cygnea* (L.) at different depths in Lake Mattsee (Salzburg, Austria) *Hydrobiologia* **341**: 65-70.

Oliver, P.G., Holmes, A.M. & Mettam, C. (1998) *Mytilopsis leucophaeta* (Conrad, 1831) [Bivalvia: Dreissenoidea]. A new species to the British fauna. *Journal of Conchology* **36**: 13-18.

O'Toole, C.S. & Wilson, J.G., (2001) Population dynamics of *Musculium lacustre* in Ireland's temperate climate. Abstratcts from *Freshwater Bivalves* – Conference held by the Malacological Society of London.

Phillips, R.A., (1916) On two species of *Pisidium* (fossil) new to Ireland. *Irish Naturalist* **25**: 101-105.

Phillips, R.A. (1928) On *Margaritifera durrovensis*, a new species of pearl mussel from Ireland. *Proceedings of the Malacological Society of London* **18**: 69-74.

Piechocki, A (1989) The Sphaeriidae of Poland (Bivalvia, Eulamellibranchia) *Annales Zoologici, Warsaw* **42**: 249-320.

Piechocki A. (1992) Mięczaki wodne (Mollusca aquatica) Roztocza. *Fragm .Faun.* **35**, 17: 285-299.

Piechocki, A. (1999) Reproductive Biology of *Unio pictorum* (Linnaeus) and *U. tumidus* Philipsson in the Pilica River (Central Poland) *Heldia* **4** Special Edition 6: 53-60.

Piechocki, A. (2002) The Fauna of pill-clams (*Pisidium* C. Pfeifer) (Bivalvia, Sphaeriidae) at various depths in Lake Ostrowite (N.W. Poland) — In: *Collectanea Malacologica. Festschrift für Gerhard Falkner*. Falkner, M., Groh, K. & Speight, M. C. D. (Eds.), S. 449-461. Hackenheim [ConchBooks].

Pinceel J., Jordaens K., Van Houtte N., De Winter A.J., & Baeckeljau T. (2004) Molecular and morphological data reveal cryptic taxonomic diversity in the terrestrial slug complex *Arion subfuscus/fuscus* (Mollusca, Pulmonata, Arionidae) in continental north-west Europe. *Biological Journal of the Linnean Society* **83**: 23-38.

Platts, E.A. & Speight, M.C.D. (1988) The taxonomy and distribution of the Kerry slug, *Geomalacus maculosus* Allman, 1843 (Mollusca: Arionidae) with a discussion of its status as a threatened species. *Irish.Naturalists' Journal* **22**: 417-430.

Quick, H.E. (1952) Rediscovery of *Arion lusitanicus* Mabille in Britain. *Proc. malac. Soc. Lond.* **29**: 93–101.

Quick H.E. (1960) British slugs (Pulmonata: Testacellidae, Arionidae, Limacidae) *Bulletin of the British Museum (Natural History) Zoology* **6**: 1-226.

Rantanen, J.T., Valtonen, E.T. & Holopainen, I.J., (1998) Digenean parasites of the bivalve mollusc *Pisidium amnicum* in a small river in eastern Finland. *Diseases of Aquatic Organisms* **33**: 201-208.

Redshaw, E.J. & Norris, A. (1974) *Sphaerium solidum* (Normand) in the British Isles. *Journal of Conchology* **28**: 209-212.

Ricciardi, A., Whoriskey, F.G. & Rasmussen, J.B., (1995) Predicting the intensity and impact of *Dreissena* infestation on native unionid bivalves from *Dreissena* field density. *Canadian Journal of Fisheries and Aquatic Sciences*: **52**: 1449-1461.

Rosas, G., Ramos, M.A., & Valdecasas, A.G. (1992). Invertebrados españoles protegidos por convenios internacionales. *ICONA – CSIC, Madrid*, 1-250.

Ross, E.D., (1988) *The reproductive biology of freshwater mussels in Ireland, with observations on their distribution and demography*. Unpublished PhD Thesis, UCG, National University of Ireland.

Ross, H.C.G. (1984) *Catalogue of the land and freshwater Mollusca of the British Isles in the Ulster Museum* Ulster Museum, Belfast. 160 pp.

Rodriguez, T., Ondina, P., Outeiro, A. & Castillejo, J. (1993) Slugs of Portugal. III. Revision of the genus *Geomalacus* Allman, 1843 (Gastropoda: Pulmonata Arionidae) *Veliger* **36**: 145-159.

Schileyko, A.A. (1978) *Fauna of the USSR, Vol. 3, No. 6. Terrestrial molluscs of the superfamily Helicoidea.* Leningrad. 36

Schileyko, A. A. & Mlnkhorst, H. P. M. G. (1997) Composition and phylogenetic relationships of the Cochlicellidae (Gastropoda, Pulmonata) *Ruthenica* **7**: 51-6.

Schloesser, D.W., Nalepa, T.F. & Mackie, G.L., (1995) Infestation of unionid bivalves (Unionidae) in North America. *American Zoologist* **36**: 300-310.

Simroth H. (1891) Die Nacktschnecken der portugiesisch-azorischen Fauna in ihrem Verhältnis zu denen der paläarktischen Region überhaupt. *Nova Acta Academiae Caesareae Leopoldino-Carolinae Germanicae Naturae Curiosorum* **56**: [1], 201-424.

South, A. (1992) *Terrestrial slugs, biology, ecology and control*. Chapman and Hall, London.

Speight, M.C.D. (1996) *Geomalacus maculosus* Allman, 1843. In: Van Helsdingen, P.J., Willemse, L. & Speight, M.C.D. (eds.) Background information on invertebrates of the Habitats Directive and the Bern Convention. Pt.III: Mollusca and Echinodermata. *Nature and Environment*, No.**81**: 433-437. Council of Europe, Strasbourg.

Speight, M.C.D., (1997) Invertebrate species lists as management tools: an example using databased information about Syrphidae (Diptera) *Proc. Colloqu. Conservation, management and restoration of habitats for invertebrates: enhancing biological diversity. Environmental Encounters Series* **33**, 74-83. Strasbourg (Council of Europe)

Speight, M.C.D., (1999) *Syrph the Net: A database of biological information about European Syrphidae (Diptera) and its use in relation to conservation and biodiversity*. In Rushton, B. (ed.) Biodiversity, the Irish dimension: 151-171. Royal Irish Academy, Dublin.

Speight, M. C. D. (2008) Database of Irish Syrphidae (Diptera). Irish Wildlife Manuals, No. 36. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Speight, M.C.D. & Castella, E. (2003) Range and Status data for European Syrphidae (Diptera), 2002. In: Speight, M.C.D., Castella, E., Obrdlik, P. and Ball, S. (eds.) *Syrph the Net, the database of European Syrphidae* , vol. 36, 203 pp., Syrph the Net publications, Dublin.

Speight, M.C.D. & Good, J.A. (2003) *Development of eco-friendly forestry practices in Europe and the maintenance of saproxylic biodiversity*. In: Mason, F., Nardi, G. & Tisato, M. (eds.) Legno Morto: Una Chiave pera Biodiversita / Dead Wood: A Key to Biodiversity. Proceedings of the international symposium 29-31 May 2003, Mantova, Italy. Sherwood **95** Supplement 2, Mantova.

Speight, M.C.D., Castella, E. & Obrdlik, P. (2003a) Microsite features used by European Syrphidae (Diptera), 2002. In: Speight, M.C.D., Castella, E., Obrdlik, P. and Ball, S. (eds.) *Syrph the Net, the database of European Syrphidae* , Vol.34, 162 pp , Syrph the Net publications, Dublin.

Speight, M.C.D., Castella, E. & Obrdlik, P. (2003b) Macrohabitat preferences of European Syrphidae (Diptera), 2002. In: Speight, M.C.D., Castella, E., Obrdlik, P. and Ball, S. (eds.) *Syrph the Net, the database of European Syrphidae*, Vol. 33, 478 pp , Syrph the Net publications, Dublin.

Stone, N.M., Earll, R., Hodgson, A & Mather, J.G., (1982) The distribution of 3 sympatric mussel species (Bivalvia: Unionidae) in Budworth Mere, Cheshire. *Journal of Molluscan Studies* **48**: 266-274.

Stelfox, A.E. (1911) A list of the Land and Freshwater Molluscs of Ireland. *Proceedings of the Roiyal Irish Academy* **29**, 65-164.

Strayer, D.L. & Smith, L. C., (1996) Relationships between zebra mussels (*Dreissena polymorpha*) and unionid clams during the early stages of zebra mussel invasion of the Hudson River. *Freshwater Biology* **36**: 771-779.

Toth, M. & Baba, K., (1981) The molluscan fauna of the Tisza and its tributaries. *Tiscia (Szeged)* **16**: 169-181.

Verween, A., Vincx, M., Mees, J. & Degraer, S., (2005) Seasonal variability of *Mytilopsis leucophaeata* larvae in the harbour of Antwerp: implications for ecologically and economically sound biofouling control. *Belgian Journal of Zoology* **135**: 91-93.

Wächtler, K., Dreher-Mansur, M.C. & Richter, T. (2000) Larval types and early postlarval biology in Naiads (Unionoida) In: Bauer, G. & Wächtler, K. (Eds.) (2000) Ecology and Evolution of the Freshwater Mussels Unionoida. *Ecological Studies*, ***145***. Springer, Berlin.

Way, C.M., (1988) An analysis of life histories in freshwater bivalves (Mollusca: Pisidiidae) *Canadian Journal of Zoology* **66**: 1179-1183.

Weber, E., (2005) Population size and structure of three mussel species (Bivalvia: Unionidae) in a northeastern German river with special regard to influences of environmental factors. *Hydrobiologia* **537**: 169-183.

Wiktor A. (1973) Die nachtschnecken Polens. Arionidae, Milacidae, Limacidae (Gastropoda, Stylommatophora) *Monographie Fauny Polski* **1**: 1-182.

Wiktor, A., (1989) Limacoidea et Zonitoidea Nuda – Ślimaki Pomrowikokształtne (Gastropoda: Stylommatophora) [Limacoidea et Zonitoidea Nuda – Limacoid and Zonitoid Slugs (Gastropoda: Stylomatophora]. *Fauna Polski* **12**, PWN, Warszawa.

Wiktor A. (2001) Fauna Greciae VIII. The slugs of Greece (Arionidae, Milacidae, Limacidae, Agrioiimacidae — Gastropoda, Styloinmatophora) Natural History Museum of Crete and the Hellenic Zoological Society, Irakleio. 241 pp.

Willing, M.J., (2005) UK BAP priority species review for *Sphaerium solidum*. Report to JNCC unpublished.

Young, M.R. & Williams, J.C., (1984) The reproductive biology of the freshwater pearl mussel *Margaritifera margaritifera* (Linn.) in Scotland. I. Field studies. *Archiv fur Hydrobiologie* **99:** 405-422.

Zettler, M.L. & Glöer, P., (2006) Zur Ökologie und Morphologie der Sphaeriidae der Norddeutschen Tiefebene. *Heldia* **6(8)**: 1-61.

Zettler, M.L. & Kuiper, J.G.J., (2002) Zur Verbreitung und Ökologie von *Pisidium moitessierianum* (Paladilhe 1866) unter besonderer Berücksichtigung von Nordostdeutschland (Mollusca: Bivalvia: Sphaeriidae) *Mitteilungen der Deutschen Malakozoologischen Gesellschaft* **67**: 9-26.

Ziuganov, V., Zotin, A., Nezlin, L. & Tretiakov, V., (1994) *The freshwater pearl mussels and their relationships with salmonid fish*. VNIRO, Moscow.

APPENDIX 1: BIVALVE MACROHABITATS

http://www.npws.ie/en/media/NPWS/Publications/IrishWildlifeManuals/BivalveDatasheets.xls

APPENDIX 2 : BIVALVE MICROHABITATS

http://www.npws.ie/en/media/NPWS/Publications/IrishWildlifeManuals/BivalveDatasheets.xls

APPENDIX 3: BIVALVE TRAITS

http://www.npws.ie/en/media/NPWS/Publications/IrishWildlifeManuals/BivalveDatasheets.xls

APPENDIX 4: SLUG MACROHABITATS

http://www.npws.ie/en/media/NPWS/Publications/IrishWildlifeManuals/SlugDatasheets.xls

APPENDIX 5: SLUG MICROHABITATS

http://www.npws.ie/en/media/NPWS/Publications/IrishWildlifeManuals/SlugDatasheets.xls

APPENDIX 6: SLUG TRAITS

http://www.npws.ie/en/media/NPWS/Publications/IrishWildlifeManuals/SlugDatasheets.xls