

Ecology of Desmoulin's Whorl Snail

Vertigo moulinsiana



Conserving Natura 2000 Rivers
Ecology Series No. 6



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Conserving Natura 2000 Rivers

This account of the ecological requirements of Desmoulin's whorl snail (*Vertigo moulinsiana*) has been produced as part of **Life in UK Rivers** – a project to develop methods for conserving the wildlife and habitats of rivers within the Natura 2000 network of protected European sites. The project's focus has been the conservation of rivers identified as Special Areas of Conservation (SACs) and of relevant habitats and species listed in annexes I and II of the European Union Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC) (the Habitats Directive).

One of the main products is a set of reports collating the best available information on the ecological requirements of each species and habitat, while a complementary series contains advice on monitoring and assessment techniques. Each report has been compiled by ecologists who are studying these species and habitats in the UK, and has been subject to peer review, including scrutiny by a Technical Advisory Group established by the project partners. In the case of the monitoring techniques, further refinement has been accomplished by field-testing and by workshops involving experts and conservation practitioners.

Life in UK Rivers is very much a demonstration project, and although the reports have no official status in the implementation of the directive, they are intended as a helpful source of information for organisations trying to set 'conservation objectives' and to monitor for 'favourable conservation status' for these habitats and species. They can also be used to help assess plans and projects affecting Natura 2000 sites, as required by Article 6.3 of the directive.

As part of the project, conservation strategies have been produced for seven different SAC rivers in the UK. In these, you can see how the statutory conservation and environment agencies have developed objectives for the conservation of the habitats and species, and drawn up action plans with their local partners for achieving 'favourable conservation status'.

Understanding the ecological requirements of river plants and animals is a prerequisite for setting conservation objectives, and for generating conservation strategies for SAC rivers under Article 6.1 of the European Habitats Directive. Thus, the questions these ecology reports try to answer include:

- What water quality does the species need to survive and reproduce successfully?
- Are there other physical conditions, such as substrate or flow, that favour these species or cause them to decline?
- What is the extent of interdependence with other species for food or breeding success?

For each of the 13 riverine species and for the *Ranunculus* habitat, the project has also published tables setting out what can be considered as 'favourable condition' for attributes such as water quality and nutrient levels, flow conditions, river channel and riparian habitat, substrate, access for migratory fish, and level of disturbance. 'Favourable condition' is taken to be the status required of Annex I habitats and Annex II species on each Natura 2000 site to contribute adequately to 'favourable conservation status' across their natural range.

Titles in the Conserving Natura 2000 Rivers ecology and monitoring series are listed inside the back cover of this report, and copies of these, together with other project publications, are available via the project website: www.riverlife.org.uk.

Introduction

Desmoulin's whorl snail, *Vertigo moulinsiana* (Dupuy 1849), is the largest of the 11 species of whorl snail (the *Vertigo* genus) living in Britain. The body of the animal is a light grey or greyish-white colour with a darker grey to black head and tentacles. The shell is dextrally coiled (mouth on the right), ovate to elongate in shape, with a tapering spire and 4.5 to 5 rounded whorls. Its shell height is 2.2–2.7 mm, its breadth 1.3–1.65 mm, with the last (body) whorl approximately two thirds of the overall height.

The aperture, or mouth (in adults) is rather triangular and narrowed towards the base, with the basal and palatal (outer) wall reflexed outwards as a lip. This aperture always has four prominent teeth – one parietal (relating to the external surface of the previous whorl), two palatal and one columellar (relating to the central column of the shell) – and sometimes additional small denticles.

Palatal teeth arise from a thickening (callus), which is usually visible through the shell wall. The pattern of teeth is an important taxonomic feature in the *Vertigo* genus, and the teeth present in Desmoulin's whorl snail, along with its relatively larger shell size compared to other whorl snails, are the key features by which it can be identified.

The shell itself is translucent, glossy, pale yellowish to reddish brown, sometimes with a delicate, darker brown band between the crest and aperture margin. Older shells are often bleached to a dull greyish-brown colour. The surface of the shell has an overall smooth appearance, but a sculpture of very fine, irregular lines is visible under x20 magnification. Further illustrations of this species are given in Kerney & Cameron (1979) and Pokryszko (1990).

The shape and proportions of the shell undergo considerable changes during growth. Shells of young individuals are rather conical and only attain their ovate cylindrical shape during the last stages of development. The aperture also changes shape with growth, and the formation of teeth and thickening of the lip occur only during the final stages. The snail is considered to be an adult when the lip has fully formed.



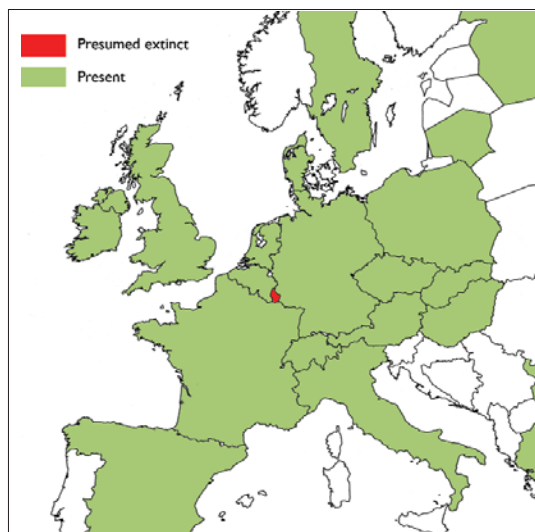
Roger Key/English Nature

Desmoulin's whorl snail has a black head and tentacles, and a translucent, reddish-brown shell. Old shells are a greyish-brown.

Status and distribution

Desmoulin's whorl snail is listed under Annex II of the European Union Habitats and Species Directive. It is a priority species in the UK Biodiversity Action Plan (HMSO 1996) and is listed in the British Red Data Book (Bratton 1991) as an RDB3 (Rare) species.

Desmoulin's whorl snail is considered to be an Atlantic-Mediterranean species with a range extending from Ireland to Russia and south to North Africa (Pokryszko 1990, Killeen 1996). In Europe, the species has been confirmed for Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Netherlands, Poland, Slovakia, Spain, Sweden, Switzerland and the United Kingdom. It is also known from Algeria, Azerbaijan, Georgia, Morocco, Russia and Turkey. The



European distribution for Desmoulin's whorl snail. It is also found in North Africa, Greece, Turkey, Azerbaijan and Georgia.

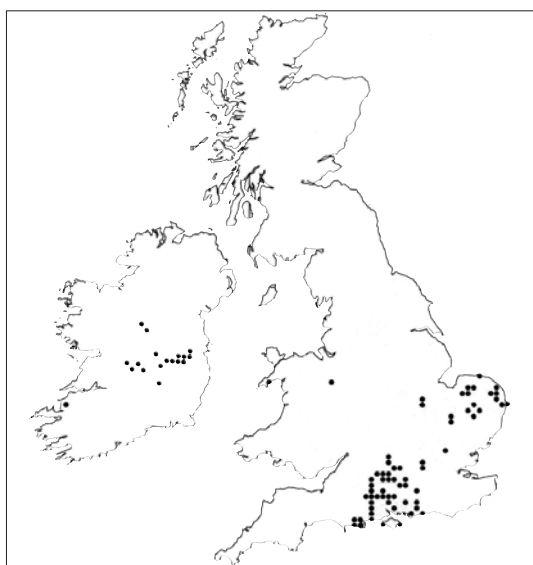
southern distribution border is poorly known owing to taxonomic confusion with similar species (Pokryszko 1990, Killeen 1996).

The most recent review of the status of Desmoulin's whorl snail is given by Seddon (1997), who gives strong evidence for its decline throughout much of its range. The principal causes of decline are wetland drainage (particularly during the 20th Century), change in agricultural and land management practice, scrub encroachment onto fen, and change of land use and development. In many countries the status ranges from Vulnerable (for example, in Ireland and Germany) to Endangered (including the Netherlands and Sweden) or Presumed Extinct (Luxembourg). Although recent surveys under the requirements of the Habitats Directive have revealed previously unknown populations, the overall status remains unchanged.

British distribution

With present information, Britain is considered to support the greatest number of Desmoulin's whorl snail populations in the European Union. The species occurs principally in a band from east Dorset to north-west Norfolk and along the centre of Ireland (Kerney 1999). Outside the key area of distribution, *V. moulinsiana* is known from Cors Geirch on the Lleyn Peninsula in North Wales (Killeen 2000c), Sweat Mere in Shropshire (Cameron 1992, Killeen 2001a), Stodmarsh in Kent (Killeen 2001a, b), and at Penhale and Perranporth in Cornwall (Holyoak in press). The greatest concentrations of individual sites are found in the river catchments of the Hampshire Basin, the Thames Basin and the Norfolk Broads. A summary of individual sites on a county and SSSI basis is given by Drake (1999), and within Special Areas of Conservation (SACs) by Killeen (2001b-h).

Desmoulin's whorl snail was more widely distributed in Britain in the early part of the postglacial era than today. There are many records from fossil deposits in southeast England, the Midlands, Lincolnshire and Yorkshire (Kerney 1999). Its retreat is believed to be partly due to a gradual cooling since the climatic optimum, about 5000 years ago. In the 19th and 20th centuries some sites were lost – for example, it has not been seen at Braunton Burrows since 1933 (Kerney 1999) – but otherwise there has been no significant change in the snail's range in Britain.



Adapted from Kearney 1999

Despite few known sites, Britain has the greatest number of Desmoulin's whorl snail in Europe.

A map showing distribution by 10 km square is given by Kerney (1999). A more detailed map showing location of sites in river catchments in southeast England is given by Drake (1999). Since these works were published, additional sites have been added in the floodplain of the River Avon (Hampshire/Wiltshire) and its tributaries, River Wensum, Norfolk Broads, southeast Suffolk and east Kent.

Life history

There have been no detailed studies specifically on the life history of Desmoulin's whorl snail. The following sections are based upon the limited data available principally through the work of Pokryszko, and from studies carried out on English populations. All available information on other *Vertigo* species has been included to provide an indication of the life history of the genus.

Reproduction and growth

Descriptions and illustrations of the reproductive system of Desmoulin's whorl snail are given by Pokryszko (1990). The species is hermaphrodite, but studies have shown that within populations, all species of *Vertigo* exhibit both a euphallic condition (individuals with normally developed male genitalia) and an aphyallic condition (individuals devoid of a penis) (Pokryszko 1987, 1990, 1992). Data for Desmoulin's whorl snail are sparse, but Pokryszko (1987) found that of 46 adult individuals examined from Polish and French localities, 25 were euphallic and 21 were aphyallic.

The only species of *Vertigo* whose life history has been studied in detail is *V. pusilla* (Pokryszko 1992). Although this is a dry-habitat species, the information on reproduction and growth is likely to be applicable to other *Vertigo* species including *V. moulinsiana*. Under laboratory conditions it was observed that copulation was rare, but when it did occur, the euphallic individuals acted as 'males' and the aphyallic individuals as 'females'.

Eggs were either laid following copulation or without it, with most resulting from self-fertilisation. The eggs were laid singly, occasionally in twos, and at intervals of three to 20 days from March to October, with the maximum reproductive activity occurring in spring and early summer. Incubation lasted from seven to 11 days. The shell of the newly hatched young had 1.5 whorls, and under favourable food and humidity conditions, reached full size in 30–40 days from hatching. Egg-laying was observed in some individuals as soon as two days after completion of shell growth.

The individual life span under laboratory conditions ranged from three to 17 months, with most individuals living for 10–15 months. Depending on the time of hatching and environmental conditions, three or four generations were possible in a year.

The ability of *Vertigo* species to self-fertilise significantly aids the life strategy. At the end of winter, when adult individuals may be relatively few and widely dispersed, the probability of two individuals meeting is at its lowest. By self-fertilisation, the low numbers of individuals are able to reconstruct the population in a few weeks (Pokryszko 1987). Moreover, a single coloniser is able to establish a new population.

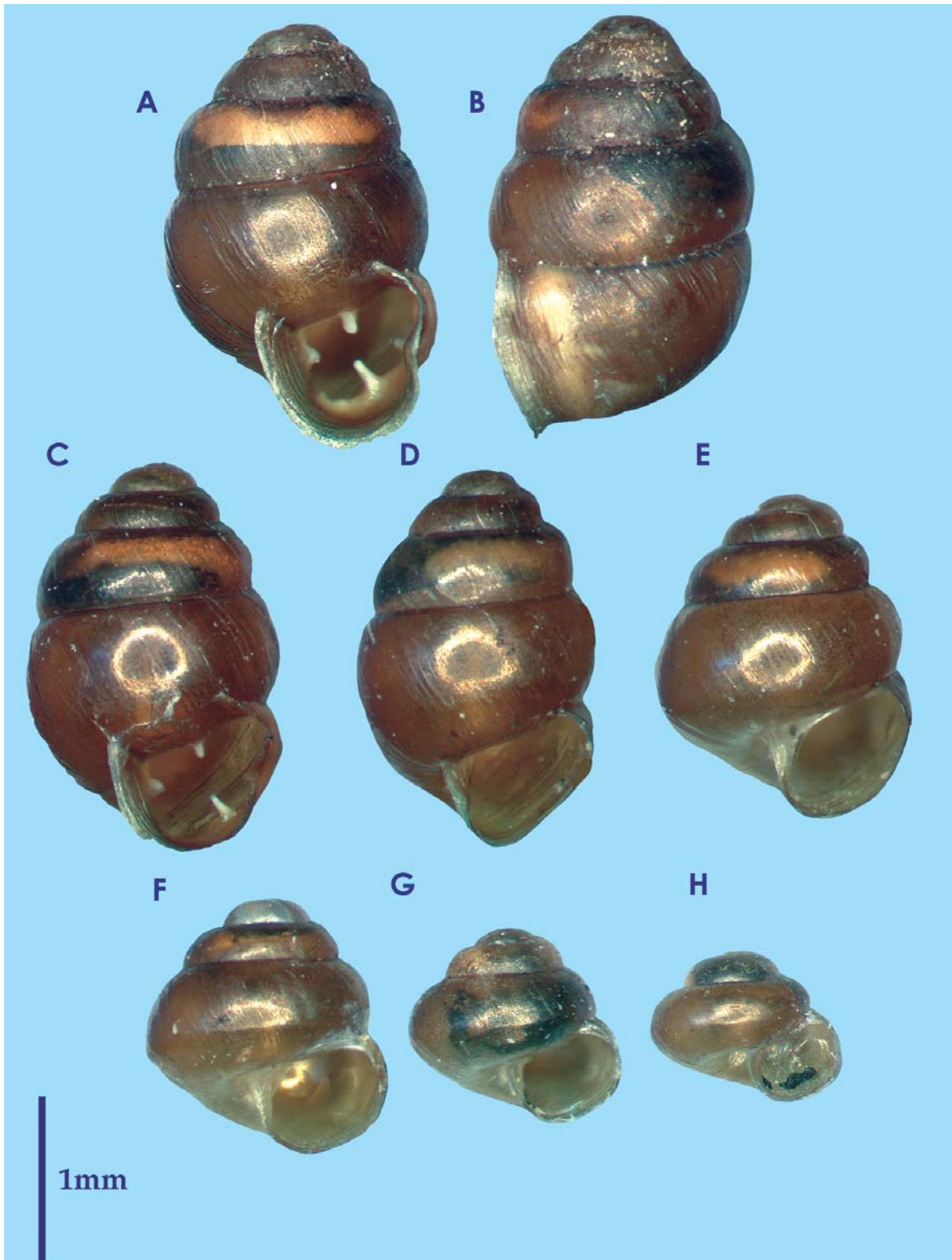
Population density and age structure

The short life span and rapid growth suggests that populations undergo drastic seasonal fluctuations in density and age structure. For *V. pusilla*, Pokryszko (1992) found the population density increased rapidly from around 120 individuals per square metre in February to a maximum of about 800 individuals per square metre in April, May and June. At the same time, the percentage of young increased from none or a few percent in February to a maximum of >80% in April. Sharland (2000) found that field sampling



Ian Killeen

Distribution of Desmoulin's whorl snail in southern England (modified from Drake 1999)



Ian Killeen

Various stages in the growth of Desmoulin's whorl snail. **A:** The shell is dextrally coiled (mouth on right), ovate to elongate in shape, with a tapering spire and 4.5 to 5 rounded whorls. Palatal teeth arise from a thickening (callus), which is usually visible through the shell wall. **C–H:** The shape and proportions of the shell undergo considerable changes during growth.

of a *V. angustior* population at Whiteford Burrows, South Wales, gave highest densities of individuals in October and November. Adults dominated the population in June and July (80% of all individuals), whereas in November, 60–70% of individuals were juveniles.

The population dynamics of Desmoulin's whorl snail appears to resemble more closely *V. angustior* than *V. pusilla*. Figure 1 shows the population density at Thatcham Reedbeds (River Kennet) from June 1997 to November 2001. Although the results were derived from sampling during the period when *V. moulinsiana* was active on tall vegetation, a clear seasonal pattern is shown. In early June the population density was relatively low, mostly less than 50 individuals per square metre. This increased gradually into mid-July and then rapidly through September to peak in October at densities as high as 600 per square metre.

Although the same general trends were shown over the five-year period, there are considerable fluctuations from year to year. The populations appear to have good and bad years; for example, in 1997 and 2000, the population densities peaked at approximately 500 and 600 individuals per square metre respectively, whereas in 1998, the population peaked at 260 per square metre and in 2001 at 200 per square metre. Similar patterns were also recorded at Bagnor Island (Kennet Valley), with high peak densities in 1997, 1999 and 2000, but lower peaks in 1998 and 2001 (Killeen & Stebbings in prep.). It is not known whether this reflects a natural cycle in the populations, or is merely an effect of the weather during the active season.

Figure 2 shows the population structure at Thatcham Reedbeds for the same period. In mid-July, the population was dominated by adults (over 90% in most years). Juveniles began to increase significantly in abundance from early September and usually peaked around mid-October, when they comprised up to 80% of the population. The very low numbers of individuals, both adult and juvenile, in late spring and early summer indicate that there was a high juvenile mortality during the winter months. Some juveniles were present in the early part of the year, suggesting that both over-wintering and opportunistic breeding were likely.

The general pattern of population densities and structure, with adults dominating in mid-summer and an explosion in juvenile numbers in late summer to early autumn, has been recorded at all British sites, but the populations are by no means synchronous (Killeen 2001b).

Biometric analysis, based on number of whorls, of populations in the Kennet and Lambourn Floodplain SAC has proved inconclusive in determining the rate of growth of *V. moulinsiana* (Stebbing & Killeen 1998). At sites on Bagnor Island and at Thatcham, there was little significant difference in the size distribution of individuals from September to December 1996, indicating that the population continued to recruit throughout the period.

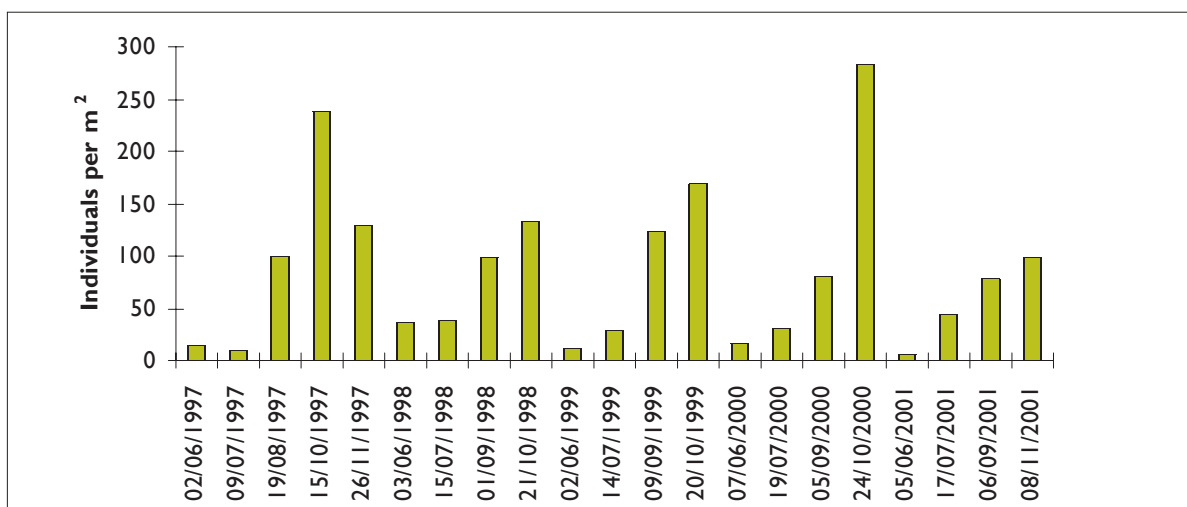


Figure 1. Variation of Desmoulin's whorl snail population density at Thatcham Reedbeds on the River Kennet, southern England, June 1997 to November 2001.

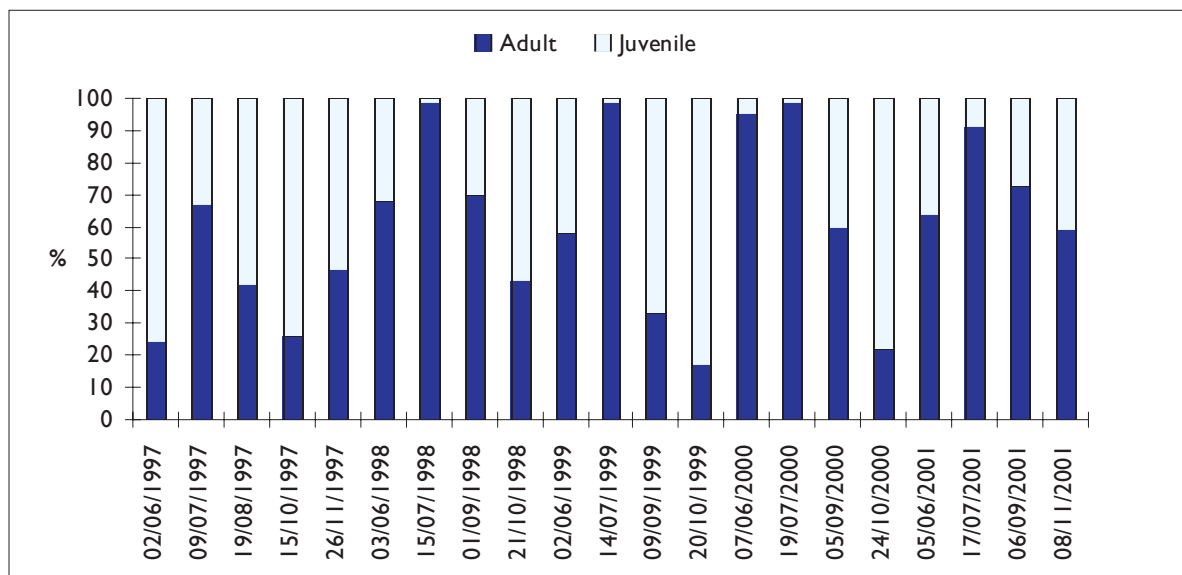


Figure 2. Variation of Desmoulin's whorl snail population structure at Thatcham Reedbeds, River Kennet, southern England, June 1997 to November 2001.

A feature of *V. moulinsiana* populations observed at a range of English sites is the relative rarity of individuals in the very last stages of shell development – those with the full number of adult whorls but having no, or only partially developed, apertural teeth. Thus, it may be inferred that completion of the last stage of shell growth is extremely rapid (within a few days).

Colonisation and dispersal

Waterborne transportation is believed to be the principal dispersal mechanism of Desmoulin's whorl snail. By the nature of its wetland habitat, the snails are likely to be able to float on the water surface or attached to floating vegetation, and could therefore disperse during periods of flooding. The snails are also believed to be dispersed by mammals, being brushed from vegetation as the animals pass, and adhering to their body hair. Similarly, the snails can probably be dispersed by becoming attached to the feet and feathers of birds – mollusc mucus is a strong adhesive. The ability of the species to self-fertilise makes it possible for a single coloniser to establish a new population.

Evidence of the snail's ability to colonise new wetland habitat arises from mitigation measures on the Newbury by-pass project in southern England (Stebbing & Killeen 1998). A marshland was created in 1996 in an area of former arable land, latterly sheep-grazed pasture, adjacent to the new road. Eight shallow pools totalling 1590 m² were dug in a line approximately 160 m long and 20 m wide. The pools were fed by water from a pipeline connected to the River Kennet and planted with *Glyceria* spp. principally from sites not supporting Desmoulin's whorl snail. A few clumps of sedge containing low numbers of the snail were planted around the edge of the southernmost pool. The pools rapidly developed into a dense *Glyceria*-dominated swamp, but despite sampling over the following months, no Desmoulin's whorl snails were detected until July 1997, 13 months after creation of the habitat.

However, in the pool nearest the water source, Desmoulin's whorl snail successfully bred and increased in abundance over the following five years (Figure 3). A similar pattern occurred in the adjacent pool following a year's delay (Figure 4). The pattern of colonisation continued throughout the entire site so that, by late 2001, all the pools were populated by Desmoulin's whorl snail (Killeen & Stebbing in prep.). Autumn densities of >1000 snails m⁻² were as high as at any other site in the Kennet valley.

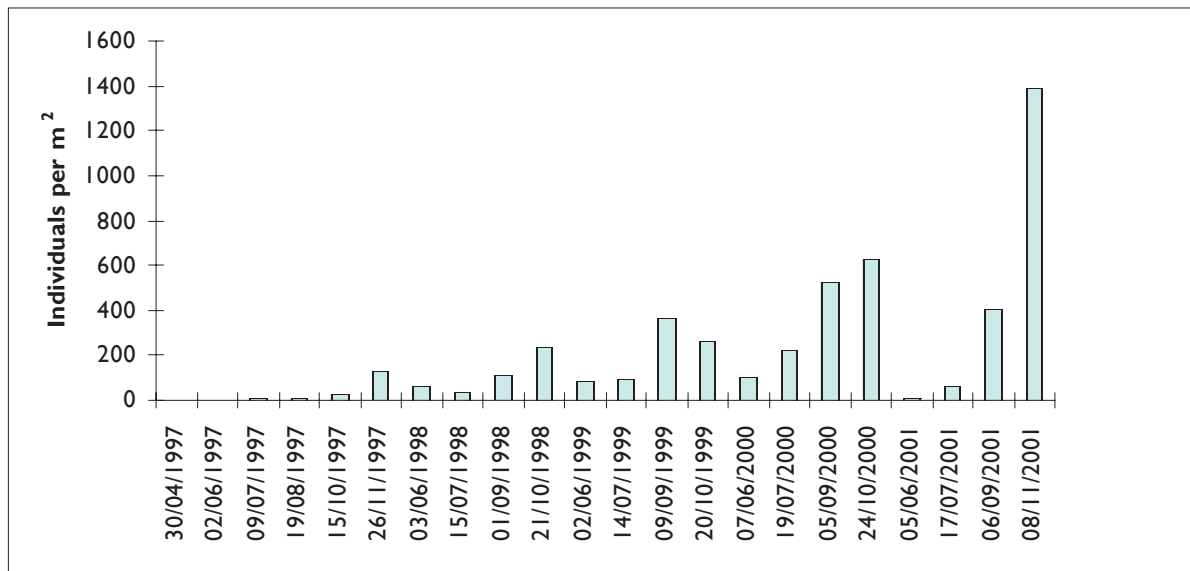
While it cannot be ascertained whether the population arose from snails present on introduced clumps of sedge only, or was supplemented by waterborne individuals from nearby populations, there is no doubt regarding the species' capacity to establish and rapidly spread into ideal habitat and increase in abundance.

Food

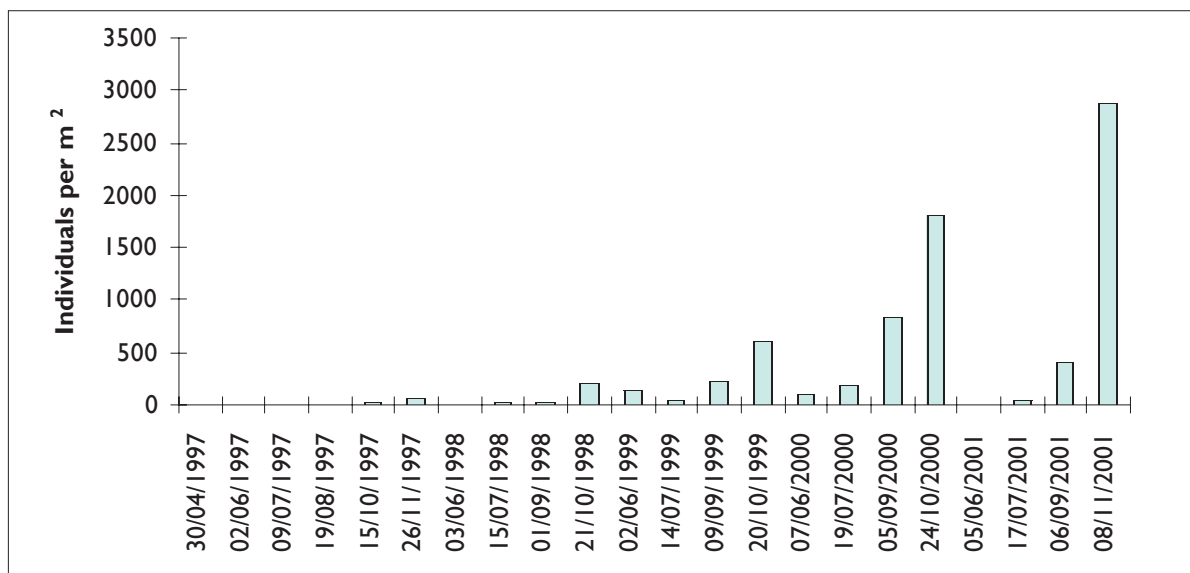
Desmoulin's whorl snail is believed to graze on fungi, micro-algae, and possibly bacteria growing on marsh plants, and decaying higher plants (Bondesen 1966). Steusloff (1937) records the species feeding on the fungi *Haplophragmium chlorocephalum*, *Puccinia urticae-caricis* and *Helminthosporium* spp.

Habit

Humidity is important to all whorl snails (*Vertigo* spp.) and the different species achieve their requirements by occupying different levels (i.e. vertical movement) within their microhabitats. Desmoulin's whorl snail is a climbing species in emergent vegetation, living over a large vertical range at different times of year, whereas other wetland *Vertigo* species live in shorter vegetation or within the litter layer on the ground. For example, *V. antiverdigo* lives in permanently wet litter, whereas *V. angustior* lives in the more open-structured moss and decaying vegetation towards the top of the litter layer.



Figures 3 and 4. Variation of Desmoulin's whorl snail population density at the Newbury bypass site, June 1997 to November 2001. In the pool nearest the water source, the snail successfully bred and increased in abundance over the following five years (above). A similar pattern occurred in the adjacent pool following a year's delay (below).





Tristan Hatton-Ellis/CCW

Desmoulin's whorl snail lives on a variety of plants, including sedges (left) and branched bur reed (right).

Desmoulin's whorl snail achieves its desired humidity by climbing above wet vegetation during warm periods and descending in cooler parts of the year. In spring, the snails are found low down, principally on the stems and leaves of monocotyledons, and then ascend the plants throughout the summer and autumn, reaching a height of over 2 m above ground level. In dense populations, as many as 100 individuals may be found on a single leaf blade.

With the onset of winter the snails descend to lower levels in the vegetation, where their location is determined by the habitat. In densely vegetated, sedge-dominated habitats, the animals over-winter on both the aerial (above-ground) leaves and stems and amongst the deep layer of dead litter. In large tussock sedges, the animals are found amongst the compacted inner part of the tussock and associated litter. In more open habitats, especially those dominated by reed sweet grass (*Glyceria maxima*), which collapses and dies off in winter, the snails are found amongst the litter and decaying vegetation.

A best-practice protocol for sampling and monitoring has been developed and published part of the **Conserving Natura 2000 Rivers Monitoring Series** (Killeen 2003).

Habitats

Desmoulin's whorl snail lives in permanently wet, usually calcareous, swamps, fens and marshes, bordering rivers, lakes and ponds, or in river floodplains. It is most often found in open situations.

Until the early 1990s, Desmoulin's whorl snail was considered to be a species restricted to old, long-established calcareous wetlands, sensitive to habitat disturbance, and scarcely known to colonise secondary, man-made habitats (Bratton 1991). Extensive recent studies, particularly in lowland river floodplains, have shown that the snail is more robust and is successfully occupying habitats that have arisen from relatively recent watercourse manipulation, and which are subject to other management such as grazing, burning and mowing (Killeen 2001b-h). For example, on Bagnor Island (River Lambourn), it is unlikely that suitable habitat existed prior to the creation of a mill stream in the late 18th/early 19th centuries (Stebbing & Killeen 1998). Water spilling from the mill stream across the slope of the resulting island allowed wetland habitat to develop.

Plant species

Desmoulin's whorl snail has been recorded living on a wide range of plants, but is most usually found on tall monocotyledons, principally:

- Reed sweet grass (*Glyceria maxima*)
- Sedges (*Carex riparia*, *C. acutiformis*, *C. paniculata*, *C. elata*)
- Saw sedge (*Cladium mariscus*)
- Reed (*Phragmites australis*)
- Reedmace (*Typha latifolia* and *T. angustifolia*)
- Branched bur reed (*Sparganium erectum*)
- Iris (*Iris pseudacorus*)
- Reed canary grass (*Phalaris arundinacea*)

It has also been recorded living on meadowsweet (*Filipendula ulmaria*), and rushes (*Juncus* spp.). However, in late summer and early autumn, when Desmoulin's whorl snail densities are at their highest, the species may be found on virtually all species of plants present in the habitat including stinging nettle (*Urtica dioica*); willowherbs (*Epilobium* spp.); umbellifers; hemp agrimony (*Eupatorium cannabinum*); valerian (*Valeriana officinalis*); dock (*Rumex* spp.); amphibious bistort (*Polygonum [Persicaria] amphibium*); bittersweet (*Solanum dulcamara*); water mint (*Mentha aquatica*); butterbur (*Petasites hybridus*); saplings of alder (*Alnus* spp.) and willow (*Salix* spp.); and even on fenceposts.

Glyceria maxima swamp/sedge marshes

This is the most typical Desmoulin's whorl snail habitat at many English sites, especially in lowland river floodplains. The habitat occurs within natural swamps and marshes, and around networks of small ditches, streams and depressions associated with open, relatively uncultivated land adjacent to rivers. Similar habitat also occurs frequently within areas of disused water meadows, grazing marshes and mill streams. The area of habitat may vary from a few tens of square metres to several hectares.



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***Glyceria* habitat in the Kennet valley, southern England. This is the most typical habitat for Desmoulin's whorl snail, particularly in lowland river floodplains.**



Ian Killeen

A sedge marsh in the Kennet valley, southern England, an example of typical habitat for Desmoulin's whorl snail, particularly in England.

Fens

In East Anglia, in particular, Desmoulin's whorl snail lives in fen habitat that has developed in glacial depressions (pingos). Characteristic habitat comprises pools or small meres with dense vegetation, particularly saw sedge (*Cladium mariscus*), and tussock sedges (*Carex elata*) and (*C. paniculata*).



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Pingo habitat in Norfolk. Desmoulin's whorl snail is often found in these glacial depressions, which form small pools, usually surrounded by dense fen vegetation, particularly sedges.

Phragmites australis swamp

Desmoulin's whorl snail may be found in *Phragmites* beds associated with river and lake margins, flooded peat workings and fens. In these habitats, the snail occurs principally in areas where the vegetation is dense and there is a layer of dead litter. It is much rarer or absent in reedbeds that are regularly cut, or with permanently flooded conditions where the plants grow directly into water and there is little or no litter layer.

Riparian margins

Desmoulin's whorl snail is found on tall monocotyledons at the margins of rivers, streams, ponds and lakes. However, its presence/absence and population density are largely determined by the structure and topography of the banks and the nature of the riparian management. The most suitable riparian habitats comprise a relatively broad strip where *Glyceria* or *Sparganium* spp. form dense floating rafts on gently sloping banks. Where the banks are steeper as a result of canalisation, impounding, channel dredging, and weed cutting, this habitat does not develop sufficiently and Desmoulin's whorl snail is uncommon or absent.

In the Norfolk Broads, Desmoulin's whorl snail lives on the margins of large rivers known as ronds, where there is often a broad zone of *Phragmites* protecting a mixed sedge/*Glyceria* habitat adjacent to higher man-made banks or bunds (Killeen 2001g). Many of these rivers are slightly brackish or have tidal back-up. In the upper section of the River Deben estuary in Suffolk, a population occurs in transitional marsh lying between saltmarsh and woodland (Killeen pers. obs.).

Alder carr

A feature of many of the Norfolk Broadland sites in particular is the presence of populations of Desmoulin's whorl snail in areas of alder carr (Ellis 1941, Killeen 2001g). Where the carr remains very wet, and is still vegetated by relatively dense areas of *Carex* spp. or *Iris pseudacorus*, a relict from when the sites were sedge swamp at the edge of water, the snail continues to survive. With advancing succession, such sites become drier and eventually too shaded to support the snail. At Sweat Mere,



Ian Killeen

Riverside beds of *Phragmites* reed in the Norfolk Broads. Desmoulin's whorl snail may be found in reedbeds associated with flooded peat workings, fens, and river and lake margins.



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Desmoulin's whorl snail is frequently found on tall plants on the banks of rivers, streams, ponds and lakes. Its population density is determined by the structure of the banks and the type of vegetation available.



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The most suitable riparian habitats for Desmoulin's whorl snail comprise dense floating rafts of *Sparganium erectum* or *Glyceria fluitans* on sloping riverbanks. The *Glyceria* raft above is on the River Lambourn, Berkshire.

Shropshire, Desmoulin's whorl snail clearly follows the vegetational succession, where it is abundant in the swampy *Carex/Typha* open-water margins, less common through the wetter alder carr, and absent from the carr transition through to drier oak/birch woodland (Killeen 2001a).

Desmoulin's whorl snail also occurs in poplar woodland that has been planted on riverside marshland. It has been recorded from *Glyceria* and sedge marsh in such habitats along the rivers Wylde, Wiltshire/Hampshire Avon and Little Ouse.

Other habitats

The vast majority of Desmoulin's whorl snail habitat in Britain falls into the above categories. However, the snail has occasionally been recorded in less typical habitats. For example, it has been recorded in Dorset from a small sloping area of fen associated with a tufaceous spring in limestone grassland (R. Cameron, pers. comm.), where the vegetation is described as

dominated by narrow-leaved sedges and rushes, which are heavily grazed and trampled by ponies. Holyoak (in press) records the species in Cornwall from a short grass- and herb-dominated fen, with *Festuca rubra* and *Salix repens* at the margins of a *Phragmites* swamp in a dune slack.

The habitat of Desmoulin's whorl snail elsewhere in its European range concurs with that for Britain. Bondesen (1966) regarded it as being typical of alder swamps in Denmark, while Nyilas & Sumegi (1991) describe it from Hungary in cool and humid 'birch marshland', and from oak forest that periodically floods. In both Denmark and Hungary, it is not clear whether the snail is found within shade in the woodlands, or in open clearings with fen vegetation.

Hydrology

High groundwater levels throughout the year are considered to be one of the most important factors influencing the distribution of Desmoulin's whorl snail. In lowland river floodplains with many snail-inhabited sites, there are also numerous, apparently suitable sedge-dominated habitats where the snail is absent, probably due to unfavourable groundwater levels. On Bagnor Island (River Kennet), detailed



Ian Killeen

Desmoulin's whorl snail can also be found in alder carr, particularly where the sedge vegetation is very wet and dense.

sampling of relatively homogenous *Carex riparia* fen demonstrated that the species occurred abundantly where seepages and springs allowed swamp conditions to form locally, but was largely absent from adjacent, drier fen (Killeen & Stebbings 1997).

Detailed studies of the hydrological requirements of Desmoulin's whorl snail have been undertaken at Chilton Foliat and Thompson Common, which are respectively within the Kennet and Lambourn Floodplain and the Norfolk Valley Fens Special Areas of Conservation (Tattersfield & McInnes 2003). Water levels were gauged by taking repeated measurements from a grid of dipwells installed on each site, while snail distribution and density were also recorded. Maximum snail densities, at locations where the hydrological conditions were considered to be at, or close to, the snail's optimum, were recorded where water levels were continuously above the ground surface throughout the year, and where mean annual water levels were more than 0.25 m above the surface. Annual fluctuation at these locations were between about 0 m and 0.6 m above ground level. Medium-density snail populations were associated with conditions where water levels fluctuated within 0.2 m of the surface, both above and below ground level. The critical minimum summer water level threshold, where the snail occurs but only at very low abundance, was estimated to be 0.5 m below surface ground level. However, it is unlikely that populations would be sustained under such conditions.

The close relationships found between the snail's abundance and water levels suggest that site hydrology is major factor determining the local distribution of the snail. However, it would seem likely that the influence of groundwater levels on the snail may be mediated via air humidity, since the snail spends much of the year climbing in the canopy of the vegetation well away from the ground. This relationship would merit further investigation, and could have practical conservation relevance, since humidity regimes are likely to be influenced by vegetation structure, which is clearly affected by management.

Table X. A summary of the hydrological requirements of *V. moulinsiana*.

<i>V. moulinsiana</i>	water level	fluctuation in water level	minimum water level	with ground surface
Presence of <i>V. moulinsiana</i>			Summer -0.5 m Winter -0.4 m	
High population	Greater than +0.25 m	0 m to +0.6 m		Water level never/very rarely falls below ground
Medium population	0 m	-0.2 m to +0.2 m		Water level fluctuates between -0.2 m and +0.2 m during the year
Low population	Less than 0 m	-0.4 m to 0 m		Surface inundation rare

Conservation and management

Desmoulin's whorl snail is considered to be dependent upon the conservation of habitat and preservation of high water levels, and is therefore vulnerable (Seddon 1997). Drainage of wetlands has been the principal cause of the snail's decline throughout its European range. However, there are many additional factors, applicable at any site, that could adversely affect Desmoulin's whorl snail populations:

- Changes in hydrology, such as water abstraction and general drainage of wetlands leading to reduced water tables and loss of periodic flushes.

- Canalisation of rivers, deepening of drainage channels, and creation of vertical profiles to riverbanks, eliminating wetland marsh habitat.
- Regular cutting of riparian margins of rivers and tidying of riverside paths, often associated with fisheries.
- Changes in land use – for example, from rough pasture or meadow to improved grassland.
- Encroachment by scrub or alien plant species, which may result in too much shade and/or drying out of the habitat.
- Intensive grazing of fens or excessive poaching of ditch margins.
- Introduction of cutting or burning programmes at sites where there is no history of these activities.
- Use of pesticides and herbicides, and the effects of eutrophication.
- Decline of alder coppicing routines, leading to increased shading.

As the snail's basic requirement is swampy, usually unshaded ground with tall plants (which helps it survive winter floods), management should be directed at maintaining these conditions. The water level must remain close to the surface so that the ground remains at least moist for most of the summer, although some seasonal drying appears to be acceptable. Relatively high groundwater also contributes to maintaining a high humidity in the vegetation.

Conversely, conditions must not become so wet that aquatic plants such as watercress (*Rorippa nasturtium-aquaticum*) and fool's watercress (*Apium nodiflorum*) become dominant. Permanent flooding of reedbeds may also be detrimental as there will be no litter layer in which the snails can over-winter, and no sites for laying eggs.

Riparian management

Although suitable Desmoulin's whorl snail habitat exists, or has the potential to exist, along many kilometres of river banks, the snail's presence or absence is largely determined by riparian management.

River channel dredging as part of flood alleviation practice creates a vertical bank and results in the loss of marginal habitat. Regular weed cutting causes a similar effect. Although the marginal vegetation may



Catherine Duigan/CCW

Invasive non-native plants such as Japanese knotweed can alter the composition of Desmoulin's whorl snail habitat by replacing native species and increasing shading.

regenerate quickly, the roots and lower stems stand in permanently flooded conditions, and the plants rarely attain the density and litter level required to support the snail.

Much habitat is lost or rendered unsuitable as a result of regular cutting of sedge and tidying of banks to provide access for anglers.

Scrub encroachment and vegetational succession

Desmoulin's whorl snail will disappear from areas where conditions become dry enough for plants such as stinging nettle and great willowherb (*Epilobium hirsutum*) to become frequent or dominant. Light shade is tolerated but scrub, tall trees and reed casting deeper shade may be detrimental to the species' longer-term survival. Scrub development on fens may also lead to excessive drying-out in summer.

A feature of many of the Norfolk Broads sites in particular is the presence of populations of Desmoulin's whorl snail in areas of alder carr (Ellis 1941, Killeen 2001g). Usually, these habitats would be considered to be too heavily shaded. However, if the carr remains very wet and is still vegetated by relatively dense areas of sedge or iris, a legacy from when the sites were sedge swamp at the edge of water, the snail continues to survive. Some partial felling may, in the short term, allow the snail's habitat to flourish, but in the longer term, with advancing succession, such sites are likely to become drier and too shaded to support it, unless further management is carried out.

A similar conservation dilemma exists at the hydrosere (the transitional zone of plant communities from shallow open water to fen to alder carr to woodland) at Sweat Mere, Shropshire, where management policy is to allow the succession to continue with minimum intervention (Killeen 2001a). While Sweat Mere is an important outpost site for Desmoulin's whorl snail, its value as a hydrosere is greater. At sites where Desmoulin's whorl snail is found within marshy areas in poplar plantations, the habitat may eventually become too shaded, and some felling may therefore be required to maintain the populations.

Desmoulin's whorl snails are potentially or actually at risk from non-native invasive plants. Such plants are a major threat to habitat due to their rapid growth and dominance over native species and the difficulty of controlling them. Species of concern include Japanese knotweed (*Polygonum [Fallopia] japonica*), Himalayan [Indian] balsam (*Impatiens glandulifera*) and giant hogweed (*Heracleum mantegazzianum*). These riparian plants may directly alter the composition of Desmoulin's whorl snail habitat by replacing preferred species and increasing shading.

Grazing

There is clear evidence from many sites that grazing has a detrimental effect on Desmoulin's whorl snail populations. There are examples from many sites in the Wiltshire/Hampshire Avon catchment, and the Kennet and Lambourn floodplain, where cattle grazing severely restricts the distribution and density of the snail populations. For example, at Jones's Mill (River Avon) the Desmoulin's whorl snail population is spread over a wide area of the site, but cattle grazing has impacted the structure and density of the fen vegetation, and the effect on the snail distribution and abundance is significant (Killeen 2001c). The ungrazed fen in the central part of the site supports the highest density of Desmoulin's whorl snail (about 230 m⁻²), compared with the grazed compartments, which ranged from 0–50 m⁻². Within the grazed areas it is only the large *Carex paniculata* tussocks (too high to be trampled by cattle) that support the higher numbers.

At other sites in the Avon and Kennet valleys, continual cattle poaching of shallow *Glyceria*-filled ditches has resulted in the loss of the snail. In contrast, at sites where the habitat is predominantly fen dominated by *Cladium* spp. *Carex* spp. (such as East Anglian pingo sites) subject to light cattle grazing, the impact is relatively minimal. The cattle preferentially graze the more herb-rich areas and the dense sedge fens, and thus the Desmoulin's whorl snail populations are less affected.

At all such sites the snail population could be enhanced or recovered by excluding the cattle from the wetter ditches and depressions that support tall sedge species. This could be achieved by fencing, with

care needed to ensure that the fenceline habitat is robust enough not to become degraded by poaching.

Cutting or mowing of fens

Evidence from locations in East Anglia indicates that at sites where there has been a very long history of management, the snail is not significantly affected by mowing (Killeen 2001e, Kirby 1997). However, it appears to be more affected when mowing is introduced at sites where there is no previous history of the practice (Killeen 2001d). Regular mowing can produce a denser sward over time, and this is why such practices may be compatible with the snail in the longer term but not in the short term.

Table 1 shows the density of snails for compartments at Market Weston Fen, Suffolk, sampled in 2000, in order of the date they were last mown (Killeen 2001e). The early history of the fen is not well known, but included peat digging, sedge mowing and grazing. Since the Suffolk Wildlife Trust acquired the site (in 1980), management of the fen has focused on mowing. The Management Plan proposes continued mowing on a rotational basis, either annually, biennially, three-yearly or four- to five-yearly. Some areas will remain uncut.

Table 1. Density of Desmoulin's whorl snail in compartments at Market Weston Fen, Suffolk, and mowing history.

A	Uncut	59
G	Uncut	64
F	pre-1995	104
J	pre-1995	60
K	pre-1995	96
I	1995	80
D	1998	60
H	1998	28
C	1998	40
B	1999	22

The differences between these values are not especially high, and are based upon only one set of samples, so they should not be over-interpreted.

However, two general categories may be recognised. The samples from the compartments that are uncut, or have not been mown since 1995, yielded more than 60 snails per square metre. With one exception (compartment D), the samples from compartments mown during or after 1998 have less than 40 snails per m². Although this suggests that the Desmoulin's whorl snail population may be slow to recover from mowing, it may merely reflect the density of vegetation in these areas. The more recently mown

compartments have a much lower vegetation density, and therefore the volume of vegetation sampled (and thus the number of snails) within the sample area is also less. Although a significant number of snails must be lost when the sedge is cut, many will drop off onto the ground. In an adjacent strip of fen that was mown in 2000, Desmoulin's whorl snails were still living on the ground litter and amongst the regenerating leaves later in that year.

The short-term effect on recovery of Desmoulin's whorl snail in relation to cutting practice was illustrated at Thatcham Reedbeds, where mowing was introduced in the 1990s on a rotational three-yearly cycle to maintain botanical diversity. In blocks of fen with two years' re-growth, where the vegetation had become relatively dense, Desmoulin's whorl snail occurred only in very low numbers, whereas adjacent, unmown fen supported relatively dense populations (Killeen 2001d). The introduction of mowing at other locations where there is no history of the practice should therefore be considered carefully in the light of these data.

Burning

There is little information on the effects of vegetation burning, but in most cases it is likely to be detrimental to the snail. A site along the River Lambourn at Hunt's Green comprises a wide floating raft of sedge, reed sweet grass and reed that is periodically burned (every two to three years). This practice rapidly destroys all the tall thatch, but does not affect the roots. There appears to be little

effect on the Desmoulin's whorl snail population, presumably since burning is usually carried out in spring, when the snails are low in the vegetation or on the wetter litter layer (Killeen 2001d).

Pesticides, herbicides and eutrophication

There is no information on the effect of pesticides on Desmoulin's whorl snail populations, either indirectly by airborne spraying of farmland adjacent to sites, or directly through the use of molluscicides to control species such as the pond snail *Lymnaea truncatula* (an intermediate host of liver fluke). In either case, the effect is likely to be detrimental. Similarly, use of herbicides on farmland adjacent to populations of Desmoulin's whorl snail could impact the habitat composition and structure.

Desmoulin's whorl snail populations are potentially or actually at risk from water quality issues, particularly elevated phosphate and nitrate levels, and organic pollution. The snails may be directly vulnerable to organic pollution, particularly during periods of high flows when they can be immersed or transported. They are also vulnerable to poor water quality if it affects their habitat. The habitat on which Desmoulin's whorl snail depends can be impacted by pollution if it results in changes to the plant community. Elevated levels of nutrients, particularly phosphates and nitrates, are likely to be detrimental if changes result in the vegetation community. This is particularly relevant to snail habitat in river margins and drains, if the vegetation is likely to become rank.

Translocation

A translocation exercise was carried out in 1996 as part of the mitigation measures on the Newbury by-pass project (Stebbing & Killeen 1998). An area of approximately 600 m² of *Glyceria*- and sedge-dominated marsh on Bagnor Island (River Lambourn) which supported a Desmoulin's whorl snail population, was destined to be lost under the route of the new road. Although not previously attempted, a decision was made to carry out an experimental translocation of the habitat.

A receptor site 20–50 m away, adjacent to existing habitat, was prepared by removing 500–700 mm of soil and peat, vegetated mostly by stinging nettle and reed canary grass (*Phalaris arundinacea*). Turfs measuring 2.4 × 1.2 m in area and 0.4–0.8 m in depth were cut from the donor site and transported to the receptor site, which comprised three separate cells or scrapes. As the turfs were laid, the edges were pressed together. A network of shallow channels was created to allow water to flow through and across the site in order to provide a permanently wet habitat.

Monitoring of the vegetation and hydrology of the habitat over the period 1996–2001 showed that the translocation was successful (Killeen & Stebbings in prep.). Plant growth was vigorous, and within 18 months the site had developed into a habitat typical of others for Desmoulin's whorl snail in the Kennet and Lambourn floodplain. The snail population also responded positively. During the first year following translocation, low numbers were recorded. However, as the habitat stabilised and vegetation density increased, Desmoulin's whorl snail increased in abundance and was successfully reproducing. While the project on the Newbury bypass was a success, habitat translocation should not be viewed as a convenient option. It is expensive, and in all circumstances, translocation should be viewed as a last resort, after all other attempts at conservation *in situ* have failed.

Further research required

More information is required on the life history of Desmoulin's whorl snail. Our present knowledge is based upon inference from other *Vertigo* species, and from field monitoring carried out as part of the Newbury bypass project. Work should include laboratory-based studies to determine details of reproduction and growth, and frequent field sampling to more accurately determine population density and structure.

Additional studies should focus on the relationship between humidity/temperature and how Desmoulin's whorl snail achieves its desired humidity by climbing above wet vegetation during warm periods and descending in cooler parts of the year. Work is also required to determine the location of

populations during winter, particularly with respect to different habitats – for example, reed sweet grass-dominated vegetation, which usually collapses, and sedge-dominated habitats where there is usually a deep litter layer. It is important to know whether the over-wintering location affects the population structure, abundance and rate of recovery in spring. Work should be linked to habitat and topography, and how the variability of these assist the snail in harsh times.

The effects of management, particularly mowing and grazing, need to be investigated in greater detail. Market Weston Fen in Suffolk, where there is a long history of sedge cutting, and Thatcham Reedbeds in Berkshire, where cutting was implemented only relatively recently, would serve as ideal study sites. The effects of grazing could be more accurately determined at Jones's Mill in Wiltshire, where new management plans include exclusion fences in some snail-rich areas.

The monitoring of the Newbury bypass sites ended in November 2001 with the cessation of mitigation funding. The dataset spanning five and a half years is by far the longest for any *Vertigo* species. Further monitoring would continue to provide information on Desmoulin's whorl snail population dynamics, and in the newly created site, on rate of colonisation.

The distribution of Desmoulin's whorl snail in the UK is so strongly linked to sites with high groundwater levels that research is needed into the critical factors and threats to these sites. This research should help to both protect the best existing sites, and enable the restoration or recovery of others.

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Life in UK Rivers was established to develop methods for conserving the wildlife and habitats of rivers within the Natura 2000 network of protected European sites.

Set up by the UK statutory conservation bodies and the European Commission's LIFE Nature programme, the project has sought to identify the ecological requirements of key plants and animals supported by river Special Areas of Conservation.

In addition, monitoring techniques and conservation strategies have been developed as practical tools for assessing and maintaining these internationally important species and habitats.



Although Desmoulin's whorl snail is found across Europe, it is declining throughout most of its range as its wetland habitat is destroyed. Britain now supports the largest population in Europe.

The presence of Desmoulin's Whorl Snail is a good indicator of the naturalness of wetland habitats and is one of the species at the heart of a major European effort to conserve key freshwater animals and plants and the river habitats that sustain them.

This report describes the ecological requirements of Desmoulin's whorl snail in a bid to assist the development of monitoring programmes and conservation strategies that are vital for its future.

Information on Conserving Natura 2000 Rivers and Life in UK Rivers can be found at www.riverlife.org.uk

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