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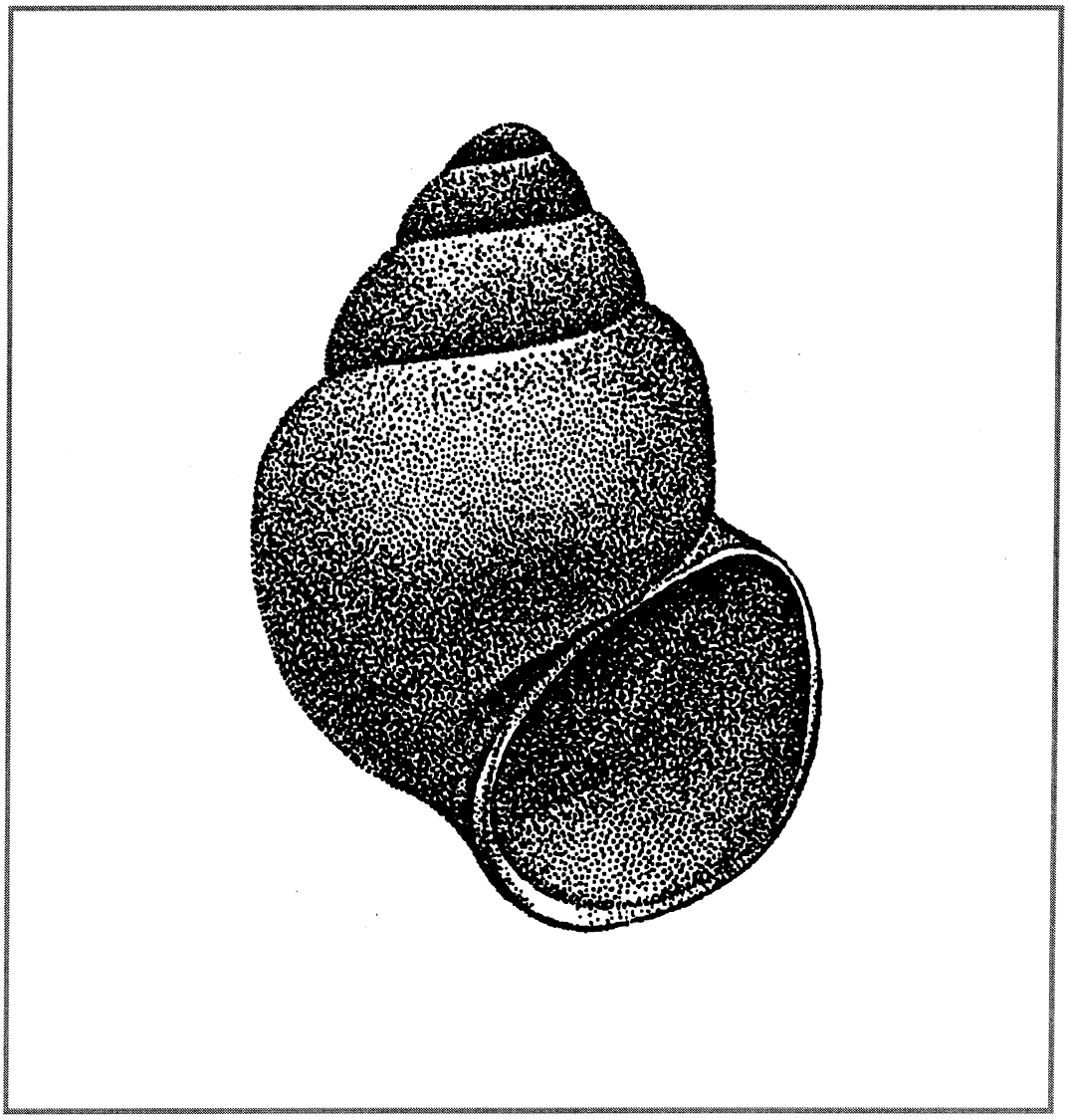

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A survey of the broadland distribution of *Pseudamnicola confusa* (Frauenfeld)

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Introduction

The Swollen Spire Shell *Pseudamnicola confusa* (Frauenfeld) is a small aquatic prosobranch snail that lives on soft mud banks at the upper limits of saline influence in a few estuaries and creeks in south-eastern and eastern England. It inhabits fresh or slightly brackish waters between the tide marks. It prefers quiet conditions and avoids strong currents. Judging from the rarity of the snail it is very sensitive to environmental changes. One of the richest populations of this species is on certain stretches of the lower River Arun in West Sussex where it is abundant, occurring in densities of 15,000 per m^2 (Abraham and Willing, 1997).

Pseudamnicola confusa (Red Data Book Category 1) is known from only four sites in Britain. Three of these sites are in East Anglia and the fourth on the River Arun in Sussex. Nationally this is an extremely rare mollusc, although where it does occur the densities can be very high. Two of its major sites are on the Rivers Waveney, including Oulton Broad, and the middle-reaches of the River Yare. It was reported from Thornham on the north Norfolk coast by D.S.Davis in 1960. E.A. (Ted) Ellis (1949) collected specimens from the River Yare opposite Cantley, from a tributary of the River Yare known as the River Chet and from the River Waveney. Killeen (1992) reports other possible sites at Snape on the River Alde (D.J.Cranmer,1970) and at Shotley (C.M.Drake, 1988).

During 1997 specimens were collected from Rockland Broad, Wheatfen Broad and marshes off Oulton Broad. The first two sites are new records and since both Ted Ellis and Arthur Ellis surveyed these waters extensively in the late 1930's to early 1940's we speculate that they are recent invaders. The swollen spire shells are known to frequent areas of open mud which are subjected to tidal fluctuations and/or flooding. The preferred broadland habitat is one dominated by reed sweet-grass *Glyceria maxima* (Hartm.) Holmberg. In the 1940s the Yare river valley was dominated by *Glyceria maxima* which subsequently has been in serious decline since the surveys of Joyce Lambert in the late 1940's (Lambert 1946:1947).

The current survey examines the distribution of *Pseudamnicola confusa* in Broadland. It aims to gain data on densities, habitat vegetation, mud structure, chloride levels, and other possible factors affecting the ecology of the species. The survey includes an assessment on the decline of *Glyceria maxima* and the management strategies to conserve the habitat for the mollusc. The Yare valley is the subject of extensive plans for bank reinforcement and development employing different rond profiles etc. (National Rivers Authority, 1995). In identifying existing sites the survey aims to advise on suitable bank profiles necessary to conserve the mollusc.

Methods

Comparative estimates, (given in relative numbers for each species), of the presence of *Pseudamnicola confusa* and other molluscs were made from sample collections of vegetation, litter and surface mud approximating to 2 litres in volume. The material was sieve-washed, plant debris floated off and the residues examined. At a number of sites accurate estimates of densities were obtained by the removal of plants, litter and mud surfaces to 3cm within a random series of $25cm^2$ quadrats. The detailed work of Abraham and Willing (1997) on the River Arun clearly showed that only by the removal of both vegetation and silts can accurate counts be made since visual field counts grossly underestimate densities. In the current survey the comparative method above was used to map the distribution of the species relative to other sites and the quadrat

method was used to gain accurate estimates of densities for comparison between East Anglian and West Sussex populations.

Broadland distribution

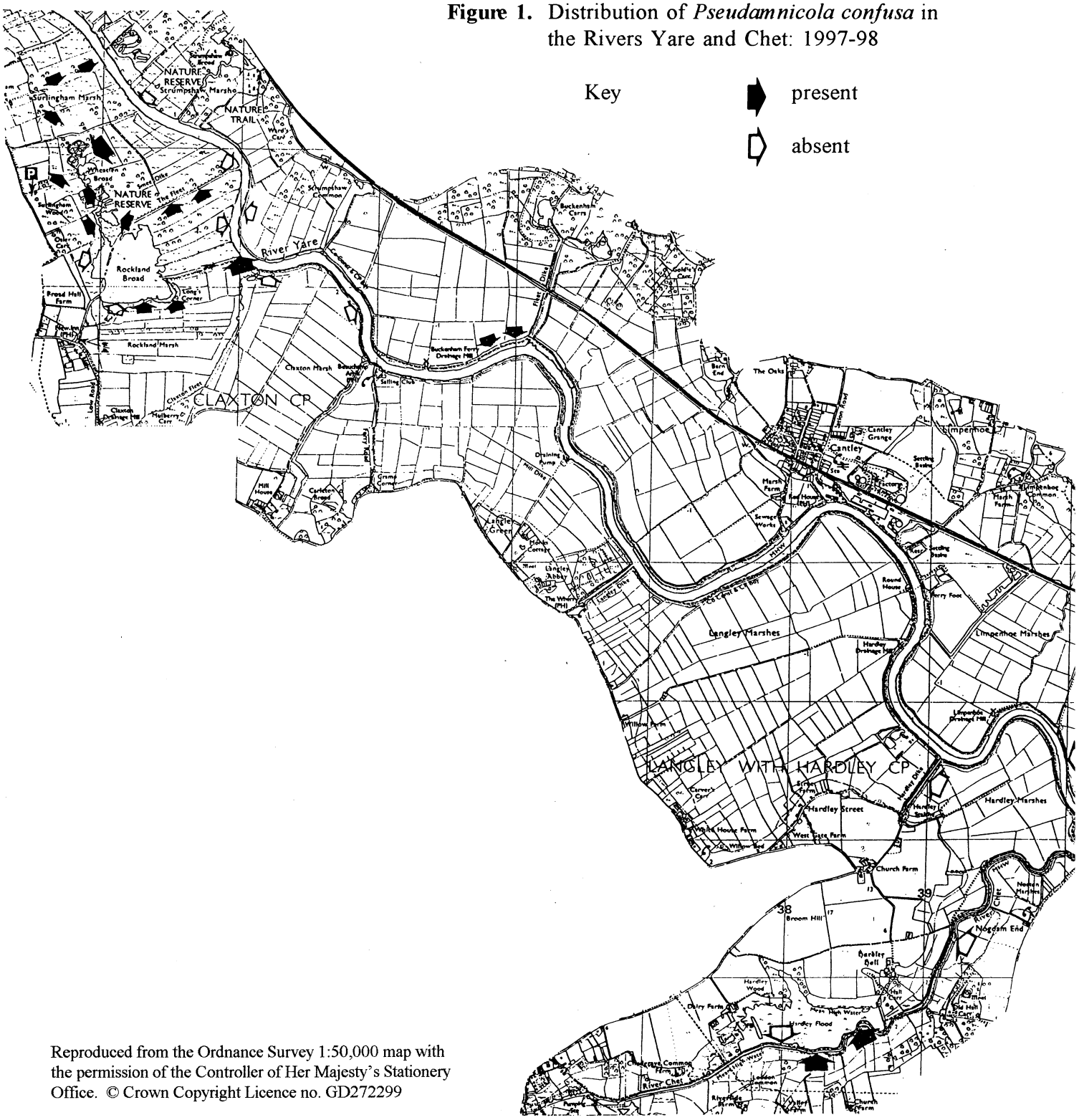
The current distribution of *Pseudamnicola confusa* in the Norfolk-Suffolk Broads is shown in Figures 1 & 2. Essentially the species is restricted to the mid-Yare and Waveney rivers and their linked broads and dykes. There is evidence since the early 1990's that the swollen spire shell is increasing its range in the Yare valley as water quality improves.

The River Yare and its three principal tributaries, Wensum, Waveney and Bure, drain some 3500km^2 of land in Norfolk and north Suffolk. The lower reaches of these rivers are tidal to points 40 to 50km from the mouth at Great Yarmouth. Most of the broads area lies below the highest river levels and thus is susceptible to flooding. The most damaging events occur when marine surges and tides combine to cause abnormally high sea levels. The salt waters flowing into the rivers increase chloride levels and penetrate far upstream. These saline intrusions cause serious damage to the ecology of the normally freshwater reaches and can lead to heavy fish kills. These intrusions normally occur in the winter but in summers, when freshwater flows are low, they can also occur (see Clarke,1990).

Table 1. Salinity levels in the River Yare surface waters of the spring flooding tide: 10th December 1993

TG 475-060	Top end of Breydon Water	8600mg/ Cl^-
TG 465-040	Berney Arms	3400mg/l Cl^-
TG 458-043	Ravenhall	2100mg/l Cl^-
TG 460-043	Wickhamptom Marsh	1800mg/l Cl^-
TG 453-034	Six Mile House	960mg/l Cl^-
TG 446-028	Upper Seven Mile House	360mg/l Cl^-
TG 408-016	Reedham Ferry	108mg/l Cl^-
TG 380-033	Cantley	80mg/l Cl^-
TG 350-043	Beauchamp Arms	76mg/l Cl^-
TG 329-056	Wheatfen Broad	84mg/l Cl^-

Figure 1. Distribution of *Pseudamnicola confusa* in the Rivers Yare and Chet: 1997-98



River Yare and associated broads

The River Yare and its tributaries, the Wensum and Tas, drain an area of 988km^2 across a low lying plateau standing 30-50m above sea level. The river flows in an east-south-easterly direction until it reaches Breydon Water at the confluence to the River Waveney. The shallow bed gradient of approximately 3cm fall per km together with the moderating capacity of the broads, produces a mean daily flow of 6.74m^{3}s^{-1}. The tidal limit reaches upstream as far as Norwich. The surface water saline interface normally occurs at Cantley at High Water.

The geology of the area comprises Cretaceous chalk covered with mixed drift, boulder clays and fluvio-glacial sands and gravels. The excavation of brushwood peats in the alluvial plain during the 12th-14th centuries has resulted in small water filled broads linked to the river. These are now rapidly filling with soft uncompacted organic, calcareous mud at a rate of approximately 1cm/a^{-1}. At Wheatfen Broad the chalk lies at a depth of 18.3m beneath fluvial-glacial sands and Norwich Crag of the Bramerton Beds.

River Yare and Rockland/Wheatfen Broads

Buckenham River Yare TG 357-045

The *Glyceria* beds on the margins of the river are often under 15+cm of water from the flooding tide. Bare mud beneath the *Glyceria* shows little or no evidence of a mat of dead vegetation. These beds appear to be in decline and currently represent the remains of once more extensive swards of reed sweet-grass. There is a question of whether or not they have been recently grazed.

Pseudamnicola confusa (3) was recorded from two sites but in very small numbers. It was absent from other two adjacent sites surveyed. The associated mollusca included *Valvata cristata* (1), *Potamopyrgus antipodarum* (13), *Lymnaea truncatula* (2), *Anisus leucostoma* (1) *and Pisidium personatum* (18).

Rockland Broad Fleet Dyke TG 334-056

Bordering the main navigation channel from Rockland Broad to the River Yare the fens are formed of ungrazed reed sweet-grass with a fringe of common reed on the margins of the dyke. This is a relatively dry site with encroaching reed. This site is transitional to a *Phragmites* reed swamp. In 1997 *Pseudamnicola confusa* was recorded from this site but no living specimens were noted in 1998. Other species recorded in 1998 were *Potamopyrgus antipodarum* (4), *Lymnaea truncatula* (7), *Pisidium personatum* (1), *Carychium mimimum* (1) *Cochlicopa lubrica* (1), *Vallonia pulchella* (4), *Zonitoides nitidus* (4), and *Ashfordia granulata* (18).

Junction of Short Dyke-River Yare TG 339-052

A small area of ungrazed *Glyceria maxima* bordering the River Yare. A wet site subject to tidal fluctuations and flooding The survey in 1998 produced *Pseudamnicola confusa* (5), *Potamopyrgus antipodarum* (2), *Lymnaea truncatula* (1), *Succinea putris* (1), *Cochlicopa lubrica* (3), *Vertigo moulinsiana* (1), *Vallonia pulchella* (3), *Vallonia costata* (1), *Vallonia excentrica* (1), *Zonitoides nitidus* (6), *Discus rotundatus* (2) and *Vitrea crystallina* (1).

A sample taken from this site in 1997 revealed no sign of *Pseudamnicola confusa.*

Rockland Broad: Slaughters TG 329-053

Dense reed beds subject to tidal flooding. *Pseudamnicola confusa* absent from this site. *Bathyomphalus contortus* (occasional), *Potamopyrgus antipodarum* (common), *Lymnaea truncatula* (occasional), *Pisidium personatum* (frequent).

Rockland Broad margins TG 335-049

The southern and eastern margins of the broad are very wet and muddy areas. During normal high tides they are not washed over with water, although one or two lows do form shallow pools as the water permeates through the peat. These areas have a small number of resident plants: *Phragmites* is the dominant one, but *Glyceria, Typha*, various *Carex* species and *Iris pseudacorus* (yellow flag) still remain either interspersed or in the form of small patches. Emerging from these are many sallow bushes and willow trees.

Site 1. A small patch of *Glyceria* with a few *Phragmites* stems emerging, sallows overhanging on one side.

- **Sample 1.** *Pseudamnicola confusa* (1), *Potamopyrgus antipodarum* (5), *Vertigo moulinsiana* (1), *Pisidium obtusale* (2), *Pisidium personatum* (3).

Site 2. A large patch of *Glyceria* with a few *Phragmites* stems emerging, surrounded on three sides by willows and sallows. All sample sites flood only at very high tides.

- **Sample 1.** *Pseudamnicola confusa* (3), *Potamopyrgus antipodarum* (18), *Vertigo moulinsiana* (1), *Pisidium obtusale* (2), *Pisidium personatum* (30).

- **Sample 2.** *Pseudamnicola confusa* (4), *Potamopyrgus antipodarum* (28), *Euconulus fulvus* (1), *Pisidium obtusale* (7), *Pisidium personatum* (20).

- **Sample 3.** *Pseudamnicola confusa* (5), *Potamopyrgus antipodarum* (32), *Vertigo moulinsiana* (1), *Pisidium obtusale* (11), *Pisidium personatum* (20).

Site 3. *Phragmites* and *Carex* spp. surrounded on three sides by willows and sallows. A very wet area at normal high tides. *Pseudamnicola confusa* absent.

Site 4. Mixed vegetation, *Phragmites, Carex, Typha* and *Glyceria,* willow and sallow on two sides. Slight flooding at normal high tides. *Pseudamnicola confusa* absent.

Site 5. Mixed vegetation of *Phragmites, Typha* and *Glyceria*. This site floods only at very high tides. *Pseudamnicola confusa* absent.

Site 6. *Carex* sward surrounded by willows and sallows, overhanging silver birch and a young oak tree. Slight flooding at normal high tide. *Pseudamnicola confusa* absent.

Howlett (1997) concluded that the key to this species survival at Rockland Broad is reed sweet-grass *Glyceria maxima* growing in relatively open situations. One possible explanation for this is the nature of the die-back each winter. The dead leaves collapse to the ground forming a soggy mat over the surface of the mud. This provides a very wet and sheltered environment beneath

which the snails can survive. When common reed and sedges die-back they remain standing and this results in a more open and exposed habitat on the mud surface. Currently there is a serious decline in the status of reed sweet-grass both in Rockland Broad and the mid-Yare valley.

Fen Channel Wheatfen Broad TG 329-054

Common reed fringe with small area of ungrazed reed sweet-grass subject to regular flooding by tides. In comparative estimates by sample volume the numbers of snails collected were *Pseudamnicola confusa* (35), *Potamopyrgus antipodarum* (28), *Lymnaea truncatula* (4), *Vertigo moulinsiana* (2), *Vallonia pulchella* (3), *Vallonia excentrica* (4) and *Zonitoides nitidus* (3).

This site was revisited on July 31st 1998 and examined in some detail. The Fen Channel is reed fringed but 2m landwards there is an area of *Glyceria maxima* fen with some *Phragmites australis*. This extends 15m from the bank. Quadrat samples were taken by removing litter and the mud surface and washing through a sieve after floating off vegetation.

- **Site 1.** 2m from Fen Channel. Vegetative cover by *Glyceria* 90%; there were 60 shoots of *Glyceria* and 60 of *Phragmites* per metre^2. However, the latter shoots were closely grouped from their rhizomes. At ground level there was little vegetative cover and exposed mud (90%) was characteristic of this site. *Pseudamnicola confusa* was abundant on the mud surface. Density estimated at 400m^2.

- **Site 2.** 12m from Fen Channel. *Glyceria* cover 80%, *Phragmites* 20%. Shoots *Glyceria* 32 and *Phragmites* 60 per metre^2. There was more litter at this site but the ground cover of mud remained large (85%). Density of *Pseudamnicola confusa* 8m^2. *Pisidium personatum* abundant.

- **Site 3.** 22m from Fen Channel. *Phragmites* dominated reed swamp. This was a drier habitat with a *Phragmites* shoot count 220/m^2, *Phalaris* 40; ground cover 25% but there was little exposed mud. A fibrous mat formed from the base of the reeds covered the surface. Also present *Typha, Solanum, Convolvulus* and *Urtica*. Density of *Pseudamnicola confusa* 0m^2 (absent).

Wheatfen Broad: Penguin Dyke Wherry Turning Circle TG 328-058

A wet area subject to tidal fluctuations with dense stands of reed sweet-grass. The site is enclosed by reed fen with *Pharagmites australis* and *Phalaris arundinacea*. The litter is very thick. *Pseudamnicola confusa* (2), *Potamopyrgus antipodarum* (14), *Pisidium personatum* (11) and *Lymnaea truncatula* (1).

Wheatfen Broad: Pool TG 328-059

The Pool is at the end of the mosaic of broads, dykes and channels of the Wheatfen system. At low water muds are exposed. The site is enclosed with reeds and is subjected to tidal changes. *Pseudamnicola confusa* (3), *Potamopyrgus antipodarum* (11), *Pisidium personatum* (9).

Wheatfen Broad: Alder Carr Marsh TG 327-064

In *Glyceria* beds subjected to tidal flooding. This fen has recently been cleared of sallow carr and the dyke system re-instated to bring water off and onto the fen twice daily. The dykes are linked directly to the River Yare. *Pseudamnicola confusa* (5), *Vertigo moulinsiana* (4), and *Potamopyrgus antipodarum* (5)

Parish Water TG 330-055

Parish Water is an area of shallow, tidal, open waters which at low tides has exposed muds. It is a major wildfowl refuge. The Swollen Spire Shell was discovered in *Glyceria* near the entrance from the Fen Channel. In comparative estimates using the volume method *Pseudamnicola confusa* may be described as being abundant.

A small stand dominated by *Glyceria maxima* on the left side at the entrance into Parish Water was examined in detail. Some *Cladium mariscus* mixed into this stand of reed sweet-grass. Number of *Glyceria* shoots per metre^2 104. Thick litter of *Glyceria.* Little exposed mud until this litter was removed.

Pseudamnicola confusa was recorded mainly on mud surfaces but also on litter. Density 500m^2. In a sample of *Glyceria* growing in the same site only a single specimen was noted on the leaves. However, this was a very low tide and further observations will be necessary to observe whether or not the snail climbs the leaves during spring flood tides. Snails kept overnight in a water filled petri dish lived happily under water. Some were noted moving on the undersurface of the water. Jeffreys (1904) observed that, "its habits are rather active, creeping and floating with tolerable rapidity." Associated species included *Potamopyrgus antipodarum, Vertigo moulinsiana, Bathyomphalus contortus, Pisidum personatum*

In *Phragmites* on opposite bank. Subjected to flooding by tides
Pseudamnicola confusa (abundant)

In *Phragmites* at distal end of Parish Water. Some *Phalaris, Carex* sp, *Glyceria.*
Pseudamnicola confusa (common)

Pseudamnicola confusa is absent from stands of sweet flag. These are often waterlogged and subjected to destructive feeding attacks by swans.

Wheatfen Broad: Hard Marsh TG329-057

This marsh borders the Fen Channel. For forty years this has been an area of dense sallow carr which was cut in the summer of 1997. The site has now returned quickly to reed fen with some reed sweet-grass. This site near the Fen Channel is subject to some flooding in high spring tides.

Pseudamnicola confusa (3), *Lymnaea truncatula* (4), *Potamopyrgus antipodarum* (6), *Pisidium personatum* (6).

Since the snail was previously absent from this site this record shows that the rate of colonisation by this snail of sites recently managed is rapid.

Surlingham: Brickyard Farm Fen; RSPB Reserve TG 327-064

Samples were taken from the flood plain adjacent to the Boat Dyke under *Glyceria maxima*. The swollen spire shell is present but in low densities. The evidence shows that reed sweet-grass is in sharp decline on this site.

- **Sample 1.** Low ground at the junction of a degenerated dyke running across the fen, and the Boat Dyke. *Glyceria* dominant, although invaded and surrounded by *Phragmites*. The site is flooded regularly by high tides. *Pseudamnicola confusa* (4), *Potamopyrgus antipodarum* (24), *Vertigo moulinsiana* (2), *Lymnaea truncatula* (1), *Vallonia pulchellum* (1), *Pisidium obtusale* (2), *Pisidium personatum* (9).

- **Sample 2.** A large area of *Glyceria* with *Phragmites* invading and surrounding the site The site is probably flooded less often by high tides than the sample site above. *Pseudamnicola confusa* (1), *Potamopyrgus antipodarum* (18), *Vertigo moulinsiana* (1) *Vitrea crystalina* (1), *Cochlicopa lubrica* (1), *Pisidium obtusale* (8).

- **Sample 3.** Low and very wet ground. *Glyceria* dominant, although invaded and surrounded by *Phragmites*. The site is flooded regularly by high tides. *Pseudamnicola confusa* (1), *Potamopyrgus antipodarum* (14), *Lymnaea truncatula* (1), *Lymnaea palustris* (1), *Vallonia pulchellum* (1), *Anisus leucostoma* (1), *Pisidium obtusale* (7), *Pisidium personatum* (9).

River chet

The River Chet is an enlarged stream dug out, widened and straightened in the late 1880s for wherry sailing traffic. It is really a canal from Loddon to the River Yare. Up until the late 1950s few boats used the Chet but in the early 1960s it was opened up for the growing holiday trade. The wash from the pleasure boats has caused considerable erosion to the banks to the extent that for most of its length the Chet is encased in piling. There are few areas of marginal ronded reed.

In 1940 the grazing marshes at Hardley were flooded and attempts to repair the banks failed. These marshes became reed dominated (*Phragmites australis, Glyceria maxima, Typha latifolia*) and today they form an extensive spillway with shallow lagoons. The tidal range of the Chet is such that water flows into and ebbs out of the now named Hardley Flood (SSSI). The bank separating Hardley Flood and the River Chet is low lying, narrow and reed dominated. At spring tides it is often under water.

Chloride levels measured on the top of the tide show that near the River Yare levels of 2170mg/l Cl^- occur whilst near the Hardley Flood the levels drop to 220 and 460mg/l Cl^-. Chloride levels were estimated using the Mohr method whereby chromate ions are unable to form silver chromate in the presence of free chloride ions. In the saline waters fresh, brackish and marine diatoms were recorded.

Table 2. Chloride levels in River Chet. October 15th 1998. Surface waters

Loddon Staithe	TG 369-991	100mg/l Cl^-
Outlet Hardley Flood	TG 379-996	220mg/l Cl^-
Hardley Hall	TG 385-996	460mg/l Cl^-
Nogdam End	TG 394-006	1100mg/l Cl^-
Hardley Cross	TG 401-011	2170mg/l Cl^-

Pseudamnicola confusa is confined to the tidally influenced reed margins of the freshwaters of Hardley Flood. The numbers are small. The first and only record from the River Chet at Hardley in 1949 was by E.A.Ellis. *Potamopyrgus antipodarum* is also present in the reed beds in considerable numbers, whilst *Viviparus viviparus* (L.) and *Unio pictorum* (L.) are found in the deeper waters of the river. This is also the site of the newly discovered *Corbicula fluminea* (Müller); a native of eastern Asia and a bivalve mollusc new to the British fauna (Baker, Clarke & Howlett, not dated).

Oulton Broad

Oulton Broad is in contact with the sea by means of a lock. It also connects with the River Waveney by means of a navigable dyke 1.5 km long, the Oulton Dyke. The lock fails to prevent seawater seepage. The River Waveney is tidal and this means that the ebb water flows from the Broad and mixes with landwater from the Waveney. The "mixing zone" is usually in the Oulton Dyke at high water and above Burgh St Peter on the River Waveney. Seawater coming from Breydon Water has an effect on the Waveney as far as Somerleyton. The chloride levels in Oulton Dyke are similar to those noted at Wheatfen and Rockland Broad during occasional tidal surges and at times of low freshwater outflow.

Oulton Broad is rich in phytoplankton, many being brackish water species. These get washed into Oulton Dyke which has a similar phytoplankton community. The Dyke has a retention period of between 40-50 days so the plankton remain in the system long enough to allow substantial populations of algae to build up and to provide ample food for the filter feeding mussels. In contrast the River Waveney has a less rich phytoplankton population.

Pseudamnicola confusa is abundant in the *Glyceria maxima* beds of **White Cast Marshes (TM 510-924)** bordering Oulton Broad. Snails can be collected up to 10cm above the mud surface on the leaves of the reed sweet-grass, amongst the leaf litter and from the mud surface. Killeen (1992) writes that Claude Morley in 1898 collected the species from the margin of Oulton Broad.

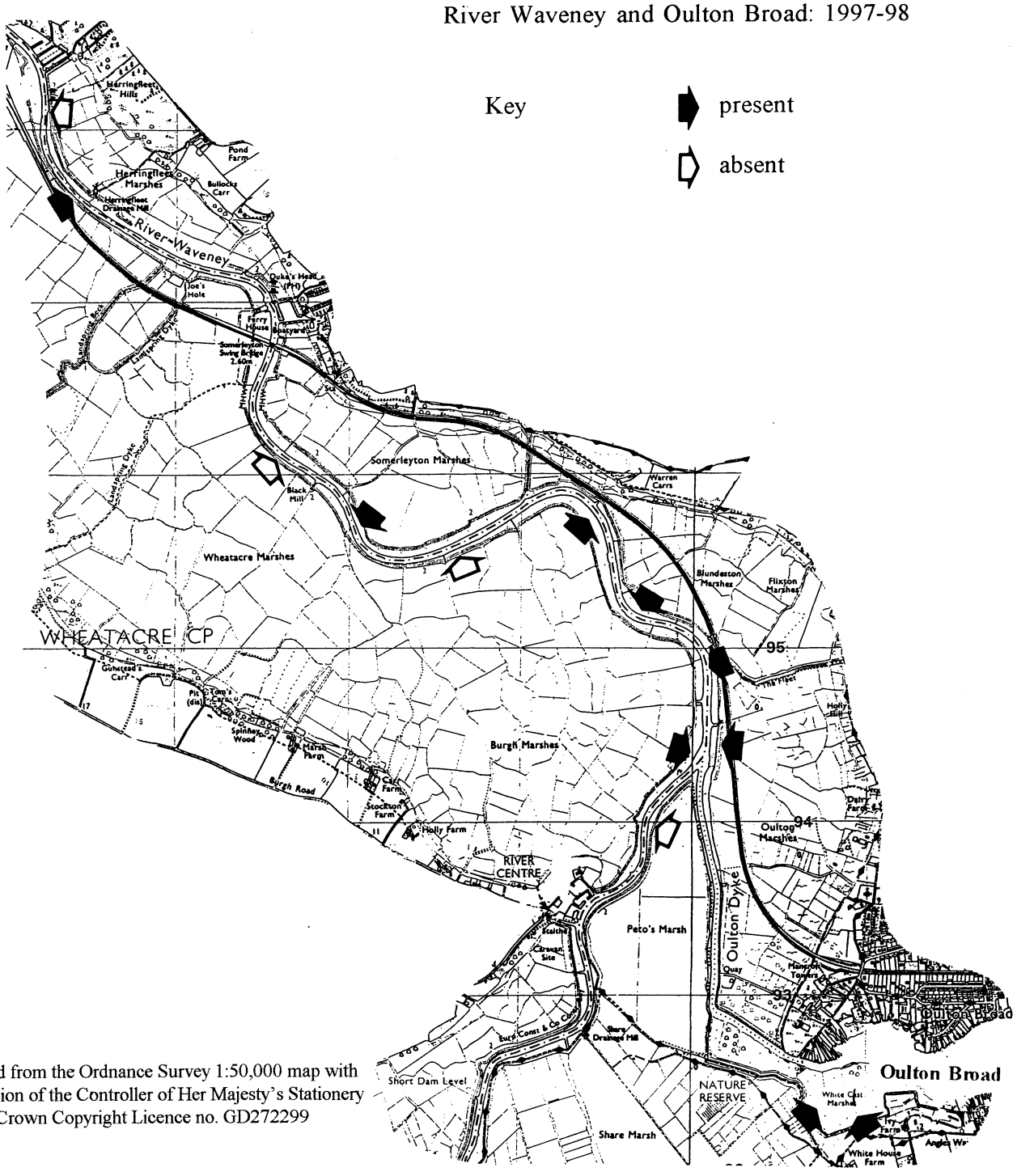
River Waveney

The River Waveney is characterised by the presence of fringing reed and/or reedmace. There is little evidence of sallow invasions of the river margins. On the Suffolk side the 1-2m wide marginal reed stands along the River Waveney are often replaced in the ronds in front of the low flood banks by reed sweet-grass and occasional reed canary-grass. These ronds are often 20-30+m wide between the river and the flood banks. On Flixton, Blundeston and Somerleyton marshes cattle have access to the ronds. There is heavy grazing of the reed grass to 20cm. The ground is trampled and full of deep water filled holes left by the cattle. The ronds are regularly subjected

to flooding to depths of 10-30cms. The river flood banks are often bare of vegetation and eroded by the movement of the cattle.

On the Norfolk bank the reed and reedmace beds are more extensive and it is only between Burgh St Peter and the mouth of Oulton Dyke that *Glyceria* beds occur in any quantity. These are cattle grazed. Elsewhere to Haddiscoe the marginal reed extends to the river or railway banks.

Figure 2. Distribution of *Pseudamnicola confusa* in the River Waveney and Oulton Broad: 1997-98



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In terms of management the *Glyceria* beds are maintained by cattle grazing. However, the overgrazing and trampling of the rond vegetation does adversely effect the presence of *Pseudamnicola confusa*. It is a question of balance between limiting the invasive *Phragmites* and the over exploitation of the *Glyceria* beds as cattle feed.

The evidence from this survey indicates that *Pseudamnicola confusa* is generally absent or in low densities in beds of common reed, is present in grazed *Glyceria maxima* beds but is abundant in ungrazed *Glyceria maxima* beds. Cattle trampling is detrimental to the success of this snail in these sensitive rond areas. Cattle grazing occurs mainly on Suffolk side, whilst on Norfolk side both cattle and sheep are often grazed.

Oldham (1922) discovered it at several sites along the River Waveney as far up river as Barsham. E.A.Ellis (1949) noted it from Beccles to St Olaves and currently Killeen (1992) observes that live specimens can still be found along the same stretch of the river. This distribution is confirmed in the current survey. Detailed data with comparative assessments of the snail populations for sites on both the Suffolk and Norfolk sides of the Waveney are given below.

Flixton Marsh, Suffolk TM 500-950.

Common reed fringe to river with ungrazed *Glyceria maxima* forming a major part of the rond. *Pseudamnicola confusa* (36), *Potamopyrgus antipodarum* (103), *Sphaerium lacustre* (2), *Pisidum personatum* (5). This site is contains the highest densities of the swollen spire shell along the banks of the Waveney river

Blundeston Marsh, Suffolk TM 495-957

Grazed *Glyceria* with numerous trampled water filled holes from activities of cattle. The River Waveney at this site is fringed with common reed and reed-canary-grass. During spring tides the margins are covered with 5-10cm flood water. Salinity levels in river 640mg/l Cl^-; centre of rond 660mg/l Cl^-; near flood bank 640mg/l Cl^-. *Pseudamnicola confusa* (14), *Potamopyrgus antipodarum* (180), *Lymnaea truncatula* (2), *Anisus leucostoma* (7),

Somerleyton Marsh, Suffolk TM 480-960

Grazed *Glyceria*. Reed fringe with reed canary-grass and reedmace. Grazed by dairy cattle. *Pseudamnicola confusa* (15), *Potamopyrgus antipodarum* (5), *Lymnaea truncatula* (5),

Haddiscoe Marsh, Norfolk: TM 465-974

A small area (3m strip parallel to river) of part-grazed *Glyceria* enclosed by thick beds of common reed. Flooded by high tides. River salinity level 1440mg/l Cl^- opposite Herringfleet smock mill (TM 465-975). *Pseudamnicola confusa* (5), *Potamopyrgus antipodarum* (76), *Lymnaea truncatula* (2).

Burgh Marsh, Norfolk TM 494-957

Grazed *Glyceria* with reed fringe to river. Some sallow on river bank. Flood bank 50m+ from river. *Pseudamnicola confusa* (1).

Burgh Marsh, Norfolk TM 499-942
Grazed *Glyceria* from Burgh St Peter to point opposite entrance to Oulton Dyke. Common reed fringe to river and *Glyceria* to flood bank.. Flooded at high tides. Salinity at Burgh St Peter 230mg/l Cl^-. *Pseudamnicola confusa* (2), *Potamopyrgus antipodarum* (56), *Bithynia tentaculata* (1), *Lymnaea truncatula* (1), *Anisus leucostoma* (8), *Pisidum personatum* (2).

Oulton Marsh, Suffolk: TM 502-948

This marsh is dominated by *Phragmites australis*. It can be classified as being reed swamp. *Potamopyrgus antipodarum* (8).

Surveys of the rivers Bure and Thurne

No evidence for the presence of *Pseudamnicola confusa* was found on either of these two rivers, other than a single empty shell discovered amongst marginal *Phragmites* near Upton Dyke. This has probably been carried by the tidal currents from either the River Yare or Waveney through Breydon Water.

Gut contents

Twenty one living specimens of P*seudamnicola confusa* were collected from the marsh surface at Wheatfen Broad in an area dominated by *Glyceria maxima*. The marsh floods from time to time but at the time of the collection it was not flooded (chloride level 80mg/l). The snails were transported to the laboratory in a jar containing soaked tissue paper from which they were removed after 2 hours and placed in a Petri dish with a little distilled water which did not cover the whole area of the dish. The snails ranged widely within the dish. After 20 hours all were still alive.

Faecal pellets noted were 100µm-270µm long and 20µm-100µm in diameter. They were mostly opaque and were tapered at one or both ends (Type A). A few translucent ones were noticed which had rounded ends rather than tapered ones (Type B). The pellets were mounted in water under a cover glass, much of the water being drawn off with a piece of absorbent paper and the pellets crushed.

The pellets of Type A contained an amorphous mass which was coloured a bright yellow-green. On one accasion a single diatom was found (*Amphora ovalis*). These data indicate that *Pseudamnicola confusa* feeds not on the marsh surface but on the stems of *Glyceria* where the lush nature of the plant is suited to this mode of feeding.

The pellets of Type B contained many diatoms, mostly broken. They also contained grass pollen, spores of dematiaceous hyphomycetes and pieces of the alga *Tribonema tenerrimum* with live cells. Several motile diatoms of the genus *Diploneis* were observed as well as motile *Nitzschia palea*, *Achnathes minutissima* and dead frustules of *Pinnularia stomatophora*. In contrastto Type A these data indicate that the snail(s) has been feeding on the mud surface.

Discussion

The current survey shows that *Pseudamnicola confusa* is thriving in its known broadland habitats with densities reaching 500m^2. There is evidence that since the recent improvements in water

quality of the River Yare, that its distribution and densities reflect these changes. It appears to have colonised sites within the middle reaches of the Yare where it had previously been absent.

In the early part of the 20th C. the reedswamp around the margins of the mid-Yare broads was dominated by reed canary-grass (*Phalaris arundinacea*) and reed sweet-grass (*Glyceria maxima*). By the 1940's these had been replaced by *Phragmites australis*. Joyce Lambert and Ted Ellis both attributed this to the fact that the fens and reedswamps were no longer being mown in the summer months, a form of management which favoured *Glyceria* and *Phalaris,* while surpressing *Phragmites.*

Lambert (1946) concluded from her studies that common reed predominates the reedswamp bordering the Yare valley because it is better able to withstand tidal scouring than the semi-floating rafts of vegetation formed by reed sweet-grass, pieces of which tend to break away and float as 'hovers' as a consequence of wind and wave actions. The rafts also tend to be underlain by the rhizomes of common reed, indicating that the latter usually precedes the former in the succession from open water to fen.

Buttery and Lambert (1965) demonstrated that both *Glyceria* and *Phragmites* have similar nutrient requirements and were not differently affected by the enrichment of the Yare waters. However, *Glyceria maxima* swamp is associated with eutrophic, fertile conditions, particularly with high phosphate levels. (Wheeler and Shaw, 1987). It is found mainly in flood-plain fens, often on substrates containing a substantial mineral component, eg mineral alluvium.

Coypu were partial to the rhizomes of *Phragmites* whilst they lightly grazed the *Glyceria.* This led to the colonisation by the latter plant of some areas previously occupied by common reed. This was particularly noticeable in Surlingham and Strumpshaw Broads in the 1960's and early 1970's where the waters were edged by *Glyceria* where once a narrow strip of reed existed. *Phragmites* has colonized the margins of both these sites since the late 1970's as coypu grazing was eliminated.

Species poor stands of *Glyceria maxima,* with *Epilobium hirsutum, Filipendula ulmaria, Solanum dulcamara,* are specially characteristic of the Yare valley fens. In the past these were regularly mown to produce a coarse fodder for cattle. Many of the fens/marshes are unsuitable for cattle grazing because of the weak peat surfaces overlying peaty mires. If cattle grazing is limited, since many of these fens are unstable to bear the weight of cattle, and mowing is no longer a viable management procedure then the loss of reed sweet-grass is a consequence of changing land use. This will adversely affect the populations of *Pseudamnicola confusa.*

For the Yare valley the recommended management procedure may be the phased cutting in selected sites of the marginal vegetation to encourage the re-instatement of reed sweet-grass at the expense of common reed.

On the River Waveney the profile of the river is such that behind the marginal common reed fringe there exists areas of reed sweet-grass upwards of 30m wide to the flood bank. These swards are cattle grazed, especially on the Suffolk side, and this maintains the vegetative structure of the sites beneficial to populations of the snail. Abraham & Willing (1997) concluded that the highest population densities along the River Arun occur in the less shaded, cattle grazed areas of *Glyceria* where the poached mosaic of trampled vegetation and small pools appear to provide ideal conditions for the snail.

For the River Waveney our data suggests that in pure stands of reed sweet-grass the snail can attain high densities, but that such swards are adversely influenced by invasive common reed over time, and that cattle grazing is an effective and acceptable management technique for this river.

Abraham & Willing (1997) examined bank and berm reinforcement work on the River Arun at Burpham. They noted that significantly lower snail numbers of this Red Data Book Category 1 species occurred where the berms had been reinforced by river sediments, but that the snail does seem to be recolonising the disturbed ground. In our broadland sites we currently have little comparable engineering work to allow for meaningful comparisions. However, in future we are aware of plans for major bank reinforcement and construction along the broadland rivers. Many of the current banks of the Rivers Yare and Chet are effectively wood or metal piled or clay banked such that the snail is excluded from colonising the sites. **If these are to be extended to other sections of these rivers then the effects on the mollusc will be severely detrimental.** The River Waveney has far fewer banks constructed directly onto the river. The flood banks lie behind often wide areas of fringe vegetation. As noted above these latter are cattle or sheep grazed. This is more beneficial for the snail populations.

The proposed raising and construction of river banks may also directly influence the saline incursions along the rivers. Willing (1997) notes that *Pseudamnicola confusa* is particlularly vulnerable to small changes in salinity, and that these are easily brought about by alterations to river channels and the construction of weirs and locks (Yare barrage/ Oulton Broad lock) which may disturb the subtle salinity gradients exisiting in the lower reaches of rivers. **The snail is effectively a freshwater species with an ability to survive in very slightly brackish waters. Any engineering constructions along the rivers should be carefully monitored for changes in salinity.**

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