GB Non-native Species Rapid Risk Assessment (NRRA)

Rapid Risk Assessment of: *Cipangopalundina chinensis* (Chinese Mystery Snail)
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Introduction:
The rapid risk assessment is used to assess invasive non-native species more rapidly than the larger GB Non-native Risk Assessment. The principles remain the same, relying on scientific knowledge of the species, expert judgement and peer review. For some species the rapid assessment alone will be sufficient, others may go on to be assessed under the larger scheme if requested by the Non-native Species Programme Board.

Guidance notes:

- We recommend that you read all of the questions in this document before starting to complete the assessment.
- Short answers, including one word answers, are acceptable for the first 10 questions. More detail should be provided under the subsequent questions on entry, establishment, spread, impacts and climate change.
- References to scientific literature, grey literature and personal observations are required where possible throughout.

1 - What is the principal reason for performing the Risk Assessment? (Include any other reasons as comments)

Response: To assess the risk associated with this species in Great Britain following the discovery of *Cipangopaludina chinensis* at one site on the Pevensey Levels, East Sussex.

2 - What is the Risk Assessment Area?

Response: *Great Britain*

3 - What is the name of the organism (scientific and accepted common; include common synonyms and notes on taxonomic complexity if relevant)?

Response: *Cipangopaludina chinensis* (Gray, 1833). Common names include Chinese Mystery Snail, also Oriental Mystery Snail, Asian Apple snail). An alternative and quite widely used name is *Bellamya chinensis*. Thus Collas *et al* (2017) argue that the snail be

placed in the genus *Bellamya* on anatomical grounds following Smith (2000). Others though (e.g. Kipp *et al* 2020) use *Cipangopaludina chinensis*. The latter name is adopted in this document following MolluscaBase (MolluscaBase 2019).

4 - Is the organism known to be invasive anywhere in the world?

Response: Yes.

Cipangopaludina chinensis is native to China, Taiwan, Korea and Japan (Global Invasive Data Base 2011).

The snail has been introduced to several regions of the world. Thus, it was introduced into the USA at the end of the 19th century for the Asian food market (Jokinen 1982, Karatayev *et al* 2009). Since then the species has spread widely throughout the country. Kipp *et al* (2020) show the widespread presence of the snail across the USA with populations present in 36 States (including three of the Hawaiian Islands). The snail is especially widespread towards the north east of the States with 41, 37, 25 and 17 reported sites in Wisconsin, Minnesota, Michigan and Ohio respectively. Perhaps these States most closely resemble climatic conditions in the Risk Assessment Area (G.B.).

Of relevance to this NRRA is the arrival and spread of *C. chinensis* in Europe. The species was first recorded in the Netherlands in a River Meuse floodplain lake at Eijsder Beemden in the south of the country in 2007 (Piters 2007). By 2016 the snail had established 12 populations in the country in the Rhine and Meuse basins (Collas *et al* 2017). It was also first recorded in Belgium in 2017 (Van den Neucker *et al*. 2017). In the Netherlands the presence of *C. chinensis* at scattered, isolated sites is considered probably due to multiple and independent introductions, probably from aquarium and pond disposals or escapes from pond and garden centres (Collas *et al* 2017, Matthews *et al* 2017a).

5 - What is the current distribution status of the organism with respect to the Risk Assessment Area?

Response: *C. chinensis* was first recorded in September 2018 in a ditch on Glynleigh Level at NGR: TQ61143 07123, a location lying on the south-west margins of the Pevensey Levels (Willing 2019a, Rowson 2019).The site was revisited by two surveyors on 27.7.2019 and a survey undertaken of the ditch where the snail was originally discovered together with several adjoining ditches (see attached: Appendix Map 1 and Map 2). This most recent survey found the snail in the original ditch spread along about 420m (on Map 1 extending from 'Point 1' to 'Point 2'). A total of 36 live snails were found, mostly in the muddy shallows of the ditch rather than in the deeper water (> 0.5m). Most of the snails were adults (50% of the sample > 50mm in height*) but a proportion of juveniles were collected indicating a breeding population. Several female snails kept in captivity produced live young in the days immediately following the field visit (young snails ranging 6 – 8mm in height)
* Typical maximum sizes for adults in the USA is about 64mm (Johnson *et al* 2009); in Europe snails have been recorded to reach 70mm (Matthews *et al* 2017b).

6 - Are there conditions present in the Risk Assessment Area that would enable the organism to survive and reproduce? Comment on any special conditions required by the species?

Response: Yes there are conditions in the Risk Assessment area that have allowed the species to survive, reproduce and spread.

The snail has a wide tolerance of a wide variety of water conditions. *C. chinensis* is a species that typically lives in still or slowly flowing water bodies (ponds, lakes streams and rivers) and in such situations it is found on a variety of substrates including silt, sand and mud (Jokinen 1982, Stancykowska *et al* 1971). In eastern North America the species lives in a wide range of waters conditions ranging from hard to soft. It has been found in waters with pH 6.5–8.4, calcium concentration of 5–97 ppm, magnesium concentration of 13–31 ppm, oxygen concentration of 7–11 ppm, depths of 0.2–3 m, conductivity of 63–400 µmhos/cm, and sodium concentration of 2–49 ppm (Jokinen 1982, Jokinen 1992, Stanczykowska *et al*. 1971). It can tolerate conditions in stagnant waters near septic tanks (Perron & Probert 1973) and is a 'temperature-hardy' species capable of surviving at temperatures as high as 45ºC and for prolonged periods < 0ºC (Burnett *et al* 2018).

7 - Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment Area or sufficiently similar for the organism to survive and thrive?

Response: Yes.

The known invasive geographic distribution of *C. chinensis* (the United States, North-West Europe) includes a very wide range of ecoclimatic zones including all of those present in Great Britain (Kipp *et al* (2020, Collas *et al* 2017, Matthews *et al* 2017a, Van den Neucker *et al*. 2017). In the USA the snail is present in all ecoclimatic zones present in the country ranging from tropical (Hawaii), subtropical (Florida) to cool temperate conditions (e.g. New York State, Wisconsin, Minnesota, Michigan and Ohio). Conditions in Belgium and the Netherlands closely match those of much of eastern England. The UK is within the Atlantic Biogeographical Region together with a considerable portion of north-western Europe including all areas in the Netherlands and Belgium currently supporting recruiting *C. chinensis* populations (Matthews *et al* 2017a, 2017b).

8 - Has the organism established viable (reproducing) populations anywhere outside of its native range (answer N/A if you have answered 'yes' to question 4)?

Response: N/A …. See full response in Q. 4 above.

9 - Can the organism spread rapidly by natural means or by human assistance?

Response: *Cipangopaludina chinensis* appears to spread slowly by natural means, with the main cause of spread in non-native areas being instead by a combination of accidental and deliberate human actions.

The only located study of the rate of natural dispersal at Eijuder Beemden by the River Meuse estimated spread at approximately 0.1 km yr^{-1} (Collas *et al* 2017). It is considered that the main *C. chinensis* introductory pathways are by the aquaria and oriental food markets (Karatayev *et al* 2009, Strecker *et al* 2011). Outside its native range the spread of the snail seems to be chiefly by deliberate or accidental human action. Despite the extensive presence of the species in the USA, most explanation of the spread is conjectural rather than evidence-based and relates to human activity. Thus, the species was recorded as being sold in a San Francisco food market in the late 1880s; it was well established enough to have allowed collection in 1914 in Boston (Kipp *et al* 2020). In addition to import as a food item *C. chinenis* may also have been transported to the United States as a passive attachment on ornamental lotus plants (Smith, 1995 in Martin, 1999). It is claimed to have been released from aquaria into the Niagara River between 1931 and 1942 (Mills *et al* 1993). The ability of the snail to attach to boat hulls in the USA and to survive long periods out of water means that accidental transport on recreational boats (both overland on trailers and via waterway networks) is feasible (McAlpine *et al* 2016, Havel 2011, Havel *et al* 2014). Boat related spread as one possible pathway is supported by a survey of 21 lakes where the snail was more likely to be found at sites near boat launches with a decrease in presence with increased distance from such sites (Solomon *et al* 2010). In the Netherlands the maintenance of water channels (by dredging and weed control) and the resulting transfer of dredged materials and the maintenance equipment is considered to be a likely source of secondary spread of *C. chinensis* between and within waterbodies (Matthews *et al* 2017a).

In addition to these human assisted spread examples there is also the suggestion that waterfowl and some aquatic mammals may also act as dispersal agents (Claudi & Leach 2000).

10 - Could the organism itself, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment Area?

Response: Yes.

C. chinensis has the potential to cause economic (clogging screens and water intake pipes), environmental (displacing native species and altering nutrient flows) and social harm (a host of parasites and potential nuisance), but in most cases, evidence is weak and a clear demonstration of significant and widespread economic, environmental or social harm is mostly lacking. Key references include Matthews *et al* 2017b and Anon. 2018. More detail is provided in the impact summary below.

Entry Summary

Estimate the overall likelihood of entry into the Risk Assessment Area for this organism (comment on key issues that lead to this conclusion).

Response: *very likely*
Confidence: *very high*

Comments (include list of entry pathways in your comments):

C. chinensis is already established in one ditch on the Pevensey Levels, East Sussex (see details in Answer 5 above). It is not known how the snail was introduced. It was originally suggested that, "it is suspected that they may have been accidentally or deliberately released from aquarium stock …." (Willing 2019a). Upon further examination of the site, the release of aquarium stock seems unlikely as the invaded ditch is not near or adjacent to any housing, lies on private land with no access and is not close to any public right of way. It is now considered most likely that the entry may have been due to a deliberate release, possibly for later harvesting to either supply the aquaria trade and /or for the Asian food market. There are other known incidents on Pevensey Levels of the illegal introduction of macrophytes (e.g. water soldier *Stratiotes aloides*) for later removal for garden centre sale (Evan Jones, personal observation). The location of the ditch is near to a road and a gate with a convenient car pull-in makes illegal access and return to the site relatively straightforward.

Establishment Summary

Estimate the overall likelihood of establishment (comment on key issues that lead to this conclusion).

Response: *very likely*
Confidence: *very high*

Comments (state where in GB this species could establish in your comments, include map if possible):

C. chinensis is already established in one ditch on Glynleigh Level on the Pevensey Levels. The original find in September 2018 included several adults with shell heights > 55mm suggesting that they were adults (a recruiting population studied in the Netherlands > 90% were < 60mm in height: Collas *et al* 2017). Adult female *C. chinensis* may live for 5 years with males up to 3 – 4 years (Jokinen 1982, Jokinen 1992). If the adult shells collected on Pevensey Levels in 2018 had all been only male then the population had might have been established at least 3 years previously and if females were present a further two years suggesting that (unless a large batch of adult snails had been introduced to the ditch) then the snail may have been introduced to the ditch no later than 2013 – 2015.

The very wide range of ecoclimatic zones successfully occupied by recruiting *C. chinensis* in the USA (see Answers 4 & 7 above) as well as the broad range of water physical and chemical properties tolerated by it suggest that the species has the potential, if accidentally or deliberately introduced, to occupy numerous still and slow moving freshwater habitats

(ponds, drainage ditches, canals, lakes and slow-flowing rivers) in lowland England, Wales and Scotland. The UK is within the Atlantic Biogeographical Region which also includes all of the known invasive populations in the Netherlands and Belgium (see answer 7 above). The inclusion of a map here therefore seems inappropriate as so many potential areas would need to be included. Unless the snail is contained or eliminated at the only known site, then it is likely to naturally (albeit slowly) colonise numerous other Pevensey Levels ditches on this very import coastal grazing marsh SAC. Once widely established in the area spread to other sites in south east England (by both natural and human assisted means) seems likely. Once in a new site the snail has the potential to rapidly increase in numbers. Thus, in a 'Capture-Mark-Release' study undertaken in a pond on Long Island (USA) the *C. chinensis* population increased 5.5-fold in a two-year period (McCann 2014). Although the snails are single-sexed, females have the potential (as do other members of the Viviparidae) to reproduce by parthenogenesis, meaning that a single female introduced into a habitat might establish a new population (a single female can produce up to 65 young per year (Johnson 1999, Mackenzie 2000).

Spread Summary

Estimate overall potential for spread (comment on key issues that lead to this conclusion).

Overall response: *rapid*
Confidence: *low*

Sub scores:

Natural spread only:
Response: *slow*
Confidence**:** *medium*

Human facilitated spread only:
Response: *rapid*
Confidence**:** *low*

Comments (in your comments list the spread pathways and discuss how much of the total habitat that the species could occupy has already been occupied):

Natural:

As discussed above (Question 9) the only quantitative study of natural spread suggests a possible rate of 0.1 km yr^{-1} (Collas *et al* 2017).

Human facilitated:

As discussed above, the primary cause of spread to new areas in the USA is widely suggested (although unequivocal evidence-based data seems to be lacking) to be by human facilitated means. Thus accidentally (e.g. transported on boats or in weed or sediments attached to them, accidental aquaria releases) or deliberately again by aquaria release or 'seeding' of sites for later supply to individuals or the trade for human food. Although *C. chinensis* is now found in

at least 12 sites in the Netherlands and one in Belgium (see Answer 4 above) the causes of introduction and spread are not documented but are likely to have been human facilitated.

The rate of spread due to human actions is very difficult to predict due to numerous uncertainties. If accidental then it is unknown how far a vector boat might be taken before relaunch; as *C. chinensis* is able to survive out of water for at least 8 weeks (Havel 2011, Unstad *et al* 2013) then the potential for accidental delayed release of the snail far from a source is tremendous. In the case of deliberate release for commercial reasons then the proximity of potential introduction sites to centres of market demand is unknown.

On Pevensey Levels one of the main causes of the rapid spread of invasive plants (e.g. New Zealand Pygmyweed *Crassula helmsii,* Floating Pennywort *Hydrocotyle ranunculoides)* is suspected to be transfer by ditch clearing machinery (K. Jackson, personal communication). It is possible that this could also facilitate the transfer of this snail to locations far from the known site, both within and outside the catchment. It is also suggested that accidental transfer of snails because of water channel clearance operations is likely to be an accidental spread factor in the Netherlands (Matthews *et al* 2017a). The transport of pond and aquaria water plants is also a possible mode of spread. Covert and illegal removal of water plants from Pevensey Levels for sale or for use by commercial landscape gardeners is a known phenomenon.

Impact Summary

Estimate overall severity of impact (comment on key issues that lead to this conclusion)

Overall response: *moderate*
Confidence: *low*

Sub-scores

Environmental impacts:
Response: *moderate*
Confidence**:** *low*

Economic impacts:
Response: *minor*
Confidence: *high*

Social impacts:
Response: *minimal*
Confidence: *high*

Comments (include list of impacts in your comments):

C. chinensis has been present as an invasive species in the USA for about 140 years and is now widespread occurring in 36 States. Despite there now being numerous populations, evidence of negative impact for all these three categories varies between negligible to slight.

Thus, in summary:

Economic:
It is suggested (but not apparently demonstrated) that the shells may clog the screens of water intake pipes (AIS 2005, Kipp *et al* 2014). At high densities the snail can clog fishing nets and so impede or reduce fish catch (Global Invasive Species Database 2011).

It is not known what economic benefit might arise from harvesting of introduced populations for human consumption (either sold in oriental groceries or collected and consumed directly by the collector). In the USA culture of the snail for the Chinese food market is suggested as having a positive effect on the economy (Claudi & Leach 2000). There is no evidence of *C. chinensis* being sold for human consumption in the EU (Matthews *et al* 2017a). Despite an appeal for information in various UK publications the authors have received no reports of the sale of live *C. chinensis* in either oriental grocers (as a food item) or from garden and aquaria stockists (Willing 2019a, 2019b). Internet searches did, however, reveal a number of aquarium stockists apparently selling the snail (e.g. https://www.ebay.co.uk/itm/trapdoor-snails/254585970798?hash=item3b4681a06e:m:mZIWt7SqHZ6M347_LOznIUA&var=554316695503) *C. chinensis* is considered to pose a 'negligible' economic risk in Europe (Matthews *et al* 2017b).

Environmental:

In a mesocosm outdoor experimental system *C. chinensis* was found to have a negative effect upon two north American water snails (both of which are found in the UK) possibly due to food competition (Johnson *et al* 2009). These declines were further increased in the presence of various crayfish species in a series of complex interactions depending upon the crayfish species.

A further experiment in Washington suggested that the presence of *C. chinensis* may aid in the establishment of one species of invasive crayfish by providing an abundant food source ('invasional meltdown'), but the hypothesis required further testing (Olden *et al* 2009).

It has been noted that the filtration rate of *C. chinensis* is comparable to a number of highly invasive freshwater bivalves (e.g. *Dreissena polymorpha*), which may give the snail a competitive feeding advantage to other filter feeders (Olden *et al* 2013). In a further mesocosm experiment *C. chinensis* feeding was found to reduce algal biomass, algal species composition and increase the N:P ratio in the water. Such effects may have important ecological results which require further study (Johnson *et al* 2009). Possibly linked to the former changes *C. chinensis* presence slightly alters the microbial community (Olden *et al* 2013).

C. chinensis has been observed as a food source for waterfowl and rodents (Soes *et al* 2016).

At a local level if *C. chinensis* spreads from its sole source ditch it has the potential to disrupt the rich and extensive freshwater ditch ecosystems on Pevensey Levels. This area is a 3.6K hectare biological SSSI, Ramsar site, supports a National Nature Reserve; it is nationally and internationally important for supporting many rare invertebrates; it is one of the best sites in the UK for a variety of rare freshwater Mollusca (Anon 2013) including the Little Whirlpool Ram's-horn Snail *Anisus vorticulus* https://sac.jncc.gov.uk/species/S4056/. This snail is listed

on the European Union Habitats and Species Directive (EUHSD) Annexes IIa and IV (strict protection) and is also an English NERC (2006) Section 41 Species of Principal Importance in England and assessed on the latest UK Status Review as 'Vulnerable' (Seddon *et al* 2014). Pevensey Levels is one of three Special Areas of Conservation (SAC) designated for the snail in England. The spread of *C. chinensis* throughout Pevensey Levels is of concern as its impact on *A. vorticulus* and indeed other rare molluscs and invertebrates living there is unknown. By the time any damaging impact is detected then control of the invasive would probably be difficult and expensive.

In summary, most generalised negative environmental impacts are projections based upon various experimental studies rather than documented reports of actual damage in the wild. It has also been pointed out that environmental impact of *C. chinensis* in North America is widely described as limited, but this should be set against a situation where species densities for the snail there are low. The potential for impact when the snail is present at higher densities (as seems to be the case for some of the Dutch sites and for the Pevensey Levels site) are largely unknown (Matthews *et al* 2017a, 2017b).

C. chinensis has the potential to cause wide-scale disruption to the ecosystems of the Pevensey Levels and thereby possibly endanger rare and protected species such as *Anisus vorticulus*. The overall environmental impact of the snail in Europe has been assessed as 'Medium' (Matthews *et al* 2017b) and this is the assessment for the UK, although on a local scale the impact could, in a 'worse-case' situation, be 'Major'. In the United States the overall risk has been categorised as 'High' based chiefly upon the snail's (1) history of invasive success, (2) climate matching to much of the country, (3) experimentally demonstrated ability to depress or exclude some native water snails and (4) the potential to block water pipes and cause a 'nuisance' on lake shores (Anon 2018).

Social:

In its native Asian range *C. chinensis* is a host for several platyhelminth parasites that affect man such as human intestinal fluke (Chung & Jung 1999, Havel 2011, NAPIS 2010) but, throughout its now extensive invasive range in the USA, there have been no reported cases of transmission (Bury *et al* 2007). There is therefore no evidenced based reason to believe that this risk will exist in Britain.

Large *C. chinensis* populations have been reported to cause nuisance by littering the shores of water bodies in the USA with dead and decaying snails (Bury *et al* 2007). Similarly, there is also a concern that in the Netherlands, decaying dead snails on the shores of the Eijsder Beemden may cause a decline in the recreational summer usage of a popular site (Collas *et al* 2017).

Climate Change

What is the likelihood that the risk posed by this species will increase as a result of climate change?

Response: *low*
Confidence: *medium*

Comments (include aspects of species biology likely to be effected by climate change (e.g. ability to establish, key impacts that might change and timescale over which significant change may occur):

If the average temperature of Great Britain increases by a few ºC it is not believed to significantly affect the invasive risk posed by *C. chinensis*. Climate change/global warming not only increases the mean and extreme summer temperatures, but may, by causing significant disruption to weather patterns, also possibly result in periods of lower than average winter temperatures and periods of flooding and drought. Slightly contradictory evidence is available giving some understanding of the temperature parameters tolerated by *C. chinensis*. It is stated that it is a temperate species with a lower limit of 0 ºC and an upper limit of 30 ºC (Kipp & Benson 2008 in Karatayev *et al* 2009). By contrast, more recent studies (Burnett *et al* 2018) which tested the temperature tolerance parameters of wild caught *C. chinensis,* found the snail to have an upper lethal limit ranging between 40 – 45ºC with complete mortality before 50 ºC. Additionally, despite exposing the snail to extended periods of freezing they did not determine a lower lethal limit. It may be instructive in assessing the consequences of climate change in Britain to study the snail's current invasive range in the United States. Here it is living in 36 States spread across the Union and covering a wide range of ecoclimatic zones (discussed in answer to Question 7 above). It is suggested that in many of these, in contradiction of the upper limit stated by Kipp & Benson but reinforcing the work of Burnett *et al* 2018, it survives occasional summer temperatures >30 ºC. Thus, these are likely to occur in the mid-west States lying to the south-west of the Great Lakes and may also be experienced in Florida, Hawaii and southern States such as North and South Carolina. Similarly and again questioning Kipp & Benson's assertions but further supporting those of Burnett *et al C. chinensis* has a lower temperature tolerance of 0ºC, winter temperatures in the Great Lakes region and in north-western States such as New York State frequently fall significantly below this point although this area supports the bulk of *C. chinensis* populations in the States (see USGS map in Kipp *et al* 2020). It has also been noted that *C. chinensis* is one of few mollusc species predicted to survive Great Lakes winter temperatures (Rixon *et al* 2005) an observation that further supports the view that the snail survives winter temperatures considerably below 0ºC. As well as raising temperatures, climate change may also lead to occasional periods of drought. These might have little negative effects on established *C. chinensis* populations as it can withstand hot dry conditions for at least 8 weeks (Havel 2011, Unstad *et al* 2013). Such drought periods might give the snail a competitive advantage in such conditions if native species are less resilient.

In view of these observations it is suggested that future temperature rises in Great Britain are unlikely to have a significant impact upon the invasive potential of *C. chinensis* which is a 'temperature hardy' species. They are unlikely to adversely affect it, but might, by contrast, assist the species in some situations if it is shown to have a competitive advantage over some native taxa in conditions of higher temperatures and/or drought.

Conclusion

Estimate the overall risk (comment on the key issues that lead to this conclusion).

Response: *medium*
Confidence: *low*

Comments:

An EU 'horizon scanning' exercise classed *C. chinensis* as a high-risk species indicating the need for a detailed risk assessment (Roy *et al* 2015).

The most detailed risk assessments studied in the preparation of this 'Non-native Species Rapid Risk Assessment [NNRRA], are those of Collas *et al* 2017 and Matthews *et al* 2017b. Although these papers provide a very useful review of most relevant *C. chinensis* literature sources, close study also reveals the considerable lack of reliable empirically sourced data on the species. This makes the setting of reliable risk 'response and confidence' levels difficult and so some have correspondingly low confidence limits.

C. chinensis has already established a recruiting population in Great Britain which is estimated to have been introduced to the site no later than 2013 – 2015. The snail's unaided natural rate of spread there is predicted to be slow. If spread studies undertaken at a site in the Netherlands are broadly replicated on the Pevensey Levels, then the snail is estimated to remain in its close-ended ditch for between 2 – 3 years. If these projections are correct, then the snail will reach a main drainage ditch in 2022 / 2023. It then has the potential to naturally spread throughout the Pevensey Levels, a nationally important wetland SAC supporting many rare and / or protected plants and animals including the EUHSD Annex IV snail *Anisus vorticulus*. The entry route into the occupied ditch is unknown, but it is argued that it was probably by a deliberate human action to provide stock for the aquarium and/or oriental food market trades.

Studies in the USA have demonstrated that in the period since the probable deliberate *C. chinensis* introduction it has, in the space of about 140 years spread widely with populations in 36 States. Data on spread routes is lacking but many studies suggest a combination of deliberate and accidental human actions rather than natural spread. There is no suggestion as to how or why the snail first became established in the Netherlands (the first confirmed European presence of the snail) in 2007 or how in the next 9 years it was able to establish 11 further populations in the country together with a single population in Belgium although a combination of aquaria/pond releases combined with escapes from commercial garden/aquaria centres has been suggested (Matthews 2017a) .

Accidental spread of *C. chinensis* spread from the Pevensey Levels will probably be slow as the ditches are not used by pleasure craft and only the largest drains are coarse fished. Ditch clearing machinery has, however, the potential to act as a vector (not only to other parts of Pevensey Levels but to sites beyond the catchment) if the already inhabited ditches are cleared and machine hygiene procedures (washing out the clearance buckets) are not adopted. The appearance of new populations in Great Britain is likely to be due to intentional introduction for later commercial harvesting or by accidental or deliberate release of aquaria stock. It is not known if or where the snail is currently sold live in the GB but several requests for information have been published. It is noted that the Ornamental Aquatic Trade Association has instructed its members not to sell *C. chinensis* although there are no legal

restrictions on sales of the snail in the EU or UK.

There is little data available from studies of the extensive *C. chinensis* populations in the USA to suggest that the snail possess any significant environmental or economic risks. Most potential negative impacts are those revealed by experimental studies rather than observed and documented from wild populations. Potential social damage seems to be minimal.

The very wide range of ecoclimatic zones occupied by the snail in the USA including areas where summer temperatures regularly or occasionally exceed 30ºC in summer or fall below 0ºC in winter suggests that a small degree of potential climatic warming in the Britain is unlikely to have any major negative effects upon potential new *C. chinensis* populations in the country although in certain circumstances higher temperatures and extended periods of drought could favour *C. chinensis* populations in relation to native freshwater Mollusca.

It is suggested that further studies be undertaken of the single Pevensey Levels population and ditches in the immediate proximity to study spread rate in the occupied ditch, population dynamics and colonisation of adjacent new ditches. In order to determine the current *C. chinensis* situation in the occupied ditch it is suggested that a return survey visit be undertaken in summer/autumn 2020 to determine: (1) if the snails are still breeding, (2) the extent of additional ditch colonised since the 2019 survey. The latter data will allow a more accurate estimate of the time when the snail will reach a major drainage channel from where it can spread more widely in the area. Further spread of the snail might be prevented if a coffer dam was installed in 2020 a short distance below the current 'colonisation front'.

Management options (brief summary):

1 - Has the species been managed elsewhere? If so, how effective has management been?

Response:

There are no known examples of fully successful *Cipangopaludina chinensis* management although several control and eradication techniques have been trialled and assessed in the USA (examples discussed in 2 below).

2 - List the available control / eradication options for this organism and indicate their efficacy.

Response:

Several eradication and control measures have been assessed and these include:

1. Chemical control: In laboratory trials the use of copper sulphate and rotenone proved ineffective, possibly due to the thick shell and operculum of *C. chinensis* (Haak *et al* 2014). In a field trial in Oregon the use of copper sulphate did partially control a population but did not eradicate it (Freeman 2010). There are, in any case, restrictions on the use of copper sulphate in the EU (Collas *et al* 2017) and if such a non-specific agent was used in aquatic systems it would have a negative effect upon non-target species of Mollusca and other aquatic organisms.

2. Air exposure of sites: The temporary drainage (drawdown) of affected sites has been unsuccessful. This is because the snail burrows into sediments (hand collecting of adults might be possible but small juveniles would be easily overlooked) and additionally can withstand long periods of desiccation (Havel 2011, Unstad *et al* 2013, Havel *et al* 2014).

3. Manual removal of snails: The hand collection of the snails by scuba and snorkel divers was trialled at a site in Missouri resulting in the collection of many adults, but failing to result in eradication due to the difficulty of detecting smaller juvenile snails which are harder to see and also often buried in sediments (Hanstein 2012). Such a technique might control populations, but recurrent removal would be required. Eradication of populations by this technique is considered unrealistic.

4. Ditch clearance of the site: In the case of the eradication of *C. chinensis* from its sole UK site isolation and the clearance of the site is a suggested option. This might entail (i) isolating the section of ditch containing the snail, (ii) further sub-division of the occupied section with coffer dams (iii) the partial or full drainage of the occupied section, (iv) the mechanical removal of weed and sediments and the transfer of dredged weed /sediments to a location well away from the ditch margins such that the removed material can dry for at least 8 weeks to ensure complete mortality of the removed snails (Havel 2011, Unstad *et al* 2013, Havel *et al* 2014).

The ditch supporting *C. chinensis* on Pevensey Levels was previously found to support a population of *Anisus vorticulus* (The Little Whirlpool Ram's-horn Snail) in surveys

undertaken in 1999 and 2006 (Killeen 1999, Willing 2007). This snail is on the EU Habitats and Species Directive Annexes II (requiring SACs) and IV (strict protection). The ditch lies within the Pevensey Levels Special Area of Conservation (SAC) designated in 2011 with *A. vorticulus* as one of the qualifying features. *C. chinensis* control measures in this and adjacent ditches will need to assess the impact upon this and other protected species living there. Possible control actions and damage to fauna and flora in the single occupied ditch may, however, need to be balanced against the greater benefit of removing this invasive snail before its possible wider spread more widely within and beyond the SAC to have an unknown (and possibly negative) effect upon the wider ecosystem in this protected area. The eradication of this single population has already been proposed (Rowson 2019).

3 - List the available pathway management options (to reduce spread) for this organism and indicate their efficacy.

Response:

1. Destruction or containment of single known population**:** The most obvious solution to minimise or eliminate *C. chinensis* spread from the single known established population is to assess all possible control measures to eliminate and/or contain the population. These might include (A) chemical treatment of the ditch with a biodegradable molluscicide (B) the weed/sediment removal possibly in conjunction with drainage of the ditch or (C) the blockage of the ditch (to be used in conjunction with ditch drainage and/or sediment removal) at a point below the occupied stretch (see attached Map 1). As the ditch is relatively short and blind-ended it may serve more as a 'wet-fence' than acting as a drain. These options need to be fully discussed with both the landowner and Natural England and further consideration is not appropriate here.

(2) Minimising accidental transmission: The most likely cause of *C. chinensis* spread from this known population or other new or as yet undiscovered established populations is by deliberate or accidental introductions by humans. If the snail was to become established beyond the lone and relatively isolated 'founder' ditch, then further action may be required. This might be reduced by a programme of public awareness to the presence of the snail (easily identified) and to make: (1) recreational boaters and fishermen aware of the risk of accidental transmission on fishing equipment and on boat hulls (attached animals or transport of snails in sediments or on macrophytes): a modification of the well-known 'Check, Clean Dry' procedures to be recommended (the currently described 'CCD' process instructs users to clean at 45ºC for 15 minutes; this may require adjustment to a higher temperature at sites actually or potentially infested with *C. chinensis* as the snail can survive temperatures of 45ºC but is killed at 50ºC). (2) Consumers (if bought live for food as 'escargots'), aquarium hobbyists and water gardeners to be made aware of the risks of deliberate or accidental release into the wild.

(3) Discouraging deliberate introduction: Collas *et al* (2017) suggest that a national or EU ban on the trade in live *C. chinensis* (as is the case in the USA [USGS 2017] should be considered, as has existed for the superficially similar *Pomacea* since 2012 [EU implementing decision 2012/697/EU]). If and where the snail is found to be offered for snail (oriental grocers, garden and aquaria centres, from online suppliers) investigation as to the safe and legal supply chain maybe required to deter illegal importation and/or snail release

for 'snail farming' (as may have been the case for this first UK population). Although no legislation currently exists prohibiting the sale of *C. chinensis*, the Ornamental Aquatic Trade Association is currently advising its members not to stock or sell non-native species including 'mystery snails' (https://ornamentalfish.org/new-recommendations-on-buying-snails-mussels-for-garden-ponds/).

4 - How quickly would management need to be implemented in order to work?

Response:

In consideration of the only known UK population of *C. chinensis* described above**.** This occupies a single blind-ended drainage ditch with minimal water flow under normal (no heavy rain) conditions. It was estimated that (in July 2019) approximately 360m of this 'founder ditch' remained to be colonised before the snail reaches Glynleigh Sewer (see attached Map 1). This is a main drainage ditch interconnecting with many other ditches in the south-eastern sector of Pevensey Levels. If the snail's natural colonisation rate of 0.1 km yr^{-1} is similar to that observed at one site in the Netherlands (Collas *et al* 2017) then *C. chinensis* will reach Glynleigh Sewer in approximately 3.5 years (from July 2019) meaning that it might reach this main channel by approximately 2023. Once in Glynleigh Sewer the snail may (in the absence of accidental or deliberate transmission) still spread at the same slow rate, but the Sewer will allow its dispersal to other parts of the Pevensey Levels. Glynleigh Sewer is too small for small boats and it is not believed to be used for coarse fishing. If these projections are correct, then there is about 2 years to further assess and implement management actions before the snail reaches a major potential dispersal channel. Further assessment of the distribution of *C. chinensis* in the 'founder' and surrounding ditches is recommended (2020/2021) to monitor spread rate and population growth. There is also a need to halt ditch clearance activity in the founder and immediately adjacent ditches until such management can be undertaken preventing *C. chinensis* transfer on clearance machinery and/or with cleared ditch materials.

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Provide here a list of the references cited in the course of completing assessment

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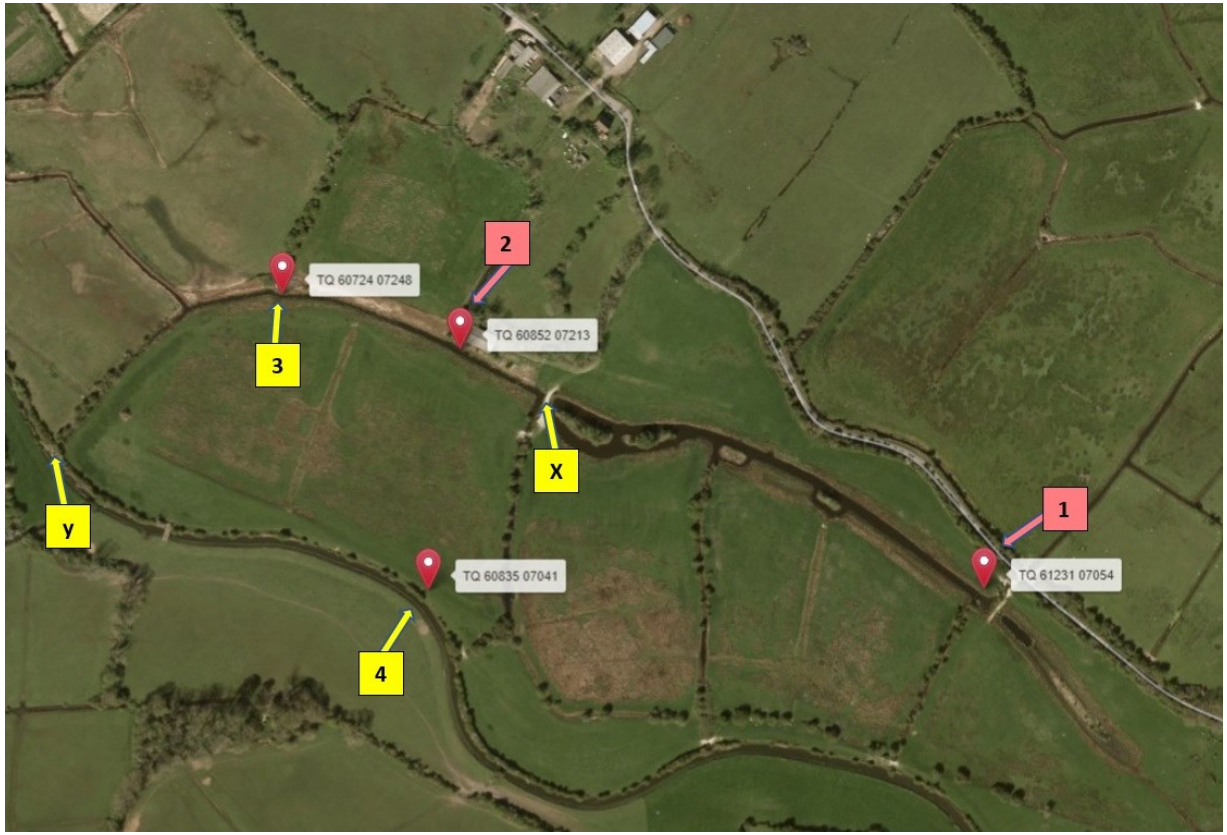
Appendix on following pages:

NRRA APPENDIX: *Cipangopaludina chinensis*: location maps for first recorded UK population



Map 1: Notes -

1. Live snails recorded between **Point 1** and **Point 2** on 29.7.2019 – (distance of about **420 m**);
2. No snails recorded at **Point 3** (in colonised ditch) or at **Point 4** (in Glynleigh Sewer);
3. **Point X** narrow pipe under ditch crossing connecting main colonised ditch to east and short colonised section to west;
4. **Point Y:** junction of colonised ditch and Glynleigh Sewer;
5. **Distance** (on 29.7.2019) between western limits of colonisation at **Point 2** and Glynleigh Sewer (**Point Y**) = about **360m**.

Map 2: Location of *Cipangopaludina chinensis* ditch on Pevensey Levels, East Sussex lying immediately south-east Hailsham