

Rapid Communication

Occurrence of the Chinese mystery snail, *Cipangopaludina chinensis* (Gray, 1834) (Mollusca: Viviparidae) in the Saint John River system, New Brunswick, with review of status in Atlantic Canada

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Abstract

The Chinese mystery snail, *Cipangopaludina* [= *Bellamya*] *chinensis*, is documented for the first time in the Saint John River, New Brunswick, a watercourse which drains the largest watershed in Atlantic Canada. This is the first non-native mollusc known to be established in the Saint John River system. Although significant ecosystem effects of the species seem unlikely, possible introduction of *C. chinensis* via boat traffic emphasizes the need for boater education combined with monitoring of the Saint John River system for potentially more troublesome non-native species, including the zebra mussel, *Dreissena polymorpha*. Review of published records and museum collections for Atlantic Canada show *C. chinensis* has been reported from 13 freshwater wetlands and waterbodies in New Brunswick, Nova Scotia and Newfoundland since 1955. The species remains extant in at least 10 of these sites and is clearly more widespread in the region than the single previously published report would suggest.

Key words: Newfoundland, Nova Scotia, distribution, species introduction, invasive species, *Bellamya*

Introduction

Knowledge of distributional status is a critical component in managing invasive species. Despite this, little is known about the distribution of the Chinese mystery snail, *Cipangopaludina* [= *Bellamya*] *chinensis* (Gray, 1834), within regions in North America where it has been introduced (Solomon et al. 2010). A native of eastern and southeastern Asia, *C. chinensis* is now well established in the United States (Jokinen 1982; Bury et al. 2007) and is considered to be invasive (Kipp et al. 2014). The species was first introduced into North America via Chinese food

markets in San Francisco, California, at the end of the 19th century (Wood 1892), and soon afterwards was reported in Massachusetts (Johnson 1915). Subsequent dispersal has been attributed mainly to the aquarium and water garden trades and recreational boating and angling (Bury et al. 2007). In the United States *C. chinensis* is now widespread but local across the continent, with distribution concentrated in the upper midwest and northeastern states (Kipp et al. 2014). In Canada *C. chinensis* has been reported from southern Ontario in the Rideau River at Ottawa; the Kawartha Lakes; and the Crowe, Moira, and Trent River drainages; as well as

Table 1. Occurrences of *Cipangopaludina chinensis* in Atlantic Canada. Numbers are coded to sites mapped in Figure 1. Locations marked with a plus (+) are represent by vouchers in museum collections. NBM = New Brunswick Museum, NSM = Nova Scotia Museum, NFM = The Rooms Provincial Museum [Newfoundland and Labrador]. Sites marked with an asterisk (*) were visited in 2015 to confirm persistence.

Location	First Known Occurrence	Source	Status
1. *Morce Pond, Westmorland Co, NB 45.927N – 64.357 W	8 September 1999	NBM 2965	extant
2. *Patterson Lake, Westmorland Co, NB 46.003N – 64.306 W	11 July 2000	NBM 2696	?
3. *Tantram Marsh, Westmorland Co., NB 45.91 N – 64.366	2006	<i>in litt.</i> & NBM 9658	extant
4. *Sand Point, Sunbury Co., NB 45.927 N – 66.298 W	11 August 2014	NBM 9651	extant
5. *French Island, Sunbury Co. NB 45.925 N – 66.300 W	12 August 2014	NBM 9652	extant
6. Lower Sackville, Halifax Co, NS 44.77 N – 63.68 W	7 June 1963	Coleman 1968	extirpated
7. *Yarmouth, Yarmouth Co., NS 43.83 N – 66.12 W	1955	NSM 17906	extirpated?
8. *Punchbowl Lake, Halifax Co., NS 44.624 N – 63.618 W	20 August 1990	NSM 11726	extant
9. *Kearney Lake, Halifax Co. NS 44.687 N – 63.684	27 July 2005	NSM 16906	extant
10. *Albro Lake, Halifax Co., NS 44.688 N – 63.576 W	27 July 2008	NSM 17433	extant
11. *Shortts Lake, Colchester Co., NS 45.231 N – 63.329 W	June 2014	NSM 17433	extant
12. *Point Pleasant Park, Halifax Co., NS 44.627 N – 63.570 W	23 September 2014	NSM 17901	extant
13. *Loon Lake, Halifax Co, NS 44.699 N – 63.494 W	16 July 2015	NSM 17905	extant
14. *Virginia Lake, St. John's, NL 47.604 N – 52.705 W	8 August 1983	NFM MO-2090	extant

on the shores of Lake Erie and embayments of western Lake Ontario (Therriault and Kott 2002–2003). However, observations suggest *C. chinensis* is much more prevalent in Ontario than published records indicate (F.W. Schueler pers. obs.). The species is also known from Québec (Clarke 1981; Tornimbeni et al. 2013) and British Columbia (Clarke 1981) and in Atlantic Canada from a single site in Nova Scotia (Coleman 1968; Clarke 1981).

Here we report additional occurrences of *C. chinensis* from Nova Scotia and document the first reports from New Brunswick and Newfoundland, with particular attention to the recent discovery of the species in the Saint John River, New Brunswick. Cunjak and Newbury (2005) note that there is much concern about the impact of invasive species on the Saint John River system, including that of established non-native fishes (*Esox masquinongy* Mitchell, 1824, *Micropterus dolomieu* Lacépède, 1802) and the possible introduction of the zebra mussel (*Dreissena polymorpha* (Pallas, 1771)). The presence of *Cipangopaludina chinensis* in the Saint John River potentially provides scope for the species' range expansion across the largest watershed in the Canadian Atlantic region via the extensive wetlands that characterize the lower river. This is also the first non-native freshwater mollusc known to be established in the Saint John River system.

Material and methods

Cipangopaludina chinensis was discovered in the Saint John River during a New Brunswick Museum-organized 2014 biological inventory program in the

Grand Lake Protected Natural Area-Portobello Creek National Wildlife Area. General aquatic mollusc surveys were conducted by searching shorelines on foot and by canoe, by dip-netting, and through use of SCUBA to a water depth of ~3 m. Vouchers were retained, notes on habitat recorded, and collection localities documented using GPS. Literature and unpublished museum records for Atlantic Canada housed in the New Brunswick Museum, Nova Scotia Museum, and The Rooms Provincial Museum [Newfoundland and Labrador] were subsequently consulted. A number of Atlantic Canadian *C. chinensis* sites were visited in 2015 to confirm presence or persistence.

Results

Figure 1 depicts the current pattern of distribution for *C. chinensis* in Atlantic Canada based on records reported here and in the literature. Figure 2 and details below show that *C. chinensis* occurs in a variety of wetland types in the region that range from river channels, through isolated lakes, to shallow vegetated wetlands.

New Brunswick

On 11 August 2014 we collected 4 empty shells of *C. chinensis* from the shoreline in front of cottages adjacent to a boat launch on the Saint John River at Sand Point, Sunbury County, New Brunswick (Site 4, Table 1, Figure 1). One of the collected shells contained the hatchling snails of this ovoviviparous species. The site is on one side of a channel <200 m wide that drains Portobello Creek and Indian Lake and is

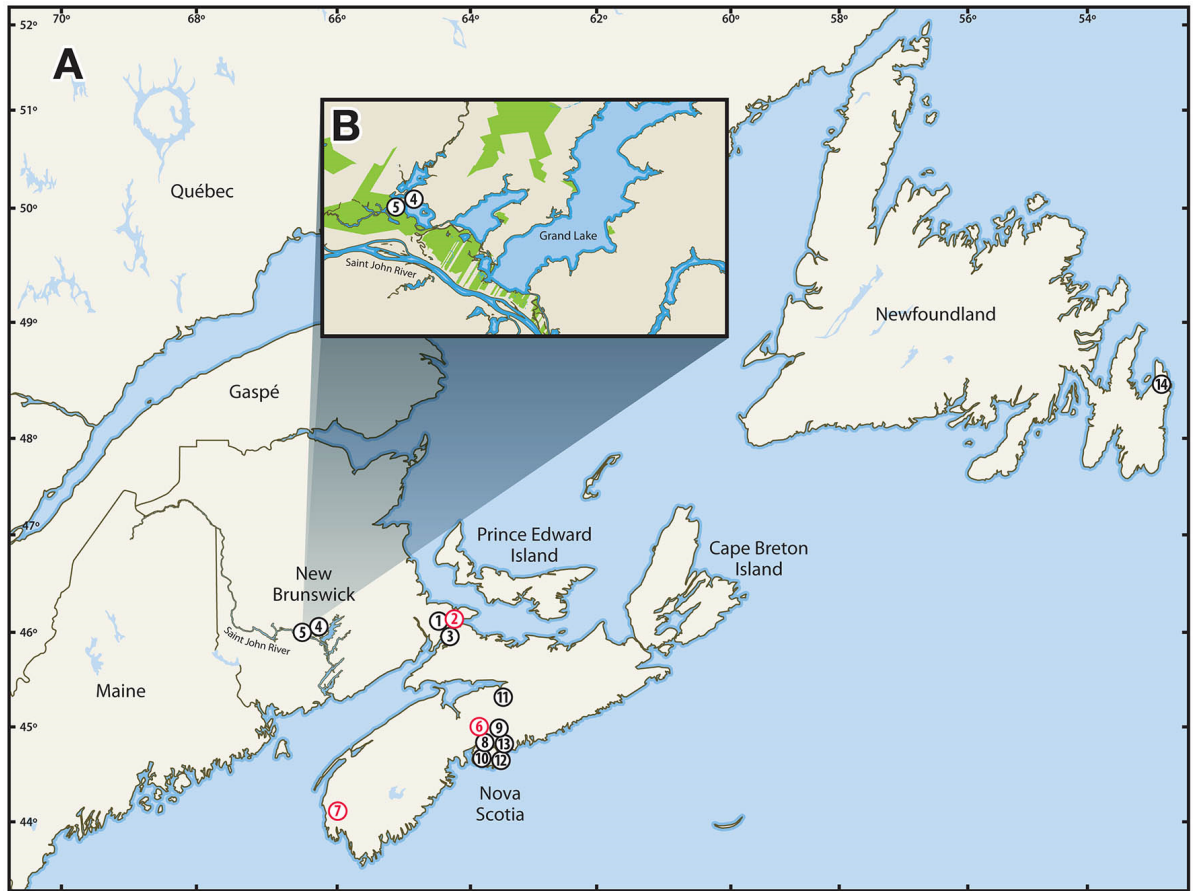


Figure 1. A. Distribution of *Cipangopaludina chinensis* in Atlantic Canada. Numbers correspond to those in Table 1; those in black mark sites where *C. chinensis* is believed to be extant. Red numbers mark sites where the species may no longer be present. Inset B details sites on the Saint John River. Solid green is Grand Lake Protected Natural Area and Portobello Creek National Wildlife Area.

part of an extensive and significant conservation wetland that occupies the lower Saint John River system. On the 12 August we re-visited the site, collecting 1 empty shell and a live individual from the shoreline and 2 empty shells from adjacent French Island (Portobello Creek National Wildlife Area; Site 5, Table 1, Figure 1). On 19 August SCUBA was used to examine the bottom on both sides of the channel. During a dive of approximately 90 person minutes (2 divers × 45 minutes), 2 live *C. chinensis* were collected from the Sand Point side of the channel (Figure 3) and a single live snail collected adjacent to French Island, both in 1–1.5 m of water. The bottom is mud and cobble, sparsely vegetated with submergents, grading to mud in mid-channel; the water is heavily stained with tannins. Anecdotal observations from local residents place *C. chinensis* at Sand Point in 2004, suggesting a possible date of introduction.

Additional records for *C. chinensis* in New Brunswick include specimens collected from Morice and Patterson Lakes, Westmorland County, during the years 1999–2014 (Sites 1–2, Table 1, Figure 1). Morice Pond (Silver Lake) is a cold- polymictic, reservoir with an area of 1.5 km² and a maximum depth of 3.5 m, while Patterson Lake is a much smaller (0.17 km²) natural, cold-polymictic lake. Both of these sites were re-visited in September 2014. The persistence of *B. chinensis* was confirmed at Morice Lake, with nine empty shells collected from the strand line along ~ 50 m of public beach during a 10 minute search. A 20 min search of ~50 m of windward shoreline at Patterson Lake in September 2014 failed to reveal the presence of *C. chinensis*. Although vouchers were collected only recently in the Tantramar Marshes, an extensive wetland area on the New Brunswick-Nova Scotia border (2015; Site 3, Table 1, Figure 1), *C. chinensis* has been

known to be present in a shallow, constructed, lake (0.10 km²) in the marshes since 2006 (N. Garrity, Tantramar Wetlands Centre, pers. comm. to DFM).

Nova Scotia

In Atlantic Canada *C. chinensis* was first recorded from Nova Scotia in 1955, from a residential pond in Yarmouth, Nova Scotia (Site 7, Table 1, Figure 1). The species is no longer believed to be extant at this site. Likewise, an unnamed pond at Lower Sackville, where *C. chinensis* was reported as present (Coleman 1968; Clarke 1981; Site 6, Table 1, Figure 1) has apparently been filled in (D. Davis, pers. comm.). However, specimens in the Nova Scotia Museum confirm the species recent (1990–2015) presence at 4 Nova Scotia lakes, a pond in the Halifax region and one lake near Truro (Sites 8–13, Table 1, Figure 1).

Newfoundland

On the island of Newfoundland *C. chinensis* has been recorded only from Virginia Lake, St. John's, where the species has been collected repeatedly (site 14; Table 1, Figure 1). *Cipangopaludina chinensis* has been found to be numerous and persistent at the site since its first discovery there in 1983 (JE Maunder and RG Noseworthy pers. obs.).

Discussion

The extensive wetlands, embayments, and meandering channels of the lower Saint John River are likely to provide an ideal opportunity for *C. chinensis* further range expansion in the region. In Wisconsin, for example, *C. chinensis* was most frequently encountered in lake or lake outflows (Bury et al. 2007) and the species is reported to typically be found in lakes or river areas with slow to moderate current (Clarke 1981; Jokinen 1982). While high *C. chinensis* densities have been recorded in North America (Bury et al. 2007; Solomon et al. 2010) the species is most commonly observed at low densities over its wide North American range (Solomon et al. 2010) and tends to be very local in distribution (Kipp et al. 2014). This is a general pattern reported for both native and non-native invasive aquatic organisms (Hansen et al. 2013). Although low densities and local distribution may hinder detection, it is noteworthy that *C. chinensis* was not detected during comprehensive surveys for freshwater unionids in the Grand Lake region in 2001–02 (Sabine et al. 2004).

The species presence in the Saint John River adjacent to a boat launch conforms to the pattern reported by Solomon et al. (2010); *C. chinensis* was

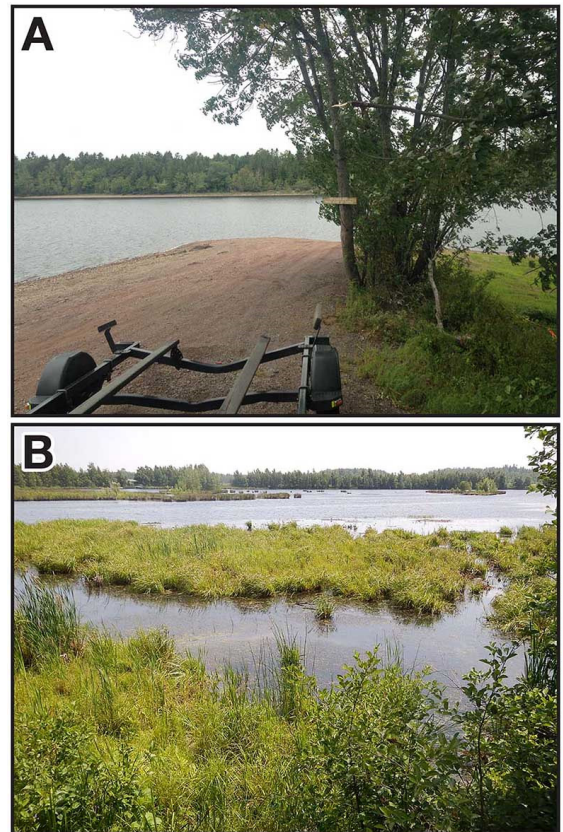


Figure 2. Representative New Brunswick habitat of *Cipangopaludina chinensis* in Atlantic Canada. Site numbers correspond to Table 1 and Figure 1. A. Sand Point (site 4) looking toward French Island (site 5) (D. McAlpine photo); note the boat launch (see text). B. Tantramar Marsh (site 3) (K. Vanderwolf photo).

patchily distributed in Wisconsin lakes but most frequently associated with boat launches. *Cipangopaludina chinensis* is extremely tolerant of exposure to air, suggesting that the species could be readily transported by boats moving between sites, especially where boats entrain aquatic plants (Havel 2011). Boater movements are thus likely to play a particularly important role in the dispersal of *C. chinensis* (Solomon et al. 2010). Boat launches may also be convenient locations for aquarium hobbyists to dump the contents of aquaria. It is perhaps significant that Morice Lake is one of only two New Brunswick sites from which another Asian invader tied to the water garden trade, the freshwater jellyfish, *Craspedacusta sowerbyi* Lankester, 1880 has been recorded (McAlpine et al. 2002). For Patterson Lake, it is possible that *C. chinensis* is no longer extant or present at very low density. The species proclivity to occur at low densities (Solomon et al. 2010) may limit detection and *C. chinensis* is likely present in Atlantic wetlands additional to those reported here.



Figure 3. *Cipangopaludina chinensis* collected live at Sand Point, New Brunswick, 19 August 2014 (NBM 9656) (D. McAlpine photo).

In locations where *C. chinensis* is present it may be among the most ubiquitous of invasive aquatic species (Solomon et al. 2010). However, opinion on its ecological impact is divided. *Cipangopaludina chinensis* has been found to produce no known impacts in the Great Lakes and is considered relatively benign (Kipp et al. 2014). In contrast, *C. chinensis* may present a threat to native molluscs (Bury et al. 2007) and experimental evidence suggests *C. chinensis* might reduce native snail populations through competitive exclusion and alter nutrient cycling and algal biomass (Clark 2009; Johnson et al. 2009). However, little field evidence has been found to support impacts on native molluscs. Solomon et al. (2010) and Mackie (2000) likewise considered *C. chinensis* to have few impacts where introduced. At the low density observed in the Saint John River it is unlikely that *C. chinensis* will cause significant ecosystem effects. However, the possible introduction of *C. chinensis* via boat traffic emphasizes the need for better boater education combined with monitoring of the Saint John River system for potentially more troublesome introductions, including the zebra mussel, *Dreissena polymorpha*. In addition, legislation applicable to the Atlantic region (perhaps modelled on the Ontario Invasive Species Act; in effect 3 November 2016) restricting the import of *C. chinensis*, popular for water gardens and in the aquarium trade, could help to limit further introductions.

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References

- Bury JA, Seitman BE, Karns BN (2007) Distribution of the non-native viviparid snails, *Bellamya chinensis* and *Viviparus georgianus*, in Minnesota and the first record of *Bellamya japonica* from Wisconsin. *Journal of Freshwater Ecology* 22: 697–703, <http://dx.doi.org/10.1080/02705060.2007.9664830>
- Clark GT (2009) Distribution, growth, and competitive impacts of the exotic Chinese mystery snail (*Bellamya chinensis*) in the James River, Southwest Missouri. MSc thesis, Missouri State University, 60 pp
- Clarke AH (1981) The freshwater molluscs of Canada. National Museum of Natural Sciences, Ottawa, 446 pp
- Coleman RW (1968) Certain mollusks of the environs of Halifax, Nova Scotia, Canada. *Iowa Academy of Science* 75: 433–466
- Cunjak RA, Newbury RW (2005) Atlantic Coast Rivers of Canada. In: Benke AC, Cushing CC (eds) *Rivers of North America*. Elsevier Academic Press, Massachusetts, pp 939–980, <http://dx.doi.org/10.1016/B978-012088253-3/50024-9>

- Hansen GJA, Vander Zanden MJ, Blum MJ, Clayton MK, Hain EF, Hauxwell J, Izzo M, Kornis MS, McIntyre PB, Kulyuk AM, Nilsson E, Olden JD, Papes M, Sharma S (2013) Commonly rare and rarely common: comparing populations of invasive and native aquatic species. *PLoS ONE* 8: e77415, <http://dx.doi.org/10.1371/journal.pone.0077415>
- Havel JE (2011) Survival of the exotic Chinese mystery snail (*Cipangopaludina chinensis malleata*) during air exposure and implications for overland dispersal by boats. *Hydrobiologia* 668: 195–202, <http://dx.doi.org/10.1007/s10750-010-0566-3>
- Johnson CW (1915) *Viviparus malleatus* Reeve in Massachusetts. *Nautilus* 29: 35–36
- Johnson PTJ, Olden JD, Solomon CT, Vander Zanden MJ (2009) Interactions among invaders: community and ecosystem effects of multiple invasive species in an experimental aquatic system. *Oecologia* 159: 161–170, <http://dx.doi.org/10.1007/s00442-008-1176-x>
- Jokinen EH (1982) *Cipangopaludina chinensis* (Gastropoda: Viviparidae) in North America, review and update. *Nautilus* 96: 89–95
- Kipp RM, Benson AJ, Larson J, Fusaro A (2014) *Cipangopaludina chinensis malleata*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL
- Mackie GL (2000) Introduction of molluscs through the import for live food. In: Claudi R, Leach JH (eds), Nonindigenous freshwater organisms: vector, biology, and impacts. Lewis Publishers, Boca Raton, Florida, pp 305–313
- McAlpine DF, Peard TL, Fletcher TJ, Hanson G (2002) First reports of the freshwater jellyfish, *Craspedacusta sowerbyi* (Hydrozoa: Oliinidae) from Maritime Canada with a review of Canadian occurrences. *Journal of Freshwater Ecology* 17: 341–344, <http://dx.doi.org/10.1080/02705060.2002.9663904>
- Sabine DL, Makepeace S, McAlpine DF (2004) The yellow lampmussel (*Lampsilis cariosa*) in New Brunswick: a population of significant conservation value. *Northeastern Naturalist* 11: 407–420, [http://dx.doi.org/10.1656/1092-6194\(2004\)011\[0407:TYLLCI\]2.0.CO;2](http://dx.doi.org/10.1656/1092-6194(2004)011[0407:TYLLCI]2.0.CO;2)
- Solomon CT, Olden JD, Johnson PTJ, Dillon Jr. RT, Vander Zanden MJ (2010) Distribution and community-level effects of the Chinese mystery snail (*Bellamya chinensis*) in northern Wisconsin lakes. *Biological Invasions* 12: 1591–1605, <http://dx.doi.org/10.1007/s10530-009-9572-7>
- Therriault TW, Kott E (2002–2003) *Cipangopaludina chinensis malleata* (Gastropoda: Viviparidae) in southern Ontario: an update of the distribution and some aspects of life history. *Malacological Review* 36: 111–121
- Tornimbeni O, Galvez R, Triffault-Bouchet G, Dassylva N, Roberge S (2013) Heavy metal concentrations in *Cipangopaludina chinensis* (Reeve, 1863) and relationships with sediments in Saint-Augustin Lake, Quebec City (Qc, Canada). *International Annales de Limnologie - International Journal of Limnology* 49: 21–29, <http://dx.doi.org/10.1051/limn/2013034>
- Wood WM (1892) *Paludina japonica* Mart. for sale in the San Francisco Chinese markets. *Nautilus* 5: 114–115