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Short communication

Occurrence of the Ponto-Caspian mysid shrimp *Hemimysis anomala* (Crustacea, Mysida) in the St. Lawrence River

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Abstract

An invasive Ponto-Caspian shrimp, the bloody-red mysid *Hemimysis anomala*, is recorded for the first time in the St. Lawrence River near Montreal. The presence of gravid females and juveniles suggest an ongoing colonization of the river, likely driven by downstream dispersal of individuals from source populations in Lake Ontario. Two years after being discovered in Lake Michigan and Lake Ontario, *H. anomala* has now been recorded in all major waterbodies within the Great Lakes-St. Lawrence system, except for Lake Superior.

Key words: crustacean, Great Lakes, *Hemimysis*, Ponto-Caspian, secondary spread, St. Lawrence River

Since the 1980s, the North American Great Lakes have experienced a wave of invasions by animals originating from the freshwater and estuarine margins of the Black, Caspian and Azov Seas – the Ponto-Caspian region (Ricciardi and MacIsaac 2000). These invaders include over a dozen species of protists, mussels, crustaceans and fishes, all likely introduced through ballast water release from transoceanic ships (Ricciardi 2006). The most recent among these is the bloody-red mysid *Hemimysis anomala* G.O. Sars, 1907, an invasive shrimp that was initially discovered in southeastern Lake Ontario in May 2006 and in southern Lake Michigan in November 2006 (Pothoven et al. 2007). It was recorded subsequently in Lake Erie and Lake Huron (http://nas.er.usgs.gov).

Mysids are known to be transported in the ballast tanks of cargo ships frequenting European ports (Gollasch et al. 2002). The North American invasion of *H. anomala* was predicted on the basis of its expansion throughout western Europe (from whence the Great Lakes receives the bulk of its overseas shipping traffic) and the likelihood that the species would survive transport in ship ballast tanks (Ricciardi and Rasmussen 1998). The introduction of a Ponto-Caspian mysid warrants concern because (i) it has added an invertebrate omnivore capable of colonizing many North American inland waters historically devoid of freshwater mysids; (ii) previous Ponto-Caspian invaders have produced substantial ecological changes in the Great Lakes-St. Lawrence River basin and elsewhere in their invaded range (Vanderploeg et al. 2002; Ojaveer et al. 2002); and (iii) introduced mysids have often had negative effects on resident species (Northcote 1991; Ketelaars et al. 1999). The only freshwater mysid indigenous to North America, *Mysis diluviana* Audzijonyte and Väinölä, 2005 (formerly identified as *M. relicta* Lovén, 1862), is a glacial relict naturally restricted to the profundal areas of boreal lakes, including the Great Lakes. By contrast, *H. anomala* inhabits a broad range of depths (<1 m to >50 m; Salemaa and Hietalahti 1993) and can invade lotic environments (Holdich et al. 2006; Wittmann and Ariani 2009). Therefore, its spread into the St. Lawrence River was anticipated (Ricciardi 2007). Here we report the first occurrence of *H. anomala* in the river.

Mysids were collected incidentally using a method that was intended to collect amphipods. Plastic trays (21 cm width, 34 cm length, 12 cm depth) filled to the brim with cobble (3–5 cm in max dimension) were placed at 0.5–1 m depths

at six sites along the north and south shores of Lake Saint-Louis, a fluvial lake in the St. Lawrence River near the Island of Montreal (Annex 1). Each site possesses rocky, cobble or mussel-covered substrates that provide interstitial habitat for crustaceans. On five different occasions throughout the summer, the trays were deployed at each site and left undisturbed for three weeks to be colonized by benthic invertebrates. During daylight hours on the date of retrieval, the trays were sealed underwater prior to removal, placed in an ice-filled cooler and transported to the laboratory within 3 hours of collection.

In the laboratory, the contents of each tray were washed through a 0.5 mm sieve and all retained invertebrates were stored in 70% ethanol for subsequent identification. Specimens of *H. anomala* (Figure 1) were recognized by their truncated, denticulate telson (Figure 2), which distinguishes the species from North American and other European mysids (Pothoven et al. 2007). Voucher specimens were deposited in the Canadian Museum of Nature, Ottawa, Canada (catalogue number CMNC 2008-1316).

Using a stereo microscope, the total body length (TL) of each specimen was measured to the nearest 0.1 mm from the anterior margin of the carapace to the distal end of the telson (Pothoven et al. 2007). Males were recognized by the presence of an elongated exopod on pleopod IV, and females were recognized by the presence of oostegites (Ketelaars et al. 1999). Females carrying embryos in their brood pouch were recorded as gravid.

The presence of *H. anomala* was detected upon examination of preserved invertebrate samples, three months after collection. The mysids were discovered in samples collected from a single site (Chateauguay West) situated on the south shore of the river across from the Island of Montreal; it is a shallow beach covered with mixed sediments of cobble and sand and partially protected from wave action by a peninsula. In total, 15 individual mysids were collected from this site on two occasions. One juvenile mysid (3.3 mm TL) was found in a single sampling tray that was retrieved on July 18; other samples from that date may have contained individuals but, unfortunately, had been discarded before it was known that mysids were present. Additionally, 14 individuals were found in four trays retrieved on August 8, at a mean density of 3.5 ± 0.6 (SE) per tray, or 50 ±9.2 m^{-2}. These consisted of 10 adult females, 3 adult males and one juvenile, yielding a female:male sex ratio of 3.5:1. A sex ratio highly-skewed toward females is consistent with summer collections of *H. anomala* in other invaded regions (Ketelaars et al. 1999; Pothoven et al. 2007). Two of the females were gravid. The mean total body length was 7.3 ± 0.1 mm for the females (n=9; one female was damaged and could not be measured) and 5.6 ± 0.1 mm for the males, which are within the ranges recorded for adult *H. anomala* in Lake Michigan (Pothoven et al. 2007). The juvenile mysid measured 5.3 mm TL. Other invertebrates found in the samples consisted predominantly of mayfly nymphs (Ephemeroptera: Heptageniidae), midge larvae (Chironomidae), tube building and net-spinning caddisfly larvae (Trichoptera), and gammarid amphipods *Gammarus fasciatus* Say, 1818, and *Echinogammarus ischnus* (Stebbing, 1899).

Figure 1. Lateral view of an ethanol-preserved adult female *Hemimysis anomala* (7.5 mm TL) collected from the St. Lawrence River (photo: Guy L'Heureux).

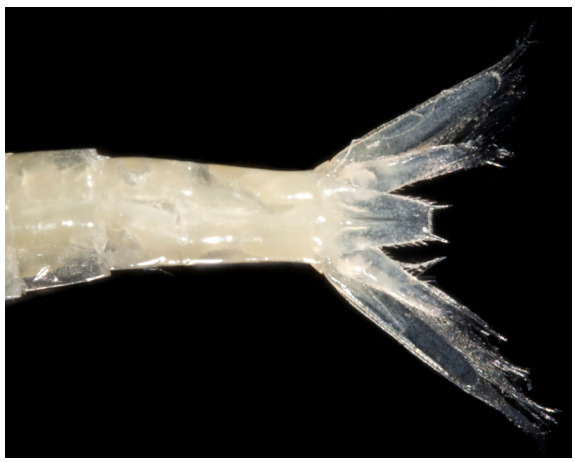

Figure 2. Dorsal view of the uropods and truncated telson of *Hemimysis anomala* (photo: Guy L'Heureux).

Chateauguay West is located 30 km upstream of the Port of Montreal; therefore, the occurrence of *H. anomala* at this site is probably the result of passive dispersal from an upstream source population, rather than of an independent introduction from a foreign or domestic ship deballasting at the port. Among Ponto-Caspian

mysids, *H. anomala* has the greatest capacity for rapid range expansion and is efficiently dispersed by passive downstream drift (Wittmann and Ariani 2009). The nearest known population is in eastern Lake Ontario, the source of the river (http://nas.er.usgs.gov). Although it is premature to conclude that the species is established in the river, the presence of multiple life stages and gravid females in our samples suggests that *H. anomala* has already formed one or more reproducing populations along the 250 km fluvial corridor between Lake Ontario and the Chateauguay West site.

Mysids avoid direct light and seek shelter within rocky crevices, amongst cobble or under stones during the day, and thus may easily escape detection by normal methods of sampling zooplankton (Salemaa and Hietalahti 1993; Pothoven et al. 2007). The large spatial heterogeneity of the river system offers many potential refugia for cryptic populations of *H. anomala*. It is unlikely that *H. anomala* can colonize our sites along the north shore of Lake Saint-Louis, given that this area is exposed to a plume of ion-poor water from the Ottawa River where it merges with the St. Lawrence River at the Island of Montreal. Low concentrations of dissolved ions along the north shore have apparently limited the establishment of other Ponto-Caspian species such as the zebra mussel *Dreissena polymorpha* (Pallas, 1771), the quagga mussel *D. bugensis* Andrusov, 1897, and the amphipod *E. ischnus*, which otherwise thrive in alkaline waters along the south shore and in the upper reaches of the St. Lawrence (Jones and Ricciardi 2005; Kestrup and Ricciardi 2009). The sporadic appearance of mysids in samples taken from Chateaguay West during the summer, and the absence of mysids in samples from our other south shore sites, may reflect spatiotemporal variation in downstream drift as well as the difficulty of locating *H. anomala* in the early phase of its colonization.

The European literature does not provide sufficient information for predicting the impact of this species in a large river (Ricciardi 2007). Strong ecological effects are often associated with the introduction of novel predators, and there are no native species in the upper St. Lawrence River that are phylogenetically or functionally similar to *H. anomala*. Like most mysids, *H. anomala* feeds primarily on zooplankton; but it is an opportunistic omnivore that also preys on benthic invertebrates such as annelids, amphipods, copepods and chironomids, and scavenges the flesh of dead mussels, crayfish and fish (Ketelaars et al. 1999). It could become a significant component of benthic food webs locally in lentic areas of the river dominated by rocky substrates, particularly areas where anthropogenic structures provide shelter (e.g. in and around marinas, jetties and canals; Stubbington et al. 2008).

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Annex 1. Sampling sites and water quality parameters in St. Lawrence River in 2008.

Site	Coordinates		Sampling date (2008)	Conductance [µS•cm^{-1}]	Ca^{2+} [mg•L^{-1}]	Temp. °C	Oxygen [mg•L^{-1}]
	Latitude, N	Longitude, W					
North shore of Lake Saint-Louis, St. Lawrence River							
Valois Bay	45°26.37'	73°46.48'	June 27	142	18	24	9.7
			July 17	153	21	25	8.7
			August 7	124	15	23	8.6
			August 27	137	18	25	9.3
			Sept 21	110	13	19	9.1
Summerlea Park	45°26.26'	73°42.95'	June 27	189	20	23	9.1
			July 17	157	19	25	9.4
			August 7	169	22	23	9.0
			August 27	178	19	25	9.3
			Sept 21	127	12	18	9.0
Lachine	45°26.01'	73°41.17'	June 27	163	19	22	8.7
			July 17	130	15	25	10.0
			August 7	115	17	23	8.3
			August 27	154	18	26	8.1
			Sept 21	101	10	18	8.7
South shore of Lake Saint-Louis, St. Lawrence River							
Léry	45°20.13'	73°49.09'	June 26	292	39	23	12.5
			July 18	303	39	23	9.9
			August 8	303	36	24	9.6
			August 28	308	27	24	7.6
			Sept 18	316	29	17	8.9
*Chateauguay West	45°21.80'	73°47.19'	June 26	293	38	22	9.8
			July 18	290	35	24	11.8
			August 8	289	31	23	9.7
			August 28	293	29	24	9.8
			Sept 18	298	28	19	10.0
Chateauguay East	45°22.52'	73°46.55'	June 26	292	38	21	9.7
			July 18	291	41	24	10.9
			August 8	293	31	22	8.1
			August 28	297	28	24	8.5
			Sept 18	296	29	20	10.6

**Hemimysis anomala* was collected at this site on July 18 and August 8, 2008