

Short Communication

First records of the quagga mussel, *Dreissena rostriformis bugensis* (Andrusov, 1897), in the Meuse River within France

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Abstract

After its first observation in the Hollandsch Diep in 2006, the quagga mussel expanded in an upstream direction within the rivers, Rhine and Meuse. The species was found throughout the Dutch and Belgian sections of the Meuse River between 2008 and 2011, but was never reported from the Meuse in France, i.e., upstream of the Belgian border. Herein, this document reports the finding of the quagga mussel at two locations in the French section of this river. The lengths of the quagga mussels collected in this study – including the initial discovery of a 23.0 mm long individual in October 2011 – suggest that their original introduction into the Meuse River within France occurred in 2009 or earlier.

Key words: Molluscs; Bivalves; *Dreissena*; invasive species; Meuse River; France

Introduction

The quagga mussel, *Dreissena rostriformis bugensis* (Andrusov, 1897) (Figure 1), was restricted to its native area, the Dnieper delta, until the 1930s (Son 2007), when it began to spread in the Ponto-Azov basin and Eastern Europe (Orlova et al. 2004; Zhulidov et al. 2005). The first observation of the species in Western Europe (Molloy et al. 2007) was made in 2006 in the Hollandsch Diep, part of the main tributary in the Rhine delta in The Netherlands. In subsequent years a rapid upstream migration within both the Rhine River and the Meuse River was observed (van der Velde and Platvoet 2007; Haybach and Christmann 2009; Marescaux et al. 2012). Indeed, Marescaux et al. (2012) reported the presence of the quagga

mussel throughout the Dutch and Belgian sections of the Meuse and provided evidence that the species was present in the Belgian part of the river since 2008. The first record of the species in France was in 2011 in the Moselle River, which is connected by canals to the Meuse River (bij de Vaate and Beisel 2011). Despite the sampling efforts of Marescaux et al. (2012) in the Meuse at the Belgian-French border, no quagga mussels were found in the French part. They noted, however, that the Meuse River is particularly vulnerable to invasive species due to its dense navigation and suggested that it was only a question of time before the quagga mussel would be found to have spread upstream into France by jump dispersal (especially commercial and recreational navigation). Herein, this document presents the first records of the quagga mussel in the French section of the Meuse River.

Figure 1. External view of the shell of *Dreissena rostriformis bugensis* collected at Vadonville in October 2011. Photograph by D. P. Molloy.

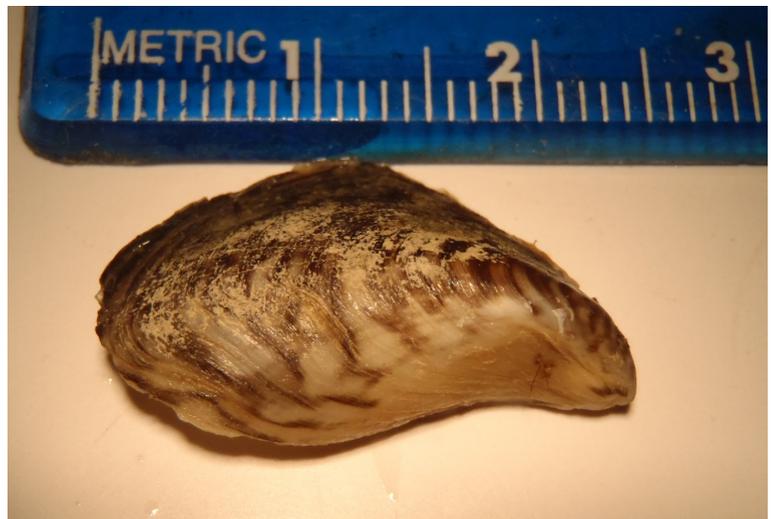
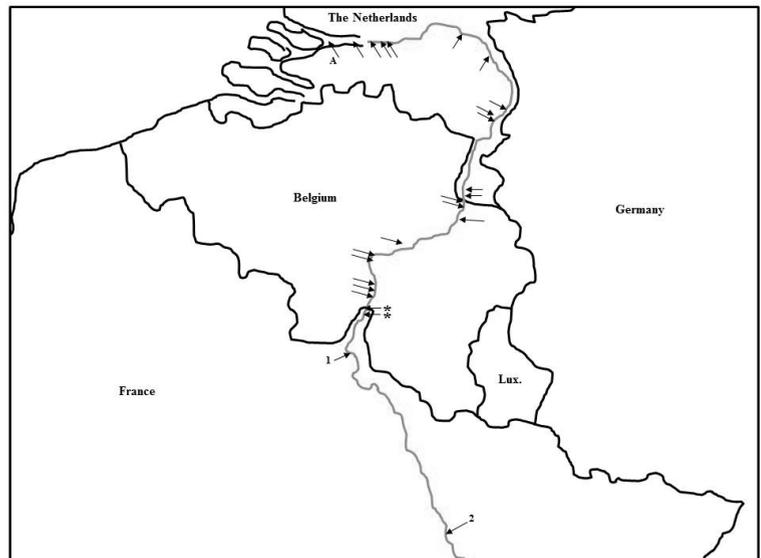


Figure 2. Expansion of *Dreissena rostriformis bugensis* in the Meuse River. Arrows 1 and 2 indicate our sampling sites (see Table 1 for coordinates). The arrow A is the first record of the quagga mussel in Western Europe (Hollandsch Diep) and other arrows indicate the locations sampled by Marescaux et al. (2012). The arrows labelled with * indicate the locations where no quagga mussels were found in the French part of the river in 2011 by Marescaux et al. (2012).



Material and methods

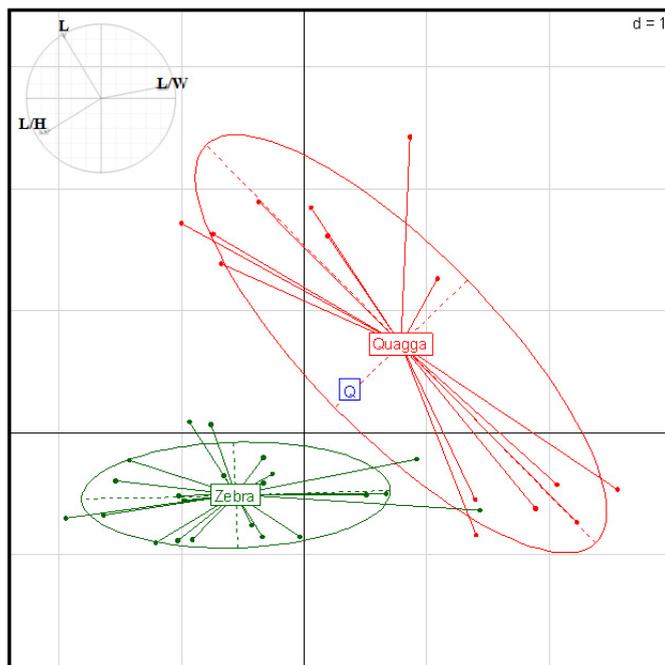
Dreissena samples were collected in the French part of the Meuse River at Dames de Meuse (within lock No. 47 of Canal de la Meuse on 25/04/2012) and Vadonville (on the walls within lock No. 7 of Canal de la Meuse on both 24/10/2011 and 15/04/2012 and from rocks along the shoreline 160 m downstream of this lock on 13/04/2012) (Table 1; Figure 2). At Dames de Meuse, the water level within the lock No. 47 was minimal, allowing us to go down into it to manually collect the mussels. At Vadonville, all

mussels were collected using a metal scraper. Individuals were preserved in absolute ethanol at Dames de Meuse and in 70% ethanol at Vadonville. Quagga and zebra mussels were identified based on shell characteristics (Pathy and Mackie 1993; Mills et al. 1996; Sablon et al. 2010). For all *Dreissena* mussels collected at Dames de Meuse and for the one quagga specimen collected at Vadonville, shell length (L), width (W) and height (H) were measured to carry out a Principal Component Analysis (PCA) to confirm the visual identification following the protocol of Marescaux et al. (2012). All individuals had their shell length measured

Table 1. Number of zebra and quagga mussels collected in the French part of the Meuse River during this study. The number in the first column refers to the number in Figure 2. Collector: *, ° and Δ represent, respectively, “Marescaux”, “Molloy and Giamberini” and “Molloy”.

Location	Coordinates of the sampling site		Collected individuals		Record date	Collector
	Latitude, N	Longitude, E	Zebra	Quagga		
1 Dames de Meuse (Fr)	49° 55' 16"	4° 40' 35"	22	15	25/04/2012	*
2 Vadonville (Fr)	48° 48' 16"	5° 31' 45"	499	1	24/10/2011	°
Vadonville (Fr)	48° 48' 21"	5° 31' 37"	148	0	13/04/2012	Δ
Vadonville (Fr)	48° 48' 16"	5° 31' 45"	584	0	15/04/2012	Δ

Figure 3. Relationship between scores on Axis 1 and Axis 2 and correlation circle for the Principal Component Analysis of shell measurements on 38 *Dreissena* individuals collected in the Meuse River [zebra mussel from Dames de Meuse in green (n=22), quagga mussel from Dames de Meuse in red (n=15) and quagga mussel from Vadonville in blue (n=1)].



(except for the sampling at Vadonville in 2011 where only 300 of the 499 zebra mussels collected were measured).

The mitochondrial cytochrome c oxidase subunit I (COI) gene was used as a barcode to confirm the identification of the quagga individual sampled at Vadonville. Total genomic DNA was extracted following the CTAB (cetyltrimethylammonium bromide) protocol described in Wilke et al. (2006). DNA vouchers were deposited at the University of Giessen Systematics and Biodiversity collection. A fragment of 699 base pairs (bp) of the COI mitochondrial gene was amplified using the primers LCO1490 and HCO2198 (Folmer et al. 1994). Bidirectional DNA sequencing was performed on a 16-capillary 3130xl Genetic Analyzer. Species identification was performed from the DNA sequence using the Basic Local Alignment Search Tool (BLAST) of GenBank/NCBI.

Results and discussion

Dreissena rostriformis bugensis was found at both Meuse River locations sampled, representing the first records of this species from this river within France.

The initial discovery of the species in October 2011 at Vadonville was somewhat inadvertent since the sampling was conducted as part of a zebra mussel parasitology project – one in which mussel collection was limited to the 11-30 mm length size class (Table 1; Figure 2). In this sample, the zebra mussel mean (\pm SD) shell length (n=300) was 19.6 (\pm 3.6) mm and the single quagga mussel that was unexpectedly collected measured 23.0 mm in length (Figure 1). Sequence identification with the NCBI BLAST tool revealed that our sequence (GenBank #JX945980) matches with *D. r. bugensis* COI mitochondrial gene, in particular AF495877.1.

In the two subsequent samples at Vadonville in April 2012, dreissenids of all available size classes were examined, but no quagga mussels were found amongst the 732 zebra mussels collected. The mean (\pm SD) lengths of zebra mussels in the collections on 13/04/2012 (n=148) and 15/04/2012 (n=584) were 17.5 (\pm 9.7) mm and 17.4 (\pm 4.2) mm, respectively.

However, in April 2012, we observed both species at the Dames de Meuse location. The mean (\pm SD) lengths of *D. polymorpha* (n=22) and *D. r. bugensis* (n=15) were 24.1 (\pm 3.3) mm and 21.0 (\pm 9.4) mm, respectively. The results of our Principal Component Analysis (Figure 3) indicate an absence of overlap between the two species suggesting a well-marked morphological distinction as previously indicated by Marescaux et al. (2012).

Because the French part of the Meuse River is connected by canals to the other major navigation routes of France, it was only a question of time before the quagga mussel would spread into it. The lengths of the quagga mussels collected in this study suggest that their original introduction into the Meuse within France had occurred in 2009 or earlier, e.g., the 23.0 mm long quagga collected in October 2011 at Vadonville was likely at least two years old. Representing 41% (15/37) of the dreissenids collected at Dames de Meuse, quagga mussels appear to be relatively well established at this location in comparison to the upstream Vadonville location (approximately 200 kilometers of river length separate these locations) where quagga mussels represented only 0.08% of the dreissenid community (only one individual was found in the combined total of 1,232 dreissenids collected at this location, Table 1).

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