Rocky Mountain Ridged Mussel (*Gonidea angulata* Lea) in the Okanagan Valley, British Columbia: Host fish field sampling and mussel surveys in 2017

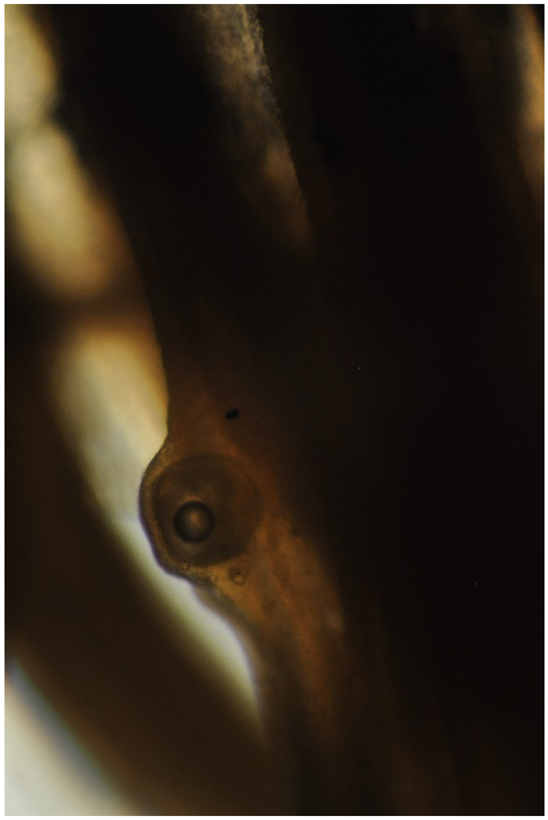

Photo: Steven Brownlee

30 November 2017

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Introduction

The Rocky Mountain Ridged mussel (*Gonidea angulata*, henceforth 'RMRM'), is listed in Canada as a species of concern, by COSEWIC (COSEWIC 2010), and endangered, by SARA (Fisheries and Oceans Canada 2010). Within Canada it is found only in British Columbia (BC), specifically in the Okanagan Valley (COSEWIC 2010, Fisheries and Oceans Canada 2010). The BC government has listed it as imperiled, thanks in large part to this limited range and potential population base (BC Conservation Data Centre 2015a). Little is known about the life history and broader ecological context of the mussel both in its Canadian range and elsewhere (COSEWIC 2003, 2010, Fisheries and Oceans Canada 2010, 2011, Jepsen *et al.* 2010, B.C. Conservation Data Centre 2015b), and, perhaps more pertinently, little is also known about its conservation status and what threats may exist that would imperil the mussel populations in BC (COSEWIC 2003, 2010, Fisheries and Oceans Canada 2010, 2011, B.C. Conservation Data Centre 2015b).

To tackle these gaps in knowledge, the Species at Risk Management Plan underlines the necessity of conducting research to plug these gaps in management-relevant information. It, further, states that efforts should be focused on answering the basic life history characteristics, such as host fish, population and habitat mapping, and the identification of threats (Fisheries and Oceans Canada 2010). The document identifies human modification of habitat as the primary threat to the species, particularly the effects of development and channelization along its riverine habitat along with pollution, introduced species and climate change. To better understand the life history and threats to the mussel, the BC Ministry of Forests, Lands and Natural Resource Operations, the BC Ministry of Environment and the University of British Columbia Okanagan launched several studies together. They conducted surveys within the Okanagan for populations of the mussel (Mageroy 2013, 2016, Brownlee *et al.* 2017a) and the identification of their habitat (Snook 2015, 2017, In prep.), as well as analyses of demography within identified populations (Mageroy 2013).

As a part of this joint research project, an investigation into the host fish usage of the RMRM was also launched. These investigations began in 2013 and included a lab-based infection experiment utilizing live captive fish representing all the likely host species present in the Okanagan and further field analyses throughout the Okanagan. The studies suggest that prickly sculpin (*Cottus asper* Richardson) is the most important host for the mussel in the Okanagan and that northern pikeminnow (*Ptychocheilus oregonensis* Richardson) may also be an important host, while longnose and leopard dace (*Rhinicthys cataractae* Valenciennes and *R. falcatus* Eigenmann & Eigenmann) are likely secondary hosts (Mageroy 2013, 2016, Brownlee *et al.* 2017b). Despite these successes in identifying host species in parts of the RMRM's range, gaps in our knowledge of the RMRM's host fish usage remain. The sampling efforts fell short of identifying likely hosts in the southern portion of the RMRM's Okanagan range, due to a lack of fish being caught. This was particularly the case within the Okanagan River system, which flows between Skaha Lake in the north and Osoyoos Lake in the south (Brownlee *et al.* 2017b). This distinction is important because of the introduction of a number of invasive fish species in the Okanagan Valley, south of the Penticton outlet dam from Okanagan Lake (Jerry Mitchell pers. com. in Mageroy 2016, Mageroy 2013, 2016, Brownlee *et al.* 2017b). Their presence has altered the assemblage of fish species in the system, and, therefore, the host fish use among the mussels in this portion of their range may be different from Okanagan Lake. This is doubly important considering the RMRM's dependence on their host species for successful reproduction, as declines in the abundance of their hosts could lead to declines in the reproductive success of the RMRM as well (COSEWIC 2003, 2010, Fisheries and Oceans Canada 2010, 2011, Jepsen *et al.* 2010, Mageroy 2013, 2016, Brownlee *et al.* 2017b). To this end, another sampling effort was launched at the beginning of June 2017 and proceeded through to July 2017, with a particular emphasis on collecting fish from within the Okanagan River and its environs.

Methods

As with the studies carried out in 2016 (Brownlee *et al.* 2017b), the 2017 field infection study followed a protocol laid out in previous studies on host species usage in the Okanagan Valley (Mageroy 2013, 2016, Brownlee *et al.* 2017b). Four sites in the south Okanagan, between Vaseux Lake and Osoyoos Lake, were selected as appropriate for sampling based on their accessibility, the presence of RMRM beds in the immediate vicinity, and the success of a previous fish sampling efforts (Mageroy 2016, Brownlee *et al.* 2017b) at these sites (Table 1). Hatfield Island represents a new sampling location compared to previous years, chosen based upon RMRM population surveys conducted in 2016 (Brownlee *et al.* 2017a) and the presence of good sculpin habitat (pers. obs.). Previous studies have identified fish in younger age classes as being more likely to act as hosts for freshwater mussels, due to previously infected fish developing immunity to the mussel larvae (glochidia, e.g. Coker et al. 1921, review in Larsen 1997). Therefore, the collection protocol utilized methods designed to target smaller, younger fish. This was accomplished through the setting of minnow traps baited with canned sardines in the riverine sites and in the lakes, as well as through seining at the Vaseux Lake Campground.

Table 1: Fish collection sites.

Site	Type	Description	UTM(s)
Hatfield Island, Vaseux Lake	Lake	Southeastern corner of island	11U 332259 5461256
Vaseux Lake Campground	Lake	Western edge of campsite	11U 316049 5463620
Oliver Downtown	River	Between pedestrian bridge and Fairview Rd bridge	11U 314236 5451625 to 11U 314407 5450979
# 22 Rd Bridge	River	Between # 22 Rd Bridge and Weir # 1	11U 314907 5440470 to 11U 315238 5440062

Conditions in the river and at Hatfield Island precluded the use of seine nets, so traps were utilized as the primary method of collection. In the riverine sites, the minnow traps were held in place, by placing rocks in the traps and tying their buoys and anchor lines to trees or other shoreline features, to keep the traps flush with the river bottom and to prevent them from drifting downriver. This was a particularly important measure, as throughout the sampling period the Okanagan River experienced very high water levels and flow rates (pers. obs.). These traps were placed at least 10 m apart from each other, to ensure that the maximum extent of the river was covered. In the lake sites, this protocol was broadly similar for trapping. Prior work in surveying and sampling in Vaseux Lake identified locations that were suitable host species habitat (particularly rocky areas with cover, pers. obs.), and minnow traps were placed in these locations. In both site types the traps were placed in the afternoon or evening and retrieved the following morning, to counteract the possibility of human tampering with the traps or of natural river conditions from carrying the traps away.

Seining at the Vaseux Lake Campground started at the shared beach access (see site UTM), because it represented an effective 'launching point' for deploying the seine. Seining effort focused on pulls to the north of this initial launch point, as the southern portion of the campground contained too many rocks, plant debris and other obstacles for effective sampling. The shoreline was seined from this point and to the northernmost campsite's beach access. During each seining session numerous seine pulls were completed in this area. The entire area was seined repeatedly (3-6 times).

When fish were caught in both the seines and the traps, a common protocol for fish collection was used. The fish were retrieved from the nets or traps and placed in large buckets with water until the end of the sampling period. At this point the fish were examined and those too large to collect were released back into the river or lake. Those that were to be collected, were euthanized by transferring the fish into another bucket with a prepared solution of MS-222 and water. Enough time was allowed to elapse in order for the fish to expire, then they were retrieved from the bucket and collected in jars filled with anhydrous ethanol for storage, and labelled based upon date of sampling. These jars were then brought back to the lab for later processing. This processing was undertaken by pulling back the operculum manually and using a scalpel to excise the individual gill filaments. The filaments were placed on microscope slides and 'hydrated' with anhydrous ethanol to allow the placement of a further slide on top, covering the sample and allowing it to be viewed under a microscope. The left and right gills were examined separately to ensure cohesive analysis of each fish. Each filament was then examined on both sides and the number of glochidia present was counted. In addition, their encystment status was noted, as metamorphosis of glochidia into juvenile mussels have only been found for fish species where the glochidia encyst on, rather than just attach to, the gills (O'Brien *et al.* 2013). The results of this examination are noted in Table 2 below in the 'Results' section.

Results

A total of 33 fish were collected over the course of the sampling period, from three of the four identified sites (Vaseux Campground, Hatfield Island and the #22 Rd Bridge, Table 5). A large majority (28) of the fish were collected from Vaseux Campground. Similarly, a significant majority of all the fish captured (25) were caught by seining, which was only undertaken at the Vaseux Campground site. Just over half of the fish caught were sculpin, with fewer bass and fewer still pumpkinseed sunfish. Of the 16 sculpin caught over the course of the experiment, 11 were found to have at least one glochidium within their gills, with a recorded maximum of 4 glochidia on one side. Four sculpin had encysted glochidia on their gills, with two of those fish collected from Vaseux Campground and one each from Hatfield Island and the #22 Rd Bridge. Each of the four sculpin with encysted glochidia on their gills also had non-encysted glochidia in their gills.

Table 2: Collected results of fish analyses. 'NEN' refers to non-encysted glochidia, whereas 'EN' refers to encysted glochidia. These are further organized by left gill (LG) and right gill (RG) and by fish, with species number and date of capture noted.

				NEN		**EN**	
Specimen #	**Specimen**	**Date**	**Location**	**LG**	**RG**	**LG**	**RG**
1	SCULPIN 1	05-06-17	VASEUX CAMPGROUND		1		3
2	SMALLMOUTH BASS 1	05-06-17	VASEUX CAMPGROUND				
3	SMALLMOUTH BASS 2	05-06-17	VASEUX CAMPGROUND				
4	PUMPKINSEED SUNFISH 1	05-05-17	VASEUX CAMPGROUND				
5	PUMPKINSEED SUNFISH 2	05-06-17	VASEUX CAMPGROUND				
6	SCULPIN 2	10-06-17	VASEUX CAMPGROUND		2		
7	SCULPIN 3	10-06-17	VASEUX CAMPGROUND	1			
8	PUMPKINSEED SUNFISH 3	10-06-17	VASEUX CAMPGROUND				
9	PUMPKINSEED SUNFISH 4	10-06-17	VASEUX CAMPGROUND				

10	PUMPKINSEED SUNFISH 5	10-06-17	VASEUX CAMPGROUND				
11	SMALLMOUTH BASS 3	10-06-17	VASEUX CAMPGROUND				
12	SMALLMOUTH BASS 4	10-06-17	VASEUX CAMPGROUND				
13	SMALLMOUTH BASS 5	10-06-17	VASEUX CAMPGROUND				
14	PUMPKINSEED SUNFISH 6	13-06-17	VASEUX CAMPGROUND				
15	SCULPIN 4	13-06-17	VASEUX CAMPGROUND		1		2
16	SCULPIN 5	13-06-17	VASEUX CAMPGROUND	3			
17	SCULPIN 6	13-06-17	VASEUX CAMPGROUND				
18	SCULPIN 7	17-06-17	VASEUX CAMPGROUND				
19	SCULPIN 8	17-06-17	VASEUX CAMPGROUND		1		
20	SCULPIN 9	17-06-17	VASEUX CAMPGROUND				
21	PUMPKINSEED SUNFISH 7	17-06-17	VASEUX CAMPGROUND				
22	SCULPIN 10	20-06-17	HATFIELD ISLAND	2	3		1
23	SCULPIN 11	20-06-17	HATFIELD ISLAND				
24	SCULPIN 12	20-06-17	HATFIELD ISLAND				
25	SMALLMOUTH BASS 6	20-06-17	VASEUX CAMPGROUND		1		
26	SMALLMOUTH BASS 7	20-06-17	VASEUX CAMPGROUND	1			
27	SMALLMOUTH BASS 8	20-06-17	VASEUX CAMPGROUND				
28	SCULPIN 13	23-06-17	# 22 RD BRIDGE		4	1	
29	SCULPIN 14	23-06-17	VASEUX CAMPGROUND	2			
30	SCULPIN 15	23-06-17	VASEUX CAMPGROUND				
31	SMALLMOUTH BASS 9	23-06-17	VASEUX CAMPGROUND				
32	SMALLMOUTH BASS 10	23-06-17	VASEUX CAMPGROUND				
33	SCULPIN 16	27-06-17	HATFIELD ISLAND				
			Totals:	9	12	2	5

Table 3: Breakdown of fish samples by site captured.

Site	Number Sampled
Vaseux Campground	28
Hatfield Island	4
Oliver Downtown	0
# 22 Rd Bridge	1
Total Specimens:	33

Table 4: Breakdown of fish samples by capture method.

Method of Capture	Number Sampled
Traps	8
Seining	25
Total Specimens:	33

Table 5: Breakdown of fish samples by species.

Species	Number Sampled
Prickly sculpin	16
Pumpkinseed sunfish	7
Smallmouth bass	10
Total Specimens:	33

Discussion

We only found encysted glochidia on prickly sculpin. This finding lends further support to the previous studies that have suggested that sculpin is the most important host for RMRM in the Okanagan Valley (Mageroy 2013, 2016, Brownlee *et al.* 2017b). As in 2016 (Brownlee *et al.* 2017b), encysted glochidia were found on sculpin at the Vaseux Campground. In addition, one sculpin with encysted glochidia was found at Hatfield Island in Vaseux Lake. These findings support sculpin being the most important host in Vaseux Lake. We also found one sculpin with encysted glochidia at the #22 Rd Bridge, demonstrating that this species functions as a host for the mussels in the river as well.

The fact that our catches were quite limited, as they were in 2016 (Brownlee *et al.* 2017b), limits the conclusions we can draw based on the fish collection data. Among other things, none of the other three potential host fish (northern pikeminnow, and longnose and leopard dace) were collected during 2016 or 2017. They may not have been caught due to the limited catch, the trapping technique may not be suitable for these fish, or they may not be present at the mussel beds. Previous studies have caught all of these species in seines in the lakes in the Okanagan (Mageroy 2013, 2016, Brownlee *et al.* 2017). This suggest that we should have caught them at the Vaseux Campground if they were present in any great numbers, which we did not. We have never caught the dace in traps (Mageroy 2013, 2016, Brownlee *et al.* 2017) and they may, therefore, be present at the other sites. We also know that northern pikeminnows are present at the mussel beds in the Okanagan River (Mageroy 2016). In addition, despite deploying 20 to 30 minnow traps on the Okanagan River every 3 to 5 days in June 2017, we only caught one fish (a sculpin at the #22 Rd Bridge) which does not allow us to conclude whether the prickly sculpin is an important host in the river. Thus, many questions remain with respect to host fish use in the southern Okanagan and especially in the Okanagan River.

To answer these questions, further studies are needed. However, the lack of sampling success with the minnow traps suggests that other methods are needed to investigate host use on the Okanagan River. The high water level in the river system, during both collections years (pers. obs.), may have contributed to both years' failure to successfully collect fish via traps. The target fish may leave for refugia during the early summer peak flow or otherwise stick close to shelter or the bottom of the river, and may not venture out enough or far enough to frequent the traps (Matthews 2012). Since a minimum flow is maintained in the Okanagan River (Lora Nield pers. com.) flow may never become low enough for traps to function efficiently. Other methods, such as seining and electro fishing are also impractical (pers. obs.). One may have to try to use other types of traps (for suggestions, see B.C. Ministry of Environment, Lands, and Parks 1997). Alternatively, one could use a new technology like eDNA. It will allow the assemblage of fish present in the river to be assayed at once and compared to other 'known' assemblages (Evans *et al*. 2017), like in Vaseux Lake or Okanagan Lake. However, it will not give any data on the prevalence and intensity of glochidial infections on the host fish. This would be an indirect means of assessing the host status in the system, but in light of few other alternatives all possibilities should be considered.

Acknowledgements

Linda Walker assisted as a volunteer during field work. We thank the BC Ministry of Environment and Climate Change Strategy for funding the 2017 work. The seine and some of the minnow traps were provided by the BC Ministry of Forest, Lands, Natural Resource Operations and Rural Development.

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