Newsletter of the Freshwater Mollusk Conservation Society
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The FMCS 2021 Virtual Symposium

Alan Christian, Local Committee Co-chair

The Local Committee for the FMCS 2021 Virtual Symposium "*Back to the Future: The Virtual Unknown*" has been working hard to put together an awesome meeting for the Society in spite of the COVID-19 pandemic. Our committee consists of myself (Alan Christian, Co-chair; Meeting Tech), Steve McMurray (Co-chair; Program), Alexa Maine (Abstracts), Patty Morrison (Abstracts), Matthew Patterson (Program), Jeremy Tiemann (Abstracts), Jenifer Archambault (Outreach Committee), Curt Elderkin (Awards Committee), Amy Maynard (Outreach Committee), and Tamara Smith (DEI Committee).

Symposium activities will start on Monday 12 April and will end on Wednesday 14 April 2021. We developed a program consisting of both live (synchronous) ZOOM-based events and pre-recorded web-linked (asynchronous) contributed presentations trying to simulate many of the activities that happen during a traditional FMCS symposium. Some live sessions will be a single ZOOM "room" with a main event or presentation where everyone is participating together, while other ZOOM sessions will have "breakout rooms" which will allow attendees to take part in separate discussions.

The special FMCS 2021 Virtual Symposium web page is now live at: https://sites.google.com/clarkson.edu/fmcs-2021-virtual-symposium/home. Up until the start of the meeting, the Symposium web page will consist of a "Home" page, a "Code of Conduct" page, a "Schedule at a Glance" page, and an "Acknowledgments" page. The "Contributed Oral and Poster Presentations" page will be viewable from 8 am Monday 12 April through 8 pm on Wednesday 14 April 2021 (all times listed in this article are US Eastern Daylight Time, = GMT-4).

According to Patty, Jeremy, and Alexa, our contributed presentation turnout has been outstanding -- 173 presentations -- which will be posted on the Symposium web page for your viewing 24 hours a day during the duration of the event! Matt and Steve are putting together a lively, but efficient, ZOOM-based daily program that includes the FMCS business sessions, a plenary speaker, two oral and poster panel discussion sessions, two informal brunch socials, a student mentoring session, and two social/networking sessions.

Pre-recorded (Asynchronous) Content

The contributed oral and poster presentations will be hosted on the Symposium web page, which will be viewable starting at 8 am on Monday 12 April 2021 and will remain continuously viewable until 8 pm on Wednesday, 14 April 2021. Contributed presentation authors will have pre-recorded their 12-minute Traditional, 7-minute Lightning, or 3-minute Poster videos and converted them to unlisted or public YouTube videos which we will post on the Symposium web page. Poster presenters, in addition to their 3-minute YouTube videos, will have provided us a JPEG of their poster that also will be posted on the Symposium web page. Attendees can view these presentations at their leisure and, if they wish, leave written comments or questions for each presenter. The presenters will be asked to check their comments section several times a day to respond to questions.

On the Contributed Presentations web page, the videos will be organized by traditional topics of an FMCS Symposium, but we also will have some interesting special topic sessions, too (i.e., several talks on a theme). And, to get a more realistic feel to the presentations, on Tuesday and Wednesday at 11 am, presenters will be asked to attend one of two live ZOOM breakout room sessions on their topics, during which they can respond to live questions or have discussions with other attendees.

Student presentation judging will occur from 8 am Monday 12 April through 8 pm on Tuesday 13 April 2021. Curt Elderkin and the awards committee have developed an electronic judging form that will be used during this Symposium.

Live ZOOM-based (Synchronous) Events

My institution, Clarkson University, will be hosting and managing the synchronous ZOOM sessions. Meeting ID and Passwords for each session, and details on session and breakout room assignments, will be shared via email with registrants about one week before the Symposium and on each morning of the Symposium. You will need these links to find and attend any of the ZOOM sessions. Due to university and ZOOM security restrictions, we will not be posting this information in the program or on any web site, so please check your email.

The tentative schedule for this Symposium is presented in the following table. On Monday at 1:15 pm, we will officially kick off the Symposium with a brief welcome followed by the live presentation by our Plenary speaker. This year's plenary speaker is August Ball, Founder of Cream City Conservation. Ms. Ball will be providing us with insights and ideas on increasing engagement of traditionally underrepresented groups in the field of conservation.

Tentative Symposium Schedule
(all times US Eastern Daylight Time, = GMT -4)

Monday April 12, 2021	Tuesday April 13, 2021	Wednesday April 14, 2021
8:00 am Virtual Symposium Opens; Contributed Talks and Posters Visible on website*	9:45 - 10:45 am Informal Brunch Social at FMCS 1 (ZOOM) *	9:45 - 10:45 am Informal Brunch Social at FMCS 2 (ZOOM)*
11:00 am - 1:00 pm Board Meeting (ZOOM) *	11:00 - 12:00 Noon Oral and Poster Discussion Breakout Rooms 1 (ZOOM)*	11:00 - 12:00 noon Oral and Poster Discussion Breakout Rooms 2 (ZOOM) *
1:15 - 2:30 pm Welcome and Plenary (ZOOM) *	12:15 - 2:00 pm Committee Meetings 1 (ZOOM)*	12:15 - 2:00 pm Committee Meetings 2 (ZOOM)*
2:45 - 3:45 pm Social/Networking Breakout 1 (ZOOM)*	2:15 - 3:15 pm Student Mentoring Session (ZOOM) *	2:15 - 4:15 pm Business Meeting and Awards (ZOOM) *
	3:30 - 4:30 pm Social/Networking Breakout 2 (ZOOM) *	8:00 pm Virtual Symposium ends Contributed Talks and Posters no longer visible on website

* A Meeting ID and Password will be required to access all ZOOM-based activities.

Our FMCS business events (Board Meeting, Committee Meetings, and Business Meeting) also will be live events hosted on ZOOM and will occur between 11:00 am and 4:30 pm each day. All registrants for the Symposium are welcome to attend both the Board Meeting and the Business Meeting but those sessions will not have any breakout rooms for side discussions.

The other live events to be held during this Symposium fall into five categories. In order of occurrence each day, these events are:

- Informal Brunch Socials: On Tuesday and Wednesday President Jeremy Tiemann will host informal live ZOOM brunch socials from 9:45 to 10:45 am.
- Oral and Poster Discussion Breakout Sessions: On Tuesday and Wednesday from 11:00 am to 12 noon, we will have a live ZOOM session in which breakout rooms will be organized with moderators for the various presentation topics. We will distribute the contributed session topics across two days, with half of the topics up for discussion on each day. Even though the actual contributed presentations will be posted on the website, these live sessions will provide a forum for members to ask questions of the presenters.

- Committee Meetings: Committee meetings will occur from 12:15 - 2:00 pm on Tuesday and Wednesday. We will assign each committee to meet on one of those days and, during each of those sessions, committee chairs and members will need to refer to the informational emails to figure out which ZOOM breakout room to visit. If committee chairs prefer a specific day for their meeting, they should contact Matt and Steve who will try to accommodate individual needs to the best of their ability.
- Student Mentoring Session: Mid-afternoon on Tuesday, we will have a live ZOOM student-mentoring session lead by the Education and Outreach Committee. This will start with a whole group ZOOM session, from which we can create on-the-fly one-on-one or group mentoring breakout room discussions.
- Social/Networking Session: On Monday and Tuesday afternoons, we will have live ZOOM informal social/networking sessions on topics proposed by the registrants. More information will be provided to registrants as we near the Symposium.

Again, to watch and, we hope, take part in any of the live ZOOM events during the Symposium, you must be registered and use the Meeting ID and various Login passwords that will be provided by email about one week before, and on each day of, this virtual Symposium.

We are looking forward to seeing everyone -- online, at least -- in mid-April, and we hope you are getting as excited as we are about our "*Back to the Future: The Virtual Unknown*" extravaganza! If you have not yet registered for this Symposium, you can do so at this page on the FMCS website: https://molluskconservation.org/EVENTS/2021SYMPOSIUM/2021_FMCSSymp_Registration.html. Registration for the virtual Symposium will close at 11:59 pm on April 1, 2021. There will be no opportunity for registration after that date due organizing and managing the ZOOM meeting information. So, do not delay!

Special thanks go to Walt Householder (student at California State University, Monterey Bay, and US Fish and Wildlife Service intern) for making the awesome 2021 logo, and to Mark Hove for supplying past meeting photographs for the Symposium web page.

Society News

Establishing Baselines for Society Demographics and Attitudes Towards Diversity, Equity, and Inclusion

Sara Andree[1], **Megan Bradley**[2], **Kentaro Inoue**[3], **John Pfeiffer**[4], **Tamara Smith**[5], and **Jeremy Tiemann**[6]
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The need to broaden accessibility of biological sciences as an educational resource and career option has become increasingly focal in recent years. In the past, scientific professions and the societies associated with them have been disproportionately dominated by white, straight, upper-class men (Bronstein & Bolnick 2018). Race, ethnicity, sexual orientation, and ability (among other dimensions) tend to lack diverse representation in the sciences (Abernethy et al. 2020). Arguably, there is a moral and ethical obligation as scientists and within our communities to promote and facilitate a diverse and inclusive working and learning environment within our field. Our field of study is itself disadvantaged when we fail to include the full range of experiences, opinions, and ideas provided by a representative sample of the communities we serve. To this end, the Freshwater Mollusk Conservation Society (FMCS) Committee for Diversity, Equity, and Inclusion (DEI) aims to evaluate needs within the Society regarding the topics that are our namesake and to facilitate positive change. A long-term goal that the Society was recently able to achieve was to distribute the first iteration of a membership survey designed to evaluate current demographics and attitudes towards DEI within FMCS. Data collected from the survey are presented here in an attempt to establish a baseline and create a platform for discussion of future projects and areas of interest to be pursued by the DEI committee and the Society overall.

In September 2020, a voluntary DEI Survey was distributed via email and social media to all FMCS members and the UNIO listserv, which includes a wider audience interested in freshwater mussels. The data collection period ended in December 2020. The survey included nine multiple-choice questions related to demographics, eight multiple-choice questions related to attitudes towards the Society, and an open-ended request for comments. All questions were optional and included a "Prefer not to answer" response. The survey was administered using Google Forms, and thus data collection was fully anonymous and responses to individual questions were not grouped by respondent. In total, 122 individuals participated in the survey, and 56 comments were submitted. Results of the multiple-choice questions were summarized across all responses, and the comments were summarized and grouped by topic.

With regard to demographics, the survey participants were overwhelmingly white, straight, highly educated, and without identified disabilities. Concerning their preferred pronouns, approximately 57% identified as he/him, 42% as she/her, and <1% as they/them (Figure 1a). About 7% of participants identified as LGBTQ+, while 92% did not (Figure 1b).

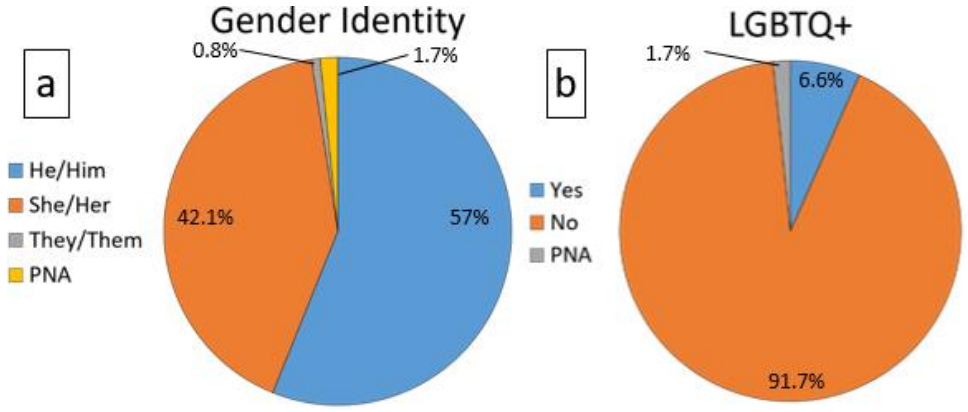

Figure 1. Preferred pronouns [gender identity - (a)] and identification as LGBTQ+ (b) of FMCS survey participants, with percentages of total survey participants (n=122). Categories displayed are those that were selected by at least one participant; categories not selected (e.g. Other) are not shown. PNA = Prefer not to answer.

Most participants were white (92%); all other races were represented by less than 3% each (Figure 2a). Other races by which participants identified were American Indian or Alaskan native, Asian, European-American, First Nation, and Arabic and Northern European. Similarly, approximately 92% of participants identified as not of Spanish, Hispanic, or Latinx descent. About 2% of participants identified as Mexican or Mexican-American, and 3% as other Spanish, Hispanic or Latinx groups (Figure 2b).

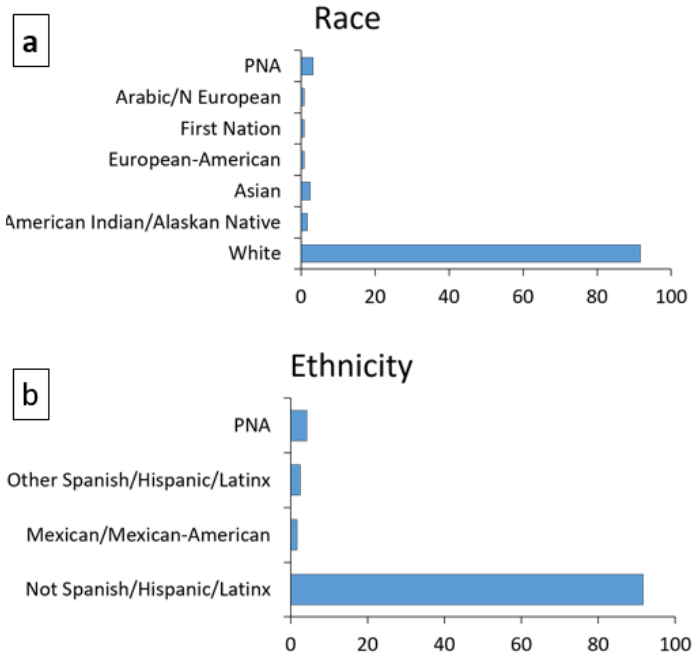

Figure 2. Race (a) and ethnicity (b) identified by FMCS survey participants by percentage of total survey participants (n=122). Categories displayed are those that were selected by at least one participant; categories not selected (e.g. Black/African American) are not shown. PNA = Prefer not to answer.

All age ranges were represented somewhat evenly (Figure 3a), with the exception of the "Under 18" range, which was not selected by any participants. Although nearly all age ranges were represented, almost half of the participants reported having been in their field of study for 20 years or more (Figure 3b), and over 85% of participants held a 2- or 4-year graduate degree (Figure 3c). About 3% of participants identified as having some cognitive or physical disability, while 94% reported no disability (Figure 4a). Finally, about 7% of participants were military veterans, with the remaining 93% reporting no military experience (Figure 4b).

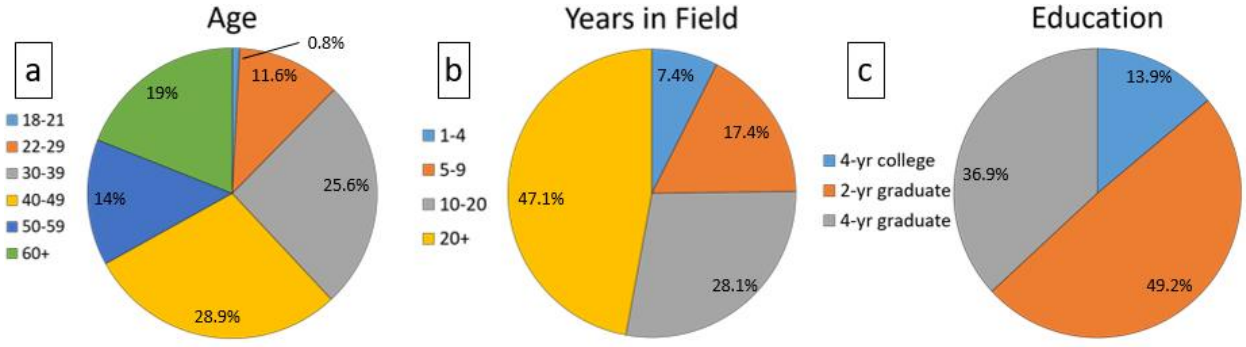

Figure 3. Age distribution (a), total years working in their current field (b), and education level (c) of FMCS survey participants, with percentages of the total survey participants (n=122). Categories displayed are those selected by at least one participant; categories not selected (e.g., Prefer not to answer) are not shown.

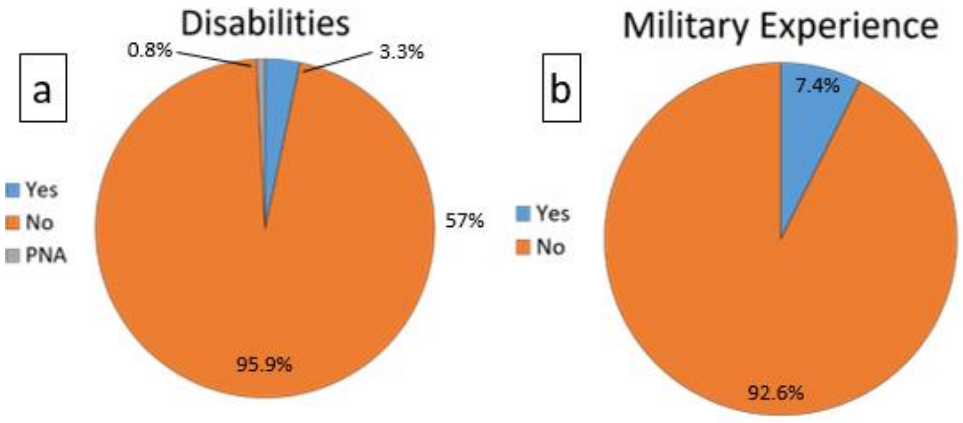

Figure 4. Identified disabilities (a) and military experience (b) of FMCS survey participants, with percentage of the total survey participants (n=122). Categories displayed are those that were selected by at least one participant; categories not selected (e.g., Prefer not to answer) are not shown.

Attitudes toward DEI issues within FMCS were generally positive, although there was some uncertainty among participants. Nearly 75% of participants agreed with the statement that FMCS leadership encourages diversity with respect to numerous factors, while the majority of the remaining 25% were unsure. Less than 3% of participants did not think that FMCS would benefit from education about DEI, while almost 80% did perceive potential benefits, and the remainder were unsure. Responses were more variable when participants were asked whether FMCS has been effective in the past promoting discussions and training about tolerance and multicultural understanding; more than half were unsure of this statement, about a quarter disagreed, and the remainder agreed. When asked if FMCS encourages leadership by underrepresented individuals or groups, 50% of participants agreed, whereas 36% were unsure, and the remainder disagreed.

The remaining four multiple-choice questions pertained to FMCS conference attendance and conduct. Nearly 85% of participants had attended an FMCS conference or workshop in the past; however, only about 67% were aware of the FMCS Code of Conduct (FMCS 2018). Similarly, 71% of participants felt sure that FMCS would take action against any inappropriate conduct, while the majority of the remaining 29% were unsure. When asked if they had ever been the victim of, or been witness to, any form of discrimination or intolerance by members of FMCS, about 6% of participants indicated that they had, while the remaining 94% did not.

Finally, participants were asked to describe any way(s) in which they would like to see FMCS improve in terms of inclusion, equity, diversity, or accessibility. Responses varied but largely aligned with one of the several topics listed in Table 1. In general, comments suggested a need for more outreach, especially to younger children in the K-12 range. Another common suggestion was to provide scholarships, grants, or fee waivers to encourage entry to the field, and to meetings and workshops. Most participants who chose to comment gave generally positive feedback, although about 5% of commentors stated that they felt there was no need for a DEI committee or that it might be a step in the wrong direction.

Table 1. Responses to comment section question, summarized by general content and listed in order of most frequent occurrence.

Suggestion	Frequency	Percent
Provide K-12 outreach to diverse populations	14	24.6
Make events/entry into the field more financially accessible	11	19.3
Continue on current path/no suggestions	7	12.3
Foster relationships with Historically Black Colleges and Universities (HBCUs)	6	10.5
Encourage diverse leadership within existing member base	4	7.0
Create opportunities for mentorship/more involvement by existing members	4	7.0
Prefer less activity, no need for DEI focus, or find it divisive	3	5.3
More broad content, such as talks/workshops/plenaries	2	3.5
Provide childcare at meetings and workshops	2	3.5
Advertise activities/outreach events more to a wider audience and within FMCS	2	3.5
Clearer ways to report discrimination/harassment	1	1.8
Increased communication and transparency	1	1.8

While it is clear that FMCS has a lot of work to do if it aims to increase diversity, equity, and inclusion, the DEI committee hopes that creating and sharing the results of this survey will help establish a baseline from which to grow and assess member attitudes. To ensure a safe environment for any future speakers, workshop leaders, or members from diverse backgrounds, it is important to create a relationship with our membership as a whole and to foster collaboration among us. The committee plans to conduct this survey every other year to continue gathering demographic data and track attitudes within the Society. As more concrete events are organized and the Society continues to work towards a more inclusive and diverse environment, we will continue to share our findings and invite feedback. In the near term, we hope to host a brainstorming and listening session during the FMCS 2021 virtual Symposium so attendees can share their views in person.

Disclaimer

Any use of trade, firm or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. The findings and conclusions in this article are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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Announcement

Freshwater Mussel Conservation – National and Ohio Perspectives

March 24, 2021
1:00-5:00 pm EST

The Ohio Biodiversity Conservation Partnership (OBCP) at the Ohio State University is hosting a VIRTUAL symposium on freshwater mussel conservation in honor of the late Dr. G. Thomas Watters.

Confirmed speakers:

- Jeremy Tiemann (Illinois Natural History Survey)
- John Pfeiffer (Smithsonian Institution)
- Wendell Haag (U.S. Forest Service, Southern Research Station)
- Ieva Roznere (Ohio State University)

OBCP is a partnership between the Ohio State University and the Ohio Division of Wildlife funded through the U.S. Fish and Wildlife Service

Register at the following Link:

HTTPS://OSU.ZOOM.US/WEBINAR/REGISTER/WN_2GBHLGCHRE-_SNY-KN0PCW

For more information, please contact Steve Smith (**smith.591@osu.edu**)

Upcoming Meetings

March 22 – 25, 2021 – National Shellfisheries Association 113th Annual Meeting, VIRTUAL https://www.shellfish.org/annual-meeting

April 12 – 14, 2021 – FMCS Virtual Symposium. Theme: *Back to the Future: The Virtual Unknown*. [website available soon] [See article on Page 1.]

May 23 – 27, 2021 – Society for Freshwater Science Virtual Meeting, Theme: *Freshwater Science in a Time of Transformation* http://sfsannualmeeting.org/

June 14 – 18, 2021 – American Malacological Society Annual Meeting, Sydney, Cape Breton Island, Nova Scotia, Canada https://ams.wildapricot.org/AMS-2021

September 5 – 9, 2021 – Ninth European Congress of Malacological Societies (EUROMAL 2@2@), Prague, Czech Republic www.euromal.cz.

October 17 – 20, 2021 – Southeastern Association of Fish and Wildlife Agencies 75th Annual Conference,. Roanoake, Virginia, USA. http://www.seafwa.org/conference/overview/

November 6 – 10, 2021 –American Fisheries Society Annual Meeting, Baltimore, Maryland, USA Theme: *Investing in People, Habitat, and Science* https://afsannualmeeting.fisheries.org/call-for-papers/

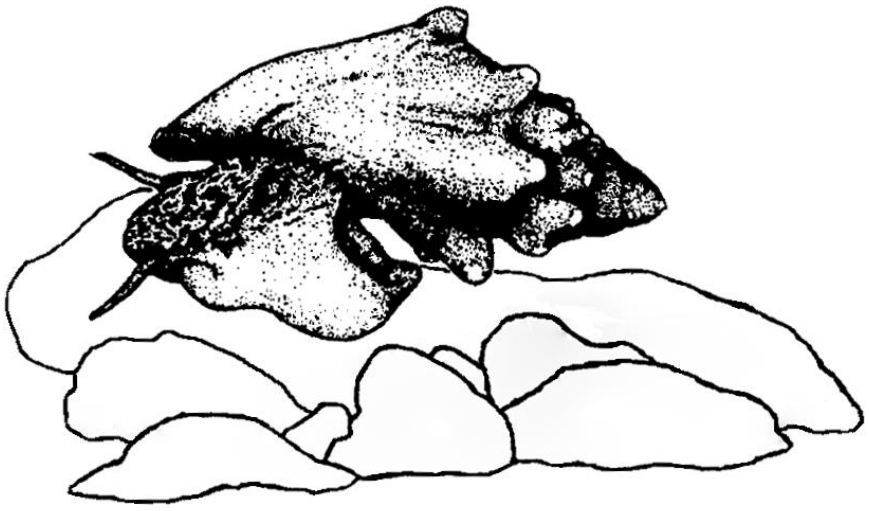
May 16 - 20, 2022 –Joint Aquatic Sciences Meeting, JASM 2022, Grand Rapids, Michigan, USA. https://jasm2022.aquaticsocieties.org/

Summer (?) 2022 – FMCS Workshop [possible options still under discussion]

Summer (?) 2022 – Society for Conservation Biology North American Sectional Meeting, [dates and location not yet posted] https://scbnorthamerica.org/index.php/about-naccb/

April 9 – 12, 2023 – FMCS Biennial Symposium, Double Tree Hotel, Portland Oregon, USA. Theme: *Mountains to Sea and Mollusks Between*. [other details yet to be determined]

Spring (?) 2025 – FMCS Biennial Symposium, somewhere in Michigan, USA. [dates, location, theme, and other details yet to be determined]



Contributed Articles

The following articles have been contributed by FMCS members and others interested in freshwater mollusks. These contributions are incorporated into Ellipsaria *without peer review and with minimal editing. The opinions expressed are those of the authors.*

Variable Shell Characteristics Observed in Propagated Freshwater Mussels

Sarah L. Colletti, Tim W. Lane, Tiffany C. Leach, and **Joseph J. Ferraro**, Virginia Department of Wildlife Resources, Marion, Virginia, 24354
-corresponding author-sarah.colletti@dwr.virginia.gov

[Not Peer-reviewed]

Color and ray patterns of freshwater mussel shells are often used as reliable characters in taxonomy and species identification (Parmalee and Bogan 1998, Williams et al. 2008); however, variation in periostracum and nacre color is frequently reported from wild populations (Watters et al. 2009), sometimes leading to misidentifications. Molecular advancements have clarified long-misunderstood taxonomy and diagnostic traits for dozens of unionid species in the past two decades. More recently, advancements in hatchery propagation and culture have offered opportunities to observe these variations in a controlled and accessible day-to-day setting. Culturing mussels now allows researchers to document shell color variations within and among cohorts and culture conditions, and provides a culture history to aid in understanding possible environmental and molecular explanations for color morphs.

The Virginia Department of Wildlife Resources' Aquatic Wildlife Conservation Center (AWCC), located on the South Fork Holston River in Marion, Virginia, was established in 1998 to aid in the augmentation and reintroduction of native freshwater mussels to Virginia's tributaries of the Upper Tennessee River basin. During these 20+ years of mussel cultivation work, the facility staff has successfully metamorphosed 35 species from host fish, and reared and released 29 of those species to lengths exceeding 15mm. Our experiences have provided us with a wealth of unpublished observational data, including observations of inconsistencies with regard to shell growth and color for many rare and endangered species.

Beginning in 2016, AWCC staff began to notice and track shell color variation within Tennessee Bean (*Venustachonca trabalis)* cohorts cultured under the same conditions. Once thought to be two different species (Ortmann 1918; Parmalee and Bogan 1998), Lane et al. (2016) determined nacre color to be a variable and inconsistent character within and among populations of *V. trabalis* and the closely related Cumberland Bean (*V. troostensis*) but both are clearly distinguishable at the molecular level. In fact, nacre color in *V. trabalis* can range from white to pink to deep purple, and periostracum color varies from nearly black to brown to yellow. These field and genetic findings are now confirmed by the variability observed in recent cohorts cultured at AWCC (**Figure 1**). We observed a range of color morphs in progeny of *V. trabalis* produced from the same (brown shell/purple nacre only) maternal broodstock. Yellow shell/white nacre *V. trabalis* individuals are rarely observed in the wild and never used as broodstock. In hindsight, we believe a proportion of these morphs probably do exist in the wild but have routinely been misidentified as *Villosa iris* or other similar species. AWCC has produced cohorts from each of the four distinct populations of *V. trabalis* described in Lane et al. (2019) and, now, has documented this range of color morphs in three of them. The range in color variation we have observed could be attributed to

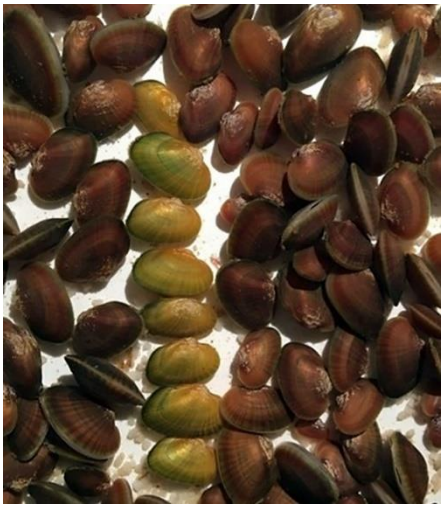


Figure 1. Color morphs seen within the same cohort of *Venustaconcha trabalis* cultured at AWCC.

paternal genetic material, as multiple paternity is observed in freshwater mussels (Christian et al. 2007), and juveniles are often more genetically diverse than their maternal broodstock (Wacker et al. 2019). Shell color variation has been studied primarily in marine mollusks (Luttikhuizen and Drent 2008) but also in the Asiatic freshwater species Triangle Pearl Mussel (*Hyriopsis cumming*i), with evidence of shell color being a heritable trait (Wen et al. 2013). Shell color and function are largely understudied in freshwater mussels (Haag 2012). In our future propagation work, we intend to cross our distinct "yellow shell/white nacre" adults to document the proportion of this phenotype in any resulting progeny.

Results from the 2019 growing season at AWCC especially emphasized the variations seen within cohorts of multiple species grown using the same pond water source but different culture techniques. Mussels grown on sand substrate and under cover from the sun consistently were observed with a darker, more-shiny periostracum compared to those grown on outdoor floating upweller screens (FLUPSYs). We noticed this difference in the majority of species in culture in 2019, but especially in species with naturally darker shells (Figure 2). We believe the sand substrate may offer valuable shell building minerals or surface area for food items like diatoms necessary to give the periostracum its shiny, dark appearance.

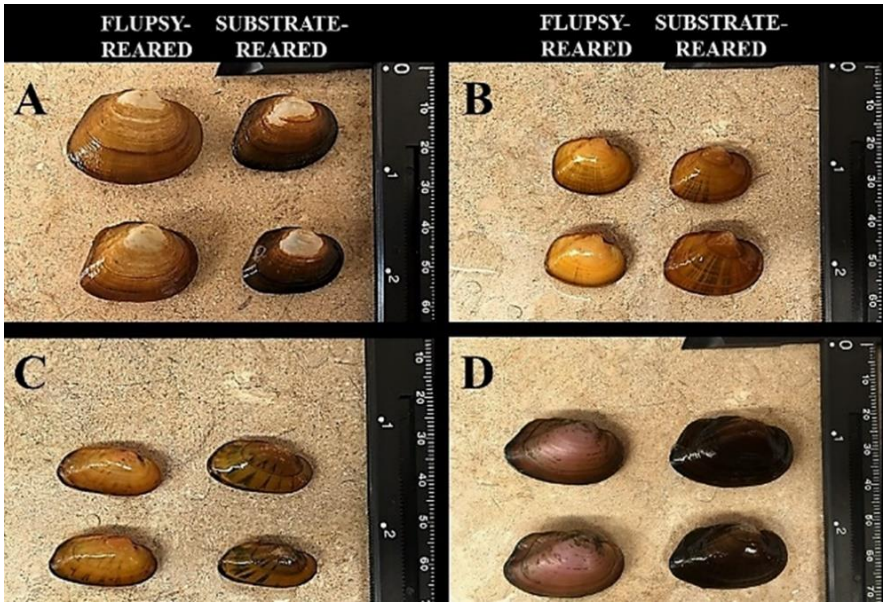


Figure 2. Periostracum color and shine variation across growing conditions. A. *Alasmidonta viridis*, B. *Pleuronaia barnesiana,* C. *Ptychobranchus subtentus,* D. *Venustaconcha trabalis.*

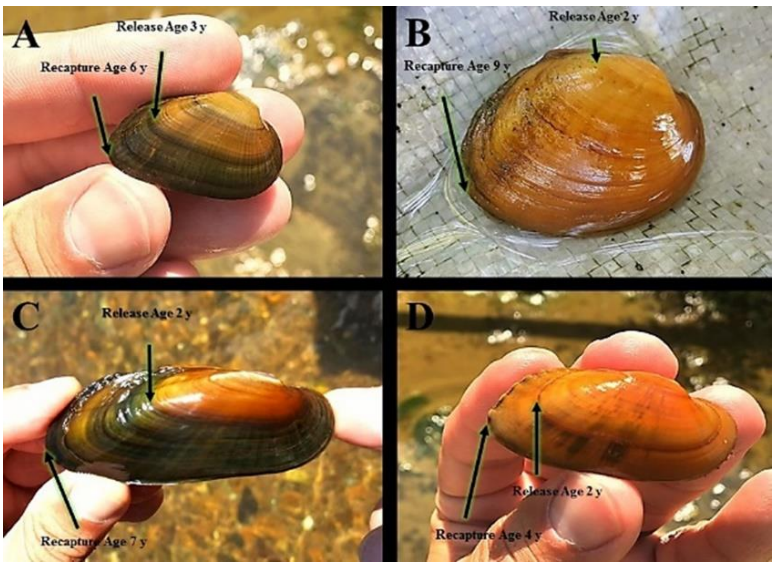


Figure 3. Mussels cultured, stocked, and recaptured by AWCC staff showing changes in shell color and ray patterns: *A. Lemiox rimosus,* B. *Lampsilis abrupta,* C. *Ligumia recta,* D. *Ptychobranchus subtentus.* Ages are approximate years since metamorphosis.

Alternatively, the lack of cover or substrate in the FLUPSYs might allow sunlight or bacteria to eat away at the exposed shell, while the abrasive nature of the sand substrate might help keep the periostracum clean. These observations suggest unique possibilities for morphometric studies at a better-equipped research facility. Controlled experiments, incorporating gene expression, metabolomics, and nutrition would likely help tease out many of these factors and highlight those most critical to the health of captive mussels.

Many of AWCC's juvenile mussels survive and grow in culture but exhibit an unnatural faded appearance, only to return to a more natural look post-release (Figure 3). Periostracum color and composition appears to be a factor of food availability and water chemistry (Haag 2012) but the prismatic and nacreous layers of the shell also could be influenced. As we learn more about the composition of natural diets across mussel species, we admit that the natural

complexity is almost impossible to recreate in a hatchery setting. Hatcheries may remain limited in what they can provide in one location when growing out multiple species with differing nutritional requirements.

We also believe there is evidence that shell color variation can be a combination of both genes and gene expression due to the environment, as demonstrated in Figure 4. This cohort of Black Sandshells (*Ligumia recta*) was produced from the same female in 2017 and maintained in water from the same source. Individuals A and B spent the last two growing seasons in sand and under cover from the sun and are most likely examples of the underlying phenotypic variation linked to individual genotypes within the species. Individuals C and D were kept on FLUPSY screens during the same two growing seasons, resulting in their faded versions of the A and B phenotypes.

While many publications and field guides rely on shell color and markings as distinguishing features, caution should be exercised when identifying closely related freshwater mussel species based solely on external shell characters. Morphometric characteristics like periostracum color, nacre color, and ray patterns will remain useful diagnostically, but often need to be substantiated by incorporating characteristics of internal anatomy, beak sculpture, glochidia, and genetics (now, even whole genomes). To quote our friend, R.S. Butler (US Fish and Wildlife Service, retired) with regard to shells of the same species showing extreme variations, "Maybe we shouldn't be surprised; they're just secretions!"

Figure 4. Examples of individuals from a single cohort of *Ligumia recta* kept in pans with sand substrate and shaded from the sun (A and B) or kept on FLUPSY screens in direct sunlight (C and D).

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Mussel Rescue During a Drawdown at St. Anthony Falls on the Mississippi River Reveals a Little-studied Mussel Assemblage

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Freshwater mussels are important components of freshwater systems and can have a significant impact on nutrient cycling and ecosystem metabolism (Atkinson et al., 2018). Many species of mussels in North America are threatened or endangered (Haag and Williams, 2014). Many potential causes for the declines have been suggested (Haag, 2012), most of which are related to relative large-scale impacts (e.g., channelization, agriculture, etc.). At the local scale, instream construction, dam removal, bridge construction, and other projects can lead to small scale disruptions and extirpations. Mussel rescues have become increasingly common as dams and locks are inspected, repaired, or removed, or when river channels are being redirected (e.g., Northwest Treaty Tribes, 2008; CURE, 2018; Crystal Springs Partnership, 2017; Nature Conservancy, 2018)

The Mississippi River flows through a narrow gorge in Minneapolis, Minnesota. St. Anthony Falls lies at the head of this gorge, originally with a 74 foot (22.5 m) drop (Mazack, 2016). The first dam in this section of the river was built in the mid-19th century but industrialization and poor management almost led to the collapse of the falls (Mazack, 2016). In the mid-1900s, the Army Corps of Engineers constructed two locks and dams on this reach of the river (Figure 1): Lower St. Anthony Falls Lock and Dam (finished in 1956) and Upper St. Anthony Falls Lock and Dam (finished in 1963). Relatively recently, the lock at Upper St. Anthony Falls Dam was closed in 2015 to prevent the upstream movement of invasive carp.

St. Anthony Falls was a historic barrier to fish and mussel migration until the construction of the St. Anthony Falls Locks and Dams (Graf, 1997; Hatch et al., 2003). Before 1900, nine mussel species were known to occur above St. Anthony Falls and 43 mussel species were known in the river below it (Graf, 1997). Poor water quality reduced the number of mussel species for some distance below St. Anthony Falls to zero in the early 1900s (there are no contemporary data for above the falls). By 1972, seven species of mussels had recolonized below St. Anthony Falls (again no data for above). In the early 2000s, the number of mussel species known downstream from the falls had increased to 28 while the number above the falls had increased to 18. The increase above the falls is likely due to fish passage through the St. Anthony locks (Graf, 1997; Kelner and Davis, 2002; Russell and Weller, 2012; Sietman et al., 2018).

Prior to this study, relatively little was known about the mussel assemblage present in the reach between the two dams. When this reach was surveyed in 2001 (Kelner and Davis, 2002), representatives of just four live and five dead species were found (Table 1). During that survey, the water level was at a normal height, resulting in fast currents and difficult diving conditions (Dan Kelner USACE, personal communication).

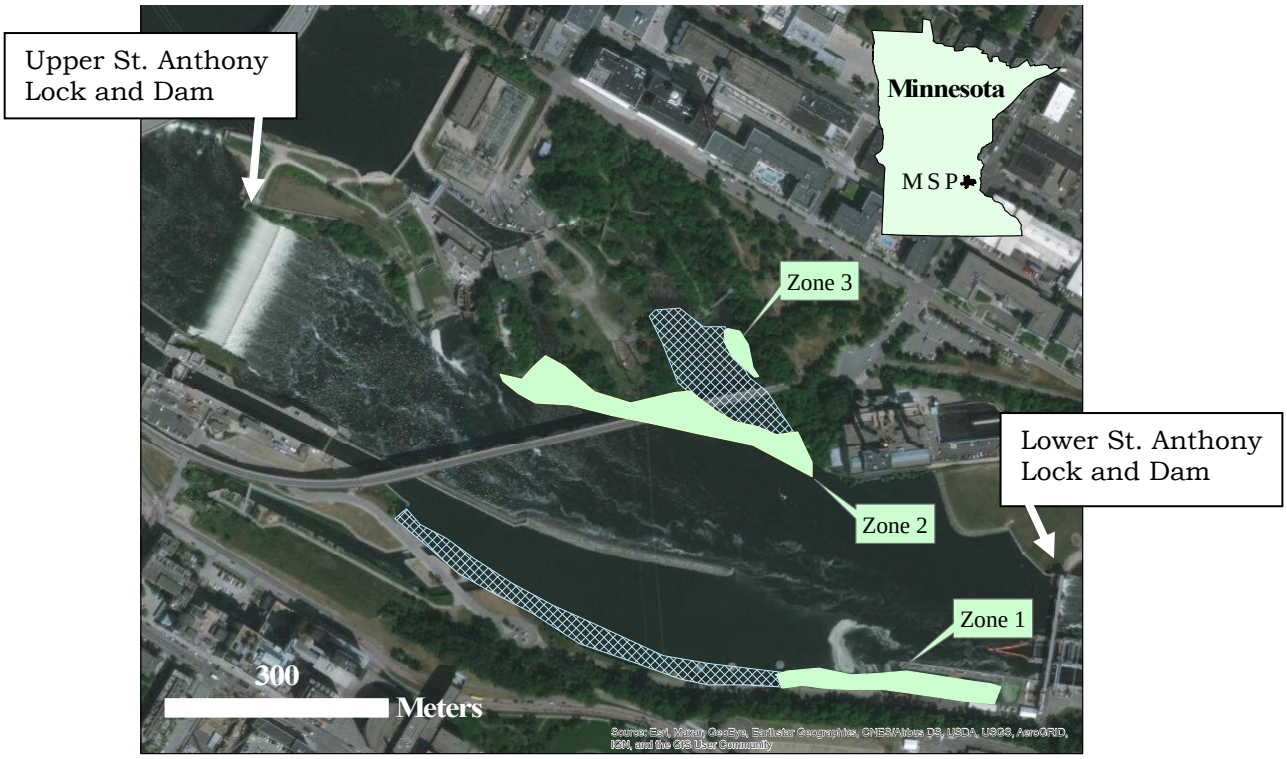

Figure 1. Map of the rescue area just below St. Anthony Falls on the Mississippi River in Minneapolis-St. Paul, Minnesota showing the locations of both dams. Solid areas indicate where timed sampling took place and hatched area indicate where only qualitative sampling occurred.

A scheduled inspection of the locks and dams at St. Anthony Falls called for the pool level between them to lowered by 12 feet (3.7 m), and in the potential for many mussels in the area to be exposed (Figure 2). On October 6, 2020, the U.S. Army Corps of Engineers, U.S. National Park Service, University of Minnesota, Minnesota Department of Natural Resources, and Macalester College came together to rescue as many mussels as possible during the low water event. Individuals walked and waded along the east and west shores of the river between the Upper and Lower St. Anthony Falls dams (Figure 1). Some groups just collected mussels (<300) keeping note of the species found, while one group tracked the number of each mussel species found and the sampling time.

Figure 2. Views of the water drawdown on the Mississippi River between the St. Anthony dams. The left image shows Minneapolis and the Upper St. Anthony Falls Lock; the right image shows the reach under the Stone Arch Bridge.

Both mussels and some fish were found stranded during the drawdown (Figure 3). All told, live representatives of 18 mussel species and a dead shell of another unionid mussel were found (Table 1), along with a few live Zebra Mussels, some fingernail clams, and numerous dead shells of *Corbicula* sp.

Figure 1. Mussel moving after *the* water *was* drawn down (left panel) and a fresh dead Johnny Darter that, apparently, had sought refuge in a pair of empty *mussel* shells.

Table 1. List of mussel species found between the St. Anthony dams on the Mississippi River during 2001 and this study (2020).

Species[1]	Common Name	Status in 2001	Status in 2020
Amblema plicata	Threeridge	L	L
Fusconaia flava	Wabash pigtoe		L
Cyclonaias nodulata[T]	Wartyback		L
Cyclonaias pustulosa	Pimpleback		L
Lampsilis cardium	Plain Pocketbook	L	L
Lampsilis siliquoidea	Fatmucket		L
Lasmigona complanata	White Heelsplitter	D	L
Leptodea fragilis	Fragile Papershell	D	L
Ligumia recta[SC]	Black Sandshell		L
Obliquaria reflexa	Threehorn Wartyback	L	L
Potamilus alatus	Pink Heelsplitter	D	L
Potamilus ohiensis	Pink Papershell		L
Pyganodon grandis	Giant Floater	L	L
Quadrula quadrula	Mapleleaf	D	L
Strophitus undulatus	Creeper		L
Toxolasma parvum	Lilliput		L
Truncilla donaciformis[T]	Fawnsfoot		D
Truncilla truncata	Deertoe	D	L
Utterbackia imbecillis	Paper Pondshell		L

[1] Nomenclature from Williams et al. 2017; [SC] Minnesota Special Concern Species; [T] Minnesota Threatened Species; Status Codes: L - found alive, D - only empty shells found

This section of the river appears to support fewer species than reaches both above and below these two locks and dams. Not only does this short reach of the Mississippi River support fewer species than upstream or downstream reaches, it also appears to support fewer individual mussels. For the group that tracked the number of individuals collected and sampling time, the catch per unit effort (CPUE) averaged 20.6 mussels/hour (Table 2), although there was a large range of values depending on the sample site (6.6-63.3 mussels/hour). [For comparison, the CPUE for this part of the river sampled in 2001 -- during normal pool level and flows -- was four mussels/hour (Site 40 - Kelner and Davis, 2002).] Additionally, a wide range of mussel habitats was observed along the left descending bank of the main channel; high-quality habitat and diverse, abundant mussel assemblages were uncommon along that bank. In 2017, overall CPUE in the pool above the Upper St. Anthony Falls Lock and Dam was 40.5 mussels/hour while below the lower St. Anthony Falls Lock and Dam the CPUE was 40.2 mussels/hr. In general, the CPUE in the section of the river between the dams was, on average, lower than reaches both above and below these dams.

Table 2. Numbers of live mussels found during times searches between the St. Anthony dams during this recovery effort. Zone locations are shown on Figure 1.

Species	Zone 1	Zone 2	Zone 3
Amblema plicata	14	6	-
Cyclonaias pustulosa	1	-	-
Fusconaia flava	3	-	-
Lampsilis cardium	-	5	3
Lampsilis siliquoidea	-	4	8
Lasmigona complanata	1	-	-
Leptodea fragilis	10	13	27
Obliquaria reflexa	8	2	-
Potamilus alatus	12	14	23
Pyganodon grandis	47	4	13
Quadrula quadrula	7	1	2
Toxolasma parvum	2	4	-
Truncilla donaciformis[T]	-	D	-
Truncilla truncata	-	3	-
Utterbackia imbecillis	2	3	-
Total number of mussels found	119	62	76
Total time spent searching (person-hours)	2	9.3	1.2
Catch per unit effort (mussels/hour)	59.5	6.7	63.3

[T] Minnesota Threatened Species

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Assessing Potential Host Fishes for Two Freshwater Mussels (Unionidae), *Obliquaria reflexa* and *Fusconaia flava*

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Unionid mussels are a global bivalve clade with many species endemic to North America (Graf and Cummings 2007) and are likely the most endangered group of animals living in the United States (Master et al. 2000). There is a large diversity of freshwater mussel species, and their former abundance underscores their ecological importance (Strayer et al. 2004).

Understanding bivalve life cycles is crucial for conservation efforts. Although adult unionids are suspension feeders, the larval glochidium stage of most species attaches to a fish and metamorphoses on that host. Incomplete understanding of many host fish relationships has complicated conservation efforts (Freshwater Mollusk Conservation Society 2016, Williams et al. 2008). *Obliquaria reflexa* and *Fusconaia flava* are relatively common freshwater mussel across the U.S. Midwest but have been listed for protection in certain states. Although some host fish associations have been identified for these two species, many possible host fishes remain unstudied or require more thorough testing.

Host suitability trials are an important process for assessing which fish species may serve as potential hosts. The methods used in this study were similar to those described by Hove et al. (2016). Fishes were collected via seining and other collection methods from varied sites in Minnesota, mainly in the Mississippi and St. Croix river watersheds. Collected fishes underwent a holding period of one month to ensure that any glochidia attached before their capture had released. Mussels were collected by hand in the Mississippi and Saint Croix rivers; gravid *O. reflexa* and *F. flava* individuals were identified in the field

and kept in aquaria to release glochidia. Fishes were inoculated in a glochidia bath and moved to species-specific aquaria held at 21-22 °C. Outflow from those aquaria was collected in individual sieves and those sieves were checked twice each week. The glochidia or juveniles found in the sieves were identified and counted via dissecting microscope. Juvenile mussels were identified by their foot movement or repeated valve closure. Fish species that released one or more juveniles were considered suitable hosts for that mussel species.

The results of these tests expand our understanding of host relationships for *Fusconaia flava* (Table 1). Several host species have been reported for *F. flava* in previous studies. This species has been shown to naturally infest cyprinids, ictalurids, and centrarchids, although metamorphosis of the glochidia was only observed on cyprinids (Surber 1913, Wilson 1916, Coker et al. 1921, Boyer et al. 2011, Hove et al. 2016, Benedict et al. 2019). Laboratory trials have shown that *F. flava* will metamorphose on some cyprinids, fundulids, and a gasterosteid species (O'Dee and Watters 2000, Donna et al. 2019). This study adds seven cyprinids (*Chrosomus eos, Macrhybopsis storeriana, Nocomis biguttatus, Notropis atherinoides, Notropis hudsonius, Rhinichthys cataractae,* and *Rhinichthys obtusus*) and one gasterosteid (*Culaea inconstans*) to the list of potential host species for *F. flava* (Table 1).

Table 1. Fish host suitability results for *Fusconaia flava*.

Fish species	Number of inoculated fish	Number of surviving fish	Days until glochidia or juveniles released	Number of juveniles recovered
Carassius auratus	11	11	2	0
Chrosomus eos	4	4	8-16	30
Macrhybopsis storeriana	5	5	11-19	98
Nocomis biguttatus	3	3	9-16	92
Notropis atherinoides	7	7	11-20	124
Notropis hudsonius	2	1	13-24	46
Pimephales vigilax	5	3	12	0
Rhinichthys cataractae	1	1	12-20	70
Rhinichthys obtusus	3	3	8-19	450
Catostomus commersonii	1	1	7	0
Moxostoma macrolepidotum	1	1	2	0
Ameiurus natalis	5	5	2	0
Ictalurus punctatus	1	1	2	0
Noturus gyrinus	2	2	2	0
Culaea inconstans	28	28	3	3
Lepomis macrochirus	9	9	3	0
Etheostoma caeruleum	8	7	2	0
Etheostoma nigrum	6	6	6	0

The results of these tests did not identify any fish hosts for *Obliquaria reflexa* (Table 2), as no juveniles were recovered from any of the fish species tested. Results from previous studies indicate that species from two fish families may be hosts for *O. reflexa*. Early studies reported *O. reflexa* naturally infesting *Alosa chrysochloris* but no glochidia metamorphosis was reported (Wilson 1916, Coker et al. 1921). Additionally, three cyprinid species have previously been shown to facilitate *O. reflexa* glochidia metamorphosis in the laboratory (Watters et al. 1998). None of the cyprinids we tested were observed to release juveniles, which may be due to the very low production reported for this fish family (Watters et al. 1998), making juvenile detection difficult.

Table 2. Fish host suitability results for *Obliquaria reflexa*.

Fish species	Trial Number	Number of inoculated fish	Number of surviving fish	Days until glochidia released	Number of juveniles recovered
Carassius auratus	1	5	5	3	0
Cyprinella spiloptera	1	6	6	3	0
Nocomis biguttatus	1	3	3	3	0
Notropis hudsonius	1	6	6	2	0
Pimephales notatus	1	9	9	2	0
Pimephales promelas	1	11	11	2	0
Rhinichthys cataractae	1	2	2	2	0
Rhinichthys obtusus	1	11	11	2	0
Catostomus commersonii	1	1	1	2	0
Moxostoma macrolepidotum	1	1	1	2	0
Ameiurus natalis	1	6	6	3	0
Ictalurus punctatus	1	1	1	3	0
Noturus gyrinus	1	2	2	3	0
Umbra limi	1 2	1 1	1 1	2 2	0 0
Fundulus diaphanus	1 2	6 5	6 5	3 2	0 0
Culaea inconstans	1	6	1	2	0
Lepomis macrochirus	1	6	6	3	0
Etheostoma caeruleum	1	5	5	3	0
Percina caprodes	1	6	6	3	0
Percina maculata	1	4	4	2	0

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More and More Exotic Species are Turning Up in the Aquatic Habitats of the Nature Reserve 'The Famberhorst', Joure, Friesland

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'The Famberhorst' in Joure, municipality the Frysian Lakes (Fryske Marren), Friesland, the Netherlands, is a small private Nature Reserve, owned by the Bergsma family. It has roughly the form of a triangle, covers an area of about 7,5 acres, and is almost completely surrounded by ditches. The ditch along the western highest side of the reserve: the Jonkersloot is the most important one (Figure 1). From that broad ditch, a short narrow side arm enters the Famberhorst and, by means of a lever, water is released into the reserve during dry periods in order to maintain a minimum water level in the other ditches surrounding the area (Figure 2). In the center of the reserve, five lower areas receive seepage and are densely covered by aquatic plants (Figure 3). Unfortunately, these areas are prone to dry out during long spells of extremely dry and hot weather.

Figure 1. The Jonkersloot.

Figure 2. Inlet of water in the Famberhorst.

Figure 3. One of the central pools.

Although the reserve is closed to the public, the author has received special permission from the owner, Mr. Dominicus Johannes Bergsma, to carry out fieldwork in the Famberhorst each time when he happens to be in the Netherlands. So far 72 species of terrestrial and aquatic molluscs have been encountered since autumn 2017 (Mienis, 2019; 2020a). The aquatic molluscs were represented by 27 species of gastropods and 15 species of bivalves.

In both the autumn of 2017 and 2018, the first six exotic freshwater species were registered for the Famberhorst: the gastropods *Potamopyrgus antipodarum*, *Physella acuta* and *Ferrissia californica* [this name has precedence over *Ferrissia fragilis*], and the bivalves *Musculium transversum*, *Dreissena bugensis* and *Dreissena polymorpha.* In 2018, the exotic Spiny-cheek crayfish *Orconectes limosus* also was caught in the outlet of the narrow side arm in the reserve (Mienis, 2018).

Figure 4. *Corbicula fluminea*.

In autumn 2019, the first specimens of *Corbicula fluminea* (Figure 4) were encountered in the Jonkersloot. Both large adult specimens and tiny juveniles were present, which indicated that the species had been living in that ditch for some time (Mienis, 2020a & 2020b).

On 16 September 2020, an exotic Pond slider of the *Trachemys scripta* complex was seen basking in the sun (Figure 5) on a thick branch of a tree which had fallen in the ditch that forms the north-eastern boundary between the Famberhorst and Park Heremastate (Mienis, 2021a). Three weeks later, on 5 October 2020, an exotic Tubenose goby *Proterorhinus semilunaris* was caught in the narrow side arm of the Jonkersloot before the inlet in the reserve (Mienis, 2021b). This means that, within a period of four years, ten exotic freshwater species (seven molluscs and one representative each of the crustaceans, reptiles, and fishes) have been encountered in the area of the Famberhorst.

Figure 5. Pond slider *Trachemys scripta*.

These exotics, of which most are rather invasive, arrived in the Netherlands from at least four different geographic areas:

1. Eastern Europe: *Dreissena bugensis*, *Dreissena polymorpha* and *Proterorhinus semilunaris*;
2. North America: *Physella acuta*, *Ferrissia californica*, *Musculium transversum*, *Orconectes limosus* and *Trachemys scripta*;
3. East Asia: *Corbicula fluminea*;
4. New Zealand: *Potamopyrgus antipodarum.*

Some of these species have been in the Netherlands for quite some time, like *Physella acuta*, *Dreissena polymorpha* and *Potamopyrgus antipodarum*, while others are relatively newcomers. The aquarium trade is without doubt responsible for the import of some of the exotics (*Orconectes limosus* and *Trachemys scripta*), while some of the others managed to arrive in the Netherlands when the drainage systems of two major European rivers, the Danube and the Rhine, were connected with each other by means of the Danube-Main Canal in 1992.

The finds of nine exotic species in the waters of the Famberhorst may be explained by the function of the Jonkersloot in the water regime of the reserve. The Jonkersloot is connected by a complex of canals with the well-known Frisian Lakes and, farther away, with the Ijsselmeer, a lake that forms an important part of the Rhine delta in the Netherlands. Any foreign species which manages to the settle in the Rhine delta may expected to arrive sooner or later also in the waters of Friesland.

Only the Pond slider *Trachemys scripta* was probably directly dropped by its owner in one of the ditches surrounding the Famberhorst. Additional fieldwork may show that we are already dealing with an integral part of a general globalization process of the Frysian aquatic fauna in the Famberhorst.

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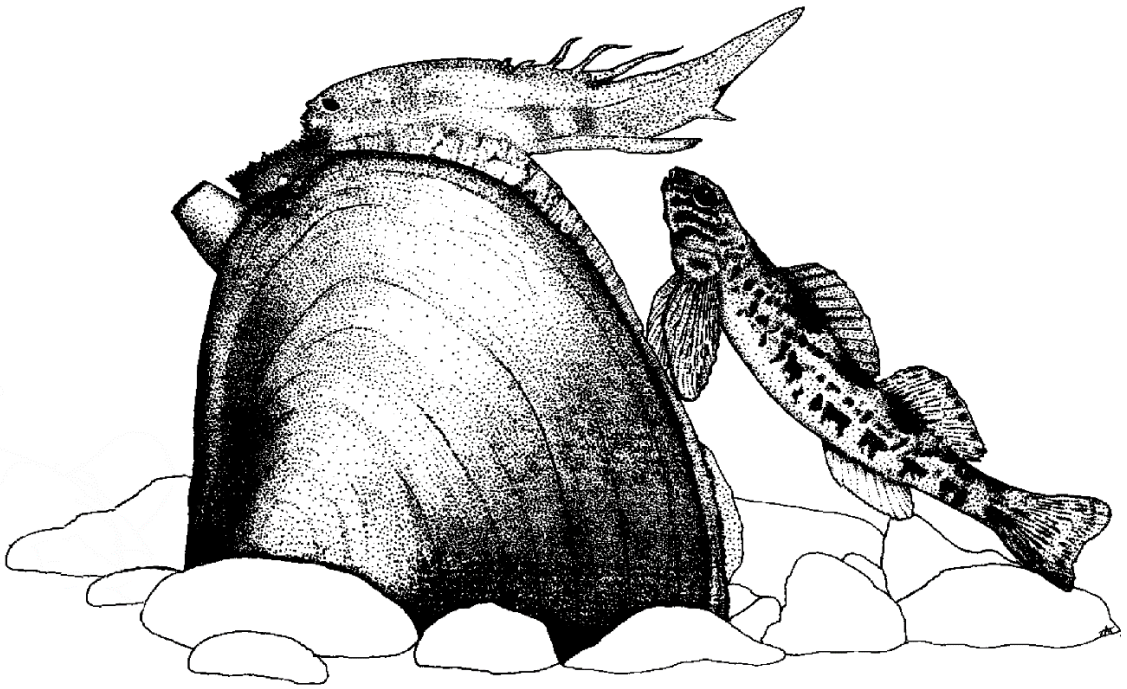

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Articles contributed to *Ellipsaria* should be preliminary or initial observations of note (e.g., natural history observations, meaningful new distribution records, interesting finds, etc.) concerning freshwater mollusks, their habitats, and/or their conservation. Articles that include quantitative analyses, draw conclusions based on analyses, or propose taxonomic revisions should not be submitted to *Ellipsaria* and, instead, should be submitted to a peer-reviewed journal such as FMBC. Please limit the length of contributed articles to about one page of text (i.e., excluding pertinent tables, figures, and references).

Information for possible inclusion in *Ellipsaria* should be submitted via e-mail to the editor, John Jenkinson, at jjjenkinson@hotmail.com. Contributions may be submitted at any time but are due by the 15th of the month before each issue is posted. MSWord is optimal for text, but the editor may be able to convert other formats. Graphics should be in a form that can be manipulated using PhotoShop. Note that submissions are not peer-reviewed but are checked for clarity and appropriateness for this freshwater mollusk newsletter. Feel free to contact the editor with questions about possible submissions or transmission concerns.

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Parting Shot

Even during the COVID-19 pandemic, students from the Atkinson laboratory at the University of Alabama were able to get out during summer 2020 to measure mussel excretion rates, but with many regulations in place. These friendly cows at the Cahaba River were very interested in learning about the role mussels play in nutrient cycling! Photograph by Irene Sanchez Gonzales, submitted by Garrett Hooper, Department of Biological Sciences, University of Alabama.

If you would like to contribute a freshwater mollusk-related image for use as a **Parting Shot** in *Ellipsaria*, e-mail the picture, informative caption, and photo credit to jjjenkinson@hotmail.com.