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Acute Toxicity of the Lampricides TFM and Niclosamide to Three Species of Unionid Mussels

By Michael A. Boogaard

The sea lamprey (*Petromyzon marinus*), a jawless parasitic eel-like fish native to the Atlantic Ocean (fig. 1), was accidentally introduced into the Great Lakes in the early 20th century through the construction of shipping canals. A member of the Petromyzonidae family, the primitive parasite has been identified as a major cause of the collapse of the Great Lakes fishery in the 1940s and 1950s. The lampricides 3–trifluoromethyl–4–nitrophenol (TFM) and 2'5–dichloro–4'–nitrosalicylanilide (niclosamide) have been used to control larval sea lampreys in tributaries of the Great Lakes since the early 1960s. The lampricide TFM is the main compound used to keep sea lamprey populations in check while niclosamide is used primarily in combination with TFM as a cost-saving measure. The addition of niclosamide at a ratio of 1% to TFM will reduce the amount of TFM required for effective treatment by about 40%.

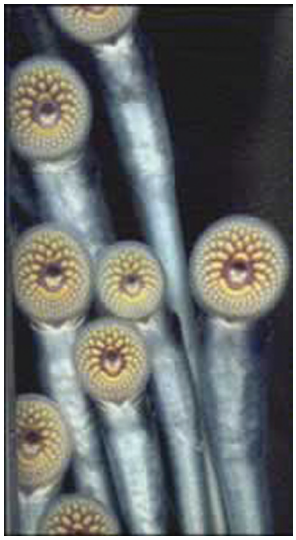

Figure 1. Sea lampreys (*Petromyzon marinus*). Note oral disk with concentric rows of teeth.

Concern has been expressed in recent years over the risk of lampricide applications to nontarget fauna. Of particular concern are several fish, mussel, amphibian, and other rare aquatic species listed as threatened, endangered, or of special concern by state and Federal agencies. As part of a long standing commitment to the Great Lakes Fishery Commission, Ann Arbor, Michigan, scientists at the Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, conduct toxicological risk assessments of the lampricides to nontarget species of interest.

Freshwater mussels are an important part of the aquatic community in many waters, often comprising a significant portion of the benthic biomass. In the past century, the diversity and abundance of freshwater mussels have dramatically declined. Freshwater mussels are now recognized as one of the most imperiled faunal groups in North America. Little information exists on the relative toxicity of the lampricides to unionid mussels. This Open-File Report highlights the results of acute toxicity tests conducted on three species of unionid mussels—giant floater (*Pyganodon grandis*), fragile papershell (*Leptodea fragilis*), and pink heelsplitter (*Potamilus alatus*; fig. 2)—exposed to TFM and a 99% TFM:1% niclosamide mixture.

Six laboratory exposures were conducted in a continuous-flow dilution system to assess the levels where mussels are sensitive to the lampricides (fig.3). Exposure duration was 12 hours and was designed to match the duration of a typical larval sea lamprey control treatment. Each exposure set consisted of nine exposure concentrations and one control with dilution water only with 10 mussels and 10 sea lampreys per concentration. Mussels were held for 2 weeks after exposure to assess delayed mortality resulting from the lampricides. Mortality of the three mussel species was compared to the observed sea lamprey minimum lethal concentration (MLC), defined as the lowest concentration resulting in 100% mortality among larval sea lampreys.

Table 1 represents acute toxicity results for the three unionid mussels compared to sea lamprey larvae after a 12-hour exposure to TFM. No mortality was observed among mussels at the observed MLC for sea lamprey of 2.6–

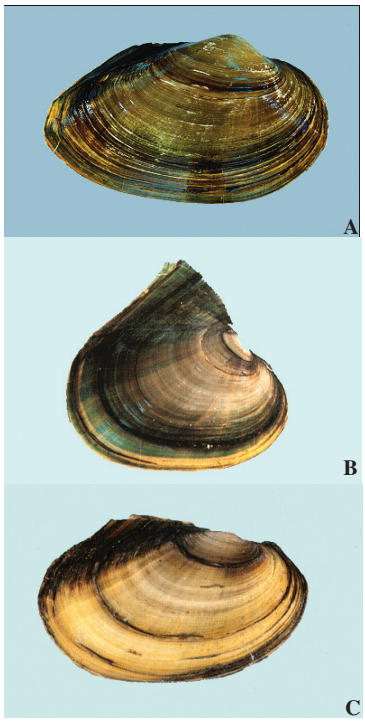

Figure 2. Three species of unionid mussels: (*A*) giant floater (*Pyganodon grandis*), (*B*) pink heelsplitter (*Potamilus alatus*), and (*C*) fragile papershell (*Leptodea fragilis*).

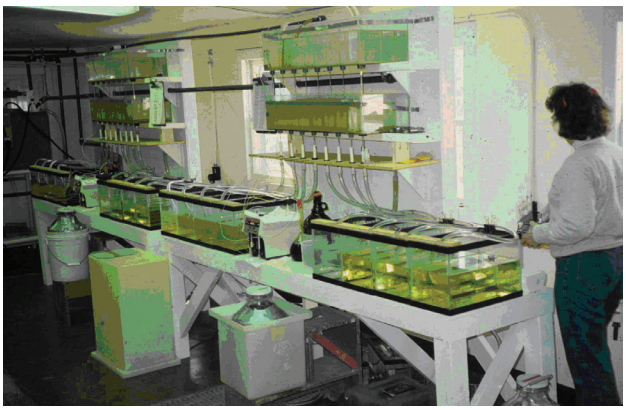

Figure 3. Photograph of the continuous-flow dilution system used to assess the toxicity of the lampricides on the three mussel species in relation to larval sea lampreys (*Petromyzon marinus*).

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Table 1. Acute toxicity (2-week post-exposure percent mortality) of 3–trifluoromethyl–4–nitrophenol (TFM) to the giant floater (*Pyganodon grandis*), fragile papershell (*Leptodea fragilis*), and pink heelsplitter (*Potamilus alatus*) exposed for 12 hours with direct comparison to larval sea lamprey (*Petromyzon marinus*).

TFM concentration (mg/L)	Percent mortality			
	Giant floater (n = 10)	Fragile papershell (n = 10)	Pink heelsplitter (n = 10)	Sea lamprey (n = 10)
6.3–6.3	60	–[a]	–[a]	100
4.9–5.1	30	30	–[a]	100
3.8–4.1	20	0	0	100
3.1–3.3	10	10	0	100
2.6–2.7	0	0	0	100
2.0–2.2	20	0	0	77
1.7–1.8	–[a]	0	0	20
1.4–1.4	–[a]	0	0	3
1.0–1.1	–[a]	–[a]	0	0
Exposure control	0	0	0	0

[a]Not exposed to these concentrations.

2.7 mg/L TFM. Occasionally, lampricide concentrations were applied at 1.5 × the MLC for sea lamprey larvae at selected points within the stream to compensate for attenuation of the chemical bank as it moves downstream. This level represents the highest lampricide concentration organisms would encounter during sea lamprey control operations. Mortality at 1.5 × (3.8–4.1 mg/L TFM) for the observed sea lamprey MLC was 20% for the giant floater and 0% for the fragile papershell and pink heelsplitter. Exposure of the mussels to the niclosamide mixture yielded slightly higher mortalities (Table 2). Mussel mortalities associated with the mixture were 10% for the giant floater and 0% for the fragile papershell and pink heelsplitter at the observed sea lamprey MLC (1.3–1.4 mg/L as TFM) and were 0% for the giant floater and 10% for the fragile papershell and pink heelsplitter at 1.5 × (2.0–2.1 mg/L as TFM) the observed sea lamprey MLC. However, 20% of giant floaters and fragile papershells were killed at 1.2 × MLC (1.6–1.7 mg/L as TFM).

Table 2. Acute toxicity (2-week post-exposure percent mortality) of a 99% 3–trifluoromethyl–4–nitrophenol (TFM):1% 2′5–dichloro–4′–nitrosalicylanilide (niclosamide) mixture to the giant floater (*Pyganodon grandis*), fragile papershell (*Leptodea fragilis*), and pink heelsplitter (*Potamilus alatus*) exposed for 12 hours with direct comparison to larval sea lamprey (*Petromyzon marinus*).

99% TFM:1% niclosamide concentration (mg/L as TFM)	Percent mortality			
	Giant floater (n = 10)	Fragile papershell (n = 10)	Pink heelsplitter (n = 10)	Sea lamprey (n = 10)
3.9–4.1	30	30	–[a]	100
3.0–3.3	50	20	60	100
2.4–2.6	40	20	40	100
2.0–2.1	0	10	10	100
1.6–1.7	20	20	0	100
1.3–1.4	10	0	0	100
1.0–1.1	–[a]	0	0	50
0.8–0.8	–[a]	–[a]	0	6.7
0.6–0.7	–[a]	–[a]	0	0
Exposure control	0	0	0	0

[a]Not exposed to these concentrations.

In the TFM exposures, mortality was minimal among the three unionid species at concentrations typically applied to streams to control sea lamprey larvae (1.0 –1.5 × sea lamprey MLC) and indicates control operations with TFM would have a negligible effect on populations of these unionid mussels. However, the slight increase in unionid mortality observed when exposed to the niclosamide mixture indicates mussels may be at risk when the mixture is used in control operations. Niclosamide was originally developed as a molluscicide to eliminate snails, the intermediate host of parasites causing schistosomiasis in humans. Therefore, it is not surprising that molluscs are more sensitive to this compound. Treatment managers should use caution when using the combination of TFM and niclosamide in streams with known mussel populations and every effort should be made to maintain lampricide concentrations at or near the MLC for sea lamprey to minimize the risk to this important faunal group.

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