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Inland Fisheries
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Ref: AFBI advice to DAERA regarding zebra mussels and the transfer of fish from Movanagher fish farm.

Dear [redacted]

Zebra mussels (*Dreissena polymorpha*) were first noted in Lough Neagh in 2005 at a single isolated site on the southern shore. Between 2005 and 2016 the spread of the mussels was slow, and by 2017 their abundance and distribution remained restricted to low numbers of adult mussels found at limited locations around the lake. In 2021 DAERA commissioned AFBI to undertake a scoping study for research on the effects of climate change on fish and fisheries of Lough Neagh (DAERA project ref: 19 04 10). This project re-assessed the status of invasive Lough Neagh zebra mussels. Subsequent surveys in 2022 highlighted an explosion of the zebra mussel population, significant numbers being observed at all areas sampled within the Lough.

In June 2023 during routine sampling undertaken through the eel work programme, AFBI staff noted significant numbers of large adult zebra mussels attached to structures at the Toome weir. This observation triggered downstream surveying for zebra mussels during concurrent elver sampling in the lower Bann. Adult Zebra mussels were observed at the Portna canal pontoon and the floating pontoon and adjacent harbour wall at The Cutts, indicating expansion of the mussels' range along the Lower Bann corridor. Within 24hrs these findings were circulated amongst AFBI FAEB and DAERA Inland Fisheries departments.

Consequently, DAERA Inland Fisheries requested advice, with reference to risks associated with the DAERA operated trout farm at Movanagher. Specifically, AFBI were asked to provide advice in relation to the risk and prevention of the spread of zebra mussels to other waters within the Public Angling Estate (PAE) through stocking events.

Whilst zebra mussel presence within a fish farm facility can cause issues with obstructed pipes, reduced oxygen levels and water chemistry changes in the holding tanks, the largest threat posed is not to the farm itself but through the potential distribution of zebra mussel larvae to the lakes, rivers, and reservoirs into which the farm's fish are stocked (Waller *et al.* 1996[1] and Edwards *et al.* 2000[2]). This threat was recognized in the Zebra mussel management strategy for Northern Ireland 2004 – 2010 (Maguire and Sykes 2004[3]) which listed fisheries and aquaculture activities as one of the

[1] Waller, D. L., Fisher, S. W., and Dabrowska, H. 1996. Prevention of Zebra Mussel Infestation and Dispersal during Aquaculture Operations. The Progressive Fish Culturist, 58: 77-84.
[2] Edwards, W. J., Babcock-Jackson, L., and Culver, D. A. 2000. Prevention of the Spread of Zebra Mussels during Fish Hatchery and Aquaculture Activities. North American Journal of Aquaculture, 62: 229-236
[3] Maguire, C. M., and Sykes, L. M. 2004. Zebra Mussel Management Strategy for Northern Ireland 2004 – 2010. Pp50.

medium risk vectors for the spread of zebra mussels within Northern Ireland at the time.

We can identify several mechanisms for the potential spread of zebra mussels through stocking events from the fish farm at Movanagher;

1. Through adult zebra mussels or larvae within the transport tank holding water (Waller *et al.* 1996, Edwards *et al.* 2000, Maguire and Sykes 2004)
2. Through larvae on the bodies or gill arches of fish being transported (Pucherelli *et al.* 2014[4])
3. Through juvenile and/or adult zebra mussels ingested by fish surviving gut passage (Gatlin *et al.* 2013[5])
4. Through juvenile zebra mussels attached to the scales of fish being transported (Ricciardi and Hill 2023[6]).

In addition, several studies have investigated the use of chemical treatments to eliminate zebra mussel larvae from fish transport water whilst leaving the fish species being transported unharmed. Waller *et al.* (1996) recommend the use of chloride solutions and found that treatment with sodium chloride at 10,000 mg/L for a period of 24 hours was the only safe treatment trialed for all fish species tested whilst also resulting in 100% larval mortality. Edwards *et al.* (2000) determined that a treatment of formalin at a concentration of 100 mg/L for a period of 2 hours killed 100% of zebra mussel larvae, leaving juveniles of both brown trout and rainbow trout unharmed. However, zebra mussels are very adaptable and localized genetic variation could result in differential susceptibility to toxins (Edwards *et al.* 2000).

Both treatment methods outlined above were noted by Maguire and Sykes (2004) in the zebra mussel management strategy for Northern Ireland. However, they also noted that protocols should be followed to ensure that "stocking water is not taken from zebra mussel infested lakes".

Edwards *et al.* (2002[7]) undertook field tests on the chemical treatment protocols previously recommended by Edwards *et al.* (2000) for the eradication of zebra mussel larvae during fish stocking operations. They recommend treatment of 750 mg/L of Potassium chloride for 1 hour followed by a 2 hour exposure to 25 mg/L of formalin for the removal of Larvae. This procedure has since become the accepted American industry standard for elimination of both zebra and quagga mussel larvae (Pucherelli *et al.* 2014). However, Pucherelli *et al.* (2014) tested Edwards *et al.* protocol (2000, 2002) and determined that it was not 100% effective against quagga mussel (*Dreissena bugensis*) larvae. Whilst Pucherelli *et al*. (2014) found variations of the potassium chloride and formalin treatments described above to be successful they recommend testing the compatibility with the fish species of interest prior to implementation.

There is also the potential for the transfer of zebra mussel larvae to new habitat via fish mucus membranes, gills, and buccal cavities (Pucherelli *et al.* 2014). Pucherelli *et al.* (2014) determined that whilst not parasitic on fish, quagga mussel larvae can become attached to fishes' mucus membranes. Decontamination is possible by immersing fish in a raceway or tank filled with filtered or well (borehole) water for a period of 12 hours (Pucherelli *et al.* 2014). The use of decontaminated nets to

[4] Pucherelli, S. F., Portz, D. E., Bloom, K., Carmon, J., Brenimer, S., and Hosler, D. 2014 Quagga Mussel Contamination of Fish Haul Trucks by Fish and Development of Effective Potassium Chloride and Formalin Treatments. Journal of applied Aquaculture, 26: 132-148

[5] Gatlin, M. R., Shoup, D. E., and Long, J. M. 2013 Invasive zebra mussels (*Driessena polymorpha*) and Asian clams (*Corbicula fluminea*) survive gut passage or migratory fish secies: implications for dispersal. Biological Invasions 15: 1195-1200

[6] Ricciardi, A., and Hill, J. M. 2023 Passive transport of a zebra mussel attached to a freshwater fish: A novel *Dreissena* dispersal mechanism? Biological Invasions, 25: 2057-2060

[7] Edwards, W. J., Babcock-Jackson, L., and Culver, D. A. 2002. Field testing of Protocols to Prevent the Spread of Zebra Mussels *Dreissena polymorpha* during Fish Hatchery and Aquaculture Activities. Norther American Journal of Aquaculture 64: 220-223

transfer fish from the rinse water tank to the transportation tank significantly reduces the risk of transferring residual larvae within the rinse water (Pucherelli *et al*. 2014). Further reduction in the risk of transfer of larvae can be achieved if fish transport tanks are filled with a clean water source such as filtered or well/borehole water (Pucherelli *et al.* 2014).

Investigations by Gatlin *et al.* (2013) highlighted the potential for transfer of live juvenile or adult zebra mussels within the gut of translocated fish. In water temperatures between 10°C and 21.1°C, twelve percent of zebra mussels consumed by blue catfish survived gut passage. There is no evidence in the scientific literature of trout actively feeding on zebra mussels, however if they are present within the rearing tanks of the fish farm there is the potential for them to do so.

One further consideration for fish farm operators and managers is the potential for transfer of juvenile zebra mussels attached to the scales of the farmed fish. Whilst rare/unusual, the first incidence of this was noted in 2023 when a juvenile zebra mussel (5.9 mm in length) was observed byssally attached (i.e. via threads secreted by the mussel) to a lake chub collected in southeastern Quebec (Ricciardi and Hill 2023).

**Recommendations**

To date no genetic investigations have been undertaken to conclusively determine if the invasive mussels present within Lough Neagh are zebra mussels (*Dreissena polymorpha*) or closely related quagga mussels (*D. bugensis*). Therefore, consideration should be given to eradication methods which address both species.

The following bullet points outline the recommended processes for transferring fish from the DAERA fish farm at Movanagher to other rivers and lakes throughout Northern Ireland to minimise the risk of transfer of any zebra mussel life phase to external areas.

- Stocking water should **not** be taken from an area known to contain zebra mussels, such as the river Bann.
- Fish to be translocated should be held in a treatment tank containing potassium chloride at a concentration of 750 mg/L for 1 hour, followed by the addition of formalin at a concentration of 25 mg/L for a period of 2 hours (**as per the accepted industry standard within American fish farms**).
- Fish should be conveyed from the formalin treatment tank to a rinsing tank containing bore hole/well water and held for a period of at least 12 hours before being transferred to the transport tank (as recommended by Pucherelli *et al.* (2014)).
- Fish should only ever be transported in sterilised water or bore hole/well water.
- Fish should be transferred between tanks via disinfected nets.
- Fish should be visually inspected for the presence of juvenile zebra mussels on scales.
- Farm workers should routinely inspect all tanks and remove any juvenile and adult zebra mussels observed.

It should be noted that the treatments/procedures outlined above are based on recommendations from the scientific literature and not through field testing at the Movanagher fish farm. Whilst these procedures will significantly reduce the likelihood of zebra mussel transfer through fish stocking events, we cannot say with absolute certainty that 100% of all larvae, settled larvae or juveniles will be eradicated.

Yours Sincerely,

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