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Preventing Hitchhiking Nonindigenous Species in Live Shipments

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The live shipment of aquatic species is attracting regulatory and public attention because of the risk that nonindigenous species might be unintentionally transported and introduced to new locations where they could harm the environment, the economy, or human health. Nonindigenous species are those introduced from a foreign country or moved outside their natural ranges in the United States. It is difficult to predict whether a nonindigenous aquatic species could survive and reproduce in a new environment and, if it did, whether it would harm the environment (see SRAC publications 4303 and 4304). Some nonindigenous species have become established in new locations and a few of them have become problematic. However, popular perception has been influenced by news and regulatory agency reports, which often depict all nonindigenous fish, reptiles, crustaceans, molluscs and plants as destructive invaders. Unfortunately, the introduction of nonindigenous aquatic species into new locations is frequently linked to commercial aquaculture, because many aquatic species cultured in the United States are shipped live from farm to farm or to processors, wholesalers, retailers or final customers. These shipments may travel just a few miles in tank trucks or thousands of miles by international air freight. The frequency of these shipments may vary from daily truck deliveries to a regional fish processing plant, to 10,000 or more boxes of ornamental fish a week delivered to major cities throughout North America, Europe, and Asia. The methods and frequencies of these shipments raises questions about live species production and about the handling, grading, packing and transportation practices that may allow nonindigenous hitchhiking species to escape or be released in new places. The response by federal, state or local regulatory agencies has been to impose species prohibitions, culture regulations, and permit requirements that add to production costs.

Figure 1. Koi farmers visually examine young koi to eliminate nonindigenous species as well as unsalable fish.

Adopting common-sense, practical procedures at the farm to prevent unintended hitchhikers will accomplish the following:

- Decrease the possibility of live animal and plant shipments containing nonindigenous species
- Reduce the risk of federal or state regulatory actions
- Improve the public's perception of aquaculture
- Reduce shipping costs and make buyers happy by shipping only the species promised

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- Reduce the effort required for post-delivery handling and inspection by the recipient

Aquaculturists are strongly encouraged to adopt the harvesting, handling, packing and shipping practices described in this publication to reduce the risk of hitchhikers. This is not only a productivity and perception issue, but also one with legal implications. At the end of this publication there are Web addresses for additional information concerning species subject to federal prohibition, restriction or permitting by the U.S. Fish and Wildlife Service and the U.S. Department of Agriculture. It is also important to know and follow pertinent state regulations concerning the possession and transport of organisms in both the shipping and receiving state.

Figure 2. Hitchhiking species are eliminated during the hand grading of swordtails for color and sex.

Hazard Analysis Critical Control Point

A management tool for preventing or eliminating hitchhikers that has been adopted by bait fishers and fish farmers in Michigan and Minnesota, as well as federal and state fish hatchery managers throughout the U.S., is Hazard Analysis Critical Control Point (HACCP). With this system, a producer examines each step of the production process—harvesting, handling, packaging and shipping—and identifies the hazards and the critical controls needed to prevent or eliminate the hazards. A plan is then developed to implement the controls. The U.S. Fish and Wildlife Service and University of Texas–Arlington Web site (*http://www.haccp-nrm.org/*) includes a free HACCP Planning Wizard. This step-by-step, interactive guide yields an aquatic invasive species HACCP plan and record-keeping forms. HACCP is particularly suited to public sector hatcheries and larger corporations. HACCP can be a useful risk management tool for identifying where contamination or escape might occur and for developing procedures to reduce this risk. Formal HACCP plans and procedures typically mandate record-keeping requirements that would be costly for family farms. However, many small-scale producers find that it is useful. A criticism of HACCP is that it is based on record-keeping, which may lack credibility unless a third-party verifies a farm's HACCP plan, employee training and records.

Live hauling fish

Shipping live fish by truck can potentially spread diseases and transfer unwanted plants and animals. Certain species are prohibited in some states and the unintentional transport of prohibited species is against the law. Public agencies that purchase live fish are now specifying that shipments must be free of specific species. To avoid these environmental, legal and marketing problems, the culture, harvesting, holding, grading and loading of fish must be done very carefully.

Prevention

Every farm should have a biosecurity plan (see SRAC publication 4703) and conduct regular inspections for diseases and nuisance species. One important biosecurity measure is to wash and disinfect hauling trucks and tanks before returning to the farm. When ponds are inspected regularly, unwanted plants or fish can be detected in the early stages of an invasion while it is still relatively easy to eradicate them. A good guideline for fish farmers who ship live fish is the Arkansas Official Standards for the Certification of Commercial Bait and Ornamental Fish (Arkansas State Plant Board, 2007). To participate in this program, farmers must follow a biosecurity plan; pay for a comprehensive, twice-yearly farm-level disease inspection program; and allow state inspectors to review fish health records and check vats and pond facilities for specific nonindigenous species. Keeping diseases and problem species off the farm is the first step in keeping them from hitchhiking along with fish shipments.

Harvesting

Most problems with hitchhiking species occur when fish are harvested and loaded directly onto a hauling truck without passing through holding vats. Often a farmer first becomes aware of an unwanted species during harvest. For example, shad may show up in the seine along with catfish. If the catfish are bound for a nearby processing plant, this is probably not a concern. But if the catfish are live-hauled to stock a fishing lake, the shad would be a very unwelcome addition. It is essential for the farmer and the live hauler to inspect the fish in the net before loading. Unwanted fish will need to be carefully hand-sorted by the seine crew, a difficult task on commercial farms where thousands of pounds of fish are harvested at a time. Assign specific employees the responsibility to watch for

Figure 3. Aquarium plants are visually examined for plant pests, clipped and rubber banded at the culture vat.

and remove unwanted species. The employee who empties the loading net into the hauling tank should also inspect each load to make sure that it is free of unwanted species. Depending on the intended market, it may be necessary to take the load to a holding shed first and sort through the fish to remove the unwanted species, although this is not practical or possible in many cases.

Holding, grading and sorting

Some fish crops, such as baitfish, are routinely taken to holding sheds for purging, acclimation and grading. Once fish are in holding vats, they are easy to inspect for unwanted species. Plant fragments and some unwanted animals can be hand-picked. Grading removes unwanted organisms that are smaller or larger than fish of the desired species. A strong flow of water sometimes sweeps unwanted species to the end of a vat for easy removal. Some tadpole species congregate in corners at the bottom of the vat and can be siphoned out with a hose.

Treatments

Fish producers who use surface water that might contain zebra (*Dreissena polymorpha*) or quagga (*Dreissena rostriformis bugensis*) mussels (hereafter, dreissenid mussels) are in danger of shipping mussel larvae (veligers) along with their fish. If fish are held in vats flushed with well water before shipment, the chance of including dreissenid mussel veligers in fish shipments is reduced but not eliminated. A treatment protocol (Edwards et al., 2002) consisting of a 1-hour treatment with 750 mg/L of potassium chloride (KCl) followed by a 2-hour treatment of formalin at 25 mg/L effectively killed all of the veligers but not the fish species tested (walleye, *Sander vitreus,* and saugeye, *Sander canadensis*). Adding 0.5% salt (NaCl) to reduce fish stress reduced the effectiveness of the treatment and left veligers alive, so this treatment is likely to be ineffective on farms with naturally salty water. Before using this treatment for other fish species and temperatures, contact your Extension fisheries specialist or another fish health professional. It is essential to conduct preliminary trials with small numbers of the cultured fish species to make sure the treatment will not harm them.

Two studies have shown that standard formalin treatments will also selectively kill tadpoles, although the efficacy varies with the species of frog. Treatment of largemouth bass (*Micropterus salmoides*) fingerlings with 60 ppm of formalin for 24 hours killed all of the tadpoles but not the bass. A 1-hour exposure to 250 ppm of formalin also killed all of the tadpoles. This is similar to the disease treatments used for some fish species. Formalin toxicity varies with fish species, temperature and pH (Helms, 1967; Carmichael and Tomasso, 1983).

Shipping

Exchanging water in hauling tanks is often necessary during extended trips. Water exchange on long trips should be from groundwater sources only. Do not add water from any surface source because it might transmit a disease or contain unwanted organisms. Using well water for exchange may be problematic during times of the year when well water temperatures are very different from the temperature of water in the hauling tanks. See SRAC publication 392 for live haul water quality management recommendations.

Turnbacks

What happens if you ship a load of fish to a buyer and you are not able to sell the fish? Maybe the buyer changed his mind, the quality was poor, or the check bounced. If any of your fish have touched someone else's facilities, or even if the customer just stuck a dip net into a hole of your tank to look at the fish, then the returned fish must not be mingled with the rest of the fish on your farm (see SRAC publication 4703).

Shellfish

Shellfish aquaculture in the U.S. typically has three phases of production: hatchery (holding and spawning mature broodstock to produce larvae), nursery (nurturing larvae to plantable seed), and growout (culturing seed in a protected environment to yield marketable shellfish). While shellfish aquaculture is similar throughout the U.S., each region has its own environmental conditions, industry practices, and regulatory oversight.

Prevention

There may be a number of unwanted species in plantable size shellfish seed in a nursery, including crustaceans (e.g., crabs), gastropods (e.g., whelks and moon snails),

and echinoderms (e.g., starfish). The tiny larvae or juveniles of these species might be concealed in seed from a hatchery; however, they will grow larger in the nursery system and can be detected and removed when finally visible to the eye. Growers should carefully inspect all seed shipments and remove undesirable species, paying particular attention during grading or washing activities.

Figure 4. Pressure-washing live haul trucks, inside and out, will eliminate hitchhiking animal and plant species.

The examination of market-ready shellfish may reveal hitchhiking indigenous or nonindigenous species that could make the shipment unacceptable for receipt in other states. For example, several species of nonindigenous tunicates and crabs have been increasing in range, including European green (*Carcinus maenas*) and Chinese mitten (*Eriocheir sinensis*) crabs. A non-native tunicate (*Didemnum vexillum*) has fouled mussel gear in the Atlantic waters of Canada. Some species have been found on large swaths of the substrate on Georges Bank off Massachusetts and New England tidal lagoons and estuaries (Morris et al., 2009). A second non-native tunicate, *Styela clava,* is affecting oyster culture in Rhode Island (Karney and Rhee, 2009). Native tunicates are common on shellfish gear in the mid-Atlantic, with *Molgula manhattensis* being predominant. The risk of their spreading to other regions via shellfish can be reduced if they are removed by hand before shipping. Fortunately, these soft-bodied invertebrates are easily seen once they grow to about ¼-inch, and they can be picked out of a shipment. Flushing shellfish with freshwater produces osmotic pressure changes in these soft-bodied animals, causing them to die. If tunicates are present in the area, it is a good idea to be alert for them and wash the seed in freshwater.

State regulations may allow only native or naturalized species to be cultured. Check with the state regulatory agency and be alert for regulations that prohibit the movement of live shellfish from one water body to another. Such requirements have been implemented to reduce the risk of spreading pests and they have been effective.

Ornamental fish and invertebrates

Aquaculture producers raise and ship hundreds of species and varieties of ornamental freshwater and marine fish and invertebrates. Most are freshwater fish, including tropical species (e.g., angelfish, barbs, mollies, swords, and tetras) and several temperate species (e.g., goldfish, and koi). Marine species include colorful reef fish, corals, molluscs, and crustaceans. Ornamental species are shipped throughout the U.S. and the world to wholesalers, retailers and the public.

Given the large volume of the trade, numerous shippers and destinations, and the variety of species shipped, there is increasing regulatory interest in the potential for transporting hitchhiking species along with shipments of ornamental fish and invertebrates. However, careful attention throughout the process of preparing specimens for shipping, the method used for shipping, and inspection by the receiving customer can effectively reduce this risk. Producers should take steps to exclude plant material and debris, as well as snails, clams, insects, crayfish, tadpoles, turtles, wild fish or other undesirable species from holding tanks and shipping bags.

Culture

Most ornamental species are raised as monocultures in tanks or in ponds. This reduces handling stress for the cultured species during harvesting and grading, leading to a better product, and reduces labor costs for the producer. In a few instances, two ornamental fish species may be cultured together in ponds, typically with one species occupying the bottom and another swimming at the surface to facilitate selective harvest. It is also relatively common to maintain several species of ornamental, sessile marine invertebrates within the same culture system. Typically, other species within culture systems are undesirable and should be eliminated because they compete with cultured species for feed, reduce water quality because of increased biomass, prey upon cultured species, or serve as reservoirs for pathogens. These pest species (wild fish, tadpoles, turtles, crayfish or snails) seldom occur in culture tanks, but may be present in culture ponds or in tanks holding recent harvests from ponds.

Grading

Producers harvest ornamental fish from ponds with traps or seines and may conduct partial or complete harvests depending on the cultured species and customer orders. Grading is done in a holding or packing facility, though some producers also grade at the pond immediately after harvest. In tank culture, fish are netted from tanks and then graded. Fish are graded for size, color and perhaps sex. Undesirable individuals and other species are

Figure 5. Ornamental fish can be visually examined for health and the presence of nonindigenous species as they are being graded for size.

removed and discarded. Although mechanical graders are used to grade some species for size, most grading is done by hand. Ornamental species are sold by the individual rather than by weight, and because appearance (e.g., color, uniformity) is important to the customer, producers pay particular attention to grading. Proper hand grading is the primary method ornamental aquaculturists use to exclude unintended hitchhikers from shipments.

Packing

Ornamentals are held in tanks until they are packed for shipping. Individual fish and invertebrates are counted out to fill orders so there is another opportunity to remove any undesirable animals. Ornamental fish and many invertebrates are shipped in plastic bags containing clean water, shipping additives (e.g., salt), and oxygen gas. Some invertebrates are shipped "dry," with individuals wrapped in moist towels inside plastic bags. The bags are placed in a polystyrene box inside a cardboard box. Ornamental fish and invertebrates are shipped by truck and by air. There is little opportunity for hitchhiking species to contaminate shipments during the packing and shipping stages.

When shipping boxes reach their destination, customers unpack and inspect the contents to determine if their expectations of quality and quantity are met. During this inspection, culls of any sort (not only undesirable species, but also poor quality individuals of the species ordered) are noted. A large number of culls will lead to customer dissatisfaction.

Aquatic plants

Native and nonindigenous tropical, subtropical and temperate freshwater plants are cultured in the U.S. for aquariums, water gardening and wetland restoration. Aquarium and water gardening plants are produced outdoors in concrete tanks or plastic-lined wooden vats, or in greenhouses in tanks or on growing tables. The tanks are filled with a shallow layer of mulch covered with a sand layer. Hydroponic growing tables are used to produce potted plants that are floated in plastic foam sheets or plastic trays on several centimeters of fertilized water.

Plant production systems are closed (i.e., water does not flow through) to exclude non-target plant species and plant pests and to retain fertilizers to benefit growing plants. Tanks and vats are managed as clear water systems for the best light penetration to the growing plants and to facilitate inspection and harvest. Native predators can be stocked in tanks and vats as biological controls for both native and nonnative species. Snails may be used to clean tank and plant surfaces; freshwater copepods and *Daphnia* sp. will maintain water clarity; fry or fingerlings of native fish (e.g., sunfish or bass) will eliminate a variety of vertebrate and invertebrate species. Production systems should be inspected frequently to 1) remove weeds that compete for space, light and nutrients and 2) remove plant pests.

Harvesting

Aquarium and water gardening plants are harvested to order because they are perishable. They are shipped as clipped bunches (primarily floating plants) or bare root or potted plants (submerged or emerged plants). Bunches are bound with rubber bands or lead strips. Potting material for potted plants is spun glass contained in a ventilated, black plastic pot.

Shipping

For shipping, all plants are wrapped in folds of damp paper, placed in a plastic bag or wrapping, then placed in a heavily waxed shipping box or foam box, and finally in a cardboard box. Aquarium and water gardening plants are ordered and shipped by count and each plant should be visually inspected for size, health, appearance and cleanliness. They should be inspected again during packing to ensure the correct number and plant species is being shipped. Each shipping box may contain several species.

To be successful, aquatic plant producers must deliver clean, undamaged plants identified by common and taxonomic names, and accurate plant counts. Nonindigenous hitchhikers (e.g., live snails and unwanted plants) should be eliminated when plants are carefully inspected during culture, harvest and packing.

Marine shrimp and freshwater prawns

Marine shrimp and freshwater prawns are transported across state and international borders in various stages of development (post-larvae, juveniles and adults). During the hatchery stage, marine shrimp larvae are fed a combination of microalgae and *Artemia*. If larvae are transported during this stage, it will be difficult to elimi-

nate the microalgae present in the water. Larval shrimp can tolerate gentle handling and can be poured through an aquarium net or screen to separate them from the water containing microalgae. Then they can be rinsed and placed in water of similar quality to ensure that minimal microalgae are present during transport. Larvae are often transported in water containing algae, then separated from the water on the receiving end. The water should be treated with bleach before it is released down a drain. These practices will prevent the spread of microalgae species to regions where they may not be native.

Nursery

Marine shrimp and freshwater prawn broodstock and hatchery facilities exist worldwide. There are large marine shrimp companies with grow-out farms in various countries. Shrimp and prawns are transported in the post-larvae or juvenile stages across state and international borders. Broodstock are maintained in specific populations selected for traits such as growth rate and disease resistance. When post-larvae develop, they are packed in plastic bags within Styrofoam® boxes and shipped via air freight. Nursery stage shrimp and prawns are usually cultured in clear water (without phytoplankton) rather than green water (with phytoplankton). Clear water production reduces the likelihood of hitchhikers being present in the shipping water. However, even under clear water conditions the water may contain many microscopic organisms. The two most common are microalgae and motile ciliates; others are zooplanktonic organisms such as rotifers, copepods and protozoa (i.e., *Vorticella* spp.) and others.

To reduce the potential of transporting these microscopic organisms, separate the post-larvae from their culture water and rinse gently before packaging them in transport water of similar quality that is free of these organisms. When shipments of post-larval shrimp and prawns are received, it is common practice to suspend the bag within the culture tank and add water from the new culture system to acclimatize post-larvae to the new water quality. The entire contents of the bag, water and post-larvae and all organisms within the water, are then introduced to the culture tank. However, you should not introduce transport water into a grow-out culture tank because you may be adding motile ciliates, which can proliferate rapidly in this new environment. A better practice is to assume these organisms are present and separate post-larvae from the transport water with an aquarium net or a screen before stocking them into the culture tanks. The water separated from the shrimp should not be put down the drain. This water should be collected in another container and treated with bleach (at 20 mg/L) to kill all the microscopic organisms.

Marketing and growout

Shrimp and prawns cultured in ponds and raceway tanks are usually separated from water and placed on ice for transport to market or a processing facility. However, adult shrimp and prawns may be shipped in live-haul tanks for live sales or to transport broodstock between two sites. Styrofoam® shipping boxes may also be used to transport small numbers of adult broodstock. Hitchhiking organisms that may contaminate these shipments include all the microscopic organisms mentioned previously, as well as sessile epicommensal organisms (e.g., *Epistylis* spp.), which can colonize the carapaces of shrimp and prawns, diving beetles (29 families in the Suborder Heteroptera), which can be free swimming or found as eggs (e.g., waterboatman, Family Corixidae) attached to the carapace of freshwater prawns, and dreissenid mussel veligers. If shrimp and prawns have visible external organisms on their carapaces, they should not be transported. Transport water drained at the receiving site should be collected and treated with 20 mg/L bleach to eliminate potential hitchhikers.

Conclusion

The culture of aquatic species in the U.S. is a diverse agribusiness with a large variety of cultured species and production systems. This short paper does not address all the ways to prevent animals or plants from hitchhiking in live product shipments. Farmers who ship live products should consult with an Extension fisheries specialist for advice specific to their operations. Call your county Extension office to find the specialist nearest you, or visit the Aquaculture Network Information Center at *http://www.aquanic.org/.*

For more information

Federal Agency Web Sites

U.S. Department of Agriculture

Animal Health, Aquaculture Disease Information:
http://www.aphis.usda.gov/animal_health/animal_dis_spec/aquaculture/

Plant Protection and Quarantine:
http://www.aphis.usda.gov/plant_health/

National Invasive Species Information Center:
http://www.invasivespeciesinfo.gov/

U.S. Department of Commerce

National Oceanic and Atmospheric Administration, National Center for Research on Aquatic Invasive Species:
http://www.glerl.noaa.gov/res/Programs/ncrais/ncrais.html

National Sea Grant Program, Aquatic Invasive Species: *http://www.seagrant.noaa.gov/themesnpa/aquaticinvasivespecies.html*

Office of Oceanic and Atmospheric Research, Aquatic Invasive Species: *http://www.oar.noaa.gov/oceans/t_invasivespecies.html*

U.S. Department of the Interior

U.S. Fish and Wildlife Service

Aquatic Nuisance Species: *http://www.fws.gov/contaminants/ANS/ANSSpecies.cfm*

Import/Export Permits: *http://www.fws.gov/permits/ImportExport/ImportExport.shtml*

Injurious Wildlife: *http://www.fws.gov/contaminants/ANS/ANSInjurious.cfm*

Managing Natural Resource Pathways (HACCP): *http://www.haccp-nrm.org/*

U.S. Geological Survey

Invasive Species Program: *http://biology.usgs.gov/invasive/*

Nonindigenous Aquatic Species: *http://nas.er.usgs.gov/*

Smithsonian Environmental Research Center

Marine Invasions Research Lab: *http://www.serc.si.edu/labs/marine_invasions/index.aspx*

Recommended reading

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SRAC fact sheets are reviewed annually by the Publications, Videos and Computer Software Steering Committee. Fact sheets are revised as new knowledge becomes available. Fact sheets that have not been revised are considered to reflect the current state of knowledge.

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