HARVEST AND POST-HARVEST TECHNIQUES

Pakorn Unprasert, Ph.D.
Fisheries Technology Extension and Development Bureau,
Department of Fisheries, Thailand

Lectured by Bunchong Chumnongsittathum

INTRODUCTION

One of the most critical determinants of the success of fish hatchery is the problem of delivering a quality product to market destinations. Fish fingerlings are confined within plastic bags that are inflated with pure oxygen, closed with rubber bands, placed in an insulated corrugated box, and sealed. The size and shape of these bags and boxes as well as the insulation can vary widely. During transport, the water in these closed containers may become oxygen-depleted, and may accumulate excessive carbon dioxide and consequently undergo a reduction in pH. Metabolic activity may also lead to elevated ammonia levels in the water, which can be damaging to fish health, or become lethal in extreme cases. A densely-packed shipping container increases these risks but reduces the cost of transportation at competitive prices. The purpose of this paper is to address some of the critical handling and packing methods that are essential for insuring the successful transport of live tropical fish to their final market destination.

CARRYING CAPACITY

The maximum weight of fish that can be safely transported within a given period of time is the carrying capacity. The carrying capacity depends on the duration of haul, water temperature, fish size, and fish species. If water quality conditions such as temperature, oxygen, carbon dioxide, alkalinity, and ammonia are constant, then carrying capacity will depend on the fish species. In general, fewer kilograms of smaller fish can be transported per liter of water than larger fish. It is important that first time or experienced shippers handling a new species test-run a batch before undertaking a large shipment.

WATER QUALITY DURING SHIPPING

Fish health is affected by changes in water quality parameters while in the plastic bags during the transportation process. The parameters to be considered are temperature, dissolved oxygen, pH, carbon dioxide, ammonia, and the salt balance of the fish’s blood. The rate of change of each parameter is affected by the weight and size of fish to be transported and the duration of transport.

Temperature

Fish are cold-blooded, so the metabolic rate of fish is affected by the temperature of the environment. The metabolic rate of fish will double for each 18°F increase in temperature and be reduced by half for each 18°F decrease in temperature. A reduced metabolic rate will decrease the oxygen consumption, ammonia production, and carbon dioxide production. Temperature of 55° to 60°F is recommended. For species such as tilapia and red temperature: should be nearer to 60°F. Cold water fish, such as trout, inhabit colder water and should be transported at even colder temperatures, such as 45° to 50°F. To achieve the desired transport temperature, fish should be held in tanks of cool water. By holding the fish in tanks for two days, the water temperature can be gradually reduced by adding cool water. After loading the fish into bags, final decreases and maintenance of temperatures during transport can be accomplished by adding ice or (more commonly) gel packs. Ice or gel packs often are used during transport, especially over longer transport periods that might allow increases in temperature. One-half pound of ice will reduce the temperature of one gallon of water by about 10°F. Insulated Styrofoam shipping boxes also are used to prevent outside temperatures from affecting the temperature of transport water. In some instances, 20 to 40 quart coolers are used for transport.

Dissolved Oxygen

Oxygen requirements for live fish are related to: 1)body size; 2)ambient temperature; 3) nutritional state, and; 4)metabolic rate. Oxygen consumption increases with temperature, body size and activity level. Diurnal rhythms also affect oxygen demand. Handling and packing procedures should be designed to keep metabolic rates at a low level. The most important single factor in transporting fish is the adequate concentrations of dissolved oxygen (DO). The importance of supplying adequate levels of DO cannot be over emphasized. Failure to do is resulted in severe stress which may contribute to fish kill two to three days after transport. The amount of oxygen that can be dissolved in fresh water is based primarily on water temperature. The water is referred to as 100% saturated when the upper saturation level is reached. DO saturation is higher for cool water than for warm water. For example, at sea level DO saturation of 45°F water is 12.1 parts per million (ppm) but at 60°F saturation is 10.0 ppm. Because pure oxygen is used during bag transport, DO levels in the water will be saturated and the low oxygen levels usually will not be a problem unless the bag is improperly sealed or develops holes caused by the spines of large fish. It is important to have a 75 percent volume of oxygen in the bag to insure adequate diffusion of oxygen at the surface of the water.

pH

The quantity of hydrogen ions (H+) in the water will determine if it is acidic or basic. The scale for measuring the degree of acidity is called the pH scale, which ranges from 1 to 14. A value of 7 is considered neutral, neither acidic nor basic; values below 7 are considered acidic; above 7 basic. The acceptable range for fish growth is between pH 6.5 and 9.0. The pH of water will be influence by the alkalinity (buffering capacity) and the amount of free carbon dioxide. The pH of the transport water will also affect the toxicity of ammonia

Carbon Dioxide

As fish respire they produce carbon dioxide as a by-product. Carbon dioxide reacts with water to form a weak acid. This weak acid will in turn decrease the pH of the water. High levels of carbon dioxide (greater than 20 ppm) will interfere with the oxygen uptake in the fish's blood. High levels of carbon dioxide sometimes are found in well water. Excess carbon dioxide in well water can be reduced by mechanical aeration or by passing the water through a degassing column.

FISH TRANSPORTATION

Bags

Many of the domestic producers use square bottom bags. These bags utilize the surface area of the box more efficiently. Use of a pleated bag (flat bottom) is highly recommended. Pleated bags utilize the entire surface area of the box allowing maximum oxygen transfer through the surface of the water. They also reduce the effects of crowding by utilizing all of the available area in the box. If the bag is properly placed in the box, crowding in the corners by the fish is kept to a minimum. Boxes are generally packed in bag sizes of full to the corners by the fish are kept to a minimum. Boxes are generally packed in bag sizes of full to quarter. Full bags are those that utilize the entire box, half bags are packed two to a box, quarter bags four to a box. These bags have the following dimensions: full size, 37.5 cm (W) x 37.5 (L) x 55 cm (H), half size, 40 cm x 20 cm x 55 cm, and quarter bags at 40 cm x 10 cm x 55 cm. Square-bottom bags are available pleated and flat.

Boxes

There are many different styles and types of boxes routinely used in the ornamental fish industry. The most commonly used is molded by styrofoam. Ornamental fish packed from Asia frequently make use of one of two size boxes, 60 cm (L) x 42 cm (W) x 30 cm (H) or, 49 cm (L) x 38 cm (W) x 38 cm (H). The larger of these two types are packed with a minimum of four bags. Although there are many different sizes and shapes used for shipping ornamental fish.

Packing Procedures

A schematic diagram illustrating the typical processes involved in packing and shipping is presented in Figure 1. Before harvesting and packing it is important to have all required material available. Any chemicals needed for pond treatment of parasites should be on hand. Insure that there is adequate room in holding tanks to house the harvested fish as well as extra tanks for sorting by size and \ or sex. A comfortable sorting table in a clean, well-lit area. Suitable bags for packing should be in stock as well as the insulated styrofoam inserts and outer boxes, all other critical supplies to have include a full oxygen cylinder and regulator to inflate the bags, rubber bands to seal the bags, and tape to seal the boxes. If any of these items are missing, packing should not be attempted.

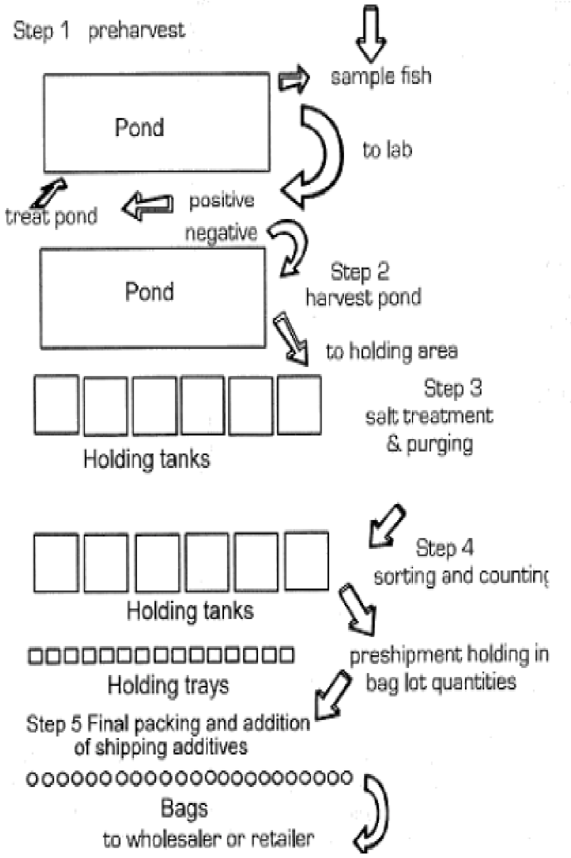

Figure 1. Flow-chart of fish packing steps and procedures.

Step 1. Pre-harvest Fish should be examined for parasites and diseases at least one week prior to harvesting. This allows sufficient lead time, should and treatments be necessary.

Step 2. Postharvest Fish brought into the holding tanks for sorting and sale should be checked again for parasites and diseases. Holding tanks should have adequate water and aeration. Iodine free salt (NaCl) can be added to the holding tank water at nine parts per thousand (9.0 ppt.). This provides an isotonic salt solution, which is effective in reducing stress and promoting a natural slime coating. This helps prevent opportunistic infection as a result of handling injuries.

Step 3. Feeding should be withheld for a minimum of two days and up to five days, depending on species. For example livebearers such as swordtails and monies require two days, whereas goldfish and carp require four days. The feces should be siphoned out of holding tanks once or twice a day to prevent the fish from eating feces. The absence of feces in the tank will indicate that fish have had an adequate purge time prior to sorting, counting and shipping.

Step 4. Fish are now sorted and counted into bag lot quantities and held in individual aquaria, trays or buckets. The pre-shipment containers should have adequate water and air flow. The water exchange rate in these containers should be a minimum of four times per day (4x/day). Ideally, the pre-shipment holding containers should have a standpipe or valves to allow the water to drain to the correct shipping volumes. The fish and water can then be poured directly into the shipping bag, which saves time and minimizes handling.

Step 5. Any shipping additives are placed into the bag at this time. The bag is purged of air and pure oxygen is injected into the bag below the waters surface. The bag is then sealed using rubber bands or one of the commercial grade sealers and placed in its box. Ice packs can be laced on after seal for best results. Avoid fish over chill. Do not allow the gel pack to touch the bag directly. Newspapers or other similar material can be used as a buffer between the coolant and the bag.

Shipping Additives

Over the last 15 years, several additives to shipping water have been developed or adapted to help reduce stress and increase survivability. They generally fall into three categories: sedatives water quality stabilizers, and antibiotics. The most common sedatives are quinaldine or quinaldine sulfate, and Tricane methane sulfonate (MS-222), Quinaldine is used 25 ppm in shipping water, MS-222 at 60 to 70 ppm with adjustments made for sensitive species. These compounds reduce the metabolic rate of fish, and can also prevent injury from jumping or swimming into the sides of the box. Water quality stabilizers include pH buffers, zeolite at 20 g./ liter (which removes ammonia), activated carbon also at 20 g./liter, ice or heat packs to maintain temperature, and sodium chloride at 9.0 ppt. Other products have become available from the bait minnow industry these usually contain a combination chelating agents, buffers, ammonia or chlorine removers and some form of antibiotic.

Table 1. Common shipping additives and concentrations typically used in water for transport of ornamental fish, Adapted from Herwig, 1979.

Concentration	Chemical
Quinaldine	25 ppm
Tricane methane sulfonate (MS-222)	60 - 70 ppm
pH buffers	as per label
Zeolite	20 g./L
Activated carbon	20 g./L
Salt (NaCl)	9.0 ppt
Commercial mixtures	as per label
Furanace	0.05-0.2 ppm
Neutral acriflavine	3-10 ppm

Caution should be used in the application of antibiotics. These compounds are subject to regulatory controls, which should be considered carefully before any applications. One of the most widely used antibiotics for shipping and treatment offish has been tetracycline at 5-20 ppm. This antibiotic has been used extensively, especially from fish shipped out of Asia. There are several indications that some bacteria have developed immunity to tetracycline due to its wide use, which is one of the reasons that not recommend its use. Other antibiotics commonly used in shipping are furnace at 0.05-0.2 ppm, and neutral acriflavine at 3-10 ppm. Other antibiotics such as kanamycin and chloramphenicol are used much less frequently and are primarily used as on-farm treatments for disease. The different sulfa base drugs are currently being used due to bacterial resistance to other forms of antibiotics historically used in the industry.

Receiving Fish

Most farms that ship fish will also be receiving fish, either to resell or to add to their brood-stock line. Appropriate care and handling of in incoming shipments of fish is another critical function to a successful farm or transship operation. Arriving shipments should be inspected immediately, particularly those that have been shipped over long distances or those which have been subject to delays. Fish that are densely packed in bags that have taken longer than expected to arrive may be suffering from exposure to accumulations of ammonia, thermal shock, or other problems. A quick assessment of the condition of the arriving fish can limit losses in such cases. In order to implement, a successful receiving program you must first have a working knowledge of what changes are taking place, chemically and physically, inside the shipping bag during the transport period. Once a bag has water, fish and oxygen sealed inside it, certain chemical changes take place due to the metabolism of the fish. When fish breathe, they absorb oxygen and excrete other gases and metabolites, primarily carbon dioxide (CO_2) and nitrogen in the form of ammonia. Total ammonia nitrogen for the purposes of this manual, consists of two forms of nitrogen that exist in a pH and temperature dependent equilibrium of unionized ammonia (NH_3) and the ammonium ion (NH_4^+). The un-ionized form (NH_3) is toxic to fish while the ammonium ion (NH_4^+) is not toxic to fish (Boyd, 1979). The ratio of NH_4^+ to NH_3 will increases as pH decreases and decreases as pH increase (Boyd 1979). The percentage of NH_3 also rises with increasing temperatures so conditions with both relatively high pH and elevated temperature are especially dangerous. Since NH_3 cannot be measured directly, several tables have been created based on an equilibrium formula that predicts the relative percentages of unionized ammonia at different temperatures and pH. Table 2 was created for the aquaculture industry and reproduced from Boyd (1979).

Table 2. Percentage un-ionized ammonia in solution at different pH values and temperatures. (Reproduced from Boyd 1979).

pH	Temperature (˚C)								
	16	18	20	22	24	26	28	30	32
7.0	0.30	0.34	0.40	0.46	0.52	0.60	0.70	0.81	0.95
7.2	0.47	0.54	0.63	0.72	0.82	0.95	1.10	1.27	1.50
7.4	0.74	0.86	0.99	1.14	1.30	1.50	1.73	2.00	2.36
7.6	1.17	1.35	1.56	1.79	2.05	2.35	2.72	3.13	3.69
7.8	1.84	2.12	2.45	2.80	3.21	3.68	4.24	4.88	5.72
8.0	2.88	3.32	3.83	4.37	4.99	5.71	6.55	7.52	8.77
8.2	4.49	5.16	5.94	6.76	7.68	8.75	10.00	11.41	13.22
8.4	6.93	7.94	9.09	10.30	11.65	13.20	14.98	16.96	19.46
8.6	10.56	12.03	13.68	15.40	17.28	19.42	21.83	24.45	27.68
8.8	15.76	17.82	20.08	22.38	24.88	27.64	30.68	33.90	37.76
9.0	22.87	25.57	28.47	31.37	34.42	37.71	41.23	44.84	49.02
9.2	31.97	35.25	38.69	42.01	45.41	48.96	52.65	56.30	60.38
9.4	42.68	46.32	50.00	53.45	56.83	60.33	63.79	67.12	70.72
9.6	54.14	57.77	61.31	64.54	67.63	70.67	73.63	76.39	79.29
9.8	65.17	68.43	71.53	74.25	76.81	79.25	81.57	83.68	85.85
10.0	74.78	77.46	79.92	82.05	84.00	85.82	87.52	89.05	90.58
10.2	82.45	84.48	86.32	87.87	89.27	90.56	91.75	92.80	93.84

Generally when a bag of fish reaches its final destination it has been in transit for 24 to 48 hours. During this period of time there has been enough carbon dioxide produced to reduce the pH of the water down to 6.5 - 7.0. As you can see from Table 2, using a temperature of 24^{o}C and a pH of 7.0, the toxic fraction is only 0.52 percent. If the total ammonia nitrogen is 10.0 parts per million (ppm) then the toxic fraction is only 0.052 ppm. (0.0052 x 10.0 = 0.052 ppm). This amount of toxic ammonia (NH_3) is well within the tolerable limits for long term exposure to most species without doing any serious physiological damage to the fish (Post, 1987). However, if the pH in that same bag of fish is 10.0 and the temperature is 24 C the un-ionized toxic fraction of ammonia from the chart above is 84.0 percent or 8.4 ppm (0.84 x 10.0 = 8.4 ppm). At this level severe stress, physiological damage and even death may occur at exposure times as short as 30 minutes or less (Post, 1987).

Procedure for unpacking fish

Unpacking is as important as packing fish in bags. Guidelines for proper unpacking are as follows.

1. Float unopened bags in a shaded area of the receiving water for at least 30 minutes to allow temperate to equalize.
2. Check water temperature and watch for mortalities.
3. Open bags and add a few of receiving water to the bag.
4. Carefully observe the fish acclimated itself to the new environment
5. Gently and slowly pour fish into the receiving water.

It is critically important when receiving fish to be aware of the temperature and pH differences between the water in the shipping bag and the receiving water. The bag should be kept out of direct sunlight The recommended method for acclimating fish is to float the sealed bag in the tank or pond that is to receive them for a period of at least five minutes per degree of temperature difference or until the temperature of the bag is within two degrees of the receiving water. The CO_2 in the shipping water will dissipate into the atmosphere and the pH of the shipping water in the bag will begin to increase rapidly along with the toxic fraction of ammonia, potentially causing severe stress or death. Adding water to an unsealed bag may only increase stress if the water being added has a high pH and temperature. At this point in the receiving procedure un-iodized salt may be added to reduce stress. Fish should also be inspected under the microscope for any parasites or disease and the proper treatment applied. Generally, water in shipping bags is discarded rather than introduced into the culture system as a means of limiting possible introductions of pathogens, anesthetics, etc.

SUMMARY AND CONCLUSIONS

Even the most effectively run hatchery fish production operation is likely to fail if insufficient attention is paid to fish packing and shipping procedures. This can be summarized as a matter of minimizing risks at every step of the packing and transport process, without going to the costly excess of shipping bags. Packing methods should take into account the species being shipped and the expected time in transit. Concentrating sales in easily reached destinations, and adherence to established packing methods, materials, and densities described in this manual will contribute to the consistent delivery offish in excellent condition. An effectively designed packing room, with harvests prepared appropriately in anticipation of shipping deadlines.