

Preparation for Transport: Fish Packaging Technology

by

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In the ornamental fish business, the ability to meet customers' needs for high quality fish is always a critical factor. As most ornamental fish are destined for export, the fish must not only be pleasing to look at but also robust enough to withstand the long journey by air transportation. Since the 1950s when polyethylene bags were first used for live fish transport, the polyethylene-bag transport system has greatly reduced the shipping weight of ornamental fish consignments, and made it feasible to ship them for air freight. Nevertheless, the freight costs of fish consignments still represent the majority of the costs involved in the ornamental fish business, and for consignments such as those from Asia to the USA, it can even cost more than

the fish in the consignment. Hence the use of modern packaging technology for air transport to increase fish loading densities and improve the postshipment survival is critical to the business.

Packaging system

There are basically two major types of live fish transport systems: the open system which uses live fish tanks, and the closed system which involves fish packed in polyethylene bags. The system used for packaging live ornamental fish for air transport is a closed system, in which all factors necessary to meet fishes' requirements for survival are self-sustained. The system involves packing the fish in sealed polyethylene bags filled with water and over-saturated with oxygen. The bottom of the bag either has a seam or a rectangular base. For the seam type bags, the 2 bottom corners are tied together with rubber bands or heat-sealed to round off the corners so that the fish are not trapped and squashed in the corners.

With the exception of a small number of freshwater fish and most of the marine species, ornamental fish are

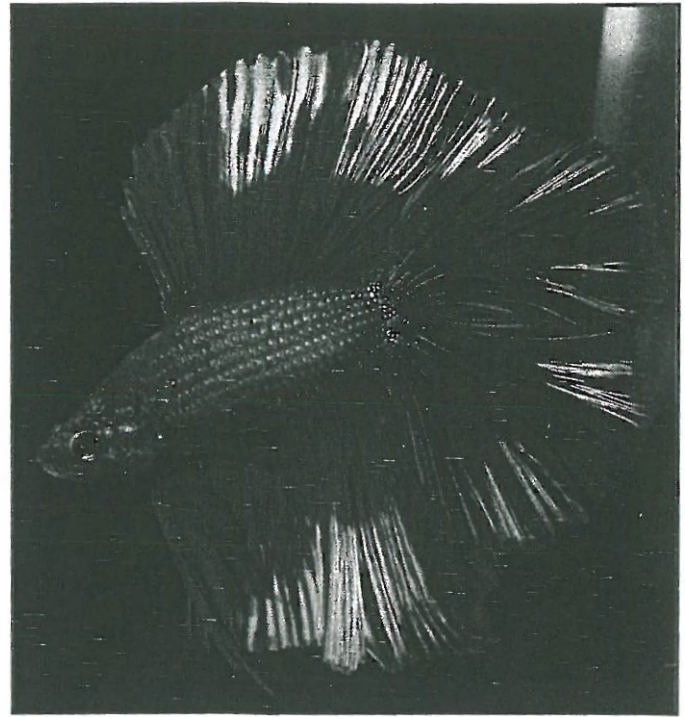
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packed at a relatively high density. Aggressive fish such as Fighting fish (*Betta splendens*) and most Cichlids are packed individually to prevent them from attacking each other, a situation that is likely to arise under the stressful conditions of transportation. Fish with fragile fins such as veil tail Angelfish (*Pterophyllum scalare*) and Pearl Gouramis (*Trichogaster leeri*) are also packed individually in order to ensure that their fragile finnage will remain intact on arrival at destinations. Individual packing is also applied to high-priced fish as a safety precaution to avoid mass mortality. These high-priced fish include most marine ornamental fish and a few freshwater species such as Asian Arowanas (*Scleropages formosus*), Discus (*Symphysodon spp*) and some rare species.

Fish that are packed individually are packed in single polyethylene bags. When many fish are packed in the same bag, double bags, with one inserted into the other, and with newspaper inserted in between, are used to prevent leakage of water and oxygen due to perforation. A fixed volume of potable water, usually pre treated with chemicals or drugs, is first poured into the bags and the fish are placed inside. Air is displaced from the space above water in the bags by squeezing the bag above the water level, and oxygen is then added to the water or overlaid on the water through a hose connected to the pressure regulator of an oxygen cylinder. It is not advisable to inflate the bag fully



Betta males are aggressive and for that reason packed individually.

Photo: Svein Fosså

with oxygen as high pressure may cause unnecessary stress to the fish and the bag may burst when lifted up.

After packing, the opening of the bag is closed. There are 3 ways of closing the bags:

- a) Using rubber bands: The upper end of the bag is twisted to prevent oxygen from leaking. The twisted part is then folded and tightened with rubber bands. This is a common practise as it allows re use of the bags especially during transshipment. However, re-use of the bags is prohibited in some countries.
- b) Using a metal clip: Same method used as in (a) above but the twisted section is tightened with a metal

clip using a clipping machine. This is faster than the rubber band method but bags can get damaged during unpacking and cannot be re used. Methods (a) and (b) are used for packing many fish in the same bag.

- c) Heat sealed method: This method is used for closing small bags using a machine, usually for fish that are packed individually.

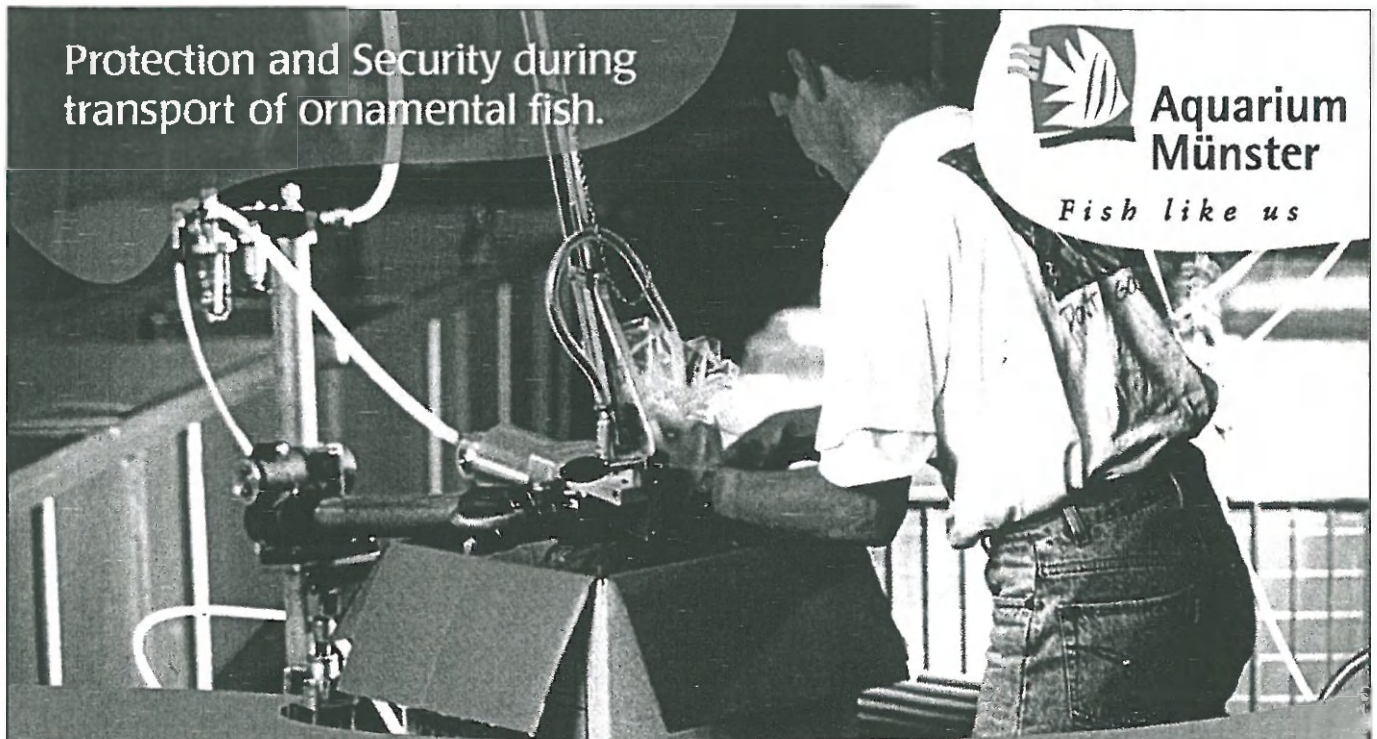
The bags with fish are then placed in a styrofoam (polystyrene) box, usually 4 to 8 bags to a box. The styrofoam box is usually placed inside a cardboard box of similar size. The styrofoam box serves to provide thermal insulation so as to prevent sudden changes in the temperature of the transport water,

especially when the consignments are in the cargo hold of the aircraft (21-22 °C) during air transport. Two sizes of styrofoam boxes are most commonly used: those which measure 48.5 cm x 36.5 cm x 36.5 cm and 60.5 cm x 45.5 cm x 30.5 cm. The thickness of the box is either 2.0 cm or 1.30 cm, thicker boxes being used for temperate climates or during the winter. The boxes serve to protect the polyethylene bags from mechanical damage during handling, keeping bags in an upright position and facilitates handling at embarkation and disembarkation.

Biomass in the packaging system

How many fish may be packed using the packaging system? The number of fish is limited by the volume of transport water, and it varies with the species

Protection and Security during transport of ornamental fish.



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and size of the fish. For example, the average density for a consignment from Singapore to Europe (transit time 26-30 hours) ranges from 480 fish/box for goldfish (*Carassius auratus*, average body weight 13.8 g) to 1,663 fish/box for neon tetra (*Paracheirodon innesi*, average weight 0.22 g). The transit time (the period from packing to unpacking) is another key factor governing the fish density of a packaging system. More fish can be packed in a given volume of water if the transit time is shorter.

Consignments to Asia with transit times of 12-14 hours, for instance, allow density increases of about 50%. Fish densities are again decreased by about 20% when sent to the United States (transit times of more than 36 hours).

We may use loading density of fish, which is expressed in terms of biomass of fish (g) per unit volume of water (l), to determine the number of fish to be packed in a packaging system. Figure 1 provides an idea of the loading density of some common freshwater ornamental fish being applied by some exporters in Singapore for consignments from Singapore to Europe with a 30-hour transit time. The average loading density varies greatly according to the fish species. It ranges from 34 g/l with neon tetras to 264 g/l in goldfish. The loading density is generally associated with the size and behaviour of the fish, and it increases with increasing body weight and in less active fish. This is dependent on the fact that large

individuals or less active fish consume less oxygen and produce less nitrogenous wastes per unit weight than do small ones. Compared with the loading densities for packing foodfish juveniles such as cyprinid and perch juveniles with the same transit time, the loading densities used for ornamental fish are relatively higher than those for cyprinid and perch juveniles of the same size.

Principles of fish transport

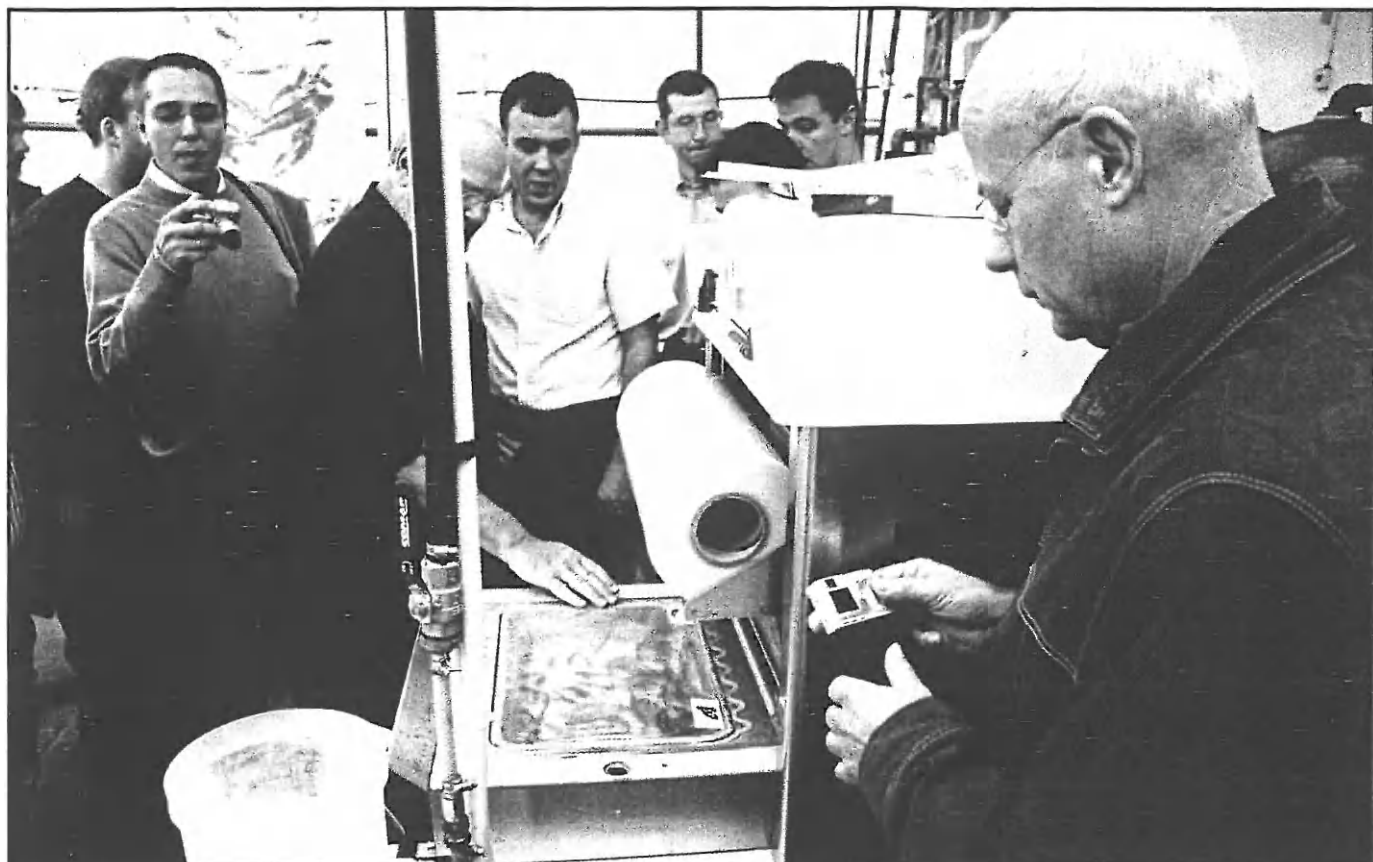
With air transport of ornamental fish, water and packing materials represent the main bulk of the weight of the consignment, with fish biomass accounting for only 5-10% of the weight of consignment. The freight cost, which is based on the weight of the consignment, can be reduced if more fish are packed in a given volume of water. The objective of live fish transport is therefore to maximise the loading density of the fish while simultaneously maintaining the fish in good conditions so as to achieve high survival rate on arrival at destinations. Hence the basic principles associated with live ornamental fish transport, as in other live fish transport, are:

- a) To enhance the stress resistance of the fish, maintain them in good conditions and reduce stress to the fish during transport, thereby ensuring good survival on and after arrival at destinations.
- b) To shorten the duration between packing and unpacking so as to reduce the total oxygen requirement and metabolic wastes excretion



Closing plastic bags with fish by "clipping", pressing a metal ring around the end of the bag, here in Ruinemans Aquarium, Netherlands.

Photo Alex Ploeg



Closing boxes with fish by sealing it, the packing method of "The Pack".

Photo Alex Ploeg

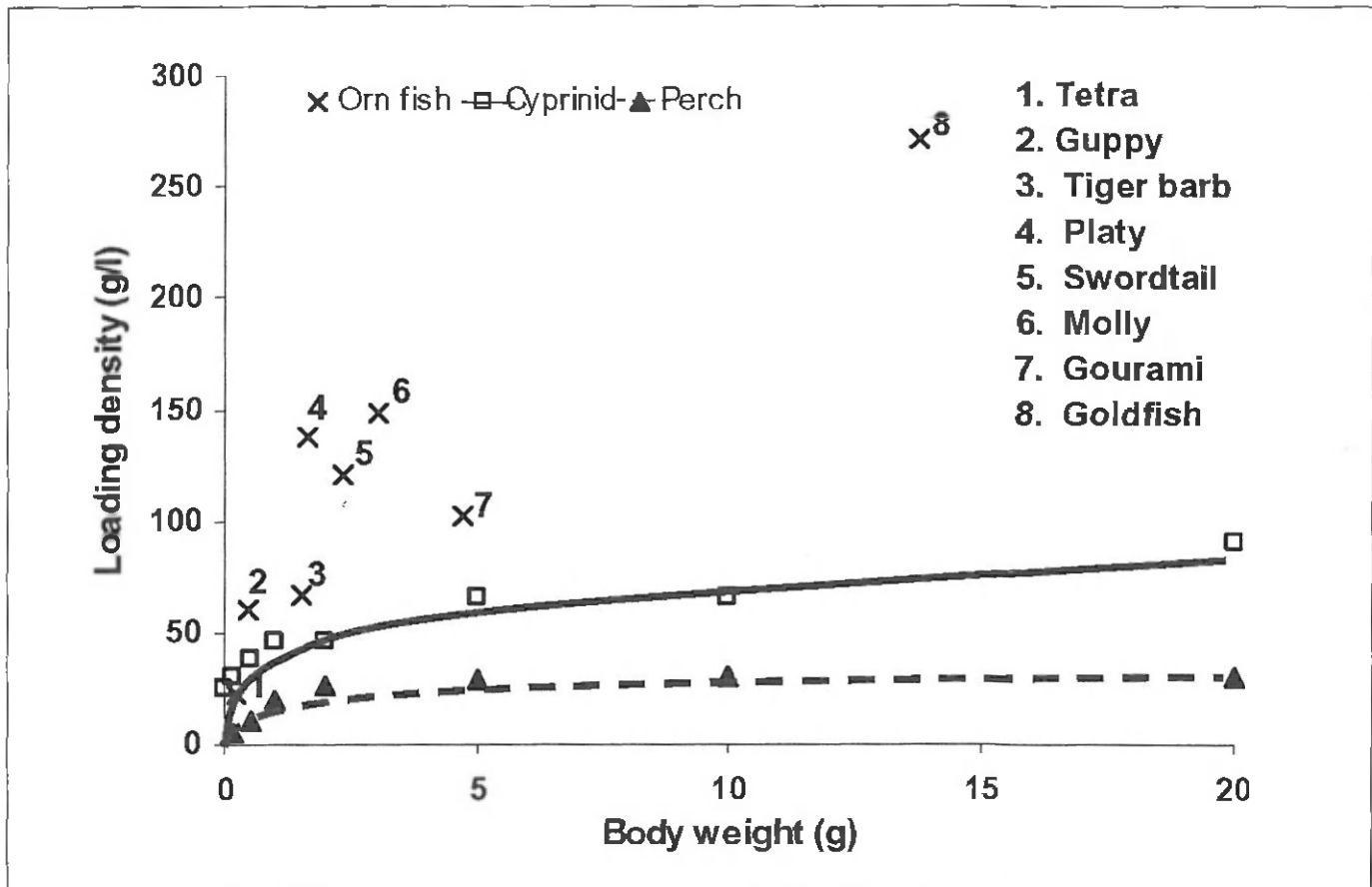


Figure 1. The average loading densities of eight common freshwater ornamental fish used by some Singapore exporters. The standard densities for foodfish juveniles (cyprinid and perch) in similar systems are shown for comparison purposes.

from the fish, as well as to shorten the period of stress the fish are subjected to during shipment

- c) To reduce the metabolism of the fish and hence lower their oxygen consumption and the accumulation of metabolic wastes in the system.

Fish packaging techniques

Shortening of transport time

One of the major factors governing the fish loading density of a packing system is the transport time. More fish

can be packed in a given volume of water if the transport time is shortened. This can be achieved through proper planning and coordination of the procedure of harvesting, conditioning, counting, distributing and packing of fish. As counting of fish is one of the most time consuming tasks, it should be performed in advance in order to shorten the time of the packing operation. In planning the flight schedule for fish consignments, the principle used by the exporters is to select the most direct route. This is to keep the number of landings and take offs and the waiting time for subsequent flights

to a minimum. This will avoid repeated handling and climatic changes thus minimising the handling stress to the fish. Since some airports do not have customs and veterinary clearance services open for fish on weekends and public holidays, exporters also ensure they are not sending consignments which will arrive at the airports on these days.

Oxygen supply

The most important factor of live fish transport is an adequate supply of dissolved oxygen to the fish throughout the transport time. Oxygen deficiency may occur in the packing water towards the latter part of the

journey if the loading density of fish and the transport time exceed the tolerable limits of the fish. The amount of dissolved oxygen required for a packing system is associated with the number, size and species of fish packed in the system. The oxygen to fish ratio, which is calculated by dividing the volume of oxygen (ml) by the total biomass of fish (gram, assuming that specific gravity of fish is 1), is a good measure of the amount of oxygen required or used in a packing system. Figure 2 provides an idea of the average oxygen to fish ratios used for 7 common freshwater ornamental fish species for air shipment from Singapore to Europe (transit time

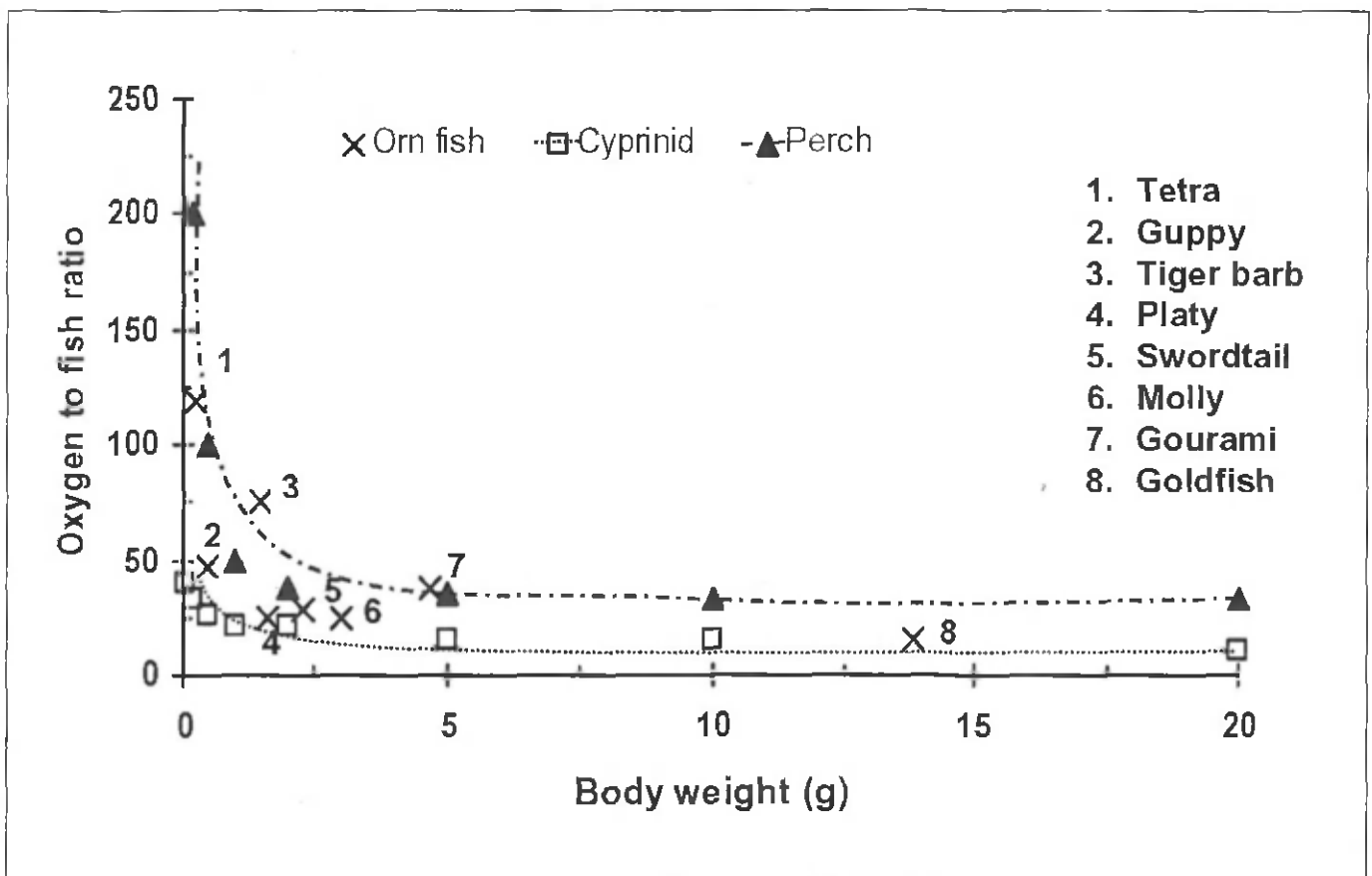


Figure 2. The average oxygen to fish ratios of eight common freshwater ornamental fish used by some exporters in Singapore. The ratios used for cyprinid and perch juveniles in similar systems are shown for comparison purposes.



Ornamental fish, ready for shipment at Sunbeam, Singapore.

Photo: Alex Ploeg

30 hours). The ratios range from 19 in large fish such as goldfish (average weight 13.8 g) to 153 in small fish such as neon tetras (average weight 0.22 g). With the exception of that of tiger barbs which is higher, all the ratios are near to or between the 2 standard curves for cyprinid and perch juveniles, indicating that the amounts of oxygen used for packing the freshwater ornamental fish are quite similar to those for cyprinid and perch juveniles.

In practise, exporters use high oxygen to water ratios ranging from 4:1 to 6:1 in packing ornamental fish for air transport. A check on a Guppy

consignment with oxygen to water ratio of 4:1 showed dissolved contents of 6.0 7.6 mg/l after 48 hours' transit time, indicating that at a 4:1 ratio, oxygen is not a limiting factor. However, the high oxygen to water ratios is still preferred as it ensures a good reserve of oxygen in the packing water so that the dissolved oxygen in the water will not become a limiting factor even if there are a few dead fish found in the bag. The large volume of oxygen used for packing will not increase the freight costs significantly as the freight charges are calculated by weight and not the volume of the consignment.

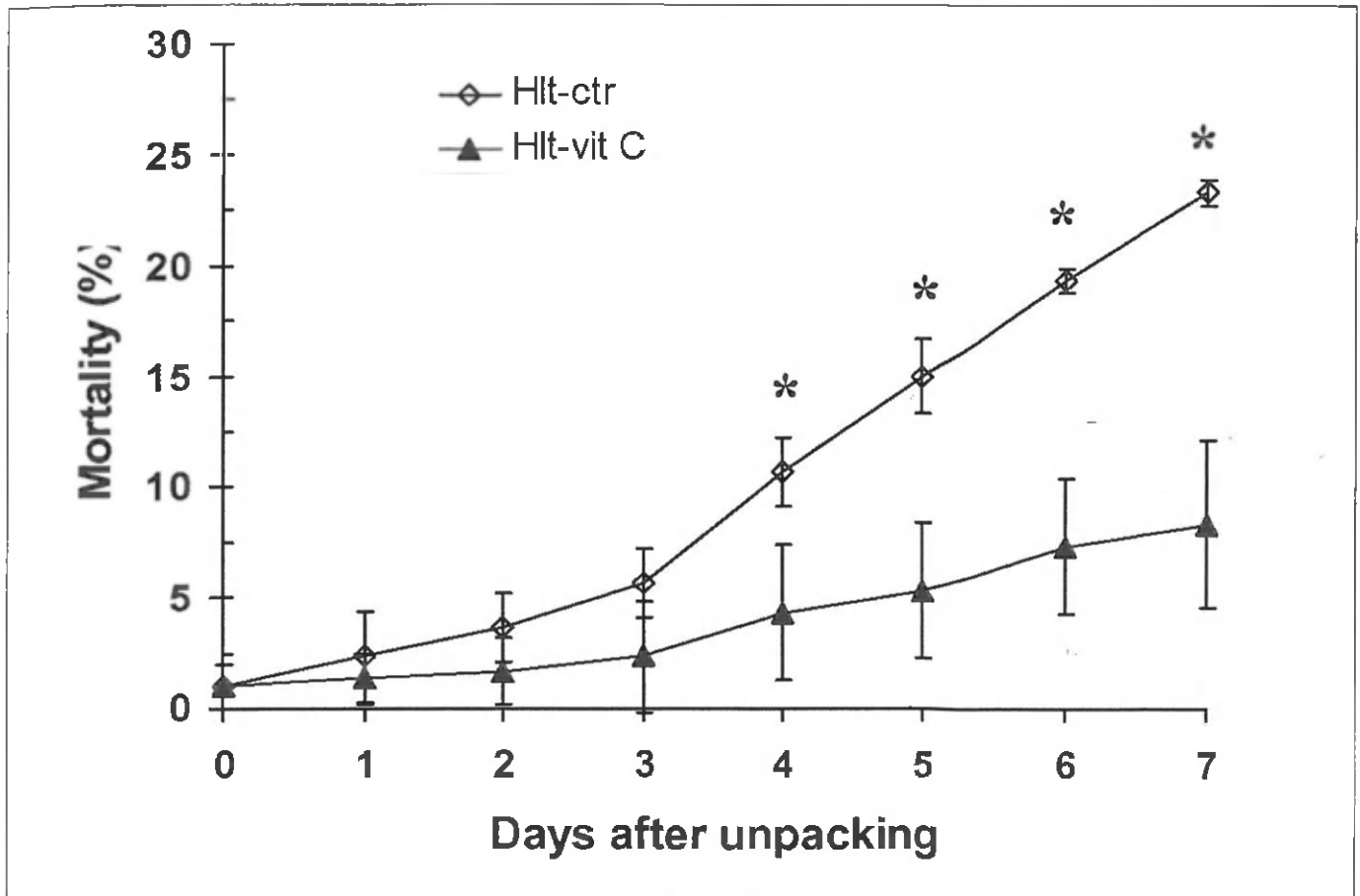


Figure 3. Comparison of post-shipment cumulative mortality between vitamin C-supplemented Guppies and control fish. The fish were not infected with *Tetrahymena*. The value represents the mean of three replicates and its standard deviation. An asterisk (*) indicates significant differences between means taken on the same observation day ($P < 0.05$).

Quality control of fish

Fish transport is a long and tedious process that consists of a series of operations, including harvesting, packing, actual transport, unpacking and stocking. The whole process is known to initiate stress in fish. When fish are unable to recover homeostasis during or after the process, it may lead to mortality. It is therefore imperative to examine and evaluate the quality of the fish prior to packaging and ship only healthy and good quality fish with strong stress resistance, so as to increase their chance of survival after

transport. Screening of the fish starts from the time the fish are counted to the actual packing of the fish in polyethylene bags. During this period, fish are inspected for pathological syndromes, which include dark body colour, closing of finnage, cloudy eyes, lack of appetite or lethargy.

Fish are usually pre-packed in polyethylene bags after counting and the bags are placed in an air-conditioned room at 22-23 °C for 4-6 hours before the actual packing. This is to enable the fish to acclimatise to

the packing conditions, such as confinement, crowding, high pressurised conditions and low water temperature. Fish that fail to adapt to the pre-packing conditions and show signs of sickness are eliminated from the shipment to reduce the risk of mass mortality. Weak or unhealthy fish are most susceptible to the stressful conditions of transport, especially during long journeys. Once a fish is dead, it competes with the living fish for oxygen. It also induces bacterial

proliferation, oxygen depletion and the formation of toxic metabolic wastes.

Nutritional prophylaxis and harvesting

Ornamental fish are subjected to stress right from the farming stage. Very often the fish are reared under intensive conditions, and they are subjected to physiological challenges from changes in water chemistry, culture procedures and behavioural interactions among fish. Control of stress responses of ornamental fish

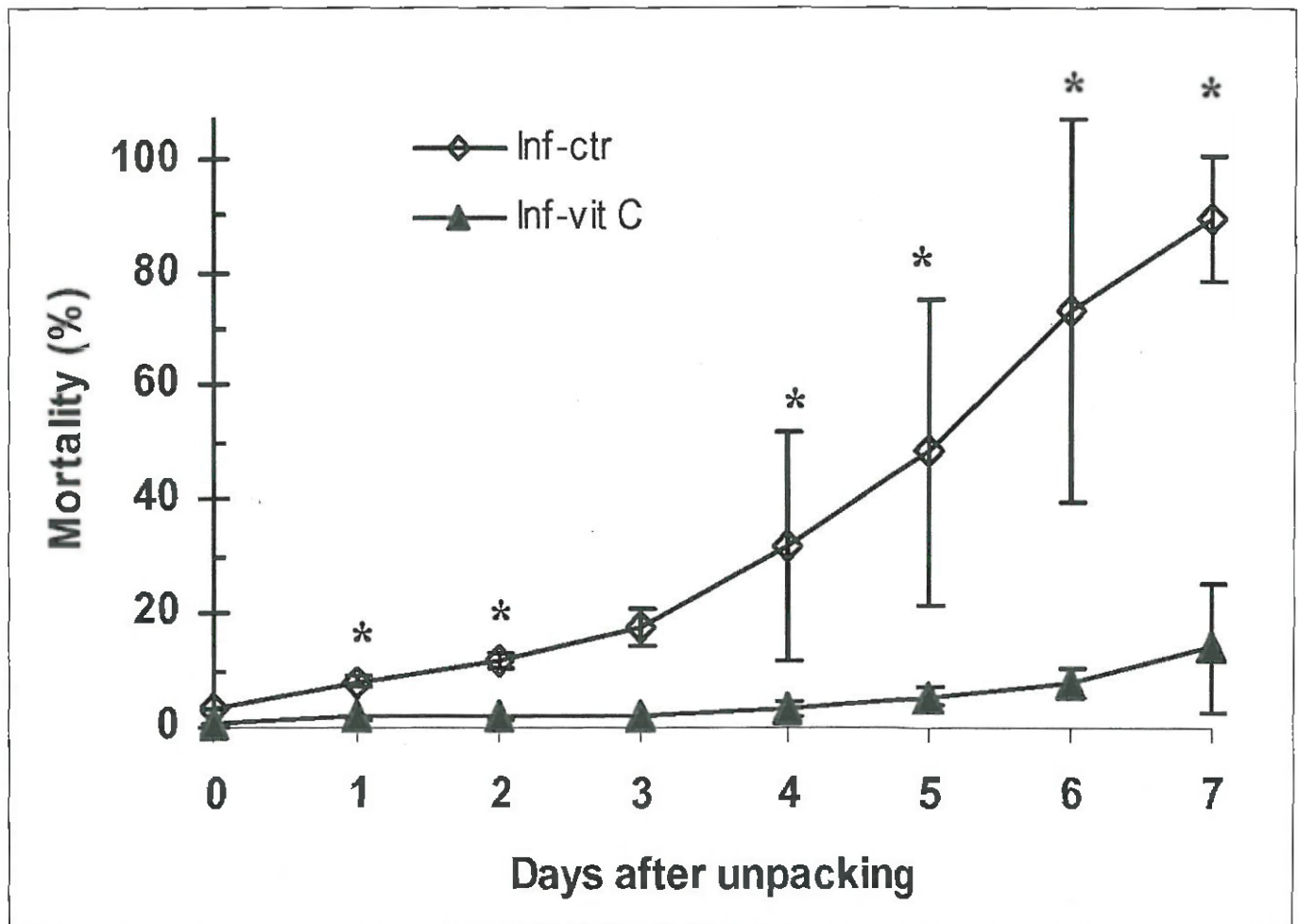
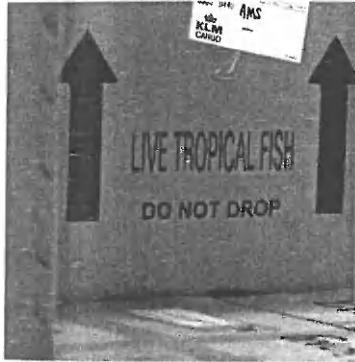


Figure 4. Comparison of post-shipment cumulative mortality between vitamin C-supplemented guppies and control fish. Both groups were found to be infected with *Tetrahymena* on Day 2. The value represents the mean of three replicates and its standard deviation. An asterisk (*) indicates significant differences between means taken on the same observation day ($P < 0.05$).

Variation Live Fish



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should therefore start during the farming stage.

Vitamin C, in particular ascorbic acid, is an essential dietary component for the various stages of aquaculture organisms. It plays a role in maintaining normal growth and collagen formation, improving disease resistance and reducing stress. Studies have shown that nutritional prophylaxis using vitamin C supplementation have worked well in enhancing the stress resistance of the Guppy. Guppies fed with vitamin C supplements (8%) for 10 days survived better than the control group (23%) at 7-day post-shipment (Figure 3). On the other hand, Guppies fed with vitamin C supplement also displayed a better resistance to disease infection. When fish were infected with *Tetrahymena*, the feeding of a vitamin C supplement helped to reduce the cumulative mortality at 7-day post-shipment from 90% in the control fish to only 14% in the vitamin C-fed fish (Figure 4). Hence ornamental fish farmers can contribute significantly to enhancing the stress resistance of their fish by applying nutritional prophylaxis using vitamin C supplementation prior to harvesting.

Harvesting of fish is a typical operation in which farmers should take precautions to avoid injury to the fish, exposing the fish to air for a prolonged period or over-crowding. These stressful factors compounded by capture could be more severe than transport itself.

Health prophylaxis

Crowding and adverse water quality conditions during transport are common stressful factors associated with outbreaks of stress-mediated diseases. When fish are infected with diseases, their stress resistance is reduced, leading to fish mortality.

Parasitic infection is common in ornamental fish, especially for those fish raised in large earthen ponds enriched with organic manure. In many cases, the infection is mild and asymptomatic, and the infection alone may not kill fish. However, the apparently harmless infection may turn lethal when the fish are stressed and their immune function is adversely suppressed during transport. Fish which arrive in fairly good condition with low death on arrival can still be heavily infested and die within a week after arrival, as commonly observed in Guppies infected with *Tetrahymena*. Parasitic infection can also pre-dispose fish to secondary bacterial infections, which further compromises the immune system and aggravates the problem of post-shipment mortality. In view of the adverse impacts of parasitic infection on stress resistance and the subsequent post-shipment performance of the fish, it is critical for exporters to treat fish for pathogenic infection prior to packaging, so as to enhance their stress resistance and hence their chances of survival after shipment. Table 1 shows some protocols for treatments of fish infected with common bacterial pathogens such as *Aeromonas* and parasites such as

Fish species	Targeted pathogens	Treatment protocols	Survival rate at 7-day post-shipment	Sources
Guppy	<i>Gyrodactylus</i> and <i>Cestode</i>	Bathe fish in 20 mg/l formalin, 2 mg/l acriflavine and 2 % salt solution for 1 hour prior to packing and add 2 mg/l acriflavine and 2% salt solution in transport water during transportation (36 hours).	Increases from 78% in control fish to 99% in treated fish	Ling <i>et al.</i> (1996)
	<i>Tetrahymena</i> and <i>Aeromonas</i> sp.	One-day bath in 10 mg/l chloramphenicol and 2 % salt solution, followed by 1-hour bath in 0.1 mg/l malachite green, 50 mg/l formalin and 2 % salt solution, and then add 0.1 mg/l malachite green and 2 % salt to transport water during transportation (36 hours)	Increases from 67% in the control group to 91% in the treated group	Loo <i>et al.</i> (1998)
	<i>Tetrahymena</i>	Add 20 mg/l chlorine dioxide to transport water during pre-packing (6 h) and actual transportation (40 hours).	Improves from 61% in control fish to 89% in treated fish.	Ling <i>et al.</i> (2000)
Angelfish	<i>Hexamita</i> , <i>Costia</i> and <i>Trichodina</i>	Bathe fish in 2 mg/l acriflavine and 2 % salt solution for 3 days, and during the first two days, feed them fish with dried pellet incorporated with 2% metronidazole, twice a day (36 hours).	Increases from 3% in control group, to 42% in group with bath treatment, and to 96% in group given full treatment	Ling & Khoo (1997)
	<i>Hexamita</i>	Add 3.5 mg/l metronidazole (soluble form) to transport water during transportation (40 hours)	Improves from 58% in the control to 95% in treated group	Ling <i>et al.</i> (2000)

Table 1 Improvements in post-shipment survival rates of Guppies and Angelfish through prophylaxis treatment by medication.

Tetrahymena, *Gyrodactylus* and *Cestode* in Guppy and *Hexamita*, *Costia* and *Trichodina* in Angelfish. In all cases, the post-shipment survival rates are vastly improved after application of the respective treatment protocols on the fish prior to packing. Most of these protocols involve bathing or feeding the fish with the appropriate chemicals or drugs for a period prior to packing and treating fish with chemicals or drugs in the transport water during transportation. For *Tetrahymena* infection in Guppy and *Hexamita* infection in Angelfish, the treatments have been vastly simplified. Fish were treated directly in the pre-packing and/or transport water with the appropriate drugs (Table 1). These protocols are

more direct and convenient. As treatments are performed only in pre-packing and/or transport water, it is no longer necessary to treat and maintain fish in the tank, and hence the tanks, space and manpower are saved accordingly.

Conditioning for transport: Starvation

Starving fish prior to live fish transport has been a traditional technique used for improving the survival of fish during transport. Starvation for a short period when fish could not find suitable food is common in nature. Prior to packing, fish are starved to empty their stomachs and intestines in order to prevent regurgitation of partially digested food material during transport. Other



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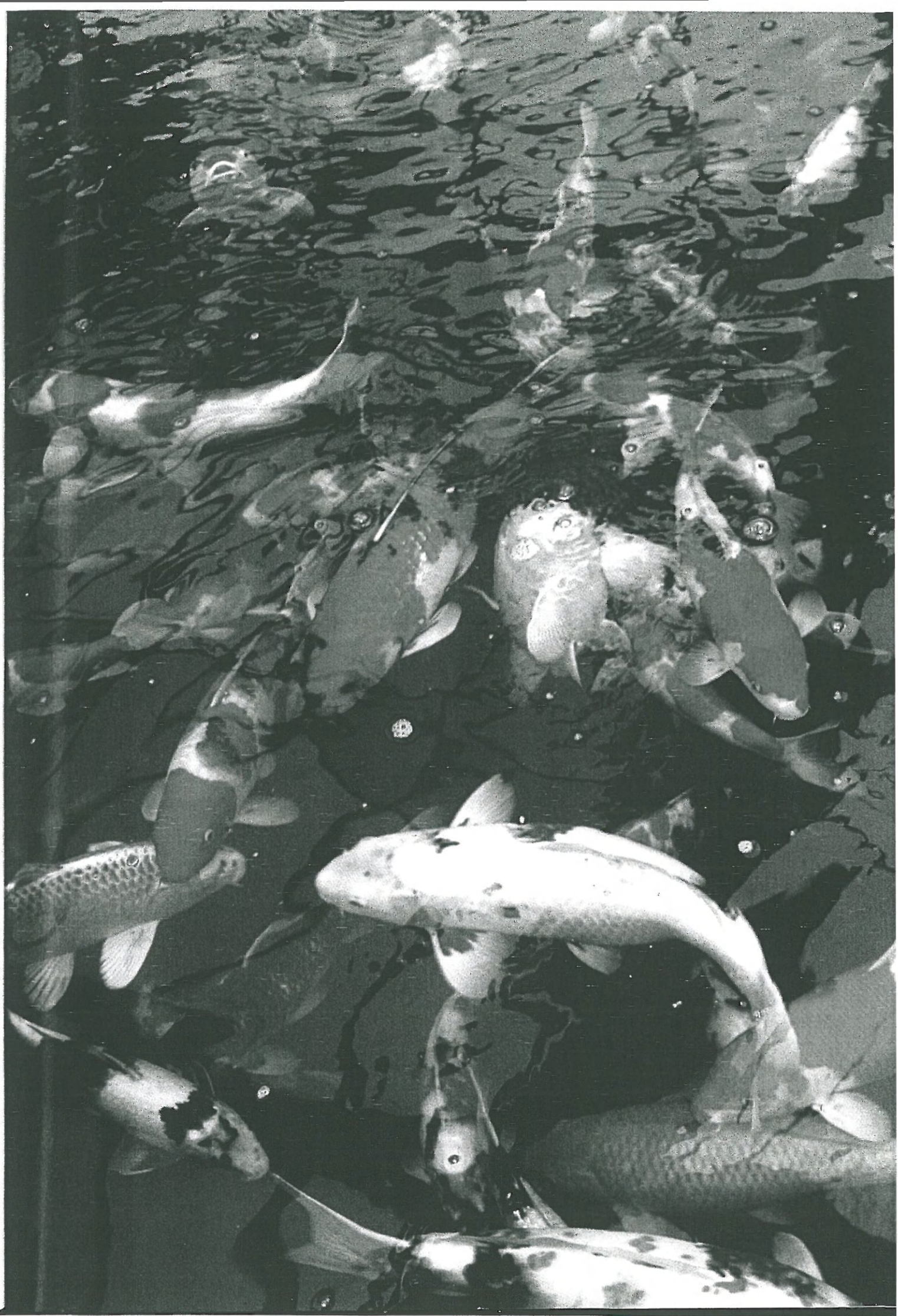
advantages of starving the fish include a decreased amount of excreta from fish and reduced metabolic rate, hence minimising pollution of the water during the journey. Starvation is also known to reduce stress response to handling, and this will cut down unnecessary loss of fish during packaging.

Studies have shown that the duration of starvation is important to the performance of the fish after transport. While starvation had no effect on the death during unpacking after arrival, Guppies starved for a day prior to shipment survived significantly better than the control fish at 7-day post-shipment. A starvation duration of only half a day or for a prolonged duration of two or three days was not as effective. On the other hand, Guppies

starved for one day showed a significant increase in the stress resistance over the non-starved fish or fish starved for only half a day. Starvation for a longer period of two or three days would lead to decreases in the stress resistance of the Guppy. Hence the optimal duration for starving small fish like Guppies and Neon Tetras should be limited to one day only, as prolonged starvation may have adverse effects on the stress resistance of the fish, and hence increase the post-shipment mortality. The optimal duration of starvation for larger fish such as Goldfish (*Carassius auratus*) and Koi (*Cyprinus carpio*) is two days.

The optimal duration of starvation for larger fish such as and Koi (Cyprinus carpio) is two days.

Photo: Alex Ploeg



Control of temperature of transport water

The temperature of the transport water is an important physical factor governing the loading density of fish in a packaging system. A high water temperature adversely affects the loading density of fish due to the increase in the metabolic rate of fish and hence resulting in a higher oxygen consumption and higher carbon dioxide and ammonia production. High water temperatures can also result in more rapid multiplication of bacteria and lower oxygen solubility, which leads to increased toxic waste production and decreased availability of dissolved oxygen to the fish. Hence, lowering of the water temperature is a useful technique for increasing the fish loading density.

In practise, the temperature of the transport water is lowered to 22 °C for packing ornamental fish of tropical origin. At this temperature, fish are less active but swim normally. This packing temperature is also very close to that in the cargo hold (21-22 °C) of most aircraft. Fish of temperate origins such as Koi and Goldfish can tolerate a much lower temperature and are therefore packed at 15-18°C. In contrast, certain tropical fish that are sensitive to low temperatures such as the Glow-light Tetra, *Hemigrammus erythrozonus* and Rummy-nose Tetra, *H. bleheri*, are packed at 24-25 °C. It is important to acclimatise the fish to the packing temperature prior to the actual packing, as sudden changes in water temperature may impose additional stress on the fish. A common practice

is to pre-pack the fish in polyethylene bags, place them on multi-layer trolleys and cool them in air-conditioned rooms for 4-6 hours or more at the required temperature. After acclimation, the fish are packed in water that has been cooled down to the same packing temperature using a water-cooling machine or through the addition of ice to the water.

During the winter months in the importing countries, it is necessary to increase the temperature in the packing box so that the water temperature of transport water will not be too cold for the fish on arrival. This is particularly important as there may be a significant drop in water temperature when the consignments are at the destination airport for several hours while waiting for connecting flights or customs clearance. A common practise used to overcome the cold-shock problem to the fish is to attach a heat pack to the underside of the cover of the packing box before sealing the box. The heat generated by the heat pack induced by rocking motions will increase the temperature in the packaging system. Due to the anticipated increase in temperature, the loading density of fish in the packaging system is also reduced accordingly.

Removal of ammonia from transport water

Ammonia accumulates in transport water due to excretion from the fish and the bacterial action on fish excreta and dead fish. For fish, ammonia is excreted mainly through the gills.

There are two forms of ammonia, ionised (NH_4^+) ammonia and un-ionised or free ammonia (NH_3). Only un-ionised ammonia is capable of passing through tissue barriers and is poisonous to fish. Fish may succumb if the toxic-free ammonia in their tissues is above the tolerable limit. A common technique for removing ammonia from the transport water is to use resins such as clinoptilolite, a natural zeolite that has the ability to absorb ammonia by selective ion exchange. To prevent water from cloudiness, the zeolite chips are rinsed thoroughly to eliminate the surface powder before use. They are either wrapped in a net bag or added directly to the transport water at 15 - 20 g/l of water.

Management of pH in transport water using buffers

During transport, the accumulation of carbon dioxide originating from fish and bacterial respiration can lower the pH of transport water. At a high carbon dioxide level and low pH, fish may succumb as a result of the reduction in the oxygen carrying capacity of their blood even if oxygen levels in the water are within acceptable ranges. The use of buffers such as tris buffer (tris-hydroxymethyl amino methane) is effective in stabilising the pH, by converting free carbon dioxide to bicarbonate ions in the transport water. However, in practice, it is usually not necessary to use buffers to stabilise the pH of the packing water. A check on packing water packed with Guppies showed that the pH of the packing water, after 48 hours transport time,

was nearly 7 (6.95-7.05), which should be tolerable for most freshwater ornamental fish. Furthermore, a decrease in the pH of packing water would help to lower the level of the toxic-free ammonia in the water. Any attempt to stabilise the pH of the packing water will lead to higher levels of toxic free ammonia. Tests on tris buffer using 2 groups of Guppies (transit time of 48 hours) have shown that the group without tris buffer had a lower pH (7.03) than that treated with 0.02 M tris buffer (7.62). Consequently, there was a tenfold increase in the toxic-free ammonia, from 0.82 mg/l in the untreated group to 8.33 mg/l in the treated group. The high cost of tris buffer also makes its routine use for fish packaging uneconomical.

For fish that require low pH, some exporters use Ketapang (*Terminalia catappa*) leaf water, which has a pH of about 6.5, as packing water. This technique is commonly used for packing the Chocolate gourami (*Sphaerichthys osphromenoides*), Harlequin rasbora (*Rasbora heteromorpha*) and Coolie loach (*Pangio kuhli sumatranus*), which do better in water with low pH levels ranging from 6.0-6.5.

Addition of salt in transport water

Osmo-regulatory dysfunction is common in fish that are exposed to confined water during transport. The addition of salt to transport water has been found to be effective in reducing osmo-regulatory disturbances and fish mortality in several foodfish species.

In practise, coarse salt containing about 95-98% sodium chloride is added directly to the transport water of freshwater ornamental fish at 0.5-9%, with 1-3% being more common.

Studies have shown that when Guppies were kept in saline water for 40 hours, their stress resistance increased with increasing salinity from 1% to 9%, which is close to isotonic conditions. These results demonstrate that the addition of salt up to 9% would help to enhance the stress resistance of the fish. On the other hand, experiments with Guppies showed that there was a dramatic increase in the total ammonia content when the salinity of the transport water was increased to 3% or 9%, due to a decrease in the efficiency of clinoptilolite. These results suggest that among the three effective salinities ranging from 1% to 9%, Guppies should be packed at 1%. Higher salinity should be avoided as it may result in an undesirable quality of the transport water.

Management of transport water quality using anaesthetics

Since ornamental fish are packed in a small volume of water at a high loading density, the metabolic wastes accumulate rapidly in the transport water. An effective method is to use anaesthetics to reduce the metabolic rate and cut down the excretion of ammonia and carbon dioxide by the fish. All of the anaesthetics used for ornamental fish transport are of the inhalation type; in other words, they

are added, either directly or first dissolved in solvent, to the water whereupon the fish are then immersed in it. For practical reasons, the drug is added to the packing water during packing and the fish are exposed to the effect of the drug throughout the transit time. In order to be effective, it is most critical to make the correct choices of anaesthetic drugs and dosages. Broad spectrum anaesthetics that can be universally applied to the common fish species destined for export are preferred. The anaesthetics should have a wide margin between the effective dose and the lethal dose, so as to reduce the risk of overdose leading to fish mortality. There should also be a large window in the effective sedating dose, so that fish can be kept under light sedation without advancing to a deeper stage throughout the transit time. At this stage, fish are lethargic but still maintain spontaneous opercular movement.

The anaesthetics used for ornamental fish packaging include tricaine methanesulfonate (MS 222) and quinaldine sulphate. The use of anaesthetics is however not so popular among exporters, because the response of the fish to the drugs varies greatly with the size and species of fish and with different water quality conditions. The high variability often causes delayed fish mortality after arrival at destinations. Other reasons are the high cost of MS 222, the unfavourable odour of quinaldine sulphate and the concern for the health hazards to human beings.

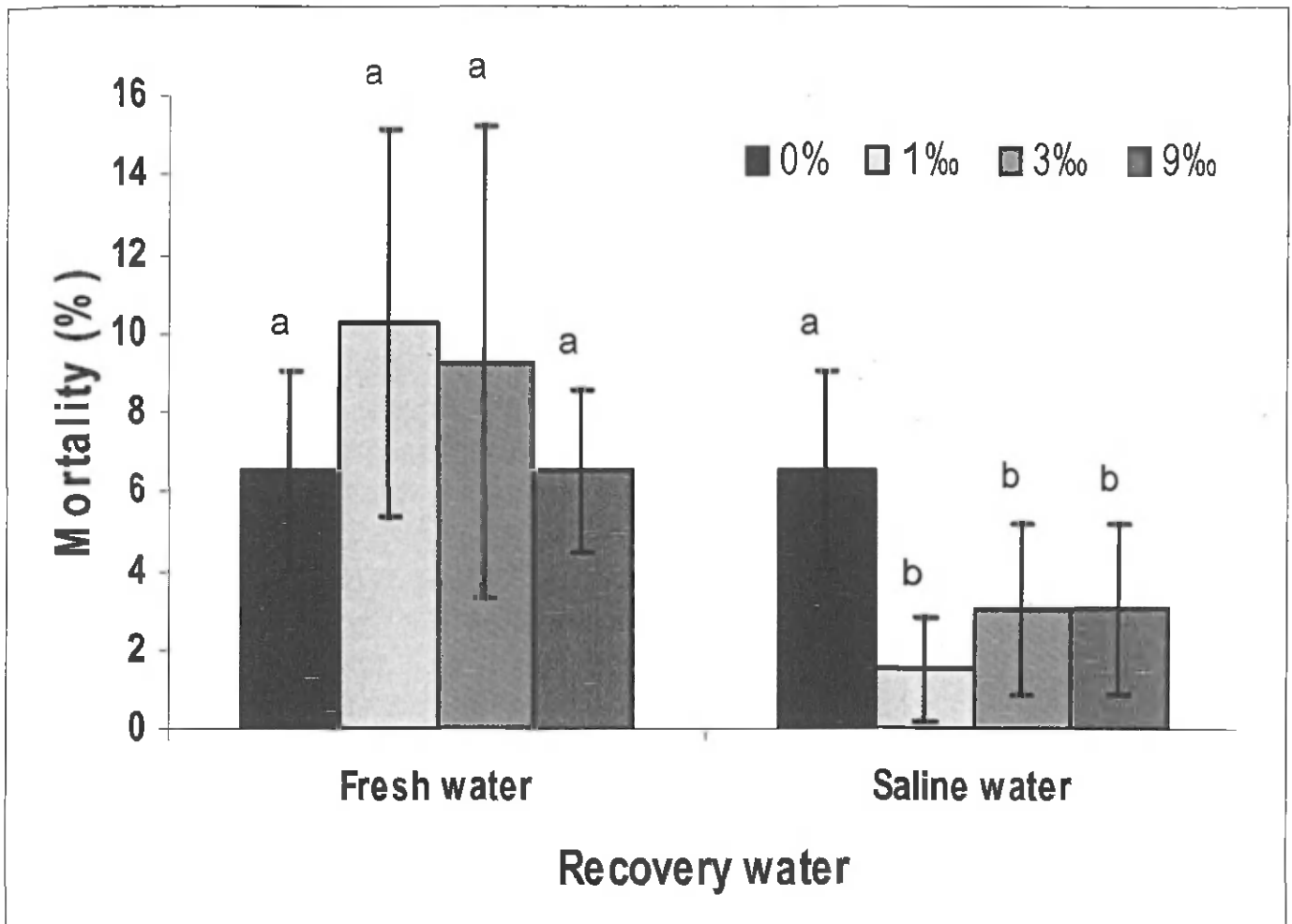


Figure 5. Effects of salt content in the transport water on cumulative mortality of guppies at 7-days post-shipment. Two batches of fish were tested and they were stocked in freshwater or in water with initial salinity similar to their transport water (with daily 30% dilution with freshwater) during the 1-week recovery period after shipment. The value represents the mean of four replicates and its standard deviation. Different alphabet letters within the same group of recovery water indicate significant differences between means ($P < 0.05$).

Some have shifted to 2 phenoxyethanol in their operations. When MS-222 is used, the pH of the transport water should be measured, as MS-222 can cause a considerable drop in pH in poorly buffered water, which may damage gill tissue and lead to osmo-regulatory dysfunction.

According to IATA regulations, when anaesthetics are used in fish

packaging, the generic name of the drug and the dosage used should be indicated on the packing boxes.

Reduced light intensity

Fish may be subjected to further stress if there is sudden influx of light when the box is opened on arrival at the destination. In order to reduce the stress due to the influx of light during unpacking, it is useful to cover the

lower half of the transparent polyethylene bags with coloured non transparent polyethylene sheets or bags, or darken the transport water with methylene blue. Methylene blue also serves to control the parasitic protozoa that may infest the fish.

Sometimes, leaves of *Terminalia catappa* (known as Ketapang in Singapore and Malaysia) are added to the transport bags. The leaf has a dual function: it serves as a hiding place for fish and lowers the pH of the transport water.

Prevention of bacteria bloom

Bacteria bloom is a major problem during live fish transport as the bacteria not only increase the ammonia load and compete with fish for oxygen in the transport water, but also weaken or can even cause diseases in fish. Many chemicals and drugs are available on the market to control the development of bacteria in transport water. In Europe and other countries, the addition of antibiotics to transport water is strictly prohibited and hence should be avoided. The most commonly used drugs for fish packaging include methylene blue and acriflavine.

Acclimation and recovery of fish after shipment

Acclimation and the recovery of fish after arrival at their destination is another important operation in the transport process. A detailed account on this subject is given in the last chapter of this book on the receipt of

ornamental fish. Hence only a brief account is given in this section.

On arrival, the fish should be allowed to recover from transport stress in tanks before being distributed to retailers, as this process may constitute another series of stressful situations for the fish. The importers should have prior knowledge of the water quality requirements of the fish in terms of the temperature, pH and hardness, so that they can prepare the tanks and water for stocking in advance of fish arrival. The acclimation operation includes floating the sealed bags in the recovery tanks until the temperature difference between the transport water and the recovery water is less than 2 °C, which takes about half an hour for a temperature difference of 4-5 °C. To minimise the risk of disease infection, care should be taken not to introduce the transport water to the recovery tank during fish transfer. The fish should first be transferred to a hand-net, dipped in a basin of clean water before being stocked in the recovery tanks. The pH and hardness of the recovery water should be as close to the optimal values for the fish as possible.

The addition of salt to the recovery water to enhance the stress resistance of the fish is effective in improving the post-shipment survival of the fish. Studies have shown that when Guppies were stocked in fresh water for recovery after transport, there were no significant differences in the cumulative mortality at 7-day post-

shipment among the three groups of fish packed in saline water (1%, 3% and 9%) and the control group (Figure 5). However, when the fish were stocked in the respective salinity of transport water for recovery (with 30% daily dilution with fresh water), all three groups of fish displayed a significantly lower cumulative mortality than the control group. Fish packed in 1% also survived significantly better in water of the same salinity than in fresh water during recovery. Hence the addition of salt, even in the small amount of 1%, is critical to the recovery of Guppies after transport.

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