Anaesthetics in the Transport of Commercial Fish

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Abstract

Upon reviewing of published papers on MS-222, it appeared that MS-222 could be used with different kinds of fishes to prevent the fishes from motion sickness during transportation. The safe dose of MS-222 for transportation of each kind of fishes within 2 days is as follows: *Clarias batrachus* 40-45 ppm, *Clarias macrocephalus* 40-50 ppm, *Ophicephalus striatus* 40-45 ppm, *Puntius gonionotus* 50-55 ppm, *Betta splendens* 65-70 ppm and *Oreochromis niloticus* 30 ppm.

In Thailand, native fresh water fishes for culture are catfish, *Clarias batrachus* (Linnaeus); *Clarias macrocephalus* Gunther; *Puntius gonionotus* (Bleeker); catfish, *Pangasius sutchi* Fowler, *Pangasius larnaudii*, carp, *Probarbus jullieni* Sauvage; the giant carp, *Catlocarpio siamensis* Boulenger and the siamese fighting fish, *Betta splendens* Regan (Tarnchalanukit, 1978). The intensive aquaculture was introduced to provide enough food for the increasing population. Aquaculture is more complicated than agriculture in many ways. For instance, young chickens and calves eat the same food as their parents, not so most of the aquatic animals. Shrimp larvae pass six stages from their hatching to their adult stages. At each stage shrimp larvae require different food. Invertebrate and fish cultures require attention and care for larvae survival and larval feeding.

One of the problems in commercial fish production is to save the fishes during transportation. This paper collects the known information on various anaesthetics used in transporting fish. The aim of this paper is to provide a useful fundamental guideline for methods in fish transportation.

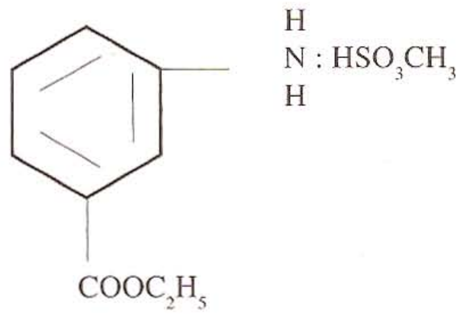
The increased demand on fisheries cultivation in recent years has focused attention of fishery biologists on a search for chemical compounds for fish handling. The chemicals for tagging, marking, weighing and sexing and particularly, transporting live fish had been tested. The technique to transport large quantities of fish from one place to another with low mortality rate has been developed.

The basic requirements for any anaesthetics suitable for the transport of mullet seed as described by Durve (1975) are as follows :

1. an anaesthetic should be water soluble.
2. dosage required should be low to lower the cost of chemicals.
3. the time of induction and recovery should be short.
4. the fish should tolerate the chemical well even for several hours at low concentrations.
5. the chemical should not have any side effects on the fish.
6. the lethal concentration should be fairly high so that the fish are not accidentally killed even if slightly excessive dosage is given by mistake, especially in the case of long transport.

In general the anaesthetics used in fishery science were MS-222 (Sandoz), quinaldine, tertiary butyl alcohol, chloral hydrate, chlorobutanol, sodium amyltal, urethane, tertiary amyl alcohol, ether, paraldehyde, pentobarbital sodium and phenobarbital sodium (Durve, 1975). Anaesthetics are known to lower the metabolic activity of the fishes by their depressing action on the brain. McFarland (1959, 1960) has done a considerable amount of work on the use of anaesthetics in fish transport. Anaesthetics have been used in aquaculture in various occasions. MS-222 has been emphasized to use efficiently as a tropical anaesthetic for immobilizing fish and other cold blooded organisms (Crawford and Husley 1963; Dick 1975).

MS-222 was first introduced by Bove' in 1962. MS-222 is the methanesulfonate of meta-aminobenzoic acid ethylester or ethyl m-aminobenzoate. It is thus an isomer of benzocaine having formula as shown in Figure 1. The commercial names for MS-222 are tricaine, tricaine methanesulphonate, metacaine or metacaine methanesulphonate



$C_9H_{11}O_2N+CH_3SO_3H$

***Figure 1**. Structure and formula of MS-222*

MS-222 can be applied by immersion of the fish or small animals into a solution of MS-222 (Marking, 1967; Sill *et al.*,1973; Johnson,1979; Lajonchere and Moreno, 1982). MS-222 was used in fish hatcheries to immobilize fish during tagging, clipping, stripping and measuring operations.

Fish anaesthetized by MS-222 has short recovery time and prolonged exposure of fish to MS-222 in low concentration is not harmful. Therefore, it is very suitable to use MS-222 in transporting live fish. MS-222 is registered and acceptable for fishery use by the U.S. Food and Drug Administration and also by U.S. Environmental Protection Agency (Meyer and Schnich, 1978).

MS-222 did not reduce the rate of oxygen consumption of Lake trout in open systems. However the consumption rate of rainbow trout in closed systems was reduced by 30 percent (McFarland, 1960). The efficacy of MS-222 was not altered by the pH between 5.0 to 8.5

(McFarland and Norris, 1958). The concentration of MS-222 that induced stage 1 (sedation) in four salmonids was 15 to 30 ppm within 15 minutes. Sedation is optimum stage in transportation (Schoettger *et al.*, 1967; Schoettger and Julin, 1967; Johnson, 1979). Toxicity of MS-222 to Lake trout and more tolerant largemouth bass ranged from 33.8 to 63.0 ppm. Larger fish of the same species was more resistant to the drug than smaller one (Marking, 1967).

In Thailand, Thaptimthai (1965) reported that MS-222 and chloretone were effective anesthetics for *Pangasius sutchi* and *Cyprinus carpio* after adding in oxygenated container. However, MS-222 was more efficient than chloretone.

Ongsakorn (1983) determined the acute toxicity of MS-222 and tertiary amyl alcohol on *Puntius gonionotus*, 1.5-2.5 cm. in length. By using Litchfield and Wilcoxon method, the 24 hrs. LC_{50} with 95 % confidence intervals of MS-222 and tertiary amyl alcohol were estimated at 71 (69.5-72.5) and 1,980 (1,948.8-2,011.7) ppm respectively. Their acute toxicities at 24 hrs. and at 96 hrs. were the same. No difference in the response of the fish to MS-222 and tertiary amyl alcohol was found. The responding reaction could be divided into 5 stages: sedation, partial loss of equilibrium, total loss of equilibrium, loss of reflex activity and medullary collapse. These five stages of the behavioral responses of fish treated with MS-222 corresponded to those of McFarland (1959, 1960).

The acute toxicity of MS-222 on *Ophicephalus striatus, Clarias macrocephalus* and *Clarias batrachus* at 24 hrs. and 96 hrs. were 72.70, 71.60, 81.50, 66.30, 89.58 and 86.29 ppm respectively (Boonyaratpalin *et al.*,1987). The MS-222 concentrations for stage 1 (sedation) for these three species were 40-45, 40-50 and 40-45 ppm. The transportation of lived fish with and without MS-222 and sodium chloride at 40-50 ppm and 40-45 ppm were conducted on *C. macrocephalus* and *C. batrachus* from Bangkok to Chiang Rai, in the double layer plastic bags at the stocking density of 2,500 fishes per 4 litres of water. MS-222 and sodium chloride could not show the better survival rate in the transport of live *C. macrocephalus and C. batrachus* in 20 hrs. period.

Mahasawasde (1989) investigated the responses of juvenile siamese fighting fish (*Betta splendens*) to sodium chloride and the anaesthetic MS-222. The static bioassay was used to estimate the acute toxicity of MS-222 on juvenile siamese fighting fish. The 96-hr. median lethal concentration (TL_{50}) for MS-222 was 174.58 ppm. The concentration of MS-222 that induced stage 1 (sedation) was 65 to 70 ppm. The 50 hrs.

lived juvenile siamese fighting fish transported with MS-222 (65 and 70 ppm) and sodium chloride (0.5% and 1.0%) in plastic bags with and without additional oxygen. Significant difference on survival rate in each treatment was not found and the anaesthetic MS-222 and sodium chloride had no effect in increasing the survival rate.

Sommani *et al.* (1999) determined the acute toxicity of MS-222 and benzocaine to *Betta splendens*. By using Litchfield and Wilcoxon method, the 96 hrs. LC_{50} with 95 % confidence intervals of MS-222 and benzocaine were estimated to be 176 (172.89-179.17) and 202 (199.21-204.83) ppm respectively. The responding reaction could be divided into 4 periods: sedation, loss of equilibrium, loss of reflex activity and medullary collapse. The suitable sedation concentrations of MS-222 and benzocaine for 48 hrs. of fish transportation were 65-70 ppm and 80-85 ppm respectively. The fish could recover from the two anaesthetics within 3 to 5 minutes.

Anaesthesia period and recovery time of *Oreochromis niloticus* to MS-222 and benzocaine were determined. The sequence of behavioral changes described from anaesthetized *O. niloticus* (Sommani *et al.*, 2001) was similar to the behavioral disturbances of other fish as described by Schoettger and Julin (1967), Durve (1975) and Boonyaratpalin *et al.* (1987). Major characteristics of the stages of anaesthesia are summarized in Table 1 and only stage 1 is desirable for fish transportation. The suitable concentration of MS-222 for sedation period within 24 hrs. of *O. niloticus* was 30 ppm and the recovery time was 67 seconds, while those of benzocaine was 15-20 ppm, and was 55-65 seconds, respectively. In comparison for applying MS-222 and benzocaine with aeration and without aeration, increasing survival time for anaesthetics with aeration was observed (Sommani *et al.*, 2001).

Table 1. Major characteristics of the stages of anaesthesia for fish (Boonyaratpalin *et al.*, 1987)

Anesthetic Stage	Observed change in behavior			
	Reaction of visual stimuli	Reaction Vibrational stimuli	Equilibrium (Eq.)and Muscle tone (M.T.)	Respiratory rate
Stage O	Reactive	Reactive	Normal	Normal
Stage I				
Plane 1	Slightly reactive	Reactive	Normal	Normal
Plane 2	No reaction	Slightly to no reaction	Normal	Normal
Stage II				
Plane 1	No reaction	Slightly to no reaction	Partial loss Eq.	Increase
Plane 2	No reaction	Slightly to no reaction	Complete loss Eq. & M.T.	Rapid decline
Stage III	No reaction	No reaction	Complete loss Eq. &M.T.	Slow, decrease in amplitude of opercular movements
Stage IV	No reaction	No reaction	Complete loss Eq. &M.T.	Ceases

Toxicity of MS-222 to various fishes is presented in Table 2.The 24 hrs. LC_{50} and 96 hrs. LC_{50} of MS-222 on siamese fighting fish, *Betta splendens,* were greater than other species (Table 2). It might be caused by species of fish, temperature, and water quality.

MS-222 has been used effectively as a tropical anaesthetic for immobilizing fish and certain other cold blooded animals. It is recommended as acceptable anaesthetia by the U.S. Food and Drug Administration and also by the U.S. Environmental Protection Agency. It is the best anaesthetic used to quiet fish during loading (Johnson,1979). The recovery time is very short and complete. Prolonged exposure to MS-222 in low concentration is not harmful, therefore it is of much value to use MS-222 as anaesthetics in the transportation of commercial fish.

Table 2. The 24 hrs. LC_{50} and 96 hrs. LC_{50} of MS-222 to Fish

Species	Average weight (g)	Water quality			24 hrs. LC_{50}		96 hrs. LC_{50}		Source
		Temp (°C)	pH	Hardness (ppm)	LC_{50} (ppm)	95% CI	LC_{50} (ppm)	95% CI	
Channel catfish	2.6	12	7.2-7.6	40-48	64.0	63.0-69.5	55.0	53.9-56.1	Schoettger *et al.*, 1967
	1.9	22	7.2-7.6	40-48	59.8	58.0-61.5	58.8	57.0-60.6	
rainbow trout	0.6	12	6.75	42	37.2	36.3-38.1	37.2	36.3-38.1	Marking, 1967
	0.6	17	6.75	42	37.5	35.6-39.6	36.5	35.9-37.1	
blue gills	1.7	12	6.75	42	43.0	41.7-44.3	43.0	41.7-44.3	
	1.6	22	6.75	42	39.8	39.6-40.6	39.8	39.0-40.6	
Puntius gonionotus	0.02-0.09	30	8.3	116	71.0	69.5-72.6	71.0	69.5-72.5	Ongsakorn, 1983
Ophicephalus striatus	3.0-5.0	29	7.8	125	72.7	71.7-73.6	71.6	70.6-72.4	Boonyaratpalin *et al.*, 1987
Clarias macrocephalus	1.5-3.0	28	8.2	128	81.5	79.4-83.9	66.3	64.6-68.0	
Clarias batrachus	1.5-3.0	28	8.1	127	89.6	87.6-91.4	86.3	82.5-55.6	
Betta splendens	1.5-2.1	29-31	7.5-7.7	70-90	-	-	174.6	-	Mahasawasde, 1989
Betta splendens	1.48	30	7.3	305	183	179.1-187.9	176	(172.9-179.2)	Sommani *et al.*, 1999
Oreochromis niloticus	0.3-0.5	30	6.9-7.1	301-305	64.5	(59.4-69.9)	54.7	(47.9-62.4)	Sommani *et al.*, 2001

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