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An Overview of Anaesthetics in Aquaculture: Role and Applications

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SUMMARY

Anesthetics are essential in aquaculture for handling fish safely during transportation, sampling, vaccination, and other procedures. They help immobilize fish, reduce stress, and lower metabolic activity, improving fish welfare and operational efficiency. Both natural and chemical anesthetics are commonly used, including agents like clove oil, MS-222, and benzocaine, along with alternative methods such as hypothermia, electro-anesthesia, and carbon dioxide exposure. Each technique has specific benefits and limitations, depending on the species and situation. Proper selection of anesthetics, correct dosing, and small-scale testing are crucial for safe and effective use.

INTRODUCTION

Anesthetics are used to immobile the fish during research and physiological investigations. Where fish need to be held immobile for extended periods. Sedation with anesthetics is also employed during transport, spawning, and vaccination to facilitate fish handling. The primary purpose of using anesthetics is to immobilize the fish, making them easier to handle for sampling while lowering the stress level associated with such procedures. During the transportation of live fish, sedation helps reduce metabolic activity and decreases oxygen consumption. Additionally, it minimizes the excretion of ammonia, carbon dioxide, and other toxic wastes. Anesthetics also control the excitability of the fish, thereby reducing the chances of injury and the time required for handling. However, care should be taken when selecting the sedative and determining its dosage. Sedation should not wholly suppress the fish's escape response and allow for the quick revival of the fish.

Role of Anaesthetics in Fish:

Anaesthesia is a reversible state induced by an external agent, resulting in the loss of sensation through depression of the central nervous system (CNS). Anesthetics can be classified as local or general, depending on their application. General anesthesia suppresses CNS activity, leading to unconsciousness and a total lack of sensation, often accompanied by varying levels of analgesia and muscle relaxation. Anesthesia and sedation are generally divided into several stages that reflect the depth of the anesthetic effect. The most common fish anesthetic technique is adding the anesthetic agent to the water. This agent is inhaled through the gills, diffuses rapidly to the secondary lamellae, and enters the efferent arterial blood. This short route delivers the anesthetic to the brain, where it exerts its effect, similar to inhalation anesthesia in terrestrial animals. This method is convenient, as it does not require physical restraint during administration. Physical restraint should be avoided as it may activate the hypothalamic–pituitary-inter-renal axis, inducing cortisol release and triggering secondary stress responses. While using the immersion method, the water should be aerated during the anesthesia's induction, maintenance, and recovery phases. Adding oxygen to the water is preferable to ensure oxygen saturation. Still, hyper-oxygenated water must be avoided as it depresses ventilation, cause hypercapnia, and potentially lead to life-threatening acidosis. Common anesthetics used in immersion techniques include benzocaine, lidocaine, MS-222, and 2-phenoxyethanol. In contrast, injectable anesthetics are less commonly used to fewer available drugs. For fish, the intra-peritoneal route is the most common method of injection. Intravenous injection of fast-acting anesthetics is feasible in larger fish during the intramuscular route for administering low volumes of anesthetics. However, the efficacy of intramuscular injection depends on the presence of developed red muscle in the fish. The optimal route of administration depends on the type of anesthetic, as well as the size and physiological characteristics of the fish.

Properties of Ideal Anaesthetics Used During Transportation of Fish:

- It should be easy to administer.
- The anesthetic should be water-soluble.
- It should induce anesthesia rapidly with minimal hyperactivity or stress.

- The anesthetic should be effective at low doses.
- The time of induction and recovery should be short.
- Recovery should be rapid When the fish is removed from the anesthetic.
- The chemical should not have any side effects on the fish.
- The lethal concentration should be high, ensuring fish are not accidentally killed even if a slightly excessive dosage is administered, especially during long transport.

Stages of anesthesia in fish:

Stage	Condition	Behavior
I	Sedation	Loss of equilibrium
II	Anesthesia	Loss of gross body movements with continued opercular movements.
III	Death	Loss of opercular movements, heartbeat, and eventual death [overdose].

The stages of anesthesia differ by species and type of anesthesia given to the fish at the time of transportation.

Types of anesthetic agents
Natural anesthetic agents:
Clove oil:

Clove oil is a dark brown liquid resulting from the distillation of flowers, flower stalks, and leaves of clove trees (*Eugenia aromatica*). It is the most common and, reputedly, the most effective fish anesthetic, with eugenol as its active compound. The safe limit for clove oil – 0.02 ppm concentration. Clove oil decreases neuro-sensory function by acting on the nervous system and also has an inhibitory effect on the fish respiratory system, lowering the respiratory rate (Keene *et al*., 1998); however, at high concentrations, it may affect the spinal cord, brainstem, and respiratory system, potentially causing respiratory failure and death. Therefore, it is essential to carefully balance the anesthetic concentration and its effect on fish to maximize benefits.

Rosewood oil:

Rosewood essential oil (*Aniba rosaeodora*) is an affordable and readily available scented herbal oil. It contains linalool, which induces anesthesia by gently acting on the central nervous system. Goldfish (*Carassius auratus*), one of the most popular ornamental freshwater fish species globally, can be anesthetized using rosewood oil. In goldfish, it causes a complete loss of equilibrium, swimming ability, opercular activity, and meddular collapse. However, clove oil has been proven more effective for immobilization in goldfish.

Chamomile oil:

Chamomile oil is another herbal anesthetic suitable for fish. It has been tested on rainbow trout and is physiologically appropriate at a concentration of 100 µL/L, with no adverse histologically or biochemically effects, even if the induction time exceeds the desired time.

Other natural anaesthetic

Seeds from the fish poison tree (*Baringtonia asiatica*), rubber seeds (*Hevea brasiliensis*), and tuba roots (*Derris elliptica*) are also used as anesthetics, although their application is rare.

Chemical anaesthetic agents:
MS-222:

The chemical name for MS-222 is tricaine methanesulfonate. A white crystalline powder dissolves easily in water (1.25 g/mL, at 20^{o}c). MS-222 is highly effective for the rapid induction of deep anesthesia.

Lidocaine

Lidocaine [2-(diethylamino)-N-(2,6-dimethyl phenyl) acetimide] is generally used in its hydrochloride salt form, which is water soluble. In its freebase form, lidocaine is insoluble in water but freely soluble in acetone or alcohol. It is a cardiac depressant.

Benzocaine:

Benzocaine [p-aminobenzoic acid ethyl ester] exists in two forms: a crystalline salt with water solubility of 0.4 g/L and a freebase form, which must be dissolved in ethyl alcohol first at 0.2 g/mL.

Quinaldine

Quinaldine is a yellowish, oily liquid with limited water solubility that must be dissolved in acetone or alcohol before mixing with water. While effective as an anesthetic, quinaldine is an irritant to fish, has an unpleasant odour, and is a carcinogen. Despite these drawbacks, its low cost has made it popular for collecting tropical fish in the aquarium trade and bait or sport fish industries.

Nonchemical anesthesia:

Hypothermia

Lowering water temperature is a technique used to tranquilize or immobilize fish. Cooler water increases water's oxygen-carrying capacity while reducing fish's activity and oxygen consumption. This method can be achieved by refrigerator or adding ice to the water. Gradual cooling is recommended to avoid thermal shock, as rapid chilling can harm the fish. Hypothermia has been primarily used for fish transportation due to its simplicity and effectiveness.

Electro-Anesthesia

Electro-anesthesia involves the use of electricity as an alternative to chemical anesthetics. Alternating current (AC) and chopped direct current (DC) have been used for many years, especially in electrofishing.
In freshwater, fish are more conductive than water, so the electrical current passes through the fish, immobilizing them. Low-voltage DC renders fish immobile but does not produce true anesthesia, and its effect lasts only while the fish are within the electrical field. AC current is more effective for larger fish, which are affected more rapidly than smaller ones. The duration of immobilization increases with the fish's body length. However, electro-anesthesia is ineffective in seawater because seawater's conductivity surpasses that of the fish.

Carbon dioxide (CO2)

Carbon dioxide is a colorless, odorless, non-flammable gas with a water solubility of 1.71 L/L at 0 ^{0C}. It is considered a safe method of anesthesia for fish, but adequate ventilation is crucial. CO2 levels exceeding 10% in the air can cause anesthesia or even death in humans (Bell, 1987).

CONCLUSION:

Anesthetics are indispensable in modern aquaculture, serving as essential tools for minimizing stress and ensuring the safe handling of fish during transportation, sampling, vaccination, and other management procedures. By immobilizing fish and inducing loss of equilibrium and consciousness, anesthetics significantly reduce the risks associated with handling and enhance the welfare of aquatic animals. However, the efficacy of anesthetic agents depends on multiple factors, including the species of fish, the dosage used, and the application method. It is crucial to adhere to recommended dosages or conduct preliminary trials on small groups of fish before scaling up to more extensive operations. The careful selection of appropriate anesthetics for specific species and ensuring the use of certified agents are vital for achieving effective and safe outcomes. As aquaculture grows, the proper application of anesthetics will remain a cornerstone of sustainable and responsible fish farming practices.

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