Journal of Research in Forestry, Wildlife & Environment Vol. 9(2) June, 2017

http://www.ajol.info/index.php/jrfwe

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E-mail:jfewr@yahoo.com

ISBN: 2141 – 1778

Omeji et al.. 2017



## STRESS CONCEPT IN TRANSPORTATION OF LIVE FISHES – A REVIEW

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***ABSTRACT***

***This paper review covers work done on various methods of transporting live fishes, factors to consider for fish transportation, the stress concept and how stress can be minimized during fish transportation. It reviews the responsibility of transport personnel(s) or company when carrying out the duty of transporting live fish, the effect of handling of fish during transportation, crowding of fish in the transport container, temperature of the transporting water, and the various water parameters that affects the water quality and how this parameters can be maintained at an optimum level of the fish.***

**Key words:** Stress, live fish, stressor, handling, crowding, water chemistry and water parameter.

## INTRODUCTION

There is supply-demand gap for fish and fisheries products in Nigeria (FAO, 2006) and this has necessitated the importation of fish to meet the dietary requirement of the people. Moehl (2003) confirm that Nigeria is one of the largest importers of fish in the developing world importing about 600,000 metric tons annually. These fish has to be transported among the states in the country. Transportation of fish is generally an important practice in aquaculture. In transporting life fishes, there are technicalities in which one needs to understand for successful transportation of the fish. Fish are at least transported twice during their life time; one from the hatchery to the growing site and secondly to slaughter station (Vitenskapskometee for mattrygghet, VKM, 2008). In most cases, fries, fingerlings and brood stock fish and even harvested fish may also be transported in life form to the market. Fries and fingerlings may be transported from the hatchery into the production tank on the same farm or another farm. Brood stock fish may be transported from one farm to another for breeding purpose. Table size fish are transported from the farm to the market and these may also be needed in life form. When fish are placed in transport container, they should be brought to their destination by the quickest possible means that will provide relatively smooth and direct route (N.A.E.R.L.S., 2001; *www.thefishsite.com*, 2006).

## FISH WELFARE DURING TRANSPORT

Attitudes towards animal welfare are rapidly changing. In particular, the welfare of fish is increasingly brought to the forefront of public concern (Pottinger, 1995; Rose, 2002; Braithwaite and Huntingford, 2004; Chandroo *et al.*, 2004; Sneddon, 2004; Ashly 2007). Some authors have concentrated on identifying conditions that must be fulfilled if an animal’s welfare is to be considered acceptable. Even still under debate suggested welfare criteria for fish are freedom from severe (long lasting) stress, suffering and pain. However, Dawkins (2004) summarized different aspects of welfare by introducing the view that one should only ask two questions in order to describe the welfare of an animal; (1) “is the animal healthy?”And (2) “does the animal get what it wants?” While suffering and pain is not as easy to deal with in fish, stress responses are much better documented in farmed fish species. Rose (2002) in his overview article reported that fish cannot experience pain and suffering owing to the fact that fish do not have the brain structures necessary to perceive the emotional side of pain. He suggested that the nociceptive activity in the nervous system observed in fish exposed to a potential noxious stimuli, are reflex responses. Researchers have now shown that fish do have a nociceptive system such as nociceptors and nerve fibres (Sneddon, 2002, 2003b; Braithwaite and Huntingford, 2004), and that change of behaviour in trout is actually a consequence of noxious stimulation (Sneddon, 2003a; Sneddon *et al*., 2003; Sneddon, 2004). Physical disturbances during the transport (Sigholt *et al*., 1995; Erikson *et al*., 1997; Jittinandana *et al*., 2005) and slaughter of fish (Azam *et al*., 1989; Faergemand *et al*., 1995; Roth, 1997; Robb *et al*., 2000; Van de Vis *et al*., 2003) are unavoidable in aquaculture and have potential to induce stress responses that affect meat quality. In general, stressed fish undergo accelerated, post-mortem metabolism and develop softer muscle texture in a manner similar to that of mammals (Jerrett *et al*., 1996; Jerrett and Holland, 1998; Sigholt et al., 1997).

All personnel handling fish throughout the transportation process are responsible for ensuring that consideration is given to the potential impact on the welfare of the fish (OIE Aquatic Animal Health Code, 2010). The roles of each of the various personnel are defined below:

1. The responsibilities of the Competent Authority for the exporting and importing jurisdiction include:
a. establishing minimum standards for fish welfare during transport, including examination before, during and after their transport, appropriate certification and record keeping;
b. ensuring awareness and training of personnel involved in transport;
c. ensuring implementation of the standards, including possible accreditation of transport companies.
2. Owners and managers of fish at the start and at the end of the journey are responsible for:
a. the general health of the fish and their fitness for transport at the start of the journey and to ensure the overall welfare of the fish during the transport regardless of whether these duties are subcontracted to other parties;
b. ensuring trained personnel supervise operations at their facilities for fish to be loaded and unloaded in a manner that causes minimum stress and injury;
c. having a contingency plan available to enable humane killing of the fish at the start and at the end of the journey, as well as during the journey, if required;
d. ensuring fish have a suitable environment to enter at their destination that ensures their welfare is maintained.
3. Transport companies, in cooperation with the farm owner/manager, are responsible for planning the transport to ensure that the transport can be carried out according to fish health and welfare standards including:
a. using a well maintained vehicle that is appropriate to the species to be transported;
b. ensuring trained staff are available for loading and unloading; and to ensure swift, humane killing of the fish, if required;
c. having contingency plans to address emergencies and minimise stress during transport;
d. selecting suitable equipment for loading and unloading of the vehicle.
4. The person in charge of supervising the transport is responsible for all documentation relevant to the transport, and practical implementation of recommendations for welfare of fish during transport.

## STRESS CONCEPT

VKM (2008) outline the factor that leads to stress in fish these includes handling, crowding, temperature, and water quality. Stress is defined as a condition in which the dynamic equilibrium of animal organisms called homeostasis is threatened or disturbed as a result of actions of intrinsic or extrinsic stimuli, commonly defined as stressors (Selye 1950, 1973; Schreck, 1982; Wendelaar Bonga, 1997; Iwama *et al*., 1997; Portz *et al*., 2006). Acute stressors produce effects that threaten or disturb the homeostatic equilibrium, and they elicit a coordinated set of behavioural and physiological responses thought to be compensatory and/or adaptive, enabling the animal to overcome the threat. If an animal is experiencing intense or chronic stress, the stress response may lose its adaptive value and become dysfunctional, which may result in inhibition of growth, reproductive failure, and reduced resistance to pathogens. Responses to both acute and chronic stress typically involve all levels of animal organization and are collectively called the integrated stress response (Wendelaar Bonga, 1997; Barton, 2002; Iversen *et al.,* 2004).

The general pattern of the stress response tends to be similar whether the challenge has resulted from fish cultural procedures (netting, transportation, and disease treatments), water chemistry changes (turbidity, pH, temperature), or changes in behaviour (fright, dominance hierarchies). A convenient paradigm for the stress response is to think of it as occurring in three stages as described in Wedemeyer (1996) and Iwama *et al*. (2006) This include an initial alarm reaction (primary response) characterised by activated pituitary-interrenal axis with release of catecholamine and corticosteroid hormones. The secondary response, or stage of resistance, includes successful compensation and acclimation, often with energy loss and growth retardation. If the stressful challenge has exceeded acclimation tolerance limits, the fish reach the final stage of exhaustion (tertiary response), with maladaptation, immune deprivation, and secondary diseases involving the whole fish population (Iwama *et al*. 2006).

Transportation of brood stock should be done with care so as to reduce stress of the brood stock. Aiyelari, *et al*., (2007) reported that external factors such as confinement, starvation, transportation, and dryness results into prediction pattern of physiological changes which among other things attributes to weight loss and poor gamete quality of the stress brood stock *Clarias gariepinus*. Therefore, it is recommended that stress should be minimal to guarantee optimal gamete quality production in fish.

## STRESS DURING TRANSPORTATION

### 1. Handling

Transportation and handling procedures consists of several potential stressors, such as capture, on-loading, transport, unloading, temperature differences, water quality changes and stocking (Iversen *et al*. 1998, 2003, 2005; Finstad *et al*. 2003; Portz *et al*. 2006; Ashley 2007). Among others, stress related cortisol releases in fish may suppress immunological capacity (Ellis 1981; Schreck *et al*. 1993; Einarsdóttir *et al*. 2000), affect seawater tolerance (Iversen *et al*. 1998; Sandodden *et al*. 2001), growth (Beitinger 1990; Bernier and Peter 2001) and survival (Barton and Iwama, 1991; Wendelaar Bonga, 1997). Handling of fish during transportation has a great effect on the fish, Barton *et al*., (1991) also reported that stress of capture and handling has profound effect on the blood chemistry and stimulated gonadotropin, androgen and the stress hormone cortisol.

### 2. Crowding

There is a difference between loading and density (Portz *et al*. 2006). While loading is defined as the weight of fish per unit of flow (kg/l/min), density refers to weight of fish per unit space (kg/m3). Confinement may describe the entire volume of a small tank (Fevolden *et al*. 2003) or to a restricted net volume within a larger tank (Ruane *et al*. 1999). When the system is static the fish have a decreased volume for water exchange, potentially affecting water quality and related stress responses. This type of stress is often associated with high stocking densities leading to crowding stress. Short term crowding stress occurs commonly in aquaculture practices; possess characteristics of acute as well as chronic stress with long-term compromised immune systems resulting in disease or death (Portz *et al*. 2006). Therefore, optimal densities at loading and in transport tanks should always be taken care of regardless of profitability or convenience (Ellis *et al*., 2002; Portz *et al*., 2006).

### 3. Temperature

Fish are poikilotherms and an increase in ambient temperature will increase their metabolic rate. Thermal stress occurs when the water temperature exceeds the optimal temperature range, with energy demanding stress responses, and potential decrease in individual survivorship (Elliot 1981; Port *et al.,* 2006). Most fish can gradually acclimate to normal temperature changes but rapid changes in temperature, as may happen under fish loading and transportation, may result in thermal stresses or lethal conditions (Portz *et al*., 2006). The ion- and osmoregulatory functions may be depressed due to thermal stress (Finstad *et al*., 1988; Houston and Schrapp, 1994). Reduced feed intakes and growth, reduced swimming behaviour, sudden or erratic movements with possible collision with the tank wall or other fishes, increased regurgitation, defecation and gill ventilation are among thermal stress related behaviour (Elliott, 1981; Kieffer, 2000; Portz *et al.*, 2006). Recommendation for short-term holding of fish according to Portz *et al.*, (2006) and Wedemeyer (1996) states that the temperature should be similar to the original source, to avoid thermal shock when the fish are transferred to the holding system. N.A.E.R.L.S., (2001) reported that warm-water fish species (tropical fish) are suitably transported in water temperatures ranging from 18 to 28 degrees centigrade. The ideal temperature is 21 to 25 degrees centigrade. Warm water holds less oxygen than cold water. Respiratory requirements of fish are also greater at higher temperatures. Thus fewer fish can be transported per unit volume of warm water. The golden rule of fish transport is to always maintain sufficient oxygen in the transport water (N.A.E.R.L.S., 2001). This can be done in the following ways:

i. Keep transport containers cool. They should always be kept shaded and out of direct sunlight. As water warms, it holds less oxygen, so prevent rapid warming of the transport containers.
ii. Ice may be packed around containers on long trips. Do not add ice directly to the water containing the fish. Be careful to prevent water from dropping below $18^{O}$C when using ice.
iii. A wet cloth may also be wrapped around containers to reduce temperature by evaporative cooling if ice is not available.

### 4. Water quality

Temperature, dissolved oxygen, ammonia, nitrite, nitrate, salinity, pH, carbon dioxide, alkalinity and hardness in relation to aluminium and iron species are the most common water quality parameters affecting physiological stress (Stefansson *et al.*, 2007).

## CONSIDERATION FOR FISH TRANSPORT

N.A.E.R.L.S., (2001) and www.thefishsite.com (2006) reported that fish transport must be done carefully in order to successfully take them to their destination. A poorly organized effort may easily result in death of fish. The following factors directly influence fish transport

a. Tolerance to transport: Tolerance of fish to transport is related to their ability to resist or adapt to stressful conditions. Their resistance also change as they pass through various life stages. Table I. indicates stress tolerance levels of some commonly cultured fish.

b. Presence of food in the intestine: Fish survive transport better if they have no food in their intestines. For this reason they could be starved for 1 or 2 full days prior to the time they will be transported. The fish stop eating and this helps them adapt to the stress of artificial spawning. Fish can also be harvested and held in net enclosures or tanks for 24 to 48 hours with clean, preferably gently running water. The fish pass food out of their intestines and will be in good condition for transport.

c. Age and size of fish: A lower weight of small fish can be transported per unit volume of water than large fish. Fish can be broadly classified into four main groups according to what life cycle stage they are in. These includes; Newly hatched fish with yoke sac are called larvae or sac fry, Post larvae do not have a yoke sac and are commonly called fry, 3 to 4 weeks old fish weighing more than 1g may be called a fingerling juveniles (5-8 weeks) may weigh 3-5g and Sexually matured fish are often called brood stock. This is summarized in table II. and the figures are based on transporting fish in sealed plastic bags containing oxygen and about 8 litres of clean water at approximately 18C.

## METHODS FOR TRANSPORTING LIFE FISH

There are two basic transportation systems for live fish: the closed system and the open system. The choice of transport system depends on the facilities available to the purchaser, the distance, number and size of fish species (N.A.E.R.L.S., (2001) and www.thefishsite.com, 2006).

1. Transportation by open system: The open system consists of water filled containers in which the basic requirements for survival are supplied continuously from outside sources. The simplest of these are small tanks, plastic containers, cans,

buckets, bowls, boxes, calabashes, clay pots, trucks, vans, etc. It is suitable for movement of fish within the farm for short distances and for periods not longer than 2 hour except for catfishes which can endure 5 hours. For longer distances, air or oxygen should be supplied constantly or intermittently. It is suitable to transport catfishes for long distances but water must be renewed (changed) at intervals of 4-5 hours or less if the weather (water) gets hot. The advantage of this method is that it is simple, economical and requires no special skill for adoption. It is however risky. Fingerlings can die through water splashing in the container. Open method is also limited by time and distance.

2. Transportation by closed system: The closed system makes use of sealed containers in which all the basic requirements for fish survival are self contained. It is by far the most ideal method for live fish transport. The suitable container is oxygenated polyethylene (plastic) bags or tanks. They are best used for long distance transportation of fingerlings of Tilapia, Carp, Heterotis and other weak species of fish. Plastic bags should not be used to transport brooder/adult fish or post fingerling with sharp spines, as this will result in bursting of the container. It is essential to maintain adequate oxygen in the water while transporting fish using this method. The technique recommended for oxygenating water during fish transport is the use of pure bottled oxygen. It may be bubbled continuously into an unsealed container during transport, or injected into a plastic bag containing water and fish which is then sealed air-tight for transport. When plastic bags are used, oxygen is added after water and fish. One-fourth of the bag usually contains water and fish and three fourths contains oxygen. After adding oxygen the bag is sealed shut with a twisted rubber band, string or other material. As a precaution against leakage, the first plastic bag should be placed inside a second bag whenever possible. The sealed double bag of fish is then placed in a box or other container for added protection and loaded onto a vehicle for transport. If properly packaged and insulated from heat, these containers can transport fish for 24 to 48 hours without water exchange.

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