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Global quality assessment in Mediterranean aquaculture

Zaragoza : CIHEAM
Cahiers Options Méditerranéennes; n. 51

2000
pages 45-49

Influence of fish health management: Bases, procedures and economic implications

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SUMMARY – As aquaculture assumes an expanding role in meeting consumer demands for fishery products, it is natural that they meet safety and quality standards. In addition to residues of agro-chemicals, veterinary drugs and heavy metal organic and inorganic contamination, infectious fish diseases represent one of the most important problems and challenges in aquaculture production, both from an economic and sanitary point of view. Diseases increase cost and reduce profit because of loss in dead fish, cost of treatment or decreased growth rate of diseased and convalescent fish. The fish is usually exposed to pathogens or potential pathogens, but in fish diseases, a simple association between the pathogen and the host fish does not occur. Environmental circumstances that arise in intensive fish farming systems represent a considerable stress, making fish more susceptible to a wide variety of pathogens. In aquaculture, many of the potential hazards at the production level can be controlled by good fish farm management practices, which control infectious diseases and improve the safety of the products. Successful fish health management starts with prevention of disease rather than treatment, and this is accomplished through the implementation of integrated measures at the production level. This global management will contribute to produce safer fish products.

Key words: Aquaculture, health management, fish diseases.

RESUME – *"Influence de la gestion sanitaire du poisson : bases, procédures et implications économiques". Tandis que l'aquaculture assure un rôle grandissant pour satisfaire les exigences des consommateurs concernant les produits aquacoles, il est naturel qu'ils répondent aux normes de sécurité et de qualité. En plus des résidus des produits agrochimiques, des médicaments vétérinaires et de la contamination organique et inorganique des métaux lourds, les maladies infectieuses des poissons représentent l'un des plus importants problèmes et défis de la production aquacole, tant du point de vue économique que sanitaire. Les maladies augmentent le coût et réduisent le bénéfice à cause des pertes en poissons morts, du coût du traitement ou d'un taux de croissance diminué pour les poissons malades ou convalescents. Les poissons sont généralement exposés à des pathogènes ou pathogènes potentiels, mais pour ce qui est des maladies des poissons, ce n'est pas une simple association entre le pathogène et le poisson-hôte. Les circonstances environnementales qui ont lieu en général dans les systèmes d'élevage aquacole intensifs représentent un stress considérable, et rendent les poissons plus vulnérables à une grande variété de pathogènes. En aquaculture, une grande partie des risques potentiels au niveau de la production peuvent être contrôlés par de bons usages de gestion des fermes aquacoles, qui représentent une bonne façon de contrôler les maladies infectieuses et d'améliorer la sécurité des produits. Une bonne gestion sanitaire des poissons commence par la prévention des maladies plutôt que le traitement curatif, et ceci se fait en mettant en place des mesures intégrées au niveau de la production. Cette gestion globale contribuera à produire des produits aquacoles plus sûrs.*

Mots-clés : *Aquaculture, gestion sanitaire, maladies des poissons.*

Aquaculture is one of the fastest growing food-producing sectors, providing an acceptable supplement to and substitute for wild fish. During the past years the total production of cultured finfish and shellfish have increased in production quantity and value. Global aquaculture production is estimated at nearly 10 million metric tons annually, and it contributes more 12% of the total consumed fish and shellfish (Pérez and Rodríguez, 1997). In general, although the global contribution of aquaculture by quantity to total world aquatic production, the relative importance of aquaculture to national aquatic production varies greatly. Regional, cultural and historic attributes have influenced both the production base and rate of expansion of aquaculture. The historic tradition of growing fish in Asia has played a significant role in maintaining its dominant position. In Europe, the aquaculture production has significantly increased both in production quantity and value during the last years. In the European Union, Norway and France are the countries with highest aquaculture production (20% each of the total UE production), followed by Italy (16%), Spain (10%), UK (6,5%) and The Netherlands (6%) (Rana, http://www.fao.org/fi/publ/circular/c886.1/tren886.asp). The main types of fish production in Europe are salmonid sea cage farming (salmon), sea farming of non-salmonid fish (sea bass, sea bream and turbot), rainbow trout raceway farming, continental pond farming (carp, crucian carp, tench) and intensive recirculating units (eel, tilapia) (Bernardet, 1998).

No animal production programme has ever been successfully performed without considering animal health. Diseases are considered the most limiting factor to aquaculture production, both from an economic and sanitary point of view. There are two types of disease that affect fish, non-infectious (environmental, nutritional or genetic), and infectious diseases. These latter are contagious and represents the most important diseases in aquaculture because they increase the cost production due to the losses in dead fish, costs of treatments or decreased growth rate of diseased and convalescent fish. As previously observed in other animal production systems undergoing similar changes, the intensification of fish farming combined with the introduction of news species through the routes of commercial exchanges, has inevitably led to the increase of some infectious diseases and to the emergence of others, all favoured by the high stocking densities and stress of intensive farming. It is difficult to evaluate the real economic losses, due to the different factors related; however, it has been estimated that 10% of all cultured aquatic animals are lost as a result of infectious diseases (Leong and Fryer, 1993). In addition, food-borne infections associated with pathogenic microorganisms have been identified as possible hazards in aquaculture products. These hazards are generally associated with the general condition of the environmental habitat, the species being farmed, and cultural habits of food preparation and consumption.

Infectious diseases are caused by pathogenic organisms (parasites, bacteria, virus and fungi) present in the environment or carried by other fish. In fact, fish are usually exposed to pathogens or potential pathogens, but in fish diseases a simple association between the microorganism and the host fish does not occur. Infectious disease results from a series of complex interacting variables of the pathogen, host and environment. Many characteristics of pathogens are directly relevant in the disease development (Hedrick, 1998). These include whether the microorganism is always associated with infection of the host ("obligate") or whether it can survive in the absence of the host ("facultative"). The virulence of the pathogen depends on the strain, biotype, serotype or genotype of the agent (Engelkin *et al.*, 1991). The occurrence of the disease upon interaction of the pathogen with the fish depends on several host factors such as age, size, development stage, nutritional and reproductive statuses and immunological defences of the host. Moreover, there are many other predisposing factors which contribute in the development of the infectious disease. Environmental circumstances (poor water quality, changes in temperature, poor nutrition, crowding, transporting, etc) usually produced in intensive fish farming systems, represent a considerable stress making fish more susceptible to a wide variety of pathogens (Reno, 1998).

The most important factor involved in fish health management is water quality. Fish perform all their bodily functions in water. Because fish are totally dependent upon water to breathe, feed and grow, excrete wastes, maintain a salt balance, and reproduce, understanding the physical and chemical qualities of water is critical to successful aquaculture. Non-infectious diseases are commonly found as a result poor water quality. The quantity of available dissolved oxygen, the pH, and the amount of waste products are the most important factors to be considered (Richards, 1983). Available dissolved oxygen is probably the most critical of these, being affected by the temperature, the origin of water and the biological demand (i.e. high concentrations of bacteria and decaying matter). The pH of the water should be stable and just below 7. The level of waste products should be low and particular attention paid to the presence of excessive carbon dioxide which will be toxic to the majority of fish, and a build up of ammonia may cause the pH to go above 7.5 (Cawley, 1983). On the other hand, water is usually a vehicle of microorganisms which are potential pathogens for fish and/or humans. The level of contamination of aquaculture products by pathogenic agents will depend on the environment and the microbiological quality of the water where the fish is cultured. There are two broad groups of microorganisms of public health significance that will contaminate products of aquaculture: those naturally present in the environment, and those introduced through environmental contamination by domestic animal excreta and/or human wastes. Non-indigenous microorganisms can be introduced into aquaculture ponds via unavoidable contamination by birds and terrestrial animals associated with farm waters, and significant numbers of these remain on the skin and in the guts of fish and can pose a health risk to consumers. In addition, some of the microorganisms contained in the water are also potentially pathogens for fish. Actually, the transmission of some diseases can occurs in areas where the high density of farms requires the use of water contaminated by neighbouring installations (Barg and Phillips, http://www.fao.org/fi/publ/circular/c886.1/env97-4.asp).

Nutrition plays a major role in economical aquaculture production as well as in the sanitary state of fish farms. In fact, nutrition disorders are usually interrelated with marketability losses and infectious diseases. Healthy fish are clearly dependent on the nutritional state, being a clear link between undernutrition and disease. Undernutrition makes the fish more susceptible to infection and decreases immune defences against invading pathogens. Thus, undernutrition predisposes fish to infections. Likewise, infections can alter nutritional status mediated by changes in dietary intake, absorption and nutrient requirements and losses of endogenous nutrients (Calder and Jackson, 2000). Nutritional diseases are difficult to diagnose and rely on histopathological examination and laboratory analysis. As most fishes are fed on artificially composed diets using feeding tables supplied by manufacturers, nutritional diseases due to an overfeeding or an underfeeding are rarely found. However, nutritional deficiencies, particularly vitamin deficiency, have been occasionally diagnosed.

Diseases occur in natural populations and the presence of pathogens can also occur in the absence of disease. Since removal of the pathogen is an unrealistic option, it is important to know how to minimize the risk of infectious disease. In this sense, the application of hygienic and preventive measures of the environment, such as fish health management practices, sanitation and disease control procedures are critical factors to prevent fish disease. Aquaculture has the advantage that it is possible to control the production system, and many of the potential hazards at the production level can be controlled by using good fish farm management practices. Daily observation of fish behaviour and feeding activity allows early detection of problems when they do occur so that a diagnosis can be made before fish becomes sick. Stress situations due to fish movement or overcrowding are usually found in aquaculture and can contribute to the appearance of fish diseases by parasites and bacteria (Francis-Floyd, http://edis.ifas.ufl.edu/BODY.FA004). Water is also a vital component of a fish farm and must be checked thoroughly by chemical (oxygen, ammonia and nitrite concentrations, pH values) and microbiological analysis.

Sanitation practices should include disinfection between groups of fish, cleanliness while fish are growing, and sanitation treatment for facilities, equipment, personnel or water. Some infectious diseases, particularly external fungal and bacterial infections and parasitic diseases are often attributed to accumulation of organic material in the culture unit. Ponds may be sanitized between groups of fish by draining, drying, and in some instances by use of a chemical sterilant such as hydrated lime. Any equipment used in a fish pond should be thoroughly dried or chemically disinfected before being used in another pond. Footbaths and areas for employees to wash hands with a disinfecting soap should be placed at the entrance to buildings and between building's rooms (Francis-Floyd, http://edis.ifas.ufl.edu/BODY.FA004). Technological advances in water filtration and the use of probiotics and bioaugmentation appear to offer the best procedures for the improvement of aquatic environmental quality.

Quarantine and health certification form part of the control disease programs addressed to prevent the spreading of epizootic bacterial and viral infectious diseases by movement of fish, eggs, and in certain cases, movement of water between different fish farms. These preventive measures must also be a first line of defence against possible adverse effects resulting from the introduction or transfer of exotic fish and shellfish (Subasinghe, http://www.fao.org/fi/publ/circular/c886.1/health.asp). As such, they must be developed within the context of larger regional, national, and international plans addressing the establishment of "free disease areas". The existence of advisory services and the development of regionally agreed-upon lists of certifiable pathogens, the standardization of diagnostic techniques and the production of health certificates of unambiguous meaning, are very important in this field. Research is also needed to create safer and faster diagnostic methods and improved treatment methods for acute diseases. During the last years, several studies have demonstrated the utility of molecular techniques for sensitive and rapid detection of important fish pathogens, particularly those which are difficult to identify by conventional methods. DNA probes and PCR assays have been successfully developed for monitoring the presence of the pathogen in environmental samples (O'Brien *et al.*, 1994), as well as in clinical samples such as broodstock and tissues (Miriam *et al.,* 1997). Other DNA-based techniques such as ribotyping, randomly amplified polymorphic DNA and pulsed-field gel electrophoresis of DNA are important methods to genetic relatedness among isolates from different geographic regions, and then they are useful in epidemiological studies (Arias *et al.,* 1998).

The control of bacterial diseases can be done by the use of chemotherapeutic agents and vaccines. The main antimicrobial drugs currently used in aquaculture are either antibiotics or synthetic compounds. As many fish pathogenic bacteria have been shown to survive in infected areas, in the environment or in carrier fish, chemoprophylaxis has become a usual practice in fish farms in order to prevent the possible development of bacterial diseases. In addition, these antimicrobials are used as growth promoters (i.e. tetracyclines). As consequence of the malpractice of the antimicrobials an increase in the drug resistance among bacterial fish pathogens has been reported during the last years. These resistances reduce the efficacy of fish disease control, but it also could contribute to their transmission to human pathogens. Another important problem derived from the use of antimicrobials in fish farms is the accumulation of residues in fish meat, as well as the environmental impact of these antimicrobials. Use of drugs in the aquatic environment had become a serious problem around 1990. Stricter legislation has been requested under the pressure of human clinicians, environmentalists and consumer associations, resulting in the reduction of the number of authorized antimicrobial drugs for aquaculture in order to prevent all these negative effects (Michel, 1998). Although the use of antimicrobial drugs in aquaculture is rapidly decreasing in major fish producing countries (Reno, 1998), the use of new antibiotics and medicines are helpful tools in the treatment of acute infectious diseases, making necessary a great collaboration between the pharmacological and feed industries.

Vaccination of fish is the alternative to the antimicrobials for controlling infectious diseases. It is becoming an increasingly important part of aquaculture, aimed at preventing and controlling infectious diseases in fish farms and at reducing the use of antimicrobial drugs. In the recent years, fish vaccination has greatly benefited from the better understanding of the immune system of fish, and of the identification of the virulence factors of the main fish pathogens (Gudding *et al*., 1999). Live, attenuated vaccines should potentially have many advantages in preventing fish infection by stimulating the cellular immunity, and by an effective dissemination of the antigen in the population (Benmansour and de Kinkelin, 1997). However, the use of live attenuated vaccines in aquaculture is highly controversial, and most authorities consider live vaccines to be undesirable because of the risk of uncontrolled spread in the aquatic environment. Commercial vaccines are available against different bacteria (*Yersinia ruckeri, Aeromonas salmonicida, Vibrio anguillarum, V. ordalii, V. salmonicida, Edwarsiella ictaluri*). These consists of formalin-killed broth cultured (bacterines), and they frequently include an adjuvant and therefore have to be administered by injection. But some vaccines can also be delivered by other routes, such as immersion, spray, and oral. Administration strategy depends on the size and species of fish, the bacterial species, and the type of vaccine available. For viral pathogens, antigens produced by several viruses administered by injection or immersion have been shown to elicit protective immunity. However, for several viral diseases, the level of protection has been too low for commercial use (Gudding *et al*., 1999). New technologies are used to obtain effective fish viral vaccines, like recombinant technology and DNA immunization (Boudinot *et al*., 1998). At present, there is only one commercial viral vaccine against IPN, which has been developed from a recombinant protein of the IPN virus.

In summary, fish diseases are the end result of interactions of the disease, the fish and the environment. Fish in intensive culture are continuously affected by environmental fluctuations and management practices. All these factors should be considered for fish health control by preventing diseases rather than treatment.

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