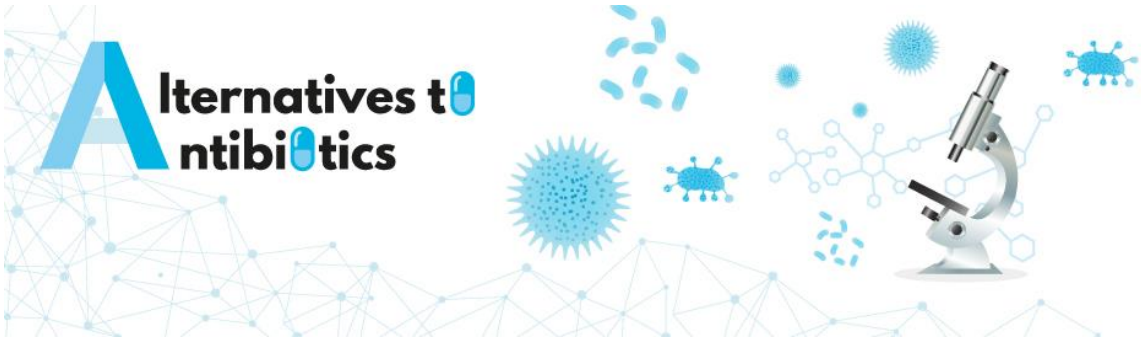

Research Gap Analysis Workshop

National Animal Disease Center
Ames, Iowa
April 5-7, 2016

Aquaculture Working Group Report

In the United States the two primary fish farming commodities are catfish and trout. According to 2016 National Agricultural Statistics Service reports, there was between $330-345 million in catfish sales and $110-115 million in trout sales for the 2014-2015 production cycles. For catfish this averaged 200 million pounds of live weight and for trout roughly 60 million pounds (1-2). A comprehensive 2010 APHIS report revealed that major losses in the catfish industry were primarily due to bacterial diseases and the 2016 trout production report also cited disease as the major cause for food fish loss. The use of antibiotics is the primary method of combating bacterial diseases in production systems. The average use of medicated feed/operation in the 2009 production year for catfish was 22.3 tons of Aquaflor, 10.8 tons of Romet and 2.8 tons of Terramycin (3). Reports on individual operational use of antibiotics in the trout industry are less well defined; however antibiotics are being used to treat bacterial diseases. Traditionally the primary pathogens associated with catfish farming have been *Flavobacterium columnare* and *Edwardsiella* sp. accounting for 30% of food fish losses (3). However since 2009, primarily in East Mississippi and West Alabama, a third pathogen has emerged, virulent *Aeromonas hydrophila* accounting for 15% of losses as opposed to only 0.6% in the Mississippi Delta (3). The latter has surpassed *Edwardsiella* sp. and is now as prevalent as *F. columnare* (3-4). In the trout industry the primary pathogen has been *Flavobacterium psychrophilum*, however more recently *F. columnare* has emerged as a significant problem. Collectively, these bacteria can affect all production stages; from fry to fingerling through food size fish, and are considered to cause the major diseases of farmed fish where the availability and use of alternative strategies could reduce the use of antibiotics (Table 1).

Potential non-antibiotic solutions may include one or more of the following: vaccines, selective breeding for enhanced disease resistance, immune stimulants/modulators, feed additives and pre/probiotics, chemical therapeutants, and innovative on-farm management or biosecurity

practices. The committee agrees that vaccine development and selective breeding strategies will likely be the most effective means of reducing the need for antibiotics in the U.S. aquaculture industry. However, the committee recognizes that a holistic approach, which collectively engages with the tightly integrated factors of fish health, pathogen dynamics, and environmental quality, is needed to not only reduce risks from bacterial diseases, but also positively impact the viability and profitability of the aquaculture industry. That being said, substantial scientific and practical issues remain. Irrespective of species, our present understanding of the teleost immune system is currently inadequate. Substantial gaps in knowledge exist, such as a lack of comprehensive understanding on the interplay between nutrition/environment, the pathogen, and host-derived immune factors that govern, or exacerbate, disease pathogenesis. Advancements in this area could propel the development of important new tools for pathogen control and management. The working group believes that meaningful improvements in fish health can be gained if the following gaps are addressed:

1. Analysis of industry relevant bacterial strains in the context of vaccine development (different between catfish and trout industries).
2. Understanding how and when protective immunity can be induced in these fish species.
3. Development of natural teleost immunity and establishing those times in the production cycle when vaccination would be most beneficial (incidence of disease during different phases of production).
4. Effective delivery of vaccines that will be highly protective and cost effective to industry (most importantly mucosal delivery).
5. Augment selective improvement efforts to identify or develop superior lines of fish that offer disease resistance without compromising other commercially important traits (e.g., growth and feed conversion).

Table 1: Major bacterial diseases of fish in which alternatives to antibiotics would reduce the need for antibiotics in U.S. Aquaculture.

Disease (hosts)	Causative agent	Antibiotic Use	Commercial alternative available	Alternative Biocompound	Major limitations/constraints to development or implementation	Priority given non-antibiotic alternative (limitations)
Columnaris disease (All food fish: catfish, salmonids, tilapia, Morone sp.)	*Flavobacterium columnare*	High	Vaccine (catfish only, limited farm use)	New vaccines/ delivery strategies	1) Characterize strain diversity and virulence; 2) Mucosal immunity likely required; 3) Multivalent vaccines needed; 4) *En masse* delivery strategies needed	High (knowledge of teleost immune systems)
				Selective breeding/ marker or genomic assisted selection	1) Resistance to multiple strains likely required; 2) Genomic resources lacking	High
				Immunomodulators/ host defense peptides	1) Fish innate immunity poorly understood; 2) Effects of immune fatigue on performance unknown;	Medium
				Prebiotics/probiotics/ feed additives/natural products	1) Published results equivocal; 2) Large scale, unbiased evaluation needed; 3) Knowledge of the microbiome (skin, gill, gut)	Medium
virulent *Aeromonas hydrophila*	*Aeromonas hydrophila*	High	No	Vaccines / delivery strategies	1) Host immune response to disease; 3) *En masse* delivery strategies needed	High
				Selective breeding/ marker or genomic assisted selection	1) Disease phenotyping required; 2) Limited genomic resources	Medium
				Host defense peptides	1) Stimulation of defense peptides in healthy fish unknown; 2) Effects of immune fatigue on performance unknown	Medium
				Prebiotics/Probiotics	1) Published results equivocal; 2) Large scale, unbiased evaluation needed; 3) Knowledge of the microbiome (skin, gill, gut)	Low
Bacterial coldwater disease (salmonids)	*Flavobacterium psychrophilum*	High	Improved rainbow trout germplasm (limited availability)	Selective breeding/ marker or genomic assisted selection	1) Protection specific to *F. psychrophilum*; 2) Durability unknown; 3) Protective mechanism unknown	High
				New vaccines / delivery strategies	1) Strain diversity high; 2) Mucosal immunity likely required; 3) Multivalent vaccines needed; 4) *En masse* delivery strategies needed	High (knowledge of teleost immune systems)
				Host defense peptides	1) Stimulation of defense peptides in healthy fish unknown; 2) Effects of immune fatigue on performance unknown	Medium
				Prebiotics/Probiotics	1) Published research equivocal; 2) Large scale, unbiased evaluation needed; 3) Knowledge of the microbiome (skin, gill, gut)	Medium
Edwardsiellosis (catfish, hybrid catfish, Morone sp., tilapia)	*Edwardsiella sp.*	High	Vaccine (catfish only, limited farm use)	New vaccines/ delivery strategies	1) Strain diversity and virulence; 2) Multivalent vaccines required for *Edwardsiella* sp.; 3) *En masse* delivery strategies needed	High (knowledge of teleost immune systems)
				Selective breeding/ marker or genomic assisted selection	1) Disease resistance phenotyping; 2) Resistance to multiple pathogens required	High
				Immunomodulators/ host defense peptides	1) Fish innate immunity; 2) Effects of immune fatigue on performance unknown;	Medium
				Prebiotics/probiotics/ feed additives/natural products	1) Published results equivocal; 2) Large scale, unbiased evaluation needed; 3) Knowledge of the microbiome (skin, gill, gut)	Low

References

1. Catfish Production. ISSN: 1948-271X. National Agricultural Statistics Service (NASS), Agricultural Statistics Board, United States Department of Agriculture (USDA). February 5, 2016.
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