



INDUSTRY BRIEFS

THE U.S. MARINE SHRIMP FARMING PROGRAM

January 2004

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Rod Williams and Bill Bray monitor oxytetracycline studies for survival, growth rate, and product quality.

(Photo by: Patty Waits Beasley, Texas A&M/SMP)

Oxytetracycline, shrimp, and the Food and Drug Administration: A status report

By Don Lightner, Rod Williams, William Bray and Addison Lawrence

We have all heard the old adage that “if a little is good, then more is better.” It is easy to understand how a shrimp farmer facing serious disease losses due to bacterial diseases, such as vibriosis and necrotizing hepatopancreatitis, might be tempted to up the dose a little in attempting to control these diseases by treating with medicated feeds containing oxytetracycline (OTC). Errors in calculating the amount of OTC premix to be added during the formulation and manufacture of medicated feeds can also occur resulting in dose rates higher or lower than the recommended rate. For these reasons, the U.S. Food and Drug Administration (FDA) requires that a “Target Animal Safety (TAS)” study be done in support of any new animal drug application (NAD). The FDA considers the results of the TAS, along with the results of other required studies, prior to official approval of a new animal drug (or new use of an existing animal drug in the case of OTC) for the U.S. market. When a drug is approved, the label must clearly indicate how the drug may be used (i.e., in feed at specific dose rate and time for a specific animal species, give the withdrawal time prior to harvest, etc.).

The major portion of the TAS study was carried out by Bill Bray, Addison Lawrence, and the staff at the Texas Agriculture Experiment Station, Texas A&M System, Shrimp Mariculture Laboratory (TAES) in Port Aransas. Rod Williams coordinated the design of the TAS study and served as the “Study Monitor.” As the Study Monitor, Rod interfaced with personnel at FDA to ensure that the study’s protocol was approved by the FDA prior to initiating the study and that the study was run according to the principles of “good laboratory practices (GLP).” Industry collaborators included Cargill (Giddings, Texas), Rangen Feeds, Inc., and Phibro, Inc. (the current manufacturer and distributor of TM-100 for aquatic animals). UAZ performed histopathological analyses on shrimp sampled at the termination of the study.

The dose levels and dosing time in the TAS study were much greater than would be used in treating shrimp with OTC responsibly. Not surprisingly, TAES and UAZ found that shrimp treated with the higher dose rates and extended continuous exposure to OTC in the feed showed a toxic response syndrome that could be potentially serious in terms of survival, growth rate, and product quality. Such overdosing would also produce shrimp that would be considered adulterated by FDA in terms of drug residue.

The Center for Veterinary Medicine of the FDA is the Federal Agency responsible for insuring the safety and efficacy of drugs

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Anthony C. Ostrowski, Ph.D.,
USMSFP Consortium Director

Remaining Vigilant on Diseases

The word vigilant has no more applicable or weighty meaning than in the area of shrimp diseases. Whether on the farm, or in the lab, a constant search for ways to prevent and respond to disease threats from home and abroad is necessary to ensure the success and ultimate long-term health of our domestic shrimp farming industry. Since its inception, the USMSFP has focused major research effort and maintained a proactive approach to the identification, pathology, epidemiology, and treatment of shrimp diseases to enable the development of a vibrant domestic farm-

ing industry. Our breeding program responded rapidly during the TSV outbreak of the mid-1990s to produce TSV-resistance lines of shrimp that are keystone to the biosecurity protocols now commonplace on US shrimp farms. It was the findings and urgings of USMSFP scientists about the risk commodity imports posed on introducing WSSV into our country that lead to the adoption in international aquatic animal health certificates of "country of origin labeling," subsequently incorporated into the 2002 USDA Farm Bill. During 2003, USMSFP scientists identified two new bacterial diseases of overseas farmed shrimp, and one viral disease. Fortunately, none of these have arisen in the US, and our farms have remained virus-free for the last six years. These factors have enabled the US shrimp farming industry to grow production by over 280% over the same time period, to a record 12.3 million pounds in 2002. Webster defines vigilant as the state of being "alertly watchful, especially to avoid danger." Constant vigilance has paid off. Disease research will continue to be an integral part of our efforts to protect and secure the future of the US shrimp farming industry.

In this issue of Industry Briefs, we offer three articles that highlight USMSFP vanguard efforts on disease prevention and control.

Oxytetracycline, shrimp, and the Food and Drug Administration: A status report.

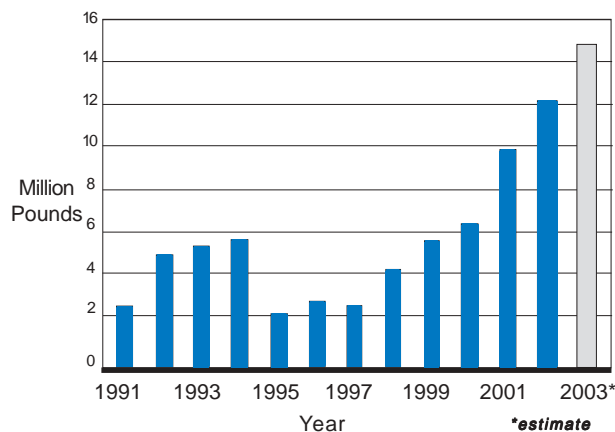
Don Lightner(UAZ), Rod Williams(UAZ), Bill Bray (TAES), and Addison Lawrence(TAES), provide a status report on an almost 30-year effort to gain approval of oxytetracycline (OTC) as a therapeutic. The Master file is being compiled and we should have word in 2004 on whether OTC will become the first drug approved by the FDA for use in shrimp in the US. This article also highlights the cooperative efforts between Consortium scientists from TAES and UAZ, and the Texas Shrimp Farmers' Association.

Advances in Research on NHP. Amanda Vincent (USM), provides a synopsis of necrotizing hepatopancreatitis (NHP), of particular concern for farmers in south Texas. This article documents the advances the GCRL has made in developing methods to test and gain insight into this bacterial disease.

Seabirds as Vectors for Penaeid Shrimp Viral Diseases. Kristie Vanpatten (UAZ), M.S. candidate, discusses the role seagulls play as mechanical vectors of viral disease transmittance.

Read on and be part of the newest information from the sentinels on the frontlines of shrimp disease research.

US Farmed Shrimp Production
1991-2003



The US Marine Shrimp Farming Program is a congressional initiative administered by the USDA/CSREES. It is an integral part of their aquaculture development effort and is executed by the US Marine Shrimp Farming Consortium:

The Oceanic Institute
Center for Applied Aquaculture
and Marine Biology
Waimanalo, HI

University of Southern Mississippi
Gulf Coast Research Laboratory
Ocean Springs, MS
Tufts University
School of Veterinary Medicine
North Grafton, MA
South Carolina

Department of Natural Resources
Waddell Mariculture Center
Bluffton, SC

Texas A&M University
Texas Agricultural Experiment Station
Port Aransas, TX

University of Arizona
Department of Veterinary Science
Tucson, AZ

Nicholls State University
Department of Biological Science
Thibodaux, LA

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US Marine Shrimp Farming Program
The Oceanic Institute
Center for Applied Aquaculture
and Marine Biology
41-202 Kalaniana'ole Hwy.
Waimanalo, HI 96795
Phone: (808) 259-3141
Fax: (808) 259-3121

www.usmsfp.org
Editor: B. Herwig

Advances in Research on NHP

By Amanda Vincent

Necrotizing hepatopancreatitis, NHP, is a severe bacterial disease of penaeid shrimp aquaculture. NHP was first reported in 1985 from shrimp ponds in Texas, and resulted in significant mortality and devastating losses to shrimp crops. Since, NHP has been observed in penaeid shrimp ponds in Central and South American countries. NHP primarily affects Western Hemisphere shrimp aquaculture with no documented reports from the Eastern Hemisphere. Synonyms of NHP include granulomatous hepatopancreatitis, Texas necrotizing hepatopancreatitis (TNHP), Texas pond mortality syndrome (TPMS), and Peru necrotizing hepatopancreatitis (PNHP). Reported hosts of NHP include *Litopenaeus vannamei*, *L. setiferus*, *L. stylirostris*, *Farfantepenaeus aztecus* and *F. californiensis*. Gross signs of NHP include reduced feed intake, empty gut, lethargy, anorexia, and discoloration and atrophy of the hepatopancreas. Diagnostic methods include wet mounts of the hepatopancreas examining for characteristic melanized tubules, histology, and molecular PCR and *in situ* analysis specific for NHP. Treatment with oxytetracycline-medicated feed has been effective in reducing the spread of NHP in the early stages of infection; however, oxytetracycline is not FDA approved for use in United States shrimp aquaculture. Environmental factors, such as temperature and salinity, are thought to greatly influence the occurrence of NHP disease in penaeid shrimp aquaculture. Epizootics associated with TNHP and PNHP followed periods of prolonged elevated temperature (greater than 29°C) and salinity (20 to 40‰). In addition, physical conditions similar to those encountered with TNHP and PNHP



Amanda Vincent, Ph.D. candidate, observes NHP-infected *L. vannamei* at the Gulf Coast Research Laboratory.

have been observed in NHP outbreaks in Central and South America shrimp ponds.

The agent responsible for NHP is a gram-negative, pleomorphic, obligate intracellular bacterium. The NHP organism is non-culturable; no methods are currently available for culturing the NHP agent in established cell lines or on laboratory media. Therefore, laboratory research of NHP is dependent on maintaining the disease agent in live animals. The Crustacean Disease Group at the Gulf Coast Research Laboratory (GCRL) in Ocean Springs, MS has recently developed a method for continuous maintenance of NHP infections in SPF Kona stock (Consortium line animals used for disease research) *Litopenaeus vannamei*. A stock of NHP-infected *L. vannamei* is maintained in 2-ton tanks filled to approximately one-third depth with artificial seawater at 30 ppt salinity and 30°C. Susceptible individuals are placed in the tank with NHP-infected individuals. As NHP-infected animals become weak and moribund, susceptible animals feed on those infected animals and acquire the NHP organism through ingestion. This stock provides infectious material for experimental studies.

An experimental system has been developed where susceptible hosts are exposed orally to tissue from an infectious shrimp. Susceptible animals are individually isolated in aerated 4-L Sterilite® storage containers at 30 ppt and 30°C. The relatively small volume containers allow numerous replicates to be included in bioassay challenges and isolation of individual shrimp ensures that susceptible hosts may become infected with NHP only through initial oral exposure to the NHP-infected tissue, and not from contact with other infected individuals. Shrimp are exposed to an approximately 0.05 g piece of an NHP-

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Detecting NHP in farmed shrimp:

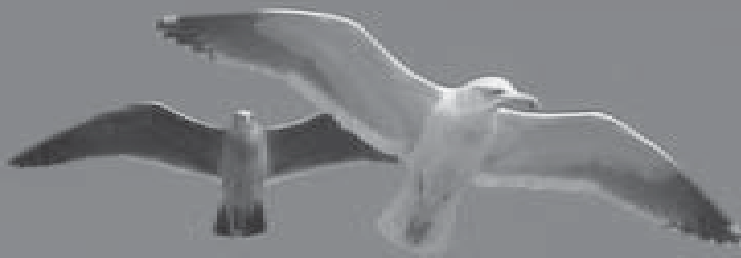
Gross Observations: Soft shells and flacid bodies with black or darkened gills and darkened edges of the pleopods and uropods due to expansion of chromatophores. Body surfaces tend to become heavily fouled with epicomensal organisms and bacterial shell disease is more prevalent. There is marked atrophy of the hepatopancreas accompanied by any of the following characteristics: pale whitish center rather than the normal tan to orange; pale with black streaks due to melanization of some tubules; and soft and watery (edematous), with a fluid filled center.

Impact on the animal:

Anorexia with empty intestinal tract, markedly reduced growth with thin tails as indicated by poor length weight ratios and lethargy. Elevated mortality rates may approach more than 90% within 30 days of the onset of clinical signs if left untreated.

Seabirds as Vectors for Penaeid Shrimp Viral Diseases

By Kristie A. Vanpatten, M.S. Candidate, Donald V. Lightner, Ph.D



The identification of the role seabirds play as possible transmission vectors for the major shrimp viruses, (WSSV, IHNV, TSV, YHV), was the focus of this study. From anecdotal observations of seabirds feeding on dead and dying shrimp, our hypothesis was that seagulls and other seabirds may serve as paratenic or mechanical vectors of the major shrimp viruses.

An early association between seagulls and human disease was noted in 1925, when researchers observed gulls foraging at dumps, and then roosting at nearby reservoirs. The gulls were blamed for depositing pathogens (such as bacteria and parasites) into the water supply.

Seagulls and other seabirds are very mobile and freely move between open feeding sites, where they may consume diseased farmed shrimp and fish, and then defecate in the surrounding waters. For example the herring gull, *Larus argentatus* and the black-headed gull, *Larus ridibundus* are often seen scavenging on shrimp trawler discards, and may be capable of transmitting viruses from wild shrimp to nearby shrimp farms.

Literature on bird feces as a possible source of viral transmission in aquatic environments is relatively scarce, however several reports demonstrate bird-associated viral transmission in fish aquaculture. These reports implicate the heron, *Ardea cinerea* as a mechanical vector of fish pathogenic VHS, SVC, and IPN to trout fry. The study determined the viral shedding duration of IPN, and a water-borne infec-

tion of trout fry was diagnosed. This study resulted in a conclusion that herons serve as mechanical vectors for VHS, SVC, and IPN, and may be a potential source of infection and spread of the diseases.

Birds pose an obvious predation threat to farmed aquatic animals, and for many years aquaculturists have suggested that as a possible link between predatory birds and the spread of aquatic diseases. Early studies to support this theory illustrated that wild herons and mallards that have eaten infected fish, excrete infectious IPN virus in their feces at similar titers found in afflicted hatchery fish. Furthermore, a reduced viral disease



Testing for presence of infectious material in seagull feces.

prevalence was observed at fish hatcheries that used electric fence barriers and netting as bird deterrence devices.

Inconclusive results were obtained when the role of loons, *Gavia immer*, as possible transmitters of IPN in trout waters was investigated in 1983. However, the study implied that regurgitation of infected material may serve as a transmission mechanism.

Seabirds have been shown to carry and transmit bacteria in their feces as well. For example, transmission of *Yersinia ruckeri*, the causative agent of enteric redmouth disease (ERM), and *Myxosoma cerebralis*, the causative agent of salmonid whirling disease, have been demonstrated.

Experimental Set-up

The US Marine Shrimp Farming Consortium funded this study as part of a Master's Thesis for the author at the University of Arizona, Aquaculture Pathology Lab. State and federal permits for wildlife collection, holding and transportation were acquired for this study to comply with state and federal regulations.

The hypothesis that shrimp eating birds may carry infectious viral particles in their feces from diseased ponds to nearby unaffected ponds, was tested in a two part study. The initial part of the study consisted of testing the feces collected at regular intervals of seagulls fed shrimp infected with either WSSV, TSV, YHV, or IHNV by PCR/RT-PCR. A Day 0 sample of the seagull feces, prior to ingestion of infected material, was also tested to ensure negative status of the feces prior to the bird consuming infected tissue.

Bioassay challenge studies were performed as the second part of this study to determine if any of the viruses detected in seagull feces remained infectious. Four separate bioassay challenge studies were run to determine if WSSV, TSV, YHV, or IHNV were infectious following passage through the seagull digestive tract. SPF *Litopenaeus vannamei* were challenged by injection with homogenized and diluted seagull feces that were collected during the first part of the study. Histological examination and molecular methods such as PCR/RT-PCR, and *in-situ* DNA hybridization were used to identify and confirm viral infection in the challenged SPF shrimp.

Results

Detection

In the feces of gulls fed the four viruses, standard PCR detected WSSV and IHNV DNA in seagull feces, and RT-PCR detected TSV RNA in seagull feces. However, YHV RNA was not detectable by RT-PCR.



Ponds have no protection from feces expelled by seagulls in flight.

Bioassay Challenges

In shrimp challenged with PCR/RT-PCR positive feces, pathognomic lesions for IHNV and TSV were observed in histological sections and confirmed by PCR/RT-PCR in the challenged shrimp. Histology and PCR/RT-PCR were negative for the presence of WSSV or YHV in the challenged shrimp. Although WSSV was detectable in the seagull feces and inoculum, the inoculum containing the virus was not infectious when injected into susceptible SPF shrimp. YHV was not detectable in gull feces in this study.

Discussion & Conclusion

In this study, seagulls were shown to be mechanical vectors of certain shrimp viruses. Seabirds are mechanical vectors because they do not become infected with the viruses that they carry in their feces. Seabirds naturally scavenge food whenever possible, thus gulls feeding on dead shrimp in open ponds can remain at the feeding site until they have become engorged with shrimp. This study demonstrated that seagulls which consume shrimp infected with the viruses IHNV and TSV are capable of shedding those infectious viral particles in their feces. The shed viruses remain infectious and can, therefore, pose a risk to native shrimp in nearby ponds or other bodies of water if the seagulls defecate virus contaminated feces, or if they regurgitate ingested shrimp soon after feeding.

DNA is typically more stable than RNA, this fact may help to explain why the DNA viruses, (WSSV and IHNV) were detectable in seagull feces fed infected shrimp, whereas only one of the RNA viruses, (TSV), was detectable by RT-PCR.

Prevention of shrimp viral diseases are dependent on increased knowledge of the pathogenic pathways of the shrimp viruses as well as technologically advanced shrimp farms. Control of scavenging seabirds is a direct implication of this study. Future construction and planning of shrimp farm sites may need to include design features to deter predation of shrimp by seabirds.

In summary, TSV and IHNV, non-enveloped icosahedrons, remained infectious following passage through the seagull digestive system. The enveloped viruses, YHV and WSSV, were apparently degraded during passage through the seagull gut, and were unable to remain infectious. The injection bioassay confirmed the infectivity, or lack of infectivity, of these viruses by both PCR/RT-PCR and routine histology.



NEWS FROM THE CONSORTIUM

Charleston Biologist Honored for Shrimp Research

The South Carolina Department of Natural Resources recently awarded its highest service award to a member of the USMSFP. The Certificate of Meritorious Service was awarded to Dr. Craig Browdy, Waddell Mariculture Center.

The Certificate of Meritorious Service was established “to recognize individuals or organizations that make outstanding contributions and provide meritorious service to the SC Department of Natural Resources (DNR) in the pursuit of its goals and responsibilities.” John Miglarese, recently retired DNR deputy director of the Marine Resources Division, nominated Dr. Browdy for the award for his breakthrough research on shrimp farming.

Shrimp research is conducted at the DNR’s Waddell Mariculture Center in Bluffton. Shrimp aquaculture provides an increasing proportion of the shrimp consumed in South Carolina and worldwide, and the center gives scientists a chance to study the animals in a controlled environment. This research has contributed to developing environmentally friendly and sustainable shrimp farming techniques. Over the past several years, efforts have been expanded to develop technologically advanced systems for stable production of fresh shrimp year round.

The systems are designed to produce more shrimp in a smaller area under biosecure conditions. Since they are based on water reuse, these technologies may be applied in areas that are not on the coast, providing new investment opportunities and new jobs for rural areas in the state.



*Dr. Craig Browdy,
Waddell Mariculture Center*

*(Oxytetracycline...
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and chemicals used for disease control purposes in the culture of aquatic animals. For a “new animal drug” to be approved for use with food animals in the U.S., data for four major studies are required. The central topics of the four study areas are 1) efficacy - the therapeutant (a drug or chemical) must be effective at the recommended dose or use rate for treating or preventing the disease(s) identified by the therapeutant’s sponsor; 2) human food safety - the use of the therapeutant for its intended use does not result in residues or the therapeutant or its metabolites which pose a hazard to humans; 3) target animal safety - the therapeutant does not pose a significant adverse effect to the animals being treated at the recommended dose or use level, and 4) environmental safety - that the therapeutant does not present adverse environmental effect such as harming non-target species or accumulating in the farm’s environment.

No antibiotics are currently approved by the FDA for use with shrimp, but OTC may be the first. Research on OTC use in shrimp in the U.S. began 30 years ago. This research has had as its intent the eventual FDA approval of the drug for use in treating bacterial diseases in shrimp. During that 30-year period, funding and in-kind assistance for OTC studies have come from the USDA Marine Shrimp Farming Consortium, the Texas Shrimp Farmers Association, the National Coastal Research Institute (NOAA), USDA Center for Tropical and Subtropical Aquaculture, the U.S. FDA Office of Science, the National Marine Fisheries Service (NOAA), Marine Culture Enterprises, Harlingen Shrimp Farms, and from companies like Pfizer and Phibro that have been in the business of making and selling

OTC. Most of the studies required by FDA for the eventual approval of the drug for use in shrimp have been completed and a plethora of data reports, supporting data and formal publications on OTC use in shrimp have been submitted to CVM/FDA. The Target Animal Safety Study may be the last major study required by CVM/FDA to complete the data package (called the “Master File”). Once the Master File is complete and accepted by FDA, the data generation process for OTC use in shrimp will be completed. The last antibacterial drug approved by the FDA for use in U.S. aquaculture was Romet 30, and that was more than 20 years ago. An approval for OTC use in managing certain bacterial diseases of shrimp could be the next approved drug if the Master File (when it is completed in 2004 with the TAS and Environmental Assessment Reports) is deemed by FDA to meet its data requirements.

Getting back to the findings of the Target Animal Safety Study: As was indicated earlier, the experimental OTC medicated feeds were made and fed to shrimp in controlled laboratory studies at TAES. UAZ did the pathological examinations of the treated shrimp. The TAS study was designed so that four (one control and three experimental) groups of shrimp were fed the drug at dose rates ranging from 0 to 5 times the recommended dose for treating certain bacterial diseases for a time period of 3 times the normal dosing period. Hence, one group of shrimp (the negative control receiving the 0X dose) received only normal shrimp feed; a second group received the recommended dose (the 1X dose or 4.5g OTC/kg feed); and a third and fourth group were fed feed at 3X (13.5 g OTC/kg feed) and 5X (22.5 g OTC/kg feed) the normal dose rate, respectively. All three groups received the medicated feed for 6 weeks (42

days), which is 3 times the recommended treatment duration of 14 days for OTC medicated feed use in shrimp.

Representative samples of experimental shrimp in this TAS study were preserved for histopathology at the termination of the study. Shrimp fed the highest (the 3X and 5X) OTC doses presented some significant signs of toxicity, while the shrimp fed the 1X dose were similar to the control group in their health status. The over-dosing of OTC in shrimp as demonstrated in this study results in shrimp with soft shells and an atrophied hepatopancreas with very low or totally depleted lipid reserves. Along with the gross signs presented by over-medicated shrimp, the histopathological changes in such shrimp can be used to diagnose OTC toxicity when the case history suggests that a misuse (due to an error in formulation of the OTC medicated feed or to deliberate over-dosing) of the drug may have occurred. This important information will very likely be incorporated into the FDA approved label for any OTC product intended for use in medicated feeds for shrimp in order to warn users of the consequences and signs of overdosing. Such information can also be used by the shrimp culture industry to ensure that OTC is used responsibly to treat bacterial diseases of shrimp and to aid shrimp disease specialists in diagnosing OTC toxicity when it occurs.

Don Lightner and Rod Williams
Aquaculture Pathology Laboratory,
The University of Arizona
Tucson, AZ 85721

William Bray and Addison Lawrence
Shrimp Mariculture Laboratory
Texas A&M Agricultural Experiment Station
Port Aransas, TX 78373



Research Profile: William Bray

Bill Bray is a Senior Research Associate with the Texas Agricultural Experiment Station, Texas A&M University, Shrimp Mariculture Project, and served as Investigator for the OTC project at the Port Aransas Laboratory. He has worked in shrimp research for 23 years, including environmental and nutritional influences on reproduction in several species, artificial insemination, testing of intensive round pond technology in South Texas, biological filtration systems for reproduction, and exclusion of WSSV in contaminated growing areas. His current areas of research include chemoattraction in shrimp feeds, nutritional influences on male reproductive quality, and low temperature and low salinity tolerance of domesticated stocks of *L. vannamei* in the USMSF program.”



*(Advances in Research on
NHP...
continued from Page 3)*

infected hepatopancreas. Shrimp feeding on this piece of infected tissue may acquire an NHP infection. Typically, symptoms of disease produced by the NHP agent are visible two to three weeks post-infection. NHP-infected shrimp exhibit reduced feed intake and eventually stop responding to the presence of food. Shrimp at this stage may display an empty gut. During this time of arrested feeding, the hepatopancreas may turn from the normal brown-orange to an abnormal pale-white coloration, which in some cases can be viewed externally through the carapace of infected animals (Figure 1). In addition, the hepatopancreas of infected animals is atrophied, displaying a noticeable reduction in size.

Experimental exposures of NHP to individuals of *L. vannamei* have been attempted to estimate several parameters, including NHP-induced mortality rate and mean survival time of infected shrimp. NHP-induced mortality from feeding exposure was observed 18 to 46 d post-exposure, with no infected animals recovering from an NHP infection. Some animals exposed orally to NHP-infected material did not exhibit signs of disease and were diagnosed NHP-negative. Mean survival time for NHP infected animals was 33.4 d. The NHP-induced mortality rate, which is the probability of death due to disease, was estimated to be 0.05 per day. In comparison to viral diseases of shrimp aquaculture, NHP incubation time is considerably longer than that of White Spot Syndrome Virus (WSSV) and Taura Syndrome Virus (TSV) in SPF Kona stock *L. vannamei* (Figure 2). In addition, mean survival time of NHP infected animals is 33.4 d compared to 2.9 d for WSSV and 11.7 d for TSV. Estimates of mortality rate for WSSV (0.4) and TSV (0.3) are nearly an order of magnitude larger than that observed for NHP (0.05).

Future research of NHP at USM-GCRL will involve laboratory and field studies to identify several aspects of NHP disease outbreaks in shrimp aquaculture ponds. First, experimental infections of NHP in Kona Stock *L. vannamei* will be attempted to estimate parameters of NHP spread in a shrimp population, which will be used to generate perature to elucidate their role in NHP outbreaks. Third, selective breeding of *L. vannamei* is currently being investigated to determine if some groups of hosts are more or less susceptible to NHP infection. Fourth, the life cycle of NHP likely involves a reservoir host and prospective laboratory research aims to identify reservoir hosts for NHP infection in the shrimp pond environment. Finally, field work involving an on-farm epidemiology study of NHP in affected shrimp farms in Texas, USA is proposed to assess NHP transmission and mortality observed during a grow-out season.



Figure 1. *Hepatopancreas pales and atrophies in an infected animal.*

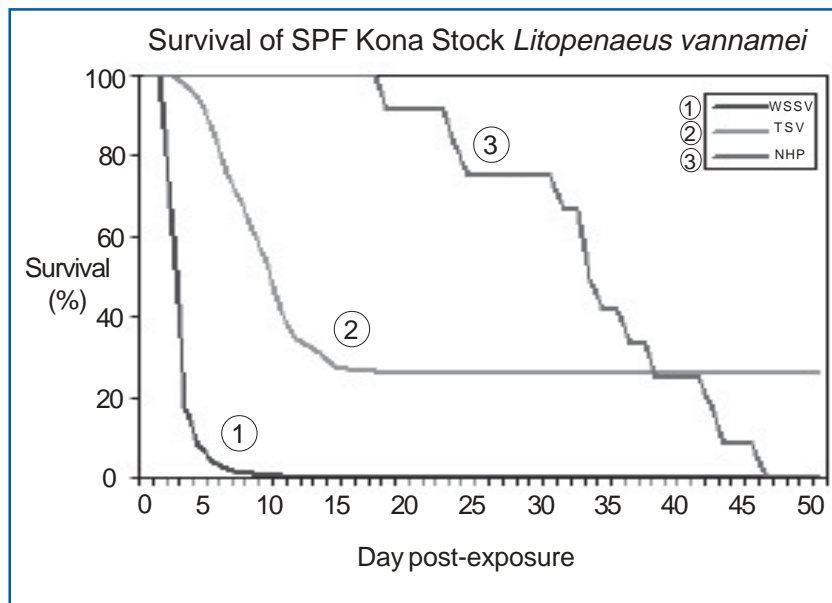
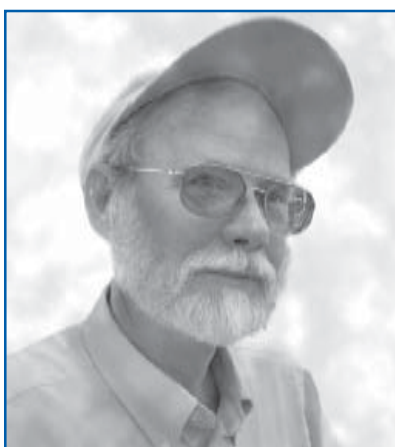


Figure 2. *Time-course response to WSSV, TSV, and NHP infection.*



Research Profile: Rod Williams

Rod Williams is a Senior Research Specialist with the University of Arizona. He has been working to obtain approval of OTC since 1980. Rod's OTC research is being funded by the Texas Shrimp Farmers' Association (TSFA) on a consulting basis.

Currently, Manufactured Feed Stability, Efficacy, and Human Food Safety portions of the overall data requirements have been completed. Rod is also involved in maintaining the contacts between the investigators in Texas and FDA, writing data reports, helping design the study protocols, gathering data on drug usage, adherence to withdrawal, amounts of drug shipped, and all data required by FDA for proper documentation for the INAD.

Don't miss the *Inland Shrimp Farming* Spring 2004 Issue of *Industry Briefs*

Inland farming accounts for about 25% of U.S. farmed shrimp production and has been responsible for the geographic expansion of our industry from three to seven states over the last ten years. In our next issue of *Industry Briefs*, we will explore this rapidly growing segment of our industry, highlighting on-farm activities, challenges faced, prospects for the future, and how USMSFP efforts have aided this expansion.

You won't want to miss these articles:

- Diet Development for low salinity culture
- Actual interviews with low salinity/inland farmers
- Physiological effects of low salinity
- Syndromes associated with non-amended low salinity water
- Breeding program and updates on low-salinity line shrimp

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AQUACULTURE 2004

March 1 - 5, 2004

(Trade Show: March 2 - 5, 2004)

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Honolulu, HI, USA

Dr. Tony Ostrowski, USMSFP Director, has assembled a comprehensive shrimp farming program for the World Aquaculture Society meeting in Hawaii including:

14 Special Sessions on Shrimp! **164 Oral Presentations!**

Technical Sessions target genomics, selective breeding, hatchery management, disease, economics, nutrition, production systems and water quality, as well as a USMSFP Special Anniversary Session.

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The US Marine Shrimp Farming Program

The Oceanic Institute
Center for Applied Aquaculture and Marine Biology
41-202 Kalaniana'ole Hwy.
Waimanalo, HI 96795

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