AQUACULTURE HEALTH INTERNATIONAL

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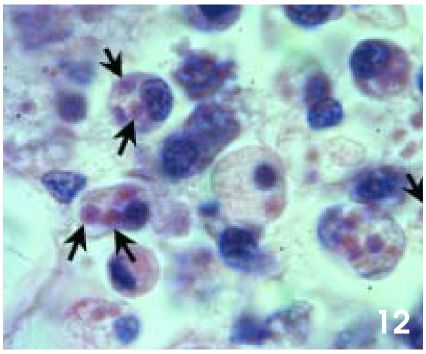
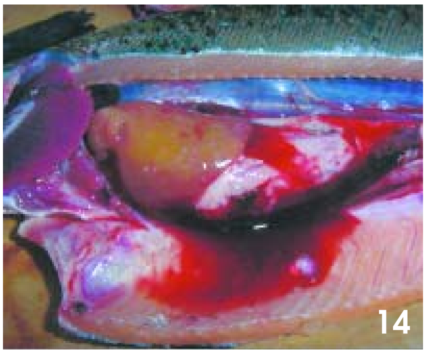


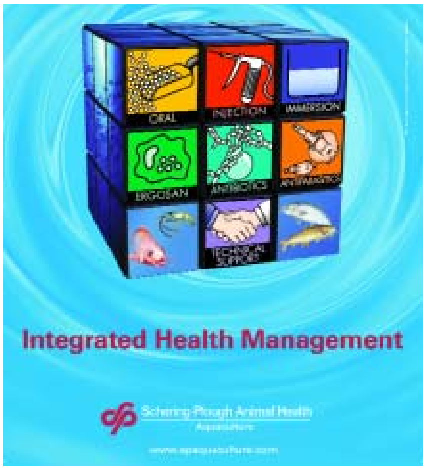


FROM THE COVER

SCHERING-PLOUGH AQUACULTURE
Aquaculture Centre, 24-26 Gold Street
Saffron Walden, Essex CB10 1EJ, UK
Telephone 44 (0) 1799 528167
Facsimile 44 (0) 1799 525546

SCHERING-PLOUGH
ANIMAL HEALTH CORPORATION
PO Box 3182, Union
New Jersey 07083-1982, USA
Telephone +1 908 629 3344
Facsimile +1 908 629 3365

www. spaquaculture.com



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4 Prince Regent Drive,
Half Moon Bay, Auckland 1706,
New Zealand
Ph 0064 9 533 4336 Fax 064 9 533 4337
email keith@aquaculturehealth.com
www.aquaculturehealth.com

EDITORIAL DIRECTOR:
Dr Scott Peddie

PUBLISHER: Keith Ingram

MANAGER: Vivienne Ingram

ASSISTANT EDITOR: Mark Barratt-Boyes

CONTRIBUTORS:
Dr Melba G Bondad-Reantaso
Dr Rohana P Subasinghe
Dr Dave Groman
Dr Franck Berthe
Dr Ben Diggles
Dr Oscar Parra
Dr Sergio Vasquez
Dr William J Enright

DESIGNER: Rachel Walker

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AQUACULTURE HEALTH HAS GLOBAL SIGNIFICANCE

DR SCOTT PEDDIE, EDITORIAL DIRECTOR

Welcome to the first issue of *Aquaculture Health International!* In today's world, aquatic livestock health and welfare is becoming a key issue of interest to an increasingly diverse audience. Fish health professionals, fish farmers, policy makers, legislators and "non-governmental" organisations are all key stakeholders in the aquaculture health arena.

Here at *Aquaculture Health International* we have identified a need for a fish and shellfish health publication that is widely available to such an audience, communicating information in an easily accessible format. The aim of *Aquaculture Health International* is to be a publication broad in appeal and style, and with a cutting-edge content.

That livestock health is a topic of truly global significance is eloquently outlined in the article by Melba Bondad-Reantaso and Rohana Subasinghe of the FAO on Aquatic Animal Diseases and their Economic Impact: a global perspective. Not only is disease responsible for huge economic losses to businesses and communities in some of the most economically vulnerable areas of the planet, it has implications for international trade and trans-boundary movements of livestock.

Subsequent articles deal with a wide range of topical health and welfare questions such bonamia in shellfish and Salmonid Rickettsial Septicaemia in cultured salmon. We are also privileged to have on board Drs David Groman and Franck Berthe of the Atlantic Veterinary College, University of Prince Edward Island to produce and edit our series on the services offered by diagnostic laboratories throughout the world. Dr Ben Diggles of DigsFish Services Pty Ltd will be another regular contributor, providing us with an Australasian perspective.

The international flavour of the magazine is reflected in the contributors who have given their time and expertise to put together the first issue of this magazine - thank you! We also extend our thanks to the advertisers who have contributed to this issue, and to Invest Northern Ireland for their financial support.

Finally, we are constantly on the lookout for news items and article ideas from your part of the world. So please do not hesitate to get in touch with us if you wish to contribute to future issues. ■

FROM THE PUBLISHER

KEITH INGRAM, PUBLISHER

VIP Publications Limited is proud to join forces with Scott Peddie of Patterson Peddie Consulting Limited to bring you this first issue of *Aquaculture Health International.*

The aquaculture industry is often ignored by other primary producers and governments as an important food producer.

Yet this industry is able to produce an economical quality source of fresh seafood for world consumption, where other primary producers are struggling to maintain growth in the face of increasing costs, climatic conditions and loss of agricultural space.

The aquaculture industry worldwide is shaping itself to meet these future demands. To ensure that the industry remains healthy and disease-free will require the support of both marine scientists and aquaculture health professionals in the future.

As publishers of the professional marine publications *Professional Skipper, NZ Workboat Review* and *NZ Aquaculture*, we are proud to support this sector of our industry, and hope you enjoy this first edition. ■

AQUATIC ANIMAL DISEASES AND THEIR ECONOMIC IMPACT: A global perspective

BY DR MELBA G BONDAD-REANTASO AND DR ROHANA P SUBASINGHE
(FOOD AND AGRICULTURE ORGANISATION OF THE UNITED NATIONS, ITALY)

With an average annual growth rate of 8.9 percent since 1970, aquaculture is now considered to be the fastest growing food-producing sector in the world. By comparison, the average annual growth rate for capture fisheries was only 1.2 percent, and for terrestrial farmed meat production systems only 2.8 percent, over the same period.

In 2002, the total world aquaculture production (including aquatic plants) was reported to be 51.4 million tonnes by volume and US$60 billion by value. This represents an annual increase of 6.1 percent in volume and 2.9 percent in value, respectively, over reported figures for 2000. Asia produced 91.2 percent (by volume) and 82 percent (by value) of global aquaculture production.

MICROSCOPIC SECTION OF A GILL INFECTED WITH KHV, DEPICTING INTRANUCLEAR FUSION (SEE ARROW)
Picture courtesy of Dr Ron Hedrick

FRESHWATER FISH (CARP) INFECTED WITH KOI HERPES VIRUS
Picture courtesy of Stuart Millar

DISEASE AS A PRIMARY CONSTRAINT

Like other farming systems, the aquaculture industry has been overwhelmed with a fair share of trans-boundary aquatic animal diseases caused by viruses, bacteria, fungi, parasites and other undiagnosed and emerging pathogens. Disease has thus become a primary constraint to the culture of many aquatic species, impeding both economic and social development in many countries. This situation can be attributed to a variety of multi-faceted and highly interconnected factors, such as:

- the increased globalisation of trade in live aquatic animals and their products
- the intensification of aquaculture through the translocation of broodstock, postlarvae, fry and fingerlings
- the introduction of new species for aquaculture and fisheries enhancement
- the development and expansion of the ornamental fish trade
- the enhancement of marine and coastal areas through stocking aquatic animals raised in hatcheries
- unanticipated negative interactions between cultured and wild fish populations
- poor or effective biosecurity measures
- slow awareness on emerging diseases
- the misunderstanding and misuse of specific pathogen-free (SPF) stocks (eg shrimps)
- climate change, and
- all other human mediated movements of aquaculture commodities.

SOCIO-ECONOMIC IMPACTS

The frequency of occurrence and the magnitude of spread and effects have prompted many countries to provide estimates of disease impacts. Although very much a grey area in the scientific literature, the impacts of disease have been estimated in socio-economic terms (eg losses in production, income, employment, market access or market share, investment and consumer confidence; food shortages, industry failure or closure of business or industry).

ADB/NACA (1991) reported that the minimum, conservatively estimated lost farm production in 1990 to fish diseases such as epizootic ulcerative syndrome of fresh and brackish water fishes, penaeid shrimp diseases and a variety of other diseases causing losses in freshwater finfish pond culture and marine cage culture in 15 developing Asian countries was US$1.36 million.

At the global level, combined estimated losses in production value due to shrimp diseases from 11 countries from 1987 to 1994 were about $3.01 billion.

At the national level, some estimates of the economic impact of key diseases are:

- Infectious salmon anaemia cost the Scottish farming industry £20 million in the 1998/1999 outbreak, and resulted in a continued annual cost to the Norwegian and Canadian industries of US$11 and $14 million, respectively.
- In Thailand, losses due to yellowhead disease and white spot disease of shrimp were estimated at $650 million.
- Losses from suspected koi herpes virus in Indonesia amounted to $15 million.
- In New South Wales, Australia, some $30 million worth of production was lost due to a single pathogen of rock oyster, Marteilia sydneyi, or QX disease.
- Abalone mortalities in Taiwan in 2003 cost the domestic abalone industry $11.5 million.

Economic impacts have also been expressed in terms of the cost of investment in disease research and control and other health management programmes. Some examples from around the world are:

- The aquatic animal health research budget for China, Thailand and Norway is around $6, $5 and $50 million, respectively.
- Australia's national plan on aquatic animal health, known as Aquaplan, costs over $4 million for development and initial years of implementation.
- The United States has budgeted $375,000 per year to develop a national aquatic animal health plan.
- Norway spends more than $77 million for overall management of fish diseases covering such aspects as legislation and support to surveillance and control programmes.

- Canada allocates $34 million for reactive disease control.
- China spends $73 million for disease control.

A recent report published by the Institute of Aquaculture in Stirling estimated that private sector research and development investment in aquatic animal products is approximately $2.1 million (for antiparasitics) to $8.2 million (for antibiotics), with a global market share worth $29.4 million and $274.4 million, respectively.

Figures remain high, a clear indication of the importance of health management and investments which governments and the private sector is willing to spend to counter production losses.

AGREEMENTS AND INSTRUMENTS ON AQUATIC ANIMAL HEALTH

A number of regional and global instruments exist, either voluntary or obligatory, wholly or partly, which aim to provide certain levels of protection in order to minimise the risks of pathogen/disease incursions associated with the international trade of aquatic animals and their products. (Table 1)

TABLE 1. Important treaties and agreements related to international trade in aquatic organisms and their products

BINDING	NON-BINDING
• Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO) • Aquatic Animal Health Code (OIE, World Organisation for Animal Health)	• ICES Code of Practice on the Introductions and Transfers of Marine Organisms
• Convention on Biological Diversity (CBD) and the Cartagena Protocol on Biosafety (UNEP)	• EIFAC Codes of Practice and Manual of Procedures for Consideration of Introductions and Transfers of Marine and Freshwater Organisms
• Convention on International Trade in Endangered Species (CITES)	• Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy (Asia TBGCIS).
• European Union (EU) related legislation and directives	• FAO's Code of Conduct for Responsible Fisheries (CCRF)

In the Asia-Pacific region, national strategies on aquatic animal health are either in the process of development or at the initial stages of implementation as part of the implementation of the Asia TGBCIS. These strategies, which contain the action plans of government for the short, medium and long term, follow the concept of "phased implementation based on national needs".

The National Strategy framework includes important elements such as national coordination, legislation and policy, list of pathogens, institutional resources, diagnostics, health certification and quarantine, surveillance and reporting, disease zoning, contingency planning and emergency response, import risk analysis, quality assurance/quality control, research and development, capacity building, awareness building and communication, farmer/private sector involvement, financial resources, monitoring and evaluation and regional/international cooperation.

Australia has implemented its Aquaplan from 1998 to 2003, and is now on its second five-year implementation, while Canada and the United States are in the process of finalising their national aquatic animal health plans.

DEMAND FOR IMPROVED AQUATIC ANIMAL BIOSECURITY

Aquatic animal health management has recently assumed high priority in many aquaculture-producing regions of the world.

Serious socio-economic losses, environmental impacts and the costs involved in disease prevention, containment, eradication and management has stimulated many countries to improve their laboratory facilities and diagnostic expertise, and advance technologies on disease control and therapeutic strategies in order to handle disease outbreaks more effectively.

There has also been some progress in dealing with aquatic animal disease problems in terms of better understanding of risks, increasing awareness, creating effective policy and legislation, enhanced research and manpower development and some capacity to respond to disease emergencies.

There has also been intensified regional and international cooperation, increased networking and better links between various stakeholders, such as fisheries and veterinary authorities and the private sector. However, all these need to be further enhanced in order to match the needs of the rapidly developing aquaculture sector.

Resource protection (aquaculture, wild fisheries and the general environment), food security, trade, consumer preference for high quality and safe products, production profitability, investment and development issues, and new threats of emerging health problems are some of the multiple objectives that will persistently drive the growing demand for aquatic animal biosecurity.

Effective compliance with regionally and internationally agreed instruments, and focussing efforts on prevention, better management practices and maintaining healthy fish may be more important than focussing on why fish get sick. Improving biosecurity, applying risk analysis and using epidemiological approaches will be important tools for disease prevention, control and management.

Health management is a shared responsibility, and each stakeholder's contribution is essential to the health management process.

ACKNOWLEDGEMENTS

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FURTHER READING

Bondad-Reantaso MG, Subasinghe RP, Arthur JR, Ogawa K, Chinabut S, Adlard R, Tan Z and Shariff M. 2005. Disease and health management in Asian aquaculture (keynote address). Special issue of Veterinary Parasitology in conjunction with the 2005 World Association for the Advancement of Veterinary Parasitology. October 2005, Christchurch, New Zealand. (in press).

Arthur JR and Bondad-Reantaso MG (eds.). Capacity and awareness building on import risk analysis for aquatic animals. Proceedings of the workshop held April 1-6, 2002 in Bangkok, Thailand and August 12-17, 2002 in Mazatlan, Mexico. APEC FWG 01/2002. Bangkok, Thailand. Network of Aquaculture Centres in Asia-Pacific (NACA). pp 203 (See www.enaca.org).

Subasinghe RP, Bondad-Reantaso MG and McGladdery SE. 2001. Aquaculture development, health and wealth. In RP Subasinghe, P Bueno, MJ Phillips, C Hough, SE McGladdery and JR Arthur. (eds.) Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, February 20-25, 2000.
See www.fao.org/DOCREP/003/AB412E/ab412309.htm

DIAGNOSTIC LABORATORY SERIES

BY DR DAVE GROMAN AND DR FRANCK BERTHE
(ATLANTIC VETERINARY COLLEGE AT THE UNIVERSITY OF PRINCE EDWARD ISLAND, CANADA)

A variety of service, research and teaching laboratories exist worldwide which support the aquaculture industry. These laboratories often offer disease screening and diagnostic services, with various levels of testing and quality assurance. In addition, some laboratories may not engage in pro-active international marketing. As a result, many aquaculture companies and their fish health service providers are not always aware of the range of laboratory resources available in the global marketplace.

This series of laboratory articles will provide *Aquaculture Health International* readers with a guide to diagnostic laboratories which offer regional, national or global "routine - fee for service" veterinary diagnostic services to finfish, mollusc and crustacean producers and their veterinary service providers.

In addition, the articles will focus on affiliations that these diagnostic laboratories may have with universities, government agencies and institutes linked to aquatic health training or research. The article will seek input from each laboratory as to their strategic goals and operational philosophy.

This objective services review, in combination with subjective input on management philosophy, will provide readers with a balanced description of the laboratory, and will ultimately help aquaculture veterinary professionals to make informed decisions on selecting appropriate diagnostic service laboratories, aquatic health training and research programmes.

To accomplish this, we will provide a formative review of the services provided by each laboratory, with the approval and assistance of the company, programme or laboratory management. To this end, we have developed an aquatic health diagnostic services evaluation checklist which will detail information on the type and scope of services offered:

- quality assurance programmes
- referral options
- reporting methods
- client base, and
- the cost of testing.

We will strive to capture a thorough description of the diagnostic component of the laboratory, with a capsulated summary of services provided. If a laboratory prefers not to participate in the series, we will only provide a description based on published information, public advertising or government documentation.

FEATURED DIAGNOSTIC LABORATORY:
Aquatic Diagnostic Services at the Atlantic Veterinary College (Canada)

DIAGNOSTICS

Since the inception of the Atlantic Veterinary College in 1986, the Diagnostic Services Unit of the college has provided a range of diagnostic and analytical testing to finfish farmers, shellfish growers and aquaculture veterinarians throughout Atlantic Canada and worldwide.

The provision of a diagnostic service component as an integral part of the AVC fish health programme is linked to the overall strategic goals of the college: to provide a fish health programme offering aquatic veterinary training, continuing education, research and service to the aquaculture industry in Atlantic Canada.

Initially, the range of diagnostic and clinical services offered to veterinarians and fish farmers was provided to support the undergraduate teaching and research programmes at the AVC. With the growth of the regional finfish aquaculture industry in the early 1990s, the college developed a "business division", Aquatic Diagnostic Services. ADS was subsequently formed in January 1996 and remains as an integrated division of the Diagnostic Services Unit of the AVC at the University of Prince Edward Island in Charlottetown, Prince Edward Island, Canada.

FRANCK BERTHE (FAR LEFT) WITH STUDENTS AND STAFF AT ONE OF THE MULTI-HEADED MICROSCOPES IN DIAGNOSTIC SERVICES, ATLANTIC VETERINARY COLLEGE, UNIVERSITY OF PRINCE EDWARD ISLAND

With the transfer from an academic to a more business-oriented function, services offered through ADS increased in diversity. Today ADS, in conjunction with the other service, research (CAHS) and continuing education units (CAI) of the college, offers a range of finfish, crustacean (LSC) and mollusc diagnostic testing, including gross and microscopic pathology, bacteriology, virology, parasitology, endocrinology, clinical pathology, toxicology and consultation (TAS).

The ADS uses testing procedures based on recommendations provided by the Office International des Epizooties (OIE), the American Fisheries Society and the Canadian Fish Health Protection Regulation. ADS, through its direct affiliation with AVC-Diagnostic Services, participates in a ring-testing quality assurance programme for veterinary diagnostic laboratories (VALQAP) which is operated by Diagnostic Chemical Ltd (DCL). The AVC was recently designated an International Reference Laboratory by the OIE for infectious salmon anaemia in North America. It is only the second such laboratory in the world.

ADS clients have traditionally been located primarily in Atlantic Canada and British Columbia (more than 70 percent). But in recent years the client base has expanded to include submissions from Quebec, Ontario, the United States, Chile, Central America

(Panama and Mexico) and Europe (primarily Greece and Denmark).

The bulk of our referral work, both regionally and worldwide, is interpretative histopathology. ADS is currently developing and offering testing in the emerging fields of immuno-cytochemistry, molecular diagnostics (in-situ hybridisation, RT-PCR and Real Time PCR) and product traceability, including antibiotics, pigments and feed additives.

It is expected that with these new tools ADS will be better able to serve clients worldwide. For routine interpretative diagnostic testing it is the policy of ADS and AVC-Diagnostic Services that all samples be submitted through a veterinarian or veterinary clinic. ADS also provides diagnostic support to scientists and government fish health inspectors seeking specific testing as part of research and surveillance.

The current fee structure for testing reflects full cost recovery related to materials and operational overheads, and a surcharge for professional labour, ie the pathologist's time. Testing offered by ADS is not subsidised by provincial or federal government contracts, and provides all clients with full confidentiality.

The service is integrated into the existing mammalian diagnostic unit. As a result, ADS utilises the expertise of 24 technical support staff, who handle finfish and shellfish submissions as well as those from mammals and birds. AVC faculty and clinical professionals assist with diagnostic interpretation on a case-by-case basis.

The ADS currently draws on the professional expertise of four fish pathologists and two field-based clinicians. Pathologists include:

- David Groman, section head for Aquatic Diagnostic Services

MAP OF ATLANTIC CANADA SHOWING PRINCE EDWARD ISLAND IN YELLOW AT THE CENTRE

- Gerald Johnson, Director of Diagnostic Services
- David Speare, professor of fish pathology, and
- Franck Berthe, Canada Research Chair in shellfish health.

They are all members of the Department of Pathology and Microbiology at AVC. Finfish clinician Larry Hammell and shellfish clinician Jeff Davidson, who are both members of the Department of Health Management at AVC, also contribute to diagnostic case consultation.

The ability of Aquatic Diagnostic Services to access this wide range of expertise in fish pathology and clinical medicine provides aquaculture veterinarians and aquaculture clients with a fully integrated diagnostic service. ▶

Aquatic health diagnostic services evaluation checklist

The following table summarises the level and diversity of aquatic diagnostic testing provided, as well as information on methods of pathogen or agent confirmation, laboratory quality assurance, referral services, reporting options, client base and cost of testing. (See key below.)

CATEGORY	CLINICAL VISITS	WATER QUALITY	PHYCOLOGY	NECROPSY	CLINICAL CHEMISTRY	HAEMATOLOGY	CYTOLOGY	HISTOPATHOLOGY	ELECTRON MICROSCOPY	BACTERIOLOGY	MYCOLOGY	VIROLOGY	PARASITOLOGY	TOXICOLOGY	SEROLOGY	ENDOCRINOLOGY
Fin-Fish	NA	NA	S	F	S	S	S	F	F	F	S	F	F	S	S	S
Mollusc	S	NA	S	F	S	S	S	F	F	F	S	S	F	S	NA	NA
Crustacean	NA	NA	S	F	S	S	S	F	F	F	S	S	F	S	NA	S
Pathogen ID			M				M	M	M	M,C,I	M,C	M,C,I,G	M,C	AC	IN	AC,I
Quality Assurance			IN	IN	IN,EX	IN,EX	IN, EX	IN	IN	IN,EX	IN,EX	IN,EX	IN,EX	IN,EX	IN	IN,EX
Referral	A	A	A		A	A	A	A	A	A	A	A	A	A	A	A
Reporting				P,F,E	P,F,E	P,F,E	P,F,E	P,F,E	P,F,E	P,F,E	P,F,E	P,F,E	P,F,E	P,F,E	P,F,E	P,F,E
Client Base				R	R,N,I	R	R,N,I	R,N,I	R,N,I	R,N,I	R,N,I	R,N,I	R,N,I	R,N,I	R,N,I	R,N,I
Cost ($)	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$

KEY

Scope of testing	Full testing available = F	Reporting options	By post = P
	Selective testing = S		By fax = F
Pathogen/agent ID	By morphology = M		By email = E
	By culture = C		By website = W
	By immunology/serology = I	Client base	Regional = R
	By genomic / molecular = G		National = N
	By analytical chemistry = AC		International = I
Quality assurance scheme	Internal quality control = IN	Cost of services	Full cost recovery = $
	External quality assurance/ring testing = EX		Partial subsidy = P$
	Certification = ISO		Full subsidy = F
Referral testing	Available = A		
	Not available = NA		

THE UNIVERSITY OF PRINCE EDWARD ISLAND WITH THE ATLANTIC VETERINARY COLLEGE IDENTIFIED AT THE FAR RIGHT

EDUCATION LINKS

The technical staff and clinical professionals working in the Diagnostic Services Unit at the AVC also play key roles in the clinical training of undergraduates, residents and graduate students. For example, fourth year undergraduates are offered rotations in aquaculture diagnostics and on-farm clinical services of up to three weeks in length. Both courses utilise ADS and Diagnostic Services personnel and facilities. Recently, AVC announced a Master of Veterinary Science degree which now provides graduate students with the opportunity to specialise in aquaculture medicine or fish pathology. It is anticipated that a full residency programme in aquatic animal health will be forthcoming in the near future.

Since AVC opened in 1986, continuing education in aquatic animal health has been a significant focus. With the formation of the Canadian Aquaculture Institute in the mid-1990s, a more formalised role for AVC faculty, clinical professionals and technologists has been developed in aquatic health. In particular, ADS pathologists and technologists have participated in numerous regional, national and international short courses.

Recent examples include:

- Aquatic Animal Health Subprogramme: training course on exotic diseases of aquatic animals. Offered by the Australian Government CSIRO Livestock Industries Department, and held at the Australian Animal Health Laboratory in Geelong, Australia during March and April, 2004.
- Care, Handling and Use of Aquatic Animals: Organised through the Canadian Aquaculture Institute and held at the University of Prince Edward Island during August, 2004.
- Shellfish Health and Disease: up-coming in June 2005. It is being organised through the Canadian Aquaculture Institute, and will be held at the University of Prince Edward Island.

RESEARCH LINKS

Aquatic Diagnostic Services staff and clinical professionals have participated in many applied research projects directed toward the development of new diagnostic tests and analyses in conjunction with both AVC/UPEI researchers and fish health colleagues worldwide.

Examples include:

- the development of an ELISA for detecting antibodies in trout and salmon to the ISA virus, and
- the identification of HPLC assays for tissue and sediment assays of antibiotics (like OTC) and sea lice therapuetants (like SLICE - emamectin-benzoate).

Research collaboration occurs most often, however, when ADS participates in both competitive government and private industry-funded grants or contracts. In this capacity, ADS generally participates by providing diagnostic support to in-vivo experiments with live fish, or as co-investigators in in-vitro experiments.

Recent examples of joint projects funded through AQUANET (Canada's research network in aquaculture) include:

- The Biology, Pathogenesis and Epizootiology of Nodavirus Strains Found in Atlantic cod *(Gadus morhua)* and haddock *(Melanogrammus aeglefinus)*.
- Advanced technology in diagnostics of economically significant mollusk infectious diseases for improved health management in Canada.

RELEVANT WEBSITES:

AVC	Atlantic Veterinary College - www.upei.ca/~avc/
ADS	Aquatic Diagnostic Services - www.upei.ca/aquatic/
DS	AVC Diagnostic Services - www.upei.ca/~diagserv/
CAHS	Centre for Aquatic Health Sciences - www.upei.ca/~cahs/
LSC	AVC Lobster Science Centre - www.lobsterscience.ca/
TAS	Toxicology & Analytic Services - www.upei.ca/~tas/
CAI	Canadian Aquaculture Institute - www.upei.ca/cai/
UPEI	University of Prince Edward Island - www.upei.ca/
PEI	Prince Edward Island - www.gov.pe.ca/
AFS	American Fisheries Society - www.fisheries.org/fhs/bb_inspection.htm
FHPR	Fish Health Protection Regulations - www.pac.dfo-mpo.gc.ca/sci/aqua/pages/fhprot_e.htm
OIE	Office International des Epizooties - www.oie.int/eng/normes/en_amanual.htm
VLAQAP	Veterinary Lab Assoc QA Programme - www.upei.ca/~diagserv/quality.htm
DCL	Diagnostic Chemicals Ltd - www.dclchem.com/veterinary/vla.html

CONTACT DETAILS

Atlantic Veterinary College, University of Prince Edward Island
550 University Avenue, Charlottetown, Prince Edward Island,
Canada C1A 4P3. Telephone 902 566 09864, Fax 902 566 0723
Email Aquaticdx@upei.ca Website www.upei.ca/aquatic/

COMPANIES UNITE TO OFFER A FISH HEALTH ECONOMICS SERVICE

A United Kingdom aquaculture consultancy, Patterson Peddie Consulting Ltd, is to work with a Queensland-based health consultancy Digsfish Services Pty Ltd. They have united to offer a fish health economics service to commercial farmers, pharmaceutical companies and government agencies in New Zealand, Australasia, the Pacific Islands and Asia. The announcement was made on March 30.

The managing director of Patterson Peddie Consulting, Dr Scott Peddie, says the health economics approach is used in two main ways:

- to assess the economic impact of disease at farm, regional, national and international level, therefore helping decision-makers prioritise disease prevention and control strategies, and
- to assess different control options and their financial implications. By putting disease management at the centre of the business planning process, it helps producers optimise returns and reduce costs and risks where possible.

"We are already involved in developing consultancy services in this area in the northern hemisphere," says Dr Peddie. "The progression to the southern hemisphere is therefore a natural extension of what we're already doing. By working with Dr Diggles and Digsfish Services we are committed to ensuring a high quality, cost-effective and professional service designed to meet the client's needs."

Dr Ben Diggles says the product provides a number of benefits to fish and shellfish farmers, as well as many in the allied fish health industries. "It's about time aquaculturalists in the southern hemisphere had access to these innovative tools.

"An objective analysis of the costs and benefits associated with various disease treatment and prevention strategies is vital in today's economic climate," says Dr Diggles. The partnership with Patterson Peddie Consulting would allow these services to be provided to those who need them in Australasia and elsewhere in the southern hemisphere.

See www.pattersonpeddie.com or www.digsfish.com

INFORMATION EXCHANGE ENCOURAGED

The European Aquaculture Society and the publishers of the new aquaculture trade magazine *Aquaculture Health International* have agreed to share articles of relevance to fish and shellfish health in Europe.

Aquaculture Health International is a joint venture between Patterson Peddie Consulting in the United Kingdom and VIP Publications Ltd in New Zealand (publishers of *NZ Aquaculture*). The magazine will initially be published every quarter in both online (pdf) and printed formats (ISSN 1176-8630).

The target readership is broad and includes fish health researchers, academics, veterinarians, fish health biologists, government scientists, pharmaceutical companies, fish farmers (finfish and shellfish) and aquaculture consultants.

"Although the magazine's content will evolve in response to reader preferences, it is our intention to provide a lively mix of global fish health news, feature articles, new product releases, in-depth country/species features and a focus on research and development in immunology, pathology and diagnostics," said the magazine's editor, Dr Scott Peddie. Conference reports and book reviews will also be included.

"The European fish and shellfish health scene will be an important focus for our magazine," Dr Peddie said. "As such, we are delighted to have the opportunity to exchange articles and information with Aquaculture Europe.

Article concepts from fish health professionals working in Europe should be directed to Dr Scott Peddie (scott@aquaculturehealth.com) or Alistair Lane (a.lane@aquaculture.cc)

ASIAN FISH VACCINES LAUNCHED

Akzo Nobel's Intervet business has launched its first two Asian fish vaccines, Norvax® Vibrio Mono and Norvax® Strep Si.

"Although fish farming is very important in Asia, fish diseases are a major hurdle to the sustainability and profitability of the industry," said Alistair Brown, the director of Intervet's Aquatic Animal Health division.

Norvax® Vibrio Mono, Intervet's first fish vaccine to be registered in Japan, is an immersion vaccine against Vibrio anguillarum infections of Japanese yellowtail. The product is expected to be followed by several more complex Intervet vaccines, which will be registered in Japan during the next few years.

Norvax® Strep Si, the company's first Asian fish vaccine outside Japan, is an immersion and injection vaccine against Streptococcus iniae infections in warm water fish. Full registration of the product is expected in Indonesia and Singapore later this year, while registration in several other countries is anticipated over the next few years.

FORTHCOMING
CONFERENCES AND MEETINGS

Aquaculture Europe 2005: Lessons from the past to optimise the future

NTNU Gløshaugen campus, Trondheim, Norway. August 9-12

This conference will contain a number of items of interest to fish health professionals working in Europe and beyond. Two of the keynote presentations will be of particular interest.

- From the United Kingdom, Sunil Kadri and co-authors will present the paper Fish Welfare: catering for the needs of the fish and the expectations of the consumer.
- Luis Tort from Spain will talk on the topic of Fish Health and Disease Prevention: immunological tools and culture management.

The parallel poster sessions are also set to reflect an interesting mix of fish health-related topics, with the organisers placing particular emphasis on applied research. Over 230 presentations have been accepted for presentation from 33 countries, including Australia and Finland.

A workshop, Recirculating Aquaculture Technology, co-organised by the European Aquaculture Society and the Aquaculture Engineering Society will also contain a component on biosecurity and disease control.

Contact the conference secretariat by email at ae2005@aquaculture.cc, or by fax at +32 59 32 10 05. To register or for further information, see www.easonline.org/agenda/en/AquaEuro2005/default.asp

12th European Association of Fish Pathologists

Conference on Diseases of Fish and Shellfish

Copenhagen, Denmark. September 11-16

The meeting is expected to include a diverse range of presentations and poster sessions. A dedicated histopathology workshop, provisionally entitled Histopathology of Early Life Stages, will be held on September 17.

For further information on registration and regular updates on the conference programme, see www.eafp.org/EAFP2005.html

6th Symposium on Diseases in Asian Aquaculture (DAA VI)

Colombo, Sri Lanka. October 25-28

The Fish Health Section of the Asian Fisheries Society is presenting the symposium under the theme Aquatic Animal Health: facing new challenges.

A workshop, a training course, an expert consultation and the 7th Triennial General Meeting of FHS are also being held in conjunction with DAA VI.

The symposium is held every three years, with the previous one taking place in Brisbane in 2002. Each has brought together more than 200 aquatic animal health scientists, students, government researchers and industry personnel from some 30 countries to discuss disease-related problems affecting aquaculture production and to find solutions for them.

DAA VI

Aquatic animal health: facing new challenges

6th SYMPOSIUM ON DISEASES IN ASIAN AQUACULTURE

25-28 October 2005

The keynote addresses are expected to include:

- Recent technological advancements in aquatic animal health and their contribution towards reducing disease risks: a review
- Maintaining biosecurity in aquaculture systems: a constraint or a challenge
- Pathogen risk assessment: a must for transboundary movement of aquatics?
- Challenges for improving safety of aquatic food: an aquatic animal health perspective
- Aquatic animal health and international trade: quo vadis?

Other topics will cover finfish, mollusc and shrimp health, stakeholder participation and regional cooperation, and the way forward.

For more on the symposium see www.daasix.org or see the FHS website at www.afs-fhs.seafdec.org.ph/ for more detailed information about the society and DAA. Expressions of interest to participate or request for inclusion in the mailing list, contact Dr Melba B Reantaso at Melba.Reantaso@fao.org using the subject line: DAA VI.

COMPANY FOCUS: SCHERING-PLOUGH AQUACULTURE

Schering-Plough Aquaculture is the dedicated aquaculture business unit of the Schering-Plough Animal Health Corporation, or SPAH. It is focused on the discovery, development, marketing and technical support of aquaculture products worldwide. The company offers a broad line of products and services for integrated health management to the aquaculture industry.

> Oral booster vaccination is now becoming a common feature of aquaculture health management as SPAH introduces the technology

SPAH says it is one of the world's leading animal health companies, with a global presence in 30 countries and distribution in 30 more, ensuring that all national aquaculture industries will be closely supported. The company's research and development has generated many new animal health products over the years, and has led the developments in aquaculture health products. It introduced the first licensed fish antibiotic, the first immersion and oral vaccines and the first-choice product for controlling sea lice.

This expertise, coupled with a specialist aquaculture research group, will continue to bring forward new products for the prevention and control of diseases affecting the aquaculture industry around the world.

Schering-Plough Animal Health, Aquaculture has continued to expand the number of registrations of its products for tilapia and shrimp since the launch of AquaVac™ Garvetil and Aquavac Garvetil Oral at the WAS meeting in Hawaii in 2004. These products are now available in Honduras, Ecuador and Mexico, with more registrations in key production markets expected in the near future.

Aquavac Garvetil is designed to provide broad-spectrum protection against streptococcosis caused by *Streptococcus iniae* and *Lactococcus garvieae* in farmed tilapia.

The vaccination programme follows SP Aquaculture's strategy of providing total protection vaccination programmes which enable farmers to use the most practical and cost-effective method of vaccination available to prevent disease outbreaks throughout the production cycle.

The programme is designed to provide protection from the early stages of the farming cycle (1 gram) until harvest. This long-term protection is achieved by the strategic use of AquaVac Garvetil Oral as a booster vaccine. Oral booster vaccination is now becoming a common feature of aquaculture health management as SPAH introduces the technology to a growing number of countries and fish species. Most recently AquaVac™ Vibrio Oral vaccine for preventing vibriosis in sea bass and rainbow trout was approved in France.

The Aquaflor™ broad-spectrum antibiotic, discovered and developed by Schering-Plough and recognised for its safety and efficacy in salmonid species, is also a highly effective tool for controlling mortality due to *Streptococcus spp.* in farmed tilapia.

In addition to its products for health management in tilapia, SPAH Aquaculture provides a range of tools for preventing and controlling disease in shrimp farms. The leading product in this range is AquaVac Vibromax.

This product is designed to increase the growth, survival and quality of shrimp exposed to vibriosis challenges. Since its original launch in Mexico last year, considerable numbers of shrimp have been treated with excellent results. Enhanced survival, size, growth rates (SGR) and food conversion rates (FCR) in treated shrimp were enhanced throughout the production cycle following the administration of AquaVac Vibromax to shrimp PLs.

See www.spaquaculture.com

SP Aquaculture wishes the team at Aquaculture Health International best wishes with the launch of this important new magazine. As a company providing health management solutions around the world to many different species, the concept of pulling practical applied fish health under a single forum to update and inform is extremely appealing. ■

FOCUS ON SHELLFISH: **Bonamia - uncovering microcell secret**

BY DR BEN DIGGLES (DIGSFISH SERVICES PTY LTD, AUSTRALIA)

THE SCOURGE OF BONAMIA

Oyster farmers throughout the world fear microcell parasites of the genus bonamia as a silent scourge which can slowly and quietly drive them out of business. These parasites belong to a small phylum of protozoans called the Haplosporidia.

Other well known haplosporidians include Haplosporidium (H nelsoni, which causes MSX disease in *Crassostrea virginica* on the eastern coast of the United States), and Marteilia (M refringens causes Aber disease in *Ostrea edulis* in France, while M sydneyi causes QX disease in Sydney rock oysters *(Saccostrea glomerata),* in Australia.

All are OIE-listed notifiable pathogens of oysters worldwide, but even within this group, bonamia is emerging as arguably the most prominent and widespread haplosporidian disease agent of oyster farming in the 21st century.

Bonamia microcells are very small (2-3 microns in diameter) and infect mainly oyster blood cells (Figure 1). The blood cell detects the parasite as foreign and engulfs it in a futile attempt to kill the parasite. However, bonamia survives and reproduces inside the blood cells, feeding off the cell's lipid reserves).

They divide until the cell bursts and dies, liberating up to 10 or more parasites, after which the process is repeated. Ironically, environmental conditions correlating to productive oyster culture (high water temperatures, high host densities and the oysters in spawning condition) also tend to favour bonamia, at least in New Zealand.

When conditions are right, the parasite multiplies there in a mind-boggling fashion. Our laboratory calculated that a heavily infected New Zealand dredge oyster contains 300 million to 500 million microcells when it dies, which is pretty horrific for the oysters around it when you consider that transmission is direct through the water, and the infective dose required to kill half of exposed oysters is only around 80,000 microcells.

The first described species of bonamia, namely B ostreae, caused

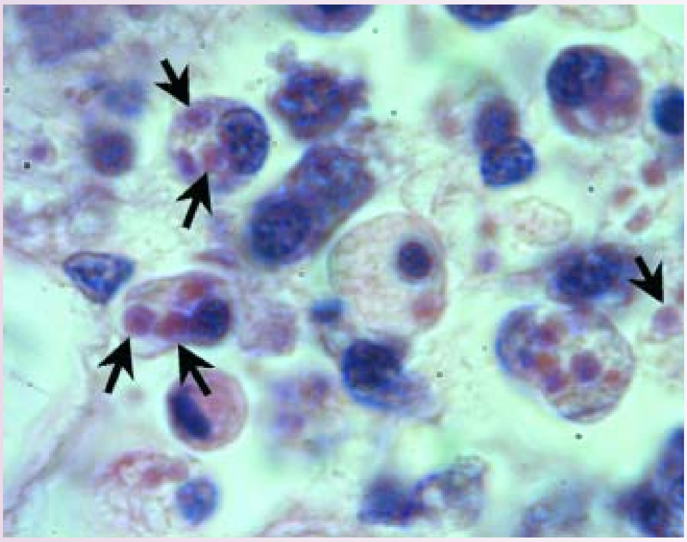

FIGURE 1. HISTOLOGY OF A HEAVY BONAMIA EXITIOSUS INFECTION SHOWING NUMEROUS MICROCELLS (ARROWED) IN THE HAEMOCYTES OF A DREDGE OYSTER OSTREA CHILENSIS FROM NEW ZEALAND. SCALE BAR = 10 µM

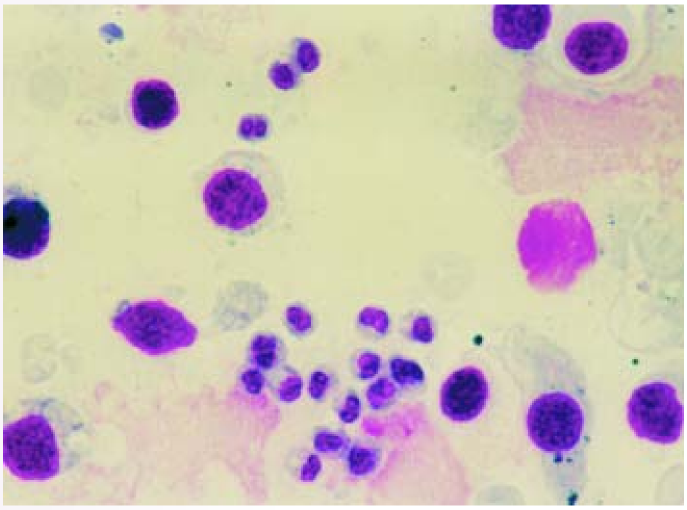

FIGURE 2. STAINED HEART IMPRINT SHOWING SYNCHRONOUS DIVISION IN WHAT IS THOUGHT TO BE A SECOND SPECIES OF BONAMIA IN THE DREDGE OYSTER OSTREA CHILENSIS FROM NEW ZEALAND. SCALE BAR = 10 µM

epizootic disease in populations of *Ostrea edulis* in France in 1979. Further research indicated that the parasite was probably introduced into France and Spain through the importation of O edulis seed from the United States, where undescribed microcell diseases had affected native flat oyster populations as early as the 1960s.

B ostreae subsequently spread throughout Europe, killing off any chances of viable flat oyster culture in many countries, a sombre lesson on the disease risks of oyster translocation. Then, between 1986 and 1992, massive mortalities of over 90 percent of dredge oysters *(Ostrea chilensis)* were recorded in a wild fishery in Foveaux Strait in New Zealand. The deaths were found to be due to a new parasite, Bonamia exitiosa.

There is evidence that this particular parasite was present in dredge oysters as far back as at least the 1960s, and that it was probably always endemic in New Zealand. The increasing frequency and severity of epizootics in this fishery in recent years (another epizootic occurred between 1999 and 2004) are thought to be related to environmental stressors such as modification of benthic substrate by dredges, which may have increased the susceptibility of oysters to bonamiosis.

More recently there is evidence that another, much rarer species of bonamia also exists in New Zealand oysters, but almost nothing is known about this species other than it divides synchronously inside the oyster blood cell (Figure 2).

BONAMIA IN AUSTRALIA

Australia now recognises that there are also two species of bonamia. The first discovery of bonamia was associated with mortalities of flat oysters *Ostrea angasi* in southeastern Australia in early 1991.

This parasite was morphologically indistinguishable from B exitiosa. This could be because large numbers of live New Zealand dredge oysters were moved from New Zealand to Australia in the early 1900s to replenish stocks of *O angasi,* which suffered from massive mortalities in the late 1800s. However, populations of *O*

In the absence of known movements of New Zealand oysters into these areas, it is possible that Bonamia sp has been present in Australia all along, as it was in New Zealand

angasi around Tasmania and in Western Australia also have Bonamia sp. In the absence of known movements of New Zealand oysters into these areas, it is possible that Bonamia sp has been present in Australia all along, as it was in New Zealand.

That scenario would certainly explain the massive mortalities of *O angasi* reported in the late 1800s before the introduction of the New Zealand oysters.

Australia's second species of bonamia was originally described as Mikrocytos roughleyi, and had been associated with the disease syndrome called "winter mortality" in the Sydney rock oyster *(Saccostrea glomerata)* as far back as the 1920s.

However, there are fundamental differences between this parasite and the ultrastructure of the only other member of the genus, Mickrocytos mackini (the cause of Denman Island disease in *C gigas* in Canada).

Subsequent studies using modern DNA technology have now indicated that M roughleyi was in fact another species of bonamia, namely B roughleyi. This parasite is therefore particularly interesting, as unlike other bonamia species, it appears to cause disease in winter, not summer.

BONAMIA IS BOOMING

In the past, the geographical distribution of microcell infections tended to follow the movements of a small number of expert pathologists, such is the difficulty in detecting these parasites with traditional diagnostic techniques. People like Ralph Elston and Mike Hine certainly have contributed enormously towards the present knowledge of the parasite bonamia and the disease bonamiosis. However, since the mid-1990s, the emergence of better diagnostic tests, better informed and equipped aquatic animal health specialists and the listing of the disease with the OIE has meant new discoveries are now spread more evenly around the world.

Recently, isolates of bonamia-like parasites have been reported from *O chilensis* in Chile, *C gigas* in Australia, *Crassostrea ariakensis* in North Carolina and *Ostrea puelchana* in Argentina.

In fact, Dr Hine confirms that there are now 11 known bonamia or bonamia-like pathogens currently being studied around the world. To fully understand the significance of the more recently discovered isolates, clearly their taxonomic relationships within the genus need to be established.

Modern DNA-based molecular diagnostic techniques are being used forensically to painstakingly piece together a global picture that gets more interesting with each new finding. For example, preliminary findings using rDNA sequencing techniques have found that the Australian Bonamia sp is closer to the Chilean bonamia than it is to B exitiosa in New Zealand.

Even more interesting is the fact that the isolate found in *Crassostrea ariakensis* in North Carolina appears to have exactly the same sequence as the Australian Bonamia sp. In the absence of known movements of oysters between the two areas this appears impossible at first, until it is realised that bonamia can probably be transmitted via oyster spat fouling boat hulls. Therefore the Bonamia sp in *C ariakensis* may indeed have been introduced from Australia by shipping.

FIGURE 3. THE EMERGENCE OF MOLECULAR DIAGNOSTIC METHODS HAS REVOLUTIONISED THE DETECTION OF BONAMIA INFECTIONS IN OYSTERS. BUT AT THIS STAGE OF THEIR DEVELOPMENT THEY HAVE PROBABLY GENERATED MORE QUESTIONS THAN ANSWERS. DRS DIGGLES (LEFT) AND COCHENNEC-LAUREAU AT WORK IN THE MOLECULAR LABORATORY

THE FUTURE

Clearly scientists are only beginning to uncover the secrets held by this intriguing group of parasites. Modern, sensitive PCR-based diagnostic techniques (Figure 3) can now detect latent sub-clinical infections which were previously impossible to detect using traditional light microscopic techniques.

Wider use of these new tools may well shed light on important epizootiological information that is currently lacking. They will almost certainly indicate that the distribution of these parasites is as much influenced by biogeography as translocation, and that they may indeed threaten economic aquaculture of many more species of oysters worldwide. Fortunately there is light at the end of the tunnel with the development of bonamia-resistant strains of oysters appearing to be a workable solution to the problem of microcells causing macro-problems in oyster culture.

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FOCUS ON FINFISH: An overview of Salmonid Rickettsial Septicaemia, or SRS

BY DR OSCAR PARRA AND DR SERGIO VASQUEZ (INTERVET LTDA, CHILE)
AND DR WILLIAM J ENRIGHT (INTERVET INTERNATIONAL BV, THE NETHERLANDS)

(Adapted from an article that appeared in Intervet's Aquatic Animal Health Newsletter no. 9, November 2004. See www.intervet.com/aah/newsletters.asp)

WHAT IS SRS?

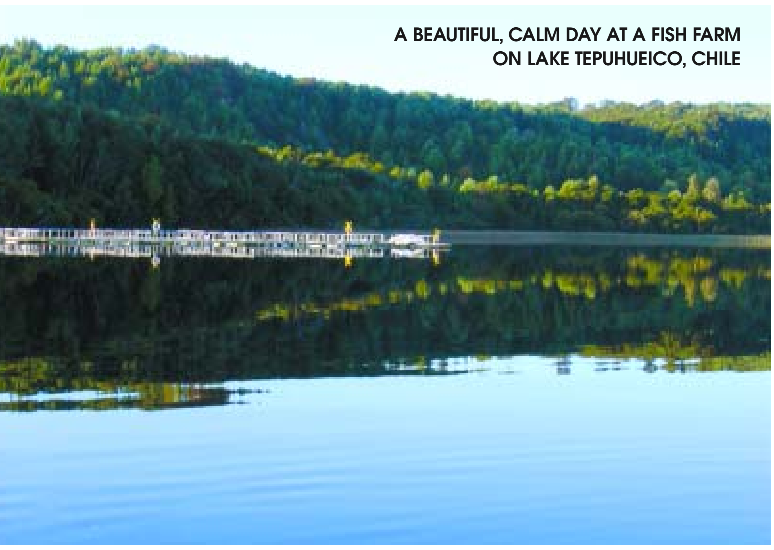
Salmonid rickettsial syndrome (also known as salmon rickettsial syndrome piscirickettsiosis, coho salmon septicaemia and huito disease) is considered to be the most important disease problem in the Chilean salmon farming industry. In some years it causes economic losses of over US$100 million. SRS was first reported from Chile in 1989, but (Pisci)rickettsia-like organisms (RLO) are now frequently associated with disease syndromes in salmonid and non-salmonid fish from both fresh and salt water worldwide.

In 1989 this disease was considered to be the cause of death of an estimated 1.5 million coho salmon, many near market size. A year later, the disease was also found in Atlantic salmon and up to 90 percent mortality was seen on some farms. However, outbreaks of SRS in other countries have not reached the levels of the Chilean outbreaks. For example, variable and inconsistent mortality of 0.6 - 15 percent has been reported in Canada and Norway.

WHAT CAUSES THE DISEASE?

SRS is caused by the Gram-negative bacterium, Piscirickettsia salmonis. This was the first "rickettsia-like" bacterium to be recognized as a pathogen of fish. *P salmonis* is the first of the RLO of fish to be fully characterised. Since its recognition, the impact of RLO in fish has become increasingly apparent.

Growing awareness of the emergence of these intracellular organisms has led to the discovery of rickettsial diseases among diverse species of fish from different geographic locations and aquatic environments. The source, reservoir and mode of transmission of many of these agents, as well as consistently effective methods of disease prevention and control, remain to be established.



A BEAUTIFUL, CALM DAY AT A FISH FARM ON LAKE TEPUHUEICO, CHILE

SRS PATHOLOGY IN SALMON. NOTE THE SEVERE INFLAMMATION AND MULTIFOCAL NECROSIS IN LIVER AND SPLEEN. HAEMORRHAGIC ASCITES ARE ALSO OBSERVED

HOST RANGE AND GEOGRAPHIC DISTRIBUTION

SRS disease in Chile typically occurs in marine waters during the on-growing process from smolt to harvest. It has also been isolated from freshwater cages of coho salmon and trout.

The disease was originally predominant in coho salmon *(Oncorhynchus kisutch)*, but is now recognised to cause serious losses in all farmed salmonid fish species, including Atlantic salmon *(Salmo salar)*, rainbow (steelhead) trout *(O mykiss)*, chinook salmon *(O tshawytscha)*, pink salmon *(O gorbuscha)* and masu salmon *(O masou)*.

Piscirickettsia sp are commonly found in fish worldwide, including Chile, Canada, Ireland, Scotland and Norway, but are of major economic importance only in Chile to date. The distribution of P salmonis and RLO is therefore widespread.

Several reports describing RLO infections in non-salmonid finfish also exist. For example, about 10 years ago, an RLO was identified as the causative agent of an outbreak associated with mass mortality among pond-reared tilapia in Taiwan. Also, RLO-related mortalities in juvenile European sea bass at 12 to 15 degrees Celsius in sea cages have been reported along the French Mediterranean coast.

TRANSMISSION AND EPIDEMIOLOGY

At present there are few reports of P salmonis coming from wild salmonids, although it is likely that the bacterium is present in naturally occurring populations of marine fish. Horizontal transmission (ie between fish) has been reported in marine-farmed salmon two weeks after the introduction of pathogen-free fish into infected sites.

The extended extracellular survival time of this organism in salt water (several weeks at 5° to 20° Celsius) may be of sufficient duration to permit horizontal transmission without a vector. Experimentally, it is documented that the bacterium can enter through the intact skin and gills, although the mode of entry is still not clear.

The possibility of vertical transmission (ie from parent to offspring) of P salmonis now looks more and more likely, according to recent research in Chile. Apparently there is an adhesion complex that allows the pathogen to enter the salmon egg. There is even a suggestion that this complex may be involved in fish-to-fish transmission.

Currently, no alternative host has been identified and the source, reservoir and means of transmission of P salmonis remain important areas of research.

The course of the clinical disease is typically chronic to subacute in nature, with mortalities normally developing 10 to 12 weeks after the transfer of fish to seawater and lasting approximately 10 weeks before they diminish. Virtually all stocks become infected, and they usually experience more then one clinical episode, typically in the spring and autumn.

CLINICAL SIGNS, GROSS PATHOLOGY AND HISTOPATHOLOGY

SRS can have a substantial economic impact at affected farm level, particularly in Chile, as typical cumulative mortality averages 20 percent during the 18-month saltwater production time to harvest. Affected fish are lethargic, dark in colour, anorexic, anaemic with mottled focal lesions within the liver, show respiratory problems and swim near the surface.

The first signs observed are often haemorrhages and lesions of the skin. The lesions range from small areas to shallow ulcers up to 2cm in diameter. Internally, the kidney is swollen and the spleen enlarged. Petechial haemorrhages are found on the swim bladder and viscera. Diagnostic ring-shaped, cream-coloured lesions are present on the livers of chronically infected fish. However, in acute cases, death may be the only gross sign of disease.

Histological changes have been classified into the broad category of necrosis and inflammation. Inflammatory cells, fibrosis, a generalised coagulative necrosis, tubular degeneration and necrosis of the endothelium infiltrate the liver, spleen, intestine and haematopoietic cells of the kidney. Moribund fish are anaemic, and haematocrit is often 20 percent to 50 percent of normal.

The rickettsial organism infects a variety of cells, including circulating macrophages, in which they can replicate and cause cell lyses. It also enters brain tissue, thus affecting swimming ability. The mechanisms by which P salmonis can enter target cells, avoid intracellular killing and survive inside the host are unclear.

DIAGNOSIS

An initial diagnosis of piscirickettsiosis can be made from gross lesions and is supported by examining tissue sections. Confirmation of the diagnosis requires isolation and/or serological identification of the causative organism. An indirect fluorescent antibody technique (IFAT) and immuno-histochemistry have been developed as alternative procedures to detect P salmonis.

These latter techniques are faster and more specific than histochemical staining. However, they require additional specialised equipment and are more expensive. The detection of P salmonis in cultivated salmonids via a nested PCR using universal primer is coming on stream and will be important for diagnosing this disease.

DISEASE CONTROL

Chemotherapy. In laboratory studies, P salmonis has been shown to be sensitive to various antibiotics, including streptomycin, gentamicin, erythromycin, chloramphenicol and oxytetracycline, but shows resistance to penicillin, penicillin G and spectinomycin.

A PROFESSIONAL VACCINATION TEAM AT WORK IN CHILE. SRS VACCINES ARE NOW COMMERCIALLY AVAILABLE

However, the use of medicated feed to control intracellular pathogens, including P salmonis, has been largely unsuccessful, possibly because antibiotic levels may not reach sufficient concentrations within the host cells. Nevertheless, injection of broodstock with antibiotics before leaving seawater in order to control the typical "summer SRS outbreak" is common.

Vaccine development. Although commercial vaccines against P salmonis have been made available recently, there is little published information or field experience on their efficacy or economic value. However, several institutes and pharmaceutical companies, including Intervet, have active research programmes directed towards developing efficacious vaccines.

MANAGEMENT

Outbreaks frequently occur after smolt transfer to seawater, but good management practices do help. Such approaches include the early removal of dead and clinically diseased fish, with appropriate sanitary disposal of blood from harvested fish, reducing fish stocking density and providing periods of site fallowing. Other strategic measures include routine screening broodstock, rejecting eggs from positive fish and individual incubation of egg batches.

Further information regarding horizontal and vertical transmission, pathogenesis, intracellular survival and immunogenicity is needed to support future control strategies. In addition, information on the geographic location and species distribution of P salmonis among isolates and stocks of fish will be helpful in developing management and control strategies in the future.

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