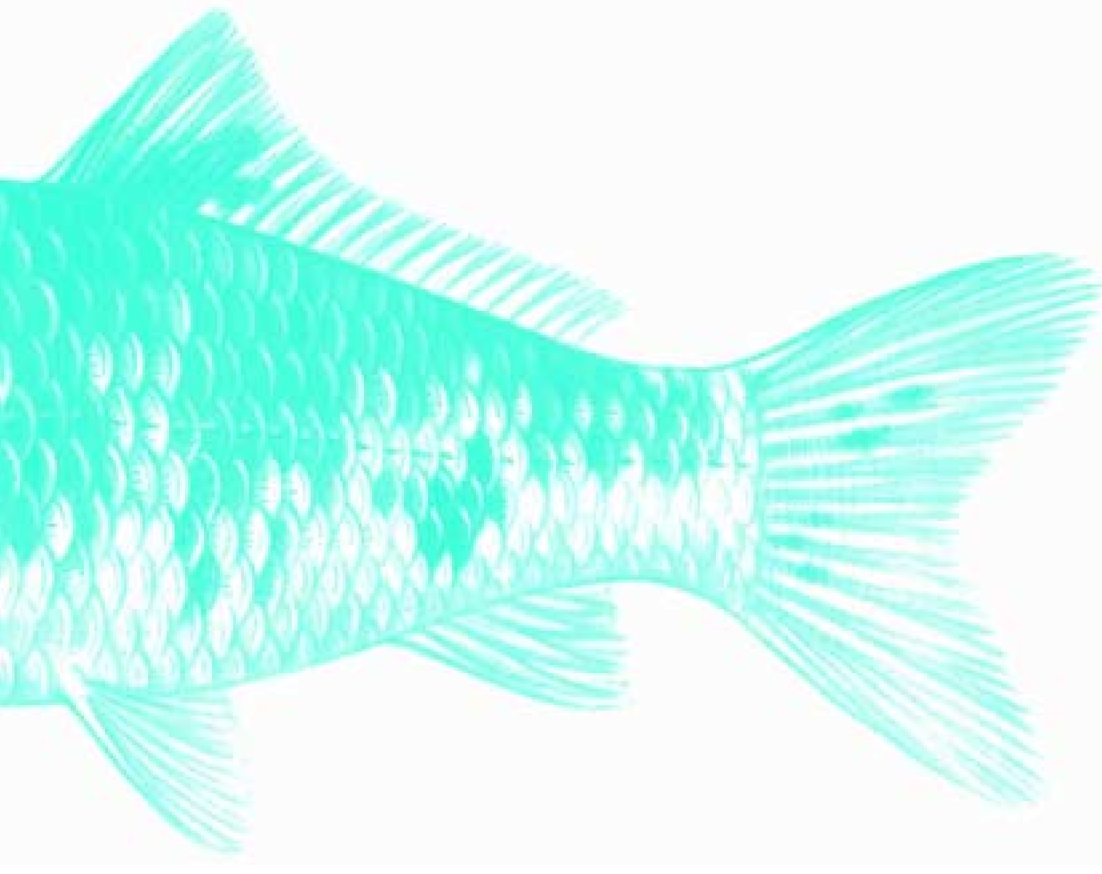
FISH VETERINARY JOURNAL

The Journal of the Fish Veterinary Society

Issue Number 7 • October 2003



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Issue Number 7 • October 2003

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The *Fish Veterinary Journal* is published by the Fish Veterinary Society and provided free to the Society's members. Additional copies can be obtained from the editorial department for £15 (UK) and £25 (overseas).

The FISH VETERINARY SOCIETY was formed in 1990, with the intention of bringing together veterinarians with an interest in fish, so that they may benefit from mutual experiences and discussions, and help to advance the veterinary care and welfare of fish.

The Society provides:

- two scientific meetings, held annually
- publication of the *Fish Veterinary Journal*
- publication of policy documents on fish health and welfare
- political lobbying and representation on behalf of the members' interests

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MEMBERSHIP of the Fish Veterinary Society is open to members of the Royal College of Veterinary Surgeons, although the Society will consider applications from overseas veterinarians and those with an appropriate interest / degree as set out in the Constitution. Currently membership costs £50 per annum. Veterinary students and suitably qualified non-veterinary graduates may become associate (non-voting) members of the Society; veterinary students pay a half-yearly fee until they graduate, at which point they will become full members if they so wish. Enquiries regarding membership of the Fish Veterinary Society should be addressed to the Honorary Treasurer – see the application form at the back of this Journal.

Notes for contributors

The *Fish Veterinary Journal* invites contributions from members and other professional colleagues and is keen to publish original research, review articles and clinical case histories on all aspects of fish health. Letters, book reviews and other comment on relevant topics are also welcomed.

Scientific articles submitted to, or published in, other refereed journals will not be considered for publication. Papers and short communications submitted for publication are subject to peer review. The editor has the final decision on publication and if accepted, the copyright becomes the property of the Fish Veterinary Society.

Manuscripts and all communications should be sent to J. McArdle, 119 Park Drive Ave, Castleknock, Dublin 15, Ireland. Manuscripts should be submitted in duplicate, typewritten using a Times or Roman font (double line spaced) on one side of A4 paper with wide margins. Scientific articles may also be submitted as a Word document on 3½" diskette (MS-DOS format) or by email to johnmcardle9@hotmail.com. The Journal cannot accept responsibility for loss or damage of manuscripts.

Format:

Papers should be headed with the full title, which should describe accurately the subject matter. The initials and surnames of the authors, with full postal addresses should follow. Each paper should have a self-contained summary (maximum of 150 words), which embodies the main conclusions.

Abbreviations should be avoided. Where they must be used, the word or phrase must be given on the first occasion, e.g. infectious pancreatic necrosis (IPN). All units of measurement should be given in the metric system and temperatures in degrees Celsius. Blood biochemistry values should be expressed in standard SI units. Medicinal products should be referred to by their generic name followed by proprietary name and manufacturer in brackets when first mentioned, e.g. amoxycillin (Vetremox®, Vetrepharm). The full Latin name for each species should appear at least once when mentioned in the text.

Length of papers:

Papers should be concise. As a guide, the maximum length for scientific articles is 3,000 words; for review articles up to 4,000 words; for short communications and clinical case reports up to 1,500 words.

Tables and illustrations:

The minimum number of figures necessary to clarify the text should be included and should contain only essential data. Tables must be typewritten on separate sheets and numbered. Illustrations should be drawn in black ink on white paper and should be suitable for direct photographic reproduction.

Legends should be typed on a separate sheet. Photographs should be clear and sharp, and in colour where possible (transparencies should be accompanied by one set of prints). Photomicrographs must state magnification and stain technique. Each illustration or photograph should bear the author's name and figure number in pencil (or on a label) on the back and an arrow used to identify the top edge. All photographs will be printed in black & white but may be reproduced in colour at the expense of the author(s).

References:

Only papers closely related to the author's work should be mentioned. These should be stated in chronological order in the body of the text and should be listed in alphabetical order and include the full title thus:

Hanson, L.A. & Grizzle, J.M. (1985) Nitrite-induced predisposition of channel catfish to bacterial disease. *Progressive Fish-Culturist* **47**, 98–101

Morrison, C.M., Cornick, J.W., Shum, G. & Zwicker, B. (1984) Histopathology of atypical *Aeromonas salmonicida* infection in Atlantic cod, *Gadus morhua* L. Journal of Fish Diseases 7, 477–494

Roberts, R.J. (1993) Motile aeromonad septicaemia. In: *Bacterial Diseases of Fish*. (eds. V. Inglis, R.J. Roberts & N.R. Bromage). Blackwell Scientific Publications, Oxford. pp143–155

If three or more authors are quoted, then all must be listed in the references and should be written as, for example, 'Morrison et al 1984' in the body of the text.

Personal communications should be cited as such.

Miscellaneous:

A brief personal profile of academic achievements and the current position of the author(s) is also required as a footnote (maximum of 100 words) for scientific articles.

The *Fish Veterinary Journal* is covered by the CAB abstracts database.

President's Reflections

Edward Branson
P.O.Box 1510, Stafford ST17 4YQ, UK

It's important that FVS continues to develop as a representative of the interests of fish health professionals and is fully involved with issues that are likely to have an impact on the health and welfare of fish generally. FVS has achieved this objective admirably over the last year, which has been, if anything, busier than previous years.

The areas where FVS have had, and are continuing to have, an influence include:

BVA Food Animals Group (special thanks to Keith Treves-Brown)
Royal Society of Edinburgh Report on ISA
Medicated Feed guidelines for FVS
Federation of Veterinarians in Europe
Standing Committee of the European Convention for the Protection of Animals Kept for Farming Purposes
Aquaculture Health Joint Working Group (special thanks to Andrew Grant)
Integrated Sea Lice Management group
DEFRA Committee for Aquaculture Health
VPC Draft Report on Antibiotic Resistance

And, of course, there have been 2 excellent scientific meetings over the year.

All of this takes a good deal of work by those who are involved and, on behalf of the FVS, I would like to thank them sincerely. However, this does bring me to one of the difficulties we've experienced over the last couple of years, the question of how the membership can be encouraged to take more part in this work.

Mostly it's always the same people who become involved, but it's important that all members have the opportunity to contribute so that when an FVS opinion or statement is formulated, we can be sure that nobody is disagreeing.

The FVS was in danger of lapsing into a 'them and us' situation in the past, with the Committee doing most of the work, and little input from members.

This was, to some extent, corrected by the instigation of sub-committees to deal with specific issues, but still more members are needed to contribute. In order to achieve this, an FVS List Server has been set up, which allows members to easily send out messages or questions to other members and allows the whole membership to be consulted on, and informed about, relevant issues much more easily than has been possible in the past.

I hope this will be used to generate interesting debates and exchange of information; please use it. It's easy to feel isolated out there, so why not use FVS to keep in touch?

The FVS web site has also been re-designed, and it should be a much more interesting and useful thing in future. There will be a general section and a password protected section for members only. I hope this will also help to keep members in touch with what's going on in the rest of the society. Thanks to Alpharma, AVL, Bayer Intervet, and Novartis for funding this.

For the future, it is clear that fish welfare is the up and coming issue, and there's lots going on in this subject: the FAWC report is apparently soon to be revisited, and fish welfare has been identified as a problem area by DEFRA and the EU.

I hope and intend that FVS, as well as continuing with the work of the type outlined above, will be closely involved in welfare over the coming years, not least with a review of the rather outdated FVS guidelines on this subject. FVS must be in the forefront of developments in this area.

From this you can see that there's been a lot going on this year, and FVS has continued to increase its recognition as a voice for members who are in fish work – long may it continue. But none of this could have been achieved without a lot of time and effort from members, no small commitment in addition to the daily grind, and thank you for this.

Finally, I would like to thank the members of the committee who put in a huge amount of work behind the scenes, most of which goes unnoticed, but without which none of this would have happened, so a big thanks to Marian McLoughlin, Fiona Macdonald, Chris Walster and John McArdle.

Editor's Comments

John McArdle
119, Park Drive Avenue, Castleknock, Dublin 15 , Ireland

Editing some of the papers in this issue reminded me of the most recent UK Foot and Mouth disease outbreak, since it led to the cancellation of our spring meeting in Cambridge in April 2001. This meeting was re-scheduled and held in Mildenhall, Cambridgeshire later that year. It was a very successful and enjoyable meeting and I know FVS members will appreciate the photograph, which Marian McLoughlin kindly passed on to me, of Mary Brancker, our only honorary member, taken at that meeting with other female FVS members. Mary Brancker has been such a strong supporter of veterinary involvement in fish in so many ways that it seemed appropriate to include the photograph. Long may she continue to attend our meetings!

Thinking of the FMD outbreak led me on to think about ISA, since the EU eradication policy for this disease is analogous to that for FMD. Some FVS members have strong views on this disease and current policy on its control and FVS made a useful submission to the Royal Society of Edinburgh's enquiry into ISA. This submission was concise and well reasoned and merits reading by our members and interested parties outside FVS.

Turning to this issue of the *Fish Veterinary Journal*, the fashionable word 'eclectic' springs to mind, as there certainly is variety here. This variety reflects the range of topics covered in presentations to our scientific meetings. It is important for FVS to publish the papers presented at these meetings and, indeed, they form the backbone of the Journal. Many of our members are unable to attend our scientific meetings, so it is important that they be kept informed about developments in relation to fish health and related topics, which are highlighted at our scientific meetings. Also, once published in the Journal, they provide a historical record of our activities.

For those who present papers at our scientific meetings, I know that it is not always easy to transform an oral presentation into a written paper. As editor of the Journal it has fallen to me to encourage those who present oral papers to submit them afterwards to the Journal for publication. With very few exceptions, those from whom I have sought papers have all readily agreed to supply them. Actually getting some to do so within a certain deadline has not always proved as easy! Nevertheless, I have not been let down yet and I can only apologise and thank those who, from time to time, I may have cajoled a little to obtain a paper. However, it must also be gratefully acknowledged that some authors have sent me manuscripts very soon after making their oral presentations at our meetings and this makes my job as editor job infinitely easier.

All our papers are peer-reviewed and I would like to thank those who, when asked, agree to act as referees for the Journal. They carry out this invaluable work anonymously and generously, usually fitting it into an already busy schedule. Their efforts are appreciated.

I would also like to thank our advertisers whose generous support helps to defray the costs of producing the Journal. Despite the, sometimes, stormy economic climate experienced by the aquaculture industry, they have been unfailing in their support of the Journal. Finally, I would like to thank Mike Williams of Akalat Publishing, without whose patience and unfailing helpfulness, the task of producing the Journal would not be possible. My apologies for the unavoidable delay in publication of this issue.

Fish Veterinary Society Autumn Scientific Meeting
Mildenhall, Suffolk 24 October 2000

Above, participants and speakers.

Front row (L–R), Wenche Kjaempenes, Mary Brancker, Catriona Webster, Lydia Brown, David McHenery, Myriam Algoet, Marian McLoughlin, Fiona Macdonald

2nd row (L–R), Jim Nicolson, Hamish Rodger, Robin Wardell, Tony Wall, Alastair Gray, John McArdle, Jonathan Guy, Peter Treves-Brown, David Solomon, Edward Branson, Peter Scott, Chris Gould, Willie Wildgoose, Chris Walster, Steve Kestin

Above, Honorary FVS member, Mary Brancker, with other female FVS members.
Front row (L–R), Fiona Macdonald, Mary Brancker, Marian McLoughlin
Back row (L–R), Myriam Algoet, Catriona Webster, Lydia Brown

PROCEEDINGS

Fish Veterinary Journal (2003) (7) 1–17

Applying Animal Health Economics to Fish Health Management

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Abstract

The principles of animal health economics can be applied to address specific questions in aquaculture. This paper outlines the key concepts of animal health economics and describes the potential most useful tools available to the fish health manager. These tools vary in complexity and include cost of treatment per fish, treatment margins, partial budgeting, cost-benefit analysis, break-even point analysis, decision tree analysis, linear programming, systems simulation and dynamic programming. The applications of these techniques in human and terrestrial animal health are explored and their potential for use in fish health management is discussed.

Introduction

Although animal health economics as a distinct discipline has only been in existence for some three decades or so, it is rapidly gaining acceptance as an important component of agricultural economics. The tools and concepts involved can be easily transferred to aquaculture where it is equally important to optimise the fish health management process. Consequently, this paper reviews the main concepts of animal health economics, the tools used and their potential applications in fish farming.

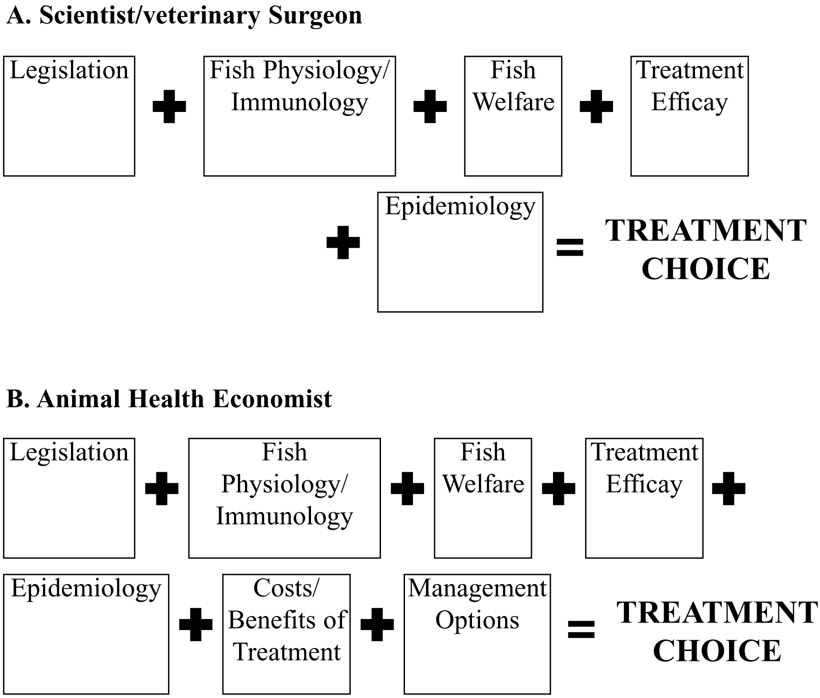
What is Animal Health Economics?

Animal health economics is a new, but rapidly evolving branch of agricultural economics. In essence, it ‘aims to provide a framework of concepts, procedures and data to support the decision making process in optimising animal health management’ (Dijkhuizen *et al.* 1995). Most of the tools used are an amalgam of established techniques drawn from economics or business studies but adapted, perhaps via use in related fields such as human health economics or agri-business management. Animal health economics is not simply a vehicle for incorporating financial data into the disease management decision-making process. Indeed, many of the models used in animal health economics incorporate a range of parameters such as legislative considerations, welfare parameters, environmental impacts of various treatment options and the epidemiological characteristics of the disease in question (Peddie & Stott 2002b). This wider perspective of economics runs contrary to popular conception but is fundamental to understanding what the discipline aims to offer animal health management. It establishes that a wide range of stakeholders have an interest in animal health, that these interests may not be compatible, and may not all be measured in financial terms. All however, will require allocation of scarce resources away from alternative activities if the desired improvements are to be made. A balance must therefore be struck between the objectives for animal health and the best means found to achieve them. So to take an extreme example, elimination of a fish disease may be desirable on grounds of animal welfare and food safety but may require unacceptably high treatment costs, including, perhaps, risks to the environment. Animal Health Economics aims to find the 'least cost' compromise where the benefits of any further improvements in animal health are exactly balance by the costs of making such an improvement. Notice that this is a much more challenging and worthwhile aim than simply putting a cost to existing levels of a disease. For further explanation and discussion of this principle of animal health economics, the reader is referred to the excellent paper of McInerney (1996).

In contrast to the economists' people centred approach, the veterinarians' approach to fish health can be described as 'fish centred', as shown in Figure 1. For example, a fish veterinarian makes treatment decisions based primarily on legal, epidemiological and fish welfare considerations. However, the economists approach, whilst also cognisant of these parameters, is somewhat broader in its outlook. Additional considerations include the financial costs and benefits of utilising particular treatments and is analogous to the situation identified in the animal welfare debate, where economists typically consider a wider range of parameters as pertinent to the decision-making process (McInerney, 1998).

Recent attention has focussed on the application of the principles of animal health economics to disease management in aquaculture. Peddie & Stott

FIG 1: Differences in the approach of veterinarians/scientists and animal health economists in determining treatment choice



(2002a) stated that animal health economics could be used in the context of aquaculture to answer 3 main questions:

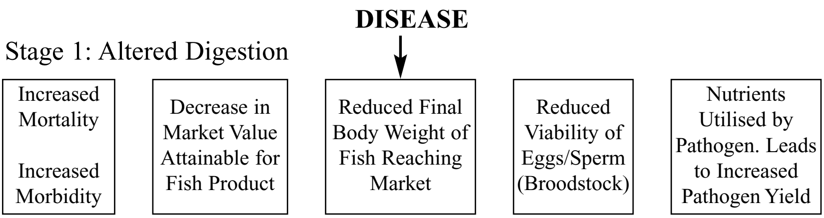
1. What is the economic impact of a particular disease at the level of interest (i.e. farm, regional, national or international).
2. How can key stakeholders (policy makers, veterinarians, farm managers) optimise the management of disease?
3. How can we quantify the financial implications of utilising a particular disease management practice?

The first question, that is, the effect a pathogen has on production, although difficult to quantify, is represented graphically in Figure 2. There are essentially 3 key points at which a pathogen can have an impact on the fish and hence on the fish farmer's returns:

1. Altered feed intake and digestibility in the host. The latter is a particular problem where pathogens alter the morphology and/or physiology of the gut.
2. Altered nutrient metabolism and excretion, thus reducing feed conversion efficiency.
3. Disease impact at the level of the individual fish. Premature death is obviously the easiest effect to quantify. Others may include lower attainable market values as a result of the visible impact of infection (e.g. sea lice induced lesions), or reduced fillet to bone ratios as a result of inappetance. In the case of broodstock, disease can adversely affect sperm/egg quality and yield (Brock & Bullis 2001), thus reducing either direct sales income, or reducing management flexibility if the progeny are to be kept for on growing purposes.

All of the above stages combine to reduce realisable income at the farm, regional, national and international level. The greatest challenge in this process is obtaining the information to enable an accurate economic assessment to be made.

FIG 2: Pathogen driven effects on productivity in aquaculture. Adapted from Morris (1997)



In order to answer questions 2 and 3, there are 3 key points that must be addressed before the most appropriate techniques are chosen. These are:

1. Identification of the nature of the disease problem in terms of epidemiology and the suitability of prophylactic, curative or management intervention.
2. The resources available to the decision-maker in terms of computing power, time available and level of expertise.
3. The provision of relevant and reliable financial, physical and biological information readily accessible to the decision-maker.

Almost invariably, these key points will identify shortcomings. Whether these are worth fixing will depend upon the anticipated gains relative to the costs and difficulties of acquiring the necessary resources and information. As such this stage is all part of the aim of animal health economics to establish the 'minimum cost' solution as described above. Given the increasing pressure to improve the 'health' of our food chain in its widest sense (Harvey, 1991) it is increasing likely that action will be justified in order to improve fish health through the use of these techniques.

Choice of Tools Used in Animal Health Economics

There is a range of tools and benchmarks of varying complexity that can be used to support the decision-making process in optimising health management. These include cost of treatment per fish, treatment margins, partial budgeting, cost-benefit analysis, break-even point analysis, decision tree analysis, linear programming, systems simulation and dynamic programming and are discussed in detail in the remainder of this paper.

A) Cost of Treatment per Fish

Cost per fish (including output losses as well as expenditure on treatment/prevention) is one of the simplest means of comparing alternative treatments from a financial perspective. In the case of sea lice medication for example, it would be necessary to consider the purchase cost of the medicine itself, the cost of labour associated with the treatment, the value of fish lost due to side effects and the possible reduction in fish growth as a consequence of inappetance following treatment. Additional costs may include the purchase price of oxygen required during bath treatments. For some treatments, it may also be necessary to consider calculating the monetary value of a decrease in production flexibility a withdrawal period imposes on farm management practices. The various regimens can then be ranked on the basis of cost per fish.

B) Treatment Margins

Comparison of 'treatment margins' can be used to assess the impact of a range of treatments on the entire fish farm business. The treatment margin is calculated by subtracting Variable Costs from Output. In essence, output is defined as the predicted value of fish sales *minus* the value of fish lost due to the adverse effects of treatment *minus* the reduction in fish growth as a consequence of treatment. Variable costs are composed of the purchase cost of the medicine *plus* labour costs *plus* any 'additional costs' *plus* the initial cost of ova/fry/parr/smolts bought in. In the context of aquaculture, such an approach has been applied by Peddie (2000) to evaluate the farm level economic implications of employing different sea lice treatment methods.

C) Partial Budget

Partial budgeting is a technique commonly applied to a range of business management problems, as well as animal health economics. With respect to the latter, various problems have been tackled using partial budgeting including an evaluation of novel porcine vaccines (Gummow & Mapham 2000), calculation of farm specific losses due to bovine respiratory disease (van der Fels-Klerz *et al.* 2001) and an assessment of novel means of animal trypanosomiasis control in Africa (Kamau *et al.* 2000). As partial budgeting does not track changes over time or incorporate any measures of risk, it requires little data in order to yield useful results. The 4 key components of the partial budget, as outlined in Peddie & Stott (2000a) are as follows:

1. Identification of additional returns as a consequence of changing the disease management regime.
2. Identification of reduced costs as a result of implementing the alternative regime.
3. Identification of returns lost as a result of the change.
4. Identification of additional costs accrued as a result of implementing the new regime.

A worked example of a partial budget is presented in Table 1. In this example, as benefits exceed costs, controlling furunculosis by switching from routine vaccination to regular application of an in-feed immunostimulant is the preferred option.

D) Cost-Benefit Analysis

In human health, cost-benefit analysis has been applied to a number of health management issues (Desjeux *et al.* 2001; Rajgopal *et al.* 2002), whilst in animal health, it has been used to assess the economic implications of topics as diverse as eradicating BVD (bovine viral diarrhoea) (Dufour *et al.* 1999) and vaccinating dairy cattle against paratuberculosis (van Schaik *et al.* 1996).

TABLE 1: A Partial Budget example (utilising an in-feed immunostimulant treatment regime against furunculosis as opposed to vaccinating routinely). The figures used are for illustrative purposes only (Adapted from Peddie & Stott 2002a).

BENEFITS		COSTS	
Additional Returns	*£75*	*Returns Foregone*	*£75*
Increased growth rates (reduced stress). Non-specific protection against a wide range of pathogens.		Reduced survival rate.	
Reduced Costs	*£50*	*Extra Costs*	*£20*
No vaccine purchase costs. No additional labour required.		Purchase cost of immunostimulant.	
TOTAL	*£125*		*£95*
NET CHANGE (Total Benefits *minus* Total Costs)	**£30**		

Cost-benefit analysis is used when the disease management option under consideration runs over an extended time period (Peddie & Stott 2002a). Thus, the future costs/benefits are discounted so that the 'time preference' of money is incorporated into the analysis. Time preference means that as a consequence of potential interest yields, a benefit of £1 received in one years' time is worth less now than a benefit of £1 received immediately. Bearing this in mind, the present value of a future cost or benefit is calculated using the following formula:

$$\text{Present Value} = \text{Future Value} / (1 + \text{Annual Percentage Interest Rate} / 100)^{\text{no. of years in the future}}$$

A working example of the discount rate as applied to the cost-benefit analysis approach is presented in Table 2. In this case, the non-discounted figures show that there is no advantage to be gained from switching from one treatment option to another. However, using the discounted figures, the costs associated with changing to a new regime outweigh the benefits, thus highlighting the importance of the time value of money.

TABLE 2: Example of the Cost-Benefit approach. The figures used are for illustrative purposes only (Adapted from Peddie & Stott 2002a)

Year	Discount Factor	Non-discounted		Discounted	
		Costs	Benefits	Costs	Benefits
1	0.93*	80	0	74.4**	0
2	0.87	10	50	8.7	43.5
3	0.82	0	40	0	32.8
		90	90	83.1	76.3

Assuming a real interest rate of 7%.
* 0.93 = 1 / (1 + 7 / 100)1
** 74.4 = 0.93 x 80

E) Break-even Point

Break-even point analysis is commonly used to assess the financial implications of both animal and human (Loeve *et al.* 2000) treatment regimens. Such an approach has also been used in fish health economics by Lillehaug (1989) and Peddie (2000) to compare vibriosis vaccines and sea lice treatment options respectively.

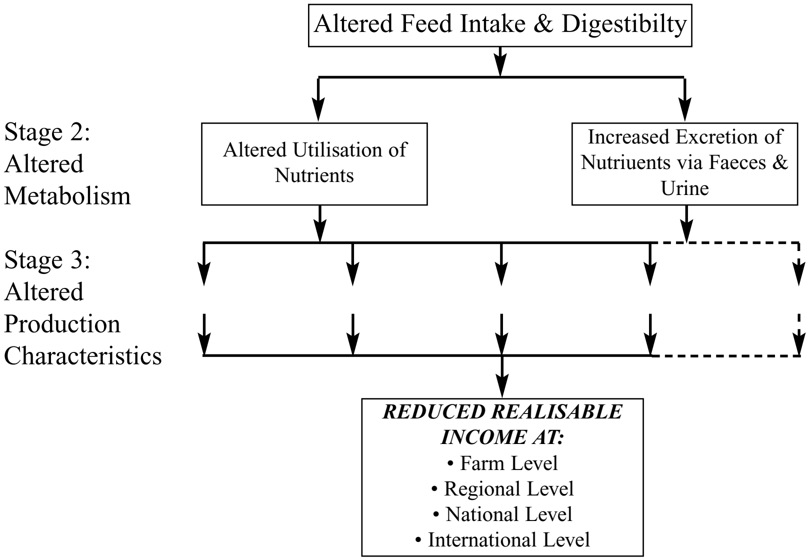
The break-even point of a treatment is reached when the savings associated with its application equal the costs. In the graphic representation in Figure 3, the area to the right of the intercept is where a particular treatment is cost-effective (i.e. where savings>costs). Conversely, the area to the left of the intercept is where treatment would not be cost-effective (i.e. where costs>savings).

F) Decision Tree Analysis

Decision tree analysis has been used in human health economics to assess the cost effectiveness of various forms of cancer treatment in diverse populations (Kosuda *et al*. 2002). This technique recognises that there is a degree of risk attached to the decisions a fish health manager takes. Figure 4 is an example of how this technique can be used to assess whether or not prophylactic use of immunostimulants is more cost effective than antibiotic treatment in controlling furunculosis. The key points of the decision tree are as follows:

1. Decision nodes i.e. the point at which a particular disease management strategy is chosen. (In Figure 4, it is represented as a square.)
2. Chance nodes i.e. events that are subject to uncertainty. In Figure 4, they are represented as circles. At each of these chance nodes, the probability (p) of the event occurring is defined. This probability ranges from 0 (no

FIG 3: A graphical representation of break-even point analysis. The more severe the effects of disease, the greater the benefits that result from treatment (Adapted from Peddie 2000)

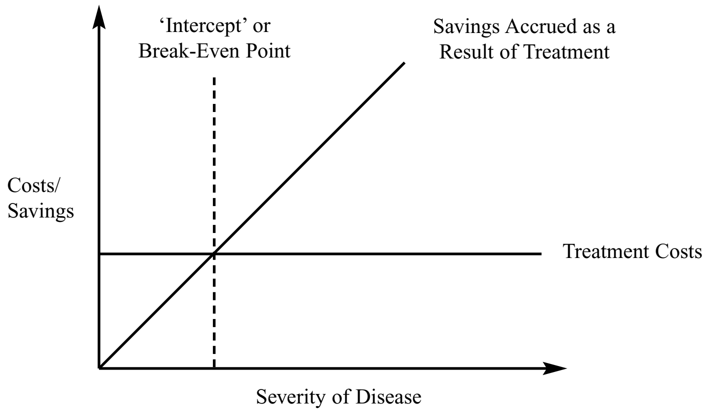


chance of the event occurring) to 1(the event is absolutely certain to occur). Each probability is assigned based on either experience or published data and is typically the most difficult figure to estimate.

3. The value of each outcome is defined.
4. The Expected Monetary Value (EMV) for each discrete outcome is calculated by multiplying its probability by the value of that outcome.
5. Total EMV for each treatment option is calculated; the option with the largest monetary value is the most financially prudent provided the decision maker is indifferent to risk. Most decision makers however are not indifferent to risk. They may for example choose a treatment because it avoids a particularly undesirable branch in the decision tree even though the decision does not give rise to the highest total EMV. Such decision-making depends on the attitude of the individual decision maker and allows the gambling and insurance industries to thrive. Attitudes towards risk can be measured and hence included in the analysis of risky decision problems. Details of the approach are given by Hardaker *et al*. (1997).

Although risky decision-making requires an element of personal judgement, the decision tree does provide certainty equivalents for each choice and its layout highlights extreme pathways. Both features can greatly assist the decision maker. Using the example in Figure 4, the Total Expected Monetary Value is greatest for the antibiotic treatment approach, therefore it would be favoured ahead of the prophylactic option. Inspection of the tree confirms that there are no less favourable outcomes associated with antibiotic treatment thus confirming this decision.

FIG 4: Example of decision tree analysis applied to a disease control situation (prophylactic use of Immunostimulants versus treatment with antibiotics). The figures used are for illustrative purposes only



G) Linear Programming

Linear programming (LP) has gained acceptance in aquaculture as a technique applicable to operational management (Shaftel & Wilson 1990; Clayton & Baker 1995; Tai *et al.* 1995; Pelot & Cyrus 1999), although it has yet to be used extensively in the context of fish health management. In the field of human health, LP approaches have been used to determine optimal use of health care facilities (Dexter *et al*. 2002), as well as evaluating a range of vaccination strategies (Becker & Starczak 1997; Weniger *et al*. 1998). Although LP has not been widely used to aid the disease management decision-making process in agriculture, it has been used to model the dairy cow replacement problem (Yates & Rehman 1998).

The 3 most important constituent parts of the LP are the linear objective function, the set of linear structural constraints and a non-negativity constraint. The objective function is a mathematical statement of what needs to be achieved by the business, such as maximisation of total net revenue through optimal health management. The objective function is obtained within the constraints of the problem. For example, withdrawal periods must be observed for a range of sea lice bath treatments prior to treated fish being placed on the market. Linearity implies that the parameters of the objective function are fixed e.g. a constant cost per unit of production. The structural constraints are the physical limitations on the objective function and are represented mathematically as linear equalities. Finally, the non-negativity constraint limits the solution to positive and therefore meaningful answers only.

In order to construct, execute and analyse the linear programme, a number of steps are followed:

1. The likely treatment options are defined. For example, the use of vaccination, antibiotics or immunostimulants may be identified as the key options in a linear programme that seeks to optimise furunculosis treatment.
2. Growth projections for each defined activity. This stage is important as there may be growth penalties incurred when vaccination or antibiotics are applied.
3. The treatment margins are constructed for each defined activity.
4. The 'objective function' in the linear programme is defined.
5. Structural constraints e.g. space, market considerations, withdrawal periods are defined.
6. Individual business constraints may also be included, for example a cashflow limit or sales contract obligation.
7. The linear programme is executed and the output analysed.
8. The physical production plan is formulated, reflecting the optimal treatment regime as defined by the linear programme.

It is important to realise that although LP is a powerful tool for forward planning purposes, events in the 'real world' can lead to enforced modification of the production and/or fish health management plan. Thus, the LP output should be viewed as a guide and not an absolute.

H) Systems Simulation

In terrestrial farming, simulation modelling approaches have been proposed to evaluate animal health control programs in general (Enevoldsen & Sorensen 1994; Buijtels *et al.* 1996). More specific simulation models have also been constructed for the cattle industry in order to evaluate tuberculosis eradication strategies (Perez *et al*. 1998), the spread and control of infectious bovine rhinotracheitis (Noordegraaft *et al*. 1998), neonatal health protection programmes (Larsen *et al*. 1998) and the economic impact of respiratory disease (Hurd *et al.* 1995).

Systems simulation involves the creation of an interactive mathematical model (Dijkhuizen *et al*. 1995). The main advantage of this approach is that it can be used in situations where it is difficult to gain input data empirically; such scenarios include the modelling of infectious disease and testing 'what if' questions (Dijkhuizen *et al*. 1995). In addition, the systems simulation model has the advantage of highlighting gaps in knowledge, thus acting as a catalyst for the collection of more extensive and detailed data. Dijkhuizen *et al*. (1995) broke down the systems simulation process into the following 6 constituent stages:

1. A detailed description of the system to be modelled is constructed and the boundaries within which solutions can be found are defined.
2. Relevant data are collected, processed and analysed prior to incorporation into the model.
3. The simulation model is constructed.
4. The model is validated where possible i.e. a quantitative assessment is made of how closely the model approximates the 'real-life' situation.
5. Sensitivity analysis is carried out. At this juncture in the process, the values of a number of key input parameters are varied in order to quantify their impact on the final outcome.

The model is used in the decision-making process.

I) Dynamic Programming

A major use of dynamic programming (DP) in agriculture concerns optimisation of plant disease management (Reynolds 1995; Onstad & Rabbinge 1985). DP was first used in the context of animal health economics to determine whether culling was justified in order to control clinical mastitis in dairy cows (Stott and Kennedy, 1993). Since then, Yalcin & Stott (2000) used a DP model to solve the replacement decision problem for dairy cows under a range of alternative mastitis control procedures. Still more recently, Stott *et al*. applied DP to estimate the financial incentive to control paratuberculosis (Johne's disease) at farm level; DP was used to find the level of control expenditure that minimised the total cost of disease (output losses plus control expenditure). Indeed, DP is a particularly useful tool in solving multi-stage management scenarios (Reynolds 1995). Regardless of the scenario to which DP is applied, there are 4 components as identified by Reynolds (1995):

1. Decision Periods – Disease management decisions are made at discrete points; this decision can either be binary (control or no control) or may consist of making a choice from a range of treatment options, or determining the optimal timing of a particular treatment.
2. State Variables – These variables represent the state of the system at a discrete point in time. For example, a state variable may reflect key life cycle stages in the pathogen of interest.
3. Transition Function – This function describes the change in state variables between decision periods and is a function of the state of the system and the disease management decisions taken.
4. Criterion Function – Describes the parameter to be optimised, typically profit maximisation or cost minimisation.

The most probable avenue for the utilisation of DP in aquaculture is in broodstock health management, where the health status of individual fish can be monitored. Thus, DP could be used to identify the quantity and timing of prophylactic and/or curative inputs for any given scenario.

Conclusions

Animal health economics has a range of applications in aquaculture, from determining the economic impact of disease to optimising the disease management process. Human and animal health economists have developed a wide range of tools that can easily be modified for use by fish health managers. Indeed, the importance of adopting these approaches as part of the overall business management function is all too apparent given the mounting pressure on fish farmers to reduce costs and increase efficiency.

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Mass Marking and Vaccination of Salmon

The feasibility of tagging and vaccinating all North Atlantic farmed salmon using NMT mass marking technology

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Abstract

This paper reviews the feasibility and costs of tagging all farmed Atlantic salmon with coded wire tags, and vaccination and accurate grading and sorting in a single operation with the NMT mass fish handling system. The technology is for the most part well established and in use on the Pacific Coast of North America, and the vaccination module is currently under development. Such a scheme offers many advantages including traceability and management of escapees, product traceability throughout rearing, processing and marketing, and very reliable and accurate grading and vaccination. Total costs are likely to be of the order of 10 cents US per fish (excluding the cost of the vaccine itself), or 1–2% of total production costs.

1. Introduction

1.1 Background

Production of farmed Atlantic salmon (*Salmo salar*) has increased tremendously in recent years; in the North Atlantic area it was almost 600,000 tonnes in 1999, which is of the order of one hundred times the declared catch of wild fish. There is currently interest in a number of countries in marking all, or a significant proportion of, farmed juveniles before they are stocked in sea cages. This interest originated from concern over the ecological impact of farmed fish which escaped, and the potential to control and manage the situation if escapees could be readily identified and their source established. However, the potential advantages from the viewpoint of fish husbandry and quality control are now rapidly gaining appreciation. The interest so far has predominantly emanated from Europe, principally Norway (the largest producer of farmed salmon) and Iceland. However, interest is now developing in Canada, the USA and Chile.

This paper presents a brief feasibility study for a programme of tagging all farmed salmon using NMT coded wire tags (CWT) and mass marking technology, incorporating grading and vaccination in the same operation. It has been prepared by NMT and does not of course represent a specific proposal that such a scheme should be introduced; its aim is to explain how such a programme might be undertaken, what it could achieve and how, and what the costs are likely to be. If such a scheme is to be introduced, it is of course essential that maximum benefit accrues all round; therefore the potential benefits to the salmon farming industry and to the consumer are also considered.

The CWT is a very small piece of magnetised stainless steel wire (standard tags 1.1mm in length) that is injected into suitable tissue. An area of connective tissue and cartilage in the snout is the usual location selected for juvenile salmonids, and fish as small as 60mm can be tagged. The tag is marked with decimal numbers which allow batch or individual identification. Presence of the tag is determined using a magnetic detector but the tag must be recovered for decoding. About 50 million CWT are currently put into hatchery-reared salmon each year, mostly on the US West Coast. They have also been used extensively on Atlantic salmon, with more than 12 million fish being tagged between 1990 and 1999 in 15 countries.

A mass marking system to automatically grade, sort, count, align, hold, fin-clip and coded-wire tag small fish has been developed in recent years and is in deployment for Pacific salmon in North America. This can handle and tag fish at a rate of up to 5,000 per hour and requires one operator plus an assistant. No anaesthetic is required. Development to incorporate vaccination into the operation is currently underway, supported by a $2 million grant from the Advanced Technology Program of the US Department of Commerce.

1.2 Ecological concerns

Escapes, and perhaps intentional releases, occur at a level that results on occasions in large numbers of fish of farmed origin mixing with wild stocks in the high seas, in coastal waters, and in rivers. For example, over half a million salmon were estimated to have escaped in Norwegian waters in both 1998 and 1999, and in 1999 almost 25% of the Norwegian “wild” catch was of farm origin. There is concern that these escapes and releases may have a significant impact on wild stocks in a number of ways, for example:

- through competition for food, space and spawning ground;
- by stimulating fisheries to develop that would also exploit wild stocks;
- by genetic interaction where escaped fish spawned with fish of local wild stocks;
- by acting as vectors of diseases and parasites.

A number of organisations including The North Atlantic Salmon Conservation Organisation (NASCO), the International Council for the Exploration of the Sea (ICES), Worldwide Fund for Nature (WWF) and government departments in several countries where Atlantic salmon are farmed have expressed concern regarding the impact of escapes, and have expressed interest in the scope for a tagging scheme to help manage the problem. While tagging would not prevent escaped fish from having an impact it is expected that having the fish identifiable will greatly encourage fish farmers to prevent escapes, and allow resources to be focussed in areas where the problem proves to be greatest.

1.3 Advantages for husbandry and quality control

There are a number of potential advantages in being able to identify fish at various stages in their rearing and marketing history. Although individual identification without having to handle the fish would be ideal, no cost-effective system can offer this nor is one likely to be developed in the foreseeable future. However, although the CWT has to be recovered from the animal before its code can be determined, the system offers several major benefits. If a coded wire tag were to be implanted at the same time as the fish were vaccinated prior to salt-water transfer, the presence of CWT (which can be determined using a magnetic detector without having to recover the tag) could be used to demonstrate vaccination status. Fish which died or were sacrificed could be identified to a particular batch, hatchery and vaccination date and its history since could be detailed.

Concerns over food safety, such as salmonella in eggs, BSE in beef, use of therapeutic chemicals and use of genetically modified organisms, means that full traceability of products is becoming increasingly important. The use of coded wire tags as proposed here would allow any individual salmon, sampled at any stage in its rearing or marketing history, anywhere in the world, to be identified with respect to juvenile rearing site, vaccination and other treatment history, marine site, dates of stocking and harvesting, and any other relevant details. This could represent a critical part of an overall product traceability programme.

2. The requirement

If all smolts stocked into North Atlantic marine farms were to be marked, about 300 million tags would be involved per year. In order to provide appropriate information to be of use to managers of wild salmon stocks, it would be necessary to be able to identify the year of smolting and the marine site involved from the tag. About 280 marine sites are involved in Scotland and 300 in Norway; it is likely that of the order of 1000 sites are involved Europe-wide. Any tagging system must therefore incorporate provision for encoding with many thousands of unique codes.

It would be essential that a tagged fish could be recognised without the requirement for killing. It is not essential for the tag to be decodable in live fish. It would be important, however, that marked farmed fish can be separated from marked wild or ranched fish.

It is clearly essential that the marks be inexpensive to purchase, inexpensive and fast to apply, cause no trauma to the fish, cause no disfigurement to the fish, and represent absolutely no human health hazard.

If the tagging system is also used as an aid to regulate and monitor production, as a certificate of vaccination, or for tracing (see Section 3.5), the following points are also important:

- the marks must have a high retention rate;
- detection of the tags must be fast and simple;
- tags should not be re-usable or transferable between fish;
- counterfeiting of tags must be effectively precluded;
- tagging machines should have tamper-proof mark counters.

The coded wire tag (CWT) system manufactured by NMT satisfies all the requirements. No other system comes close to doing so.

3. A possible approach

3.1 Outline

The proposal is that ultimately all salmon smolts that are to be stocked into marine rearing facilities should be marked with a CWT. The decimal coding of each batch of tags would uniquely identify the date of tagging, the rearing station and the marine site involved. Typically tags would be supplied in spools of 10,000 bearing a single code. Any number of spools can be produced bearing the same code for different size batches. This would allow differential marking of different treatment groups e.g. by genetic origin or husbandry history. In most previous applications the adipose fin was clipped at the time of tagging to aid identification of tagged fish. This is not proposed for this application, which would allow immediate differentiation of farmed and tagged wild or ranched fish.

The marking protocol would clearly have to be established by the appropriate bodies in each country. It is likely that the tagging would be undertaken by a specialist contractor, who would be supplied with appropriate numbers and codes of tags. Tags would be applied prior to smolting. The obvious opportunity is when fish are being graded and vaccinated; indeed there is scope for cost-effective multi-tasking by the one machine (see below).

3.2 Type of tags

Standard length (1.1 mm x 0.25 mm diameter) or one and a half length (1.55 mm x 0.25 mm) CWT are suggested, though a coding system would be developed that was unique to farmed Atlantic salmon (e.g. a specific master word, or alpha-numeric coding). This would be desirable to ensure ready identification of farmed fish, and to protect existing allocations under the present formats. The optimal format would require careful consideration and consultation.

It would be proposed that sequentially-numbered batches of tags could also be made available to allow identification of small batches of fish for husbandry purposes. The rationale here is to ensure that the maximum possible benefit from tagging is available to all parties, including the fish farmer.

3. The mass marking machine

While hand tagging using NMT Mark IV injectors has been used to tag of the order of 50 million juvenile salmon each year, using such an approach to

FIG 1: Single tagging and marking line of a mass marking machine. Four or five lines are contained in a single trailer. Fish are accurately measured and graded, and distributed to the appropriate line. Incorporation of automatic vaccination into the process is currently under development.

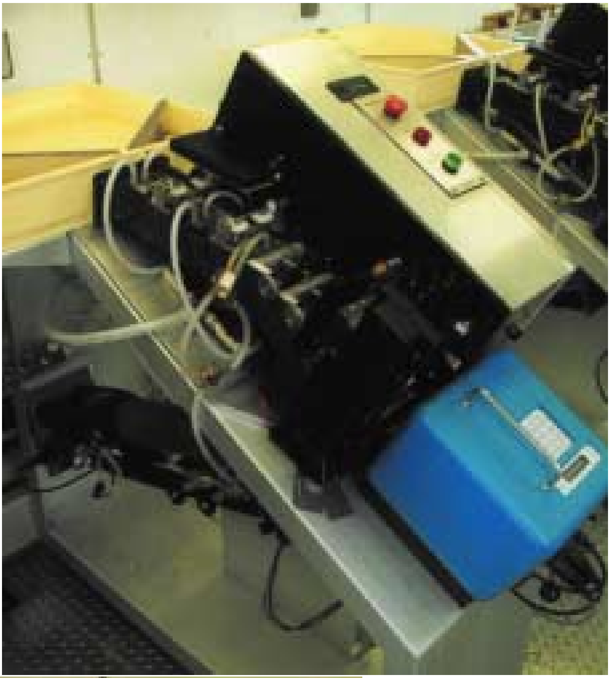

FIG 2: The volitional entry tray of a single line in a mass marking trailer. The fish are not anaesthetised and enter the tagging line through their own swimming action. Each line can tag, mark and vaccinate up to 2000 fish per hour.

FIG 3: The interior of a mass marking trailer showing four tagging and marking lines.

tag 300 million fish in a matter of weeks would pose major logistical problems. What makes this proposal viable is the availability of the NMT mass marking technology.

The mass marking machine was originally developed to address the requirement to remove the adipose fin from hundreds of millions of juvenile chinook and coho salmon each year on the Pacific Coast of north America, following a decision that all hatchery-reared fish for release to the wild would be marked in this way. The opportunity was taken to incorporate coded wire tagging into the process, though it was not the intention to CWT all fish in this application. This format of the system, termed the Marking and Tagging System (MATS), is currently in full-scale operation with several agencies in the US.

The process is computer controlled throughout and at no time are the fish touched by hand or anaesthetised. The machine uses a patented volitional entry device at two stages of the process. First, fish enter the sorter by swimming against the flow. This determines the length of the fish to within 1.0 mm using video imaging, and sorts them into of seven size classes. Five of these are fed to individual clipping and tagging lines; the other two classes, too small and too large, are rejected for later processing. The fish distributed to each line again pass through a volitional entry device into the clipping and tagging chamber. Here the fish is firmly but gently held. The adipose fin is removed using a clipper guided to the correct location by automatic video imaging; the imaging system also acts as a quality control, to check that the fin has been effectively excised. A coded wire tag is injected into the snout at the same time. The fish then passes through a CWT quality control device which checks that it contains a properly magnetised tag; any that are not properly tagged are rejected and the system computer is informed. A five-line trailer is capable of clipping and tagging up to two fish per second, or 40,000 per eight hour shift.

It became apparent early on that this fish handling system could potentially be adapted to perform a range of tasks, including vaccination, in one pass. However, in order for the machine to overcome problems associated with some other attempts to develop automatic and semi-automatic vaccination machines significant development was required. This is currently underway and includes achieving a very accurate location for needle penetration, accurate needle penetration depth, and carefully controlled dosing. This is made feasible by the ability of the equipment to determining the length of the fish within close tolerances, and allocate them to different processing lines. The scope for this technology to be incorporated into stand-alone grading and grading/vaccination machines is also being assessed.

3.4 Location of tag

Positioning the tag in a non-eaten part of the fish would be prudent. The obvious choice of site would be the area of connective tissue and cartilage in the snout, as is generally used for wild salmonids. This has the following advantages:

- it is a well established benign tag location;
- fish can be tagged at high speed – in excess of 800 per hour using a Mk IV injector, or up to 5,000 per hour with a mass marking machine;
- the tag is located well away from parts of the fish that are usually eaten.
- it is possible to recover the tag without affecting the market value of the fish.

3.5 Advantages to the industry

While it is inevitable that a tagging programme would represent some (hopefully minor) inconvenience to the fish farmer, there are a number of ways in which the overall scheme might offer positive advantages to the industry. These include:

- Vaccination can be achieved at low cost, with minimal trauma and without anaesthetic.
- The presence of a CWT could be used to indicate vaccination status.
- Very accurate grading can be achieved at the same time that the fish are tagged and vaccinated. This may preclude the requirement for a further grading before the fish are transferred to sea water.
- The machine produces an accurate record of the size (within 1.0 mm) of all fish processed and sorted.
- Allocation of tags could be used to control the production on each farm and by each country, preventing over-production. In Norway, 10% overproduction appears to lead to a 25% fall in first-sale prices. The small cost of the scheme (calculated at 1% of costs of production) could therefore be more than outweighed by the advantages of production and price control.

- Fish believed to have been stolen, or being marketed in an unfit state or in a non-approved manner could be traced back to the unit of origin. In this way honest and honourable operators would be protected.
- Farmers could use tagging data for husbandry purposes or trial evaluation.
- Offering product traceability could be a huge PR coup for the industry (see Section 1.3).
- Responsibility for escapes would be correctly identified, protecting blameless farmers from accusation.

3.6 Costs

Operating costs would be dependent upon the logistics of deploying the equipment, including the number of sites involved and their remoteness with respect to transport of equipment, the scope for spreading operations over several months, staff costs, and details of agreements with partners in each country. To some extent too the cost will depend upon which operations the equipment would perform at one time, though the marginal cost of each operation is fairly minor once the equipment is deployed. From experience in North America, NMT estimates that a large-scale operation (100 million plus fish per year), involving sorting/grading, counting, coded wire tagging and vaccination would cost of the order of 10 cents US per fish, including the cost of the tag, the equipment and personnel but excluding the cost of the vaccine itself. This represents of the order of 1 to 2% of the first sale value of the adult fish. It must be noted that the costs quoted above are for a scheme involving processing more than 100 million fish per year. Costs per fish may be somewhat higher for any scheme involving much lower numbers.

3.7 Animal welfare issues

All livestock farming activities and the associated treatment of animals are the subject of increasing concern regarding the welfare of the animals. Clearly any marking technique must be considered from this viewpoint.

The coded wire tag, being small, biologically inert, and completely enclosed in tissue represents the most benign of all existing fish tagging methods. Histological studies have demonstrated that there is no adverse tissue reaction to the presence of the tag, while other investigations have shown there is no effect upon survival, growth or behaviour. These observations contrast with those for some other marking methods, particularly those involving permanent penetration of the skin. We are confident that the CWT system will satisfy the most vigorous examination of animal welfare issues.

3.8 Human health issues

As stated in Section 2, it is essential that any marking system represents no hazard whatsoever for human health. The coded wire tag is a tiny, biologically inert section of stainless steel wire. It represents no hazard to humans if ingested, and in any case would be injected into tissue (the snout) which is not commonly consumed in any country or culture. Up to 45 million CWT are put into Pacific salmon released to the wild each year in North America. The Japanese, who are fastidious over food hygiene and safety and consume most edible parts of fish, readily accept landings of salmon with CWT and are now using this marking system in their own investigation. NMT is confident that the CWT system will satisfy the most vigorous examination of human health concerns.

Further, in allowing individual fish traceability, the CWT system would make a major potential contribution to the interests of consumer safety and reassurance. Thus routine checks, or special checks of batches or individual fish of concern, at any stage in the rearing, wholesaling or retailing process, would allow the full rearing and husbandry history to be accessed.

4. Conclusions

From the above consideration it is concluded that coded wire tags deployed using the NMT Mass Marking technology represents a realistic, cost-effective and safe approach to marking all farmed salmon. The scope for tagging to be integrated with grading and vaccination could represent a major cost-saving opportunity. The potential for learning about the dispersion and migration of escapees, quality control and product traceability is tremendous.

It is stressed that the approach to tagging and associated operations discussed above is indicative only and that there is great flexibility possible in the overall planning and implementation of such a scheme.

David Solomon graduated from the University of Exeter with a degree in zoology and then went on to study fish physiology to gain a PhD from the University of London. He worked for 15 years for the MAFF Fisheries Laboratories in London and Lowestoft before going independent in 1986. Since then he has been involved in a wide range of fisheries investigations, mostly involving salmon and freshwater fisheries. Since 1994 he has also acted as the European Representative for Northwest Marine Technology, a US company who manufacture fish marking and tagging systems.

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Radiography of Fish

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Abstract

Radiographic examination is a non-lethal and non-invasive procedure that can provide useful information about internal disorders in fish. Cases with abnormal body shape, swimming and buoyancy disorders and suspected foreign bodies are commonly presented for examination. Using an appropriate anaesthetic agent, fish can be removed safely from water for radiography using equipment and techniques available in most veterinary practices. This paper provides an overview of the subject and discusses radiographic abnormalities of the skeleton, swim-bladder and soft tissue, and foreign bodies found in fish.

The use of advanced diagnostic imaging in fish may initially appear challenging and of limited value. However, after anaesthesia has been successfully achieved, the use of radiography can be performed as easily and as successfully as in other animals. Most veterinary practices have radiographic facilities with staff that are experienced in its use and can apply their skills to fish radiography.

Many ornamental fish cases presented in general practice have internal disorders, which fail to respond to proprietary medicines that are available from pet shops. Diagnosis in these cases is often difficult due to the limited value of external examination and other tests. However, good radiographic technique enables several internal disorders to be identified and a prognosis given. Suitable cases include fish with abnormal body shape, swimming and buoyancy disorders, and suspected foreign bodies. Radiography has the advantage of being a non-lethal and non-invasive procedure that provides a permanent photographic record.

Equipment

The same equipment and techniques used for radiography of domestic animals can be used for fish. The use of rare-earth intensifying screens and high definition film is recommended due to the small size of many patients and to help identify subtle radiographic features. The radiographic cassettes can be wrapped in a polythene bag to prevent damage from the ingress of water. The use of a grid is rarely required to reduce scatter radiation since many fish are less than 10 cm thick.

The legislation controlling the use of ionising radiations applies to the use of equipment such as the X-ray generator and personal equipment (protective clothing), supervised areas, personal dosimetry and record keeping. Although no additional measures are required for the radiography of fish, the safety of all staff must be considered. Electrical safety and the use of high voltage equipment close to aquatic environments must be carefully controlled.

Technique

Good radiographic technique will produce high quality images of diagnostic value. This requires standardising many of the procedures involved such as anaesthesia, positioning, collimation, exposure settings and processing of the films. Despite the brevity of the procedure, it is essential that all the necessary equipment is ready and in place before the patient is prepared. In most cases, the fish is removed from the water and placed on the radiographic cassette. Suitable tanks with airstones should be in the radiography room or adjacent to it so that handling and time out of water is kept to a minimum.

Anaesthesia is recommended for most cases. Although some fish can be manually restrained, sedation or anaesthesia reduces stress to the patient and allows for better positioning. The lack of movement prevents blurring of the image and from a safety perspective, reduces the need for repeated exposures. In most cases, anaesthetised fish can be safely removed from water for up to four minutes. This is adequate for most radiographic examinations and the patient can then be returned to the recovery tank while the film is processed. Should further exposures be required, then the patient can be anaesthetised repeatedly. Manual restraint using towels or placing the patient inside a polythene bag with a minimum amount of water reduces radiographic contrast and detail.

Good positioning improves the consistency of radiographic interpretation. In most cases, two views are required. A standard lateral view should be taken with the fish placed in right lateral recumbency using a vertical beam. Some species can be placed on ventral recumbency to provide a dorsoventral view but others may be difficult to position accurately without additional support. Alternatively, a horizontal beam can be used with the fish in lateral recumbency and placed against the cassette. Fish that have a rotund body shape will require the use of radiolucent foam wedge supports as positioning aids. For example, these may be placed under the dorsum of fancy goldfish so that a true lateral view is obtained. Correct positioning for lateral views can be confirmed by the superimposition of ribs and the paired pectoral and pelvic fins on the radiograph.

Exposure factors used will depend on the body thickness at the site under examination but are similar to those used for other animals. However, the cartilaginous skeleton of most fish is relatively radiolucent and radiographic detail can be very limited, particularly in young fish and small species. Due to the tapered body shape of many fish, different exposure settings will be required to visualise the anterior and posterior spine. The use of an automatic film processor will ensure a uniform standard of development. This will enable an accurate exposure chart to be drawn and minimise the need for additional exposures to be taken.

Contrast media such as barium sulphate or iohexol can be used for gastrointestinal studies and may help identify the size and location of other internal organs. The volume of the agent administered depends on the size of the patient and the presence or absence of a stomach but 5 ml/kg bodyweight is often used. The medium is administered by stomach tube under light anaesthesia and radiographs taken at varying intervals, depending on the site under investigation. Although air and gas can be used as a negative contrast medium within the body cavity, it disturbs the fish's natural buoyancy. Free gas can be found in the body cavity following abdominal surgery or following rupture of the swim-bladder. The gas within the swim-bladder is a useful negative contrast medium that can help identify overlying structures.

Normal radiographic anatomy

Coldwater ornamental fish such as koi (*Cyprinus carpio*) and goldfish (*Carassius auratus*) are commonly presented to the author in practice and their normal radiographic features (Fig 1) will be discussed. However, there are marked differences between other species and knowledge of normal variations is essential to prevent misinterpreting normal structures as abnormalities.

The bony structures are most easily visualised: vertebrae are uniform and appear to have a diagonal cross in the body of the bone. Other skeletal fea-

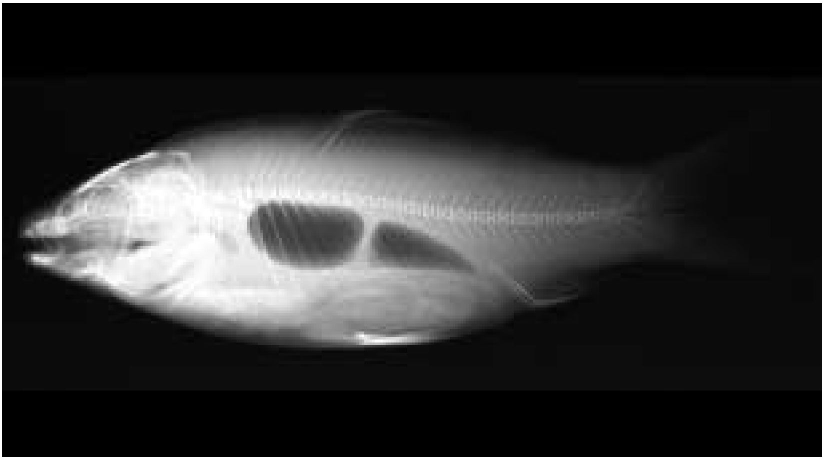

FIG 1: Lateral view radiograph of a normal koi. The skeletal features are clearly visible as are the two chambers of the gas-filled swim-bladder.

FIG 2: Lateral radiograph of a koi with a large gonadal tumour in the posterior body cavity which has caused some displacement of the swim-bladder.

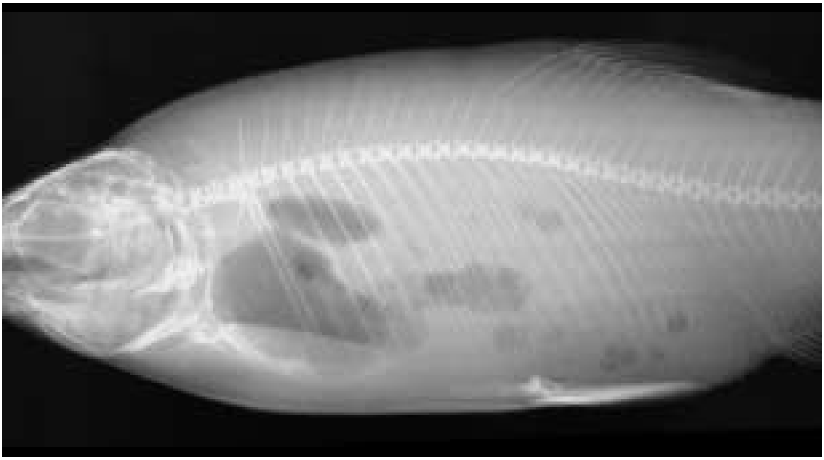

FIG 3: Radiograph of an orfe with buoyancy problems due to rupture of the posterior chamber of the swim-bladder and free gas in the body cavity. A fungal infection was present in the swim-bladder and caused peritonitis.

FIG 4: Horizontal beam radiograph of a goldfish with buoyancy problems. Both chambers of the swim-bladder were partly filled with fluid from which *Aeromonas hydrophila* was cultured. Gas is also present in the bowel.

tures vary with species as does the skull and dentition. In carp, pharyngeal teeth are readily visible in the posterior pharynx rather than on the mandible or maxilla.

The swim-bladder, a gas-filled organ that assists buoyancy, is situated in the dorsal aspect of the body cavity and is also a major feature on radiographs. In koi and goldfish, this consists of two interlinked chambers but can vary from one to three chambers among other species.

The abdominal organs often appear in the rather homogeneous area ventral to the swim-bladder. Due to the similar radiodensity and compact nature of the internal organs, it is rarely possible to identify anything other than gas or radio-opaque matter in the bowel.

Radiographic abnormalities

Various radiographic abnormalities may be seen and the examples that follow are based on the author's personal experience with cold-water pond fish such as koi and goldfish.

Skeleton
Skeletal lesions are primarily limited to those affecting the skull and spine. Fractures, luxation and malformation of the spine may result in abnormal curvature with varying degrees of kyphosis, lordosis and scoliosis.

Fracture:
Vertebral fractures may result from physical trauma (e.g. poor handling), electrocution or following violent muscle spasm from overdose with chemicals such as organophosphates or formalin. They are common in orfe (*Leuciscus idus*), a long slender fish, producing varying degrees of spinal deviation and subsequent difficulty with swimming.

Luxation:
Intervertebral dislocation may be difficult to distinguish from fractures unless the fish are large and radiographic detail is good. These lesions may have similar aetiologies and produce similar clinical signs to those listed under fractures.

Malformation:
Abnormal spinal curvature can arise in the absence of fractures or dislocation. Due to the length of the spine and the large number of vertebrae present, subtle vertebral defects can produce marked deviations. These can be difficult to identify in small fish and may be congenital or acquired in origin.

Deformity of cranial bones in farmed salmon (*Salmo salar*) and trout (*Oncorhynchus mykiss*) produces varying abnormalities such as brachycephaly (e.g. 'pug head') and lower jaw deformity. Congenital defects may be inherited or developmental following damage (e.g. temperature shock) to the egg during critical stages of the incubation period. Other causes include nutritional deficiency (e.g. tryptophan, vitamin C, phosphorus) and infection such as granulomas produced by mycobacteria and *Ichthyophonus*, and from parasitic cysts.

Hyperplasia:
In a few isolated cases, a proliferative bone disease affecting most of the vertebral column has been noted in koi. These fish developed a rigid spine, with loss of spinal flexibility, even when anaesthetised. Only the vertebral bodies were affected: the skull, ribs and spinous processes of the vertebrae were not involved. No parasites or bacteria were found on histological examination of one case. The herbicide trifluralin causes fluorosis and produces similar hyperplasia of bone cells and irregular bone growth. It was not possible to establish if these isolated koi had been exposed to such chemicals or if other koi in the same pond had sub-clinical lesions. The spinal lesion has some radiographic similarity to cats with hypervitaminosis A as a result of being fed on a diet containing a high proportion of liver or excessive vitamin A supplements. A similar disease affects the spine of snakes but the cause remains unknown in these animals: it is often called osteitis deformans and is similar to Paget's disease in man.

Swim-Bladder
The swim-bladder is a large gas-filled organ and consists of one, two or three interconnected chambers, depending on the species. It is reduced in size or absent in some bottom-dwelling fish. In koi and goldfish, the swim-bladder is a bilobed structure but the size, shape and relative proportions may vary significantly in normal fish of the same species. It is involved in maintaining buoyancy and may play a role in sound perception or production in some fish. Abnormalities of the swim-bladder that may be visible by radiography include displacement, over-inflation, rupture and fluid filling. Most of these cause buoyancy disorders, particularly in fancy varieties of goldfish. However, granulomas produced by mycobacteria and other organisms in the cranial cavity may cause pressure on adjacent parts of the brain and result in a similar loss of balance. Despite the longstanding nature of some swim-bladder disorders and those caused by intra-cranial granulomas, fish commonly present with a sudden onset loss of balance.

Displacement:
The fibrous nature of the swim-bladder in some species causes the organ to be displaced from its normal position by local space-occupying lesions more readily than species in which it is a thin membranous structure. In the latter, distortion or herniation may occur. Polycystic lesions in the kidneys are common in goldfish and is sometimes called kidney enlargement disease. This is a chronic disease and produces massive abdominal enlargement that is often asymmetrical. It is usually a slow and progressive disease, which is thought to be either due to infection with a myxosporean *Hoferellus carassii* or be a developmental anomaly. In normal goldfish, the kidney is found dorsal to the connection between the anterior and posterior chambers of the swim-bladder. On radiographs of fish with polycystic kidneys, the two chambers may appear further apart than normal or one chamber, usually the posterior chamber, may be deviated in a ventral or lateral direction. Large intra-abdominal tumours such as those commonly found in large old koi, may equally cause pressure on the swim-bladder, sufficient to cause the two chambers to appear closer together or deviate from their normal position (Fig 2).

Over-inflation:
Fish that have excessive positive buoyancy, float on the water surface and must swim actively to submerge themselves. However, when they cease swimming they will float up to the surface again. In fancy varieties of goldfish, the anterior chamber is often significantly larger than the posterior chamber, which is sometimes barely visible on radiographs. Because of the wide variation in size of the swim-bladder, it can be difficult to assess if there is true over-inflation of the organ. However, affected fish often have a swim-bladder which appears much larger than would be expected for their size.

Rupture:
Rupture and collapse of the swim-bladder is uncommon and can follow traumatic injury or local pathological change (Fig 3) but may arise spontaneously. Affected fish may have abnormal pitch (often head down) or list to one side. Radiographically, gas can be seen in a retroperitoneal pocket and the irregular outline of the deflated swim-bladder may be visible.

Fluid filling:
Fish with a swim-bladder full of fluid will tend to lie on the bottom and have to swim actively up to the surface to feed. In these cases, gas in the swim-bladder may be reduced or absent and fluid production may be due to bacterial or fungal infection. Occasionally, the organ is enlarged due to distension

with fluid and may be visible on radiographs in the dorsal abdominal cavity. A lateral view taken using a horizontal beam is useful in cases where the swim-bladder is partially filled with fluid (Fig 4): a horizontal line will reveal the interface between the gas and the fluid. The author has also seen one case in a goldfish where fluid had filled the anterior chamber and the posterior chamber had ruptured, releasing gas into the body cavity.

Soft tissue

The lack of radiographic contrast makes it difficult to identify other internal organs such as the heart, liver, kidney and gonad. Common pathological changes in these organs include neoplasia and cyst formation. Tumours of the liver and gonad are common in old koi, although histologically it is often difficult to identify the tissue of origin. In many ornamental fish, tumours often become enormous before causing clinical problems. These large tumours may exhibit a homogenous increased radiodensity and may have areas of calcification within the mass. Some tumours may be well circumscribed on radiographs and be well defined within the abdomen while others may have large cystic cavities, be more diffuse in nature and less visible. Some tumours produce large volumes of ascitic fluid, which reduces the radiographic detail within the body cavity. The margins of small space-occupying lesions may be seen against the background of the swim-bladder whereas larger lesions may displace the swim-bladder (see above). In oscars (*Astronotus ocellatus*), renal and bladder tumours are common and cause localised abdominal swelling near the vent. In affected fish, there may be compression and herniation of the swim-bladder but there is often marked radiographic differences between cases.

The bowel may contain small radio-opaque particles that are ingested in food or debris from feeding off the bottom of the facility. Small amounts of gas may normally be present within the loops of bowel but this may increase due to infection and cause excessive positive buoyancy.

Some superficial tumours present on the outer surface of the fish such as melanomas, may be deeply invasive. Radiography can be used in these cases to determine the invasiveness of the tumour and help identify the best approach prior to surgery.

Foreign bodies

Gastric foreign bodies are common in red-tailed catfish (*Phractocephalus hemioliopterus*) but other species may swallow small pebbles that may be clearly visible on a radiograph. Many foreign bodies are radio-opaque but radiolucent materials such as rubber suckers, which are used to attach water heaters to tanks, are less visible. Normal radio-dense structures such as the pharyngeal teeth of some species (e.g. koi and goldfish) and auditory ossicles should not be confused with abnormalities.

Conclusion

Although the identification of bony lesions in fish using radiography is relatively easy, the diagnosis of some internal disorders requires skill and practice. Where possible, interpretive skills can be developed by routinely radiographing euthanasia cases prior to autopsy. Since the necessary equipment and expertise is present in most veterinary practices, it is hoped that this paper may stimulate readers to use this invaluable diagnostic tool more frequently.

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SCIENTIFIC PAPER

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Zoonotic Disease in Aquaculture Products - An Overview of Legal, Economic and Marketing Issues.

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Abstract

The general public is increasingly concerned about food quality and safety issues, particularly in the wake of the BSE crisis in the UK. Such concerns are not restricted to meat products alone however. Recent surveys have shown consumer confidence in some fish products, particularly shellfish, to be relatively low. Of key importance to consumers is the perceived threat of chemical contaminants, veterinary residues, biological toxins and zoonotic disease tainting the food products they purchase. This paper concentrates on the latter by firstly providing an outline of the main characteristics of zoonoses relevant to fishery products overall, and aquaculture products in particular. Secondly, the main International, European and UK legislation/agreements designed to minimise the risk of food-borne disease entering the food chain are reviewed. Importantly, such legislative control is multifaceted and addresses the issue of both indigenously produced and imported products. Finally, some of the key economic implications of the increasing awareness of zoonotic disease and resultant control measures are discussed, as are the marketing implications for producers, processors and retailers alike.

Introduction

Against a backdrop of increasing public concerns over food safety combined with a rapid rise in the worldwide trade in aquaculture products, the issue of zoonotic disease is assuming greater importance to key stakeholders in the food safety management process, including veterinary surgeons and fish health professionals. Consequently, this paper reviews zoonotic disease in aquaculture products and the legal, economic and food marketing implications.

Food Safety In Aquaculture – Zoonotic Disease In Context.

Zoonotic disease is only one aspect of food safety in the context of aquaculture, as illustrated in Figure 1. Others include veterinary drug residues, chemical contaminants, viral and bacterial pathogens of human origin and toxins produced by marine plankton.

What is Zoonosis?

The World Health Organisation (WHO) defines zoonoses as 'Diseases and infections that are transmitted naturally between vertebrate animals and Man'; this definition can be expanded to include invertebrate animals as additional reservoirs of pathogenic organisms. Zoonotic diseases can be caused by bacterial, viral, fungal, parasitic or protozoal pathogens. As a result, they have divergent epidemiological and clinical characteristics and respond differently to various control methods (DEFRA 2002). An overview of some of the key zoonotic agents in aquaculture and fishery products is presented in Table 1. General issues relating to each of the key categories of pathogen are detailed below.

A) Bacteria

In general, humans contract fish-borne bacterial disease through ingestion of contaminated fish products. Although exposure normally only results in mild episodes of gastroenteritis, some bacteria are highly pathogenic, thus precipitating relatively high rates of morbidity and even mortality (Stoskopf 1993; FAO/NACA/WHO 1999).

When comparing terrestrial animals to farmed fish, the latter generally constitute a relatively low risk to public health (FAO/NACA/WHO 1999). For example, available data suggest that the risks of campylobacter infection and salmonellosis associated with the consumption of farmed fish are low. Indeed, in the UK, 44 cases of salmonellosis were reported in 2000, of which only 2 of these (4.5%) were associated with the consumption of fish/shellfish products (DEFRA 2002). In addition, whilst cholera has been associated with the consumption of raw fishery products, there is little evidence to suggest that farmed fish or crustaceans present even a low magnitude risk. Finally, if fish are properly handled and processed to prevent growth of *Clostridium botulinum*, there is almost no risk of botulism induced illness in consumers of aquaculture derived products (FAO/NACA/WHO 1999).

B) Parasites

In the USA and the EU, the incidence of parasitic zoonoses attributable to fish is very small; this is not the case in countries like Japan and Russia where the greatest risk of fish-borne parasitism comes from the consumption of raw or undercooked fish products (Stoskopf, 1993). Overall, the incidence of parasitic infection from aquaculture systems may be expected to be substantially lower than in commercial fishery products as a result of the widespread usage of processed feeds (FAO/NACA/WHO 1999). For example, there are no reports that indicate any association between capliariasis and farmed fish. In addition, although many species that are significant in aquaculture, including the snakehead (*Channa* spp.), catfish (*Clarias* spp.), eel (*Anguilla* spp.) and carp (Cyprinus spp.) are carriers of *G. spingerum*, it is not thought to be of importance in aquaculture products (FAO/NACA/WHO 1999). Also of concern is the theoretical risk of cyprinids transmitting clonorchiasis, although no conclusive evidence has been produced to substantiate such concerns (FAO/NACA/WHO 1999).

C) Viruses and Fungi

To date, no incidence of human viral or fungal infection with fish pathogens has been documented (Stoskopf 1993; FAO/NACA/WHO 1999). However, this situation is continually under review. For example, the European Commission published a report that assessed the zoonotic risk from Infectious Salmon Anaemia Virus (ISAV). The report concluded that there is 'no reason to regard ISA as a zoonosis, and there is no evidence for risk to man.' (EC, 2000).

Classification of Zoonoses

A system based on the type of life cycle of the infective organism is used to classify zoonoses. The World Health Organization Expert Committee on Zoonoses, as outlined by the Office of Research, University of California at Santa Barbara (UCSB, undated), has classified zoonotic disease as follows:

Direct Zoonoses. Transmitted from infected vertebrate host to a susceptible vertebrate host by direct contact; no developmental change or propagation of the organism occurs during transmission. In the context of aquaculture, *Salmonella* spp. is an example of this form of zoonosis.

Cyclozoonoses. Requires more than one vertebrate host, but no invertebrate host.

Metazoonoses. The agent multiplies, develops, or both in an invertebrate host before transmission to a vertebrate host is possible. Anisakiasis, a disease caused by the larval stage of *Anisakis simplex* is an example of this form of zoonoses in fish and fishery products. In this disease, fish are the secondary host and become infected when they ingest either the primary invertebrate host or other infected fish. Normally, the definitive hosts are marine mammals, although humans can be infected following the consumption of raw or undercooked fish (FAO/NACA/WHO 1999).

Saprozoonoses. To transmit these infections a non-animal development site or reservoir is required, such as vegetation or other organic material.

A variety of pathways can lead to infection in the human population, although in European countries, the food-borne route is thought to be the most common (DEFRA 2002). Whatever the route of transmission, transfer between fish and Man is influenced by several factors:

- The length of time the fish is infective.
- Length of the incubation period in fish.
- The stability of the infective agent. This is of critical importance in direct transmission, where the agent is exposed to the environment.
- The prevalence of disease in the fish population.
- Husbandry practices.
- Virulence of the infective agent (UCSB undated)

Incidence of Zoonotic Disease

As Stoskopf (1993) points out, examination of literature pertaining to fish-borne zoonotic diseases reveals two main points:

1. The number of fish related disease outbreaks are increasing. This is a result of several factors:

- Increased consumer awareness of food-borne disease and related symptoms.
- Increased rates of exposure to contaminated/infected fish via consumption or recreational activities, particularly in the ‘developing world’.

- Increased susceptibility to disease in immunocompromised individuals. This phenomenon is of particular importance to countries where AIDS is an increasing problem; disease episodes in such individuals are often self-limited bouts of gastroenteritis-type illness.

2. Overall incidence of fish-related diseases in the 'developed world' remains relatively low.

Interestingly, DEFRA (2002) stated that the recorded cases of zoonotic disease represent only the 'tip of the iceberg'. The primary reasons for this are that patients generally do not seek medical attention for minor ailments, their doctor does not request a laboratory investigation, a positive result is either not notified or the occurrence of the disease is not notifiable. Moreover, reported cases also tend to be biased towards more clinically severe cases in high-risk groups. Also, as some zoonoses, such as salmonellosis, do not cause clinically significant disease in aquaculture, samples would not generally be submitted to the authorities for examination (DEFRA 2002).

Legal Considerations

There are a number of agreements, codes of conduct and binding legislation that apply to the control and monitoring of zoonotic disease in aquaculture and fisheries products. These operate at a number of International, European and Member State level, as discussed below.

International Agreements and Codes of Practice

In an international context, the Codex Alimentarius Commission (CAC) is the pre-eminent international organisation concerned with the setting of international food standards. It is jointly funded by the FAO and WHO and was established in 1962. The main Codex 'Subsidiary Bodies' that deal with zoonotic disease in aquaculture/fishery products are the 'food hygiene' world-wide general subject committee and the 'fish and fishery products' world wide commodity committee. The latter has revised all Codes of Practice for Fish and Fishery Products to include the principles of HACCP (Hazard Analysis and Critical Control Point). Indeed, both North America and the EU have mandatory requirements for the adoption of HACCP procedures as a measure for the regulation and documentation of quality control (FAO/NACA/WHO 1999). HACCP is a procedure that identifies and controls the points of contamination in the food production process. It takes the following step-by-step approach:

1. Hazard assessment.
2. Identification of the critical control points.
3. Setting up the procedures and standards for each critical control point.
4. Monitoring the critical control points.
5. Taking remedial action, if necessary.
6. Initiation of a detailed record-keeping protocol.
7. Reviewing/updating the various procedures on a regular basis.

Also of international significance are the agreements formulated by the World Trade Organisation (WTO) which was formed in 1995 to replace the General Agreement on Tariffs and Trade (GATT). Of particular relevance to zoonotic disease, the WTO has a subsidiary agreement on Sanitary and Phytosanitary Measures (the 'SPS' Agreement). This agreement states that countries should base their risk assessment/food safety standards on those presented by CAC. However, higher standards can be set by member countries, providing that such standards 'take into account the objective of minimising negative trade effects' (Jukes 1998). The objective of the SPS Agreement is to ensure that states do not use food safety requirements to erect trade barriers in order to protect their indigenous industries. Moreover, the issue of traceability is covered by the SPS Agreement (Wilson & Beers 2001).

With respect to the FAO codes of conduct, article 11.1 of the code (Responsible Fish Utilization) says that 'States should adopt appropriate measures to ensure the right of consumers to safe, wholesome and unadulterated fish and fishery products' (FAO 1998). More specifically, it calls for the setting of minimum standards for safety and quality assurance schemes, in line with the FAO/WHO Codex Alimentarius Commission (FAO 1998). The code is aimed primarily at traditional fisheries and is only of peripheral interest to aquaculturists.

European Union Legislation
The EU control systems for the control of food products are Council Directive 89/397/EEC (Control of Foodstuffs) and Council Directive 93/99/EEC (Additional Measures Concerning the Official Control of Foodstuffs). In addition, a comprehensive group of rules applies to the control of food products of animal origin as set out in Council Directive 89/662/EEC (Veterinary Checks in Intra-Community Trade With a View to

the Completion of the Internal Market). Also, Directive 92/117/EEC (Monitoring of Zoonoses and Zoonotic Agents) established a monitoring system for certain zoonotic agents at both Member State and community level. Under this directive, each member state reports the trends and sources of zoonotic infections in animals and humans on an annual basis.

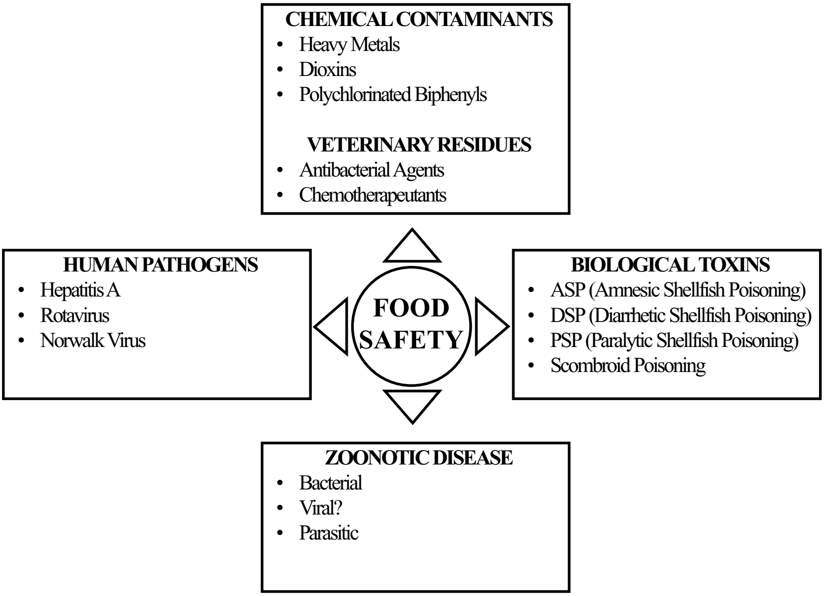
In September 2001, the European Commission issued an ‘information paper’ in which further monitoring and control programmes were proposed, following on from the White Paper on Food Safety published in January 2000. The Commission proposed a new Directive that would oblige member states to initiate improved and better co-ordinated monitoring systems. In addition, a Regulation is proposed to set out a framework for pathogen reduction to reduce the occurrence of certain food-borne zoonotic agents; it would function by setting Community-wide targets for zoonotic agents in specific animal populations, and possibly at other stages along the food chain. To date, these specific rules are only proposed for poultry and pigs in all EU member states. More specifically, ‘the proposed directive on the monitoring of zoonoses lays down a system for monitoring certain zoonotic agents throughout the human food chain and animal feed chain. Member states will be required to take part in co-ordinated monitoring programmes in order to establish baseline values on the level of most important zoonotic infections in each Member state. The new monitoring requirements also include the collection of data on the incidence of zoonotic diseases in humans, on the occurrence of food-borne outbreaks and the monitoring of antimicrobial resistance in certain zoonotic agents.’ (DEFRA 2001).

More recently still, on 28 January 2002, Regulation (EC) No.178/2002 outlined the general requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. This regulation acknowledged that ‘scientific and technical issues in relation to food safety are becoming increasingly important and complex. The establishment of a European Food Safety Authority should re-inforce the present system of scientific and technical support which is no longer able to respond to the increasing demands on it’

UK Legislation

In the UK, the two main domestic areas of food safety legislation are the Food Safety Act 1990 and the Food Standards Act 1999 (FSA 2001). The former deals with diverse issues including registration/licensing of food premises, provision of food hygiene training and the regulation of food product sampling. Although general in nature, this legislation also makes specific reference to aquaculture with respect to the 'provision of facilities for cleansing shellfish'. In essence, this states that the 'food authority may provide tanks or other apparatus for cleansing shellfish' prior to sale.

Fig. 1. The key elements of food safety with relevance to aquaculture.



The Food Standards Act 1999 amended the Food Safety Act to provide for the establishment of the Food Standards Agency. The FSA advises on the development of policy by other departments on matters relevant to the Agency's own area of responsibility; these include activities on the farm that may have an impact on food safety, including the occurrence of food borne zoonoses. The Food Safety Act brought together and updated all food legislation and implemented some European legislation requirements. A key feature of this legislation relates to 'due diligence defence' that requires a person to prove that they have taken all reasonable precautions when dealing with food. In the UK, there is a structured risk analysis procedure that incorporates risk assessment, management and communication.

TABLE 1: Some examples of bacterial and parasitic pathogens found in fish products that are known to cause human disease.

ORGANISM	DISEASE
BACTERIA	
Salmonella spp.	Salmonellosis
Clostridium botulinum	Botulism
Campylobacter spp.	Diarrheal Illness
Plesiomonas shigelloides	Gastroenteritis
Vibrio cholerae	Cholera
Vibrio parahaemolyticus	Gastroenteritis
Erysipelothrix rhusiopathiae	Erysipelas
PARASITE	
Cestodes	
Diphyllobothrium latum	Diphyllobothriasis
Nematodes	
Gnathostoma spinigerum	Gnathostomiasis
Capillaria phillipenensis	Capillariasis
Anisakis simplex	Anisakiasis/Anisakidosis
Pseudoterranova decipiens	Seal Worm/Cod Worm Disease
Dioctophyme sinensis	Dioctophymosis
Trematodes	
Heterophyes heterophyes	Heterophyiases
Opisthorchis viverrini	Opisthorchiasis
Metagonimus yokogawai	Metagonimiasis
Clonorchis sinensis	Oriental Liver Fluke Disease

Other Codes of Conduct/Legislation of Interest

Other codes and directives aimed at the control of fish disease are complementary with the regulations dealing with the prevention of the occurrence of zoonotic disease. These include the International Aquatic Animal Health Code, as formulated by the OIE (2002) and the European Council Directives 93/54/EEC, 95/22/EC and 95/70/EC which stipulate standards of stock health and disease management procedures (Josepeit et al 2000; McArdle 2002). At UK level, the Food Safety (Fishery Products and Live Shellfish) (Hygiene) Regulations (1998) lay down the health conditions for production and placing on the market of live bivalve molluscs/fishery products, as required by Council Directives 91/493/EEC and 91/492/EEC and subsequent amendments (FSA 2001).

Economics of Food Safety

The economic impact of zoonotic disease can be viewed from 'macro' and 'micro' economic perspectives. In the case of the former, economists use a range of methods, as outlined in Peddie & Peddie (2002) to assess the impact of food safety and its regulation. Such techniques consider both the costs and benefits. Costs are identified as being wide-ranging and apply to individual households (due mainly to loss of earnings), the public/private health sector and the aquaculture industry in general. These costs include loss in productivity caused by disease, costs of investigating the outbreak of the illness and subsequent disease surveillance costs. As absolute safety is not possible, the appropriate level depends largely on consumption preferences and income levels (Swinbank 1993). In the case of zoonotic disease, very few quantitiative assessments have been made regarding its impact from an economic perspective (Oberender & Heissel 1999). Nevertheless, Eckert (1996) stated that the economic impact of fish-borne parasitic zoonoses is 'considerable in terms of morbidity and even mortality in humans as well as losses due to reduced productivity and condemnation of parasitised fish.' Catto (1998) attempted to quantify the costs/benefits of implementing HACCP procedures in the seafood industry; the broad conclusions of this analysis are of relevance to control of zoonotic disease in aquaculture products and are presented in Table 2.

TABLE 2: The Economic Implications of Hazard Analysis and Critical Control Point (HACCP) programmes (adapted from Catto 1998).

SECTOR	POTENTIAL BENEFITS	POTENTIAL COSTS
Producer	Higher price for safer product. Longer term acceptance of product and rearing practices.	Reduced production. More costly rearing practices
Processor	Higher price for safer product.	Higher input costs. Higher costs due to more regulated processing practices.
Distributor	Higher price for fish product.	Higher production costs. Reduced availability of product (reduced supply due to reduced production). Changes in distribution practices.
Consumer	Decreased morbidity. Decreased mortality.	Higher price for product.
Government	Lower society-borne medical costs.	Cost of regulatory programme.

Another important area where zoonotic disease has an economic impact concerns the international trade in animal products. Put simply, the presence of zoonotic disease can distort trade (Swinbank 1993). In the case of terrestrial farming, the value of the UK beef market fell by almost 10% in volume and monetary terms between 1995 and 1999 as a result of the BSE crisis (Mintel, 2000). Moreover, not only were EU beef exports in 1995-1996 approximately 13% lower than the average level of the previous two years, world beef trade was directly affected by concerns relating to the safety of consuming beef. Whilst household consumption surveys in Japan during the same period reported a drop in consumption by 14%, the world price of beef dropped by almost 10% in response to the beef demand shock, as outlined by the Food and Agricultural Policy Research Institute, Iowa State University (FAPRI undated).

Marketing Implications

Although the marketing implications of zoonotic disease in aquaculture products are multifaceted, the main concerns relate to consumer perception and traceability. Consequently, both of these topics are discussed in depth below.

Consumer Perception

That food safety is a key issue for UK consumers is highlighted in the FSA's 'Consumer Attitudes to Food Standards' report (2002), where over one fifth of consumers described themselves as being very concerned about it, whilst only a minority expressed minimal concern. Although in 2000 and 2001, only 12% of UK consumers claimed to have suffered from food poisoning in the preceeding year, it remained the key issue of concern along with BSE contaminating meat products. Of further concern to the aquaculture industry is the fact that 39% of consumers registered safety concerns about fish in the FSA survey. Another survey, this time conducted by SeaFish, found that different seafood products elicited very different responses from UK consumers (Gross 2001). More specifically, 53% of survey respondents classified shellfish as 'unsafe' food products, primarily due to the perceived risk of food poisoning. Conversely, only 2% of respondents cited 'white fish' as an unsafe food product. A further difficulty with today's consumer is their lack of cooking skill or knowledge. Where shellfish are classified as 'unsafe', it is also true to say that consumers are unsure of how shellfish should be cooked; this is in direct contrast to the more familiar 'white fish'. Thus, different aquaculture products provide different challenges to food marketers with respect to safety issues.

Traceability

Traceability is the 'ability to maintain a credible custody of identification for animals or animal products through various steps within the food chain from the farm to the retailer' (McKean 2001). Thus, there are two key components to the product traceability concept: A system of identification, and credible mechanisms for the preservation of identity.

The increasing power of multi-national retailers, particularly in the USA and the UK has diminished local control of production and processing functions. Consequently, consumers are exposed to aquaculture products that in some cases originate from different continents, depending on product availability and market demands. Although such flexibility in sourcing has clear advantages, it also exposes consumers to potential public health risks and varied production practices (McKean 2001). In addition, the 'lengthening' of the food chain has substantially increased the complexity of information transfer between producers, processors, retailers and consumers.

Traceability of aquaculture and fishery products can be subdivided into four categories: Country of origin, retail labelled, processor origin and farm-to-retail identity. Information on the country of origin provides a range of information on the regulatory and production standards that the product has been subjected to. Retail labelled products conform to standards designed to meet the needs or desires of consumers and may therefore have an important food safety element. Processor origin traceability relates to the ability of the processor to differentiate their products on the basis of price, quality and safety characteristics. Finally, the 'farm-to-retail' identity category relates to 'speciality marketing', such as the direct marketing of aquaculture products via the internet. Such direct contact between consumers and producers creates a 'common bond of safety and quality credibility' (McKean 2001).

In the future, it may be the case that the traceability of aquaculture and fishery products will determine whether or not a product gains access to a particular market. Thus, it is in the interest of all sectors of the food chain to accept traceability as a valid vehicle for the improvement of public health, otherwise market opportunities will become increasingly limited (McKean 2001; Stein et al 2001). Moreover, traceability enhances consumer confidence and allows the use of important information to enhance sales in particular, and the marketing function overall. Indeed, such schemes work effectively in other sectors, such as beef, where the cattle 'passport scheme' has been successfully introduced. Having said that, the tracing of aquaculture products to the initial source is technically more challenging than is the case in terrestrial farming.

Documenting the steps that occur in the production, distribution, packaging, processing and harvesting of an aquaculture-derived product is a difficult and time-consuming task (Josupeit et al 2001). Thus, in many cases the means of identification is rather limited (Stein et al 2001). In the case of prawns for example, traceback is carried out using movement invoices, health certificates and the labelling of boxes. With respect to the latter, the labelling information contains details on the content of the packages in terms of species, quantity, name and address of producer, packing place and importer/exporter of the product (Stein et al 2001). That this situation is changing rapidly is evidenced in the release of an EU Communication entitled 'The future for the market in fisheries products in the European Union: responsibility, partnership and competitiveness' (IP/97/1132). This communication suggests that all fish sold by retailers should be tagged in a manner that facilitates the trace-back of the product to the geographical location of origin (Stein et al 2001). By implementing such procedures, the end consumer is satisfied that through quality control and traceability they have a 'safe' product, thus enhancing perception of the food type overall.

Conclusions

Zoonotic diseases are those that can be transmitted from animals to Man and are of increasing concern to consumers, primarily as a result of recent food scares in the UK and other European countries. A decrease in trade barriers has facilitated an increase in the importation of aquaculture products into the EU, thus further augmenting consumer concerns. The key zoonotic agents in aquaculture products are either bacterial or parasitic in origin; no fish viral infections are known to infect human populations.

Zoonotic disease is monitored and controlled by legislation and codes of practice that operate at International, European and Member State levels. International agreements include those derived from the Codex Alimentarius Commission of the FAO/WHO, the SPS agreement of the WTO and the FAO code on Responsible Fish Utilisation. EU legislation is more complex, with a number of directives dealing with generalised food safety issues, veterinary checks on traded products and the monitoring and control of zoonotic disease. At the national (UK) level, the key food safety legislation is the Food Safety Act 1990 and the Food Standards Act 1999, although fishery specific regulations also exist.

Despite being frequently overlooked in the discussion of disease, the actual or perceived threat of zoonotic disease exerts a multitude of economic effects at both the 'macro' and 'micro' levels. However, very few studies have been published which quantify these effects. Finally, the key impacts of zoonoses on the marketing function of aquaculture enterprises relate primarily to consumer perception and the importance of traceability in maintaining consumer confidence. An appreciation of these wide-ranging issues is important to aquaculturists and associated professionals operating in an increasingly consumer driven industry.

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Fish vaccination – methodologies and outcomes

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Abstract

Most salmon smolts are vaccinated with various products by intra-peritoneal injection. The technique is known to be stressful to fish. Farmers often report poor return to feed post vaccination, occasional mortalities and also trauma attributable to vaccination itself. A study was conducted at a fish farm trial facility to evaluate management processes before, during and after vaccination as opposed to effects of the vaccine itself. The results show that careful treatment of fish around vaccination time is more important in reducing adverse events than the type of vaccine. Keeping fish submerged in clean water on the vaccination table – the 'wet' method of vaccination, is considered to offer significant benefits over that of holding fish out of water while awaiting injection – the 'dry' method, applied on many Scottish fish farms.

Introduction

The study was designed to evaluate the effect of different vaccines coupled with two separate husbandry and vaccination procedures on appetite, growth and as potential factors in the development of vaccine related adhesions. The study was conducted as close to Good Clinical Practice (GCP) as possible, whilst handling fish in the way they would be managed on a commercial farm. Although all techniques and all but one of the vaccines used were those normally seen on UK fish farms, a saline control and a vaccine licensed in the Republic of Ireland were also included which meant that the study came under the terms of the Animals (Scientific Procedures) Act 1966.

Materials and Methods

A single population of 2400 Atlantic salmon (*Salmo salar*) S1 (LM15 strain) (average weight 16 g ± 3g) was randomly divided equally into two 4m diameter, circular rearing tanks (volume 7m^3) each supplied with 25 litres of freshwater per minute at ambient temperature (range 4–15°C). All fish were individually identified, weighed and their lengths measured. Throughout the study the feeding levels were maintained between 1.5–2% bodyweight per day.

One group of 1200 were termed ‘control’, the other ‘test’ treatments. Whereas the ‘control’ fish were reared according to the farm’s normal feeding practice throughout the pre-vaccination period of six weeks, the ‘test’ treatment fish were fed the same diet containing an immunestimulant (Vetregard, Alpharma) at 1 kg per tonne of feed for six weeks prior to vaccination, followed by another six week treatment post-vaccination. Fish in both treatments were starved for 48 hours prior to vaccination, and at 12 hours post vaccination each group’s appetite was tested by offering feed pellets by hand. The immunestimulant was fed again to the ‘test’ treatment from seawater entry until termination of the study (ten weeks later). Individual weights from 100 fish from each treatment were taken at the beginning of the study.

Thirty fish from each group were weighed at vaccination and at sea water transfer. Weight data were analysed to determine statistical differences between Test and Control treatments in the pre-vaccination (20 August – 3 October), post-vaccination freshwater (4 October – 7 January) and Seawater phases (8 January –19 March).

Statistical analysis was performed using an analysis of variance (ANOVA) model by PC SAS® v 6.12. Specific Growth Rates were calculated according to the formula:

$$SGR_{weight} = (LnW_2 - LnW_1)/\Delta T \times 100$$

Where:

LnW_2	=	natural log of final weight
LnW_1	=	natural log of initial weight
ΔT	=	time of the period under analysis in days

Adverse effects such as degree of visceral adhesions and melanisation were assessed by the same person as a blind study according to the Speilberg scale (Melgard 2001).

TABLE 1: The treatments in Control and Test groups

	Before Vaccination	Vaccination	After Vaccination	Sea Water Transfer
Test Treatment 1200 fish	Vetregard[a] six weeks	MS-222[b] Halamid[c] 'wet' method No Vetregard[a] for 2 weeks during which vaccination took place	Vetregard[a] for six weeks	Vetregard[a] for five weeks
Control Treatment 1200 fish		Benzocaine[d] Virkon S[e] 'dry' method	–	–

[a] immunestimulant (Vetregard) Alpharma
[b] tricaine methanesulphonate (MS222) Thompson and Joseph, Dist. Alpharma
[c] Sodium N-Chloro-para-Toluenesulfonchloramide(Halamid) Axcentive
[d] Ethyl amino benzoate (Benzocaine) Hayman Ltd
[e] Stabilised blend of peroxygen compounds, surfactant, organic acids and an inorganic buffer system (Virkon S™) Antec

During vaccination Control and Test groups were randomly sub-divided into six groups of 200 fish and different vaccines (or placebo) were given as shown in Table 2.

TABLE 2: Vaccine sub groups used in each treatment group (n=200).

Vaccine code	Name	Intraperitoneal injection dose
V1	Alpha Ject™ 1200[1]	0.2ml
V2	Alpha Ject™ 1200[2]	0.1ml
V3	Alpha Ject™ 5200[3]	0.2ml
V4	Phosphate buffered saline (PBS)[4]	0.1ml
V5	Compact 4[5]	0.1ml
V6	Furogen 2[6]	0.1ml

[1] *A. salmonicida* (Alpha Ject™ 1200) Alpharma
[2] *A. salmonicida* (Alpha Ject™ 1200) Alpharma

[3] *A. salmonicida, V. anguillarum types I and II, V. salmonicida, M. viscosa* (Alpha Ject™ 5200) Alpharma

[4] Prepared on site (KH_2PO_4, NaCl, $Na_2HPO4.7H_2O$)

[5] *A. salmonicida, V. anguillarum types I and II, V. salmonicida* (Norvax Compact 4) Intervet.

[6] *A. salmonicida* (Furogen 2) Novartis.

The Control group was first to be vaccinated by staff at the facility. Fish were netted in small groups into an anaesthetic bath containing 25 ppm benzocaine in ethanol. This caused fish to be anaesthetised to the appropriate degree in about three minutes. As fish were being anaesthetised, the vaccination table was washed down and cleaned with a dilute 1% solution (10,000 ppm) Virkon S. The vaccination table had a drainage hole in it and water from a pipe was allowed to pour over the table making the surface wet but the water did not remain on the table. As fish were anaesthetised, they were netted out of the anaesthetic bath and placed on the table where two vaccinators picked them up with gloved hands, turned them to visualise the ventral surface and then injected them using a KayCee vaccinator (Fishjector Mk 1, KayCee Veterinary Products Ltd). After vaccination, the fish were individually identified with Alcian Blue dye using a Panjet inoculator (Panjet, Wright Dental Group) and placed in the recovery tank. This method is referred to throughout as the 'dry' method.

In the Test treatment, tricaine methanesulphonate (MS222, Thomson & Joseph) was used to anaesthetise the fish, initially at a dose of 50 ppm. The development of anaesthesia was surprisingly slow. The concentration was increased to 100 ppm to speed up anaesthesia and to maintain the equivalent time for anaesthesia as for the Control group. Prior to vaccination, the table was cleaned with a 4-ppm solution of Halamid. The vaccination table had raised, smooth edges and the central drainage hole was plugged so that water-containing Halamid at 4 ppm remained on the vaccination table to a depth of 2–3 inches. Once fish were anaesthetised they were netted out of the anaesthetic bath and placed in the water on the vaccination table and the vaccinators held as much of the body of the fish as possible in the water while they vaccinated them (again using gloved hands). Once vaccinated the fish were marked and placed in a recovery tank.

The same team of workers were used to anaesthetise, vaccinate, feed and care for all fish. Although the vaccine sub-groups were 'blinded' for the duration of the study (i.e. the identities were unknown to the team) the phosphate buffered saline was immediately recognisable by its aqueous consistency.

The pH values of the anaesthetic baths were recorded as was the total cell count of water in the anaesthetic bath, on the vaccination table and in the recovery tank for each treatment group. Measurement of pH utilised an aquarium test kit (Hach Ltd). Total cell counts were measured using total bacterial count dipslides (BT2, Dimanco). These dipslides contained nutrient agar with TTC (red spot dye). Most colonies show up as red dots.

Fish were transferred to sea cages with no obvious problems at 13 weeks 4 days post vaccination after going through the standard PP1 S0 photoperiod regime in preparation for sea water transfer. The Test group was placed in one cage and the Control treatment in another. The trial was terminated at 5 weeks post seawater transfer because the fish in each cage were attacked by predators.

Results

Use of Vetregard

Weights of each group are recorded over time in Figure 1. No significant difference was found between weight of fish in the Test and Control groups up to the time of vaccination or during the seawater phase. However differences between vaccines, treatment and the vaccine treatment interaction were significant ($p < 0.001$ in all three cases) in the post vaccination freshwater phase. The increase in mean weights over time were statistically significantly high-

FIG 1: Use of immunostimulant

Date	Test treatment	Control treatment
20-Aug-01	16.1	16.6
5-Sep-01	20.9	20.6
20-Sep-01	28.4	25.3
4-Oct-01	29.9	26.7
17-Oct-01	34.7	31.7
2-Nov-01	43.6	41.1
19-Nov-01	47.7	47.5
8-Dec-01	53.6	47.7
7-Jan-02	57.4	53.6
19-Mar-02	64.4	60.9

er on the Test treatment compared to the Control treatment for each vaccine sub group. For example, fish vaccinated with Alpha Ject 1200 at 0.2ml but utilising the Test treatment were significantly heavier than the fish utilising the same vaccine with the Control treatment. Overall, Test treatment fish were 12.8% heavier than Control treatment fish.

Specific growth rates were calculated and data are shown in Table 3.

TABLE 3: $SGR_{weights}$ for selected time periods

ΔT Time period under analysis (days)	Test Treatment	Control Treatment
30 Aug 01 to 08 Dec 01 – Total Vetregard period	1.2712	1.1759
30 Aug 01 to 04 Oct 01 – 1st six wks of Vetregard	1.7687	1.3579
04 Oct 01 to 08 Dec 01 – 2nd 6 wks of Vetregard*	1.0034	1.0779

* This includes a two-week period without Vetregard followed by six weeks on Vetregard followed by no Vetregard.

Vaccination

Anaesthesia:

In order satisfactorily to anaesthetise fish on the study site it was necessary to increase the concentration of MS-222 to twice normal.

Overall, both benzocaine and MS-222 treated fish took 2-3 minutes to be ready for vaccination although the benzocaine treated fish needed to stay in the anaesthetic bath longer for full immobilisation to occur. Recovery from anaesthesia was much faster with MS-222 (15-30 seconds) against 60-90 seconds with benzocaine.

It has been reported (Brown 1992) that MS-222 can cause a pH reduction in soft acid waters. However in this study (water of pH 6.2 but variable depending on runoff) there was no discernible change in pH with the use of either anaesthetic agent.

Biosecurity:

Results of dipslide tests for bacterial contamination are recorded in Table 4 as interpreted with the instructions provided by Dimanco.

FIG 2: This shows a photograph of dipslides used to sample the vaccination table using the Control (here called Standard method) and the Test (here called Alpharma method) Treatments.

TABLE 4: Total Bacterial Counts in water before and after vaccination

Control	**Anaesthetic Bath**	**Vaccination Table**	**Recovery Tank**
Before vaccination	10^5	10^5	10^3
After vaccination	10^6	10^4	10^5

Test	**Anaesthetic Bath**	**Vaccination Table**	**Recovery Tank**
Before vaccination	10^4	10^5	10^6
After vaccination	10^5	0	0

The use of Halamid at 4ppm in the water on the vaccination table using the ‘wet’ method seems to have cleared bacteria from the table – and therefore from the fish themselves. This continued into the recovery tank.

Return to Feed:
The results in Table 5 show that fish on the Test treatment returned to feed faster (they were taking feed 12 hours after vaccination) than the Control treatment. All fish returned to feed within 48 hours. Fish were offered the volume of feed shown post-vaccination and uneaten feed left in the tank was recorded as present (Yes) or absent (No). If absent, the fish were offered more food the following day.

TABLE 5: Return to Feed

Time Post Vaccination	**+ 1 day**	**+ 2 days**	**+ 3 days**	**+ 4 days**	**+ 5 days**
Test Group	200g	300g	400g	400g	500g
Feed left over	No	No	Yes	No	Yes
Control Group	200g	200g	200g	300g	300g
Feed left over	Yes	Yes	No	Yes	Yes

Mortality:
No deaths occurred in the Test or Control treatment during the peri-vaccination period.

Post Vaccination

Adhesions and Pigmentation scores

Fish were examined for adhesions and pigmentation 24 weeks post vaccination (approximately 1235 degree days). The evaluation was performed 'blind' i.e. the evaluator did not know the vaccine used during the assessments recorded in Table 6 (based on the Speilberg Scale (Melgard, 2001)).

Note: Adhesions are scored 0-6 and Pigmentation is usually scored 0-3 where low numbers reflect low adverse effects and high numbers indicate serious adhesions and pigmentations. The standard method of Speilberg analysis uses whole numbers but in this study the recorders also used intervals of 0.5.

There was very little difference in the amount of adhesions or pigmentation in the groups of fish receiving different vaccines. However there appears to be a greater difference in these parameters according to how the fish were handled at vaccination. Those given the Test treatment consistently show

TABLE 6: Adhesions and pigmentation scores in groups of fish on different treatments

Product		**Test**		**Control**	
		Average	**Range**	**Average**	**Range**
Alpha Ject 1200 at 0.2ml	Adhesions Pigmentation	1.10 0.60	1.00–1.50 0.00–1.50	1.50 0.95	0.00–2.50 0.00–1.50
Alpha Ject 1200 at 0.1 ml	Adhesions Pigmentation	0.60 0.20	0.00–1.50 0.00–1.00	1.30 0.80	1.00–2.50 0.00–1.00
Alpha Ject 5200 at 0.2ml	Adhesions Pigmentation	1.00 0.60	0.00–1.50 0.00–2.00	1.60 1.00	0.00–3.00 0.00–1.50
Saline Control	Adhesions Pigmentation	0.00 0.00	All 0.00 All 0.00	0.00 0.00	All 0.00 All 0.00
Norvax Compact 4 at 0.1ml	Adhesions Pigmentation	1.00 0.40	0.00–2.00 0.00–1.00	1.60 0.45	0.50–3.00 0.00–1.50
Furogen 2 at 0.1ml	Adhesions Pigmentation	0.60 0.50	0.50–1.00 0.00–1.00	0.90 0.70	0.00–2.00 0.00–1.50

lower adhesions and pigmentation scores compared to the Control treatment. A general linear model analysis of variance (GLM Anovar) was used to look for significant differences between adhesion scores and pigment scores for sub-groups of vaccines in the ‘wet’ method versus the ‘dry’ method and also between sub-groups within each of the two methods. Since only ten fish were used in each sub-group, a significance level of $p<0.001$ was chosen. The analysis showed no significant difference between any vaccine sub-groups for pigmentation scores although there was a significant difference ($P<0.001$) in pigmentation score between the ‘wet’ method and the ‘dry’ method. With respect to adhesion scores, there was a significant difference ($p<0.001$) between the ‘wet’ and the ‘dry’ method. There were no significant differences between any of the vaccine sub-groups within treatments ($p<0.001$).

Discussion

Fish benefit from reduction of stressors such as unnecessary handling, poor hygiene and sub-optimal feeding during the peri-vaccination period. While these remarks are truisms, it has not often been demonstrated in the literature. The results of this study show that a combination of several factors associated with good husbandry provide advantages to vaccinated fish in terms of weight gain, faster return to feed, lower adhesion scores and reduced pigmentation post vaccination. It is impossible to separate each of the beneficial processes utilising the 'wet' method of vaccination in the 'test' treatment compared with the 'dry' method in the 'control' treatment. However, it seems likely that the 'wet' method provides a combination of minimal handling, efficient disinfection, and appropriate anaesthetic techniques which lead to improvement in fish quality. The 'wet' method has been promoted in Europe at various fish vaccination workshops. Difficulties are reported with vaccinators working outside at extremely cold temperatures when their hands are placed in a water table whilst vaccinating fish (Thorarinsson Pers. Comm). This should be borne in mind at the coldest times of the year and attention to the welfare and comfort of the vaccinators should be considered too from a Health and Safety perspective. In the United Kingdom, due attention must be paid to using authorised products (i.e. registered with approved discharge consents). Apart from vaccination technique ('wet' versus 'dry') in feed Vetregard was the only difference between the Test treatment and the Control treatment.

A much higher concentration of MS222 was required to anaesthetise the fish in the 'wet' method than was expected. Since the freshwater went through an ozone disinfection system the redox potential of the water may have contributed to this effect. However we are at a loss to understand why there would be such a difference.

Assessment of adhesions and pigmentation was made 24 weeks post-vaccination. In general these parameters increase in severity up to 6-9 months post vaccination and then appear less drastic as the fish grow larger and reach slaughter weight. In any event, none of the scores shown in Table 6 would have produced a downgrade had they been observed at harvest.

We have demonstrated that care with fish husbandry techniques, before, during and after vaccination are more important to the continuing well-being of the fish than variations between vaccines. We hope that these results will encourage veterinary surgeons and fish farmers to evaluate methodologies in handling and husbandry of fish around the vaccination process.

Acknowledgements

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Fish Veterinary Journal (2003) (7) 67–70

A note on the Suspected Adverse Reaction Surveillance Scheme (SARSS): A Scheme for All Species

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Abstract

The paper describes the UK Suspected Adverse Reaction Surveillance Scheme (SARSS) and looks at ways that it can be applied to fish farming.

The SARSS in embryonic form began its life in 1981, initially concentrating on the severe canine parvovirus epidemic which arrived in Britain at the beginning of the eighties. However it was only in 1985 that the first computerisation was undertaken and the scheme officially started on 1st January 1986.

From the start the scheme was voluntary with a less than sophisticated yellow reporting form.

The pattern of reporting generally resembled that of today with the majority (circa 70%) of reports concentrated in two species, the dog and cat, with smaller contributions from cattle, horses and sheep. The three intensive industries, poultry, pigs and fish, apart from occasional peaks, only constitute a small part of the SARSS despite efforts to encourage reporting.

This note looks at fish medicines and the challenges to overcome in order to run a meaningful scheme. The products currently authorised are basically vaccines, ectoparasiticides and antimicrobials.

Like any other species, fish require:

- medication against viral and bacterial disease (vaccines);
- medication to treat bacterial disease and;
- medication to treat and/or prevent parasitic disease.

Therefore SARSS would expect to see:

1) Efficacy breakdowns
2) Injection site reactions (animals)
3) Injection site incidents (human)
4) Safety issues at the correct dose level for one reason or another
5) Overdose

This educated guess is borne out by the 100 or so reaction reports and incidents we have received in the last 15 years.

As expected the list is compact, comprising mainly ectoparasiticides, some vaccine reports and a very few antimicrobials reports.

Previous experience with farmed fish reporting shows the need for careful consideration of what exactly should be reported and how it should be reported.

There is EU guidance on what should be reported by companies, including the fact that serious reactions must be reported to the authorities within 15 days.

In terms of fish farming what then is a serious reaction? How do we apply the definition?

Fish farming like any mass production process is, as we know, associated with an incidence of mortality and morbidity. A particular farm will tend to have a recognised range of mortality. In addition, concurrent disease will complicate the picture. In simple terms an increase over the existing basal mortality, associated with administering a medicine should be considered as a candidate for a suspected serious reaction.

Nothing is simple, however, and judgement is necessary on individual cases particularly taking account of environmental and husbandry factors.

Common to pig, poultry and farmed fish medication/vaccination is the belief among quite a widespread number of vets and farm managers that SARSS is only there to detect reactions and remove products from the market - this belief is outmoded and does not reflect the UK SARSS of today at all. By starving SARSS of information an interesting possibility could arise of an actual inhibition of product licensing, because SARSS is routinely asked for advice on all products licensed in the UK.

Resistance to antimicrobials and antiparasitics is a real problem. Rather than seeing SARSS as a threat to products, it is perhaps better to take a positive view by reporting possible cases and seeing what can be done to control the problem.

Lack of efficacy to products may well highlight resistance problems, but lack of efficacy can also be associated with how well a vaccine protects against field challenge. Applying the criteria described above re basal death rates and significant mortality increases post vaccination, where an identifiable disease agent is identified, provides the SARSS with valuable information to discuss in-house with product assessors. Regular monthly meetings of SARSS and assessors analyse patterns of reactions. Decisions are never taken on individual reports, only on groups of reactions.

From the outset the impact of environmental factors on a possible adverse reaction or lack of efficacy has been appreciated. Clearly, the division between the fresh and saltwater environments has an important bearing on the adverse event. Water quality is, however, a common factor and taken together with the history of the site in terms of fallowing policy of the farm group, this will have a strong bearing on the impact of infective agents. Environment plays a part in all farm animal situations, but is more acute in the case of fish farming. SARSS has a responsibility to record and monitor environmental incidents related to veterinary medicines. To achieve this objective SARSS keeps in close touch with all UK environmental agencies and receives reports from them. In pragmatic terms fish farming medication (depending on the type of medicine) will always introduce a small environmental insult, but this has to be placed in the total risk/benefit equation.

Injection site reactions encompass both animals and humans. For most species injection site reactions are externally expressed, but with fish because of intraperitoneal injection the lesions are intra-abdominal. Clear evidence exists that varying degrees of reaction occur following IP injection. From SARSS viewpoint, these lesions do not constitute a straightforward adverse reaction if the animal is well and behaving normally, but it is a matter we follow closely with the VMD assessors. Human operator reactions occur as a result of self-injection and if the adjuvant is an oil type a well-documented reaction occurs, which can be very serious. The products have a standard warning on the labelling and it is important that a) medical advice is sought urgently and b) that such reactions are reported to SARSS either directly or via the pharmaceutical company.

Overall then, SARSS is looking for a dialogue with fish veterinary surgeons with the aim of establishing realistic risk profiles for all fish veterinary medicines.

Alastair Gray qualified from the Royal Veterinary College in 1967 and after a short time in practice entered the MAFF Central Veterinary Laboratory (CVL) in 1970. He worked at the CVL in laboratory work until 1978, when he moved to the Medicines Unit at the CVL and spent the next 12 years assessing veterinary products for licensing under the Medicines Act.

In 1985, in collaboration with a colleague, he computerised the entire existing card index adverse reaction scheme and on January 1, 1986 the new adverse reaction scheme was launched. Between that date and the present day the scheme has grown considerably and has been regarded as the leading EU surveillance scheme.

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PROCEEDINGS

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Rainbow Trout Gastro-Enteritis (RTGE) – first diagnosis in UK

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Abstract

This paper records the detection of a case of, what is known as, Rainbow Trout Gastro-Enteritis (RTGE) in rainbow trout in England, the first recorded case of this condition in UK. RTGE is an enteric condition of rainbow trout which causes losses in the summer, and is associated with the presence of large quantities of filamentous organisms within the digestive tract. These organisms have been identified as Segmented Filamentous Bacteria (SFB), probably members of the Candidatus Arthromitis group of bacteria.

The first recorded incidence of Rainbow Trout Gastro-Enteritis, in UK was on a well-managed rainbow trout farm in S England, with a fairly standard layout of earth ponds (Fig 1). The farm suffered high losses over the summer of 2000, but only in certain ponds.

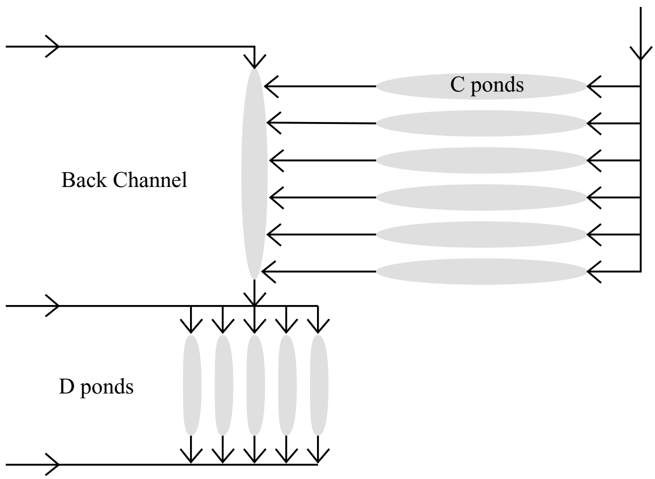

FIG 1: Farm layout

The ponds affected were designated C ponds, and received first-use water. Fingerlings were put into these ponds at approximately 60g, when they first arrived on the farm, and the fish were then moved to other ponds at about 200g. Disease was only seen when the water temperature exceeded 12°C. By scrutinising farm records it could be seen that, for fish which were present on the farm when the temperature crossed this threshold, losses started about 3 weeks after 12°C was reached. For fish arriving after the temperature threshold was passed, losses started about 3 weeks after arrival. Generally, losses peaked approximately 10–14 days after onset, with daily losses up to 0.6%.

The first signs of the condition being present in a pond were the appearance of a large quantity of faecal casts on the bottom of the pond, and an increase in mortalities. But the external appearance and appetite of the remaining fish was normal. Losses tended to fall if feeding was restricted.

On post mortem examination of affected fish, there was a pronounced haemorrhagic enteritis in the hind gut, and the gut and sometimes the stomach were filled with a straw coloured liquid. There were no other significant findings.

On histopathology, there was a clear enteritis in the hind gut, and large segmented filamentous organisms were associated with this enteritis. These organisms were mostly present in the hind gut, but sometimes they could be seen in the caeca, but in lower numbers. There were no other consistent findings in the fish examined.

Bacteriological samples from the kidneys inoculated onto TSA and Low Nutrient Agar plates, incubated at 20°C and 17°C respectively, yielded no growth. A profuse, mixed growth of bacteria was obtained from gut material inoculated onto these same plate types, although none of the isolates resembled the organisms seen in histopathology, and no particular organism predominated.

Mortalities due to the condition ceased approximately 3–4 weeks after initial onset, or once the fish reached 160–200g in weight, or when the temperature fell below 12°C. Total losses were as high as 10% in some ponds. Fish in other ponds on the farm, (all larger than 200g), including those in ponds receiving water directly from the C ponds, were not affected.

None of the usual principal diseases of rainbow trout were present on the farm, namely Proliferative Kidney Disease (PKD), Enteric Redmouth (ERM) – absent since the initiation of a vaccination programme – and Rainbow Trout Fry Syndrome (RTFS).

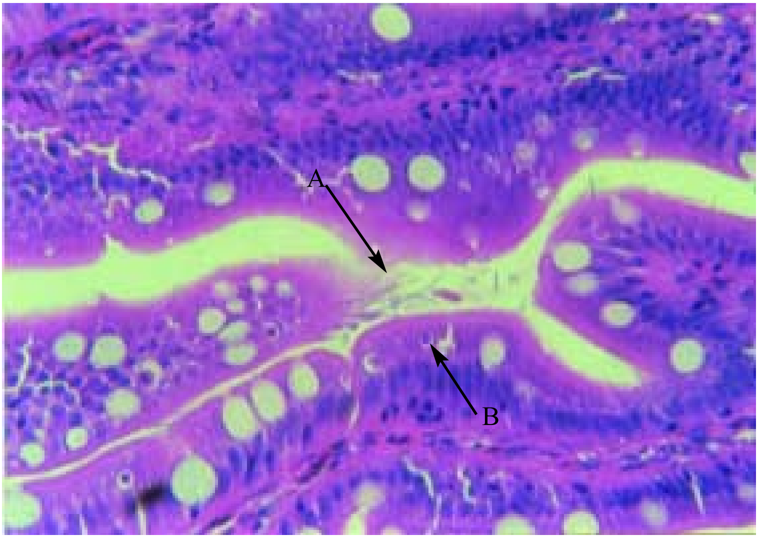

FIG 2: LSFOs in the gut of infected rainbow trout.
(A – LFSO, B – necrotic enterocyte)

Based on the findings in this case, a diagnosis of Rainbow Trout Gastro-Enteritis (RTGE) was made. Unexplained mortalities in the same ponds, but at much lower levels, were reported by the farm to have occurred in previous years, and it is possible that these may have had the same cause.

RTGE was first seen on a few farms in France in 1992 (F. Esnault, pers. comm.), and in Spain in 1995, with approximately 60% of Spanish farms affected by 1999, when the term RTGE was first coined (F. Sanz, pers. comm.),. Although the disease reported in France and Spain was broadly similar to that described here, there was one important difference: cases tend to occur at temperatures above 15°C, (Michel *et al*, 2002), rather than the 12°C seen in UK. Treatment with the antibiotics amoxycillin, oxytetracycline and potentiated sulphonamide has been found to be effective in alleviating the condition, but it often recurs once treatment is withdrawn. The most effective treatment for the condition is yet to be determined.

The organism involved in the continental cases of this disease has never been cultured, despite extensive efforts, but they are considered to be Segmented Filamentous Bacteria (SFB), otherwise known as Long Segmented Filamentous Organisms (LSFOs), and have been tentatively identified as members of the *Candidatus* Arthromitis group of bacteria by fluorescent *in situ* hybridisation (Urdaci et al, 2001). Despite the screening work carried out during this study, LSFOs have never been seen in trout not suffering from RTGE.

Urdaci (2001) reviews what is known about the LSFOs: they were first reported over 150 years ago by Leidy in1849, and are peripherally related to Clostridium phylogenetic group 1. They are Gram-positive and endospore-forming, and have never been cultured *in vitro*. They are ubiquitous in the animal kingdom, and have been described in the gut of a wide range of vertebrates (including carp), and invertebrates, and are potent activators of mucosal immunity. Transmission studies suggest a host specificity, but they are widely regarded as non-pathogenic commensals.

However, there are some reports of association with diarrhoea, malabsorption, fluid and gas filled intestines in avian species (Angel *et al*, 1990, Goodwin et al, 1989, Goodwin *et al*, 1991), and inflammation of intestinal mucosa and vacuolation of enterocytes in poultry (Goodwin *et al*, 1989).

The findings in the diseased fish on this UK trout farm, and the similarities to those described for RTGE in France and Spain, indicate that this is the first diagnosis of RTGE in UK. The cause of the condition is unclear but, as in the continental cases, it is always associated with the presence of LSFOs in the gut, but whether this is cause or effect is not clear.

The condition was seen again on this farm, and on other English trout farms, in 2001. In addition it has now also been found on Scottish farms where the trigger temperature seems to have been as low as 9°C.

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PROCEEDINGS

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A note on Koi Herpes Virus (KHV): current situation and issues arising

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Abstract

Koi Herpes Virus is a relatively new syndrome which has caused serious concern within the ornamental fish industry and has the potential to spread to both wild and farmed carp fisheries. Current knowledge regarding the disease is discussed as well as implications and possible strategies to control its spread.

Introduction

Koi Herpes Virus (KHV) is believed to be the causative agent of a disease specific for *Cyprinus carpio* that causes high morbidity and mortality. The earliest recorded cases were in Germany (September 1997) and Israel (May 1998). Since then the disease has been reported across much of Europe, the United States of America and South Africa. In addition, this year suspected cases have been reported in Indonesia and China. Consequently, the disease can now be considered worldwide.

Clinical Symptoms

The disease only occurs at water temperatures between 18°C and 25°C and only affects *Cyprinus carpio*. It commonly occurs after recent introductions of fish and after rapid alterations in water temperature. However there are confirmed cases where there have been no introductions of fish for several years.

In an outbreak one would expect morbidity of 100% and mortality up to 80%. The incubation period is fourteen days although this can be reduced to ten to twelve days at higher temperatures. Where naïve fish are introduced to a pond with a concurrent infection then they can exhibit clinical symptoms in three days.

Typically one sees a severe gill necrosis and the skin of the fish will feel similar to sandpaper. Alternatively the mucus layer will be thickened with "blebs" of mucus apparent. There may be ulceration of the skin present with some fish showing a severe external parasite infestation or no parasites at all. Internal pathology is non-specific but similar to what one would expect from a systemic viral infection.

Additional clinical signs can include anorexia for ten days prior to the onset of obvious clinical signs, erratic, uncoordinated swimming and acute death.

Diagnosis and Treatment

Where typical signs are seen and no other species of fish in the pond are affected then one can be confident of the diagnosis. Confirmation requires PCR/virus isolation. In the UK this can be carried out at CEFAS (Centre for Environment Fisheries and Aquaculture Studies) Weymouth. Currently this service can be obtained free as CEFAS are involved in studies to assess the prevalence of the disease in the UK.

There is no specific treatment. Optimal water quality and salt can help control the secondary infections. It is possible to reduce mortalities by increasing the water temperature above 26°C as soon as clinical signs are observed and maintaining the water temperature at this level until the fish's immune system has had time to recover. It is likely that a disease outbreak will re-occur when the temperature falls between 18°C and 25°C. Either increasing or decreasing the temperature as required can then control such a recurrence. A similar protocol is followed by koi producers in Israel which follows the natural variation in water temperatures there. In this way they are able to produce fish which are immune to the disease (Ariav and others 1999).

However, there is much debate as to whether this strategy produces carrier fish. Work in Israel (S. Tinman, unpublished data) suggests that the fish are not carriers. Experience to date would also suggest this to be likely, given the number of fish imported from Israel that have been exposed to the virus. However many herpes viruses exhibit latency. This has been shown to be the case with cyprinid herpes virus 1 (CHV) infection, the causative agent of 'carp pox'.

Current Situation

The disease occurs worldwide and has been made notifiable in Israel where 90% of carp production was lost in 2000 (R. Ariev, pers. Comm.). Interestingly, there have only been two reported outbreaks in carp fisheries in Western Europe, one in Germany and one in Belgium (F. Lieffrig, pers. comm.), neither of which the author understands to have been confirmed. In the UK the virus has not been isolated from mortalities at carp fisheries or in the wild.

There have been discussions within the EU to list the disease. Certainly the disease fulfils many of the criteria for listing. However:

1. It would appear that the disease is endemic within the EU, and possibly Eastern Europe, on the basis of suspected cases. In the UK only ten cases were confirmed by CEFAS last year (2001) but many suspected cases were not followed up. The number of cases in Holland and Germany has increased this year.
2. The currently available PCR test cannot detect asymptomatic fish and is poor at confirming KHV from Asian countries. At CEFAS they have had to resort to using a nested PCR test for these samples. It is possible that the Asian virus is a different strain.
3. The disease is certainly transmitted from fish to fish. There are also anecdotal reports that it can be spread by contaminated water or ectoparasites. These reports may be explained by latency. In Israel the rapid spread of the disease suggests that birds may play a part in its dissemination since the water supply for many farms comes from bore holes and for much of the year, rivers do not flow.
4. There is a lack of information on the potential for latency.
5. Certainly it is possible that the disease has been present for much of the last decade in the UK but not recognised. With hindsight the disease probably occurred in two areas of the UK in 1996 and probably on the continent in the Low Countries.
6. There is a suggestion that another trigger, not just water temperature, is necessary to cause an outbreak.

Given the above uncertainties it is unlikely the disease will be listed, unless an accurate and reliable diagnostic test is widely available and capable of detecting asymptomatic fish. The possible methods of transmission, prevalence of the disease and potential for latency should also be ascertained. In the UK the size of the ornamental industry is not sufficient to provide the necessary resources to carry out this work. Much of the funding that has been provided for research has been because of the potential devastating effects on carp fisheries. It is clear that those countries, which have large carp fisheries, have expended more time and money on research into this disease.

Recommendations

The priority must be to find a reliable, effective and widely available diagnostic tool which can identify infected asymptomatic fish so that the true prevalence of the disease can be established. Until then the following recommendations should be considered:

1. Importers, retailers and hobbyists should quarantine new fish for at least four weeks at water temperatures between 18°C and 25°C. Sentinel fish should also be used.
2. Given the question mark over carrier fish, where fish have survived an outbreak it is probably best to advise owners to either isolate surviving fish as a precaution or slaughter all stock and disinfect the pond.
3. Ornamental and coarse fisheries should not be held on the same site to prevent the potential for cross infection.
4. Trade practices should be reviewed. It is widely accepted that the rapid movement and mixing of animals from several producers, being held at high stocking densities, aids in the spread of disease. In the past it has been common for ornamental fish to pass from the country of origin, through several dealers and end up in the hobbyist pond within a matter of days.

Current legislation gives little or no protection against the introduction of novel diseases. Also, it does not provide any mechanism for control of new and emerging diseases. Koi herpes virus illustrates the need for such legislation to be introduced. Four years after the disease was first recognised, it is likely that koi herpes virus is already well established in many countries around the world.

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Fish Quality Assurance Schemes

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Abstract

The current status of fish quality assurance schemes and their certification systems is reviewed. Some concerns regarding fish welfare standards covered by these schemes and the future move towards possible harmonization are discussed

Introduction

Over the last two decades a number of quality assurance schemes for the aquaculture industry have been developed, similar to schemes for other livestock sectors.

The stimulus for such schemes has been consumer concern regarding the provenance of their food in terms of safety and quality and also in terms of animal health and welfare. Market research has shown that consumers put their trust in an assured product and quality assurance schemes aim to reassure the consumer while, it is hoped, raising awareness and overall standards within the industry. It must be borne in mind that there is a difference between ‘quality assurance’ and ‘farm assurance’ schemes. Where quality assurance can refer to all processes involved in producing the final product, farm assurance refers to the animal production systems only. Fish quality schemes in general cover farm production systems (although not always through the whole production cycle) and all primary and secondary processing up to the point of retailer supply.

All quality schemes are voluntary and run by the private sector. They tend to be market-driven and establish standards and codes of practice over and above the mandatory regulatory requirements of legislation. These are already in place to assure consumer and environmental safety as well as animal health and welfare.

EN45011

The European Standard EN45011 has been established to provide assurance that an organisation (the certifying body) is competent to certify that a product is being produced to the criteria set out in any given standard. EN45011 has no authority over the contents of any one standard: it is simply a system of ensuring the standard of the auditing process. It can therefore certify the auditing of the production of, for example, salmon, to many different sets of standards. EN45011 requires that there is regular independent verification of standards of production by trained inspectors. The inspectors assess conformity to the requirements of that standard, judge non-conformity and agree actions and timescale to address the non-conformities. These inspections provide assurance of the compliance or non-compliance with a particular set of standards at a particular point in time. The certifying bodies who audit the industry's salmon and trout schemes are accredited to the requirements of EN45011.

Quality schemes

Many schemes are in place for most animal production systems including several for fish. Most were primarily developed by consortia of producers, but are now run by independent bodies within the industry. All aim to give some assurance of the quality of the product and provide a minimum standard for all aspects of the production system from 'egg to harvest'.

In addition to industry-created schemes, retailer schemes (codes of practice) have been developed. The development of these codes of practice has very much been driven by the Food Safety Act of 1990 which requires retailers to demonstrate due diligence to consumer safety. These codes have also been prompted by consumers seeking some assurance of the safety and quality of their purchases.

All quality schemes, by their very nature, are based on systems of verifying the quality and safety of the product. However, the different schemes vary widely in their requirements, i.e. there is no uniform standard for aquaculture production. Frequently, there is also a different emphasis on the requirements between standards; some may go into great detail with regard to aspects of food safety, while others place more emphasis on environmental impact. Although all sets of standards cover some details of fish welfare, such as, in setting limits on stocking density, nonetheless, most place more emphasis and detail on consumer and environmental safety.

Fish schemes

Industry-driven schemes have been developed for salmon production in Scotland, Ireland and Shetland and a single quality scheme covers all UK trout production. In addition to these there are the organic aquaculture and RSPCA Freedom Foods schemes. All major retailers have their own set of standards which are either independently audited or monitored by the retailers' own technical departments. Of these, only the RSPCA scheme has the primary objective of the welfare of the farmed fish.

Fish Welfare

There is almost a misconception that quality schemes give a guarantee of high standards of animal welfare. In many cases, welfare may, in fact, be of secondary importance to food safety and the requirements of some schemes may even have the potential of compromising fish welfare through restrictions on legitimate disease control measures.

The Farm Animal Welfare Council (FAWC) published an interim report on the animal welfare implications of farm assurance schemes in 2001. It expressed concern that schemes do not fully realise their potential for maximising animal welfare and that the consumer was not being fully informed regarding welfare standards.

There are a number of areas in some fish schemes where standards could place more emphasis on fish welfare; for example, the hatchery and fresh water stages of salmon production are either totally ignored by some codes of practice, or codes pay scant regard to the welfare of the juvenile fish. Slaughter is another area that is often dealt with in a superficial manner or sometimes ignored completely. It can be argued that some schemes will compromise fish welfare due to their requirements of minimising the use of therapeutic agents and applying extended withdrawal periods because of the perceived risk to consumer safety. Although there may be a need to use a particular disease control treatment, the fish farmer may be very reluctant to do so if it means the loss of his quality certification. Other scheme requirements such as the restriction on the use of anti-fouling agents and predator control measures, could also have an effect on fish welfare.

To demonstrate that quality schemes are concerned with fish welfare, they should incorporate the methods by which fish welfare can be assessed by the certifying body. This in itself is fraught with difficulty, but nonetheless should be addressed. FAWC states that accurate assessment remains difficult and often subjective – it still depends on human perception and refers to husbandry conditions – qualitative and scientifically imprecise. There is a need to translate scientific welfare assessment to practical assessment in the field and there is a need for clear, unambiguous standards demanding a high standard of animal welfare. This must be backed up by rigorous assessments. There is also a need to strike a balance between welfare requirements and the practical application of these requirements. It is all very well having a 'gold standard' achieved by a few and ignored by the many, when there could be a 'silver standard' which would draw many more producers into the scheme and result in an overall increase in welfare standards.

There is plenty of evidence to suggest that consumers will support foods which have been produced humanely, but in reality, a great deal of purchasing is price-driven with no regard to animal welfare. Consumer interest in welfare apparently becomes less the more a product is processed. In other words, they appear to be less concerned about the welfare of an animal which is processed into a 'ready meal' than they are about a fresh piece of meat or fish. This would not matter if the retailer took the primary responsibility in demanding maximum welfare criteria in the production of their products. The retailer, however, may be reluctant to highlight welfare issues and they may not even wish to restrict their purchasing to 'welfare friendly' products, on economic grounds. They may want to carry lines which are not produced to high standards of animal welfare alongside their 'quality assured' products.

Harmonisation

There are many quality assurance schemes and codes of practice and there has been a trend towards trying to harmonise these into a single scheme such as the Assured Food Standards "red tractor" symbol.

This has the advantage of producing common standards as well as less duplication of assessments and reduced costs, but there may also be disadvantages in creating the lowest acceptable standard and a reduced ability to develop schemes and raise standards through competition.

'Stable to Table'

Most quality schemes have been retailer or industry-driven. It can be argued that there may be vested interests in the way these schemes have been developed and the standards set and that a truly independent umbrella scheme should be developed covering the whole production cycle from 'stable to table'. This is an initiative that has been considered by the British Veterinary Association, the European Food Safety Authority and the Standing Committee on the Food Chain and Animal Health. It would establish an independent harmonised scheme setting criteria for all stages of production and covering consumer and environmental safety, animal welfare and health and may overcome some of the criticisms presently levelled at quality assurance schemes.

In general the very presence of quality assurance schemes has improved overall management and welfare.

Reference

Interim Report on the Animal Welfare Implications of Farm Assurance Schemes. Farm Animal Welfare Council. (FAWC). August 2001. Published by DEFRA. pp45.

Pete Southgate qualified from the Royal Veterinary College in 1979. He worked in practice for about five years before going to the Institute of Aquaculture at Stirling University where he obtained an MSc in aquatic veterinary studies. He worked at the Institute for six years before becoming an independent fish vet. He joined Fish Vet Group in 1997. He is a founder member and past president of the Fish Veterinary Society. He is also a RCVS recognized specialist in fish health and production since 1992 and is a trustee of the BVA Animal Welfare Foundation.

This paper is based on a presentation given at the spring scientific meeting of the Fish Veterinary Society in Edinburgh on 24 April 2002. It was submitted for publication on 9 February 2003

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BSAVA Manual of Ornamental Fish
Second Edition
William H. Wildgoose (Editor) (2001)
312 pages, paperback, £80.00
(BSAVA, BVNA & FECAVA members' price £52.00)
BSAVA (distributed by Blackwell Science Ltd., Oxford, OX4 2DQ).
ISBN 0905214579

I suspect that many veterinary practitioners, when presented with a sick fish, groan inwardly. The fact is, that veterinary surgeons are often reluctant to treat fish and will often prefer to call on the help of a specialist. There is some justification for this reaction since fish do present particular difficulties with regard to both diagnosis and treatment. Clinical signs in fish tend not to be as specific or as easy to observe as in mammals, and the use of thermometers and stethoscopes is not an option in fish. There also tends to be a heavier reliance on laboratory techniques in diagnosis. Nonetheless, practising veterinary surgeons could probably do more to build up personal expertise in dealing with fish. Expertise in the area of fish is highly valued and a useful and welcome service can be provided to clients who keep fish as a hobby, and also to aquatic traders and those involved in public aquaria.

So, the the all-new second edition of the *BSAVA Manual of Ornamental Fish*, edited by respected FVS member, Willie Wildgoose, has made a timely and welcome appearance as the number of clients keeping freshwater and marine aquaria increases. Willie Wildgoose has single-handedly made an enormous contribution to ornamental fish medicine through his written papers and presentations at FVS and other meetings, and his editorship of this manual, as well as contributing some of the chapters, is quite appropriate.

The authorship of this manual reads like a "Who's Who" of veterinary and other fish health specialists from the UK and USA and the range of topics covered by these specialists is truly comprehensive. In all 29 authors contributed chapters to this new manual, which is clearly, and rightly, aimed at an international readership. There can be drawbacks associated with multi-authored textbooks, notably, a tendency to duplication of material and also, a real possibility of important areas not being covered adequately or at all. This does not arise in this case as the editor has chosen his authors well, and ensured that all the important areas are covered, without obvious duplication or overlap. Also, from beginning to end, there is a logical flow to the way the subject matter is dealt with.

Part I of the manual sets the scene with a chapter containing a concise and accurate description of the aquatic environment with just the right number of figures and tables to illustrate key information. The first part of the manual goes on, in subsequent chapters, to describe the ornamental fish industry, including production, trade and methods of fish keeping. It is important to provide this background, particularly for those readers not familiar with the global nature of the ornamental fish trade, and how ornamental fish are farmed and, ultimately, end up in the tanks of high street retailers and garden centres. It also helps to highlight where professional involvement is required and welcomed such as the growth in public aquaria, which are subject to zoo licensing regulations and require regular veterinary inspections.

Part II of the manual deals with clinical investigation and covers the general approach, the environment, clinical examination, as well as restraint and anaesthesia, laboratory techniques and diagnostic imaging. In some fish books, there is a tendency to play down the importance of carrying out a full clinical examination by moving quickly on to post-mortem findings and laboratory techniques. In this manual, the clinical examination of fish is given its due importance by being placed in a separate chapter. The idea of interspersing the text in these chapters with several, short one or two sentence 'tips' is also helpful. Full-colour photographs illustrate the clinical features of diseases in a number of species.

Diseases of ornamental fish are described according to bodily system affected in Part III of the manual. This sections contains chapters on skin diseases, respiratory diseases and also internal and eye disorders. It also contains a chapter describing behavioural changes associated with various diseases. Changes in colour, swimming and feeding behaviour can yield important clues as to the nature of disease problems in ornamental fish. This section also contains a useful chapter on sudden death in ornamental fish, which includes a helpful systematic approach to the investigation of sudden death.

Part IV of the manual deals with specific disease problems according to the cause, whether bacterial, viral, nutritional, etc., and contains nine chapters which are all short and contain many full-colour photographs illustrating the clinical features of the diseases described. These photographs help to convey an appreciation of the variety of infectious and other diseases which can be encountered in ornamental fish, as well as providing a useful pictorial image of some of the diseases and parasites described.

One of the reasons veterinary practitioners are sometimes reluctant to get involved with fish may be a concern about how to treat them, having made some sort of diagnosis. Part V of this manual deals with treatment and prevention of disease and even includes a chapter on surgery. The chapter on therapeutics considers the whole range of possible medicinal treatments which may be administered to ornamental fish as well as routes of administration. The tables in this chapter, giving information on proprietary medicines, dose rates, indications and helpful comments and warnings, are particularly useful and, I suspect, will be frequently referred to for information.

Finally, the manual concludes with a miscellaneous section, Part VI, containing three chapters on aquatic vertebrates, US and UK legislation, and health and safety, followed by some useful appendices. The chapter on legislation is divided into two parts, each part summarising legislation in the UK and US and contains useful information principally on medicines, disease, welfare and zoos legislation.

All in all, this is a superb manual and represents a tremendous effort by all the contributors, not least the editor. The BSAVA must also take great credit for commissioning and publishing it. The amount of information, all of it useful, contained between its covers, is truly staggering and one would be hard put to find any fault or omissions in it. The material is, conveniently, broken up into manageable portions in the form of relatively short chapters, which are well, and liberally, illustrated and extremely comprehensive. If a veterinary practitioner were to buy only one book dealing with fish, then this should be the one.

This manual is a must for all veterinary practitioners who have or might have occasion to deal with fish.

John McArdle

RCVS NEWS

Keeping up to date with knowledge

Did you know that there were 1,400 references recorded on fish veterinary work in the last three months? That was on just one major database and related only to English language material. Just how do you keep up to date in the field? Your knowledge builds through practice and discussion with colleagues. But knowledge and practice do not stand still. Accessing the amount of information being published is a challenge. Books, journals, and the internet all continue to add to the profession's knowledge base.

The RCVS Library can help you with this challenge in a number of ways:

The catalogue of the library can be searched online via the website **www.rcvslibrary.org.uk**

Membership enables access to a number of electronic journals including *Journal of Fish Diseases*, *Fisheries Management* and *Ecology and Marine Environmental Research*. The ScienceDirect digital library website gives access to 1,800 journals and millions of peer reviewed papers.

The library can supply copies of papers from its collection or from a wide variety of other information resources. It also circulates current issues of veterinary journals, and lends books to members.

Expert information specialists can undertake thorough or targeted searches of what is available on the main animal and fish databases.

The RCVS library website provides links to a number of other resources of use to fish veterinary practitioners. For example, VetGate www.vetgate.ac.uk gives extensive coverage to UK resources and access to high quality resources from across the world.

All these services are available to all but Library members receive them at a discounted rate. Details of membership can be found at **www.rcvslibrary.org.uk/membership_scheme.htm**

The Library is open from Mondays to Fridays between 9.15 and 5.00, except for public holidays. Its website www.rcvslibrary.org.uk is generally available 24 hours daily and points to further high quality resources across the world.

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John McArdle

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Issue No. 5 (June 2000)

Dental overgrowth and trimming in a pufferfish. *R. Rees Davies*
Mycobacteriosis: detection and identification of aquatic *Mycobacterium* species. *S. Puttinaowarat, K.D. Thompson & A. Adams*
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Myxosporidiosis of fish and the bryozoan link with proliferative kidney disease (PKD) of salmonids. *S.W.Feist & M. Longshaw*
An overview of carp diseases in the UK. *D. Bucke*
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Koi carp mortality syndrome: an update. *C.I. Walster*
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Institute of Fisheries Management: fish disease discussion group
Book Review:
The UFAW Handbook on the Care and Management of Laboratory Animals. (7th edition)
Volume 2: Amphibious and aquatic vertebrates and advanced invertebrates (ed T. Poole)

Issue No. 6 (February 2002)

Aerobic microflora of imported ornamental fish from Singapore and South America. Part 2: Antimicrobial Resistant Profiles of motile Aeromonads. *R. E. del Rio-Rodriguez and J. F. Turnbull*
Approaches to the eradication of infectious disease from farm animal livestock. *R.M. McCracken*
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Atlantic salmon broodstock and vertical transmission of Infectious Pancreatic Necrosis Virus (IPNV). *T. Laidler*
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MEMBERSHIP APPLICATION

Eligibility
Membership of the Fish Veterinary Society is open to all members of the Royal College of Veterinary Surgeons, to those on the Supplementary Veterinary Register and to students studying for a degree entitling them to membership of the RCVS. The Society will also consider applications from overseas veterinarians and those with an appropriate interest / degree as set out in the Constitution of the Society (available on request from Treasurer).

I wish to become a member of the Fish Veterinary society, subject to the conditions governing the same as set out in the Constitution of the Society.

I agree to pay my annual subscription in advance on 1st January each year, and if at any time I wish to resign from membership, undertake to send my resignation to the Honorary Treasurer by 1st December.

Name :

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Telephone : **Fax**:

e-mail :

University :

Degrees :

Date of graduation :

Fees **: £50 per annum** (January to December)
(There is no charge to veterinary undergraduates)

*The sum of £50 is enclosed for full enrolment into the Fish Veterinary Society and membership for the current year. Future payments will be made by Standing Order each year in January (mandates available from Honorary Treasurer)

*I am a veterinary undergraduate and wish to become an associate member of the Fish Veterinary Society and I am due to graduate in_________(year)

**delete as appropriate*

Signature :

MEMBERSHIP DATABASE

To help the Society provide a better service to its members we would be grateful if you could complete the following questionnaire by indicating your area of special interest.

Species of interest:

Salmon	❐	Trout	❐
Flatfish	❐	Shellfish	❐
Ornamental	❐	Other (please specify)…	

Areas of interest:

Pathology	❐	*Histopathology*	❐
Bacteriology	❐	*Parasitology*	❐
Mycology	❐	*Virology*	❐
Diagnostics	❐	Genetics	❐
Immunology	❐	Legislation	❐
Management	❐	Nutrition	❐
Pollution	❐	Reproduction	❐
Surgery	❐	Therapeutics	❐
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Other (please specify)…			

Other Membership:

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Associate membership for non-veterinarians

The Fish Veterinary Society (FVS) was formed in July 1990 to provide veterinarians working with fish the opportunity to benefit from the experience of others through regular meetings and latterly through the pages of the *Fish Veterinary Journal*. The formation of the FVS was recognition that there are scientific, legal and ethical issues of particular relevance and importance to the profession which were not being addressed elsewhere. For this reason, membership to date has been confined to veterinarians since it was not felt that other fish health professionals would be particularly interested in joining the Society. However, in the 10 years since its inception the FVS has gone from strength to strength and has credibility in the wider fish health community.

For this reason, and as a result of interested expressed by non-veterinarians, a proposal to amend the constitution and to extend membership was put to those who attended the annual general meeting (AGM) in Weymouth in December 1999. After much debate, it was agreed without serious dissent that a new category of member, Associate, be created for those who might be interested in the Society's activities. Associate Members will enjoy all the benefits of Full Members but without the right to sit on the committee or vote at any of the Society's meetings or attend the AGM. This is not an attempt to disenfranchise new members but is intended to ensure that the Society retains its unique identity and particular objectives identified at its formation. Prospective members should be proposed and seconded by current Full Members.

We hope that new members, both within and outwith the profession, will be encouraged to apply to the Treasurer and allow the FVS to fulfil its purpose to advance the care and welfare of fish. Further details of the Society can be found at its web-site at **www.fishvetsociety.org.uk**

Andrew Grant
President 1997–1999

FVS Web Site

The Fish Veterinary Society has a web site which can be found at:

www.fishvetsociety.org.uk

Not only does it contain information about the Society itself, but there are regular updates on relevant forthcoming events and scientific meetings. It will soon be possible to download the membership application form and check the contents of previous editions of the Fish Veterinary Journal. It is hoped that the site can be developed further and incorporate a ‘chat room’ or an on-line discussion forum. We are open to any suggestions about the content and format – this is your chance to become more directly involved with the public face of the Fish Veterinary Society.

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