CENTRE FOR ENVIRONMENT, FISHERIES AND
AQUACULTURE SCIENCE

TROUT NEWS

NUMBER 31

JANUARY 2001

CEFAS
The Centre for Environment, Fisheries & Aquaculture Science

MAFF

CEFAS is an Executive Agency of the Ministry of Agriculture, Fisheries and Food (MAFF)

'TROUT NEWS' is produced and edited by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) on behalf of the Ministry of Agriculture, Fisheries and Food (MAFF), Fisheries II Division, London as a service to the British trout farming industry. Copies are available free, on request to the editor or may be viewed on the CEFAS website at www.cefas.co.uk.

Articles, letters and news relating to trout farming are always welcome and may be included in future issues.

The views expressed in this issue are those of the contributors and are not necessarily those of the editors; and the reference to proprietary products should not be construed as an official endorsement of these products. The editors reserve the right to edit articles or other contributions.

Dick Lincoln, Editor
Denis Glasscock, Assistant Editor

CEFAS Lowestoft Laboratory
Pakefield Road
Lowestoft
Suffolk
NR33 0HT
Tel: 01502 562244
Fax: 01502 513865
email: d.glasscock@cefas.co.uk

www.cefas.co.uk

CONTENTS **Page**

TROUT PRODUCTION

1999 SURVEY OF TROUT PRODUCTION IN SCOTLAND

The figures for rainbow trout, egg production and egg imports for Scotland were not available in time for inclusion in the July 2000 edition of Trout News. This data is now included here and is supplied from SERAD (Rural Affairs Department of the Scottish Executive) Annual Production Survey, 1999.

Rainbow trout were produced from 68 sites involving 54 companies with an overall production of 5,834 tonnes in 1999 (4,913 tonnes in 1998) an increase of 921 tonnes on the previous year (a rise of almost 19%). Trends in production over the last 10 years are given in Table 1 below.

Table production

Table 2 gives trends in production for table fish over the past 6 years. Production in 1999 amounted to 4,857 tonnes representing an increase of 788 tonnes (19%) on the previous year and accounting for 83% of total production.

Fish weighing up to 450 g and over 900 g made up the bulk of table production representing 65% and 32% of the total respectively.

Restocking production

Table 3 provides production data for the restocking trade for the last 6 years. Production for restocking increased by 131 tonnes (15%) to 975 tonnes representing 17% of the total production (17.2% in 1998).

Table 1. Total production for the period 1990-1999

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Tonnes	3,183	3,334	3,953	4,023	4,263	4,683	4,630	4,653	4,913	5,834

Table 2. Production of table fish for the period 1994-1999

Year	<450 g < 1 lb	450-900 g 1-2 lb	>900g >2 lb	Total tonnes
1994	2,376	288	1,038	3,702
1995	2,736	199	1,149	4,084
1996	2,701	181	1,002	3,884
1997	2,646	104	1,098	3,848
1998	3,009	173	887	4,069
1999	3,151	144	1,562	4,857

Table 3. Production for the restocking trade in 1994-1999

Year	<450 g < 1 lb	450-900 g 1-2 lb	>900 g >2 lb	Total tonnes
1994	125	337	99	561
1995	107	411	81	599
1996	188	484	74	746
1997	97	589	119	805
1998	69	538	237	844
1999	236	552	187	975

Method of Production

Table 4 provides a breakdown of trout farms by system and scale of production. Freshwater production remained relatively stable at 4,756 tonnes (82% of the total) while seawater production increased by 113% on the previous year to 1,078 tonnes (18% of the total).

Production and manpower by region

The regional production and manpower information shown in Table 5 relate to Scottish Local Government Regions following their reorganization in 1996. These are shown in Figure 1.

Historically rainbow trout production has tended to be located in the south of Scotland due largely to the location of the pioneering producers and the relative easy access to markets. This pattern of development has continued and relatively few rainbow trout farms have been established in the north of Scotland.

Productivity ranged from 22.4 to 44.9 tonnes/person between production areas, being greatest in the West and least in the Northern area.

Mean productivity in tonnes/person for the 4 production areas reached 32.1 tonnes in 1999 representing an increase of 25.9% on the previous year's figure of 25.5 tonnes. Over the same period staff employed decreased by 9 to 177.

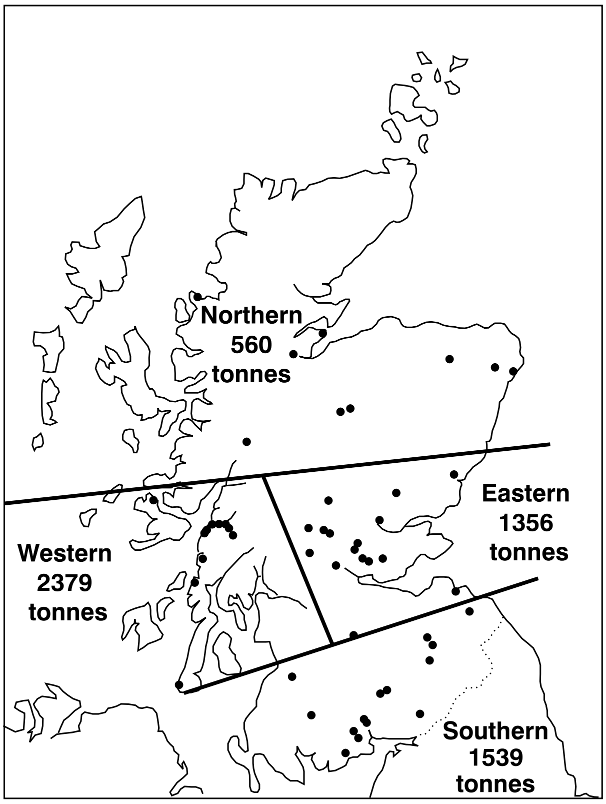


Figure 1. Map of Scotland showing total production in the four trout areas for 1999 and distribution of active sites

Table 4. Analysis of rainbow trout farms by system and scale of production

Production method	Production grouping (tonnes) in 1999					Total tonnage	Total no.of sites	% contribution
	<10	10-25	26-50	51-100	>100			
FW cages	2	1	1	0	5	2,245	9	38.0
FW ponds & raceways	3	7	4	6	9	2,399	29	41.0
FW tanks & hatcheries	3	1	1	1	0	112	6	2.0
SW cages	1	0	1	1	3	1,075	6	18.0
SW tanks	1	0	0	0	0	2.75	1	<1
Total	10	9	7	8	17	5,834	51	100

Table 5. Rainbow trout production and staffing by area in 1999

Area	No. of sites	Production			Mean tonnes/ sites	Staffing			Productivity tonnes/ person
		Table	Restocking	Total		F/T	P/T	Total	
North	8	450	110	560	70.0	18	7	25	22.4
East	18	1,059	297	1,356	75.3	42	14	56	25.1
West	22	2,239	140	2,379	108.1	34	19	53	44.9
South	20	1,110	429	1,539	76.9	32	11	43	35.8
All	68	4,858	976	5,834	85.9	126	51	177	32.1

Other species

Other species farmed in Scotland together with the production values for 1999 and 2000 are given in Table 6.

Table 6. Production of other species in tonnes for 1999 and estimated production for 2000

Species	Production 1999	Estimated production 2000
Atlantic salmon	126,686	130,837
Arctic char	2.8	6
Brown trout	0.5	1.5
Brown trout/sea trout	92.0	182.5
Cod	0.1	26.0
Halibut	3.6+	57.5+

Ova production

The number of rainbow trout eyed ova laid down for hatching from home-produced stock, from other sources within Great Britain and from foreign imports are given in Table 7 for the period 1993 to 1999. The proportion of ova laid down from GB broodstock decreased to 1.27 million representing 7% of the total. The total number of eyed-ova laid down decreased by over 6.6 million (26.2%) on the 1998 figure.

Type of ova

Details of the number and type of ova laid down for hatching are given in Table 8. The preference for all female diploid stock was again evident, accounting for 88% of all ova laid down. Triploid ova increased again in 1999 mainly for use by the restocking trade, representing 10% of total ova production.

Table 7. Number and sources of ova laid down for hatching in 1993-1999

Year	Own stock	Other GB Stock	Total GB	Total foreign	Grand total	% GB
1993	1,830,000	405,000	2,235,000	17,509,000	19,744,000	11.3
1994	479,000	625,000	1,104,000	18,500,000	19,604,000	5.6
1995	165,000	360,000	525,000	20,310,000	20,835,000	2.5
1996	420,000	988,000	1,408,000	21,270,000	22,678,000	6.2
1997	1,232,000	837,000	2,069,000	21,434,000	23,503,000	8.8
1998	2,559,000	60,000	2,619,000	22,623,000	25,242,000	10.4
1999	878,000	392,000	1,270,000	17,361,000	18,631,000	7.0

Table 8. Number and proportions (%) of ova types laid down for hatching in 1993-1999

Year	Total ova	All female diploid Nos. (%)	Triploid Nos. (%)	Mixed sex diploid Nos. (%)
1993	19,744,000	17,261,000 (87)	1,396,000 (7)	1,087,000 (6)
1994	19,604,000	18,105,000 (92)	1,134,000 (6)	365,000 (2)
1995	20,835,000	19,546,000 (94)	1,170,000 (6)	119,000 (+)
1996	22,678,000	21,308,000 (94)	935,000 (4)	435,000 (2)
1997	23,503,000	21,118,000 (90)	1,386,000 (6)	1,000,000 (4)
1998	25,242,000	23,222,000 (92)	1,515,000 (6)	504,000 (2)
1999	18,633,000	16,324,000 (88)	1,853,000 (10)	456,000 (2)

SUMMARY OF UK RAINBOW TROUT PRODUCTION IN 1999

Details of rainbow trout production both for the table trade and restocking are given in Table 1 below for England and Wales, Scotland and Northern Ireland.

Total production in 1999 amounted to 17,185 tonnes (16,109 tonnes in 1998) representing an increase of 1,076 tonnes (6.7%) on the previous year.

Table 1. UK Rainbow trout production for 1999

	Production in tonnes		
	Table	Restocking	Totals
England and Wales	6,709 (67.5%)	3,224 (32.5%)	9,933
Scotland	4,857 (83.3%)	975 (16.7%)	5,832
Northern Ireland	1,350 (95.1%)	70 (4.9%)	1,420
Totals	12,916 (75.2%)	4,269 (24.8%)	17,185

RAINBOW TROUT EGG IMPORTS IN 1999

England and Wales

Imports of rainbow trout eggs into England and Wales during 1999 totalled 27.7 million (Table 1), the lowest level since 1995 (23.8 million), and a fall to 72% of the 1998 total (38.4 million).

Imported eggs accounted for 42.6% of the 65 million eggs laid down in England and Wales in 1999. The overall total of eggs laid down was 81.5% of that for 1998, showing that imports were disproportionately hit by the fall in demand for eggs, fry and fingerlings in 1999.

A total of 9 companies exported eggs, 5 in Denmark, 2 in Northern Ireland, and one each in the Isle of Man and South Africa. Hardest hit by the reduced demand was South Africa from which only 8 million eggs were imported, a fall from 17.5 million in 1998. This represented a fall from 46 to 29% of the total import market. Only Northern Ireland exported more eggs than in 1998, the extra 1.6 million eggs increasing its share of the market from 8 to 17%.

The imported eggs were laid down on 40 different farms, of which 23 took eggs from a single source, 13 from 2 sources, 2 from 3 sources and one each from 4 or 5 different source farms.

Nineteen of the farms imported stock from the Isle of Man, seventeen from Northern Ireland, sixteen from South Africa and only nine from Denmark.

Of the 40 importing farms, 21 laid down eggs from their own broodstock, in addition to those imported. The remaining 19 were entirely dependent on external suppliers, and purchased stock predominately from the importing sites rather than other British suppliers.

Table 1. Number and source of rainbow trout imported by month in 1999 (no. of consignments in brackets)

	Denmark	Isle of Man	Northern Ireland	South Africa	Total
January		1,530,000 (9)	37,000 (2)		1,567,000 (11)
February	1,500,000 (3)	1,970,000 (8)			3,470,000 (11)
March	1,100,000 (9)	1,445,000 (9)	238,000 (4)		2,783,000 (22)
April	1,190,000 (4)	60,000 (5)			1,250,000 (9)
May	1,000,000 (4)	15,000 (1)			1,015,000 (5)
June		250,000 (2)	300,000 (2)	1,250,000 (8)	1,800,000 (12)
July			1,270,000 (6)	4,900,000 (9)	6,170,000 (15)
August			102,000 (3)	1,625,000 (9)	1,727,000 (12)
September			666,000 (4)	325,000 (2)	991,000 (6)
October		207,000 (3)	800,000 (3)		1,007,000 (6)
November	1,000,000 (3)	2,300,000 (10)	500,000 (2)		3,800,000 (15)
December	100,000 (1)	1,327,000 (8)	700,000 (2)		2,127,000 (11)
Totals	5,890,000 (24)	9,104,000 (55)	4,613,000 (28)	8,100,000 (28)	27,707,000 (135)
Percentage	21	33	17	29	

Scotland

The number and source of imported rainbow trout ova for 1999 are given in Table 2 below. The total imported - over 18.24 million represents a decrease of 4.4 million eggs over the 1998 figure (22.6 m) Denmark, the Isle of Man and Northern Ireland accounted for over 12 million eggs, representing 66% of ova imports. Imports from South Africa were nearly half that of 1998 amounting to 6.14 million (11.59 million in 1998) representing 34% of imports.

Table 2. Number and source of trout ova imported into Scotland plus number of consignments (in brackets) by month in 1999

Month	Northern Ireland	Isle of Man	Denmark	South Africa	Total
January	915,000 (6)	593,000 (4)	-	-	1,508,000 (10)
February	70,000 (1)	320,000 (1)	1,288,000 (2)	-	1,678,000 (4)
March	150,000 (1)	199,000 (1)	1,442,000 (4)	-	1,791,000 (6)
April	70,000 (1)	60,000 (1)	1,516,000 (4)	-	1,646,000 (6)
May	50,000 (1)	20,000 (1)	300,000 (2)	-	370,000 (4)
June	-	-	-	1,460,000 (3)	1,460,000 (3)
July	200,000 (2)	-	-	4,026,000 (2)	4,226,000 (4)
August	420,000 (2)	-	-	550,000 (4)	970,000 (6)
September	820,000 (3)	-	-	100,000 (1)	920,000 (4)
October	515,000 (4)	150,000 (1)	-	-	665,000 (5)
November	-	1,030,000 (3)	-	-	1,030,000 (3)
December	125,000 (1)	1,850,000 (3)	-	-	1,975,000 (4)
Totals	3,335,000	4,222,000	4,546,000	6,136,000	18,239,000
Consignments	22	15	12	10	59

Total egg imports

Overall the total number of eggs imported into the UK from foreign sources in 1999 amounted to almost 46 million (61 million in 1998) representing a decrease of 15 million (24.7%) on the previous year.

ARTICLES

THE FIRST OCCURRENCE OF *LACTOCOCCOSIS* IN FARMED TROUT IN ENGLAND

Sam Bark and David McGregor,
CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB

September 2000 saw the first occurrence of a case of Lactococcosis in rainbow trout in the UK. *Lactococcus garvieae* has been associated with major economic loss to aquaculture globally since the early 1970s. Originally described in Japan in 1958, spreading to South Africa and the USA by the late 1970s, the disease has now been reported as a cause of economic loss across Continental Europe. It does not, however, have any public health implications.

The isolation of *Lactococcus garvieae* from fish in the south of England followed the onset of a dramatic mortality, which was centred in a reservoir fishery. Sub-optimal environmental conditions at this location combined with grading stress were undoubtedly major contributory factors to the deaths of the fish. Although *Lactococcus garvieae* is not a notifiable disease, CEFAS were asked by the reservoir owners to investigate the outbreak. During the subsequent investigation by the Fish

Health Inspectorate (FHI), the pathogen was not found in those cages located some distance away from the focus of the mortality. Neither was it confirmed to be present at sites from which the fish had been sourced, nor from sites which were supplied by the infected fishery.

The precise source of the infection was not established. However it remains possible that the organism had originated from a non-fish source. The organism has been specifically linked with mortalities in rainbow trout farms in Europe, with evidence linking the spread of infection with live fish movements between sites. In this case, however, there was no evidence linking live fish movements to the occurrence of the disease.

What is evident, is a clear link between prevailing environmental conditions, infection, and resultant mortality. This was demonstrated in this case, as the dramatic mortality was focused on the part of a site which suffered from poor water exchange.

Work at CEFAS, Weymouth

As a direct response to the disease out-break, we have developed a rapid and accurate method to identify *Lactococcus garvieae*. Although relatively easy to isolate, Gram-positive cocci such as these are difficult to identify by biochemical characterisation (i.e. the traditional methods applied to for identification of micro-organisms). The differentiation of Gram-positive cocci of the taxon *Streptococcus* from the closely related *Lactococcus* and *Vagococcus*, is important not least because of the potential human health implications of Streptococcal infections. A method sensitive to these requirements is based on PCR amplification and sequencing of the 16S ribosomal gene. The gene is universally found in all bacteria, and is currently considered one of the best genes for use in new-species identification because of its slow molecular and evolutionary clock. This diagnostic PCR-based method, optimised by Alyson Shepherd of Weymouth's Molecular Biology Department, will enable the quick and conclusive identification of *Lactococcus garvieae*.

We have also been investigating the efficacy of a number of disinfectants employed as preventative measures, against Lactococcosis. The results of these trials are presented in Table 1. In total five disinfectants readily available to aquaculture were assayed: Two chlorine based disinfectants, Klorosept 35 and Hypochlorite; Two iodophors, Fam 30 and Buffodine; and a medical disinfectant, Virkon. All of the above disinfectants proved effective in killing *Lactococcus garvieae* at the specified concentrations. It should be emphasised, at this stage that the results of this study are preliminary in nature and should only be used as a guide. Care should be taken to adhere to manufacturers' recommendations and especially to any precautions which are advised as to the use of their products.

Further studies on disinfectants and their method and conditions of use are currently underway with the aim of producing a more detailed report/booklet on disinfectants and their use in the future.

What Should I do?

Preventive measures

- In common with good farming practice, remember the principles of buying fish only from reputable suppliers and making sure you are satisfied with the appearance of the fish at point of arrival.

- If possible, make sure that you are able to separate off new arrivals so that you can observe them at a later stage e.g., a minimum of 2 weeks after arrival.

- Bearing in mind the well known routes by which disease is transferred, combine chemical disinfection (Guidelines, Table1)with routine cleaning of tanks, ponds, equipment including nets and protective clothing.

- If in doubt, seek advice from the FHI or from someone who knows about fish disease prevention.

Table 1. Disinfectant trial results (S. Bark and S. Dunbar 2000)

Product tested	Concentration of active ingredients as supplied by the manufacturer		Recommended concentration for use	Dilution ml/litre
	w/v	ppm	ppm	
Buffodine	1%	10000	200	20ml
Hypochlorite	10%	100000	600	6ml
Fam 30	2.75%	27500	200	7ml
**Virkon*	1%	10000	625	62.5ml
***Klorosept 35*	0.02%	200	200	(1 tablet)

* *A 1% w/v solution was gained by adding 10g of Virkon powder to one litre of water*
** *A 0.02% w/v solution was gained by adding one tablet to 1 litre of water*

- Maintain accurate and up to date mortality records so that you can detect problems. Most importantly observe fish stocks daily and record how the fish look.

In the case of *Lactococcus* infection, external signs of *Lactococcus* may include bilateral exopthalmia and corneal opacity, loss of appetite, dark body coloration and hemorrhaging. Internally, clinical signs may include swollen kidney, spleen and hemorrhaging of the liver, musculature and lower intestine. In addition *Lactococcus* is typically a disease which occurs above 15°C e.g. between July and September when you can expect to see clinical signs and mortality.

If you see signs of a problem, seek help in both the diagnosis of your problem and what can be done to reduce its severity and ideally to attempt a successful treatment. Early recognition and identification is crucial not only for the treatment of disease, but it is essential if we are to control the spread of any pathogen in the UK. If you suspect Lactococcosis please contact us at CEFAS Weymouth. We can only act if you contact us as the disease is not notifiable and the FHI will not be automatically alerted to the occurrence of unexplained mortalities. For this reason and in the long-term interests of farming, we wish to enlist the assistance of the Industry.

Treatment

The use of antibiotics such as oxytetracyclin, erythromycin, amoxycillin and ampicillin, has been successful. However, the benefits have often been short lived. Whilst their use has suppressed out breaks, their application does not eliminate susceptible species from re-infection.

Unlike antibiotics, the concept of vaccination is to convey immunity to those susceptible species to which they are administered, i.e. to prevent disease from the word go. As yet there is no licensed vaccine for Lactococcosis in the UK. To date, Aquaculture Vaccines Ltd. have developed a vaccine against *Lactococcus garvieae* and a number of successful trials have been conducted on the continent. This year AVL plan to conduct a further series of trials in the UK. If these continue to prove successful the company will apply for a UK license from the Veterinary Medicines Directorate (VMD).

Help us to help you

Using the time honoured phrase, to '**help us help you**' we would ask that you to contact us at Weymouth if you are experiencing higher than normal mortalities on your farm. You can contact us on **01305 206673/4** or **01305 206682/3** and you will be able to discuss your particular problem or concern with a competent member of our team.

RISK ANALYSIS IN AQUATIC ANIMAL HEALTH

Alasdair Scott, CEFAS Weymouth, Barrack Road, The Nothe, Weymouth, Dorset DT 4 8UB

Early last year I was asked to attend a conference at the headquarters of the Office International des Epizooties (OIE) in Paris, the first of its kind on risk analysis in aquatic animal health. The venue was highly appropriate as the development and requirement for risk analysis in the animal health sector is primarily in the area of that Organisation's responsibilities.
The OIE was founded in 1924 and given the task of gathering and bringing to the attention of Member Countries information of general interest on animal health, and also of assessing all international agreements relating to animal health regulations.

The task assumed greater importance for the OIE following the establishment of the World Trade Organisation (WTO). The Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), which was included in the constitutive texts of the WTO and which came into force on 1 January 1995, conferred a crucial role on the OIE. This Agreement stipulates that the animal health standards applied by countries to ensure the protection of animal and public heath must be based on international standards, guidelines and recommendations of the OIE. The practical application of OIE recommendations relating to international trade requires that both the exporting and importing countries conduct risk analyses. This International conference on Risk Analysis in Aquatic animal Health was organised with the objective of nurturing international dialogue and providing information on this subject to officials responsible for the preparation and application of import measures in the field of aquatic animal health.

The Conference was of clear importance for regulating bodies such as the Fish Health Inspectorate at Weymouth, as the principles involved are likely to have significant impact on the future management of fish health issues. They represent a significant departure from some of the principles enshrined in the Diseases of Fish Act 1937, which have provided significant protection for our salmonid and freshwater fish stocks, and ensured our high fish health status relative to other countries with similar patterns of fishery and aquaculture development. The challenges of maintaining this high health status, in the face of increasing pressure to remove barriers to world trade, mean that we need to be able to effectively apply methods of risk analysis to support our policy on fish health control. The days of placing total bans on fish imports on the basis of theoretical or potential risks, without risk of challenge, are long gone. The Conference was broken into 3 theme sessions and 3 discussion groups. The themes were: 1. Risk Analysis and its need; 2. Risk Analysis methodology; and 3. Areas of application. The discussion groups covered: 1. Standardisation of monitoring programmes and competent authorities; 2. Pathogen survival and infectivity; and 3. Diagnostic methods. Session reports recommendations, and proposals for the way forward followed these.

A total of 40 formal presentations were made, alongside lengthy discussion sessions. This report will not cover every presentation, but rather give an overview of each session to illustrate the current state of the art and problems requiring action.

1. Risk Analysis, its need and basic methodology

Four papers were presented in this session: three on the principles of risk analysis and what is required to complete one, and the fourth on why risk analysis is needed in the sphere of animal health.

Alan Thiermann, the senior trade co-ordinator for the US Department of Agriculture (APHIS), based in Brussels, presented the latter paper. He explained that it was a WTO aim, enshrined in GATT agreements, to remove all non-tariff barriers to trade. GATT Article XX(b) states that there is a need for clearer rules on animal health matters with respect to trade, as evidence suggests that countries try to block trade on health grounds. There was therefore a need to establish rules to facilitate trade, while protecting animal health status. The SPS Agreements establish these rules and form part of the broader Technical Barriers to Trade (TBT) Agreements. The SPS Agreements provide rights for an importing country to determine its own level of fish health protection. They place obligations and disciplines on that country in how it justifies such protection. The Agreements also establish mechanisms for the settlement of disputes, and for the implementation of special provisions where countries feel they are needed. The Agreements cover measures specifically associated with fish health controls, and do not cover other interests such as environment protection, animal welfare or consumer interests *per se*, though clearly these may be part of a country's justification for restricting imports.

The basic principle of the SPS Agreements is that any measures a country wishes to adopt must be based on the best available scientific evidence. There are two routes to this. The first being to use existing international standards on fish health controls. The second is for the importing country to conduct its own analysis of the risks, where either there are no appropriate international standards, or where the country does not agree with those standards. The overall aim is the harmonisation of world trade around internationally accepted standards. Mr Thiermann voiced this as "do as your neighbours do, if possible", though this sentiment is clearly only appropriate where your neighbours' aims are the same as your own.

The SPS Agreements go into some depth in defining Risk Analysis (Annex A.4) and how it should be used to determine the appropriate level of protection (ALP). The risk analysis techniques used must be recognised by the relevant international body. The analysis must be based on scientific evidence and take only relevant economic measures into account. Advice is also given on what to do where no scientific evidence is available.

The completed Risk Analysis provides guidance for decision-makers, in a consistent and necessarily transparent form. It should form the framework for any import controls. Risk Analysis allows national principles to be taken into account while ensuring that consistency is achieved with the SPS Agreement principles, i.e. that the data be science-based and able to withstand review.

The SPS Agreements place other obligations on countries. They must be consistent in their application of controls, and avoid arbitrary decisions. They should only use SPS measures for health controls. Countries must also recognise the equivalence of different techniques for health protection adopted by different countries. Different diagnostic methods may be equally satisfactory for health screening and this should be recognised wherever possible, though it is the responsibility of an exporting country to produce evidence of the equivalence of its testing to that of the potential importer.

Countries should work together to establish regional information on health matters, and recognise disease-free areas (zones). There should be a geographical basis for any controls, and it is important that trading countries adopt veterinary certification procedures to a high standard if they wish to facilitate trade.

The SPS Agreements also cover dispute settlement procedures, which can operate at three levels. First, through OIE, a non-binding voluntary system, using neutral expertise. Second, through the SPS Committee which provides informal, confidential discussions and, finally, through the dispute settlement committee of the

WTO. It is hoped that the SPS principles when adopted will lead to early resolution of any trade disputes and prevent the need for formal dispute procedures through WTO.

In summarising, Mr Thiermann stated that the SPS Agreements were expected to prevent flagrant violation of world trade rules, and institute the golden rule that we should treat others as we wish to be treated by them. He suggested that fish health officials world-wide need to work together, adopt and agree on RA methodologies, build a disease surveillance infrastructure, be aware of SPS principles, and educate traders about SPS. In addition they should support OIE in the development of world standards, and in the development of appropriate risk analysis methodologies for fish health.

The three other speakers in this opening session presented information describing what a risk analysis was, how it is to be carried out, and how the information generated can be most profitably used. There were many similarities in content in these talks and some needless repetition, but at least the speakers did not contradict one another. I have therefore merged the three into one, starting with a definition "Animal health risk analysis is the systematic approach to identifying what could go wrong in any procedure involving animals, assessing the likelihood and consequences of that event occurring, and formulating measures to manage that risk".

A risk analysis is made up of four different components:

A. Hazard identification - a hazard is something with the potential to harm, and can be a thing such as a pathogen or a toxin, or a "process" such as the infection of fish X with pathogen Y, or the development of antibiotic resistance. For any risk analysis to be carried out there must be at least one hazard identified, and adequate attention to hazard identification is vital if the overall risk of any action is to be properly assessed.

B. Risk assessment - this is the process of evaluating the risk resulting from any one particular hazard. It can be divided into different stages: risk-release assessment, exposure assessment, and consequence assessment. These form the framework of the pathway from identified hazard to the unwanted outcome, and it is the estimate of the likelihood of this chain of events occurring that is the assessed risk. Risk assessments can be qualitative or quantitative and should represent the output from the best information currently available in accord with scientific thinking. Whatever form they take, each individual risk assessment should be fully documented and transparent to all parties involved. The output from all of the individual risk assessments for the hazards identified go together to provide the overall risk figure for the risk analysis.

C. Risk management - when risks have been assessed there is a need to formulate and implement measures to address the problems identified and hopefully lower the risks involved. In order for someone to manage the identified risks, there needs to be:

D. Risk communication - an essential part of any risk analysis is the clear, open exchange of information between risk assessors, risk managers, and stakeholders in the area subject to the risk analysis.

The four phases of risk analysis are all inter-connected, and a successful analysis depends on feedback between each of the phases such that the analysis becomes an iterative process by which the level of risk and options for its management become apparent.

With the principles of conducting a risk analysis clearly established, we were then informed of how they can be carried out and what advantages and disadvantages they have.

The first important point was that a risk analysis can be either qualitative or quantitative. To quote one of the speakers "Qualitative risk analysis offers a means of making quick, rational and reasonably defensible decisions about prospective risks. The lack of mathematics means it can be readily employed by veterinary scientists, epidemiologists, etc, the arguments and results are understandable by most people, and its methodical approach shows us where there are important gaps in our knowledge." Unfortunately, qualitative risk analysis uses phrases such as possible, probable and highly unlikely, which are highly subjective and mean that decisions based on these analyses are difficult to defend against opposite opinion in any adversarial situation.

A qualitative risk analysis is, however, always conducted as a precursor to a quantitative risk analysis, as it is essential to define the various matters requiring inclusion in the latter.

"Quantitative risk analysis uses probability theory - a generally little understood area of mathematics - to estimate the probability and potential magnitude of a risk. The output from a quantitative analysis is a probability estimate which can be readily compared with other accepted or rejected probabilities for other risks, thereby ensuring and demonstrating the application of a consistent risk policy and facilitating efficient risk management."

"Quantitative risk analysis is certainly the best option where possible and when the problem warrants the resources and time that such analysis requires."

So what advantages does risk analysis bring us? First, if properly conducted, it provides transparent evidence for all interested parties of the risks associated with a particular proposal and thereby improves decision making (theoretically, at least). With respect to fish health controls, it provides a mechanism for modelling the pathways by which pathogens can be, or are most likely to be, spread from infected to non-infected areas. The more we carry out import risk analyses, the better our understanding of the risks is likely to become. This is perceived, or certainly sold, as a major reason for employing risk analysis as a primary component of world fish health controls.

What then are the disadvantages of risk analyses? First, the method is not objective, even in its quantitative form and, given the range and type of questions posed, it is highly unlikely that all risks involved can be properly assessed, even in the best possible risk analyses. The method itself is prone to uncertainty when assigning probability distributions to various parameters. The example given was that a baby's potential sex is 50:50 male or female prior to conception, but 0 or 1 immediately afterwards. Using one or the other distribution at the wrong time could give very different outcomes on the likelihood of a child being one sex or the other.

There have been so few risk analyses conducted in the field of fish health that there is, as yet, no solid body of information on how they are best carried out under different circumstances. One purpose of this Conference was to develop a set of contacts between those engaged in the field to attempt to bring forward improvements in the methodologies used.

Finally, and to my mind most importantly, there are precious little data available world-wide on the factors required for inclusion in any risk analysis in the field of fish health. While risk analysis can help to identify where the data shortfalls are most important, there are few instances where clear-cut data are currently available. The papers presented in the remainder of the meeting repeatedly highlighted this problem.

2. Risk Analysis, areas of application

The methods section was followed by some 28 papers looking at situations in which risk analyses have been (or could be) used, and assessing the benefits accruing and the problems encountered.

In the majority of papers presented, the authors concluded that a lack of data seriously reduced the value of the risk analysis carried out. As examples, They cited lack of data on routes of infection, on pathogen detection in diagnostic tests, on the nature of infectious diseases or in knowledge of the presence of any diseases in the source region of imported fish. One author, in addressing the problems of controlling the spread of shellfish diseases, cited the total lack on a global scale of any real expertise in the field. "You are all sitting in this room" being a fairly telling if not strictly accurate statement.

One speaker pointed out that the rate of discovery of new pathogens and diseases of aquatic animals had increased over the last 10 years, suggesting we were far from knowing, let alone understanding, the full range of pathogen hazards associated with fish movement. He believed the implication of these data were that risk analysis based on known hazards must underestimate the real risk of pathogen transfer, and a precautionary approach may be appropriate, even if this does not fit in with WTO rules.

Kenton Morgan, from Liverpool University, used the example of epizootic ulcerative syndrome (EUS) to show the lack of appropriate investigations in the fish health field relative to that of other animal groups. He discussed how an epidemiological approach to the problem of controlling disease spread could help focus on the major issues and avoid us being side-tracked by less relevant issues. He appealed for a greater use of epidemiology in the field of fish import risk analyses.

Several authors gave presentations in praise of risk assessment techniques, which had provided useful guidance on problem management. These papers were invariably on single item risk assessments where the specific data required as inputs to the risk assessment could be collected as part of the process. Such studies had helped confirm how to reduce gill amoeba problems in fish farms in Tasmania, how to manage *Gyrodactylus salaris* risk from a specific Norwegian river system, and how to identify factors involved in increasing ISA risk in Canadian salmon farms.

Alasdair McVicar from FRS Aberdeen gave a talk on the practical aspects of risk assessment in relation to the management of ISA in Scotland. His opening statement was that anyone involved in fish health regulation had to carry out practical risk assessments as part of their everyday duties. While the vast majority of such assessments were qualitative, if the principles of risk analysis were properly applied then the application of actions based on them could be made acceptable to all stakeholders. He illustrated how early investigations into the ISA outbreak in Scotland identified major risk activities, such as transfers of fish, bus-stop smolt stocking, and discharges from processing plants. The outputs of work on pathogen survival and dispersal in tidal waters allowed FRS to establish appropriate control zones.

Following this risk assessment phase, a set of risk management measures were implemented, including increased surveillance, movement controls, disposal of mortalities, fallowing and, of course, eradication in confirmed cases. The industry undertook re-structuring to reduce the risks identified, including the development of management and fallowing zones. Throughout the outbreak risk communication was a key, with FRS providing guidance on disinfection procedures and diagnostic test procedures, and training for the industry. They held regular meetings with industry, produced public information on a regular basis, and maintained clear communication lines to OIE and the EU and its reference laboratory. He concluded that overall the control achieved of the ISA problem in the time-scale seen represented a success story in fish health terms, thanks largely to the scientific approach adopted. For me, this talk highlighted the level at which risk analysis principles can best be applied at present in the fish health arena. The lack of quantifiable scientific data on ISA did not prevent the effective use of the principles, particularly those relating to transparency and communication. Other talks showed that the drive to produce quantitative risk analyses, had largely failed because the lack of data in key areas meant that certain stakeholders felt their concerns were not being given appropriate weight.

The discussion sessions on standardisation of testing and official services, on pathogen survival and infectivity, and on diagnostic methods, followed a similar pattern to those on the use of risk analysis methods. There was good agreement that if fish health standards were to be protected, then standardisation of test methods, disease surveillance, and the work of the official services would be required. There are, however, enormous problems in attempting to harmonise standards between developed countries and those which are less developed, and lack the resources to progress quickly. As with the development of risk analysis methodologies, it was proposed that the only way forward was to bring the work of competent authorities together by mutual agreement in order to establish standards that can be adopted world-wide. The OIE was again seen as having the pivotal role in taking this forward.

The discussions on pathogen survival and infectivity simply served to illustrate what an under-developed field fish health is. Numerous speakers made comments on specific problems using data on pathogen survival and infectivity in risk analyses. While these speakers could all see the problems in interpretation of data, none had been given enough resources to resolve the problems identified.

The general discussions, which followed these sessions, gave delegates the chance to air their own views on the value or otherwise of risk analysis and the means by which it should be carried out. Most delegates accepted that the application of risk analysis in the fish health area would necessarily increase because of its pivotal role in establishing import control standards. It was therefore in most countries' interests to contribute to the development of this relatively new field.

From my perspective, some of the most important comments came from British delegates. Marian Wooldridge from MAFF's Veterinary Laboratory Agency (VLA), who presented one of the methods talks, stressed that when teaching risk analysis methods she always highlighted the need for stakeholder involvement alongside the assessors. In practical terms, that means that fish farmers like yourselves have a very important role in raising your concerns about the type and level of control you would wish to see for particular diseases and on how management measures for any diseases should be implemented.

Kenton Morgan (Liverpool University) stressed how it was important to establish your risk analyses before they were needed. It is particularly important to look at the epidemiological aspects such that the most important matters can be addressed first.

So what were the outcomes of the meeting and how is MAFF/CEFAS and the Fish Health Inspectorate reacting to this new area of concern?

The meeting identified the need to establish standard approaches to the conduct of import risk analyses in fish health. It was proposed that OIE should work not only to clarify its guidance on the use of risk analysis, but to help organise workshops for those active in this field to help bring together standards for future risk analysis work. The meeting also identified gaps in knowledge in almost all aspects of fish health. One of the pivotal areas, however, is in the distribution of known pathogens around the world. To resolve this problem, CEFAS has developed a database in conjunction with the OIE which it is hoped will provide a definitive dataset on the known distribution of both the OIE-listed diseases and any others of potential concern.

MAFF/CEFAS have recognised that, while the drive to insist on risk analysis before implementing import controls will be unlikely to compromise our existing fish health controls, there may be problems in implementing new controls without such information. As a result, CEFAS has been able to appoint an epidemiologist who will be able to take on detailed investigations of the likely impact of particular disease problems. Operating alongside the Government's Chief Adviser on Fish Health, who has responsibility for the diseases database, the epidemiologist should be in a strong position to take pro-active measures to identify emerging disease risks.

The Fish Health Inspectorate will continue to monitor imported fish for evidence of new and emerging diseases, and the scientific literature for potential problems. It has, this month, discussed with the MAFF policy customer the desirability of increasing the expertise of the laboratory's diagnostic groups in respect of the identification of pathogens currently not known to be present in Britain. It would appear that if we are to maintain our closed door to potentially serious diseases, then we must in future take a more proactive role in assessing the risks they pose.

BRITISH TROUT FARMING CONFERENCE, SPARSHOLT 6 – 7 SEPTEMBER, 2000

Dick Lincoln, CEFAS, Lowestoft.

Introduction

This conference attracted the usual mix of fish farmers, representatives from the fish farming service and supply industries, scientists, administrators and trainers and was again well attended with around 220 delegates. A total of 18 papers were given over the two days with theme sessions covering nutrition, water quality, discharge regulation, marketing and fish health. The following covers the first day's proceedings while part 2 of my report covering the final day will be published in the July edition of Trout News.

Enzymes in aquaculture feeds

Jackie Linden of Hoffman La Roche, currently a member of the global aquaculture marketing group at the Company's headquarters in Basle, Switzerland gave an account of her 3 year involvement in research on enzymes for use in aquaculture feeds. The primary aim of this research was to reduce both the dependency on fish meal as the main ingredient in fish feeds and the environmental impact of fish farming.

Enzymes, she explained are naturally occurring proteins which act as biological catalysts by speeding up chemical reactions. Each enzyme is highly specific, only working on a particular molecule, in a narrow pH and temperature range and remaining unchanged after the reaction has taken place. Typical examples include digestive enzymes in the gut which combine with target food molecules (substrate) to form a complex which then splits into smaller molecules which are released for absorbtion or further splitting by other enzymes. Enzymes have been used by man for centuries to process food, for example in making bread, beer and wine.

The inclusion of enzymes in animal feeds began in the late 1980's in the pig and poultry industries for increasing the availability of nutrients and their use is now covered by EC legislation which came into force in 1993. At present enzymes have not been used in aquaculture feeds because of the differences in raw materials used and the digestive processes in fish but current research has shown they can play a significant role.

Fish meal is an important ingredient in commercial aquaculture diets accounting for about 2 million tonnes of the 9.7 million tonnes used in animal feeds. The utilization of fish meal by the salmonid industry alone accounts for about 30% of the total. The main reason for this, she said, is because fish meal closely matches the nutrient requirements of fish. It is also highly digestible, palatable, good value and currently plentiful. Against this is the rising demand which increases the price and the supply is not infinite and prone to fluctuations depending, for example, on climatic factors such as El Nino. This has led to the search for alternative food sources which currently focus on vegetable proteins such as maize, wheat gluten and soybean meal all of which have shown good potential for fish meal replacement. The use of enzymes for utilizing these food sources is not fully understood and several negative factors in cereals have been identified. Success relies on maintaining a balance between the stability and activity of enzymes and their ability to work at low temperatures in fish. Nevertheless their use has been shown to improve nutrient utilization and reduce environmental impact. A more even food product can also be made which provides greater flexibility by broadening the range of materials and formulations available while at the same time reducing the dependency on fish meal. She concluded her talk with some results of experimental diets containing enzymes on growth rates and phosphorus excretion in rainbow trout.

Comparative growth trials using juvenile fish of 0.6 g in weight over 117 days fed a test diet of 32% soybean meal plus enzyme and 46% fish meal were 5.4% heavier than controls fed on 46% fish meal alone. A second trial using larger trout of 20 g over 154 days given 41% soya plus enzyme and 33% fish meal finished 5.3% heavier than controls.

Phosphorus (P) is an essential mineral for growth and bone development and must be supplied in the diet. Fish meal provides a rich source of this mineral and fish excrete large amounts of excess P constituting a contributory source of pollution which must be controlled. Much of the P in vegetable protein is bound with phytate (phytic acid) and therefore unavailable to fish but inclusion of the enzyme phytase releases the bound P which then becomes available. By regulating the amount of phytase present in feed a more balanced supply of the mineral to the requirements of the fish can be achieved. This has been demonstrated in a further trial in which 15 g trout were fed a diet of 55% soya meal containing 1000 units of phytase per kg of feed. Faecal P was reduced to less than 1% as against 4% in control fish fed on 54% fishmeal. These trials, she concluded, indicated great potential for both reducing fish meal dependency and pollution thereby helping to increase the sustainability and long term viability of aquaculture.

The future of fish oils and meals

Ian Pike from the International Fishmeal and Oil Manufacturers Association (IFOMA) began his talk by outlining what the customer thought about fish. Fish, he said, was perceived as a healthy food rich in protein and minerals and healthy fats in which the farmed product was to be as close as possible to the wild counterpart. Nutritionally fish are rich in amino acids and vitamins of the AB complex, D and E and rich in minerals, especially calcium, phosphorus and trace elements and in omega-3 fatty acids. The part played by fats in human nutrition played a vital role in the life processes of humans and all animals. The long chain polyunsaturated fatty acids (PUFAs) are central to this as they control cell function and many acted as cell messengers like eicosanoids, prostaglandins and leukotrienes. The two main categories of PUFAs – omega-6 and omega-3 fatty acids play a central role in controlling vital life processes including reproduction, development of the brain and nervous system, the immune system and inflammatory processes. The balance of the two fatty acids is important and should be 5:1 omega-6 : omega-3. Fish and crustacea are almost exclusive sources of omega-3 fatty acids although they can be manufactured from plants but only very slowly. Up to 200 years ago vegetables formed a large part of the diet and fat intake was low giving a ratio of about 1:1 of omega-6:omega-3 fatty acids. Since then saturated fat intake has increased by 20:1 leading to a rise in inflammatory diseases such as coronary heart disease, eczema, asthma and Crones disease. These diseases do not occur in fish eating populations due to a high omega-3 intake and to avoid them three meals of oily fish per week is recommended for a healthy diet.

He then outlined the likely future changes in fish feed formulations. The move to more nutrient dense diets would continue by increasing the fat content to spare protein as an energy source. Protein levels would be lowered to reduce the requirement of fish meal and minerals and vitamins increased. Some substitution of fish meal and fish oil would occur but only for fast growing species where growth and feed conversion efficiency would not be compromised. Vegetable fibres would have to be removed to reduce pollution as well as indigestible nitrogen and phosphorus. Immune competence should not be compromised after prolonged feeding and reproduction must not suffer. The aim was to reduce feed costs but not at the expense of product quality particularly appearance, taste and fatty acid composition. The substitution of fish protein for carnivorous fish and crustaceans, he thought, was limited and relied on sophisticated processing of vegetable protein to remove fibres and toxins otherwise conversion efficiency rates would suffer. The use of vegetable proteins for omnivorous and herbivorous fish, however, was easier and more promising. Substitution of fish oil with vegetable oils was limited due to possible changes in taste, quality and especially composition of the end product and there was some evidence of a breakdown in the immune system of fish fed vegetable oils.

Turning to the issue of environmental sustainability of fish meal and oil he said the species used in meal production were mainly small inedible bony fish caught subject to government quotas on a sustainable basis. It was likely more of these may go for direct human consumption in future. Tighter controls on discarding of by-catches from commercial fishing of species for direct human consumption may see these being landed in future for meal production.

He concluded with some predictions for aquaculture beyond 2010. Fertilising the sea to increase plankton production would be encouraged both for direct harvesting for oil extraction for use in feed and as an effective way of reducing atmospheric carbon dioxide. Genetic modification of fish and plants may also become important. The 2.3 million tonnes of fish meal used at present for aquaculture was likely to increase to 3.4 million tonnes and fish oil consumption, currently 710 thousand tonnes, would increase to 1.2 million tonnes. The percentage of fish meal used in aquaculture would increase from 35% now to 56% and fish oil from 54% now to around 90% by 2010.

Photoperiod effects on growth and reproduction

Clive Randall, formerly with the Institute of Aquaculture at Stirling University and now based at the University of Abertay, Dundee gave a detailed account of research on the effect of changing day length on the timing of reproduction and growth in rainbow trout. He said seasonal changes in day length provide the most reliable, 'noise-free' information on the time of year and many animals in middle and higher latitudes use it to time seasonal functions such as reproduction and growth. In fish it forms the principal determinant of maturation in many farmed species.The main reason for altering the timing of trout reproduction is to overcome the seasonal availability of eggs which in the northern hemisphere occurs between November and February. An all year round supply helps to lower costs by stabilising prices, reduce gluts and makes full use of hatchery facilities. Currently imports, mainly from southern hemisphere countries are used to supply out of season requirements for rainbow trout eggs but this is unsatisfactory because of the risk of introducing exotic diseases.

Altering the timing of spawning

Both advanced and retarded photoperiods can alter the timing of spawning. Combinations of constant long and short photoperiods advances spawning in early winter by 3–4 months while an extended 18 month photoperiod delays spawning by 3–4 months. Manipulation of photoperiod requires covered light-proof tanks which has the disadvantage that the covers may get blown off in high winds. For this reason continuous 24 hour light cycles are an advantage and additionally requires no time clocks and therefore simple and inexpensive to operate. Here the lights are switched on permanently or only during the hours of darkness. However the exposure of rainbow trout to continuous light throughout the year results in an irregular spawning regime and also a reduction in the proportion of fish reaching sexual maturity. Exposing trout to shorter 2 month periods of continuous light is much more successful in which a larger proportion of the stock spawn in a synchronised manner. Using this method advanced spawning can be made to take place in July and August for both male and female trout.

Applying continuous lighting to outside tanks has not proved successful due to the high ambient light levels. This suggested that the intensity of light is very important and it has been found necessary to incorporate strong lighting to outside tanks using 3 x 250w submerged or floating lamps. Exposure of fish to continuous light in this manner delays spawning in outside tanks.

Enhancing growth using photoperiod
Some trials have suggested that extending the photoperiod enhances growth in some species and this has been found for rainbow trout where increases of up to 25% have been recorded. Experiments conducted over a 19 week period in outdoor tanks during the winter months with continuous artificial lighting and extended feeding into the night period resulted in a growth increment of +475% in trout illuminated with indoor lights (fluorescent tubes) and +504% in trout illuminated with floating 400w metal halide lamps as against +329% for control fish. Trials have also been carried out on the effect of artificial lighting of demand fed trout. Juvenile trout weighing 100g + stocked at the rate of 20,000 fish in ponds increased in weight by 181% against 141% for controls over a 15 week period.

Experiments have also been conducted on trout in cages where illumination, using high intensity submerged lighting, is easier to carry out due to the better spread of light in water and also to the fact that fish tend to swim around a light source. Trials conducted in spring using juvenile fish weighing 75g over an 8 week period showed that initially, fish exposed to continuous light had a lower specific growth rate than controls but this increased towards the end of the trial with the experimental group finishing heavier than those on ambient light levels. These trials indicate there is a good potential to advance growth in rainbow trout using low and high intensity lighting in both indoor and external tanks and cages.

Muscle fibre development and flesh quality

Dick Alderson, a free-lance consultant currently working for BioMar in Scotland and Heritage Salmon in Canada and Chile described research examining the relationship between muscle structure parameters and flesh quality as affected by genetics, diet, growth, maturity and season. Although this research had been carried out on Atlantic salmon under the LINK scheme he said the principles nevertheless also applied to trout.

The experimental work was carried out on two year classes of salmon from the Locky and Namsen strains which were established in 1997 and 1998 and the trials conducted by Marine Harvest in Scotland using 5 metre square cages. Two families from each strain were given identical diets in terms of protein, energy and pigment levels but different amounts of oil designated high and low. No significant differences were observed for growth rate, conversion efficiency or muscle fibre density (expressed as number per square mm) or size, new fibres being recruited and enlarged with growth. Fat content increased as the fish grew but there was little effect between dietary protein and fat levels. There was however a significant effect of the genetic component on fat deposition between the two strains. Pronounced seasonal effects on fat deposition was also observed in immature fish grown in Norway in which fish began laying down fat in August, reaching a maximum level of 14% followed by depletion over the winter and spring months down to 10% in May/June. The effect of the various factors in percentage terms on lipid deposition were diet 0–1%, genetics up to 2% and season up to 5%.

No significant effects on pigmentation was observed from the diet in terms of fat or protein but a marked seasonal effect was revealed which showed an increase in levels over the winter period followed by a fall in spring. The genetic constitution of fish was an important factor influencing pigmentation as well as muscle fibre density. The more densly packed the fibres the more intense the flesh colouration. Moreover fish with high muscle density required less pigment to reach a given flesh colour level. The effect of the various factors on astaxanthin levels in parts per million were genetics (the most powerful effect) up to 2 ppm, season – spring fall in uptake 1.5 ppm, the spring fall in flesh colour up to 2.5 ppm and muscle fibre density 2 ppm. Muscle fibre density did not appear to be affected by diet.

The overall conclusions drawn from this study were that both seasonal and genetic factors are the most important affecting lipid and pigment deposition and that muscle fibre density influenced flesh quality in terms of colour, texture and gaping. These all interact to produce much of the product variability seen at harvest. The diets tested, which essentially varied in the protein/oil ratios had only a minimal affect.

Recirculation

K.C. Hosler from PR Aqua Technologies Ltd in Canada, a projects manager with extensive experience in the design and construction of recirculation hatcheries for the culture of salmon and trout, briefly reviewed the advantages of recirculation followed by an overview of the options available in terms of the various technologies required in water treatment. Recirculation is primarily concerned with water conservation in which only a relatively small amount of 'new' water is used making possible a potentially higher production of fish in areas of little or no water availability. The effluent released is of sufficiently small volume to recover and treat waste easily, reduces both heating and pumping costs (typically the pumping head is less than 25 feet) and makes possible the exclusion of parasites by micro-filtration. He then listed and described the various operations taking place in a recirculation system, namely solids removal, bio filtration, carbon dioxide removal, oxygen and ozone addition and ozone destruction using ultra violet light.

Solids in the form of faecal waste, uneaten food, sand, grit and fish scales cause direct damage to the gills and introduce off flavors in fish. They also reduce the efficiency of bio-filtration and decomposition increases the biological oxygen demand of the system. The less time solids are retained the easier they are to remove and several methods are available to do this. The 'Cornell' double drain system removes high concentrations of solids using low flows. Side drains require high flows to remove low concentrations of solids. Bottom drains are low flow, high solid removal and may be used with swirl separators. These have transgential inlets which push solids to the bottom drain while the overflow drain at the top removes comparatively clean water. Up to 90% of solids removal can be achieved using swirl separators with low water usage.

Mechanical filtration, using rotary drums are quite popular. Water enters inside the drum and passes out through the revolving screens (89 µ normal sieve size). Back washing occurs automatically as the screen clogs. There is a minimal head loss with the system and average back washing losses are between 2–10%.

Biofiltration utilises a media on which aerobic bacteria grow and oxidise ammonia, the main excretory product in fish, to nitrate by nitrifying bacteria. To work efficiently solids must be removed quickly to prevent fouling of the bio-filters and excess growth of bio-film must be constantly reduced by back washing. Typical systems used are fluidised beds incorporating sand or a similar medium. Water enters at the bottom and is distributed evenly at the base causing the sand grains to move around sheering off the excess growth of bio-film. The system is simple and efficient and easily scaled up or down by adjusting the particle size to increase or decrease the surface area available. Bead filters are available as proprietary technology produced in America. The beads are larger in size than sand grains and therefore have less surface area and are often quite expensive.

Gas balancing becomes necessary in intensive systems where oxygen is added requiring carbon dioxide stripping. This can be controlled by management of pH and oxygen addition. Carbon dioxide removal is carried out using a forced air stripper. Water is first broken up into droplets with a low pressure fan followed by a high volume of air passing over the droplets which removes the carbon dioxide. An alternative system utilises a packed column filled with media through which water passes together with a flow of air passing upwards.

Oxygenation is a very important part of recirculation systems for use both by fish and the bio-filter. It is usually more economical to oxygenate after gas balancing which limits the amount of oxygen required since air also oxygenates in carbon dioxide stripping. Low head oxygenators working on a 2 foot head produces 80% oxygenation efficiency and also removes nitrogen. Pressurised devices may also be employed in which the water flow is pressurised during oxygen injection which increases the efficiency due to supersaturation.

The use of ozone is growing in popularity as a disinfectant and also for reducing water colour. Ultra violet light may also be used for the same purpose.

Recirculation systems are often housed in insulated buildings, usually to conserve heat in cold areas but also to prevent overheating during hot spells of weather. This enables heating or cooling, where necessary, to be carried out economically. For all systems, he concluded, control monitoring of water chemistry was essential.

Carbon dioxide problems in intensive aquaculture

The next speaker, Steven Summerfelt of the Freshwater Institute, Western Virginia, who specialises in the technological aspects of intensive recycling systems provided a comprehensive account of the nature and treatment of CO_2 problems in intensive aquaculture systems. He said CO_2 accumulation becomes a problem when systems are oxygenated. Fish excrete 1.27 g of CO_2 for every 1 g of O_2 consumed but the efficiency of the process decreases where there is a build up of CO_2 in the water. When this happens CO_2 increases the blood acidity which decreases the ability of the fish's haemoglobin to transport oxygen. A level of 20 mg/L CO_2 in water is safe for most fish species but in trout levels of 20–40 mg/L CO_2 begins to impact on the health of the fish and a level of 50 mg/L CO_2 is toxic. Safe levels for rainbow trout should be in the region of 9–30 mg/L CO_2. The excretion of CO_2 and ammonia (NH_3) occurs in the mucous layer of the gills where an enzyme carbonic anhydrase catalyses the hydration of CO_2 into HCO_3^- and H^+ thereby effectively removing CO_2 and NH_3.

He then discussed the methods available for removing excess CO_2. Aeration removes CO_2 but for maximum efficiency water droplets falling through air is the best method. This is because CO_2 is extremely soluble in water but not much in air and a large driving force for stripping is required. The volume of air required needs to be at least 5 times the volume of water i.e. a high gas to liquid contact. The systems most used for this incorporate force ventilation of air through cascade columns using a hydraulic fall of about 1 to 1.5 metres. Stripping becomes more effective if plastic packing material is used or screens which break up the water into droplets. In recirculation or raceway systems it is recommended to air strip before the oxygenation unit as air stripping can elevate dissolved oxygen to 90% of the saturation level.

Marketing

The final session of the first day looked at aspects of marketing. The first speaker, Michael Bunney, a specialist in business and people development in agriculture food supply chains provided an insight into how marketing techniques had changed with the rapid development of information and communication technologies. These, he said, were now the main market drivers enabling more information to be available faster and to a wider audience than ever before, citing e-mail, mobile phones and the wap as recent examples of this technology. Traditional commodity selling had now changed to product marketing involving the world of unique offers and niche products which has resulted in new ways of doing business. In managing this new market process he said it was necessary to: (a) carry out swot analysis from different perspectives on how people perceived the product, (b) filter information on market research and focus it on your particular business, (c) create a vision by looking at niche and temporary market monopolies and milking them as quickly as possible, and (d) ensure marketing plans are flexible and responsive.

In coping with this new marketing approach he considered the trout industry should: (a) keep its marketing strategy simple and think ahead of the game, (b) let the market manage any offers – it will tell you the price and how to market it, (c) use your own strengths in marketing and (d) work with others to fill the gaps. He finished by offering a few starters. The industry should put service into every product, customise every offer, anticipate your customers, build in feedback to gain updates and put any offers on-line.

A trout farmer's perspective

Nick Read of Alderley Trout Ltd and former head of marketing for the BTA gave a personal view of the likely future changes to the marketing of trout and what the industry must do in adapting to the changing demands of the consumer. He began with a breakdown of the current UK trout production which stood at 16,000 tonnes of which 4,000t (25%) went to restocking, 9,500t (59%) to processors, 1000t (6%) to multi species processors and 1,500 (10%) to inland markets.

He then considered todays consumers which, he said, were more affluent and choosey over what they purchased and the people who consumed trout were generally well educated and communicative. They were not only more demanding on price, quality and total value but more intrusive into how the product is produced. Environmental issues were important even down to the sustainability of the fish utilized in fish meal and oil production for use as trout food. Organic production was increasing across many food sectors and may be forced on the trout industry by popular demand. Animal welfare was another area of concern which required industry to improve its performance both in better harvesting methods and general husbandry conditions. Food safety is automatically assumed by the public and is an absolute requirement by retailers. A single quality assurance scheme must be implemented, he said, and there are now signs that this may be achieved soon.

Turning to product performance, he said convenience with short preparation times which required no skill was paramount which meant retailing trout with no head, tail, bones or skin. New trout products would be required all the time which meant some lines would have a short life. The industry should also be socially responsible and not be exploitive. On the economic front he said there was less wild fish being marketed because over-exploitation was reducing stocks which might mean better prices for trout but set against this was the prospect of other farmed species coming on stream.

He concluded by saying the industry was not currently structured to cope with future market demands and went on to make the following predictions: (a) there would be fewer independent growers and fingerling producers unless they could adapt. The processors would control 70% of production leaving the remaining 30% as private growers who without an assured outlet may not be able to market their fish. Fish would have to meet stringent requirements and contract rearing, currently widespread in the pig and poultry industry, is likely to apply to the trout industry. (b) ex-farm prices would fall and keep falling because other protein producers are continually making economies to become more efficient and cheaper. The French, he said, are already 10% cheaper which may encourage imports unless we also reduced prices. Considerable opposition to this last statement was raised during the discussion session in which it was pointed out that the total production of trout in the UK was so small as to constitute an irrelevance to the nation's food supply and prices should be maintained or even increased. (c) farms or processors not accredited with a quality assurance scheme would not be able to market their fish. (d) large trout currently make up less than 10% of UK production compared with 25% in Europe. There would be a greater use of large fish to produce a variety of products which cannot be manufactured from portion sized fish. (e) UK table production would double to 20,000 tonnes over the next 10 years with the growth of better products more suited to the market. (f) there were a number of people within the industry intent on expanding trout consumption. The next decade, he said, would be one of considerable technical advance for the industry.

Promotional campaign

The final presentation of the marketing session and an addition to the conference programme was a talk given by Suzanna Hammond who runs a promotion company which had been involved in various marketing campaigns including Freedom Foods, Geest, British Tomato Growers Association and Jersey Royal Potatoes. Hammonds had been contracted by the BTA to run a marketing campaign for trout with four objectives: (a) to raise awareness of the health benefits of eating trout, its freshness and contemporary meal solution (b) reposition trout as a contemporary meal solution (c) encourage greater trial and usage of trout among consumers and (d) position trout fishing as an accessible, fun and desireable leasure pursuit whilst reinforcing the values of fresh trout.

The aim of the campaign was not to spread the budget too thinly and use the media to give trout a profile. The initiative concentrated on (a) establishing a press office, creating a comprehensive, informative press pack of modern design, providing trout samples to key food writers, recipe development with supporting photography, coverage of medical issues and media training and (b) creating a focus by organising a 'national trout week'. Coverage here included emphasizing the health benefits of omega – 3 oils (apparently a deficiency has been linked to depression) and generally extending the profile of trout into the mainstream health sectors. Photo calls were organised in London with Professor Crawford and the Welsh Assembly, trout samples provided to top food writers and celebrity chefs (Antony Worrall Thompson) recipes issued to the regional press, trout farm open days organised and NOP surveys undertaken.

The press office had concentrated on maximising TV opportunities involving food programmes such as BBC 2's Food and Drink and also regional TV 'day out' programmes. Total media coverage to date included 3 TV items, 13 national press articles, 7 consumer magazine articles, 98 regional newspaper stories and 29 regional radio interviews.

IS SELECTIVE BREEDING FOR STRESS TOLERANCE A VIABLE STRATEGY?

Tom Pottinger, NERC Centre for Ecology and Hydrology, Windermere Laboratory,
The Ferry House, Ambleside, Cumbria LA22 0LP

Between December 1995 and November 1999 the European Commission, under EC Contract FAIR-CT95-0152, funded a multinational research effort that was designed to determine whether it was feasible to selectively breed aquacultured fish for an increased tolerance of stress. The project has now ended and this article presents a brief summary of the major findings of the study, together with some unexpected findings on the lines of fish selected for stress responsiveness.

Background

The rationale behind the project has been outlined in previous articles in Trout News. In brief, husbandry practices in aquaculture are of necessity compromised by the economic realities of large-scale fish production. Therefore, fish are exposed to a variety of stressors of varying severity and duration. Perhaps surprisingly, considering the negative connotations of the term "stress", the physiological response of animals to an isolated stressor is adaptive and of benefit to the individual. The stress response is actually an important mechanism that promotes survival under threatening conditions. Only when the stressor is frequently repeated or prolonged does the stress response becomes damaging. This is when we see adverse effects on growth, reproduction and disease resistance.

The assumption underpinning the project was that under aquaculture conditions fish showing a reduced responsiveness to stress would be at an advantage relative to those displaying more pronounced sensitivity to stress. Arguably, selection for increased tolerance to stress can be considered to be a means of accelerating the domestication of a species. Most farm animals that are reared intensively have been exposed to centuries of both intentional and inadvertent selection for traits that favour performance under agricultural conditions – aquacultured salmonid fish remain wild animals by comparison.

Objectives and achievements

The specific objectives and main achievements of this project were:

(i) To establish a protocol for the selective breeding of finfish for reduced responsiveness to stress – *the Norwegian and UK partners successfully achieved this. At CEH we now have second generation (F2) lines of rainbow trout showing divergent high- and low-responsiveness to stress (HR, LR).*

(ii) To confirm that stress-related traits identified in the parents are inherited by the progeny, and to quantify the heritability of the selected traits - *It was confirmed that the stress-responsiveness of the parents was inherited by the progeny, and the heritability of the selected trait has been quantified as being moderately high (h^2 = 0.6; 60% of the variation in stress responsiveness in these trout is of genetic origin and therefore susceptible to modification by selection*).

(iii) To assess whether the progeny of stress-tolerant parents are at an advantage under aquaculture conditions, relative to the progeny of unselected parents, in terms of growth, disease resistance and reproductive performance - *Results are inconclusive so far, probably because the degree of divergence in responsiveness which was achieved in the first generation was moderate. No clear and unequivocal differences in reproductive performance, disease resistance or flesh quality were found (see below for comments on relative growth). However, the F2 fish display a greater degree of divergence, with a three-fold difference between HR and LR lines compared to the two-fold difference obtained in the F1 lines and differences in performance may become more evident.*

It is with respect to objective (iii) that most uncertainty remains. We are not yet in a position to state in absolute terms whether high- or low-responsiveness is advantageous or disadvantageous, or even of negligible significance, under aquaculture conditions. This is unsurprising given that for most of the lifetime of the project we had only the first generation of progeny from selected parents with which to work. It would be remarkable if selection produced tangible improvements in performance within a single generation. However, there is a three-fold difference between the responsiveness of HR and LR fish in the F2 lines compared to a two-fold difference in the F1 lines, which offers the prospect of detecting meaningful differences in performance between the lines.

Growth differences arising from selection for stress responsiveness

We know that high cortisol levels during stress underlie many of the adverse changes in growth, reproductive performance and disease resistance in stressed fish. Therefore, this trait was chosen for modification as most likely to be of significance to individual performance. As outlined in previous articles, the high- and low-responding lines of fish were selected on the basis of the extent to which their blood cortisol levels were elevated in response to a standardised confinement stressor. The stress response is largely non-specific – the same physiological changes occur in response to a wide range of stressors – so confinement is a reproducible and humane way of eliciting these changes under experimental conditions. We opted for a divergent selection scheme to provide the best chance of detecting effects of selection on physiology and performance by contrasting the two lines (HR, LR) with each other and with an unselected (US) random-bred line. The results of selection for cortisol responsiveness can be seen for the F1 and F2 generations in Figure 1.

While monitoring the growth of the F1 fish we observed that when reared in isolation, the two selected lines displayed similar growth rates. However, when HR and LR fish were reared together, the LR fish marginally out-performed the HR line. These observations seemed to discount a physiological basis for the differences in growth and suggested instead that the LR fish were better able to acquire food than HR fish, possibly reflecting differences in competitiveness or aggression.

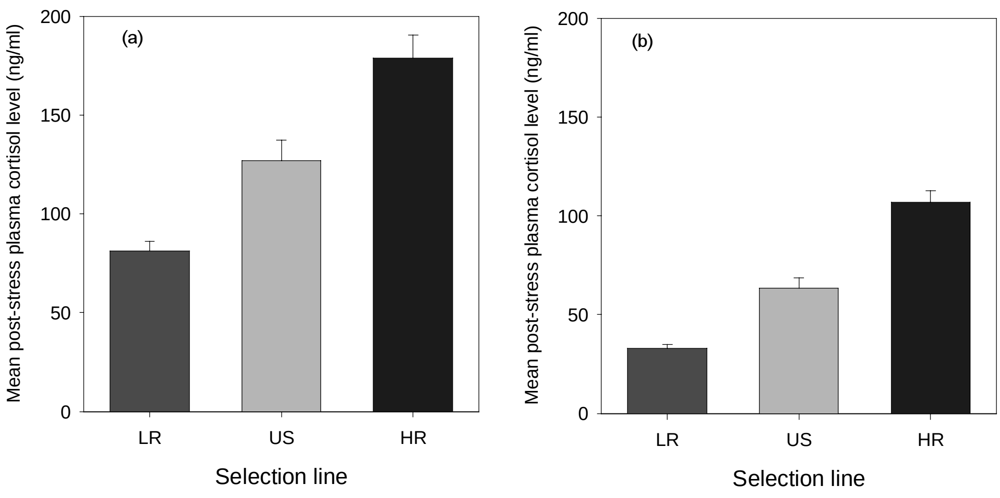


Figure 1. The mean levels of cortisol in the blood of fish stressed by a standardised period of grouped confinement in small (50 l) tanks for 3 hours. (a) The mean results (n = 36 for each line) of a single test of the F1 high-responding (HR), low-responding (LR) and unselected (US) lines. (b) The mean results (n = 60 for each line) of a single test of the F2 lines. For each comparison the means are significantly different from each other (P<0.001).

Is stress responsiveness linked to competitiveness?

At nearly three-years old the F1 fish were too large to carry out the aquarium-based observations of social interaction that were necessary to investigate these results further. Investigation of the behavioural characteristics of the HR and LR lines was therefore undertaken with the F2 generation. This was generated from the CEH F1 fish by an individual-within-family selection scheme based on cortisol elevation in response to confinement. As Figure 1 shows, the cortisol responsiveness to a confinement stressor diverged significantly in the F2 lines and to a proportionally greater extent (three-fold) than in the F1 fish (two-fold).

Testing aggressiveness/ competitiveness in the HR and LR fish

We investigated the relative aggressiveness/ competitiveness of the HR and LR lines using a method that exploits the innate territoriality of rainbow trout. Juvenile rainbow trout, in common with other predominantly stream-resident salmonids, are intensely territorial animals and when introduced simultaneously into an aquarium will compete for control of the 'territory' which usually results in one individual becoming dominant and the other displaying a subordinate posture. The dominant and subordinate individuals can easily be identified because of the characteristic behaviour patterns they adopt. Dominant individuals actively swim in mid-water, and nip and/or chase the subordinate. Subordinate fish exhibit little activity, remaining on the base of the aquarium adjacent to a wall, and directing no aggressive activity towards the dominant fish. Food is normally intercepted by the dominant individual and attempts to do so by the subordinate individual result in chasing by the dominant. [It should be noted that the result of a paired test depends upon the behavioural interaction of both individuals and so only indicates their *relative* attributes – it does not provide an *absolute* measure of the individual's aggressiveness]

LR fish are more dominant than HR fish

The results of the study were surprisingly clear (Figure 2). In a total of 46 separate paired tests the fish from the LR line was identified as dominant in 43 tests while fish from the HR line were dominant in only 3 tests. The results suggest that selection has either increased aggressiveness in the LR line or increased submissiveness in the HR line or has had a combination of these effects on the two lines.

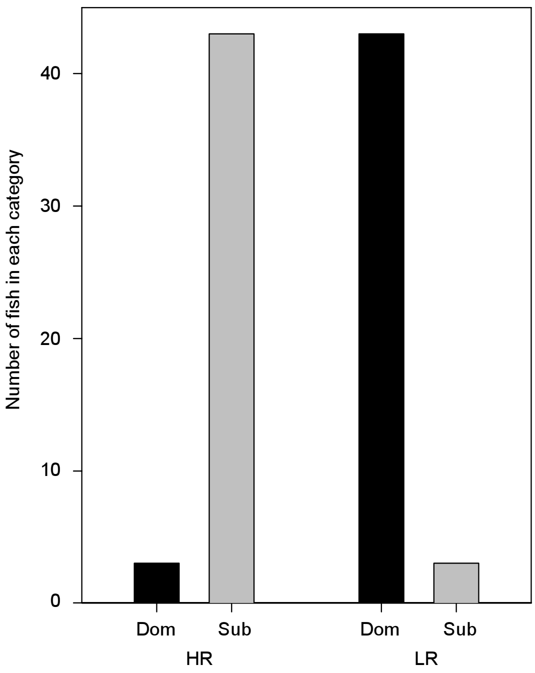


Figure 2. The relative numbers of HR and LR fish of the F2 generation that were identified as either dominant (Dom) or subordinate (Sub) in paired competition tests.

Implications for selective breeding practices

These results are potentially interesting in terms of the links between behaviour and physiology in fish, an area about which relatively little is known. We are currently investigating the physiological basis for this difference in behaviour between the two lines, and the extent to which other behaviours might be affected by selection for stress responsiveness. However, from an aquaculture point of view, the results raise some questions about which traits should be selected in order to optimise performance by selective breeding. Our initial assumption was that the physiological aspects of the stress response were likely to be critically important in defining individual performance in a stressful environment. Therefore selection was applied to a trait known to be associated with stress-related problems – the magnitude of plasma cortisol elevation during stress. However, it has now become apparent that this aspect of the stress response is linked to behavioural characteristics of the individual. The stress responsiveness of an individual fish comprises both physiological and behavioural features, which are interdependent. Selection for one apparently desirable feature may inadvertently co-select additional, less desirable, characteristics.

At least one potential problem is evident when the growth patterns of the F2 LR and HR families are considered (Figure 3). The relative variation in both weight and length in the LR line is nearly twice that in the HR line – a feature that is characteristic of populations in which a high level of inter-individual competition is occurring.

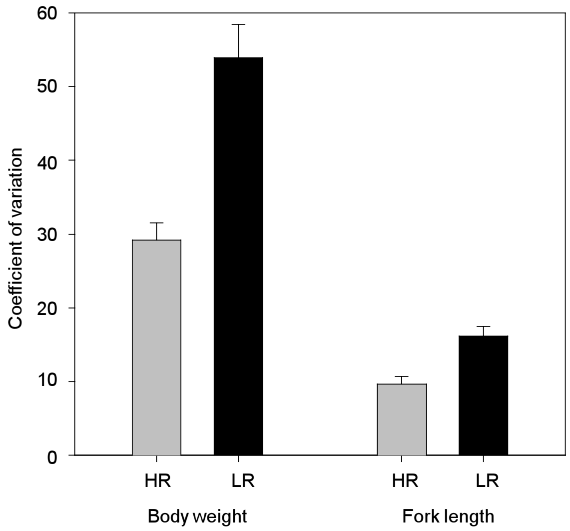


Figure 3. The coefficient of variation (CV = standard deviation expressed as a percentage of the mean) for body weight and fork length of the F2 HR and LR lines. Each value is the mean of the CVs for 10 families, each family estimate of weight or length being derived from measurements of 40 individual fish/family. For both measurements the CV of HR and LR fish was significantly different (P<0.001).

Conclusions

The most distinctive difference between two lines of rainbow trout, selected on stress responsiveness, is behavioural. Fish displaying low cortisol responsiveness to a stressor (a desirable trait) appear to be more dominant and competitive individuals than those fish displaying a high cortisol responsiveness to a stressor. As far as the individual fish is concerned this combination of attributes is likely to be a good thing – the fish is less adversely affected by stress and is an effective competitor for food and territory. These traits (LR) may therefore be advantageous to the individual fish in a mixed culture environment (or in the wild). But in an aquaculture environment a population comprising entirely LR fish may not be desirable. Further work on the F2 generation will establish whether other performance characteristics of the LR line outweigh these apparent disadvantages.

Acknowledgements

This brief summary has focused on results obtained by CEH during the project. Full results of the study are presented in the Annual and Final Reports to the EC, and in papers published by the individual partners. Groups from three countries in addition to the UK were involved in this programme. These were: University of Tromsø, Norway; Norwegian College of Veterinary Medicine, Norway; Grupo de Investigación en Acuicultura, ULPGC, Spain; Universidad de Granada, Spain; TEHAG Fish Centre, Hungary; Pannon Agricultural University, Hungary; Gödöllõ Agricultural University, Hungary. Preparation of the original proposal to the EC was funded in the UK by MAFF.

THE UK ORNAMENTAL FISH INDUSTRY

Keith Davenport, Ornamental Aquatic Trade Association,
Unit 5 Narrow Wine Street, Trowbridge, Wilts BA14 8YY

Tropical marine ornamentals

Keeping ornamental fish as a hobby is enjoyed by tens of millions of households across the world and provides employment for many thousands.

In the UK some 3.5 million households (14% of the total) own ornamental fish. These are kept in indoor aquaria (500,000 new ones are sold annually) or garden ponds. Ornamental fish are the third most popular pet group owned after cats and dogs (owned in 5.3 and 5.0 million households respectively but it is the most populous pet in the UK. (See Figure 1).

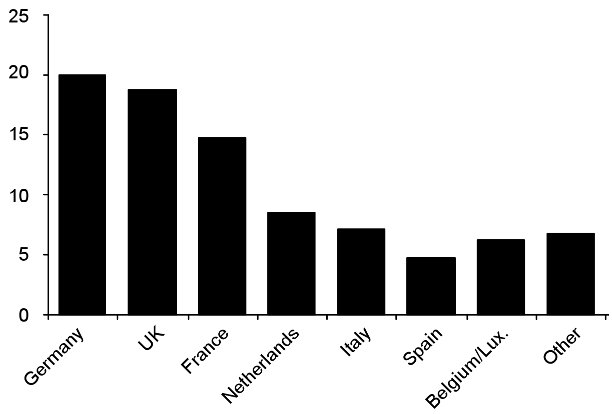


Figure 1. The value of ornamental fish (ECU millions) imported by Member States of the EU during 1999

It is estimated that over 2,000 businesses in the UK rely on the industry, and some 10,000 people are employed within it. With a turnover of between £250-300 million (including sales of dry goods) in the UK and £1.5 billion in the EU it is larger than many other fish sale based industries far outstripping the trout industry.

The value of ornamental fish imported into the EU during 1999 exceeded £54 million. Imports into the UK in that year were £12.5 million. The rather greater value at the time of sale to the public reflects the costs of distribution and maintaining retail outlets. If there were no fish available there would be no ornamental fish industry (including dry goods manufacturers etc.) or fish-keeping hobby.

As many as 9 million households in the EU own an aquarium. 10% of households (approximately 9.4 million) own ornamental fish in the USA where between 9,000 and 12,000 retail outlets sell pet fish.16% of all Australian homes own fish as pets Approximately 800 retail outlets employing 5,000 staff supply the requirement of the hobby population.

History

Ornamental fish have been raised and transported to distant markets for centuries in the Far East.

In the late 1800s there was an established trade in goldfish between Italy and Yugoslavia and possibly Russia. By 1939, a supply line for goldfish was well established from Italy via Switzerland to Calais by train and by ferry to England. Water changes took place in Switzerland and before the ferry journey. At the same time, fish from the Far East and the USA arrived in the UK by ship, in metal cans with perforated lids, enabling frequent water changes.

Following the war, long haul flights were available and ornamental fish were brought from the far east, initially in metal cans. In the early 1950s the use of polythene bags and the arrival of planes with jet engines on these routes allowed the trade to grow.

Thus the international trade in ornamentals has been established for over a century and for at least 50 years there has been a significant volume of trade in ornamental species in the manner seen today.

Sources of ornamental fish

In 1999 freshwater (both coldwater and tropical) ornamental fish were imported into the EU from 66 countries, tropical marine fish were imported from 47. (See Table 1)

It will perhaps come as a surprise to many that the Czech Republic is such an important source of ornamental fish, a bigger shock will be that these are predominantly tropical not coldwater fish. 27% by value of freshwater ornamentals imported into Germany during 1999 originated in the Czech Republic.

Table 1. Top ten sources of ornamentals

Freshwater ornamentals		Marine ornamentals	
Country	% of EU imports by value	Country	% of EU imports by value
Singapore	34.0	Indonesia	43.3
Czech Republic	11.6	USA	12.0
Japan	11.2	Philippines	11.2
Israel	7.3	Sri Lanka	9.2
China	6.3	Singapore	4.2
Brazil	5.3	Kenya	3.7
Thailand	5.0	Maldives	3.4
USA	3.6	Brazil	2.2
Sri Lanka	3.5	Yemen	1.7
Malaysia	3.4	Saudi Arabia	1.4
66 countries were recorded as exporting freshwater ornamentals to the EU during 1999.		In total 47 countries exported ornamental marines to the EU during 1999.	

The UK market

All EU countries import ornamental fish. The UK as can be seen from Figure 1, is the second largest importer behind Germany.

Ornamental fish are kept as a hobby and thus are purchased from excess disposable income. The sales and hence imports of ornamental fish are thus strongly influenced by the general economic climate.

During periods of recession sales reduce, in boom times they increase. This relationship can be seen when the freight weight of ornamental fish imports over the last 10 years are reviewed (Figure 2). There was growth

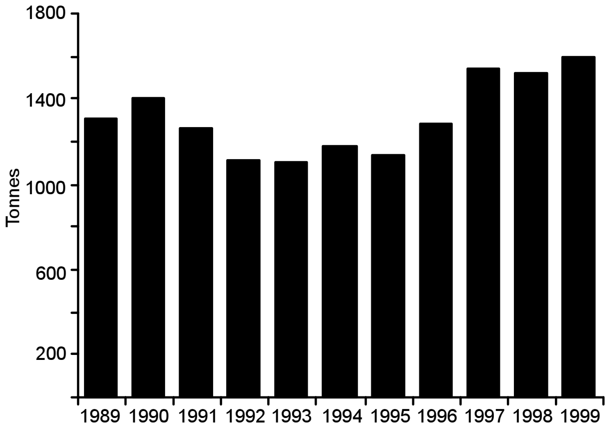


Figure 2. Freight weight (tonnes) of ornamental fish imports 1989-99 (including water and other packaging materials)

during the boom years at the end of the eighties followed by a significant fall and bottoming out during the recession of the early and mid nineties. This period was followed by a rise in imports mirroring once again the wider economic situation. Certainly nobody should run away with the idea that involvement in industry is a stress-free licence to print money.

The hobby of fish keeping faces competition from the new technology hobbies and virtual aquarium website. The choice of hobbies and pastime activities available now is far wider than was the case even ten, let alone 20 years ago.

Seasonality

Tropical fish are imported throughout the year. Traditionally there tended to be a noticeable peak in demand in the winter particularly leading up to Christmas. However in the past couple of years the demand has been equally distributed during the year.

There is a very marked peak in demand for coldwater species, to stock gardens, during the spring months. Imports during the winter months are relatively light.

UK production - opportunities for diversification?

It has been estimated that as many as 4 million coldwater fish are produced in the UK for the home market. There are a number of generally small scale tropical fish producers. One company however does export coral reef fish species spawned, hatched and grown on in a hatchery in the South of England.

Over the years a number of trout farmers have on-grown ornamentals, particulary koi, as a sideline. However anyone considering diversifying might wish to re-read Chris Seagrave's article published in 1993 (see Trout News No. 16, June 1993) in which he lists the problems faced by newcomers to the market.

Ornamentals as a threat – risk or rhetoric

Ornamental imports have tended to be demonised by some salmonid producers, though a number of others have seen it as an opportunity to diversify. Exaggerated hostile claims have been made that confuse rather than clarify issues concerning risk analysis of any movement of animals. Indeed such comments serve to polarise debate rather than promote rational evaluation of any available data. Examples are given below.

In evidence given to a Select Committee in 1994 concerning live fish imports, the British Trout Association (BTA) wrote "we are at great risk from the continued import of ornamental fish". This extraordinary statement was made inspite of the number of trout farmers who had diversified at one level or another into koi rearing without incident. This diversification in its members interests was acknowledged in its verbal evidence by the BTA when their representative commented "one substantial member in Wiltshire who has a carp operation directly adjacent to his trout operation and we regard this as a potential serious threat." Moreover in response to further questions their representative conceded that "Currently to date there is no proven case of salmonid disease having entered via ornamental species."

Table 2. Categorisation of ornamental fish in trade

Category	Principle sources	Species	Wild vs Farmed	Comments on use
Coldwater	Japan, Israel, USA, China	20 species principally koi (Cyprinus carpio) and Goldfish (Carassius auratus)	100% farmed	Held in closed ornamental garden ponds
Tropical Freshwater	Singapore, Brazil, Czech Republic	1000+ species	95% farmed	Held in indoor aquaria. Unlikely to survive in temperate regions
Tropical marine	Indonesia, Philippines, and Pacific Islands	1000+ species	99% wild caught	Held in indoor aquaria. Unlikely to survive in temperate regions

The views expressed by the British Trout Association find resonance in those recently expressed by the Tasmanian Salmonid Growers Association in their response to the Australian government's ornamental fish Import Risk Assessment. They urged "That imports of ornamental fish should be banned". However one must question the real rather than theoretical risk posed to (the alien species) salmon farmed on spring fed sites and then transferred to cages in the open sea by either koi, goldfish or tropical fish species entering the ornamental fish industry and hobby sector.

The theoretical risks inferred in their comment might more easily and appropriately be addressed by effective husbandry and management of water sources used by hatcheries. Such measures might better protect their alien stock from native Australian fish pathogens.

The ornamental fish industry has moved fish around the world for 100 years or more. It is subject to many regulations. The vast majority of imported ornamental fish enter closed systems from which transmission of pathogens is highly unlikely. The interpretation of theoretical considerations of what could possibly occur must be tempered by a review of real life practical outcomes.

Ill founded comments may serve to confound rational risk assessment rather than promote the elaboration of realistic practical and efficient safeguards necessary to ensure the livelihoods all fish industry sectors.

The way forward – collaboration not conflict

At the most recent Sparsholt Conference after a paper concerning the advance of *Lactococcus* across Europe and its arrival in Northern France, a member of the audience asked what part ornamentals might play in bringing it into the UK. This showed quiet clearly the fear in the salmonid community of the ornamental industry.

No ornamentals come from the north of France. But apparently there is a healthy illegal trade, recognised by ministers in both Labour and Conservative governments, in coarse fish for angling waters. Apparently at least some originate from France, where both *Lactococcus* and IHN are known to occur, enter the UK and are stocked in the wild, maybe close to trout farms, without any control. Contrast this with ornamentals whose pre-notified entry is overwhelmingly through MAFF supervised international airports from where they are taken and kept, in the vast majority of instances, in closed systems open to public scrutiny.

Koi carp

There will always be differences between fish-based industries. Concerns that are felt to be legitimate about the impact of one industry on the other will probably always be voiced. These differences must be resolved by discussion rather than barbed rhetoric. We should never lose sight of the fact that both industries face a common threat, namely what might accompany illegal imports from across the Channel. Working together we are more likely to bring effective pressure to bear on the situation.

OATA

The Ornamental Aquatic Trade Association (OATA) has some 600 business members. These include importers, wholesalers and retailers of fish and other livestock as well as manufacturers of dry goods such as aquariums, pond liners and the like.

OATA represents its members' views at local and national government levels as well as within the EC. Additionally it actively represents its members by attending international meetings of the OIE, the Convention on the International Trade in Endangered Species (CITES) and the Convention on Biodiversity (CBD). The CBD signed by 175 countries is currently undertaking programmes of work on both marine and freshwater systems including the impact aquaculture has on them.

OATA provides distance learning materials at two levels to its members. This material will shortly be available on CD ROM and via the web.

It also provides members with benefits such as enhanced credit/debit card merchant rates saving participating members over £250,000 per year, commercial insurance reducing annual costs for individual members by up to £600, utility prices for example offering savings of up to £300 per month on electricity and more recently access to a group stakeholder pension scheme. Further information about OATA can be found on our web site at www.ornamentalfish.org

MAFF/BTA FUNDED RESEARCH

LINK AQUACULTURE - TROUT RELATED R&D

Compiled by Dr Mark James of LINK Aquaculure

Six LINK Aquaculture trout projects are now underway and three have been completed. The total value of these projects is £1.2 million with industry committing 54% of this sum (11% in cash).

Over the past 5 years LINK Aquaculture has provided a mechanism for the trout industry to develop an R&D portfolio that addresses the industry's agreed priorities in areas as diverse as disease, fish welfare, the environment and quality and pollution breeding.

In many cases the synergy that has developed between the industrial and scientific members of project teams has resulted in well focussed and innovative research.

Pyceze, a long awaited alternative to malachite green, (identified under LINK project TRT01) will be available in 2001. Potential chemical treatments for both PKD (TRT04) and Whitespot (TRT06) have also been identified. The search for an RTFS vaccine continues and there are indications that this project could provide some promising candidate vaccines by the time it is completed. Automated humane trout slaughter is now a real possibility. A prototype unit has been developed by Silsoe Research Centre using animal welfare data provided by the University of Bristol. Silsoe's expertise in developing practical machinery for the agricultural sector has resulted in a system that will be both practical and cost effective.

Waste minimisation from trout farms will be paramount in the future. Regrettably project TRT08, collection of waste from caged trout facilities was not successful in developing an efficient waste captive system. A number of important lessons were learned, however, from this project, in particular the need to understand the nature of water flows in and immediately around fish cages and to understand how fish movement and behaviour can affect these hydrodynamics. Perhaps an area of research where fish behaviourists, cage design engineers and hydrodynamicists should get together!

Taint in trout has long been a problem and LINK project TRT13 is now in the process of trying to find a solution. In the future LINK project TRT12 will provide a detailed understanding of trout genetics which will allow rapid and cost effective selective breeding programmes.

Whilst the LINK Aquaculture programme is now closed for applications, the Trout LINK projects will continue to be monitored and reported in Trout News and elsewhere in the trade and scientific press.

Project progress summaries:

Identification and assessment of chemical control methods for PKD – TRT04

Project Leader: ***Dr Sandra Adams,***
Institute of Aquaculture,
University of Stirling
Sponsor: MAFF
Research Partner: ***University of Stirling***
Industrial Partners: ***Vetrepharm Ltd;***
Aquaculture Vaccines Ltd;
British Trout Association

Proliferative kidney disease (PKD) continues to affect many trout farm sites on different water supplies in the UK annually. Mortalities as high as 50% of infected stocks have been recorded on some farms on the rivers Test and Avon. This project extension (one year, finishing in March 2001) builds on the encouraging results obtained in the preceding three year Link project-TRT04 where two compounds were identified as potential chemical treatments for PKD. Research partners from the Institute of Aquaculture (IOA) at Stirling, and industrial partners from the British trout Association (BTA), Vetrepharm limited (VET) and Aquaculture Vaccines Limited (AVL) form the consortium.

One of the compounds was shown to directly affect the survival of *Tetracapsula bryosalmonae* (formerly known as PKX) *in vivo,* while the other compound appeared to provide protection against the disease by delaying infection or reducing fish mortalities (due to PKD and co-infections). The latter may be useful as a general health promoter, delaying PKD long enough to bring stock through the critical time of deteriorating environmental conditions and progression of PKD. Methods of administration, dose levels and toxicity trials have been performed to select the most efficient treatment strategy. Both compounds are palatable but one (acting directly on the parasite) was found to be toxic for rainbow trout at the high doses used, and may even be immunosuppressive following prolonged administration. Recent trials with this compound have shown that it is effective against the parasite at low doses and for shorter treatment times (6 days), however, some tissue damage to the kidney is still evident. The recovery of fish tissues after treatment is presently being investigated. Large scale trials with the other compound were performed by the Industrial partners and the results from this are presently being analysed.

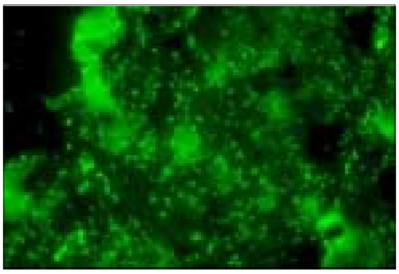
David Morris, Sandra Adams & Randolph Richards
Institute of Aquaculture, University of Stirling,
Stirling, FK9 4LA Scotland

Development of vaccination methods for the control of BKD – SAL10

Project Leader: ***Dr Sandra Adams, Institute of Aquaculture, University of Stirling***
Sponsor: MAFF
Research Partners: University of Stirling; University of Plymouth
Industrial Partners: Aquaculture Vaccines Ltd; Scottish Quality Salmon; British Trout Association

Bacterial kidney disease (BKD), caused by *Renibacterium salmoninarum*, is a chronic bacterial disease affecting both wild and cultured salmonid fish. Presently, there is no effective treatment for BKD, although vaccination would be an ideal approach. Vaccine preparations are often simply composed of formalin-killed bacteria, and the different bacterial components (antigens) elicit a protective immune response in fish. However, this approach has been unsuccessful for the development of a BKD vaccine. In this project (now in the final year), individual antigens are being identified and synthesised in the laboratory using Biotechnology. The synthesised proteins are referred to as recombinant antigens/vaccines. Scientists at the University of Plymouth produce the recombinant vaccines and they are tested for efficacy at the Institute of Aquaculture, University of Stirling. The British Trout Association, Scottish Quality Salmon and Aquaculture Vaccines Limited are industrial partners on the project.

The results to date indicate that one particular virulence factor may be protective. Aquarium trails to confirm these results are now nearing completion and field trials will follow. Another four putative vaccine antigens have also been identified and the production of two of the recombinant antigens has been optimised. A range of recombinant antigens, including specific sections of the P57 protein, is presently being assessed in the aquarium. Toxicity, efficacy and immune response in fish are all currently being determined.



Rainbow trout head kidney infected with Renibacterium salmonarum detected by immunofluorescence antibody staining (IFAT)

Kim Thompson[1], Michell Keirnan[2], Martyn Gilpin[2], Colin Munn[2], Randolph Richards[1] & Sandra Adams[1]
[1] Institute of Aquaculture, University of Stirling, Stirling, FK9 4LA
[2] Department of Biological Sciences, University of Plymouth, Plymouth PL4 8AA

Assessment of chemical and potential immunological control methods for *Ichthyophthirius multifiliis* – TRT06

Project Leader:Dr Rodney Wootten, Institute of Aquaculture, University of Stirling
Sponsor: MAFF
Research Partners: University of Stirling; University of Plymouth
Industrial Partners: British Trout Association; Novartis Ltd; Scottish Quality Salmon

The Institute of Aquaculture assessed the efficacy of 13 compounds against all stages of the ciliate protozoan, Ichthyophthirius multifiliis. The project identified two bath compounds which when given over a 10-day period proved efficacious, killing mature trophonts as they exited fish and thus preventing re-infestation. The efficacy of three in-feed compounds was also demonstrated. In-feed compounds were assessed either by a course of medicated feed for 10 days prior to parasite exposure or by treating the established whitespot disease in fingerling trout directly with a 10-day course of medicated feed. Two compounds administered prior to periods of high infection significantly reduced subsequent infections by c.35%

and c.62% respectively, whilst two compounds given to fish already infected with whitespot brought about a c.75% and c.93% reduction in trophont numbers.

Plymouth established 3D primary cell cultures using rainbow trout skin, scale and gill explants. I. multifiliis was isolated from a single trout and the infective theront stage was used as the starting point for in vitro culture. The behaviour of theronts on introduction to primary cell cultures was comparable with that expected in vivo on exposure to a fish host; parasites associated with the host cells and penetrated under the surface layer. In some experiments 100% parasite survival was recorded for up to 5 days, which approximates to the duration of infection within the fish host at similar temperatures, with a maximum survival of 12 days. Within 12 hours the theront had rounded up with a change of behaviour associated with the trophont stage, spinning in one location within cell layers or cell debris. Although parasites survived and remained very active, the research would suggest that 3D primary cell cultures alone appear to be unable to provide the feeding conditions to sustain trophont development. Nevertheless, we believe that significant advances have been made in developing fish cell culture systems with wide applications in fish Parasitology.

The LINK Aquaculture project has now been completed but further funds are being sought to allow this research to continue.

Andy Shinn, Institute of Aquaculture, University of Stirling, Stirling, FK9 4LA, Scotland

Automated humane slaughter of trout – TRT07

Project Leader: ***Mr Jeff Lines, Silsoe Research Institute, Bedford***
Sponsor: ***MAFF***
Research Partners: ***Silsoe Research Institute; Bristol University***
Industrial Partners: ***British Trout Association; Humane Slaughter Association; Aquatess Ltd; Waitrose Ltd; Tesco Stores Ltd; Safeway Stores plc; Marks and Spencer plc; Sainsburys Supermarkets Ltd.***

Industry concern to improve the welfare of trout at slaughter resulted in a Link Aquaculture project supported by MAFF, The British Trout Association, Tesco, Sainsburys, Marks & Spencer, Waitrose, Safeway, the Humane Slaughter Association and GW Aquaculture. The objective was to develop and test a system capable of automatically slaughtering 10,000 trout per hour while maintaining current standards of carcass quality and operator safety. The development project is being carried out by Silsoe Research Institute and the University of Bristol.

In November the resulting machine was tested for the first time. Initial results indicate that it will achieve its objective. The fish are removed from harvest races using a fish pump and pumped directly into a channel in the harvesting machine where an electric field in the water renders them instantly insensible. The fish are held in this electric field for a period to ensure permanent insensibility after which they are carried by the flow of water to bins of ice slurry for cooling prior to processing.

The effects of electrical stunning parameters on fish welfare and carcass were examined early in the project. Highest carcass quality and welfare standards were achieved with a high frequency alternating current (1000Hz), a relatively low voltage gradient in the water (2 to 3 volts /cm) and a long exposure time (1 minute). Operator safety is assured by stunning the fish in narrow channels so the voltage required does not exceed 45 volts. These channels are arranged around a slowly rotating drum like the magazine of a revolver. As each channel becomes aligned with the inlet pipe the trout are swept into the channel by the water flow and stunned instantly by the electric field. The slow rotation of the drum aligns the next channel with the inlet tube before the first channel becomes full of fish. After minute of rotation the channel becomes aligned with the exit tube and the now permanently stunned fish are swept out of the channel by the rush of water. A high power audio amplifier is currently used to generate the electric field in the channels however discussions with the industry indicate that a simpler power supply could be designed for a commercial machine. The prototype under test is small enough to be transported in a transit van and light enough to be moved without lifting equipment.

Further testing and demonstrations are planned for the spring and summer 2001. Anyone who would like to attend a demonstration or offer their farm for the purpose of testing should contact the project team (jeff.lines@bbsrc.ac.uk).

Humane slaughter trials in progress

Jeff Lines, Silsoe Research Institute, Bedford

Subcage collection and treatment of aquaculture effluents from the freshwater cage production of rainbow trout – TRT08

Project Leader: Mr Michael Aldridge,
Drummond Fish Farm, Muthill
Sponsor: NERC
Research Partners: Heriot-Watt University;
University of Stirling
Industrial Partners: Drummond Fish Farm;
Caledonian Trout Co;
Kames Fish Farming Ltd;
Glenkens Fish Farming Ltd;
J&W Stuart Ltd; SEPA

The project objectives were to evaluate the potential of subcage collection systems to prevent the deposition of solid wastes in freshwater lakes, and the treatment of collected wastes. Particle size of wastes was assessed together with the likely effectiveness of various net types and configurations for optimal design of an undercage collector. A subcage collection system was designed and installed at Drummond fish farm on Loch Earn. The performance of the collection system was monitored in terms of its impact on water quality and effectiveness of solid waste capture.

Water quality and oxygen levels were unaffected by the presence of the undercage collection system. However, the waste collection device had little impact on the prevention of waste deposition from the cage with results revealing less than 1% capture efficiency. Sediment trap studies around the periphery of the fish cages revealed it was the tendency for loss of material through the sides of the cage rather than the bottom which severely limited the capacity of the collection system to adequately trap solid wastes. Measurement of water current velocities within the fish cage revealed current speeds of a similar magnitude to faecal waste fall velocities, making it unlikely that individual particles would sediment to the bottom of the cage to be collected. Movement of fish themselves inside the cage was also critical with current speeds recorded at 10 times the background level of the Loch itself. It must, therefore, be concluded from waste recovery efficiencies, sediment trap surveys and water current velocity measurement that such collection systems are unlikely to be effective in sites such as Loch Earn where exposure to such water currents and movement of cages contribute to short range dispersal of solid wastes.

The potential of anaerobic digestion as a treatment technology for collected solid wastes was examined in a series of experiments at laboratory scale, the test digesters being fed with solids from a land based fish farm. The biodegradation process was highly successful, with 75 and 90% reductions in suspended solids and biological oxygen demand respectively. Anaerobic digestion was also successful in the destruction of enteric redmouth disease (ERM), *Yersinia ruckeri*, at both ambient (20°C) and high (55°C) temperatures. The process also produced a biogas composing of 65% methane for the generation of electricity or heat. However, an economic analysis of the digestion system with relevance to Drummond fish farm revealed it would not be financially attractive unless another waste stream such as cattle slurry was incorporated and full utilisation of its products such as composting was undertaken.

In summary, the project was successful in examining the feasibility of a subcage collection device for the capture of solid wastes. Although solid waste capture proved unsuccessful, the importance of water movement at the site in relation to waste deposition was highlighted. The movement and behaviour of the fish themselves will also contribute largely to the effectiveness of an undercage collection system. Treatment of aquaculture waste by anaerobic digestion is highly feasible but at present not financially attractive.

Dr Barry McDermott and Dr Julian Goodwin,
Heriot Watt University, Riccarton,
Edinburgh, EH14 4AS, Scotland

Investigations into immune responses to RTFS, with a view to disease control – TRT10

Project Leader: Professor Randolph Richards,
Institute of Aquaculture
University of Stirling
Sponsor: MAFF
Research Partner: University of Stirling
Industrial Partner: Vetrepharm Ltd;
British Trout Association

Rainbow trout fry syndrome (RTFS) continues to cause significant damage to the industry, particularly affecting trout hatcheries. Further progress towards a better understanding of the disease has been made in the Link Aquaculture project now in it's second year at the Institute of Aquaculture, Stirling University and CEFAS, Weymouth, with BTA and Vetrepharm Limited as industrial partners.

Studies were undertaken to assess the response of fish to potential vaccines. The results indicate that the important immunogenic antigens are located on the cell surface and are likely to be protein in nature. Heat-inactivated whole cells or crude soluble proteins injected into trout appeared to offer protection in the early stages of infection when fish were experimentally challenged with RTFS. The use of formalin in the vaccine preparations, was shown to reduce their effectiveness. Future studies will compare bacterins produced by different methods and will also concentrate on immersion vaccination, this being the only appropriate application method for fry.

A passive immunisation study to investigate the protective nature of antibodies raised in rainbow trout suggested that transient, short-term protection could be conferred by injecting fry with immune serum prior to challenge with *F.psychrophilum*. This provides evidence of the importance of the humoral antibody response in protection against RTFS.

As part of this project, alternative media for the culture of *F.psychrophilum* which avoid the use of beef products have successfully been developed. Two alternatives have been found and it appears that the protein profile and virulence of the pathogen are unaffected by growing in these media.

The role of the polysaccharide slime layer, present at varying thickness during the life cycle of the pathogen, has been a matter for speculation for some time. Using a modified capsular extraction method to quantify polysaccharide production, a peak in polysaccharide production was detected which appears to correlate with an increase in virulence of the bacterium. The significance of this layer will be further investigated.

Note: *Two other projects (PhD students supervised by Drs Adams and Thompson) on RTFS are presently in progress at Stirling. Ioannis Vatsos from Greece has developed a PCR method to detect F.psychrophilum in fish, water and eggs, while Manuel Fuentes from Equador is studying control strategies for the disease in Chile.*

Ruth Campbell[1], Rachel Rangdale[2], Kim Thompson[1], Sandra Adams[1] & Randolph Richards[1]
[1]Institute of Aquaculture, University of Stirling, Stirling, FK9 4LA
[2]CEFAS, Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB

Off-flavour problems in farmed trout: Identification of causative organisms and development of management strategies – TRT13

Project Leader: Dr Linda Lawton, The Robert Gordon University, Aberdeen
Sponsor: MAFF
Research Partner: The Robert Gordon University; University of Stirling
Industrial Partner: British Trout Association

The MAFF-LINK Aquaculture project, focusing on the identification of causative organisms and the development of management strategies of micro-organisms that cause ‘off-flavours’ or tainting in farmed rainbow trout, began in September this year. The project involves researchers from the School of Applied Sciences at the Robert Gordon University, Aberdeen and the Institute of Aquaculture, University of Stirling, and members of the British Trout Association.

The first few months of the project have been busy. Dr Russell Robertson, an animal physiologist with a background both in aquaculture and in biochemical bioassay work, has been appointed as Post Doctoral Research Fellow. We have established contacts with English and Scottish producers and processors, set up routine sampling programmes and discussed with farm staff about how water, algae, periphyton (the film of micro-organisms and small animals that often covers stones, tanks walls, etc.) and fish samples will be taken and processed for analysis. We have a number of micro-organism isolates in culture and will shortly begin screening these for the presence of taint compounds. We have also made progress on analytical techniques, establishing how fish, plant and water samples are best analysed.

Malcolm Beveridge, Institute of Aquaculture, Stirling University, Stirling FK9 4LA, Scotland

INFORMATION FILE

WHERE TO GET HELP OR ADVICE

Policy Matters

Ministry of Agriculture, Fisheries and Food,
Nobel House, 17 Smith Square, London SW1P 3JR
(Switchboard tel. 020 7238 3000)
(General fax. 020 7238 6591)

Fish farming policy:-
Fisheries Division IIA, Room 308, Nobel House,
(Tel. 020 7238 5947) (Fax. 020 7238 5938)

Grant Aid:-
Fisheries Division 1B, Room 441 Nobel House,
(Tel. 020 7238 5710) (Fax. 020 7238 5951)

Research and Development Programmes:-
Chief Scientist's Group, 1A, Page Street,
London SW1P 4PQ
(Tel. 020 7904 6000) (Fax. 020 7904 6715)

You can also visit the MAFF website at
http://www.maff.gov.uk/

The National Assembly for Wales,
Agricultural Department, Division 2B,
New Crown Buildings, Cathays Park, Cardiff CF1 3NQ
(Tel. 01222 823567) (Fax. 01222 823562)

Scottish Executive of Rural Affairs Department,
Pentland House, 47 Robbs Loan, Edinburgh EH14 1TW
(Tel. 0131 244 6224) (Fax. 0131 244 6313)

Department of Agriculture for Northern Ireland,
Fisheries Division, Annexe 5, Castle Grounds,
Stormont, Belfast, BT4 3PW
(Tel. 028 9052 3431) (Fax. 028 9052 2394)

Scientific and technical advice

Health regulations and disease control -
CEFAS Weymouth Laboratory, Barrack Road,
The Nothe, Weymouth, Dorset DT4 8UB
(Tel. 01305 206673/4) (Fax. 01305 206602)
Email: s.fishii@fish.maff.gsi.gov.uk

Pollutants and their effects -
CEFAS Burnham Laboratory, Remembrance Avenue,
Burnham-on-Crouch, Essex, CMO 8HA
(Tel. 01621 787200) (Fax. 01621 784989)

You can also visit the CEFAS website at
http://www.cefas.co.uk

Department of Agriculture for Northern Ireland,
Fisheries Division, Annexe 5, Castle Grounds,
Stormont, Belfast, BT4 3PW
(Tel. 028 9052 3431) (Fax. 028 9052 2394)

Farm animal welfare -
Ministry of Agriculture, Fisheries and Food,
Government Buildings, Hook Rise South,
Tolworth, Surbiton, Surrey KT6 7NF
(Tel. 0181 330 4411) (Fax. 0181 330 8764)

Environmental issues -
Environmental Agency, Rio House, Aztec West,
Almondsbury, Bristol, BS32 4UD
(Tel. 01454 624400) (Fax. 01454 624033)

Veterinary medicines -
The Veterinary Medicines Directorate,
Woodham Lane, New Haw,
Addlestone, Surrey KT15 3LS
(Tel. 01932 336911) (Fax. 01932 336618)
http://www.open.gov.uk./vmd/vmdhome.htm

Food hygiene -
Food Standards Agency
PO Box 31037
Ergon House, 17 Smith Square, London SW1P 3JR
(Tel: 0207 238 3000)

Advice on commercial activities

The British Trout Association,
8/9 Lambton Place, London W11 2SH
(Tel. 020 7221 6065) (Fax. 020 7221 6049)

Wildlife conservation

Joint Nature Conservation Committee,
Monkstone House, City Road, Peterborough PE1 1JY
(Tel. 01733 562626) (Fax. 01733 555948)

English Nature,
Northminster House, Peterborough, PE1 1UA
(Tel. 01733 455000) (Fax. 01733 568834)

Countryside Council for Wales,
Ffordd Penrhos, Bangor, LL57 2LQ
(Tel. 01248 385500) (Fax. 01248 355782)

Scottish Natural Heritage
12 Hope Terrace, Edinburgh, Scotland, EH9 2AS
(Tel. 0131 447 4784) (Fax. 0131 446 2277)

Other Useful Numbers

LINK Aquaculture
Dr Mark James, Marine Resource Consultants Ltd,
c/o Freshwater Fisheries Laboratory
Faskally, Pitlochry, Perthshire PH16 5LB
(Tel. 01796 472060) (Fax. 01796 473523)
E-mail: majames@compuserve.com

eFishBusiness

A NEW WEBSITE FOR BUSINESS AND OTHERS INVOLVED IN TRADE AND/OR MOVEMENT OF LIVE FISH

Early in 2000 it was announced that CEFAS had been successful in winning Treasury funds to develop a website in conjunction with the Ministry of Agriculture Fisheries and Food, the National Assembly for Wales and the Environment Agency.

The Treasury funding also provided for the development of an interactive database to enable the government bodies involved to share their data electronically, where appropriate, and this is progressing.

The first phase of the project, the website (http://www.efishbusiness.com) is now live.

As well as providing information and guidance on the legislative controls that apply to the live fish trade in England and Wales eFishBusiness provides background on how these controls are intended to prevent the introduction and control the spread of serious fish diseases.

The rules for all categories of fish movements are covered, including those within the UK, within the EU and those with the rest of the world. Information can be found covering movements both to and from fish farms and inland fisheries and those applying to the keeping of non-native fish.

Importers, dealers, fish farmers and fishery managers can download the various application, registration and notification forms that they need direct from the efishbusiness site. There is also a search facility to help navigate the site and links to the website of the government bodies and agencies responsible for these and related controls, from where further information may be obtained. The site has further links to the web sites of the fish trade associations and pages covering the latest news releases and summaries along with references to other relevant publications. A registered area of the site, which is free to use, provides access to supporting information, including detailed descriptions of the most serious fish diseases and lists of disease-free (approved) areas. A feedback form is provided for users to send in their comments and make suggestions to improve the site.

This is the first time that all the related information on the controls that apply to live fish movements has been brought together at one location. It is another step towards electronic joined-up government.

BOOST TO THE CONSERVATION OF SALMON AND FRESHWATER FISHERIES

Fisheries Division II, MAFF Nobel House, London SW1P 3JR

MAFF Parliamentary Secretary, Elliot Morley, has reaffirmed the Government's commitment to protect declining stocks of salmon and freshwater fish in England. He welcomed the report of the independent Salmon and Freshwater Fisheries Review Group and accepted the large majority of its recommendations.

The independent Review Group was formed in April 1998 to review existing policies and legislation in England and Wales concerning the management and conservation of salmon, trout, eels and freshwater fish. Its report was published in March 2000. Over 700 individuals and organisations subsequently commented, and these have been taken into account in deciding the Government's response to the Review.

In outlining the Government's response Mr Morley endorsed the Review's recommendations on the rationale for Government involvement in the conservation and management of salmon and freshwater fish. When parliamentary time permits the Government intends to introduce proposals for new salmon and freshwater fisheries legislation to implement the agreed changes.

Mr Morley announced an increase in fisheries grant-in-aid to the Environment Agency to £6.2 million, a 30% increase on the 2000/01 allocation. Salmon stocks are at an historically low level and Government has set a priority for the Environment Agency to conserve and restore salmon stocks through furthering Salmon Action Plans in England. A second priority to improve controls over unauthorised transfers of coarse and non-native fish has also been set. The Government will also contribute £750,000 of matching funds to an accelerated buy-out of mixed stock fisheries.

THE FOOD ADVISORY COMMITTEE DISCUSSED MALACHITE GREEN ON 26 OCTOBER 2000

Fisheries Division II, MAFF Nobel House, London SW1P 3JR

At its meeting on 26 October 2000 the Food Advisory Committee (FAC) discussed the continuing problem of residues of malachite green (MG), and its metabolite leucomalachite green (LMG), being found in samples analysed by the Veterinary Medicines Directorate.

In the last five years the issue has been discussed twice by the Committee on Toxocology and by the Committee on Mutagenicity. The latter advised that both MG and LMG may be mutagens and that further concerns could arise from long-term carcinogenicity tests which are currently underway in the USA. As a result, the Food Standards Agency, in agreement with the VMD's Advisory Group on Veterinary Residues, asked the FAC to advise on the various options available to ensure that public health remains fully protected.

In its discussions, the FAC recognised the efforts made by the BTA, the Veterinary Medicines Directorate (VMD) and MAFF Fisheries Division to publicise the issue. These had achieved a significant reduction in the incidence of, and concentrations of, residues in trout. It is clear that much of the reduction in residues had been achieved by changing the management of trout farms, particularly to ensure that those who had used malachite green in accordance with BTA guidelines did not, deliberately or inadvertently, expose adult fish to treated water.

In its Press Release after the October meeting the FAC said, "The Committee expressed its concern over the continued presence of residues of MG and LMG in a small percentage of farmed fish and concluded that further action is required. It advised that industry should be encouraged to extend the implementation of good production practices pioneered by the British Trout Association which had helped to ensure that residues were absent in a large proportion of the farmed fish now being supplied. The Committee also recommended that the situation be reviewed once further toxicological data became available."

MAFF, the Food Standards Agency and the VMD are now developing a strategy to put out the message once again that MG has to be used responsibly and that residues can, and must, be avoided. An essential part of this strategy will be to undertake further analyses of farmed fish and to publicise the results. Industry is concerned that MG persists in the environment and that, through pathways which are not yet understood, LMG residues might occur in fish from farms which have either not recently used MG or have used it in accordance with BTA guidelines. However, the evidence of the VMD's statutory surveillance programme is that, in general, the problem persists in inappropriate usage of MG on small farms. It is possible that these are not members of the BTA and will not, therefore, have received all the re-inforcing messages about the problem over the last few years. Officials will be targeting them to put over the message that it might be much easier than they think to manage their operations so as to avoid residues of MG and LMG in trout and thereby maintain consumer confidence in the product.

ISA CODE OF PRACTICE

In August last year a code of practice was published by the Crown Estate detailing the measures required to avoid or minimise the impact of infectious salmon anaemia (ISA). The 16 page code was drawn up by a joint working group after many months of discussion between representatives of the salmon industry and Government. The stated aim of the COP is "to help to provide a more secure and positive future for our salmon farming industry by creating a framework to minimise the threat from infectious salmon anaemia (ISA) and other diseases". Since recent studies have indicated that both rainbow and brown trout may act as carriers of the disease it is intended that for ISA purposes the code should also apply to the marine farming of trout.

Copies of the COP may be obtained from:
The Crown Estate,
10 Charlotte Square,
Edinburgh,
EH2 4DR

BTA NEWS

By Rebecca Cresswell, British Trout Association

Quality Standard

One of the most significant issues to arise in the trout industry over the last six months is the development of a single quality standard for trout, the realisation of which is getting closer.

After much discussion between the BTA, Scottish Quality Trout (SQT) and key players in the Industry, SQT have agreed to roll out their standard to the rest of the trout sector. The SQT assurance scheme which conforms to EN45011 is widely respected throughout the Industry and by major UK Retailers.

The need for a common standard amongst trout producers was identified as a priority at the MAFF sponsored 'Future Strategies for the Industry' seminar which took place in March 2000 following discussions about inconsistency in the market place and the presence of 'taint' in trout.

Producers both north and south of the border and in Northern Ireland recognise that the establishment of a single standard must be for the benefit of the whole of the Industry in producing a consistently high quality product.

An interim Management Group has been appointed to manage the 'roll out' of the existing scheme and to establish principles for the new scheme which will be know as Quality Trout UK. A Technical Advisory Committee has also been established to review the existing standards to ensure that they are acceptable to all but are in no way compromised as a result of the broadening out of the scheme.

Subject to commitment from some of the larger players, it is hoped that that Quality Trout UK will be launched in the spring.

Promotional activities

Following the success of National Trout Week, barbecued trout was central to the summer campaign. The aim of the campaign was to encourage people to break away from the traditional sausages and burgers and turn to trout as a safe and healthy alternative. A survey was commissioned which was intended to provide a light hearted perspective on British BBQ cooking and the battle between the sexes.

To add weight to the campaign celebrity chef, Antony Worrall-Thompson cooked up trout at Clearwater in Gloucestershire and fielded a number of interviews for local radio. Worrall-Thompson, already a fan of trout, needed no great encouragement in extolling the virtues of trout and promoting it as ideal barbecue food. He also produced a special recipe and hints and tips on barbecuing.

Some BTA members used the campaign as an opportunity to open up their farms to the public and demonstrate how to barbecue trout. One farm in Wales drew a staggering 1,300 visitors for their open day and two other members invited local food writers to their farms, in return for which they received double page spreads in their local press.

Christmas's theme concentrated on smoked trout as an alternative to the more traditional salmon. Samples of hot and cold smoked trout were sent to key national food writers and Hello Magazine dedicated 3 pages to cold smoked trout comparing it favourably with salmon: "trout are lower in calories and fat and have a more delicate flavour and texture than salmon".

Current market

Despite greater optimism amongst table producers, the price of trout has remained stable. At a recent BTA Regional Meeting in Taunton a lively debate took place amongst producers and fingerling suppliers concerning the relative merits of price rises against long term market security; the issue of lower continental production costs and the threat of imports was also highlighted as an area of concern. There remains a need for more security through the supply chain with long term purchasing and greater supply chain management. In the re-stocking sector, it was expected that the flooding last autumn would cause a shortage in the new year possibly leading to price rises.

Research and Development

This year has also see a significant growth in collaboration between government and the trout industry and MAFF support for a range of research and development projects; all of these developed by the BTA in response to issues raised by our members. In addition to on-going programmes of work on PKD, RTFS, BKD, all-year egg supplies and method of humane harvest there are new projects on off-flavours in trout flesh, stocking density and fish welfare, selective breeding and strain development and the management and treatment of the fish louse (*Argulus)*. The project on *Argulus* involves collaboration between the BTA/BTFRA and the Environment Agency, the Association of Still Water Game Fishery Managers, the Salmon and Trout Association, the Association of Scottish Game Fisheries Managers and the Salmon and Trout Trust. Collectively, the BTA now has research and development projects the cost of which totals some £4million – a remarkable achievement for our membership considering the relatively small size of the UK trout industry.

RESEARCH NEWS

1. Short term storage of trout sperm

The short term storage of salmonid sperm is a useful technique where it is not practical or possible to harvest semen and fertilise eggs immediately. Successful storage is dependant upon several factors which include the gaseous environment under which it is stored. Because fish sperm consumes oxygen *in vitro* the most commonly used and successful method of short-term storage has been under an atmosphere of oxygen. However at high oxygen tensions the reactive effect of O_2 may have potentially negative effects and in order to better understand the requirements this paper re-examines the effects of air versus oxygen on successful short-term storage of sperm from chinook salmon, rainbow trout, and steelhead trout. For each species sperm motility declined over storage time and was generally about 50% of the initial value after 72 hours but there was no difference in motility between samples maintained under either ambient air or 100% O_2. Because blowing up a bag is a simple method of introducing air to semen samples in the field this practice was also compared with atmospheric air and 95% O_2 plus 5% CO_2. Sperm motility under exhaled air or 95% O_2 + CO_2 was significantly decreased after 24 hours. However sperm samples demonstrating a significant loss of motility under these conditions recovered much of the motility after subsequent incubation under ambient air for 24 hours. It was concluded that although O_2 is necessary for successful short-term storage of salmonid semen, ambient air appears to be at least as effective as 100% O_2 when viability and motility are considered. The presence of a relatively modest amount (3-4%) of CO_2 significantly inhibits sperm motility but does not alter sperm viability or spermatocrit values. These results suggest that ambient air serves as an appropriate gas for the short-term storage of salmonid semen.

Reference

BENCIC, D.C., KRISFALUSI, M., CLOUD, J.G., AND INGERMANN, R.L. (Department of Biological Sciences, University of Idaho, Moscow, Idaho 83844-3051, USA. Email: rolfi @uidaho.edu), 2000. Short-term storage of salmonid sperm in air versus oxygen. North American Journal of Aquaculture, 62(1): 19-25.

2. Dietary ascorbic acid requirements

Most fish lack the ability to biosynthesize ascorbic acid (AA) or, if they have the capability to synthesize the vitamin, the quantity produced is insufficient to meet metabolic needs. Thus AA must be provided in the diet. Since it is an essential dietary component that functions in numerous metabolic processes, considerable research has been conducted concerning the role of AA in the nutrition of fish. Literature pertaining to AA in fish nutrition and its relationship with fish health are examined in this paper. Topics addressed include deficiency signs, dietary requirement, effect on reproduction, immune response and disease resistance, stress response, tissue storage, assessment of status, stability during feed manufacture and storage, bio-availability, and supplementation.

Reference

MENG, H. LI. AND ROBINSON, E.H. (Thad Cochran National Warmwater Aquaculture Center, Mississippi State University, Stoneville, MS 38776 USA), 1999. Dietary ascorbic acid requirement for growth and health in fish. Journal of Applied Aquaculture, 9(2): 53-79.

3. The use of locally produced fish meal

This paper describes a comparative trial on the performance of rainbow trout fed diets which included local or imported fish meal as the main protein sources, and to test the effect of reducing the fish meal content or including a fish protein hydrolysate in the diets. Two experimental diets were formulated to include 35% (diet 2) or 20% (diet 3) of a local processed whole fish meal. Two other diets were formulated similar to diets 2 and 3 but with 5% fish protein hydrolysate replacing the same amount of fish meal (diets 4 and 5 respectively). A diet similar to diet 2 but including Norwegian fish meal was used as a control (diet 1). The growth trial lasted 14 weeks and was carried out in floating net cages (325 L capacity), with duplicate groups of 20 rainbow trout of initial average weight of 58 g. The apparent digestibility coefficients (ADC) of the diets were evaluated in a separate laboratory trial. At the end of the growth trial, there were no significant differences in growth rate and protein efficiency ratio among groups. Feed conversion ratios were significantly better in groups fed diets 3, 4 and 5 than in the other groups. Nitrogen retention, as a percentage of N intake, was significantly higher in fish fed diets 4 and 5 than in those fed diet 2. There were no significant differences in energy retention, as a percentage of energy intake, among the groups. At the end of the trial, there were no significant differences among groups in the proximate composition of whole fish. The ADC of protein, energy and phosphorus of diets 1 and 2 were significantly lower than those of diets 3 and 5. It was concluded that, under the experimental conditions tested, performance of rainbow trout fed practical diets including good quality local processed fish meal is similar to that of fish fed diets including Norwegian fish meal. A reduction in the fish meal from 35% to 20% of the diet or the inclusion of a fish protein hydrolysate had no negative effects on growth performance and improved feed utilization.

Reference

BARRIAS, C. AND OLIVA-TELES, A. (Departamento de Zoologia e Antropologia e Centro de Investigaçâo Marinha e Ambbiental, Faculdade de Ciéncias da Universidade do Porto, 4099-022 Porto, Portugal), 2000. The use of locally produced fish meal and other dietary manipulations in practical diets for rainbow trout *Oncorhynchus mykiss* (Walbaum). Aquaculture Research, 31(2): 213-218.

4. Trout X Salmon parr hybrid

Hybridization between Atlantic salmon *Salmo salar* and brown trout *Salmo trutta* is frequently reported, and the role of mature male Atlantic salmon parr has been suspected but never proven. Salmon fry were stocked into a headwater tributary stream of the Connecticut River, where no adult salmon are present. The stream has a self-sustaining population of brown trout. Enzyme electrophoresis revealed the presence of one hybrid (0.81% of the sample population). The maternal species was identified as brown trout; therefore, the only possibility for the male parent was that it was a mature male Atlantic salmon parr. This is the first direct evidence of parr producing hybrid offspring in a totally natural setting and in the absence of any sea-return salmon.

Reference

GEPHARD, S. (Connecticut Department of Environmental Protection, Fisheries Division, Post Office Box 719, Old Lyme, Connecticut 06371, USA) MORAN P., AND GARCIA-VAZQUEZ, E., 2000. Evidence of successful natural reproduction between brown trout and mature male Atlantic salmon parr. Transactions of the American Fisheries Society, 129(1): 301-306.

5. Genetic improvement of salmonid fish

Carnivorous fish are two to three times as efficient as pigs and broilers in converting energy and protein to edible food for humans. As the domestication of fish continues, they will become more and more efficient and competitive with these industries. In the future, this will be very important, as more efficient utilization of available food resources is required to supply the growing human population with enough food. Today, about 1% of aquaculture production is based on genetically improved fish and shellfish. For salmonid fishes, we have the necessary knowledge to establish efficient breeding programmes. Large genetic variation has been associated with important economic traits. For growth rate, heritability ranges from 0.2 to 0.3, with a coefficient of variation of 20–30%. This implies that it is possible to obtain large responses from selection for growth rate. In several large-scale experiments and in breeding programmes, 10–15% genetic change has been obtained per generation, which is much higher than that reported for other farm animals. In Norway, extensive breeding experiments with Atlantic salmon and rainbow trout were started in 1971. For the first two generations of selection, the breeding goal was growth rate. Age at sexual maturation (measured by challenge test for furunculosis and the virus ISA) and meat quality (measured as fat percentage, fat distribution and flesh colour) were included. Today, Norsk Lakseavl AS (Norwegian Salmon Breeding Company Ltd) or NLA runs the National Breeding Programme and has two breeding stations where 400 full-sib and half-sib families of Atlantic salmon are tested in each of four year classes. For rainbow trout, the number of families totals 120 in each of three year classes. In 1997, the Norwegian production was 310,000 tonnes of Atlantic salmon and 33,000 tonnes of rainbow trout. At present, about 65% of the salmon and trout produced in Norway use genetically improved fish from NLA and multipliers. The cost-benefit ratio for the National Breeding Programme in Norway is estimated to be 1:15.

Reference

Gjedrem, T. (AKVAFORSK, Postbox 5010, 1432 Aas, Norway), 2000. Genetic improvement of cold-water fish species. Aquaculture Research, 31(1): 25- 33.

6. Feather, meat and bone meals in trout diets

Feather meal and meat and bonemeal are two types of animal protein ingredients which have been used in salmonid diets for decades. There use has been limited however, because of poor digestibility and variability in quality. Better manufacturing practices have demonstrated that meals produced from these ingredients may be relatively highly digestible and this paper re-evaluates their use as protein sources in rainbow trout diets. Two feeding trails were conducted on three feather meals over a 20 week period with trout reared at 8.5°C. The feather meals, alone or in combination with corn gluten meal and blood meal replaced herring meal in diets formulated to be isoproteic (ca. 47% digestible protein (DP)) and isoenergetic (ca. 22 MJ/kg digestible energy (DE)) assuming apparent digestibility coefficient (ADC) values for protein and energy of 75% for the three feather meals. Three meat and bone meals were used in a 12-week trial with fish reared at 15°C. Increasing levels of meat and bone meal replaced herring meal in diets formulated to be isoproteic (ca. 43% DP) and isoenergetic (ca. 19 MJ/kg DE) based on ADC for protein of 85% and ADC for energy of 70% for the three meat and bone meals. The incorporation of up to 15% feather meal (providing about 20% of total DP) in the diet was possible without affecting growth, feed efficiency, nitrogen or energy gains of the fish. The incorporation of up to 24% meat and bone meals (providing about 25% of total DP) in the diet was possible without affecting growth but resulted in a small yet significant reduction in feed efficiency compared to the control diet. No significant differences were observed among feather meals and meat and bone meals from various origins. The results from this study show that feather meal and meat and bone meal have good potential for use in rainbow trout diets.

Reference

Bureau, D.P. (Department of Animal and Poultry Science, University of Guelph, Guelph Ontario, Canada, NIG 2WI, Email: dbureau@aps.uoguelph.ca) Harris, A.M., Bevan, D.J., Simmons, L.A., Azevedo, P.A. and Cho, C.Y., 2000. Feather meals and meat and bone meals from different origins as protein sources in rainbow trout *(Oncorhynchus mykiss)* diets. Aquaculture, 181(3-4): 281-291.

7. Probiotics in aquaculture – a review

The research of probiotics for aquatic animals is increasing with the demand for environment-friendly aquaculture. Probiotics are defined as live microbial feed supplements that improve both the health of man and terrestrial livestock. The gastrointestinal microbiota of fish and shellfish are peculiarly dependent on the external environment, due to the water flow passing through the digestive tract. Most bacterial cells are transient in the gut, with continuous intrusion of microbes coming from water and food. Some commercial products are referred to as probiotics, though they were designed to treat the rearing medium, not to supplement the diet. This extension of probiotic concept is pertinent when the administered microbes survive in the gastrointestinal tract. Otherwise, more general terms are suggested, like biocontrol when the treatment is antagonistic to pathogens, or bioremediation when water quality is improved. However, the first probiotics tested in fish were commercial preparations devised for land animals. Though some effects were observed with such preparations, the survival of these bacteria was uncertain in aquatic environments. Most attempts to propose probiotics have been undertaken by isolating and selecting strains from aquatic environments. These microbes were *Vibrionaceae,* pseudomonads, lactic acid bacteria, *Bacillus* spp. and yeasts. Three main characteristics have been searched in microbes as condidates to improve the health of their host. (1) The antagonism to pathogens was shown in vitro in most cases. (2) The colonization potential of some candidate probionts was also studied. (3) Challenge tests confirmed that some strains could increase the resistance to disease of their host. Many other benefical effects may be expected from probiotics, e.g. comptetition with pathogens for nutrients or for adhesion sites, and stimulation of the immune system. The most promising prospects are sketched out, but considerable efforts of research will be necessary to develop the applications to aquaculture.

Reference

Gatesoupe, F.J. (IFREMER, Ctr Brest, INRA, Unite Mixte Nutr Poissons, BP 70, F-29280 Plouzane, France), 1999. The use of probiotics in aquaculture (Review). Aquaculture, Vol. 180: 147-165.

8. Maternal effects on embryo survival

The viability of fish embryos and larvae is important for both aquaculturists and fisheries biologists, as early embryo survival of both freshwater and marine fishes can vary dramatically. Numerous biotic (e.g. genetics) and physical factors such as temperature, oxygen concentration etc may contribute to this variability and one important factor undoubtedly is the gametes that combine to produce the zygote. The maternal and paternal influences on early embryo survival in rainbow trout are not established. The purpose of this study was to determine whether variability in the survival of rainbow trout embryos could be attributed to either the female or male parent. Gametes from individual female and male rainbow trout were used in single pair matings to produce families whose survival was followed from fertilization to the time of swim-up (i.e. - 7 weeks post-fertilization). Survival was assessed at 0.5, 9, 19, 33, and 48 days post-fertilization, corresponding to second cleavage, embryonic keel formation, retinal pigmentation, hatch, and swim-up, respectively. The variaability of survival at all times was significantly influenced by the female parent, whereas the influence of the male parent was negligible. Therefore, in rainbow trout embryo survival can be equated with the quality of the egg. To predict survival at swim-up (i.e., after 48 days) it was found that embryonic keel formation, measured 9 days after fertilization, was the earliest time at which a highly significant positive correlation was demonstrated.

Reference

Nagler, J.J. (Center for Reproductive Biology, Department of Biological Sciences, University of Idaho, Moscow, ID 83844-3051, USA. e-mail:jamesn@novell.uidaho.edu), Parsons, J.E. and Cloud, J.G., 2000. Single pair mating indicates maternal effects on embryo survival in rainbow trout, *Oncorhynchus mykiss.* Aquaculture, 184: 177-183.

9. Immunostimulants in fish diets

An immunostimulant may be defined as a substance that enhances the immune system by interacting directly with cells of the system activating them. There use in fish diets has accelerated in recent years as more production-grade diets are fortified with a variety of natural substances that promise to heighten innate immunity. In this review various immunostimulants and their methods of application in fish culture are examined. Important variables such as life stage and innate disease resistance of the fish; immunostimulant used, its structure and mode of action; and the fish's environment are discussed. Conflicting results have been published about the efficacy of immunostimulants in fish diets. Some researchers have had positive responses demonstrated as increased fish survival, others have not. Generally, immunostimulants enhance individual components of the non-specific immune response but that does not always translate into increased fish survival. In addition, immunostimulants fed at too high a dose or for too long can be immunosuppressive.

Reference

Gannam, A.L. (U.S. Fish and Wildlife Service, Abernathy Fish Technology Center, 1440 Abernathy Road, Longview, WA 98632) and Schrock, R.M., 1999. Immunostimulants in fish diets. Journal of Applied Aquaculture, Vol 9(4), pp 53-86.

10. Acute stress response in triploid trout

The purpose of this study was to determine whether triploid salmonid fishes differ from diploids in their hematological and physiological responses to an acute handling and confinement stress, induced by netting fish from their tanks and placing them in a bucket. Blood samples were collected from fish prior to the handling stress and at either 30 min (rainbow trout) or 20 and 40 min (brook trout) confinement in the bucket. Plasma cortisol, glucose and chloride levels, hematocrit, hemoglobin concentration, total blood cell concentrations (erythrocytes and leucocytes), and differential leucocyte concentrations and their relative proportions were measured. As expected, resting blood cell concentrations were significantly lower in triploids than in diploids. In all other respects, triploids showed little difference from diploids in either values prior to the stress or in changes in these values induced by the acute stress. Both diploids and triploids showed a marked stress-induced increase in hematocrit and plasma cortisol and glucose, accompanied by a decrease in lymphocyte concentrations. Other values showed minimal or no change resulting from the stress. Triploid salmonid fishes therefore appear to exhibit a typical acute stress response, as has been well described for diploids.

Reference

Benfey, T.J. (Department of Biology, University of New Brunswick, Bag Service,45111, Fredericton, New Brunswick, Canada E3B 6E1. e-mail: benfey@unb.ca) and Biron, M., 2000. Acute stress response in triploid rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*). Aquaculture 184: 167-176.

11. Manipulation of end-product quality with finishing diets

High energy diets have several benefits the most important of which are their propensity to spare protein and enhance food conversion efficiency. However they may produce animals of a lower general quality than fish fed leaner feeds e.g. high dietary fat may be deposited in the viscera resulting in reduced slaughter yields. This paper examines the effect of dietary lipid level upon various quality parameters of smoked rainbow trout. Fish were fed four experimental diets differing in lipid content (18.8-31.4%). Groups received either a lipid-rich diet throughout the trial (101 days), a lipid-rich feed for 46 days followed by a lower fat diet for 55 days and vice versa, or a low fat diet throughout. A fifth group (controls), consisting of commercially reared animals, was employed for comparative purposes. The visceral fraction of experimental fish increased with increasing lipid ingestion, whereas final process yield decreased. Chemical analyses following salting and hot-smoking revealed that fillet lipid and ash was higher and moisture lower for fish fed the high-lipid diet throughout and during the last 55 days of the trial. No differences were recorded with respect to sensory atributes between treatment groups, although differences were observed between tank-reared and control fish. In experimental animals, fillet protein content was negatively correlated with juiciness and fibreness, while dry matter was correlated with juiciness, fresh oily taste and rose flesh colour. The present study indicates that high lipid feeds can be employed without negatively influencing sensory characteristics or yield provided that lean finishing diets are fed prior to slaughter. Fasting of fish for 61 days improved slaughter yields without affecting relative yields among dietary groups.

Reference

Rasmussen, R.S., Ostenfeld, T.H., Rønsholdt and McLean, E. (Aalborg University, Biotechnology Laboratory, Aguaculture Division, Sohngaardsholmsvej 57, DK-9000 Aalborg, Denmark. E-mail: 15em@civil.auc.dk), 2000. Manipulation of end-product quality of rainbow trout with finishing diets. Aquaculture Nutrition, Vol 6: 17-23.

12. Effect of feeding time on digestibility and growth performance

A number of studies have demonstrated that feeding time affects growth performance in fish. Optimal feeding time to promote growth may correspond to the natural daily peak of feeding activity which mostly occurs in the light phase for rainbow trout which show a peak of feeding activity at dawn. The aim of this study was to investigate the effect of feeding time and the interactions between feeding time and dietary fat level on the apparent digestibility of the nutrients, growth performance, nutrient retention and protein synthesis in rainbow trout. For this purpose, fish were fed either a low energy diet (LE, 6% lipid) or a high energy diet (HE, 23% lipid) at two feeding times: 1 hour after the onset of light or 1 hour after light off. Protein synthesis rates were determined just before and 4 hours after feeding. Regardless of the diet, apparent digestibility and post-prandial protein synthesis were higher in fish fed in the morning than in those fed at the beginning of the night. In fish fed the LE diet in the morning, growth performance and nutrient retention efficiency tended to be higher than in those fed at the beginning of the night. In contrast, fish fed the HE diet in the morning had lower protein growth rate, protein content and protein retention efficiency than those fed in the evening. These results suggest that protein metabolism might be involved in the effect of feeding time on growth and that there is an interaction between the time of feeding and dietary level of fat on growth.

Reference

Bolliet, V., Cheewasedtham, C., Houlihan, D., Gélineau, A. and Boujard, T. (Equipe nutrition, aquaculture et environment, unité mixte Inra/Ifremer de nutrition des poissons, station d'hydrobiologie Inra, BP3, 64310 Saint-Pée-sur-Nivelle, France. E-mail: boujard@st-pee.inra.fr), 2000. Effect of feeding time on digestibility, growth performance and protein metabolism in the rainbow trout *Oncorhynchus mykiss*: interactions with dietary fat levels. Aquatic Living Resources, Vol 13(2): 107:113.

13. Improvement of aquaculture species using traditional and molecular genetic technology

Genetic improvement of aquaculture species offers a substantial opportunity for increased production efficiency, health, product quality and, ultimately, profitability in aquacultural enterprises. Technologies exist that can be implemented immediately to improve multiple traits that have economic value, while simultaneously accounting for inbreeding effects. Genetic improvement techniques for delivering genetic gain include formal definition of the breeding objective, estimation of genetic parameters that describe populations and their differences, evaluation of additive and non-additive genetic merit of individuals or families and defining the structure of a breeding programme in terms of mating plans. Novel genetic technologies involving the use of DNA-based tools are also under development for a range of aquaculture species. These gene marker technologies can be used for indentification and monitoring of lines, families and individuals, monitoring and control of inbreeding, diagnosis of simply inherited traits and genetic improvement through selection for favourable genes and gene combinations. The identification of quantitative trait loci (QTL), and direct or linked markers for them, will facilitate marker-assisted selection in aquaculture species, enabling improvement in economically important traits, particularly those that are difficult to breed for, such as food conversion efficiency and disease resistance. This paper discusses the implementation of genetic improvement programmes through their component technologies. In particular, it focuses on the use of gene markers and their integration into, and enhancement of, genetic improvement programmes based on traditional analytical genetic technologies.

Reference

Davis,G.P. (Genetic Solutions Pty. Ltd, PO Box 6082, Fairfield Gardens, Queensland, Australia 4103) and Hetzel, D.J.S., 2000. Integrating molecular genetic technology with traditional approaches for genetic improvement in aquaculture species. Aquaculture Research, Vol 31(1): 3-10.

14. Stress and reproductive performance

This study assessed the variation in a range of indicators of reproductive performance in fish selected on the basis of their responsiveness (plasma cortisol levels) to a standardized stressor, under relatively benign minimal stress conditions. For both male and female rainbow trout body weight was significantly related to stress responsiveness. High-responding (HR) females were significantly heavier than low-responding (LR) females overall, and HR males were significantly heavier than LR males overall. There was no significant difference in the specific growth rate (SGR) of HR and LR female fish during the experimental period, whereas in contrast the mean SGR of HR males was significantly greater than that of LR males. The divergent confinement-induced levels of blood cortisol in HR and LR groups were stable for more than 1 year after selection. There was no significant difference in the extent to which confinement stress reduced blood oestradiol-17β levels in HR and LR females, despite a large difference in relative blood cortisol levels. The onset and rate of ovulation was similar within the HR and LR groups. Differences in fecundity, relative fecundity and egg volume and weight were wholly attributable to the different mean body weights of the HR and LR fish. There was no difference between the sperm counts of HR and LR males. There was significantly higher mortality among eggs derived from HR parents overall between fertilization and hatch, but maximum mean mortality did not exceed 12%. Mean time to eyeing in the HR groups was 224 degree days, and in the LR groups was 244 degree days. Hatching commenced at 344 and 347 degree days in the HR and LR groups, respectively, and was complete within 412 and 416 degree days respectively. Overall, selection for stress responsiveness was associated with no significant benefits or costs in reproductive performance.

Reference

Pottinger, T.G. (NERC Institute of Freshwater Ecology, Windermere Laboratory, The Ferry House, Far Sawrey, Ambleside, Cumbria LA22 OLP, UK) and Carrick, T.R. 2000. Aquaculture Research, 31(4): 367-375.

15. Survival and growth of triploid rainbow trout/charr hybrids

The combination of induced triploidy and interspecific hybridization in salmonids has led to improvements in hybrid viability creating new opportunities for commercial fish farming. This study assessed the performance of triploid hybrids between rainbow trout *Oncorhynchus mykiss* and male brook charr *Salvelinus fontinalis,* Arctic charr *S. alpinus* and lake charr *S. namaycush,* together with diploid and triploid rainbow trout controls from the same dams under freshwater farming conditions up to their fourth year of life. All hybrids displayed lower survival rates than the controls, the weakest genotype being the Arctic charr hybrid. Mortalities were mostly observed at the embryonic and larval stages and at the adult stage as a consequence of male sexual maturation. Growth of all hybrids was hindered (compared with controls) during the first year, but only moderate differences remained after 3 years. Sexual maturation resulted in a weight inferiority of males in all genotypes. Female hybrids displayed a slightly higher dressing percentage than female triploid rainbow trout as a result of lower visceral losses. These results are discussed with reference to hybrid resistance to rhabdoviruses from the viewpoint of fish farming improvement.

Reference

BLANC, J.M. (Station d'Hydrobiologie INRA, BP 3, 64310 Saint-Pee-sur-Nivelles, France), VALLÉE, F. AND DORSON, M., 2000. Survival, growth and dressing traits of tripoid hybrids between rainbow trout and three charr species. Aquaculture Research, Vol. 31(4): 349-358.

16. Fertilization success of normal and sex-reversed female rainbow trout

This paper presents the first systematic comparison of the sperm traits and fertilization success of sex-reversed and normal male rainbow trout. Fertilization rates were compared and assessed in relation to sperm motility, sperm density, ATP content, and the weight and gonadosomatic index (GSI) of individual fish. The fertilization rate of sperm stripped from normal males averaged 81% . The sperm of sex-reversed females had to be removed directly from the testes and achieved average fertilization rates of 60%. Testicular sperm from normal males was motile for shorter periods of time and produced lower fertilization rates than testicular sperm from sex-reversed fish. Fertilization rates were positively correlated with higher initial sperm motility, but not with sperm density or ATP concentrations. These results suggest there is a cost, in terms of reduced fertilization rate, to using milt from sex-reversed females which should be taken into account when assessing the benefits of using these fish.

Reference

GEFFEN, A.J. (Port Erin Marine Laboratory, School of Biological Sciences, University of Liverpool, Port Erin, Isle of Man, IM9 6JA, British Isles, UK. E-mail: geffen@liv.ac.uk) AND EVANS, J.P., 2000. Sperm traits and fertilization success of male and sex-reversed female rainbow trout (*Oncorhynchus mykiss*). Aquaculture, Vol. 182(1-2): 61-72.

17. Effect of diet on dorsal fin erosion

This study determined the effect of dietary protein and lipid source on dorsal fin erosion in rainbow trout. Seven diets were each fed to four replicate lots of 300 first-feeding fry cultured in 75 l aluminum troughs for 8 weeks. Two basal diets were manufactured with approximately equal nutrient content, one using krill and squid meals and the other anchovy meal as the primary protein-containing ingredients. The meals used to manufacture the diets were separated into two fractions: lipid (ether-extractable) and protein/ash (non-ether-extractable). The fractions were then recombined to create two additional diets: one containing anchovy protein/ash with krill/squid lipid, the other krill/squid protein/ash with fish lipid. A fifth diet recombined krill/squid protein/ash with krill/squid lipid to evaluate effects of the extraction process. Two additional treatments included a diet with a portion of the krill meal replaced by poultry by-product meal, and the basal anchovy meal diet supplemented with sodium,magnesium, and copper. Fish consuming diets containing anchovy meal as the primary protein source gained significantly more weight than fish consuming krill/squid meal-based diets. Dorsal fin index (DFI, measured as mean dorsal fin height x 100/total fish length) was significantly greater for fish consuming diets containing krill/squid meal protein/ash fraction (DFI = 9.9-10.0 %) than for fish consuming diets containing anchovy meal protein/ash fraction (DFI = 4.9-5.3%), regardless of lipid source. Supplementation of the anchovy meal diet with sodium, magnesium, and copper significantly improved DFI by approximately 20%, but not to the level supported by the krill/squid meal protein/ash fraction diets. The cost of the krill meal diet was reduced by inclusion of poultry by-product meal without affecting dorsal fin condition. These data indicate that the dietary agent contributing to dorsal fin erosion in rainbow trout is not present in the ether-extractable fraction of the diet, but rather in the protein or mineral fraction.

Reference

BARROWS, F.T. (U.S. Fish and Wildlife Service, Fish Technology Center, 4050 Bridger Canyon Road, Bozeman, MT59715, USA. E-mail: rbarrows@montana.campuswix.net) AND LELLIS, W.A., 1999. The effect of dietary protein and lipid source on dorsal fin erosion in rainbow trout *Oncorhynchus mykiss.* Aquaculture, Vol. 180(1 and 2): 167-175.

18. New design of instream incubator

This paper describes the design and field testing of an incubator for monitoring eggs of Atlantic salmon planted out in streams. The unit is robust, reusable, and could be adapted to accommodate the eggs of other salmonid species. It comprises eight individual incubation trays within a portable wire basket that inserts into a frame installed in or on the streambed. Each tray can accommodate an independent group of about 450 eggs, with an overall capacity of about 3,000-4,000 eggs. Average survival rates to hatch were 84% for newly fertilized eggs and generally greater than 99% for eyed eggs. Survival was unaffected by inspection of the eggs during incubation. The ability of the device to allow for the monitoring of newly fertilized as well as eyed eggs represents an advance over previously reported instream incubators. This facilitates the quantification of variables such as egg mortality and hatch date. The device has applications in both salmonid research and enhancement projects.

Reference

DONAGHY, M.J. (Fisheries Research Services, Freshwater Fisheries Laboratory, Pitlochry, PH16 5LB, Scotland, UK. E-mail: m.donaghy@marlab.ac.uk) AND VERSPOOR, E., 2000. A new design of instream incubator for planting out and monitoring Atlantic salmon eggs. North American Journal of Fisheries Management, Vol. 20(2): 521-527.

19. Evaluation of transgenic fish

Transgenic fish have many potential applications in aquaculture, but also raise concerns regarding the possible deleterious effects of escaped or released transgenic fish on natural ecosystems. In this review the potential applications of transgenic fish are considered, the probable benefits reviewed, the posssible risks to the environment identified and the measures which might be taken to minimise these risks are evaluated. Growth trials of transgenic fish have already been carried out in outdoor facilities and some of these are discussed in the light of possible risks and benefits. Regarding the hazards associated with release or escape, whilst there is some evidence to suggest that transgenic fish may be less fit compared to their wild counterparts, there is insufficient evidence to say that this will be true in all cases. Using mathematical models, an attempt has been made to predict the magnitude of the genetic effects in a range of different scenarios. A number of possible containment techniques are considered amongst which containment by sterility is probably the most promising. This can be engineered either by triploidy or by transgenic methods. The conclusions include a tabulated balance sheet of likely benefits and risks, with appropriate weighting.

Reference

MACLEAN, N. (Division of Biodiversity and Ecology, School of Biological Sciences, University of Southamption, Biomedical Sciences Building, Bassett Cresent East, Southampton, SO16 7PX, UK. E-mail: nm4@soton.ac.uk) AND LAIGHT, R.J., 2000. Transgenic fish: an evaluation of benefits and risks. Fish and Fisheries, Vol.1(2): 146-172.

20. Aiding osmoregulation in Arctic charr

Gill sodium and potassium ATPase is a key enzyme in the salt (sodium chloride) excretion mechanism of the teleost gill in sea water. An increase in the activity of this enzyme during smolting is ascribed to a pre-adaptive mechanism for coping with the salt load when smolts enter the sea. In several salmonids, dietary salt supplementation has been found to increase gill sodium and potassium ATPase activity and sea water tolerance. The objective of this study was to determine whether a dietary salt supplement could be used to improve the sea water tolerance and marine survival rate of one-year old smolts of Arctic charr. Groups of one-year-old smolts reared under a simulated natural photoperiod were fed pelleted feed with a NaCl content of either 1.5% or 9.5% for 6 weeks before release in a river in northern Norway. There were no differences in growth before release between fish fed the two diets. Smolts fed the 9.5% NaCl diet had better hypo-osmoregulatory ability than those fed the 1.5% diet, and a level of gill Na+ - K+ - ATPase activity that was several times higher. One of the two groups that had been fed the 9.5% NaCl diet had both a significantly higher recapture rate and growth in sea than the two groups fed the 1.5% NaCl diet, whereas this was not true for the other 9.5% NaCl diet group. The results indicate that a NaCl-enriched diet could be used to ensure sufficient hypo-osmoregulatory ability of charr smolts that would otherwise have insufficient regulatory ability.

Reference

STAURNES, M. AND FINSTAD, B. (Norwegian Institute for Nature Research, Tungasletta 2, N-7485, Trondheim, Norway), 2000. The effects of dietary NaCl supplement on hypo-osmoregulatory ability and sea water performance of Arctic charr (*Salvelinus alpinus* L) smolts. Aquaculture Research, 31(10): 737-743.

21. Ascorbic acid and sperm viability

Previous studies on the male reproductive system of rainbow trout have shown that ascorbic acid (AA) is mainly present in the seminal plasma at concentrations proportional to dietary intake. Long term feeding with diets deficient in AA results in decreases in sperm concentration, motility, fertilizing ability, decrease in protein concentration and anti-proteinase activity in seminal plasma and an increase in sperm lipid peroxidation value. *In vitro* supplementation of AA to trout semen did not protect sperm from damage induced by UV-irradiation resulting in abnormal embryos. Since short term storage of milt involves flushing with oxygen, accelerated oxidative damage may be expected in semen with low levels of anti-oxidants such as AA. This study evaluated the motility and fertilizing ability of rainbow trout semen, after storage *in vitro* on ice (O°C) for 14 days obtained from fish fed a diet without AA and a diet supplemented with 870 mg Kg of ascorbyl monophosphate (a protected form of AA resistant to heat and diet processing but with excellent bio-availability to fish). Spermatozoa from the supplemented fish had the highest motility and lowest decline in fertilizing ability after storage. Direct supplementation of 50 mg L AA to semen samples obtained from fish without AA in the diet failed to have any positive effect on sperm quality. This suggested that the positive effect of ascorbic acid on semen quality was related to its long-term effects during sperm development (spermatogenesis).

Reference

CIERESZKO, A. AND DABROWSKI, K. (School of Natural Resources, The Ohio State University, Columbus, OH 433333210, USA, e-mail:dabrowski.1@osu.edu). 2000. Effect of ascorbic supplementation *in vitro* on rainbow trout sperm viability. Aquaculture International, 8(1): 1-8.

Trout News in the News

Because of copyright requirements this review of press cuttings is not available in this web version of Trout News