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

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TROUT PRODUCTION

2001 SURVEY OF TROUT PRODUCTION IN SCOTLAND

Data supplied from SERAD (Rural Affairs Department of the Scottish Executive) Annual Production Survey, 2001 via the website: www.marlab.ac.uk

Rainbow trout were produced from 57 sites involving 50 companies with an overall production of 5,466 tonnes in 2001 (5,154 tonnes in 2000) an increase of 312 tonnes on the previous year (6%). 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 8 years. Production in 2001 amounted to 4,674 tonnes representing an increase of 363 tonnes (8%) on the previous year and accounting for 85.5% of total production.

Fish weighing up to 450 g made up the bulk of table production representing 65% of total production.

Restocking production

Table 3 provides production data for the restocking trade for the last 8 years. Production for restocking decreased by 51 tonnes (6%) to 792 tonnes representing 14.5% of the total production (16% in 2000).

Escapes

There were no reported escapes from rainbow trout farms in Scotland in 2001.

Table 1. Total production for the period 1992-2001

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Tonnes	3,953	4,023	4,263	4,683	4,630	4,653	4,913	5,834	5,154	5,466

Table 2. Production of table fish for the period 1994-2001

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
2000	3,005	203	1,103	4,311
2001	3,053	404	1,217	4,674

Table 3. Production for the restocking trade in 1994-2001

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	977
2000	41	609	193	843
2001	18	526	248	792

Method of production

Table 4 provides a breakdown of trout farms by system and scale of production. Freshwater production accounted for 4,905 tonnes (90% of the total) while seawater production decreased by 28% on the previous year to 561 tonnes (10.3% 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.

Productivity ranged from 22.9 to 43.3 tonnes/person between production areas, being greatest in the West and least in the Northern and Eastern areas.

Mean productivity in tonnes/person for the 4 production areas reached 34.4 tonnes in 2001 representing an increase of 4.7 tonnes on the previous year. Over the same period staff employed decreased by 9 to 159.

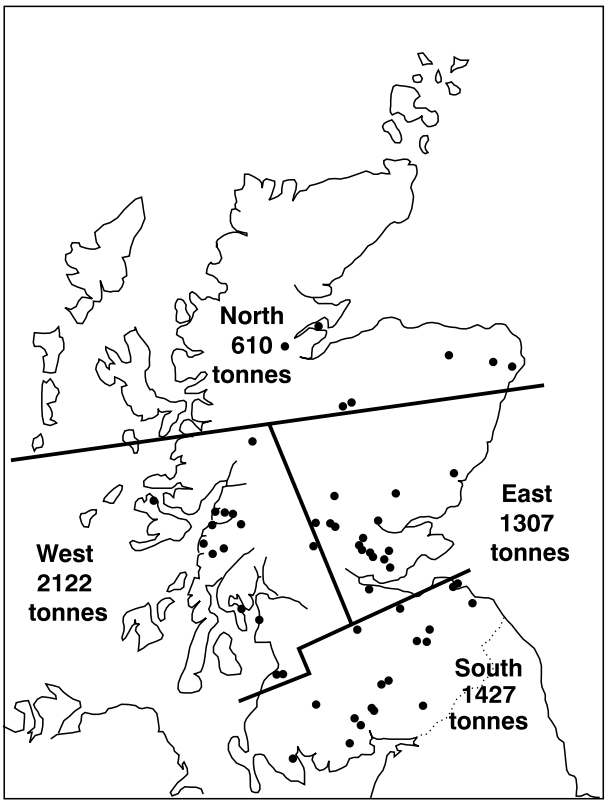

Figure 1. Map of Scotland showing total production in the four trout areas for 2001 and distribution of active sites

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

Production method	Production grouping (tonnes) in 2001					Total tonnage	Total no.of sites	% contribution
	<10	10-25	26-50	51-100	>100			
FW cages	1	2	0	1	6	2,639	10	48.3
FW ponds & raceways	4	5	5	4	7	2,146	25	39.2
FW tanks & hatcheries	5	0	1	1	0	120	7	2.2
SW cages	0	0	0	0	3	561	3	10.3
SW tanks	0	0	0	0	0	0	0	0.0
Total	10	7	6	6	16	5,466	45	100

Table 5. Rainbow trout production and staffing by area in 2001

Area	No. of sites	Production			Mean tonnes/ sites	Staffing			Productivity tonnes/ person
		Table	Restocking	Total		F/T	P/T	Total	
North	7	505	105	610	87.1	14	5	19	32.1
East	18	972	335	1,307	72.6	45	12	57	22.9
West	16	2,012	110	2,122	132.6	35	14	49	43.3
South	16	1,185	242	1,427	89.2	24	10	34	42.0
All	57	4,674	792	4,674	95.9	118	41	159	34.4

Other species

Other species farmed in Scotland together with the production figures for 2000 and 2001 are given in Table 6.

Table 6. Production of other species in tonnes for 2000 and 2001

Species	Production	
	2000	2001
Atlantic salmon	128,595	138,519
Arctic char	7	3.75
Brown trout/sea trout	138	105
Cod	15.7	15
Halibut	4.5	80

Ova production in Scotland

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 2001. The proportion of ova laid down from GB broodstock decreased to 1.44 million representing nearly 6.3% of the total. The total number of eyed-ova laid down increased by over 2.0 million (9.8%) on the 2000 figure.

Type of ova

Details of the number and type of ova laid down for hatching in Scotland are given in Table 8. The preference for all female diploid stock was again evident, accounting for 90% of all ova laid down. Triploid ova increased to 9% of the total, while mixed sex ova showed an eighteen-fold decrease on the previous year to only 140,000 tonnes.

Table 7. Number and sources of ova laid down for hatching in 1993-2001

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
2000	1,397,000	900,000	2,297,000	18,686,000	20,983,000	10.9
2001	918,000	525,000	1,443,000	21,590,000	23,033,000	6.3

Table 8. Number and proportions (%) of ova types laid down for hatching in 1993-2001

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 (<1)
1996	22,678,000	21,308,000 (94)	935,000 (4)	435,000 (2)
1997	23,504,000	21,118,000 (90)	1,386,000 (6)	1,000,000 (4)
1998	25,241,000	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)
2000	20,979,000	17,264,000 (82)	1,202,000 (6)	2,513,000 (12)
2001	23,035,000	20,788,000 (90)	2,107,000 (9)	140,000 (1)

Imported rainbow trout eggs in 2001

The number and source of imported rainbow trout ova for the period 1995-2001 are given in Table 9. The total imported in 2001 - 21,590,000 represents an increase of 2.7 million (14%) on the previous year.

Table 9. Number (000s) and sources of ova imported into Scotland during 1995-2001

Source	1995	1996	1997	1998	1999	2000	2001
Northern Ireland	6,285	4,095	2,425	2,065	3,335	1,085	710
Isle of Man	3,550	4,182	4,205	3,273	4,222	5,842	6,670
Denmark	2,650	5,075	5,354	5,700	4,546	4,225	6,135
South Africa	7,825	8,023	9,450	11,585	6,036	7,762	8,075
Others (EU)	-	220	-	-	-	-	-
Totals	20,310	21,595	21,434	22,623	18,139	18,914	21,590

CORRECTION TO YEAR DATE OF NORTHERN IRELAND PRODUCTION FIGURES

In the previous issue of Trout News (July, 2002) the year attributed to the Northern Ireland trout production figure was wrong printed as 2000, when it should have been 2001. The editors apologise for any inconvenience caused by this error.

SUMMARY OF UK RAINBOW TROUT PRODUCTION IN 2001

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 2001 amounted to 16,446 tonnes (15,805 tonnes in 2000) representing an increase of 641 tonnes (4%) on the previous year.

Table 1. UK Rainbow trout production for 2001

	Production in tonnes		
	Table	Restocking	Totals
England and Wales	6,563 (68.2%)	3,062 (31.8%)	9,625
Scotland	4,674 (85.5%)	792 (14.5%)	5,466
Northern Ireland	1,125 (83.0%)	230 (17.0%)	1,355
Totals	12,362 (75.2%)	4,084 (24.8%)	16,446

EUROPEAN TROUT PRODUCTION

The latest production figures for rainbow trout released by the Federation of European Aquaculture Producers (FEAP) on its website (http://www.feap.org) are given in Table l below for 22 European countries. The figures for large rainbow trout are for fish in excess of l kilo in weight and include both fresh-water and sea-grown (salmon trout) production.

Total European production for 2001 is estimated to be nearly 334,000 tonnes with Norway as the leading producer at 60,000 tonnnes followed by France and Italy with 47,500 and 44,000 tonnes respectively. UK production estimated at 19,100 tonnes ranked eighth in the league of European trout producing countries.

Table 1. European production of portion-sized (P) and large (L) rainbow trout for the period 1996-2001

Country	1996	1997	1998	1999	2000	2001
Austria	3,000 P	3,000 P	3,000 P	3,000 P	3,000 P	3,000 P
	400 L	400 L	400 L	400 L	400 L	400 L
Belgium/Luxemberg	700 P	700 P	700 P	700 P	600 P	600 P
	100 L	120 L	100 L	100 L	100 L	100 L
Cyprus	110 P	105 P	90 P	66 P	90 P	90 P
Czech Republic	647 P	499 P	554 P	723 P	700 P	700 P
Denmark	30,000 P	29,300 P	32,000 P	30,000 P	30,000 P	30,000 P
	7,000 L	7,000 L	7,500 L	7,500 L	7,500 L	7,000 L
Faroe Islands	63 L	100 L	1,000 L	2,169 L	1,141 L	4,000 L
Finland	18,000 L	16,500 L	16,500 L	15,300 L	15,200 L	15,200 L
France	48,000 P	42,000 P	42,500 P	37,000 P	37,500 P	37,500 P
	8,000 L	8,000 L	8,000 L	8,000 L	10,000 L	10,000 L
Germany	23,500 P	23,500 P	23,500 P	22,500 P	22,500 P	22,500 P
	1,500 L	1,500 L	1,500 L	2,500 L	2,500 L	2,500 L
Hungary					27 P	30 P
Greece	2,500 P	2,322 P	2,334 P	2,800 P	2,500 P	3,000 P
Iceland	728 L	580 L	300 L	100 L	180 L	500 L
Ireland	1,000 P	1,000 P	1,000 P	1,000 P	1,000 P	1,000 P
	300 L	300 L	300 L	1,100 L	1,400 L	1,600 L
Italy	48,500 P	50,000 P	47,000 P	43,200 P	43,700 P	43,000 P
	500 L	1,000 L	1,000 L	800 L	800 L	1,000 L
Netherlands	200 P	200 P	200 P	10 P	10 P	10 P
Norway	40,000 L	34,000 L	47,000 L	50,000 L	47,000 L	60,000 L
Poland	5,800 P	6,500 P	9,000 P	9,000 P	10,160 P	11,000 P
Portugal	1,500 P	1,500 P	1,500 P	1,500 P	1,500 P	1,500 P
Spain	24,000 P	25,000 P	26,000 P	27,000 P	28,500 P	29,500 P
	1,000 L	850 L	700 L	700 L	1,500 L	1,500 L
Sweden	150 P	200 P	200 P			
	6,000 L	4,875 L	6,500 L	7,250 L	7,000 L	7,000 L
Turkey	8,000 P	18,075 P	20,125 P	17,200 P	18,220 P	18,220 P
		2,000 L	2,500 L	2,200 L	2,400 L	2,400 L
UK	13,500 P	11,800 P	12,640 P	13,200 P	15,200 P	16,500 P
	1,350 L	800 L	950 L	600 L	2,600 L	2,600 L
Totals portion size	211,107	215,701	222,343	208,899	215,207	218,150
Totals large size	84,941	78,025	94,250	98,719	99,721	115,800
Grand total	296,048	293,726	316,593	307,618	314,928	333,950

SURVEY OF FIN FISH PRODUCTION IN ENGLAND AND WALES FIVE-YEAR REVIEW 1997-2001

Peter Dunn, Fish Health Inspectorate, CEFAS Weymouth, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB

The Fish Health Inspectorate carries out the programme of inspection and monitoring of all salmonid and coarse fish farms, on behalf of Defra and NAWAD, which are required to maintain Great Britain's health status under the EC Directive 91/67/EEC. During these inspections farmers are requested to provide the production figures for the farm, on a voluntary basis. The production data for salmonid farms has been collated and published annually in Trout News for a number of years. For the first time, we have compiled this five-year review of salmonid farm production in England and Wales based on the annual data published in previous reports. We hope that details of variation in the numbers of sites over this period, and the numbers of rainbow trout, brown trout and salmon produced will provide the industry with an overview over this period, and also provide a base against which we can monitor future changes.

Also produced here for the first time are production statistics for the coarse fish farming industry in England and Wales for the period 1997-2001. There has been, and still is, a great variation in the categories by which farmers record production of coarse fish. This coupled with some initial reluctance to provide data to the Fish Health Inspectorate has prevented us publishing these data previously. Significant efforts have been made to gather the information in the format presented. It is believed that it now provides a reasonable picture of the pattern and distribution of trade, and certainly a base from which future trends can be assessed. Due to the difficulties experienced in collating this data, readers should however view the total production figures for coarse fish with a degree of caution. We believe the data will be of interest to those aware of current, and past, market demand in the coarse fish industry.

Salmonid production

The Salmonid production figures are presented here in much the same way as they are for the annual production statistics. However, the figures given will be for the whole of England and Wales for each year rather than be broken down by Environment Agency Region.

Rainbow trout

The total number of sites producing rainbow trout is an appropriate place to start. It shows the general health of the salmonid industry by demonstrating the numbers of farms involved in the production of the main species over the period. As can be seen from Figure 1, the total number of sites that were actively involved in farming rainbow trout was falling at the start of the period, a trend that had been apparent since the early 1990s. In the last two years, however, the total number of sites has remained relatively steady and it would appear that the industry may have reached a period of stability. The numbers of sites with no production, or not reporting production, has remained low each year, averaging 7% of the total number of sites. The proportion of sites reporting production exclusively for the table market has remained steady at around 16% each year. There has been an increase in the proportion of sites concentrating in the restocking/ongrowing area of the market, from 43% in 1997 to 53% in 2001 and a corresponding fall in the proportion of sites farming for both table and restocking purposes. This suggests an increased level of specialisation in the industry over this period. Those farms specialising in table production have gained a greater proportion of that market over the period, as they have acted to meet the increased demands from supermarkets for consistency of product and quality

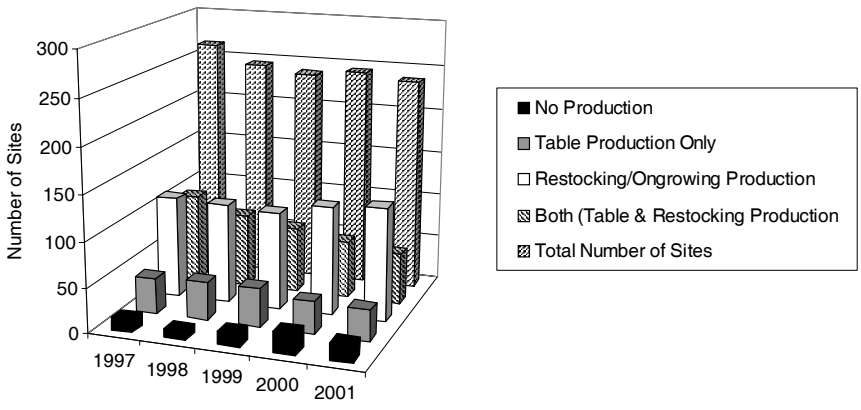

Figure 1. The numbers of farms producing rainbow trout, by production category

assurance. These same demands appear to have worked to the detriment of the smaller farms with and those previously involved in mixed trade.

The figures for rainbow trout production (in Figure 2 and Table 1) are presented in three categories:

1) Fish which were produced for the table market (tonnes),
2) Fish produced for the restocking of fisheries and supplying to other farms at large sizes (tonnes), and
3) Fry produced for ongrowing on other farms – recorded in thousands of fish.

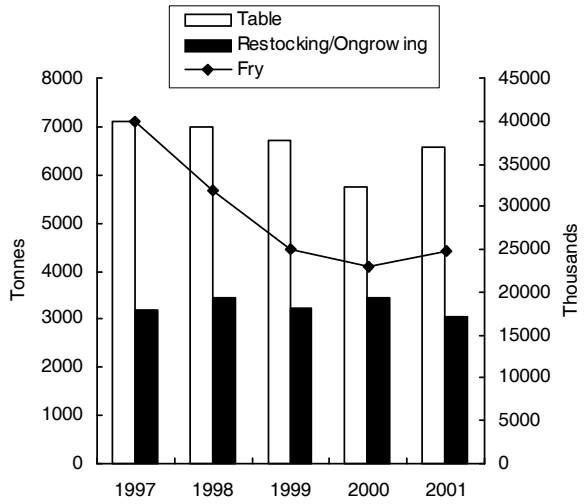

Figure 2. Rainbow trout production

Table 1. Production of rainbow trout in England and Wales, 1997-2001

Year	Table (Tonnes)	Restocking/ Ongrowing (Tonnes)	Total tonnage	Fry (Thousands)
1997	7,102	3,188	10,290	39,996
1998	6,979	3,432	10,411	31,832
1999	6,710	3,224	9,934	25,109
2000	5,757	3,427	9,184	23,047
2001	6,563	3,062	9,625	24,793

There had been a general downward trend in the total tonnage of rainbow trout produced between 1997 and 2000. In 2001 however the total output rose by almost 500 tonnes, and recovered half of the loss seen over the previous 4 years. The fall in production has been most apparent in the table market. We note that the most significant drop in sales of table trout occurred in 2000, immediately ahead of the recovery in 2001. It has been suggested that the rise in 2001 was in part a reaction to imposed restrictions on movement of livestock and decreased demand for fish for angling during the Foot and Mouth outbreak. Sites unable to sell live fish to other sites for ongrowing or restocking purposes had to find an alternative and sell to the table market. It will be interesting to see how table and total trout sales re-adjusted in 2002.

Total fry production followed the same pattern of decline as total fish production between 1997 and 2000, but the fall in fry production for sale to other farms was much greater, at 43%, over the period. This is in comparison to a fall of only just over 11% in the total rainbow trout production. The reasons for this reduced production are not immediately obvious, and it could be a reflection of a number of changes in the industry. More farms may have invested in their own fry production. This would not be reflected in the fry data presented, which records only fish produced and moved off site. There may be significant improvements in post-fry survival over this period, leading to a reduced demand for these fish. The ova production data below may help clarify the reason for the recorded fall in fry production.

Production of rainbow trout for restocking angling waters has remained steady throughout the five year period. This reflects the continued popularity of stillwater trout fishing which has created a healthy demand for such fish.

Brown trout

Production of brown trout is much lower than that of rainbow trout, reaching just over 5% of the rainbow trout figure in 2001. Brown trout are almost exclusively produced as live fish for the re-stocking of fishery waters, and production for the table market has at best reached 3% of total brown trout production during this period.

There has been a steady increase in the numbers of sites that are producing brown trout for the various markets. The proportion of sites holding brown trout that have reported significant production has also increased each year. In 1997 only 53% of sites holding brown trout reported significant production but by 2001 that proportion had increased to 73% of sites. Over the five-year period the total number of sites holding brown trout has increased by 22%, although the majority of these sites hold both brown trout and rainbow trout. These data therefore show something of a resurgence in interest in the farming of this species for the angling market. Production of brown trout was declining as the period started but has started to rise from the low of 311 tonnes in 1999. Production of fry increased rapidly between 1997 and 2000, and this has been re ected by the increased production of adult fish from 1999. These data suggest that 2002 could have seen a further increase in output. The reason for the sudden fall in fry output in 2001 is not clear but this may re ect an impact of the Foot and Mouth outbreak, which caused problems for many farms reliant on live fish sales.

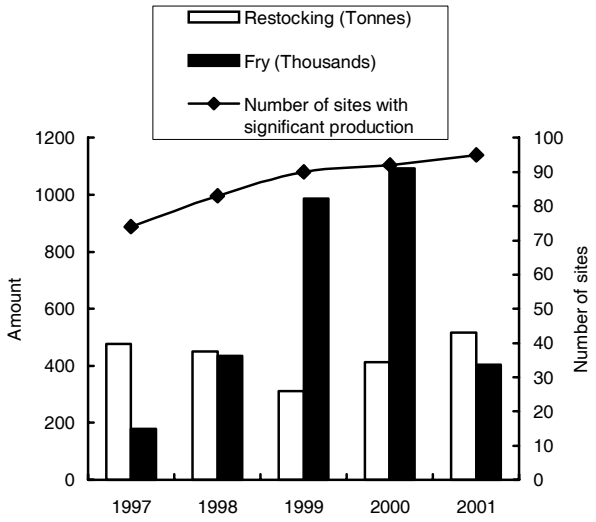

Figure 3. Brown trout production, 1997-2001

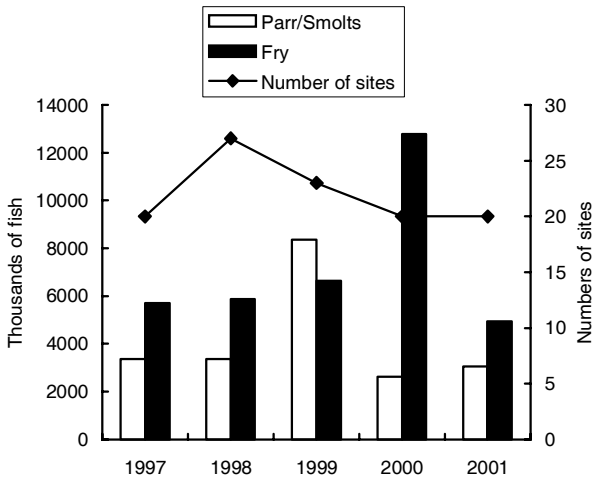

Figure 4. Salmon production, 1997-2001

Table 2. Production of brown trout, 1997-2001

Year	Restocking (Tonnes)	Fry (Thousands)	Number of Sites Involved
1997	478	179	74
1998	450	435	83
1999	311	987	90
2000	413	1,092	92
2001	516	405	95

Table 3. Production of salmon in England and Wales, 1997-2001

Year	Parr/Smolts	Fry
1997	3,366	5,700
1998	3,364	5,880
1999	8,361	6,640
2000	2,631	12,782
2001	3,060	4,949

The production of brown trout fry, showed a rapid increase from 1997, which exceeded the rate of increase in the production of adult fish. This is a complete reverse to the trends reported for rainbow trout. If improvements in husbandry and fish health were responsible for reduced fry demand in rainbow trout, these do not appear to have resulted in similar benefits for brown trout production. Given that the very high production of brown trout fry reported in 2000 was derived from a very low reported ova production for the same season (1999 ova), we must consider that at least part of the explanation may be due to inaccuracies in the reported production figures.

Salmon production

All salmon production in England and Wales in the period has been of juvenile fish to supply the Scottish ongrowing industry or of fish to re-stock rivers, predominantly from Environment Agency sites. The number of sites involved in the production of salmon rose substantially in 1998 but has since fallen back to the levels seen previously. Figure 4 shows that there had been an increase in salmon production over the period with production in 1999 and 2000 at almost double that of previous years. However, production fell to below these previous levels in 2001.

The figures for 1999 and 2000 show a distinct change in the sizes at which salmon was transferred to ongrowing sites in Scotland. Parr and smolt transfers predominated in 1999, but in 2000 most fish were transferred as fry. This probably reflected the availability of ongrowing facilities in the Scottish industry in these two years rather than any major change in approach by the industry. In addition to the production noted below, a small amount of post-smolts have been produced during the period, varying from 1 and 3.5 tonnes per year.

Ova production

The production of eyed ova has been broken down by species in the same way as that for fish and also by egg type.

Rainbow trout

Production of rainbow trout ova from farms in England and Wales decreased throughout the period until 2001, when total production rose back above the 40 million mark to a level previously seen in 1998. Surprisingly this fall in ova production appeared to exactly parallel the fall in fry production reported earlier. As the ova data reflects production from the end of year spawning season, we would have anticipated that ova and fry

production would be out of phase by 1 year in the data. An examination of the ova import data however revealed a minimum total ova supply to the industry during 1999, which does correspond to the lowest recorded fry production in 2000. The combined ova figures for 2000 and fry figures for 2001 show the first upturn in production for a number of years. It will be interesting to see if the large increase in ova production in 2001 also leads to a similar increase in fry production for 2002. The ova figures for 2001 may reflect the aftermath of the Foot and Mouth outbreak with sites holding more potential broodstock due to the lack of market for re-stocking fish and therefore increasing the numbers of ova laid down. We hope the figures instead reflect a true increase in need for the extra ova production

Figure 5 shows that the observed decline in home produced ova was most marked in the largest category, all-female ova. By contrast, the production of triploid ova has shown a slow but steady increase throughout the period. Organic farming briefly spurred a rise in the level of mixed sex ova production to 1999, but this has fallen again, presumably because the production of males still carries the economic penalty that led the industry to all female stocks many years previously.

Table 4 shows that the numbers of farms producing eggs for sale or to lay down for their own use, rose from 26 to 42 in 1997-98 but has since fallen to 35 in the last year. This suggests that some of the reduction in fry production reported earlier reflected an increase in the number of farms running their own hatcheries, presumably in an effort to reduce costs. The production of adults per fry may therefore not have shown such a dramatic increase as Figure 2 above would initially suggest. It is also interesting to note from Table 4 the proportions of eggs sold compared to those retained on site. This shows that 2001 was the first year that a higher percentage of eggs was sold to other farms, reflecting perhaps the increased self reliance in the early part of this period and perhaps the anticipation of some upturn in the industry over the last two years.

Brown trout

The total production of brown trout ova is, at its highest level, a quarter of that of rainbow trout ova. The main area of production is in the mixed sex category, however, up until 2001 there has been a small increase of both all-female and triploid eggs. Production increased dramatically in 1998 but has returned to roughly 1997 levels since. This rise in production was attributable to a

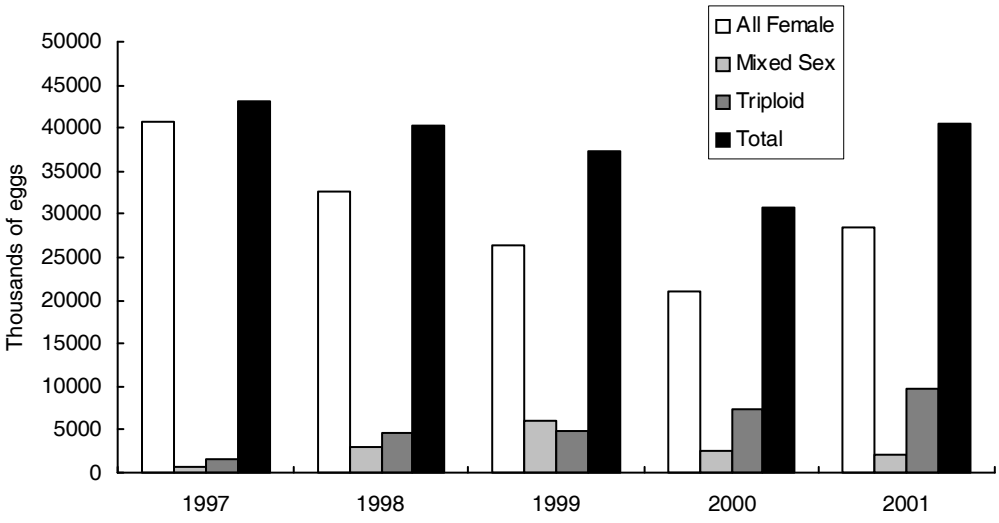

Figure 5. Eyed rainbow trout ova production (000s)

Table 4. Yearly production of rainbow trout ova, 1997–2001 (000s)

	All Female	Mixed Sex	Triploid	Total	Active sites	% Sold on	% own eggs laid down
1997	40,713	788	1,664	43,165	26	42	58
1998	32,741	2,990	4,603	40,334	42	26	74
1999	26,343	6,018	4,898	37,259	42	25	75
2000	21,005	2,431	7,334	30,770	40	20	80
2001	28,561	2,105	9,837	40,503	35	57	43

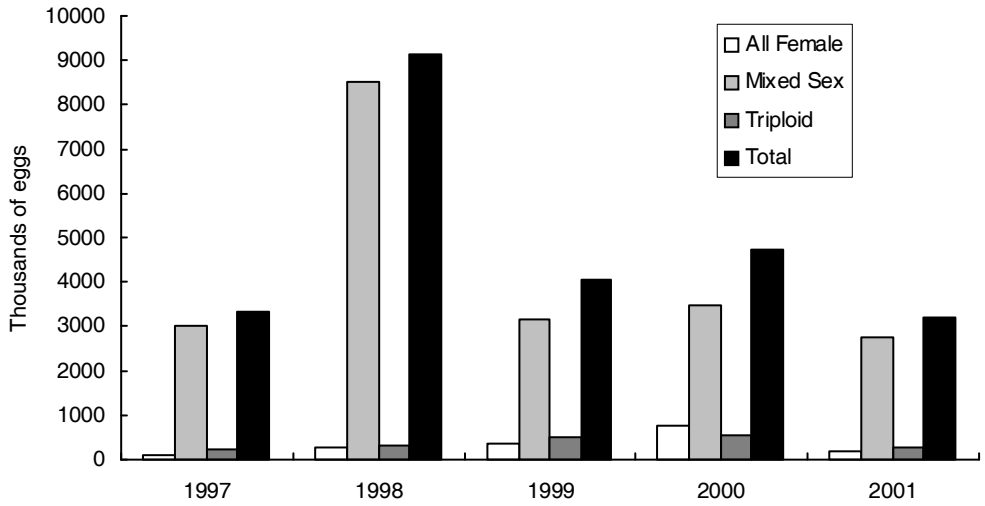

Figure 6. Eyed brown trout ova production (000s)

Table 5. Yearly production of brown trout ova, 1997–2001 (000s)

	All Female	Mixed Sex	Triploid	Total	Active sites	% Sold on	% Own Eggs laid down
1997	94	3,010	221	3,325	26	21	79
1998	290	8,533	313	9,136	38	4	96
1999	368	3,171	504	4,043	36	26	74
2000	745	3,455	535	4,735	33	25	75
2001	200	2,733	260	3,193	29	21	79

single farm, and subsequent events suggest that the market was not available to sustain such a level of production. The numbers of active sites followed the same pattern as that of rainbow trout, a large increase in 1998 followed by a steady decline. In each year, apart from 1998, the proportion of eggs kept on each site has remained relatively stable, between 70-80% of total production of ova was kept on the site in each of these years. These data suggest that though there is a clear upturn in interest in brown trout, the main body of production of this species remains the well established sites.

Salmon

The production of Salmon ova has varied more than the production of trout ova. This in part reflects the variation inherent in the collection of ova from wild broodstock by the Environment Agency and others, but may also show anomalies in production data collection.

Most of the salmon eggs laid down in English sites are derived from Scottish broodstock, and are not recorded in these statistics (Readers will note that fry numbers produced exceed ova numbers, and the industry is not that good!). It may be that some sites have reported some of the eggs imported from Scotland as their own production in the last two years.

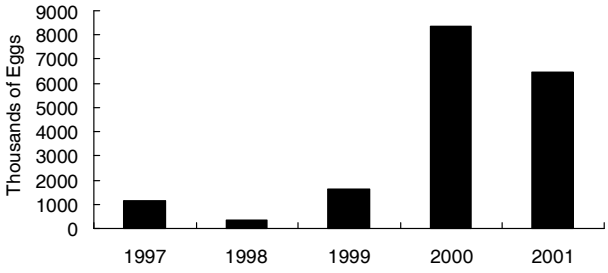

Figure 7. Eyed salmon ova production (000s)

Table 6. Production of salmon ova in England and Wales for the given years

	Salmon mixed sex
1997	1,135
1998	350
1999	1,632
2000	8,380
2001	6,457

Coarse fish production

The UK currently operates national controls to prevent the entry and spread of the main disease threat to coarse fish, Spring Viraemia of Carp (SVC) in England and Wales. As part of these national controls the Fish Health Inspectorate is charged with registering and inspecting annually all coarse fish farms. Stock health and records are checked as for salmonid farms and production data is requested in the same way. Due to variations in recording systems and willingness to supply data, we have not previously published annual coarse fish production data. The data below represents an attempt to standardise the information gathered in the hope that it will encourage improved co-operation in subsequent years. These data do not include information regarding coarse fish harvested from unregistered fishery sites, which often market their excess fish production. Such production may however, represent a significant proportion of the total coarse fish movements and production in England and Wales.

Number and distribution of farms

The total number of sites reporting production increased for 1997-1999 fell slightly in 2000 but rose again in 2001. Unlike salmonid farms it is quite normal for some coarse fish sites to produce no fish in a given year or to remain unharvested for longer periods. Some fish farmers do not see the need to provide information on production to the FHI for 'commercial reasons' and therefore refuse to provide data. This is disappointing, as all data collected by the Fish Health Inspectorate is treated in commercial confidence, and its publication in reports such as this will not give details of specific sites. Fortunately, we are able to review data from the majority of sites, whose owners are happy to provide the data and therefore assess the general health of the industry.

Figure 8 gives the distribution of coarse fish farms reporting production in England and Wales, by Environment Agency Region for the period 1997-2001. Not included are those sites reporting no production and those which did not provide any data. The figure clearly shows the largest concentration of coarse fish farms is in the Southern, South West and Thames regions. These regions have a climate that is more suitable to the growth of coarse fish. We have noted that a number of farms produce both coarse and salmonid fish, and feel these dat may provide some ideas for the production of different species across the fish farm community in England and Wales.

Production statistics

We have identified 4 main categories of coarse fish production. These are -

(i) For restocking angling waters
(ii) For the ornamental trade
(iii) For ongrowing on other fish farms, and
(iv) For the table market

Table production

The smallest production category is that of fish for the table market. In this country coarse fish have not been widely considered as food fish for centuries, however, there is a small market for carp for use in ethnic cuisine. The main species involved is the Common carp (*Cyprinus carpio*), which farmers variously record as

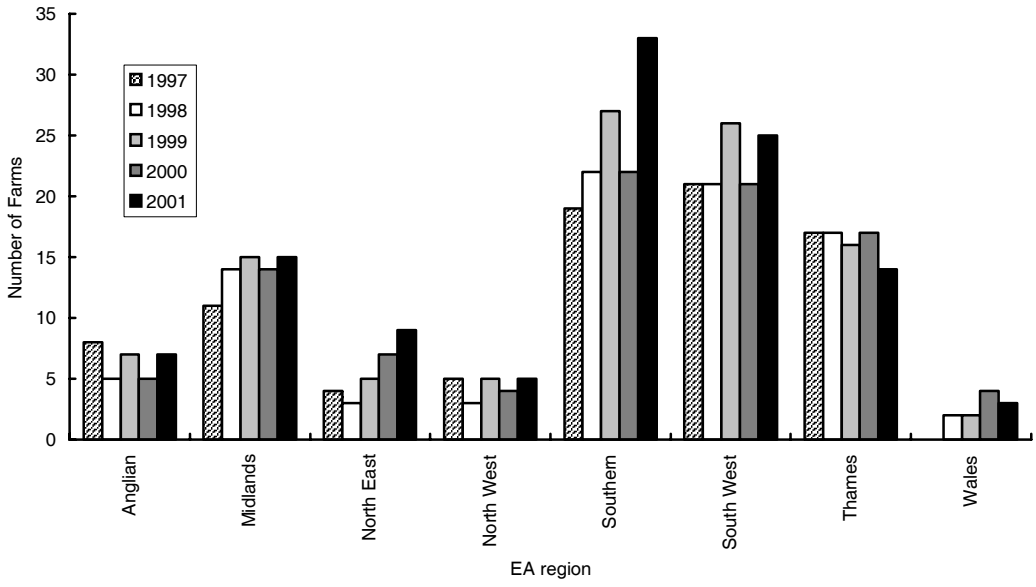

Figure 8. Farms reporting production of coarse fish by EA region

Common carp (fully scaled) and Mirror carp. There has been a steady decline in the numbers of Mirror carp produced for the table but, up until 2000, there was a steady increase in the production of Common carp for this market. From 1997 to 1999 the market remained fairly steady but there was a relatively large drop in production for the year 2000. It should be noted that in the current climate, as the value of live fish for angling exceeds that for table fish, and demand for live fish is high, the production of carp for food is likely to decrease further.

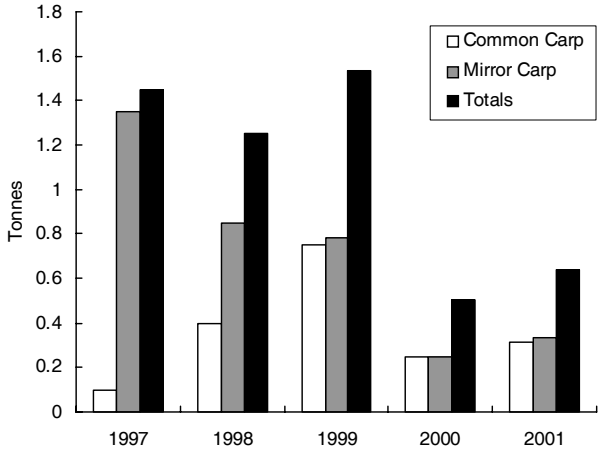

Figure 9. Production of carp for the table market

Table 7. Table production of coarse fish in England and Wales for 1997–2001

	1997	1998	1999	2000	2001
Common carp	0.1	0.4	0.75	0.25	0.31
Mirror carp	1.35	0.85	0.78	0.25	0.332
Totals	**1.45**	**1.25**	**1.53**	**0.5**	**0.642**

The ongrowing trade

There is no readily apparent pattern to the trade in coarse fish for further ongrowing on farms. Many producers maintain production on their own sites to supply varying demands from the fishery industry, rather than specialising on a particular market sector as in the salmonid industry. As a consequence production for ongrowing principally appears to arise from disposal of surplus fish from particularly successful production batches. The main species involved have varied little over the period, with carp (both Mirror and Common) dominating this trade. There is a smaller volume of trade in the varieties of tench, roach and some bream over the period, but usually the demand for such fish makes it profitable to maintain them on the farm of origin until they reach market size for the fishery trade. The production figures for tench in 2000 (Figure 10) illustrate a large production increase in the 151-200 mm, virtually all of which was attributable to an unusually high success rate at one farm site. Similarly, in 2001 there was a dramatic increase in the production of fish in the three larger size categories. This arose when a single farm changing its trade from ornamental fish production to supply large quantities of fish (Koi carp, Mirror carp and Chub) for the ongrowing trade. These data suggest that the industry has yet to see any production specialisms, and that many coarse fish farms look to supply fish to the commercial coarse fishing industry on a somewhat *ad-hoc* basis.

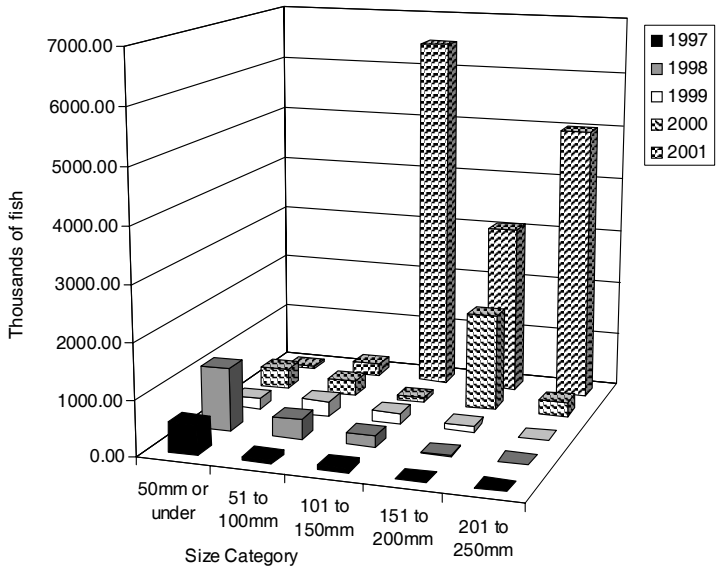

Figure 10. Production of coarse fish ongrowing trade

Table 8. Ongrowing production of coarse fish for the period

	Thousands of fish				
	50 mm or under	51 to 100 mm	101 to 150 mm	151 to 200 mm	201 to 250 mm
1997	533.00	73.85	75.28	0.00	0.00
1998	1152.09	356.28	207.47	12.03	4.71
1999	193.20	280.66	197.50	105.95	3.11
2000	368.40	268.85	90.70	1768.22	269.78
2001	53.70	229.50	6508.16	3078.70	5009.54

The ornamental trade

The trade in homegrown ornamental fish (Figure 11) has risen steadily from a low of 1.5 million in 1998 to a total of 7.3 million in 2001. This represents a very significant growth of the coldwater ornamental fish farm trade in England and Wales for this period. We suggest that this increase in production demonstrates a positive reaction by the trade to seize the opportunities presented by consumer uncertainty about the quality of fish available from established foreign sources. The impact of diseases such as SVC and most notably Koi Herpes Virus (KHV) which has had a significant impact on the import of koi from countries such as Israel, may well have had a positive effect on the home-grown ornamental fish production. We hope that the trade will be able to sustain and further develop its share of the very large UK ornamental fish market.

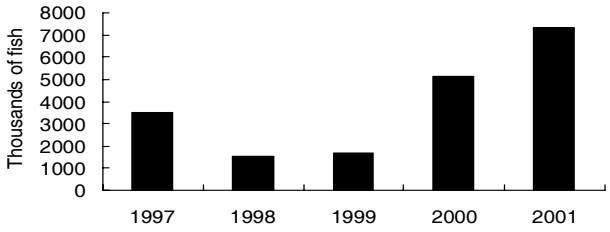

Figure 11. Total ornamental production

Table 9. Total production of fish for the ornamental trade 1997-2001

	1997	1998	1999	2000	2001
Total Production (Thousands)	3519.99	1533.78	1669.94	5142.65	7348.612

Breaking down the total ornamental fish production by species illustrates recent trends very clearly. Figure 12 shows that the main species produced for the ornamental trade in the last two years have been Koi and Ghost Koi. Together with varieties of Orfe, they form the major part of the total production; in 2001 these species formed almost 90% of the ornamental production in England and Wales. The increase in production of koi is almost certainly a response to the industry's concerns about the impact of KHV and the problems in detecting the presence of this virus.

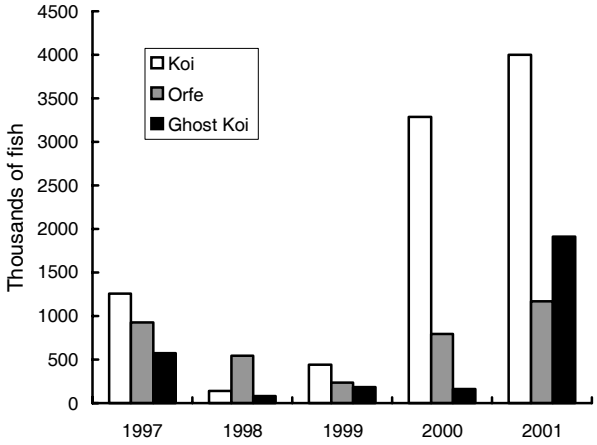

Figure 12. Production of the three main species involved in the ornamental trade

It is also of interest to look at the other species produced for the ornamental trade, as illustrated in Figure 13. Of some surprise is the scale of trade in common carp. The variation in production probably reflects the fact that their sale as ornamentals reflects the level of surplus from farms growing for re-stocking, but clearly the ornamental industry is able to sell these fish. We assume these fish principally find homes in larger ornamental waters.

Production of goldfish and Grass carp was very high in 1997, for reasons unknown, but since then their production patterns have contrasted sharply. Goldfish production has increased from its low in 1998, despite the fact that this species is readily available from a large

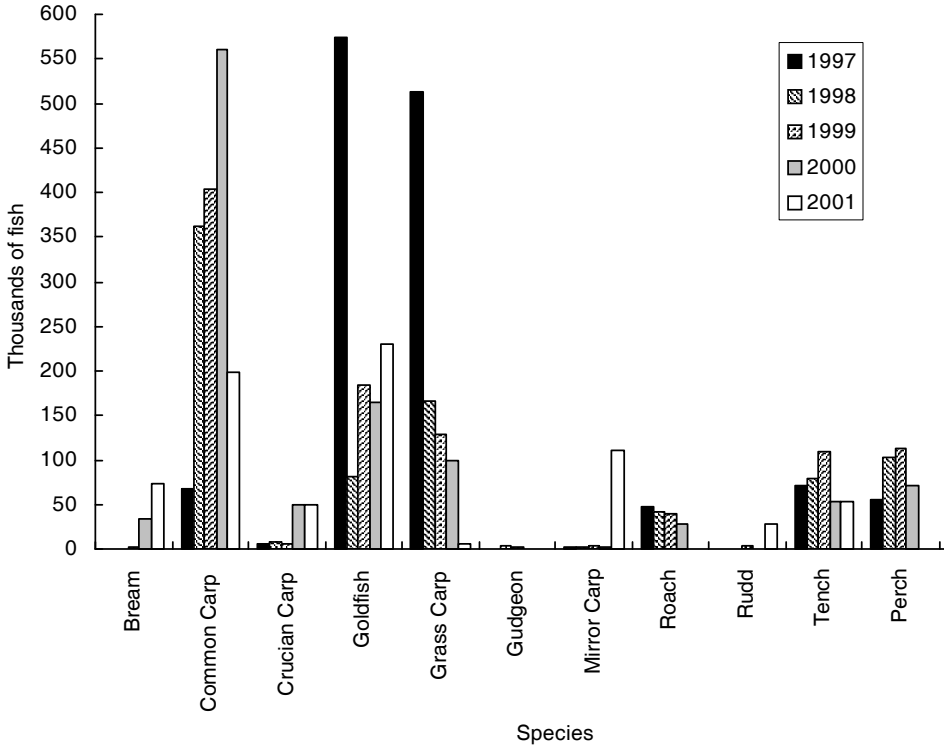

Figure 13. Production of other species involved in the Ornamental Trade

variety of import sources at low prices. It would appear that our goldfish producers are producing a desirable product, as they will always struggle to compete on price. By contrast grass carp production has fallen steadily throughout the period. Initial thoughts were that this production was now being used for fishery re-stocking but the data below (Figure 16) show that this is not the case. It appears that the ready availability of imported grass carp has prevented the establishment of this species within the farm industry.

Restocking production

The market for restocking of coarse fishery waters appears healthy, due to the continued popularity of angling. There has been a steady increase in the production of fish for the restocking of angling waters and the trade has doubled in size over the period. It will be interesting to see if the slight fall in production in 2001 represents a ceiling to the market, or whether this was another sign that the Foot and Mouth disease outbreak significantly curtailed fishery activities in this year. Given that, these data do not include the sales of stock from fishery management operations, it seem unlikely that production has reached a ceiling.

The main fish produced for the angling trade are the Common and Mirror Carp. These fish count for approximately 75 to 80% of the total coarse fish production. From 1997 to 1999 the production of Common carp fell gradually while the production of Mirror Carp was on the increase, however, during 2000 this trend was reversed. Total production of both of these species has continued to increase up until 2001 where there was a very slight drop in total production

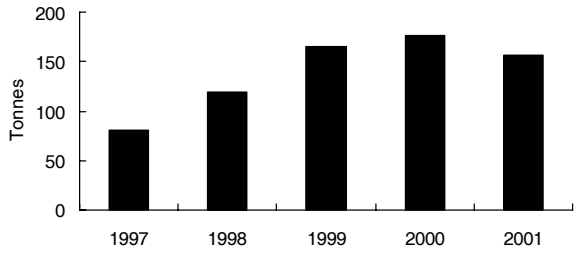

Figure 14. Total restocking production of coarse fish

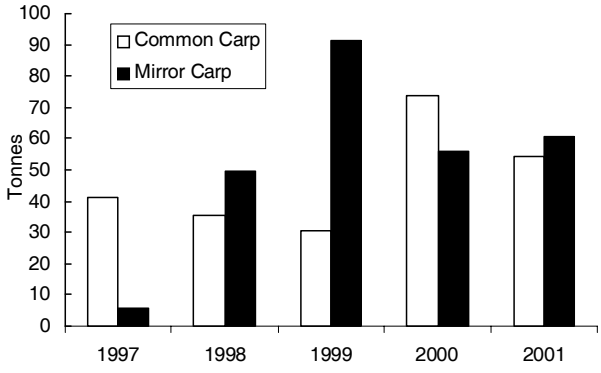

Figure 15. Production of Mirror and Common Carp for the restocking market

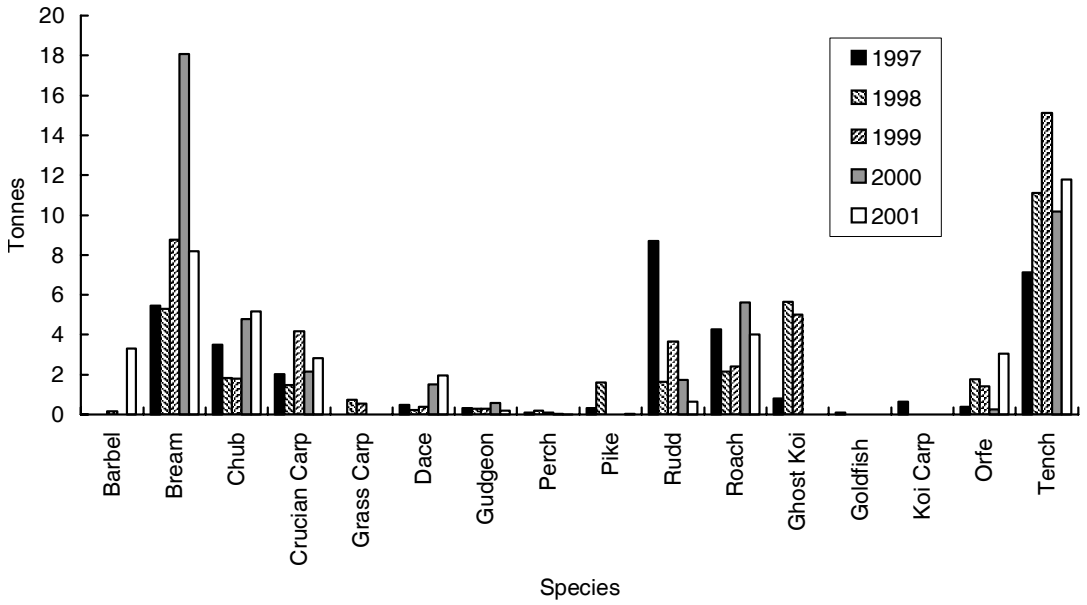

Figure 16. Production of coarse fish (excluding Mirror and Common carp) for the restocking market

as mirrored in the overall figures. The general trend in increased production is encouraging, and it should be noted that this trade is unlikely to be badly affected by the Foot and Mouth outbreak and most producers are in areas not affected by the outbreak.

Of the other species farmed, only Bream and Tench have had consistent levels of production. Of the other species only Chub, Crucian carp, Rudd, Roach and Ghost Koi have had any periods of significant production, although these have not shown any really consistent trends of production. These data confirm that the majority of non-carp coarse fish production is still produced on a rather *ad-hoc* basis from natural spawning within farm ponds. The market demand for coarse fish for re-stocking is such that fisheries will generally stock with whatever fish is available. There are clearly opportunities for coarse fish producers to target particular areas of consistent demand for several of the main species sought by angling clubs, such as tench. It will be interesting to see if coarse fish aquaculture in England and Wales matures to fill such opportunities or continues to operate to an almost random pattern for the majority of species produced.

Conclusion: The perceived status of the trade in coarse fish

The reported production statistics for coarse fish show few real trends, other than the fact that production has typically been poorly focused on market demand. We have therefore gathered the views of our field inspectors who have visited these farms, in order to obtain a view of the immediate state of the coarse fish farming industry.

The opinions of the field inspectors varied considerably regarding the overall health of the coarse fish trade, however, the majority felt that overall the trade was in a fairly buoyant state. They expected some areas to expand over the next few years and others to contract. They thought that the market in carp may be close to its peak and that there is some concern that the carp market may begin to fade. Most felt that that the market in smaller carp, up to 5lb, will remain steady due to the popularity of this size of fish in Match Angling. The demand for larger specimen sized fish is not expected to decline in the foreseeable future, and it will be interesting to see if carp producers feel they can respond to the demand for such fish. Both of these types of angling continue to remain popular and should ensure that the trade is sustained.

Fish farmers have also spoken of a demand for 'Silver Fish' such as bream, roach and tench varieties, to create mixed fisheries. However, these fish are desired at a size that is relatively 'cormorant proof'. Farmers currently have a real difficulty in filling the demand for these fish, which in the case of Tench is satisfied by fish imported from continental Europe.

There is, however, an expressed desire from some angling clubs to obtain home-grown fish. This has arisen partly because of public awareness of the risks posed by

the introduction of disease and those associated with the illegal import of fish. Fishery operators are increasingly realising the benefits of buying fish from a registered fish farm site. They are aware that the stock on these sites is subject to inspection, and the history of the stock on the site is more accessible. Many angling clubs have expressed this interest in home-grown fish direct to the Inspectors, especially those who have experience of, or are worried about, the impact of disease on their waters.

Inspectors also felt that traditional fishery management practices and the sale of 'surplus' fish was increasingly being pressurised by public opinion regarding the welfare of the fish caught. They see this as another opportunity for fish farmers to expand their market share.

The emergence of, and recent publicity regarding, Koi Herpes Virus (KHV) has made the coldwater ornamental trade look closely at home grown Koi as a source of disease free fish in the last couple of years. It is anticipated that the upward trend in production will continue into the 2002 data, which will be collected during the coming year. The availability of cheap imports of other ornamental fish is expected to remain a significant factor in restraining the overall development of the coldwater ornamental fish trade. As most ornamental fish are moved via wholesalers, the market is likely to remain price driven for the foreseeable future.

Finally it was pleasing to find in compiling this review that there are significant suggestions that fish farming in England and Wales may, after a period of contraction, now be in a position to show some growth. There are clearly opportunities to further develop and refine the farming of freshwater fish species. It will be interesting to see how the industry responds to these opportunities.

ARTICLES

SOCIO-ECONOMIC MODEL OF THE UK TROUT INDUSTRY

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Introduction

In March 2001 Nautilus was appointed by the BTA to develop a socio-economic model for the UK trout industry. The study came about as a result of the 'Trout Development Strategy' – a BTA funded project into the future of the industry. This identified lack of consistent and detailed data on both the farming sector and the market as a problem that could potentially be hindering strategic development of the industry.
The aims of the project were to:

- Understand the relative importance of each sector of the industry along the supply chain including contributors such as feed suppliers, processors and retailers as well as farmers.
- Quantify the contribution the industry makes to the rural community in terms of employment and the economic contribution.
- Develop a model of the industry that could be used as a strategic planning tool that could be updated on a regular basis.

This should enable an 'industry balance sheet' to be produced that could be monitored and updated to track the economic changes in the industry and aid strategic planning and development. This required collecting a lot of information from the 'core industry' i.e. trout farmers about the operation and costs of farming and from the operators in the 'wider industry' that supply and are supplied by trout farms such as feed producers, processors, pharmaceutical companies, R & D and trout anglers. The major part of the project was seen as developing an economic model of the 'core industry' of trout farmers that could be revisited and updated.

Information gathering

To obtain information from trout farmers a questionnaire was devised that would collect all the data required and be relatively straightforward to fill in. An option table of turnover ranges and inferred revenues from production quantities and prices was used to gain sensitive information on estimates of revenue. Some information which, although not specifically necessary to produce an industry balance sheet, was also asked for such as type of ownership – rented, privately owned or limited company which the BTA thought would be useful. This not only provided broad information about the structure of the industry but also something that does not change regularly and would not have to be included in each update of the survey.

In addition to the questionnaire trout farmers were also telephoned and visited throughout the country. These included both large and small hatcheries, re-stocking farms, table producers, farms with their own processing operations, farms with their own angling ponds and those with various combinations of these activities. This

helped to provide a greater understanding of the practical operation and the various issues affecting the different types of farms. Because the MAFF (now Defra) comprehensive listing of trout farms was not available the BTA supplied contact details of their membership together with contact lists for sites with extraction and/or discharge consents of fish farms from the Environment Agency and Scottish Environmental Protection Agency (SEPA). From these combined sources a contacts database of 481 UK trout farms was obtained.

The response

A total of 75 questionnaires were received by mail, fax, e-mail and from interviews, giving a return rate of about 15%. Of the 75 questionnaires, 40 contained sufficient information about the costs, revenue and operations of farms to build the model. These 40% represented 11% of the total number of farms and about 53% of total UK trout production. The other 35 questionnaires were partially completed and provided some, but not all, of the information required.

Building the model

It was decided to build the model in Excel to keep it simple. The costs and earnings model of the 'core industry' was split into three farm size categories – small (<50 tonnes per annum), medium (50-200 tonnes) and large (>200 tonnes). Farms were also divided according to their main (more than 50%) income streams into table trout producers, restocking trout producers, mixed table and restocking producers, inter-farm producers and mixed trout production + 'other activity' (e.g. hatchery, own processing, angling ponds and non-trout related activities). Not all size categories contained all types of farm and not all types contained farms of each size category. The five main farm types ended up as >200 t table production, 50-200 t table production, 50-200 t restocking, <50 t table production and <50 t restocking farms.

The derivation of some important calculations contained in the report are:

- **Estimating revenues.** Estimates of farm revenue were obtained by asking how much fish was sold by different routes – to processors, to supermarkets, to other farms, through a farm shop, etc. and what average prices were via each route (see Table 1 below). Information on prices was supplied by FEAP, the industry and from some general assumptions. In future surveys we strongly recommend that BTA collects actual price data from each survey farmer so that the accuracy of sales revenue data, which is critical to the economic performance, can be improved.

Table 1. Prices used to estimate farm revenue (£ per kg)

Sales route	Average price (£ per kg)
To processors[1]	1.53
To wholesaler[1]	1.92
To catering[2]	1.92
To supermarket[3]	2.30
Via own shop/direst sales[1]	2.71
By mail order/internet[4]	5.42
Interfarm sales/interfarm >20 g[1]	2.06
To restocking[1]	2.86
For fry & fingerling/interfarm <20 g[1]	7.79
Via own angling operation[3]	4.00
Via own processing operation[4]	5.42

[1] average FEAP price for 2000
[2] assumes 'catering' price = 'wholesale' price
[3] based on industry estimate
[4] assumes price is 2x 'direct sales' price due to additional processing and added value by this route

- **Scale up factors.** These were based on the proportion of the whole industry represented by the survey data using the formula:

Table 2. Scale up factors

	Farm size categories			
	≥200 t fish production	50-200 t fish production	<50 t fish production	Total t
England & Wales[1]	4,442	4,012	2,369	10,823
Scotland[2]	3,072	1,701	382	5,155
Northern Ireland[3]	-	780	550	1,330
Total UK production	**7,514**	**6,493**	**3,301**	**17,308**
Survey data	7,205	1,664	352	9,221
Survey production as % of UK production	96%	26%	11%	53%
Scale up factor	1.04	3.90	9.38	1.88

[1] CEFAS data
[2] FRS data
[3] DARDNI data

Table 3. Trout farm performance indicators by major farm type

	≥200 t table	50-200 t table	50-200 t restocking	<50 t table	<50 t table
Average est. product value (£/kg)	1.64	1.73	2.50	2.80	2.92
Net revenue (£/kg)	0.44	-0.10	0.53	0.79	0.89
Profit margin	27%	-6%	21%	28%	31%
Value added (£/kg)	0.63	0.25	0.91	1.28	1.48
Wages per FTE (£)	16,349	15,453	11,462	2,475	6,119
Tonnes/FTE	83	20	30	5	11
FCR	1.14	1.07	0.87	1.05	0.93
Total cost (£/kg)	1.20	1.83	1.98	2.00	2.03
Feed cost (£/kg)	0.55	0.68	0.54	0.67	0.59

Scale up factor = total UK production by size category divided by sample production size category (see Table 2). Data relating to the whole industry was obtained from government production surveys produced by CEFAS, SEERAD and DARDNI.

- **Other calculations.** Calculated averages for each size category, major farm type and the industry as a whole were made for costs (feed, wages, stock, transport, depreciation, maintenance, mortgage/loan interest, heat, light and power, insurance, fish health, environmental charges, marketing and other costs based on survey information), sales revenue (in most cases equal to farm turnover and based on price and sales route information) and profit or net revenue (turnover – costs).

- **Performance indicators.** A number of performance indicators were also generated that could be used as benchmarks. These included net revenue, profit margin, value added, wage costs per full time equivalent, production per full time equivalent, production per m^3, FCR, total costs of production per kg of trout and feed costs of production per kg of trout, see Table 3.

Results

The core industry

The performance indicators given in Table 3 show that average product value changes with different farm types with a consistent trend towards increasing values as farm size decreases. Most of the main farm types are performing well with good profit margins of over 20% except for the medium sized table trout producers, which appear to be making a net loss of 6%. This appears to be because they are literally 'stuck in the middle'. Total costs per kg of trout produced are increased by 1.5 times and so they cannot compete with large farms mass producing for the table market. They also cannot compete with small farms which often supply local markets direct to the customer and therefore have a shorter supply chain.

Economic contribution

Table 4 provides relative turnover values for large, medium and small trout producers. Total UK turnover is estimated to be £36 million.

Table 4. Trout farm turnover

	Farm size categories		
	≥200 t production	50-200 t fish production	<50 t fish production
Survey data £	12 million	3.5 million	1 million
Scale up factor	1.04	3.90	9.38
Estimated total turnover (£)	12.5 million	13.7 million	9.6 million
Estimated total UK turnover (£)	36 million		

Employment contribution

Table 5 gives trout farm employment figures for large medium and small producers. Estimated total UK employment for full time equivalents amounted to 632.

Table 5. Trout farm employment

	Farm size categories		
	≥200 t production	50-200 t fish production	<50 t fish production
Survey data FTE[1]	93	50	36
Scale up factor*	1.04	3.90	9.38
Estimated total employment FTE	97	197	338
Estimated total UK employment FTE	632		

[1] FTE assumes FT summer employees are employed for 6 months and winter employees are employed for 6 months and that part time labour is equal to 0.5 full time labour i.e. the equivalent of 3 months.

FTE = no. summer employees ÷ 2 + no. summer PT employees ÷ 4 + no. winter FT employees ÷ 2 + no. PT winter employees ÷ 2

** scale up factor given to 2 decimal places only*

Sub-sectors

The core trout farming industry can be roughly divided into three sectors:

1. Hatcheries producing ova/fry/fingerlings. The whole UK trout farming industry requires approximately 100 million eggs per year. Most ova are imported from outside of mainland Britain – from the Isle of Man, Denmark, South Africa and Northern Ireland. Many of the mainland UK farms that do produce ova/fry/fingerlings retain some or all of them for their own use. About half of the UK demand for fingerlings is met through sales from one farm to another, while the remaining demand is met by farms producing their own fry and fingerlings. The sale of ova/fry/fingerlings typically contributes only a small proportion of the total farm income - less than 5%. Other activities such as table and restocking production are more important sources of income.

2. Table trout producers. Total UK table trout production is approximately 14,000 t. The 38 table trout producing farms contributing to the study produce a total of 8,330 t of table fish. This represents 69% of UK table fish production. This is the most important sector for the largest farms (those producing >200 t per year), accounting for over 88% of turnover. The most important route of sale for most UK table trout is from farmer to processor. Direct sales to supermarkets are not important to the majority of farms. Most trout finds its way into supermarkets via processors.

3. Restocking trout producers. Total UK trout restocking production is approximately 2,000 t. The 35 farms contributing to this sector in the survey produce a total of 1,204 t of fish, corresponding to 60% of UK production. Restocking farms are generally smaller than table farms but can receive up to twice the farm gate price of table fish. Sales are generally more localised and product volumes lower. This is largely because of lower stocking densities and high transportation costs associated with moving large live fish. Production of restocking trout is most important for small farms producing <50 t fish per year, accounting for over 70% of turnover. Many of these smaller farms producing trout for restocking have their own recreational fisheries the income from which is also important.

The wider industry

Upstream industries

These support the core trout farming industry by supplying goods and services and include feed manufacture, research and development and pharmaceuticals - see Table 6.

- **Feed manufacture.** This is the largest sector and on average account for 35% of total operating costs across the whole trout farming industry. The study identified seven different sources of feed used by UK farms supplying approximately 18,000 t per year, worth over £11 million. The largest manufacturers of trout feed – Ewos and Trouw, account for over 90% of these sales. Food production provides employment for around 40 people and generates turnover of £9.71 million per year.

- **Research and development.** Six research projects are funded by Defra that are specifically connected to the trout industry. Running partially or wholly between 2000 and 2005 and costing over £1.1 million, they account for about 15% of the total finfish culture R & D budget. In addition, a number of other aquaculture research projects are running that are likely to benefit the trout industry in some way.

- **Pharmaceuticals.** The survey revealed that average farm expenditure on fish health during 2000/2001 was £4,708 (range £0 - £39,000). Fish health costs are greatest for hatcheries and farms producing fry and/or fingerlings because they are more susceptible to disease than ova or larger fish. Novartis, Alpharma and Aquaculture Vaccines Ltd are the main companies in this sector.

Downstream industries

These are industries that are supplied by the core trout farming industry. They include processors, retailers (supermarkets, fishmongers, restaurants, catering, pubs etc) and recreational trout fisheries.

Table 6. Estimates of total UK trout industry employment and turnover

	Total no. businesses	No. employees	Turnover (£ million)	Value added (£ million)
Angling	>1,000	>1,000	>125	22
Trout farms	481	632	36	13
Processing	24	~300	~30	9
Feed manufacture	7	33	10	1
Research		~7	0.2	
Pharmaceuticals	3	3	0.2	
Total	**>1,515**	**>1,975**	**>201**	**46**

The table trout market

Trout processing employs over 250 people, generates a turnover of over £23 million and added value of over £6.7 million per year. Five processing companies supplied by a relatively small number (about 30) of large farms produce approximately 95% of all trout processed in the UK. The remaining 5% is produced from small companies and from trout farms themselves. Four of the five large processors supply all the major UK supermarkets, which sell approximately 8,000 t (about 60%) of the trout produced for the table while two of the five supply a large proportion of the commercial catering industry (e.g. airline catering, commercial catering services for pubs, restaurants etc.). The local catering and retail markets such as pubs, restaurants, hotels and fishmongers are important markets for smaller farms and for trout sold wholesale, accounting for about 2,000 t or 14% of UK table trout.

The small-scale element of the catering market is especially important to farms producing <50 t of fish per year. These farms build up a loyal customer base providing fresh and processed (gutted, fillets, smoked) trout. Sales direct to the consumer through farm shops, farmers markets, mail order or internet sales account for another one per cent of table trout sales (approximately 200 t) and are again particularly important for smaller farms.

Angling

Recreational anglers are the 'consumers' (often literally) of farmed trout sold for restocking purposes. They pay for the opportunity to catch such fish through fees to angling clubs and fisheries as part of the angling experience. Trout fisheries are known as 'put and take' fisheries because the fishery operator puts the fish in the pond or river and the angler catches and takes it away. A reduction in the number of trout that people want to take home with them (because of increased availability of prepared trout in supermarkets), and in the total number of anglers has reduced the demand for restocking trout.

There are few data relating to the number of fisheries in the UK but over 19,000 still-water trout ponds and lakes have been identified in E & W alone. There are about 474,000 trout anglers in the UK spending approximately £99 million per year on fishing for trout. It is estimated that recreational trout angling employs over 700 people.

The future

In order that the model, performance indicators and benchmarks can be revisited in the future the questionnaire has been revised to make it more user friendly, based on feedback received during the survey. In addition a framework spreadsheet model has been generated with built-in macros and results tables. All that will be needed is the data.

OXYGEN AND AERATION SYSTEMS

by Ivar Warrer-Hansen, Trouw (UK) Ltd, Wincham, Northwich, Cheshire CW9 6DF

This article has been reproduced from the Autumn 2002 edition of Trouw Outlook, the magazine from Trouw Aquaculture

Oxygen injection systems using pure oxygen or aeration systems using atmospheric air are used on most trout farms today. Elevating oxygen concentrations in water can be considered for production enhancement purposes, i.e. as a permanent substitution for an inadequate water supply. It can also be used for emergency situations - for instance if there is a history of water shortage in dry summer periods.

In a situation where a system will be used for longer periods, even all year round, the emphasis is on low running costs and not as much on capital costs. There will of course be an upper limit where depreciation will have too high an impact. On the other hand, used for emergency situations, one would not spend too much on capital costs whereas high running costs for a short period of time is immaterial as long as the fish are kept alive.

In the following will be described the two principles in elevating oxygen concentrations in water 1) aeration systems and 2) pure oxygen systems.

Aeration systems

The exchange of oxygen between air and water takes place when the concentration of oxygen in the water is not in equilibrium with the atmosphere. The absorption of oxygen by water is a first order process, i.e. the rate of absorption is directly proportional to the oxygen deficit (the oxygen saturation concentration minus the actual concentration).

Cascade aerator

Linn Low pressure surface mixer

In other words, when oxygen levels are low, it is relatively easy to raise oxygen concentrations. When levels are high, the efficiency drops drastically. As oxygen levels approach 100% saturation, aeration efficiency approaches zero.

The two broad categories of aeration types are:

1. Diffused aeration, working either from a compressor/blower or through airlifts.

2. Surface agitators, e.g. Paddlewheel agitators, cascade aerators, and injectors.

The efficiency of different types of aerators is shown in Table 1.

Table 1. Energy requirements for different aerators under standard conditions (Water Quality Institute, 1993)

Type of aerator	kWh/kg oxygen
Injector	0.21
Bubble diffusion	0.27
Cascade aerator	0.60
Paddlewheel	0.58

The figures shown are based on standard trial conditions for aerators and show the energy use by aerating water from 0 mg/l up to 6 mg/l at 20°C.

From above it can be seen that cascade and paddlewheel aerators are relatively efficient, at least up to 6 mg/l under standard trial conditions. Above this level efficiency drops significantly.

Bubble diffusion, which is used widely on fish farms, is not as efficient as the surface agitators. This is basically because the depth normally encountered in inlet channels or fish tanks are often too low, 1-1.5 m, for efficient uptake of oxygen. If depths were higher, 3-3.5 m, diffusion can be quite efficient, even more so than surface agitators.

Recently, a number of fish farms have installed oxygen wells. These consist basically of round concrete rings (or squares) sunk into the ground. The depth needs to be 3.5 metres. The ring is divided into two chambers: a down flow chamber and an up flow one. The dimension has to be matched with the water flow so that a specific down flow water velocity is maintained. The diffused air is added in the down flow chamber and because of the down flow; the air/water contact time is prolonged. As the depth is 3.5 metres, the oxygen up take is very efficient. The depth must not exceed 3.5 metres, as there then is a risk of supersaturation with nitrogen.

The diffusers are easily made from 4 inch Wavin piping drilled with 2 mm holes. The bubble velocity is 0.28 m/sec. The down flow water velocity should be around 0.14-0.18 m/sec (see Figure 1).

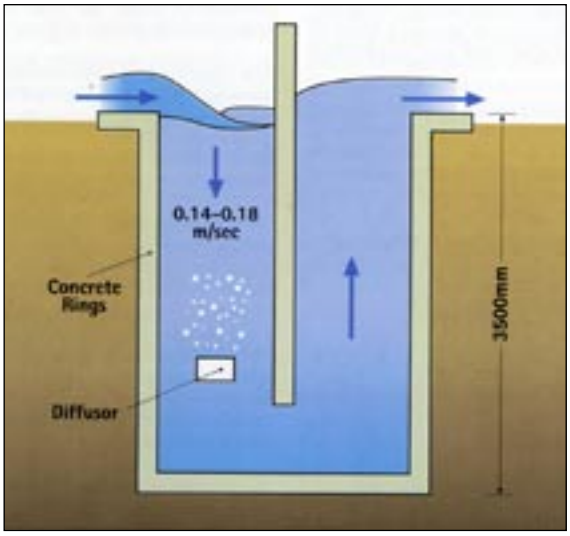

Figure 1. Aerator well

Wells as described above can raise water saturation levels from 60% to 90% with an energy consumption of 1.3 kWh per 100 l/sec. This equals 0.82 kg oxygen per kWh, which is significantly higher than paddlewheel and cascade aerators.

Oxygen injection systems

If a fish farmer wishes to maintain an oxygen regime of above 70-80% saturation with the aim of significant improvements in fish performance and reduction in stress related diseases, then pure oxygen systems will be suitable. Except that the recently developed principles in aeration wells mentioned previously are possibly equally as viable. However, any choice will always depend on the physical layout of a farm and some systems will on some farms be more suitable than others.

Adding pure oxygen to water is more of a linear process than a first order process. It is not much more expensive to raise oxygen levels from 80 to 100% than say, from 50 to 70% saturation. It is also possible to operate supersaturation levels.

There are many principles for adding oxygen to water some of which are:

1. Diffusion: e.g. with low pressure bubble diffusion. This is not normally economic at low water depths.
2. High pressure systems: e.g. dry mounted pressure cones.
3. Low energy systems: e.g. surface mixers or mixed columns.

Dry mounted pressure cones are very good at dissolving oxygen with high transfer efficiency, but at some cost. The pressure in the cones is around 1.2-1.5 bar and it costs in the region of 1.5 to 2 kW per kg of oxygen dissolved. Cones are used in numerous re-circulation systems, as it is easy to distribute a partial flow of supersaturated water in a separate pipe to each tank.

Low energy systems in the form of surface mixers are much cheaper to run, around 0.25 to 0.5 kW per kg of oxygen dissolved. They operate by lifting water with a propeller and trickling it over specially designed cascade steps where oxygen is added. These types are mainly used for inlet channels or larger ponds on trout farms.

Mixed columns operate by pumping a partial flow of water up into a cascade tower under some pressure and obtaining supersaturation levels of 150 to 180%. The water is then mixed with the main flow before entering the rearing unit. These would be more suitable for tank units.

The latest innovation within oxygenation is the oxygen turbo mixers. These are units, which can be mounted inline in connection with the inlet to individual tanks. They are 3.5 metres high which means that one has to go below ground level to mount them.

They work on the principle that water enters the top and is distributed over a perforated screen and drops into the oxygen mixing zone. They need 1 metre water head in the ring mains, which together with the slight gas pressure from the oxygen itself creates enough pressure to 'pump' the water to the tanks. See Figure 2.

The turbo oxygen mixer achieves 75% oxygen transfer efficiency with very little water head and is properly the most cost-efficient device.

Turbo oxygen mixer

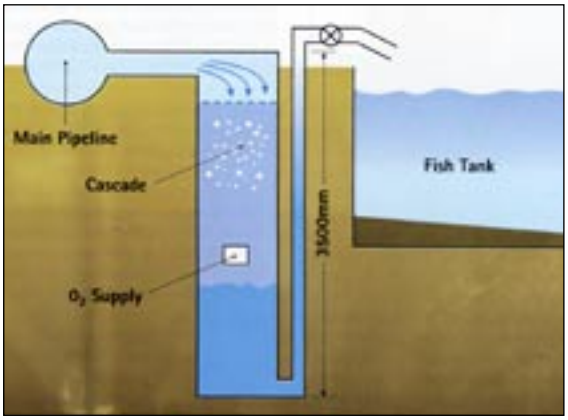

Figure 2. Oxygen turbo mixer - Interagua (patented)

Conclusion

An aeration or pure oxygen injection system can improve the performance of a fish farm including improved fish health. Aeration systems, either bubble diffusion or cascade aerators, are normally quite straightforward to install. Aeration systems are ideal in situations where water quality is very poor and will help keep fish alive. However, there are limitations on the dissolved oxygen levels which can be achieved.

Pure oxygen systems give further advantages in the range of oxygen levels that can be achieved and are more suitable for production enhancement purposes. Compensation for low water flows with doses of high oxygen can, however, create a potential risk of excess carbon dioxide levels, which has to be taken into consideration.

SLEEPING DISEASE

by Edward Branson, MRCVS

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In the early summer of this year, Sleeping Disease has been diagnosed in rainbow trout in the UK. Sleeping Disease (SD) is an infectious disease of rainbow trout (Boucher and Baudin Laurencin 1994) caused by a very similar, if not the same, virus to that responsible for Pancreas Disease (PD) in Atlantic salmon (Castric and others 1997).

PD is historically an infectious disease of Atlantic salmon in the sea, is endemic in Scotland, Ireland and Norway, and has recently also been seen in rainbow trout in the sea in Norway. Despite this, SD has not apparently been present in UK fresh water trout farms until now. It has been reported in Spain and Italy, but especially France, where it has been present for several years, particularly in Brittany.

SD is so named because affected fish usually become inappetant and, in many cases, lie on the bottom of their raceway/pond until disturbed. They will then swim away, but soon settle back onto the bottom. Although there is little or no gross pathology associated with the condition, the histopathology is very characteristic, with pancreatic, red muscle and, often, heart muscle damage. Later on in the disease antibodies to the virus can be detected in the blood. Not all affected fish will display the 'sleeping' behaviour however, and fish can contract the disease, suffer some of the pathological changes described above, but show no clinical symptoms.

It is reported from France that the disease usually occurs at water temperatures between 9 and 15°C, and can affect all sizes of rainbow trout, but is most serious in fingerlings (around 10-15 g) where it can cause around 50% mortality over 3 to 4 weeks, and even more if other diseases are present concurrently. Generally the 'sleeping' behaviour will be seen in this size of fish. These findings have been borne out by the UK cases.

The disease definitely spreads horizontally, and reports from France suggest that vertical spread is also likely. There is no specific treatment for the condition. Although there is apparently little effect on the subsequent performance of fish which recover from the disease, some people have reported possible carcase quality problems in these fish at harvest.

It seems likely that the recent identification of SD in UK is its first occurrence here. Because of the preferred temperature range of this disease, it is possible that it

could be a significant problem in some areas of UK, and potentially more of a threat than in France where it was first reported. Also, it is not clear how Atlantic salmon in fresh water would react to the disease, an important consideration given the temperatures at which most salmon parr are kept. Despite these facts, SD is not a notifiable disease, so no statutory controls are available to control its spread.

If the disease occurs in fingerlings, because of the probable high mortality, slaughter of the infected stock should be considered. Slaughtering the stock would eliminate the immediate source of the virus, and thus reduce the risk of spread. However, even if this is done, there is a strong possibility that the virus may already have spread, the degree of this spread being determined by the biosecurity measures in place on the farm. If fish are slaughtered, once the fish have been removed, raceways or ponds where they were held should be thoroughly cleaned and disinfected. Because of the current lack of knowledge on appropriate disinfectants, a known viricidal agent should be used.

Whatever is done to infected stock, it is important to apply good biosecurity precautions at all times, in order to reduce the risk of contracting and spreading the disease. Entry of the disease onto a farm, (or exit from), should be prevented by limiting the flow of vehicles, personnel, equipment and fish on and off the farm, with suitable cleaning and disinfection taking place where this is necessary. The risk of spreading disease around the farm can be reduced by, for example, having dedicated brushes and nets for each individual or distinct group of pond/ raceways, working from clean areas to dirty, ensuring that personnel carry out suitable cleaning and disinfection of clothes and hands between areas, etc. Maximum risk of disease transfer is associated with fish or anything which has been in contact with fish or fish products.

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THE POTENTIAL FOR RESTOCKING USING ALL-FEMALE TRIPLOID BROWN TROUT TO AVOID GENETIC IMPACT UPON NATIVE STOCKS

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Background

The aim of this note is to draw together information on the potential for the use of all-female triploid brown trout for stocking in situations where there is concern about the possible genetic effects of introducing fertile fish.

Resistance to the use of triploids in the past has been based on three issues:-

i. Arguments regarding the need and whether there are in fact any real genetic 'risks' associated with introductions of fertile fish.
ii. Concern that the triploid fish might have an adverse effect on native stocks through behavioural interactions, predation on eggs etc; and
iii. Concern about whether triploids are 'genetically modified organisms'.

This note concentrates on the last two of these areas of potential concern, other potential benefits and drawbacks, and on the logistics of stocking using all-female triploids.

Why all female triploids?

Triploids are infertile and thus remove the risk of genetic interaction with wild stocks in waters where they are introduced.

Male triploids may still develop functional gonad tissue and may participate in spawning behaviour, which could interfere with reproduction of wild stocks.

Female triploids do not develop mature gonads and do not exhibit spawning behaviour. This reduces the potential for harmful interactions with spawning wild fish, and increases somatic growth and over-winter survival.

For these reasons stocking with triploids should be with females only.

Production of triploids

Developing eggs are rendered triploid by applying a pressure, heat or chemical shock at the time of the second meiotic division (in the first hour after fertilization), causing retention of the polar body in the egg (Crozier and Moffett 1989; Purdom 1983). Chemical and heat shock treatments have given mixed results with a variable proportion of diploids remaining among those successfully transformed to triploids, and pressure shock treatment is generally the method of choice nowadays. Lincoln (1996) reported on tests at Allenbrook Trout Farm which showed a 100% induction of triploids and a very high survival throughout the incubation and first feeding stages. Survival to four weeks after first feeding was 71.1 compared to 69.8% for untreated controls. Subsequent experience has shown that triploids generally have a slightly lower early survival, as alevins, than diploids.

Triploids can also be produced by crossing tetraploids with diploids. Sheehan *et al* (1999) suggested that, as this method can produce guaranteed 100% triploids, it could be useful for situations where introduction of any fertile diploids is totally unacceptable.

How do triploids differ from diploid trout?

Apart from having three sets of chromosomes, as opposed to the usual two in trout, there are a number of other relevant differences.

Many organs and tissues have larger but fewer cells in triploids, including the brain, muscle, retina, liver and kidney (Benfey, 1999). This appears to arise because the extra set of chromosomes dictates an increase in cell nucleus dimensions which in turn affects overall cell size. However, this rather fundamental difference appears to have remarkably little knock-on effect upon physiology, behaviour and general performance. Development rates appear very similar, until the onset

of sexual maturity in diploids. Diet utilisation and energetics appear unaffected. Triploids are generally less aggressive than diploids, which leads to poorer performance when the two are reared together in intensive culture - but these differences disappear when the two are reared separately.

Stillwell and Benfey (1997) found no difference in the swimming ability of diploid and triploid brook trout *(Salvelinus fontinalis).*

Reduced gonadal growth in triploids may allow increased energy allocation to somatic growth, but this may be largely offset by diminished levels of steroids which have an anabolic effect. Over-winter survival of triploids appears higher than that of equivalent mature diploids, and their appearance is different reflecting this non-mature status. The muscle pigmentation in triploids remains strong compared to maturing diploid females, which shift muscle canthaxanthin to the developing eggs.

It is difficult to differentiate visually between triploids and diploids, particularly when both are immature. Diploids will develop spawning coloration, and the males develop kypes, when they mature whereas triploids will maintain their non-mature appearance. There are a number of ways they can be differentiated in the laboratory, the usual one being by examination of the nuclei of red blood cells taken from fry (Lincoln 1996).

Some field experiences with triploids

Dillon *et al* (2000) stocked equal numbers of tagged diploid and (mixed sex) triploid rainbow trout into 18 streams in Idaho. A total of 5400 of each were released, and total returns to anglers catches were 931 triploids and 918 diploid. Most were reported in the year of release; only 29 diploids and 23 triploids were reported in the following year. Thus in this case the performance of the two types was similar, with apparently low over-winter survival of both. The authors suggested that they had used a highly-domesticated strain of fish and that low over-winter survival was to be expected.

The growth of mixed-sex diploid (MSD), all female diploid (AFD) and all female triploid (AFT) rainbow trout in raceways was studied by Sheehan *et al* (1999). The three groups were reared separately, and the feeding regime was adjusted each month according to the weight of fish in each raceway. After 265 days the daily weight gain averaged 1.6 g for MSD, 1.8 g for AFD, and 2.4 g for AFT. The authors suggested that the weight gain of the AFT group would have been higher except that it included about 13% diploid females due to partial failure of the triploid treatment (heat shock). An important point here is that the groups of fish were reared separately. Galbreath *et al* (1994), working with Atlantic salmon, noted superior growth in triploids reared in the absence of diploids which disappeared if triploids and diploids were reared together.

An EU AIR project was conducted to examine the scope for use of triploid Atlantic salmon in farms to remove the risk of genetic interactions between escapees and wild stocks (Anon 1999). Survival to the smolt stage was similar for diploids and triploids, as were somatic growth, swimming performance of product quality. However, overall yields were 10-15% lower for triploids due to reduced seawater survival.

Ray Hill, fisheries manager at the Houghton Club in Stockbridge, produces and supplies triploid trout to several other fisheries as well as using them on his own. He started using them to improve over-winter survival of large stock fish (to be released at 2 lb+) which otherwise (since the banning of the use of malachite) exhibited a high level of infection with *Saprolegnia* associated with sexual maturation; on occasions he would lose in excess of half the stock. With triploids, losses are typically less than 1%. The triploids feed more reliably over winter, and so grow more evenly. An experiment on the lichen involved stocking in the autumn with triploid fish of 300g as an alternative to larger fish the following spring. Survival and growth over winter were good and the fish were free-rising early in the season, and were considered a more reliable contribution to early-season catches than fish just stocked. Ray reports that anglers consider the triploids as a stronger fighter when hooked, but this may be due at least partly to better condition rather than being triploid *per se.* Observations on his own water suggest that triploids do not accompany spawning fish onto the shallow redd areas but remain in their normal feeding areas throughout the autumn and winter.

Reliability of triploid production

While early attempts at producing triploids had varying success (i.e. a variable proportion of the fish produced were still diploids) careful application of the pressure shock technique appears more reliable; Trevor Whyatt (Allenbrook Trout Farm) claims a very high success rate - close to 100%.

Any ‘failure’ would result in normal diploid fish that would mature and be capable of spawning normally.

Availability and cost

All-female triploid brown trout are in commercial production at a number of fish farms. Much of the pioneering work has been undertaken by Trevor Whyatt at Allenbrook Trout Farm. He produces large numbers of eggs, which he sells at £13.50 per thousand

compared to £12.50 for diploids. There is a slightly lower survival rate in triploid fry. These two factors increase the cost of triploid production compared to diploid. Allenbrook charge £3.00 per lb for triploid stock fish compared to £2.75 for diploids. Ray Hill (Houghton Club) has a small premium on triploids. Westacre (Kings Lynn) charge £2.75 for both triploids and diploids, absorbing the extra cost. Croxley Hall Trout Farm (Rickmansworth) supply only triploids. Other possible suppliers are Anna Valley Fish Farm, Andover; Rooksbury Mill Fishery, Andover, (mixed-sex triploids); Roadwater Fisheries; and Lechlade Trout Farm. Contact details are given at the end of this note.

Concern over 'GMOs'

With current concerns over 'GMOs' ('genetically modified organisms') and chemicals used in food production all manipulations such as sex reversal (all-female stocks) and triploid production will be carefully scrutinised.

The production of all-female stocks involves hormone treatment of the 'father' (a genetic female that is treated to develop into a functional male). However, there is no hormone treatment of the offspring (the fish of concern here) and the eggs are perfectly normal females.

Triploids are not 'GMOs' in that there is no introduction of genetic material from other organisms. Although triploidy sometimes occurs naturally in fish (Benfey 1999), it can be deliberately produced, usually by high pressure shock at the appropriate development egg stage. Triploids have the same genetic material as diploid trout but more of it, three sets of chromosomes as opposed to two. A key concern about 'GMOs' is that their use may result in their foreign genes being inadvertently released. The whole point about the proposal to use triploids is they are infertile and will not release their genes into the wild. Any 'failures' are entirely normal diploids.

A consideration of limitation and risks

In the past it has been suggested that triploids are more aggressive than diploids and may displace them from the optimal territories. As all-female triploids do not mature and continue feeding while diploid fish are spawning it has been suggested that they may prey on the eggs of wild stocks. It has also been suggested that stocked triploids may lock-up a significant part of the ecological resource without contributing to future recruitment.

These issues are now considered in turn.

The origin of the suggestion that triploids may be more aggressive than diploids is obscure. There is no such evidence in scientific reviews, and user experience with brown trout in the UK is that the diploids are more aggressive. Further, the evidence that any growth advantage of triploids in captivity is lost when they are reared together with diploids suggests that triploids are not dominant.

The fact that triploids continue to feed through the autumn while maturing diploid fish do not points to the possibility that triploids could predate on the eggs of spawning fish - certainly immature trout are known to do so. However, this has not been observed, and Ray Hill states that the triploids remain in their natural territories and do not follow spawning fish onto the redds. Overall, however, there is insufficient evidence to answer this concern with authority.

The issue of locking up a significant part of the ecological resource without contributing to future recruitment is an interesting one. Preventing the fish from contributing to recruitment is of course a prime reason for the use of triploids. The extent to which they divert ecological resources depends upon stocking levels and the production of wild fish. It must be assumed that there is spare 'ecological resource' to justify restocking in the first place and stocking must be at an appropriate level whether it involves diploids, triploids or rainbow trout. Trevor Whyatt suggests that if you over-stock with triploids it is they that are displaced downstream, not the wild fish.

The overwhelming argument in favour of use of triploids is that it will cause no permanent damage to the wild stock. If any undesirable effects become apparent merely stopping stocking will cause the problem to disappear.

It appears that the extent of use of triploid brown trout for restocking in rivers in Southern England is considerable but unknown. A survey of its extent is strongly recommended; this could be usefully combined with canvassing user views and experiences.

There remain some uncertainties regarding potential interactions with wild diploids, and over-winter survival. These could readily be addressed with some straightforward monitoring of experimental stockings. This would greatly help the case for more extensive use of triploids.

Conclusions

All-female triploids would appear to satisfy the requirements for a fish for stocking that have all the beneficial attributes of diploids without the genetic risk to the native stock. They appear to be in extensive use in the south of England at least, being preferred for their higher over-winter survival in both farm and river. Consideration of a firm policy for their use in situations where a genetic risk is perceived with the use of diploids would appear to be a sound and justified

development. Before that is done, however, it would be prudent to examine in more detail the performance of stocked all-female triploids, especially with respect to possible interactions with wild fish.

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BRITISH TROUT FARMING CONFERENCE, SPARSHOLT

5-6 SEPTEMBER, 2002

Dick Lincoln, CEFAS, Pakefield Road, Lowestoft, Suffolk, NR33 0HT

A total of 14 papers were presented over the 2 days of this conference covering a wide range of industry related issues. Two survey reports, on the trout industry and the importance of angling, provided a revealing insight into the present state of these two industries in the UK. Aspects of farming technology covered re-circulation, feeding systems and ozone applications and the present position on fish waste disposal was discussed in relation to new EC legislation. Further papers on feed raw materials, restocking, health care and trout production in France and Italy provided a well balanced programme with something of interest to all sections of the audience.

The following covers papers delivered on the first day of the conference except the Nautilus socio-economic survey of the UK trout industry which has been printed in full in this issue.

Use of Ozone

The first paper presented by Erik Jurgensen, a biologist, fish farmer and now involved in the construction and manufacture of wastewater treatment plants for Bio Aqua AS discussed the nature and use of ozone in aquaculture and fish processing. All stages of fish production and processing, he said, requires a constant

need to reduce cross infection in the prevention of disease. Ozone (0_3), acts as a strong oxidising agent that not only breaks down organic matter but kills most micro-organisms making it ideal for disinfecting and waste water treatment purposes. Chemically ozone is an unstable form of oxygen produced by adding energy to 0_2 to produce 0_3. It forms a light blue gas and may be generated naturally in lightning strikes and during sunny days in woods.

The industrial generation of ozone involves dialectic crystals and high voltage electricity. The process is relatively inefficient however, producing only 6-7% ozone but large generators can manufacture several kilos per hour. Ultra violet light at a particular wavelength can also be used to generate ozone. However it is less efficient than using electricity and more expensive since the lamps used only last for one year compared to the much longer durability of electrical equipment. Air or pure O_2 can be used as the feed gas producing 2-4% and 12-16% ozone respectively.

The oxidation potential of ozone is very high, he explained, although not as high as chlorine, breaking down C=C and C=H bonds in all organic matter. It is effective in decomposing humus compounds in lakes to improve water colour and some inorganic compounds can be removed by oxidation and precipitation such as metal ions (iron, copper, lead, cadmium etc). When used as a disinfectant ozone attacks universal biological compounds by breaking down cell surfaces killing both viruses and bacterial spores. The process is independent of pH, does not pollute water afterwards and is quick and efficient. For example 0.4 ppm ozone for 4 minutes kills most pathogens including cryptosporidium. It can also remove bad smells, pesticides and phenols. The disadvantages of ozone are it is dangerous to inhale, cannot be stored for long periods and must therefore be produced on site and it reacts adversely with some materials such as natural rubber.

The low running costs and neutral effect of ozone on the environment lends itself well for the treatment and re-use of waste water from the food industry where it is effective in the flocculation and decomposition of fat, protein and amino acids. Pre-treatment of waste water to decompose fat, protein, benzene and phenols, for example, improves the performance of biological filters. Other uses involve cleaning of aquaculture waste water, adding oxygen as it does so, sterilisation and cleaning of sanitary water and the detoxification of drinking water. Ozone can also be used to remove odour from the atmosphere where, for example, people are crowded together. The concentration of ozone is short lasting, from a few seconds to 30 minutes and can be measured as the redox potential from probes manufactured for use in air or water.

During discussion of this paper it was revealed that ozone removes algal taint from water but fungal spores are difficult to eradicate and requires high concentrations of ozone. Salt water treatment with ozone produces bromate from bromine which is dangerous and must be removed with chlorine. The average cost of treating water for a hatchery (using one cubic metre of water per hour) would be approximately £15,000 per year.

Recirculation

Recirculation technology has made considerable advances over the past 20 years to a stage where it is now possible to grow a variety of fish species under commercially operating conditions. Bent Hojgaard, an aquaculture consultant specialising in the planning, design and construction of fish farms described the operational features and practical applications of super intensive and semi intensive recirculation systems to fish rearing. He began by describing how a typical system is built up, taking as an example a rearing unit in Chile producing 6 million salmon smolts.

Egg incubation and fry rearing takes place in two hatcheries and on-growing in tanks all under intensive recirculation conditions using disc or drum filters for removal of suspended solids from the rearing tanks. After hatching fry are reared in fibreglass tanks up to the size of 4-5 g and then transferred to larger concrete tanks lined with epoxy resin. Cleaning up water from the rearing tanks commences with mechanical filtration using disc or drum filters for removal of suspended solids followed by forced aeration through diffusers to strip off carbon dioxide. Pressure pumps then distribute water from a sump tank to the biological filter units where dissolved excretory products, mainly ammonia, is converted to nitrate. Fluid bed filters are used for this process but these often produce fine particles in the water and therefore fixed film filters are often preferred. These come in a range of configurations, he said, designed to greatly increase the surface area on which the micro-organisms that degrade the waste grow. Those used in the Chilean plant consisted of metre square bio-blocks (bio block 150) held in place with iron grids, each providing a surface area equivalent to150 square metres. Water next passes over trickling filters using bio- block 200 which is more resistant to clogging followed by oxygenation using oxygen cones. Pressure pumps are used in this process which incorporate regulators to conserve power. Low pressure propeller pumps, which have a small energy consumption, then pass water through a UV treatment plant where suspended bacteria are killed before return to the fish tanks.

Hatchery operations are carried out under a strict regime of disinfection procedures to prevent disease. All workers are required to wear gowns and wash hands

before entering production areas and visitors may only view facilities through a plexiglass visitor gallery.

Semi intensive recirculation systems were then discussed which, he said, could be used for trout production. These incorporated mechanical and moving bed biofilters and an oxygenation system but only a certain proportion of the water was recirculated using low cost air lift or Archimedes screw pumps.

Generally recirculation systems are reliable and function well, he said, but currently involve high capital investment and running costs. The next generation would concentrate on the development of low investment systems that are cheaper to operate enabling them to be more cost effective for salmon and trout which currently they were not. The features of a cost-effective system are a well functioning design using quality equipment and operated by good staff using best management practices.

Some points raised in discussion of this paper involved disease outbreaks and operating details. In the event of a disease outbreak, he said, early detection was imperative and if, for example, IPN was contracted the procedure would involve raising the temperature from 12 to 16°C to minimise its effects. Carbon dioxide stripping is very necessary and a simple procedure to carry out, which, if allowed to build up would reduce fish growth. Removal of CO_2 influences the pH of water which must be regulated with the use of chalk ($CaCO_3$). The reasons for two biological filters, he said, was because a submerged filter sediments out particles while a trickling filter adds oxygen to the water very cheaply.

Raw materials in fish feeds

John Williamson, Business Develoment Manager for Trouw Aquaculture provided an overview of the principles behind the formulation of manufactured feeds taking into account nutritional requirements, the raw materials available and the constraints and implications of using alternative feed sources.

Fish, he explained, have no specific need for any particular ingredient but do require an energy source and a few essential nutrients. Their requirements are well documented and include 10 amino acids, 6 macro minerals, 6 trace minerals and 4 fat-soluble vitamins. The declarables of a particular feed are crude protein, fat and ash, nutritional values, the digestibility of essential fatty acids and total available vitamins. There are many factors involved in formulating a feed including consumer acceptance, the target market, cost, physical properties and fish growth although the last factor is also very dependent on genetics and feed presentation. The available raw materials are fish and plant meals and oils, animal by-products, single cell products and crystalline additives.

Global production of fish meal and oil currently stands at 6.2 and 1.2 million tonnes respectively and these levels are unlikely to change much, he said, although fish oil will eventually become limiting. Aquaculture accounted for 40% of global production in 2001 of which 70% was used for fin fish production. Fish meal prices continually vary and always increase in El-nino years. Currently fish oil costs $600 per tonne.

Fish meal is the preferred choice for fish diets because of its high protein content and correct amino acid profile. It is also easily digested, contains all the essential fatty acids and is high in phosphorus. Alternatives to fish meal are the oil seeds – soya, rape, cotton, lupin, sun flower and cereals such as wheat and maize. In 2001, 198 million tonnes of protein raw material was manufactured from these sources 4% of which was used for aquaculture purposes. There are disadvantages of using plant material however. These include a low protein content, reduced digestibility, high fibre and the presence of anti-nutritional factors. In spite of this soya products can be included in salmonid diets at rates of up to 20-30% but in excess of this pathological changes may develop in fish. Soya prices have fallen in recent years and are likely to remain static. Gluten (a by-product of wheat and maize), lupin and potato proteins can also be used as replacements for fish meal. Animal products are an excellent source of protein but are now forbidden in animal feeds. Single cell proteins from yeast, algae and bacteria are potentially useful but these have yet to make an impact. Global production of vegetable oils in 1998 amounted to 111 million tonnes, mainly from soya and rape seeds. Vegetable oils contain C18 fatty acids and lack the long chain N-3 fatty acids characteristic of fish oils.

Production trials with trout grown from 250 to 800g on diets containing rape, linseed, capelin and soya oil showed no differences in performance parameters. Sensory evaluation studies indicated that trout grown on a diet containing capelin oil tasted best but generally the results were indistinguishable. This, he said, was good news for fish farming, enabling vegetable oils to be substituted for fish oils which were already in limited supply.

The talk concluded with the results of an attitude survey which revealed 62.7% thought most salmon were supplied from the wild, 66.1% thought wild salmon were in plentiful supply and 78.2% thought wild stocks were diminishing.

Feeding systems

The next paper by Sunil Kadri of Aquaculture Innovation surveyed the range of feeding systems available that could be used for trout farming, highlighting the relative advantages and disadvantages of each in terms of feed delivery and control technology.

Feed is the largest single cost in fish farming and the main thrust of technical development and sales had mostly centred on the sea cage culture industry for salmon. This, he said, was likely to change because of the low profit margin on salmon, the progressive rise in marine fish culture and EC proposals to move cage farming from coastal regions to offshore.

The two main components of a feeding system are the method of food delivery, which can range from simple hand feeding to a fully automated system and the method of feed control which is available for all delivery methods. Starting with the simplest, traditional hand feeding, he said the advantages of this method are that staff had the opportunity to regularly inspect fish stocks and good feed distribution could be achieved. The main disadvantages were the high labour costs and the subjective assessments and inconsistencies between individuals over the amount of feed to give. In addition, feeding capacity is limited and delivery timed for staff benefit rather than the fish, usually taking place during daylight hours whereas trout are mainly crepuscular feeders during dawn and dusk. Improvements in efficiency could be achieved on larger farms by using a manually operated cannon feeding system incorporating a blower unit which increases both feed delivery rate and spread.

Turning to automated systems he said the main advantages here are that feeding capacity was no longer limited by manpower and timing could be optimised to suite the fish. Starting with the traditional hopper system this had the advantage of low initial capital cost and the facility of adding more units when required but with the disadvantage of high labour maintenance costs. A variety of power configurations are possible with different types of spreading dosing motors all under programmable control. Variable hopper capacities are available allowing delivery of up to 2 tonnes of feed but most were less than this. Robot feeding systems mounted on rails have been developed to dispense feed along raceway systems and multiple tanks. Although efficient with low labour costs they are only presently available for indoor farming facilities but out-door systems are currently under trial.

Blower feeders involve large feed silos of up to 100 tonnes allowing high rates of delivery at low cost but with high capital investment. Modern software feed management programmes are used but if improperly configured they can result in unacceptably high feed breakage and wastage and poor distribution. Blower units both cool and distribute the feed through multiple pipes via a selector valve.

Having surveyed the methods of feed delivery Dr Kadri then turned to control systems responsible for starting, adjusting and stopping feed delivery. Manual control was possible but the same advantages and disadvantages applied as for manual feeding delivery. Both surface observations using the human eye and sub-surface cameras involve subjective judgements on feeding which is not satisfactory. Pellet sensors that provide information on the number of uneaten pellets at different depths can improve objectivity and provide more accurate information on feeding rates. Automated feed control systems most commonly employ timer control.

Environmental sensors can be used to modify feeding rate on the basis of temperature, oxygen saturation etc. Pellet sensors require a significant water depth to be effective and for this reason are mainly used in cages. Infra red sensors or hydro acoustic systems can be applied to tanks and raceway systems. Active demand feeders or trigger feeders have undergone considerable improvement in recent years; a new type requiring the trigger to be pulled has proved effective for trout but not salmon.

For the future he saw the development of environmental and behavioural sensors continuing with more sophisticated trigger feeders being used in conjunction with pellet sensors. Camera imaging systems and hydrophone monitoring, for example, to hear the movement of the fish's jaws presented further possibilities for improving feeding efficiency.

Veal production – lessons for trout?

Alfred Boeve, general director of the Netherlands Alpuro Group described his company's innovative approach to the production of milk fed veal that developed from an enhanced welfare friendly concept under the brand name 'Peters Farm'. In the past, he said, agribusiness was production driven by market demands but now many companies were developing a consumer driven strategy that was more complex and much of it now operated by e-mail technology. Here the consumer is in the driving seat affecting how and in what way production is carried out.

Alpuro began the strategy in 1997 by developing a new business model, which concentrated on the concepts of intrinsic values, transparency and identity. The development of intrinsic values established new feeding and stabling systems for small self-contained herds of 60 calves in which animal welfare is given the highest priority. Transparency or open information is considered very important by the group and is provided by a dedicated internet site (www.petersfarm.com) giving details on all aspects of veal production (feeding systems, disease control, slaughtering procedures, marketing etc.) and also the staff involved in caring for the animals. Computer training is provided to ensure all staff involved in the chain can regularly update the web site.

The brand label 'Peters Farm' established a clear identity that developed from university based and farm animal welfare studies. Over the past 5 years the company has completely re-designed its business development to a 30 million Euro industry today. The establishment of internet and intranet technology

provides a complete customer information service termed IVI (integrated veal information). This is a collective standards symbol which is fully ISO 9002 certified to meet traceability requirements of both customers and retailers.

The development of partnerships between producers and customers is growing within the food industry, he said. The systems described, he thought, would lend themselves well to the trout farming industry using the same intrinsic, transparency and identity principles and partnerships.

Marketing communications

The final talk of the first day's proceedings was given by Carol Stewart, head of consumer marketing division of Hammonds Marketing Communications. Her talk on the broader promotional picture covered food marketing, outlining how it operates, the tools available to it and why the trout industry must adopt these to survive. Starting with the 1900s shopper who might have had 130 different products available to choose from, the supermarkets of today now carry around 40,000 different lines with many more not on the shelves because companies cannot afford the marketing costs. Currently 10 food manufacturers with combined revenue of £100 billion and a workforce of 858 million people dominate supporting food brands in Europe. In contrast the UK spend on food marketing is around £100,000 million.

Turning to trends in food purchasing, she said the average person in the UK spends £17.64 each week on food consumed in the home in 2000. Snacking now replaces the traditional 3 meals per day with young people between the ages of 25-34 spending £11.05 a week on eating out compared to an average £7.02 a week for the 55-64 age group. Consumers now eat more fish than 5 years ago providing more opportunities for trout. With disposable incomes due to rise from 10 – 20/25% more money will be available to spend on food in the future. Healthier eating will increase, she continued, with value added products playing a more prominent role reflecting the lifestyle of the more affluent. All this should create increased opportunities for the trout industry with the importance of omega 3 oils and the potential of value added products based on trout. In spite of this there were many threats facing the trout industry, she said. Lack of funds limited the ability of the industry to keep products in the public eye and there was no concerted industry focus to dispel the negative misconceptions about farming trout. The approach to promoting products was also fragmented and only limited investment was being made in added value products.

The way forward required a single-minded approach concentrating on generic promotion and the managing of issues facing the industry. Investment in the development of added-value products represented a real opportunity but above all the industry must continue to communicate.

The tools to achieve this involve (a) advertising to build up awareness and generate sales, (b) direct marketing which is only successful if specifically targeted, (c) sales promotion to increase sales by attracting new customers to existing products and (d) PR – specifically media relations which is the most cost effective means of maintaining a voice and generating awareness. If no advertising takes place no adverts appear and negative aspects will continue to erode the market.

Media obsessions with food issues in recent years has concentrated on disease – BSE, salmonella, foot and mouth etc, on the rise of organics and a greater focus on health and the environment. In dealing with all these issues effective management of communication by the industry is required. Essentially this involves a unified approach to responses and constant updating of issue statements. Daily monitoring of track issues must be maintained with trained spokes people and independent ambassadors to speak up in response. Monitoring of pressure groups was also important in maintaining contact with hostile groups.

ENVIRONMENTAL REQUIREMENTS OF SEA TROUT AND SALMON: END OF YEAR 1

By Alan M. Walker, Mike Pawson and Robert Bush, CEFAS Lowestoft

In the July 2002 issue of Trout News, we introduced our study on the habitat use of adult sea trout and salmon as they migrate upriver to spawn. This is part of a 5-year DEFRA-funded research programme to investigate the factors that may be associated with the distributions and abundance of sea trout and salmon in river systems in England and Wales. The purpose of this research is to provide information as a basis for advice to UK and international bodies regarding the status and conservation of sea trout and salmon populations.

We have now completed the first year's work on the River Kent in Cumbria, where we have been monitoring the progress of adult sea trout and salmon tagged with small, individually identifiable, radio transmitters in the

lower reaches of the river in June/July. This has been done using both active tracking using hand-held aerials, and by an array of automatic listening receivers (ALS) sited appropriately throughout the catchment. Seven of the 9 fish released also carried a Data Storage Tag (DST), to record water temperature experienced by the fish.

In addition to locating the positions in which these fish were lying, so that we can identify the habitats used and their small-scale movements in relation to river flow etc, we also measured depth, water temperature and dissolved oxygen concentration in and around the positions where these fish 'rested' during their upstream migration. These data have yet to be analysed, but a brief summary of the behaviour of the tagged fish is provided below.

The four sea trout and five salmon were caught, tagged and released at the site of capture between Force Falls and the Levens Park waters just above the estuary of the river Kent. All these fish were aged from scale samples taken during the tagging procedure. The three salmon tagged during June had returned to the river two years after descending as smolts, whereas the two smaller salmon tagged in early July were grilse, having spent only one winter at sea. Two of the four sea trout had returned to the river after having previously spawned: the largest, a hen, had spawned during each of the last four years. By mid-July, and following low water levels, all tagged fish remained in the lower river between Levens Park and Water Crook, though one sea trout and two salmon had ascended Force Falls since being tagged and released.

By mid-August, the sea trout and salmon that were tagged in June remained near to the locations where they were found during the previous trip (July), i.e. within the lower river and not more that 5 km above Force Falls. In contrast, the two grilse tagged in July had been recorded by the ALS sited at the north end of Kendal, some 9 km upstream and just below the confluence of the Mint and Kent, though one grilse could not subsequently be found. It appeared that most of these fish were in the 'resting' phase of their migration.

During our visit to the River Kent in mid-September, it was found that the first salmon and sea trout to be tagged had both moved upstream in early September. The salmon, a female of about 11 lbs, remained in the lower river, but the sea trout, a female of 3.5 lbs, moved from below Kendal into the River Mint during the night of 9-10 September towards tributaries where sea trout are known to spawn, and where it was caught by an angler on the 21 September. The other three sea trout and one salmon remained in the pools they occupied during August.

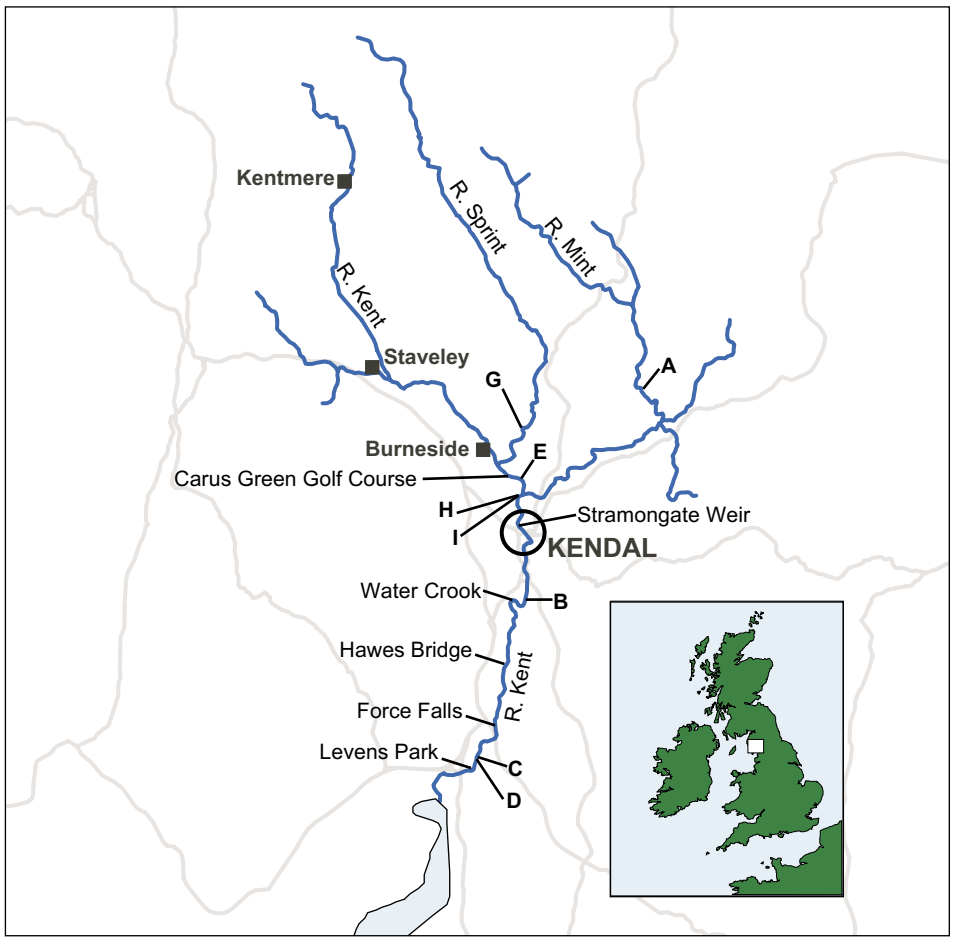
Four of the six remaining tagged fish moved locations during the second half of October. The salmon (12 lbs) that had rested below Kendal since 4 July, and the sea trout (9 lbs) which had laid further downstream

Salmon leaping at Stramongate Weir, Kendal

since 12 August, both moved upstream to Stramongate Weir in Kendal during the night of 21-22 October, where they remained throughout the week (see photo). In contrast, the two smaller sea trout (3 lbs) that had occupied the pool below Force Falls since being tagged there in late June both moved downstream on 21 October and were recorded passing the ALS just above Levens Hall. One of these sea trout was again detected by the ALS on 24 October but was not subsequently located within the river. The first salmon to be tagged remained near Hawes Bridge where it had resided since 2 September. The remaining grilse had moved from its last location downstream of the confluence of the Mint and Kent but was not relocated.

During November and early December, visits were made to locate and recapture tagged fish as they moved towards spawning sites. The salmon which had rested downstream of Hawes Bridge throughout the summer moved to Watercrook on 2 November, where it remained until it disappeared on 13 November. This fish was not subsequently detected by any ALS or by active tracking from Burneside down to the estuary.

One of the two sea trout that moved downstream from Force Falls and past the Levens Hall ALS on 21 October, was again detected there on 29 to 30 November and located by active tracking in Force Falls pool on 4 December.



Species	Length (cm)	Weight (lbs)	Age	Sex	Date Tagged	Summary	Key
Sea Trout	51.4	3.5	R.1+SM+	F	14-Jun	Recaptured on 21 September	A
Salmon	78.4	11	2.2+	M	15-Jun	Last detected near Kendal on 13 November	B
Sea Trout	47.8	3	R.1+	F	17-Jun	Left river on 21 October but returned to Force Falls on 30 November	C
Sea Trout	48.5	3	2.2+	M	17-Jun	Left river on 24 October	D
Salmon	78	11	2.2+	F	18-Jun	Recaptured on 16 December	E
Salmon	82.4	12	2.2+	F	18-Jun	Recovered on 16 July	F
Sea Trout	73	9	3.4SM+	F	17-Jul	Recovered on 21 November	G
Salmon	59.2	5	R.1+	F	18-Jul	Last detected near Kendal on 7 August	H
Salmon	57.5	4.75	2.1+	F	18-Jul	Last detected near Kendal on 11 September	I

The salmon that moved upstream to Stramongate Weir on 22 October continued as far as Carus Green Golf Course on 2 November. It is thought to have spawned there before dropping back through Kendal on 2 December and returning to Water Crook, where it was recaptured by AW and Environment Agency staff on 16 December.

The sea trout that also moved upstream to Stramongate Weir on 22 October went as far as the lower River Sprint, where it is thought to have spawned between 1 and 18 November before dropping back downstream through Kendal. It was recovered dead on 21 November.

The map shows the positions furthest upriver that these fish reached during the study.

The project has provided some novel results regarding the freshwater migratory behaviour of adult salmon and sea trout. The data from the DSTs and from the environmental monitoring have been successfully downloaded and are presently being analysed. The results will provide much needed information on the thermal environments occupied by adult salmonids.

We would like to thank all those who have assisted us in this study.

ALTERNATIVE COMPOUNDS FOR THE TREATMENT OF *ICHTHYOPHTHIRIUS MULTIFILIIS* INFECTING RAINBOW TROUT

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Introduction

Ichthyophthirius multifiliis, "white spot" or "ich", is regarded as one of the most pathogenic diseases of freshwater fish. Infections in farmed fish are common and the British Trout Association (BTA) have estimated that approximately 30% of British trout farms are affected by *I. multifiliis* and that, on average, 5% of the infected stock can be lost, although losses can be as high as 30-80%.

Of the chemicals that were once commonly used in the British trout industry against ichthyophthiriasis, both dimetridazole and malachite green in food-producing animals have been banned by the EC because of their potential carcinogenicity to humans. The use of formalin and chloramine-T is permitted against *I. multifiliis* in the EU, although the activity of these chemicals is limited and they are effective only against the external stages of the parasite, necessitating multiple bath treatments. There is, therefore, a real need to find an efficacious in-feed treatment to replace dimetridazole and malachite green for the treatment of *I. multifiliis*.

Since the trophonts or feeding stage of *I. multifiliis* are situated within the epithelium of the host (see Figure 1), an in-feed treatment represents an appropriate system of drug delivery. The activity of in-feed compounds is not compromised by environmental conditions (water solubility, activity diminished by organic loading, pH, O_2 etc.) to the same degree as bath treatments. In-feeds may have a longer window of activity, are less stressful to administer and, the by-products generated in the host tissues can be more efficacious than the parent compound. In-feed compounds are, however, dependent upon the host having an appetite sufficient to take the medicated diet. In an attempt to find an appropriate replacement for malachite green, the efficacies of six in-feed anti-coccidiostats (amprolium hydrochloride, clopidol, decoquinate, monensin, nicarbazin and salinomycin sodium) were tested alongside two bath compounds (bronopol (Pyceze®) and chloramine T) against *I. multifiliis* in experimental infections of rainbow trout.

Materials and methods

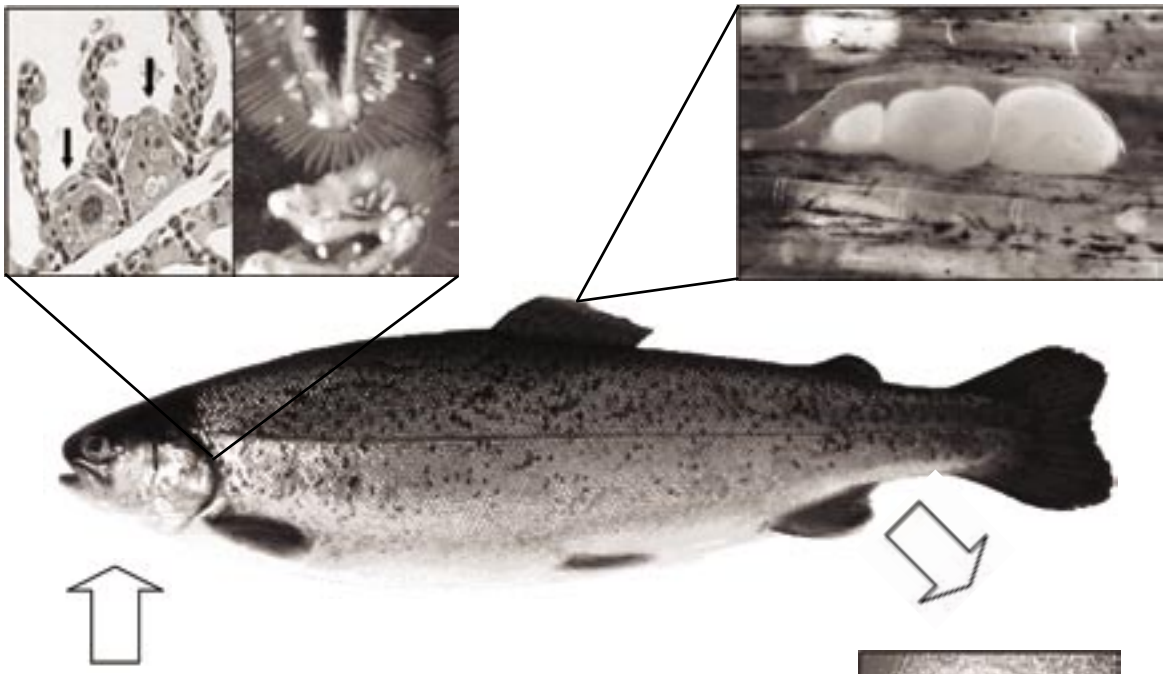
To assess the efficacy of the various compounds, four treatment regimes were tested.

Bath treatments: Regime 1:
The appropriate dose of compound was pre-mixed in tank water and distributed evenly throughout the tank. Experimentally infected trout were maintained in the bath for the appropriate time period with aeration and monitored throughout the treatment period. On completion of the treatment, fish were transferred to a tank containing clean water, the treated tank water in the original tank was carefully poured off as not to dislodge any potential cysts adhering to the tank base, fresh water was replaced and the fish returned to their original tank. On days 12-13 post-infection, fish were killed by an overdose of anaesthetic and the total number of trophonts on the entire body surface, fins and gills were determined.

Bath treatments: Regime 2:
Trout infected with I. multifiliis from a first theront exposure were maintained at 15ºC and the life-cycle allowed to proceed for 10 days. On day 10 post-infection, 10 naïve marked trout were added to each tank of fish already infected with *I. multifiliis* from the first exposure. Tomonts of *I. multifiliis* began exiting the original fish on day 14 post-infection. Fish in each tank were treated daily with the appropriate concentration of chemical on days 10-20. After the exposure period, the water was replaced with clean dechlorinated water at 15ºC in the manner described above. On day 20 post-infection, only marked fish were sampled and the total number of trophonts on each fish counted. By assessing the level of infection on marked fish we ensured that the tank had gone through two cycles of infection and that the number of trophonts on the fish was not a remainder of the first infection cycle. Any trial proving to be efficacious was repeated to confirm that the treatment regime was eliciting a real effect.

In-feed treatments: Regimes 3 & 4:
For the in-feed treatments, two regimes were tested. Uninfected rainbow trout received a 1% body weight ration of either a normal pelleted diet top-coated with cod liver oil (control fish) or a medicated diet top-coated with cod liver oil for the first ten days (test fish). On day 11, all fish were experimentally challenged by exposure to the infective theronts, placed on a normal pelleted and then randomly allocated to a test tank. After a further 10 days, all the fish were processed and the number of trophonts on each fish determined (regime 3). For the last regime (regime 4), fish were infected and then fed medicated feed for 10 days after which the number of trophonts on each fish were determined.

The parasite stage within the fish is called a trophont. It is typified by a large 'U-shaped' nucleus, is covered in cilia and matures within the epidermis. Development of the trophont within the fish is temperature dependant and takes approx. 3-4 months at 3°C or 7 days at 20°C. When the trophont is ~0.3mm in diameter it exits the fish leaving a wound and swims off. Heavy infections can lead to physiological dysfunction (an inability to osmoregulate) and death. Gills may also be destroyed. A critical phase of the life-cycle is when the trophont exits the fish.



The theronts infect the fish host in large numbers. Theronts can survive for 2 days at 15°C.

Tomites are released into the water. The tomites differentiate into theronts which swim in the water and must find a host or die.

The cyst now undergoes repeated binary fission to produce tomites. One cyst may produce anything from 100 to 1000 tomites. Complete development takes ~36 hours at 15°C.

The exited trophont, now called a tomont, swims off and settles on a substrate (within 3 hours) and encysts.

Figure 1. Diagrammatic representation of the life-cycle of Ichthyophthirius multifiliis. Rainbow trout picture courtesy of Ben North (IoA)

Table 1. Bath treatments. For each experiment, performed in triplicate, the number of trophonts (mean ± standard deviation) and the statistical significance of the treatment is given (NS = not significant; Sig. = significant and level of significance)

Compound/Regime	Dose ppm ± St. dev.	Number of trophonts per fish (n)		Test significance
		Test	Control	
Regime 1: Single treatments, day 7				
Chloramine T	100ppm 60mins	49 ± 37	57 ± 20	NS
Chloramine T	10ppm 360mins	324 ± 158	305 ± 103	NS
Pyceze	100ppm 60 mins	380 ± 182	252 ± 78	NS
Regime 1: Daily treatments, days 1-10				
Pyceze	50ppm 60mins	33 ± 17	16 ± 11	NS
Pyceze	100ppm 30mins	10 ± 11	15 ± 21	Sig. in 1 tank
Regime 2: Two-cycle experiments, 10 daily treatments				
Chloramine T	100ppm 30mins	138 ± 48	1456 ± 648	Sig. 0.01%
Chloramine T	100ppm 30mins	10 ± 5	358 ± 110	Sig. 0.1%
Pyceze	100ppm 30mins	133 ± 64	704 ± 201	Sig. 1%
Pyceze	100ppm 30 mins	297 ± 143	358 ± 110	Sig. in 1 tank

Results

The two bath compounds, when administered as a series of multiple baths to target the external stages of the parasite (tomonts, cysts, tomites and theronts), significantly reduced parasite levels (Table 1). A treatment of 100ppm bronopol (Pyceze®) given as a daily, 30-minute bath, over a period of 10 days reduced the number of surviving trophonts on infected fish by 17%. Similarly, a daily, 30-minute bath of 100ppm chloramine T over a 10-day period given to tanks of naïve fish co-habiting with infected fish, significantly reduced the number of trophonts establishing in naïve fish by 90.5% and 97.3%.

The in-feed compounds were tested either for the protection they might provide prior to periods of high theront exposure (regime 3) or as a means of treating stock once infected (regime 4) (Table 2). Trial doses of 104 ppm amprolium hydrochloride or 65ppm clopidol fed to trout for ten days prior to infection with *I. multifiliis* theronts, significantly reduced the number of trophonts establishing in trout fingerlings by 62% and 35% respectively. These compounds also gave significant results when given as a medicated feed to fish already infected with *I. multifiliis*. A treatment with 63ppm or 75ppm amprolium hydrochloride or 92ppm clopidol reduced the number of surviving trophonts by 77%, 32% and 20%, respectively. Of the compounds tested, salinomycin sodium gave the best results when incorporated into a pellet feed at a nominal dose of 100ppm, top-dressed with cod liver oil and fed to trout for 10 days. In three consecutive trials, experimental trout ingested 38ppm, 43ppm and 47ppm salinomycin

Table 2. In-feed treatments. For each experiment, performed in triplicate, the number of trophonts (mean ± standard deviation) and the statistical significance of the treatment is given (NS = not significant; Sig. = significant and level of significance)

Compound/Regime		Dose ppm ± St. dev.	Number of trophonts per fish (n)		Test significance
			Test	Control	
Regime 3: Drug (100ppm) administered for 10 days prior to parasite exposure					
Amprolium hydrochloride		104 ± 12	38 ± 27	101 ± 43	Sig. 0.01%
Clopidol		98 ± 12	65 ± 38		Sig. 1%
Decoquinate		101 ± 18	98 ± 36		NS
Monensin		73 ± 26	110 ± 43		NS
Nicarbazin		96 ± 46	143 ± 56		NS
Salinomycin sodium		63 ± 21	72 ± 30		NS
Regime 4: Drug (100ppm) administered for 10 days after parasite exposure					
Amprolium hydrochloride	(1)	75 ± 21	69 ± 32	101 ± 34	Sig. in 1 tank
	(2)	63 ± 20	26 ± 14	104 ± 61	Sig. 0.1%
Clopidol		92 ± 31	81 ± 37	101 ± 34	Sig. in 1 tank
Salinomycin sodium	(1)	47 ± 14	7 ± 5	101 ± 34	Sig. 0.1%
	(2)	38 ± 12	10 ± 6	51 ± 21	Sig. 1%
Regime 4: Salinomycin sodium administered at a dose of either 50ppm or 100ppm for 5 or 10 days after parasite exposure					
Salinomycin sodium	(1)	25 ± 7 (50ppm 10 days)	40 ± 31	48 ± 34	NS
	(2)	43 ± 8 (100ppm 10 days)	14 ± 10	48 ± 34	Sig. 1%
	(3)	43 ± 10 (100ppm 5 days)	50 ± 46	25 ± 18	NS

sodium, which significantly reduced the number of surviving trophonts in trout by 80%, 72% and 93%, respectively. Trials reducing either the inclusion dose of salinomycin sodium to 50ppm or the number of medicated feed days to 5, yielded non-significant results. The trials indicated that salinomycin sodium must be administered for 10 days and at a nominal inclusion dose of 100ppm when top-dressed with cod-liver oil to be effective.

Discussion

These trials have demonstrated the efficacy of a 10-day course of medicated feed containing salinomycin sodium to reduce the surviving number of trophonts on experimentally infected fish by 72-93%. As the salinomycin sodium, when top-dressed with cod liver oil, was unpalatable, it was essential to include the drug at 100ppm to ensure that fish ingested the minimum ~40ppm necessary to provide protection against *I. multifiliis*. Current, on-going, trials have demonstrated that gelatin-coated medicated feed is readily accepted, however, the effects of reducing the inclusion dose and the protection offered remains to be established. These trials have also demonstrated the protection that certain drugs are able to provide prior to periods of high theront exposure. The use of 100ppm amprolium for 10 days prior to infection reduced the number of trophonts establishing within fish by up to 62%. It would be valuable to establish whether these results could be further improved upon by using these drugs in combination in a shuttle programme, using one drug first followed by a second, as has been successfully employed within the poultry industry. In summary, the bath treatments were found to be effective when used to target the external stages of the parasite. However, this regime of multiple treatments is potentially stressful to the fish, is expensive and produces results similar to those generated using current formalin treatments.

Acknowledgements

The authors would like to thank Dr Julian Braidwood (Triveritas), Richard Hunter (Novartis), Gordon Rae (Scottish Quality Salmon) and the British Trout Association and in particular Mark Davies and Peter Routledge for their valuable input and assistance in these trials.

Further reading

Shinn, A.P., Wootten, R., Côté, I. & Sommerville, C. (in press). The efficacy of selected oral chemotherapeutants against *Ichthyophthirius multifiliis* Fouquet, 1876 (Ciliophora: Ophyroglenidae) infecting rainbow trout (*Oncorhynchus mykiss* Walbaum). Diseases of Aquatic Organisms.

THE LAST OF THE TROUT RELATED LINK AQUACULTURE PROJECTS

Compiled by Dr Mark James FRM Ltd, LINK Co-ordinator

R&D Funding – a Curates Egg!

After recently reviewing the funding available for aquaculture related research and development (R&D) in the UK, I was struck by the way that the view and expectation of aquaculture, from both industry and political pundits, has changed over the past five years.

At the start of the LINK Aquaculture programme in 1996, there was a sense that there was still potential for novel species diversification and continued expansion of the industry; provided that the life cycles of novel species could be closed, and effective disease treatments found for existing and emerging species. Since that time, strong downward pressure on production costs, environmental concerns and welfare considerations have all increased significantly.

The current view of the aquaculture sector in the UK appears to be much more conservative. The numbers of species likely to be cultivated on any scale in the UK is probably no more than 8 including, mussels, oysters (native and Pacific), trout, salmon, cod, halibut and possibly haddock. Turbot is making a modest comeback to our shores through recirculation technology and there may be small volumes of other niche market species produced. Economics, market opportunity and market development are now considered explicitly and much more carefully at the early stages of species selection for cultivation

Economic models of various industry sectors (including trout) have been developed alongside ‘strategic visions’ based on price and volume projections. Often referred to as ‘maturation’, there is a harsh reality in these scenarios for both the industry and the R&D sector that services it. Within industry, smaller players will continue to serve niche markets, larger players will emerge through consolidation of medium sized businesses and survive through economies of scale. The assumption is that the least cost-effective medium sized operations may not survive.

From a business perspective, if one takes a cold hard look at the funding now available for aquaculture R&D and compares this to the number of research workers available and competing for these resources, it is clearly an oversupplied market. The reliance on relatively low paid scientific contract labour is symptomatic of this condition. Throughout the period of aquaculture expansion in the UK a number of Universities and research facilities have worked hard to develop expertise in aquaculture. Alongside the industry, the type and level of expertise has also 'matured' with members of the research community now focusing much more on applied 'problem solving' science.

It seems logical that with less funding available for aquaculture R&D *per se*, consolidation within the industry, together with a more conservative vision of future UK aquaculture, that some rationalisation of R&D providers in this sector is inevitable.

As some sectors of the industry have been forced to assess their own viability and make strategic decisions about their commercial future, so too will research providers.

Given the forgoing arguments, R&D is clearly a buyers market. The language of 'consumer choice', now applies to the principal sponsors of R&D. In sourcing R&D, they too, are beginning to develop more objective measures of value for money and quality.

As the resources available for R&D have become more constrained and the need to justify this expenditure more acute, it is clear that R&D requirements will tend to become much more prescriptive. With respect to public funds available for aquaculture R&D, indications are that the focus is very much on providing R&D that supports policies centred on consumer protection, the environment and animal welfare. Increasingly, the industry itself will be required to support R&D directly or in partnership with non-governmental sponsors. Through schemes like LINK, industry provided in-kind and cash support, to the tune of 50% of the total project cost. In the future applied production oriented research will probably have to be funded solely by industry. As such, individual companies as well as their respective trade associations need to consider how this can be achieved in the short term and strategically.

Full-blown research projects cost between £40,000 and £60,000 per year. As this is a cash requirement rather than in-kind support, to take forward such projects will need a sea change in the way that industry currently prioritises and invests in R&D.

The Government has started to recognise the need to provide industry with incentives to engage in R&D and a tax credit for small and medium sized enterprises (SMEs) was introduced in 2000. Recently this credit was also extended to cover all companies. Large companies will be entitled to an additional deduction from their taxable income of 25% of their current spending on qualifying R&D, in addition to the normal 100% deduction.

For example, if a company spends £100,000 on qualifying R&D it will be able to deduct £100,000 from its taxable income under ordinary tax rules and an additional £25,000 under the R&D tax credit. For a company paying the main rate of corporation tax at 30% the credit would therefore give a reduction in tax of £7,500.

In the future, as pressure on the public purse increases, it is likely that all successful companies and sectors in the UK wishing to maintain a competitive edge will need to make significantly greater investment in R&D than is currently the case.

Current aquaculture R&D funding opportunities within the UK are somewhat bleak. The Scottish Executive is sponsoring R&D through its agency laboratories, but there seems little prospect of any additional funding for non-agency research. Post devolution, Defra funding for aquaculture has been significantly reduced and appears to have settled at around £200,000 per year for the next five years. The research councils BBSRC and NERC are, in principle, open to proposals, but in reality support few aquaculture-related projects and fewer still that are applied.

The Crown Estate is committed to reinvesting some of its money derived from aquaculture leases and is currently allocating around £200,000 per annum.

Whilst other Departments within government such as the Food Science Directorate, the Environment Agency and the Veterinary Medicines Directorate have interests in aquaculture and support some aquaculture related projects, there is clearly a need for this support to be better co-ordinated. Despite the wonders of modern communication, all too often staff within the same organisation will have no knowledge of research that a sister department is funding.

On the European stage, the principle funding mechanism of interest to the UK aquaculture industry is likely to be through the recently announced Framework Programme 6 (FP6). Opportunities for Small to Medium Sized Enterprises (SMEs) have been expanded significantly from those offered under the previous Framework Programmes. Within the EU there are 20 million SMEs employing 80 million people. SMEs are major contributors to the European economy, they are generally the source of new products and technologies, and they provide vital support for larger companies and generate significant employment opportunities. In recognising the potential of SMEs 1.2 billion Euro (about £624 million – 15% of the total FP6 budget), has been allocated to SME related measures under FP6. SME participation in projects related to the 7 Thematic Priorities is 1.7 billion

Euro, with a further 395 million Euro being allocated to SME specific projects. Of this sum 295 million Euro is to be allocated to the CRAFT scheme, with the remaining 100 million Euro being allocated to Collective research.

The CRAFT and Collective research funds are available to support projects on any subject across any area of science. CRAFT pays for R&D to be undertaken by R&D providers ('the scientists') on behalf of a group of SMEs. Collective research pays for R&D to be undertaken by R&D providers on behalf of a group of industry associations or groupings benefiting their SME members. In both cases, the industry partners as individuals or groups, must provide 50% of the total project cost in cash or in-kind.

The first call for proposal for FP6 was issued on 17 December with a submission date for applications of mid March 2003 (details can be found on http://europa.eu.int/comm/research/fp6/index-en.html).

To support an R&D sector capable of effectively underpinning the continued development of UK aquaculture, prudent co-ordination of public R&D funds will be required. We must also capitalise on European funding opportunities and seek mechanisms to encourage and increase industry's investment in R&D.

Only two trout related LINK Aquaculture projects now remain. A project on taint in trout (TRT13) and the well-publicised trout selective breeding programme (TRT12). The taint project has been successful in identifying the cause of taint and has suggested practical strategies for on-farm management of this problem. A fundamental problem highlighted by this research has been the inconsistency of taste panel results as a means of quality control. The trout selective breeding project is, after a delayed start, in full swing and set to generate important scientific results particularly with respect to the potential to develop more disease resistant strains of trout.

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

Project Leader: Dr. Linda Lawton, The Robert Gordon University, Aberdeen
Sponsor: Defra

Research Partners: The Robert Gordon University, Aberdeen
University of Stirling

Industrial Partners: British Trout Association

The completion of a two and half year research project investigating the origins of earthy-musty taints in farmed trout is near its end. At the start of this project no prior scientific studies had been carried out on this problem and thus our knowledge and understanding of the origins and extent of the problem was at best speculative. The following summarises some of our key findings.

Geosmin (GSM) was found to be the main compound associated with the seasonal occurrence of earthy taints in UK farmed trout. Negligible levels of 2-methylisoborneol (2-MIB) were also detected. In Northern UK trout farms a benthic species of blue-green algae (*Oscillatoria* sp.) was shown to be the causative organism. No pelagic species of blue-green algae (cyanobacteria) were detected at these sites. Geosmin levels were found to be high in the intake water of fish farms. As an upstream problem, this will seriously restrict management options e.g. the use of algaecides. Of those farms studied high phosphate levels were recorded in the river water intake supply. Phosphates are known to stimulate the growth of blue-green algae.

Comparison between organoleptic scores and chemical analysis identified the sensory threshold of Geosmin in trout at around 1.0 µg/kg. Discrepancies between the ability of some fish processors to detect tainted fish by organoleptic methods have highlighted the need for more industry training. However, taste panels are currently the best method to determine taint levels in fish, as there are no practical alternatives for commercial processors. Depuration of fish using bore hole water, where applicable, may provide a cheap reliable method of taint removal. In addition UV/TiO2 photocatalysis has been shown to destroy 2-MIB and GSM under laboratory conditions and may provide a potential solution to removing earthy taints from water supplies in the future. These findings have greatly improved our current understanding of earthy taints in farmed trout and should enable us to form better management strategies to deal with them in the future.

For further information on this project you can contact:
Dr. Linda Lawton at L.Lawton@rgu.ac.uk
Or write to her at The Robert Gordon University, St. Andrew Street, Aberdeen AB25 1HG.

Selective improvement of rainbow trout: mass selection and markers - TRT12

Project Leader: Professor Brendan McAndrew, Institute of Aquaculture, University of Stirling

Sponsor: NERC

Research Partner: Professor John Wooliams, Roslin Institute

Industrial Partners: British Trout Association

The first stage of the selective breeding programme has been completed. Crosses were performed on each of the partner farms using the strains available, Glen Wyllin Trout Farm on the IoM, Houghton Spring Farm in Dorset

and Trafalgar Trout Farm in Hampshire. The experiments were designed to generate a number of related families so that the maternal and paternal effects could be separated in the offspring. Each female was crossed to a number of neomales and each neomale was crossed to a number of females. The families were incubated separately upto the eyed stage and then equal numbers of each family combined to generate the experimental populations. The Glen Wyllin eggs will be divided into three groups, one to remain at the farm as potential replacement broodstock after performance testing, the second and third populations going to Test Valley Trout (TVT) and Trafalgar respectively for testing under commercial conditions. The Glen Wyllin will be tested against the Houghton Spring at TVT and alongside a wild-type and gold strain at Trafalgar. All the female broodstock have been PIT tagged for future reference, so that high performing females, based on the performance of their offspring, can be used in the next spawning season.

The performance of the offspring will be assessed at different points during the production cycle. At 5-10 g a sample of 1000 from each strain will be PIT tagged and measured and a fin clip taken to identify their parentage. These fish can then be monitored individually throughout the rest of the production cycle. This will give information on both individual and family performance within and between the strains being tested. Mortalities will be collected and the cause of death recorded; this will be used to assess the robustness of each strain for any diseases they might encounter.

This project will generate important data on the levels of genetic variation present in 5 important commercial rainbow trout strains in the UK; it will also provide the foundation for the design of future selective improvement programmes.

INFORMATION FILE

CHANGE OF EDITORSHIP OF TROUT NEWS

This issue of Trout News will be the last under my editorship after sixteen years from its first publication in February 1987. Since my retirement from the Ministry in March 1996 I have felt increasingly isolated from the industry and now feel it is time the reins were taken up by someone more involved on the research side and in closer contact with current events.

Starting with the July issue Trout News will be produced from the Weymouth laboratory of CEFAS under the joint editorship of Tim Ellis and Ian Laing (who currently edits Shellfish News) with assistant editor remaining with Denis Glasscock at Lowestoft.

I should like to thank all those who regularly contributed to the newsletter over the years and wish you all good luck for the future.

Dick Lincoln

FIRST ANNUAL REPORT ON SURVEILLANCE FOR VETERINERY RESIDUES COMMITTEE

The Veterinary Residues Committee (VRC) was set up in January, 2001 and replaces the Advisory Group on Veterinary Residues (AGVR) which formerly advised on veterinary residues surveillance. The VRC has no serving civil servants and draws its membership from consumers, the farming community, local authorities and industries associated with farming and food. The purpose of the committee is to independently scrutinise the surveillance of veterinary residues in the UK and provide advice for the Chief Executives of the Veterinary Medicines Directorate (VMD) and Food Standards Agency (FSA). It also provides advice on the formulation of residues surveillance programmes and comments on the significance of the results for consumer safety.

The first Annual Report on Surveillance for Veterinary Residues was published on 17 October, 2002 and replaces the residues report published annually by the VMD between 1995 and 2000.

A copy of the report, which includes all the results of the surveys, can be downloaded from the website: www.vmd.gov.uk under General/Publications/Annual Reports.

Hard copies of the report and results tables can be obtained from Isabel Sharma (VMD, 01932 338330, e-mail: i.sharma@vmd.defra.gsi.gov.uk) or by writing to:

Secretariat
Veterinary Residues Committee
Woodham Lane
New Haw
Addlestone
Surrey KT15 3LS

WHERE TO GET HELP OR ADVICE

Policy Matters

Department for Environment, Food and Rural Affairs,
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:-
Science Directorate, Cromwell House,
Dean Stanley Street, London SW1 3JH
(Tel. 020 7238 3000) (Fax. 020 7238 1590)

You can also visit the DEFRA website at
www.defra.gov.uk/

The National Assembly for Wales,
Agricultural Policy Division 5,
New Crown Buildings, Cathays Park, Cardiff CF1 3NQ
(Tel. 02920 823567) (Fax. 02920 823562)
www.wales.gov.uk

Scottish Executive of Rural Affairs Department,
Pentland House, 47 Robbs Loan, Edinburgh EH14 1TW
(Tel. 0131 244 6224) (Fax. 0131 244 6313)
www.scotland.gov.uk/who/dept_rural.asp

Department of Agriculture and Rural Development,
Fisheries Division, Annexe 5, Castle Grounds,
Stormont, Belfast, BT4 3PW
(Tel. 028 9052 3431) (Fax. 028 9052 2394)
www.dardni.gov.uk

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: Fish.Health.Inspectorate@cefas.co.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
www.cefas.co.uk

Farm animal welfare -
Department for Environment, Food and Rural Affairs,
Animal Welfare Division, 6th Floor, 1A Page Street
London SW1P 4PQ

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

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

Food hygiene -
Food Standards Agency
Aviation House, 125 Kingsway, London WC2B 6NH
(Tel: 020 7276 8000)

Advice on commercial activities

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

Wildlife conservation

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

English Nature,
Northminster House, Peterborough, PE1 1UA
(Tel. 01733 455000) (Fax. 01733 568834)
www.english-nature.org.uk

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

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

Other Useful Numbers

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(Tel. 01796 472060) (Fax. 01796 473523)
www.linkaquaculture.co.uk

RESEARCH NEWS

1. Cryopreservation of trout sperm

In fish the procedures for cryopreserving spermatozoa have been well developed in many species for use in both aquaculture and conservation of natural resources. Data on performance of individuals produced using cryopreserved spermatozoa reveal no differences in growth, mortality or malformation rates compared to those produced from untreated semen. However no data is available regarding the reproductive abilities of fish produced with cryopreserved sperm. This study aimed to test the fertilisation ability and suitability for cryopreservation of semen from sibs and half-sib males produced with the use of cryopreserved or untreated semen. Oocytes from three female rainbow trout were inseminated separately with untreated or cryopreserved semen, which had been produced using either untreated (three males) or cryopreserved (three males) spermatozoa. In half the variants, the cryopreservation did not significantly affect fertilisation efficiency. Regardless of whether the sperm donors were produced from cryopreseved or intact semen, insemination of oocytes with their intact sperm resulted in the same percentage of eyed embryos (94.4 and 94.3%, respectively). When eggs were inseminated with cryopreserved semen, the use of sperm from males produced with cryopreserved spermatozoa resulted in a significantly higher percentage of eyed eggs than in the case of donors produced with intact sperm (89.6 and 81.7%, respectively). It was concluded that production of rainbow trout using cryopreserved sperm does not appear to negatively affect the reproductive abilities of male progeny and semen from donors, which were produced using cryopreseved sperm, is more suitable for cryopreservation than the semen from donors produced with intact spermatozoa.

Reference

BABIAK, I. (Department of Animal Biochemistry, Warmia and Mazury University in Olsztyn, 10-957 Olsztyn, Poland. E-mail: babiak@uwm.edu.pl), GLOGOWSKI, J., DOBOSZ, S., KUZMINSKI, H. AND GORYCZKO, K., 2002. Semen from rainbow trout produced using cryopreserved spermatozoa is more suitable for cryopreservation. Journal of Fish Biology, 60: 561–570.

2. Soybean meal-red blood cell coextruded diets for trout

Soybean meal is often limiting in key essential amino acids and also contains antinutritional factors. Blood-based feedstuffs however are generally not limiting in essential amino acids, but dehydrating the blood to produce blood meal or whole blood powder is expensive. A new method of using the red cell fraction of blood in diets has recently been described in which liquid red blood cells are mixed with a dry carrier such as soybean meal, bran, rice husk or corn meal and extruded to form a single dry feed ingredient. This study evaluated the growth of rainbow trout in which varying amounts of a soybean meal-red blood cell (SBM-RBC) coextruded feed ingredient was substituted for fish meal. The SBM-RBC ingredient was incorporated at either 0, 21, 42, or 63% of the dietary protein, replacing an isonitrogenous amount of fish meal. All diets were fed for 8 weeks to triplicate groups of juvenile rainbow trout (average initial weight 49.5 g) stocked into a recirculting system consisting of 48, 114-L aquaria. There were no significant differences in weight gain, feed conversion ratio, digestibility, apparent gross energy digestibility, dress-out percentage, or fillet protein and fat concentrations in fish fed any of the experimental diets. Based on these data, extruded SBM-RBC appears to be a suitable ingredient in diets fed to rainbow trout.

Reference

SELDEN, G.L., BROWN, P.B. (Purdue University, Department of Forestry and Natural Resources, 1159 Forestry Building, West Lafayette, Indiana 47907-1159 USA), OSTROWSKI, A.C., FLORES, R.A. AND JOHNSON, L.A., 2001. Evaluation of soybean meal-red blood cell coextruded feed ingredient in diets fed to rainbow trout *Oncorhynchus mykiss*. Journal of the World Aquaculture Society, 32(4): 409–415.

3. Genetics and body composition

Body composition and flesh quality are essential characteristics of farmed fish for human consumption since they influence consumer acceptance and the ability to refine fish material. Quantitative genetic studies aimed at improving product quality are therefore important but few estimates have been carried out even though phentotypic correlations and environmental manipulations for growth rate have revealed that proximate composition, especially protein, fat and water content are often closely connected with body size. However phenotypic correlations do not necessarily reflect underlying genetic correlations and where these have been estimated they show inconsistent results for body weight and its composition. This paper therefore examines whether selection for rapid growth rate in rainbow trout would potentially lead to correlated genetic responses in body composition. The potential correlated responses was evaluated by estimating heritabilities and genetic correlations for body weight and traits characterising body composition (condition factor, wasted biomass, fillet weight, three measures of fat, flesh redness, percent fillet protein, ash and water) at the age of 3 years in a half/full-sib mating design.

Percent abdominal fat from body weight, percent fillet protein, ash and water were the only traits to display heritabilities close to zero ($h^2 = 0.02 – 0.06$). The other body comosition traits and body weight displayed moderate levels of genetic variation ($h^2 = 0.11 – 0.45$), making direct and correlated genetic responses to selection possible. Genetic correlations of body weight with percent fillet fat, protein, ash and water and flesh redness were low indicating that the quality of fillets is not strongly changed by the selection for rapid growth rate. In contrast, the weight of abdominal fat and waste would be increased as a correlated response, because due to a part-whole relationship, the traits showed strong positive genetic correlations with the body weight. Moreover, it was found that large differences between sexes especially in the traits that are closely related to body size (i.e., condition factor, weight of waste and abdominal fat) and, to a lesser extent, in the traits related to fillet quality. However, the differences between sexes in body composition could be mainly explained by the difference between sexes in body size. It was concluded that the genetic properties of body weight and body composition traits of the rainbow trout population studied did not impose strong constraints on the progress of the breeding programme.

Reference

KAUSE, A. (MTT Agrifood Research Finland, Animal Production Research, Animal Breeding, FIN-31600 Jokioinen, Finland. E-mail: Antti.Kause@mtt.fi), RITOLA, O., PAANANEN, T., MÄNTYSAARI, E. AND ESKELININ, U. 2002. Coupling body weight and its comosition: a quantitative genetic analysis in rainbow trout. Aquaculture, 211(1-4): 65-79.

4. Effect of different anaesthetics on broodstock stress and viability of fertilised eggs

Anaesthetics are widely used in aquacultue as an aid to handling fish, particularly broodstocks, to minimise stress. The effects of stress has been shown to include reduced immuno-competence, increased susceptibility to disease, reduced egg quality and spermatocrit and reduced growth. This study was conducted to compare the effects of three anaesthetics – AQUI-S (a commercial product containing 50% isoeugenol, a derivative of clove oil), tricaine methane sulfonate (tricaine or MS –222) and carbon dioxide gas, on the stress responses of rainbow trout broodstock and also on the viability of fertilised eggs from anaesthetised parents. The duration of activity and percent motility of sperm in anaesthetic was also examined with the objective of comparing the direct effects of anaesthetics. Concentrations of 60 mg/l tricaine, 20 mg/l isoeugenol (40 mg/l AQUI-S) and 220-275 mg/l carbon dioxide were based on preliminary tests and chosen to standardise induction time among anaesthetics. Plasma glucose, chloride and cortisol concentrations indicated that none of the anaesthetics used after crowding and netting completely eliminated the stress response. The return to pre-stress cortisol levels differed among the three anaesthetics. Fish anaesthetised with AQUI-S had significantly lower contisol concentrations at 1 or 7 h post-immersion than the other anaesthetics and controls, but were elevated at 24 h. Plasma cortisol in tricaine and CO_2 –treated fish retured to pre-stress levels within 7 and 24h, respectively, whereas cortisol levels in control fish remained elevated at 24 h. Sperm motility and duration of motility were assessed for a practical range of concentrations: tricaine, 15 -100 mg/l; AQUI-S, 10 – 100 mg/l; CO_2, 50-173 mg/l. The percentage of motile sperm was unaffected by anaesthetic treatment, averages ranging from 68% to 87%. However, duration of motility decreased as anaesthetic concentration increase, averages ranging from 55 to 36 s for tricaine and from 56 to 37 s for AQUI-S. Duration of sperm motility was low (31-43 s) for all levels of CO_2 tested. Fish recovery time was significantly longer for fish anaesthetised by AQUI-S (370 s) than either CO_2 or tricaine (192 and 199 s, respectively). Gender had no effect on recovery time. Egg survival to the eyed stage and to hatch was not significantly different among anaesthetic treatments and controls. No delayed mortality was observed for any of the fish handled and bled for the test. The results indicated that tricaine, AQUI-S and CO_2 were all suitable for broodfish anaesthesia, but the longer recovery time and lower cost for AQUI-S may make it more useful than the alternatives. None of the anaesthetics wholly suppressed the stress responses during a typical spawning process, but did help reduce the duration of the stress response and eased handling without compromising egg viability.

Reference

WAGNER, E. (Fisheries Experiment Station, 1465 West 200 North, Logan, UT 84321, USA. E-mail: ewagner@sisna.com), ARNDT, R. AND HILTON, B. 2002. Physiological stress responses, egg survival and sperm motility for rainbow trout broodstock anaesthetised with clove oil, tricaine methanesulfonate or carbon dioxide. Aquaculture 211(1-4): 353-366.

5. Nutritional value of cotton seed meal

Cotton seed meal (CSM) has been used in animal feeds since the early part of the 20th century. Adult ruminant animals can utilise high levels of cottonseeds and hulls in their diet because they are able to detoxify gossypol (a yellow pigment that has toxic effects on animals) in their rumen. Other non-ruminant animals such as swine and poultry have a limited ability to utilise cotton seed while fish can tolerate relatively higher levels of free gossypol than either swine or poultry. Although several studies have evaluated the availability of phosphorus, apparent digestibility coefficients (ADCs) of crude protein (CP), dry matter and energy, in CSM diets on reproductive performance of rainbow trout,

no studies have evaluated the ADCs of trace minerals and amino acids which are required in order to make full use of CSM in trout feeds. Therefore this study evaluated the ADCs of dry matter, fat, CP, minerals, and amino acids in CSM for rainbow trout to determine the optimum replacement levels for fish meal in rainbow trout diets.

CSM from 4 different locations in the southern US were used at O% (diet O), 5% (diet 5), 10% (diet 10), 15% (diet 15) and 20% (diet 20) inclusion rates in experimental diets (44% crude protein, 22% crude fat) to evaluate its nutritional value. A total of 450 rainbow trout (initial mean body weight 11.2 ± 0.4g) were randomly stocked into fifteen 150-l fibreglass tanks with 30 fish per tank and 3 tanks per diet. Fish were fed to apparent satiation 3 times a day and 7 days per week. The ADC of the four CSM groups were: dry matter, 50.8-75.5%; fat, 60.2-78.6%; crude protein, 81.6-87.9%; potassium, 98.9-99.6%; magnesium, 45.1 -60.5%; sodium, 89.1-92.7%; phosphorus, 53.3-56.2%; copper, 53.3-65.6%; iron, 34.0-60.4%, manganese, 15.1 -31.6%, zinc, 6.1-33.4%; essential amino acids, 80.2 -96.1%; and non-essential amino acids, 62.5-94.3%. After a 6-week growth period, average weight gain of fish fed diets 0 to 20 was: 42.4, 39.1, 39.4, 34.2 and 31.8 g respectively. Average feed conversion ratio of fish fed diets 0 to 20 was: 0.94, 0.99, 1.01, 1.12 and 1.13 respectively. Survival was > 98% for fish fed all diets. These results indicated that the ADC of most nutrients in CSM obtained from different locations were different. Fish fed CSM diets at the 5% or 10% inclusion rates were not significantly different compared to fish fed the fish meal control diet in terms of weight gain, feed conversion ratio and survival *(P>0.05)*, indicating that CSM could be used at the 10% inclusion rate in rainbow trout feed formulations.

Reference

CHENG, Z.J. (Hagerman Fish Experiment Station, University of Idaho, 3059F National Fish Hatchery Road, Hagerman, ID 83332, USA. E-mail: chengz@uidaho.edu) AND HARDY, R.W. 2002. Apparent digestibility coefficients and nutritional value of cottonseed meal for rainbow trout (*Oncorhynchus mykiss*). Aquaculture, 212(1-4): 361-372.

6. In uence of dietary fat and whole body fat level on energy intake

Appetite in fish as, in higher vertebrates, appears to be controlled by numerous factors among which nutritional factors, particularly energy content has been shown to have a marked and well-known affect. It has been suggested that rainbow trout are able to adjust their energy intake according to the protein to energy ratios of their food. However some controversy still exists over the affect of body fatness on food intake and this study aimed to evaluate both dietary fat level and whole-body fat level on voluntary energy intake in juvenile rainbow trout under self-feeding conditions. Groups of lean fish [crude fat (CF) = 7%] and fat fish (CF = 11%), pre-treated with a commercial diet with or without supplemental pollock oil, were self-fed one of three fat level diets (CF = 8%, 13.5% and 19%) for 48 days at 17°C. The affects of these two factors were evaluated over a medium term of 48 days because any influence of initial body fat level on energy intake might be obscured in a longer term experiment as a result of considerable changes in body fat levels by the experimental dietary treatment. The results indicated that final body weight (BW) and total digestible energy (DE) intake (kj per fish) were positively affected by the initial BW. Relative to the initial BW, however, fat fish consumed less DE than lean fish. Although the affect of dietary fat level was not significant, percentage weight gain and daily DE intake per BW (kj kg BW day) of fat fish were significantly lower than those of lean fish. Energy, digestibility, feed efficiency and protein retention were improved with the dietary fat level; however, there was no difference resulting from body fat level. The whole-body fat levels at the end of the experiment increased with the dietary fat level. Between groups self-fed the same diet, fat levels of the initially fat fish were still higher than those of the lean fish. The results of this medium-term study suggest that rainbow trout adjust DE intake from diets with fat levels ranging from 8% to 19%. Although body fat level affects neither energy digestibility nor protein utilisation, a high body fat level may reduce DE intake and consequently depress growth.

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YAMAMOTO, T. (Inland Station, National Research Institute of Aquaculture, Fisheries Research Agency,Tamaki, Mie, Japan. E-mail: takejpn@fra.affrc.go.jp), SHIMA, T. AND SUZUKI, N. 2002. Influence of dietary fat level and whole-body adiposity on voluntary energy intake by juvenile rainbow trout *Oncorhynchus mykiss* (Walbaum) under self-feeding conditions. Aquaculture Research, 33(9): 715-723.

7. Effect of temperature on photoperiodic advancement of reproduction

Several environmental factors play a role in the control of reproduction in rainbow trout and other fish species including the yearly cycle of change in day length (photoperiod) and seasonal temperatures. A large body of information exists on photoperiod effects on the maturation of rainbow trout and protocols are now available for the successful advance or delay of spawning by up to 6 months under conditions of constant temperature. The role of water temperature in determining spawning time has largely been ignored however, especially in conjunction with photoperiodic manipulation. This study looked at the effects of two different water sources, river and bore-hole (two common sources of water for trout production) providing differing seasonal water temperatures on the advance and delay in maturation of female rainbow

trout under long-short photoperiod regimes. The photoperiod and water temperature regimes were combined in order to compare their relative effects on the maturation, physiology and subsequent egg production and to determine the potential use of such technology to produce out-of-season eggs on farms with variable water supplies.

Long-short photoperiod regimes, i.e. long days of LD18:6 followed by an abrupt change to short days of LD6:18 under two different seasonal water temperatures supplied by river (range 0-20.5°C) or bore-hole (range 7.0-10.5°C) were used to advance or delay maturation to summer months. The photoperiod regime was seen to have the primary effect on altering the timing of maturation and appeared similar, irrespective of the prevailing water temperature. However, water temperature had a modulating effect on time of maturation and ovulation; fish showing an ability to delay the timing of final maturation and ovulation, when temperatures were at extremes, high or low. Extreme temperatures also had a major effect on the later stages of ovary development and subsequent egg quality. When the major time of spawning was advanced to July-August, when river water temperatures regularly approached 20°C, a dysfunction in ovarian development occurred, and no viable eggs were obtainable in these conditions. When the maximum water temperature was reduced to 16°C, fish stripped in a normal fashion, but egg quality was significantly reduced. Possible alterations in farming practice in order to improve egg survival in such situations are discussed.

Reference

DAVIES, B. (Institute of Aquaculture, University of Stirling, Stirling, FK9 4LA, UK.) AND BROMAGE, N. 2002. The effects of fluctuating seasonal and constant water temperatures on the photoperiodic advancement of reproduction in female rainbow trout, *Oncorhynchus mykiss*. Aquaculture, 205 (1 & 2): 183-200.

8. Electrical stunning of trout

Many present commercial methods of slaughtering fish for food cause stress and aversive behaviour, which could be considered inhumane. This is especially true for rainbow trout which are usually slaughtered by removal from water resulting in death by anoxia. In the context of fish farming, this slaughter method is becoming less acceptable both from a welfare perspective and in terms of providing consistent and potentially improved flesh quality characteristics. The increasing concern for the welfare of fish has led to research to improve the situation. The use of electricity at slaughter could offer a humane procedure for stunning and/or killing large numbers of small fish when carried out correctly. This paper separately investigates the importance of stun application time, frequency and current magnitude of a sinusoidal alternating current on the ability to stun and stun/kill rainbow trout. In particular, increasing current magnitude and current application time were both found to increase the time for which the animals were effectively stunned. Also, above a current magnitude threshold, the trout were killed by the application. Increasing the frequency of the current waveform decreased the stun duration, until a threshold frequency was reached, at which it is suggested that it may not be possible to stun trout with the current parameters used. All three parameters need to be considered to ensure a humane stun or stun/kill, but such applications may also have implications for quality attributes of the flesh. This investigation will assist in the design of a humane electrical slaughter device for rainbow trout.

Reference

ROBB, D.H. (Division of Food Animal Science, Department of Clinical Veterinary Science, University of Bristol, Langford House, Langford, Bristol BS40 5DY, UK. E-mail: david.robb@bristol.ac.uk), O'CALLAGHAN, M., LINES, J.A. AND KESTIN, S.C. 2002. Electrical stunning of rainbow trout (Oncorhynchus mykiss): factors that affect stun duration. Aquaculture, 205(3 & 4): 359-371.

9. Circadian rhythms of self feeding

It has been shown that daily self-feeding activity (using demand feeding systems) in trout fluctuates rhythmically, has an endogenous origin and persist in fish held in isolation. Whether groups of trout exhibit endogenous circadian self-feeding rhythms remains unexplored. In addition trout in small groups form dominance hierarchies of self-feeding in which a few fish monopolise trigger actuation. Significant relationships between status of self-feeding activity and growth rate have been found in one study but not in others. This present study monitored self-feeding rhythms in groups of rainbow trout, individual variability of self-feeding activity and growth rate. The objectives were to determine whether endogenous circadian self-feeding rhythms exist in groups of trout and to investigate the dominance hierarchy of self-feeding and its influence on growth. Ten trout of mean weight 144.9 ± 12.0 g were transferred to each of eight 290-L tanks and given free access to feed via a self-feeder. Fish in four of the eight groups were individually tagged, and the individual activating the trigger was identified using video observations. The self-feeding activity of each group was recorded under a light:dark cycle of 16.5:7.5 h and under continuous light (LL) conditions. Although diel self-feeding rhythms in the groups of trout were, in general, diurnal, night-feeding activity was observed in the initial LD phase, but there was a progressive reduction and eventual cessation in most groups. Endogenous circadian self-feeding rhythms were detected in the groups of trout under LL conditions. The trout formed dominance hierarchies of self-feeding activity, with one or two individuals accounting for the majority of trigger actuations. However, the dominants did not occupy

the area surrounding the trigger. Growth rates did not differ significantly between the dominants and the subordinates within the groups.

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CHEN, WEI-MIN (Department of Biosciences, Teikyo University of Science and Technology, 2525 Uenohara, Yamanashi, Japan. E-mail: weimchen@nissui.co.jp), NARUSE, M. AND TABATA, M. 2002. Circadian rhythms and individual variability of self-feeding activity in groups of rainbow trout *Oncorhynchus mykiss* (Walbaum). Aquaculture Research, 33: 491-500.

10. The use of AquaMats to enhance growth and improve fin condition

AquaMats are a type of artificial sea weed with a large surface area that is designed to encourage colonisation and growth of algae, zooplankton and other aquatic organisms. They have been used in aquaculture to provide structure in ponds used for fish culture and as a substrate for the growth of aquatic plants and animals which in turn provide a source of nutrition in cultured species. In two separate tests AquaMats were placed into raceways used to rear rainbow trout to evaluate their effect on fish growth and fin condition. In the first test, the AquaMats were placed perpendicular to the raceway length similar to a baffle design. One treatment consisted of AquaMats that were cleaned on a regular basis, and the other treatment consisted of AquaMats that were not cleaned throughout the test. By the end of the test no differences were found between treatments with respect to final fish weight, specific growth rate, or feed conversion ratio. The use of AquaMats did not improve fin condition, in fact several fins measured were significantly better among control fish. In the second test AquaMats were placed on the raceway bottom parallel to their length and to the water flow. AquaMats were also hung from the side of the raceway to provide cover. At the conclusion of this test no differences were found between treatments with respect to final fish weight, specific growth rate, or feed conversion ratio. The placement of AquaMats did have a transitory impact on fin condition. Mid-way through the test treatment fish generally exhibited longer fins compared with the controls. However, by the end of the test, these differences were no longer detectable. The results from both tests indicate that fish were not provided with additional nutrition to the extent it improved growth. However, the use of AquaMats did make a significant, albeit transitory, impact on fin condition.

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ARNDT, R.E. (Utah Division of Wildlife Resources, Fisheries Experiment Station, Logan, UT, USA. E-mail: nrdwr.r arndt@state.ut.us), ROUTLEDGE, M.D., WAGNER, E.J. AND MELLENTHIN, R.F. 2002. The use of AquaMats to enhance growth and improve fin condition among raceway cultured rainbow trout *Oncorhynchus mykiss* (Walbaum). Aquaculture Research, 33(5): 359-367.

11. Effect of formalin and hand-picking regimes on sac fry survival

Investigations using formalin as the anti-fungal control agent during salmonid egg culture have generally involved ceasing chemical treatments at hatch. No studies have examined the effects of post-hatch chemical fungus control on salmonid sac fry survival. The objective of this study was to determine the effects of posthatch formalin treatments and the hand-picking of dead fry on salmonid fry survival in vertical-flow tray incubators. Various combinations of daily formalin treatments, with or without fry picking, were investigated starting at either the eyed stage of egg development or at hatch and continuing until their removal from the incubator trays at fry swim-up. In all experiments, increases in the frequency of hand-picking resulted in increased mortality. The elimination of hand-picking by the use of daily formalin treatments consistently produced the greatest fry survival. Attempts to determine the effect of no fungal control measures were unsuccessful because of excessive fungal growth. To achieve substantial labour reductions and maximise fry survival, it was recommended that daily formalin treatments of 1,667 mg/L for 15 min throughout the entire residence of salmonid eggs and sac fry in vertical-flow incubators, unless there are overriding human health or environmental concerns.

Reference

BARNES, M.E. (South Dakota Department of Game, Fish and Parks, McNenny State Fish Hatchery, 19619 Trout Loop, Spearfish, South Dakota 57783-8905, USA. E-mail: mike.barnes@state.sd.us), SAYLER, W.A., AND CORDES, R.J. 2002. Survival of rainbow trout sac fry subjected to various formalin and hand-picking regimes during rearing in vertical-flow tray incubators. North American Journal of Aquaculture, 64(2): 129-135.

12. Genetic variation for growth, FCR and disease resistance

Breeding objectives for the commercial production of portion-sized rainbow trout demonstrate that production efficiency would be maximised by the development of fish with high survival (including disease resistance), growth rate and feed conversion efficiency (FCR). The success of any breeding programme largely depends upon the amount of additive genetic variation existing within populations. Low levels have generally been found for survival under normal commercial conditions while higher levels of additive genetic variation have been found for growth rate (assessed as body weight and length at specific ages), resistance to specific pathogens and for FCR. In addition favourable genetic correlations have also been demonstrated for each of these traits. These findings suggest that sufficient additive genetic variation exists within farmed populations of trout to enable breeding programmes to be successfully implemented. The objective of this study was to

test that additive genetic (co)variation for survival, growth rate, FCR, and resistance to viral haemorrhagic septicaemia (VHS) exists within a farmed population of rainbow trout. Thirty sires and 30 dams were mated by a partly factorial mating design. Each sire was mated to two dams, and each dam was mated to two sires, producing 50 viable full-sib families (29 sires, 25 dams). The fish from these families were reared for a 215-day grow-out period, and were assessed for survival between days 52 and 215, growth rate (i.e., body weight on days 52, 76, 96, 123, 157, 185, and 215, and body length on days 52 and 215); feed conversion efficiency between days 52-215, 52-76, 77-96, 97-123, 124-157, 158-185, and 186-215, and VHS resistance. REML estimates of additive genetic variation for body weights, length and FCR were obtained by fitting univariate linear (reduced) animal models. Additive genetic variation for VHS resistance was estimated by fitting a Weibull, sire-dam frailty model to time until death of fish challenged with VHS. Genetic correlations were estimated among body weight, length and FCRs that espressed additive genetic variation, while genetic correlatios between VHS resistance and the body weights, length and FCRs were approximated as product-moment correlations among predicted breeding values of the sires and dams. Additive genetic variation was found to be very low for survival, body weight on days 52 and 76, body length on day 52, and FCR between days 185 and 215. However, additive genetic variation was detected for body weight on days 96, 123, 157, 185, and 215 {coefficient of additive genetic variation (CV) = 8.4 –28.4%, heritability (h^2)=0.35 for body weight on day 215}, body length on day 215 (CV=6.9%, h^2=0.53), FCR between days 52-215, 52-76, 77-96, 97-123, 124-157, and 158-185(CV=4.0-13.9%), and VHS resistance (additive genetic variance for log-frailty=0.24, h^2 on the logarithmic-time scale =0.13). Genetic correlations among the body weights, body length, and feed conversion efficiencies that expessed additive genetic variation were generally favourable and moderate-to-very strong (0.55-0.99), though there were unfavourable correlations (-0.01 to –0.33) between the predicted breeding values for VHS resistance and the predicted breeding values for the body weights, body length, and feed conversion efficiencies. These results demonstrate that additive genetic (co) variation for growth rate, feed conversion efficiency, and VHS resistance does exist within the farmed population of rainbow trout, and indicates that selective breeding for these traits can be successful.

Reference

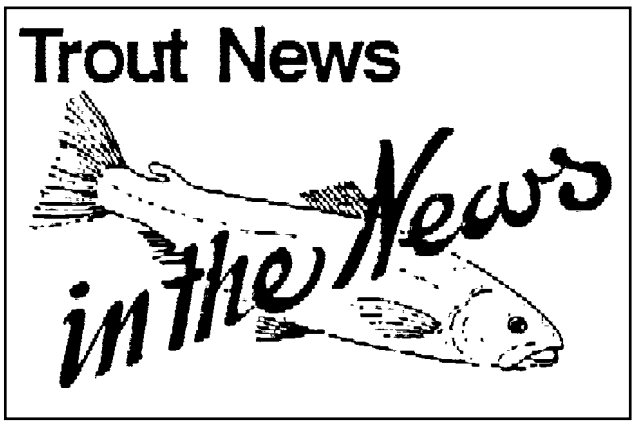
HENRYON, M. (Department of Animal Breeding and Genetics, Danish Institute of Agricultural Sciences, Research Centre Foulum, P.O. Box 50, DK-8830 Tjele, Denmark. E-mail: Mark.Henryon@agrsci.dk), JOKUMSEN, A., BERG, P., LUND, I., PEDERSEN, P.B., OLESEN, N.J. AND SLIERENDRECHT, W.J. 2002. Genetic variation for growth rate, feed conversion efficiency and disease resistance exists within a farmed population of rainbow trout. Aquaculture, 209(1-4): 59-76.

13. Insemination of large egg batches with cryopreserved semen

The use of cryopreserved semen for commercial aquaculture operations requires methods which allow the freezing of large semen volumes to take place or the simultaneous handling of numerous straws or pellets. Cryopreservation of large samples is difficult however, due mainly to non-homogenous and low freezing and thawing rates. Previous work has shown that rainbow trout semen frozen in 4.5 ml straws gave reduced post thaw fertility rates of only 50% while the highest fertilization rates came from frozen pellets of 100 – 250 µL or 1.2 ml straws. However the high numbers of pellets or straws required to fertilise large egg batches (e.g. 500g or around 7000 eggs) requires 16 1.2 ml straws which cannot be handled by one person at the same time without severe deviations from the cryopreservation protocol. This paper describes a new method for fertilization of large egg batches with cryopreserved semen in rainbow trout. Egg batches of 500 g were inseminated with semen frozen in sixteen 1.2-ml straws (sperm/egg ratio=2.7 X 10 : 1). To be able to handle this number of straws at the same time, they were connected in self-made, flexible plastic racks into 'straw packages'. The straws were filled with diluted semen, and the whole straw packages frozen in the vapour of liquid nitrogen 1 cm above the surface of the liquid. As the racks remained flexible in liquid nitrogen, the straw packages could be rolled together for storage in cans in a commercial liquid nitrogen container. For thawing, the straw packages were rolled out and thawed in warm water (30°C, 30 s). They were then placed over the eggs and the straws cut open to release the semen. The semen was mixed with the eggs and, thereafter, 250-ml fertilization solution was added under constant mixing. The fertilization rates achieved were 87.5 ± 1.6% (n = 3) when inseminating 500-g egg batches with cryopreserved semen and 86.7 ± 2.2% for fresh semen controls. Only the dry fertilization technique yielded high fertilization rates when inseminating large egg quantities with cryopreserved semen, while other investigated parameters (amount of fertilization solution, arrangement of eggs) had no influence. The use of these straw packages allows thirty five 1.2 ml straws to be handled at the same time by one person which is sufficient to inseminate egg batches of up to 1000 g (13,000 – 15,000 eggs) – a useful quantity for commercial hatchery purposes.

Reference

LAHNSTEINER, F. (Institute for Zoology, University of Salzburg, Helbrunnerstrasse 34, A-5020 Salzburg, Austria. E-mail:Franz.Lahnsteiner@sbg.ac.at), MANSOUR, N. AND WEISMANN, T. 2002. A new technique for insemination of large egg batches with cryopreserved semen in the rainbow trout. Aquaculture, 209(1-4): 359-367.



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