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Articles, letters and news relating to trout farming or the production of coarse and coldwater ornamental fish are always welcome and may be included in future issues.

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TROUT PRODUCTION

2003 SURVEY OF TROUT PRODUCTION IN SCOTLAND

Data supplied from SEERAD (Rural Affairs Department of the Scottish Executive) Annual Production Survey, 2002 via the website: www.marlab.ac.uk

In 2003 rainbow trout were produced from 56 sites involving 37 companies in Scotland. The overall production of 7,085 tonnes represents a 6.4% increase (426 tonnes) on the previous year (6,659 tonnes in 2002). Production figures for 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 2003 amounted to 6,189 tonnes representing an increase of 478 tonnes (8.4%) on the previous year and accounting for 87% of total production. Fish weighing up to 450g made up 41% of table production.

Restocking Production

Table 3 provides production data for the restocking trade for the last 8 years. Production for restocking decreased by 52 tonnes (almost 5.5%) to 896 tonnes representing 13% of the total production (14.2% in 2002)

Escapes

There was a single escape event in 2003 which involved the loss of 1,560 fish.

Table 1. Total production for the period 1994-2003

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Tonnes	4,263	4,683	4,630	4,653	4,913	5,834	5,154	5,466	6,659	7,085

Table 2. Production of table fish for the period 1996-2003

Year	<450g <1lb	450 - 900g 1-2 lb	>900g >2lb	Total Tonnes
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
2002	2,937	1,056	1,718	5,711
2003	2,531	1,181	2,477	6,189

Table 3. Production of restocking fish for the period 1996-2003

Year	<450g <1lb	450 - 900g 1-2 lb	>900g >2lb	Total Tonnes
1996	188	484	74	746
1997	97	589	119	805
1998	69	538	237	844
1999	236	552	187	975
2000	41	609	193	843
2001	18	526	248	792
2002	28	484	436	948
2003	63	490	343	896

Method of production

Table 4 provides a breakdown of trout farms by system and scale of production. Freshwater production accounted for 5,694 tonnes (80.4% of the total) while seawater production increased by 40% on the previous year to 1,391 tonnes (19.6% 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. Productivity ranged from 25.4 to 77.6 tonnes/person between production areas, being greatest in the West and least in the Southern area.

Mean productivity in tonnes/person for the four population areas reached 47.9 tonnes in 2003 representing an increase of 6.3 tonnes on the previous year. Over the same period staff employed decreased by 12 to 148.

Other species

Other species farmed in Scotland together with the production figures for the last two years are given in Table 6.

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 1995 – 2003. The proportion of ova laid down from GB broodstock decreased to 710,000 representing almost 2.7% of the total. The total number of eyed-ova laid down increased by 4.2 million (19%) on the 2002 figure.

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

Production method	Production grouping (tonnes) in 2002					Total tonnage and (%) by method		Number of Sites	
	<10	10-25	26-50	51-100	>100	2002	2003	2002	2003
FW Cages	0	2	0	0	7	3,462 (52)	3,664 (51.8)	9	9
FW Ponds and Raceways	2	10	3	5	7	2,194 (32.9)	1,998 (28)	30	27
FW Tanks and Hatcheries	3	0	1	0	0	6 (0.1)	42 (0.6)	3	4
SW cages	0	0	0	0	3	997 (15)	1,391 (19.6)	3	3
SW tanks	0	0	0	0	0	0	0	0	0
Total	**5**	**12**	**4**	**5**	**17**	**6,659**	**7,085**	**45**	**43**

NB: Only sites reporting production are included here. Additional sites not reporting production (e.g. hatcheries) are included in Table 5.

Table 5. Rainbow trout production and staffing by area in 2003

Area	No. of Sites	Production			Mean tonnes/ Sites	Staffing			Mean productivity tonnes/ person
		Table	Restocking	Total		F/T	P/T	Total	
North	6	918	116	1,034	172.3	11	4	15	68.9
East	19	1,383	366	1,749	92	35	15	50	35
West	14	3,159	102	3,261	232.9	34	8	42	77.6
South	17	729	312	1,041	61.2	27	14	41	25.4
All	**56**	**6189**	**896**	**7,085**	**126.5**	**107**	**41**	**148**	**47.9**

Table 6. Production of other species in tonnes for 2002 and 2003

Species	Production	
	2002	2003
Atlantic Salmon	145,609	173,373
Arctic Char	7.2	3.1
Brown trout/Sea trout	175.7	198.3
Cod	0	82.1
Halibut	187.2	231.8

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 94% of all ova laid down. Triploid ova decreased to 6% of the total, while mixed sex ova showed a decrease from 570,000 to 60,000, less than 1% of the total.

Imported rainbow trout eggs in 2003

The number and source of imported rainbow trout ova for the period 1996 – 2003 are given in Table 9. The total imported in 2003 – 24,085,000 represents an increase of 2,860,000 (13.5%) on the previous year.

Table 7. Number (000s) and sources of ova laid down for hatching in 1995-2003

Year	Own Stock	Other GB Stock	Total GB	Total 3rd Country	Grand Total	% GB
1995	165	360	525	20,310	20,835	2.5
1996	420	988	1,408	21,270	22,678	6.2
1997	1,232	837	2,069	21,434	23,503	8.8
1998	2,559	60	2,619	22,633	25,252	10.4
1999	878	392	1,270	17,361	18,631	6.8
2000	1,397	900	2,297	18,686	20,983	10.9
2001	918	525	1,443	21,590	23,033	6.3
2002	530	200	730	21,394	22,124	3.3
2003	430	280	710	25,628	26,338	2.7

Table 8. Number (000s) and proportions (%) of ova types laid down for hatching in 1995-2003

Year	All Female Diploid Nos. (%)	Triploid Nos. (%)	Mixed Sex diploid Nos. (%)	Total Ova
1995	19,546 (94)	1,170 (6)	119 (<1)	20,835
1996	21,308 (94)	935 (4)	435 (2)	22,678
1997	21,118 (90)	1,386 (6)	1,000 (4)	23,503
1998	23,222 (92)	1,515 (6)	504 (2)	25,241
1999	16,324 (88)	1,853 (10)	456 (2)	18,633
2000	17,264 (82)	1,202 (6)	2,513 (12)	20,979
2001	20,788 (90)	2,107 (9)	140 (1)	23,035
2002	19,733 (89)	1,822 (8)	570 (3)	22,125
2003	24692 (94)	1,586 (6)	60 (<1)	26,338

Table 9. Number (000s) and sources of ova imported into Scotland during 1996-2003

Source	1996	1997	1998	1999	2000	2001	2002	2003
Northern Ireland	4,095	2,425	2,065	3,335	1,085	710	-	-
Isle of Man	4,182	4,205	3,273	4,222	5,842	6,670	6,775	6,855
Denmark	5,075	5,354	5,700	4,546	4,225	6,135	5,000	5,270
France	-	-	-	-	-	-	-	875
Other EU	220	-	-	-	-	-	-	-
South Africa	8,023	9,450	11,585	6,036	7,762	8,075	7,750	50
USA	-	-	-	-	-	-	1,700	11,035
Totals	**21,595**	**21,434**	**22,623**	**18,139**	**18,914**	**21,590**	**21,225**	**24,085**

ARTICLES

BRITISH TROUT FARMING CONFERENCE, SPARSHOLT, 2-3 SEPTEMBER 2004

Neil Tredwin, Jonathan Hulland, Tim Ellis & Keith Jeffery
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A total of 15 talks were presented over the two days of this conference, which ran alongside the associated trade show. The talks covered a broad range of industry related issues which, on the first day, included diets, stocking, pheromones and trade associations. The presentations on the second day addressed food safety, feeding, health and welfare. The following report covers the talks delivered on the first day of the conference.

Tim Jackson, Principal of Sparsholt College, opened by welcoming the 168 attendees to the 16th annual conference. He praised the work of the academic staff associated with the Aquaculture and Fisheries studies that had recently been graded as 'outstanding' by *OfSTED*.

Paul Morris, a research and technical advisor for Skretting, started the formal presentations by talking on '*The Vegetarian Trout*'. The presentation described the work that has been completed over recent years, on finding alternatives to fish oil and fishmeal in feeds for cultured fish. Paul discussed the rising demand for fishmeal and fish oil globally, in a market where supplies are at very best stable. It is estimated that by 2010 the aquaculture industry alone will require approximately 45 and 80% of the global supplies of fishmeal and fish oil. Factors that can threaten the global supply of raw materials were discussed, for example weather phenomenon such as El Nino, and recent concerns over the accumulation of persistent organic pollutants (POPs) in the marine food chain that could potentially be transferred into fish feeds.

The presentation illustrated the substantial research that has been devoted to the partial and complete replacement of fishmeal and fish oil in fish feeds with plant products. In salmonids, it has been shown that a substantial proportion of the dietary protein and fat can be supplied through the use of various oil seed and grain substitutes. In the laboratory it has been demonstrated that with suitable treatment of the raw materials and amino acid supplementation, it is possible to replace all of the fishmeal in feeds, although the industrial replication of these successes is not guaranteed.

There have been problems in rainbow trout diets when crude plant raw materials have been utilized, such as imbalanced digestive amino acid content, presence of anti-nutritional and antigenic factors, poor mineral uptake and palatability. It was stated that more intensive processing techniques could improve the quality of the diets, however additional processing has cost implications that make the use of vegetable raw materials less cost effective, when compared to conventional fishmeal diets.

Feed trials conducted by Skretting have demonstrated that diets where significant proportions or all of the fishmeal has been substituted with vegetable protein can deliver acceptable levels of growth. However, comparing this acceptable performance with some of the high performance fishmeal feeds that are currently available on the market does show that there is a reduction in growth and feed conversion rates with the vegetable protein feed. This minor reduction in performance could possibly be deemed acceptable if the cost of the vegetable protein diet was significantly cheaper.

Globally the partial replacement of fish protein with plant raw materials is widespread. However despite the popularity of these vegetable derived diets, they have yet to be accepted by the UK market. Paul concluded by stating that if global aquaculture is to continue to grow, fish diets will have to contain an increasing proportion of plant protein. This trend in aquaculture diets will result in the production of an 'omnivorous' trout but, if the demand was sufficient, the growing of a 'vegetarian trout' is definitely feasible.

Ravi Chatterji and Dominic Stubbing of the Game Conservancy Trust presented the next talk entitled '*The Success and Effects of Brown Trout Stocking in Rivers*'. For over 100 years the stocking of reared (domestic) brown trout has been commonplace to boost rod catches on fishing rivers. However, the potential effect of these stockings on the indigenous population has been put under the spotlight in recent years. The speakers described their experimental field trials to investigate the success of stocking brown trout and the resultant effects on the growth and abundance of the wild trout populations.

The first trial was carried out in both upland rain-fed and lowland spring-fed chalk streams. A total of forty-eight 500 m sites were selected, with 12 designated as controls and 36 sites designated as experimental sites (12 sites at each of three stocking treatments). Firstly the initial population of wild brown trout was estimated via electro-fishing and the catch depletion method. The stock was measured and weighed with all wild brown trout over 100 mm being micro-tagged. In the experimental sites, the baseline wild brown trout populations were then increased by either 25%, 50%, or 100%, by stocking reared brown trout obtained from two large suppliers. The numbers and sizes of the stocked fish approximated to current stocking practice. All the fish were measured, weighed and tagged before stocking

The second trial was undertaken to investigate the success of stocking fry, which had been marked using a calcein osmotic induction technique. The experimental design and methodology were similar to that for the adult trial, except that stocking treatments were 25%, 100% and 200% of predicted spring 2002 fry densities (after assuming a 90% mortality from autumn 0+ densities).

Monitoring has been carried out to examine the effect of the introductions on the survival, abundance, biomass and growth rate of both the wild and stocked fish. As the studies are still ongoing, the results are yet to be fully analysed and published. The experimental design will enable the river-dependent and strain-dependent effects of the two size groups to be assessed. The quality and quantity of suitable salmonid habitat was also assessed using HABSCORE in the hope that it may be possible to formulate stocking practices appropriate for the habitat.

Guy Mawle from the Environment Agency then followed with a talk entitled 'S*tocking and the Strategy*', which discussed stocking in relation to the recently published "National Trout and Grayling Strategy". This talk is presented as a full article elsewhere in this issue of *Trout News*.

After lunch, Colin Waring from the University of Portsmouth spoke on '*Sex Pheromones in Salmonids*'. He introduced the subject area by describing a pheromone as a substance that is released by one individual of a species and received by another individual of the same species. Sex pheromones are those chemicals associated with communication connected with reproduction. He then explained why fish use pheromones. Firstly the males and females must be able to synchronise spawning, which is especially important for the females as the eggs deteriorate after ovulation. Secondly, many species migrate vast distances to spawn and pheromones help to synchronise spawning. Thirdly, chemical communication is used in some fish species that spawn at night or in murky water where visual communication is limited.

The initial discovery that fish use sex pheromones was made by accident in goldfish, and there is a now a significant amount of information for this species. There has also been work on lampreys and salmonids. There is now data on sex pheromones for Atlantic salmon, brown trout, Arctic charr and rainbow trout. All the fish pheromones identified to date are detected by smell (olfaction), rather than taste. A fish's nose is highly sensitive, despite its small size. The nose consists of a highly folded epithelium containing high densities of sensory (ciliated and microvillar) receptor cells, which stick out into water effectively giving the nose a huge sensory surface area. Pheromones bind to receptors in the nose and nerve impulses are sent to the brain's olfactory lobe, and then relayed to other centres of the brain. For sex pheromones, it is the pituitary region of the brain that is stimulated, which in turn stimulates the gonads.

Because fish release thousands of chemicals – via the gills, urine and faeces - identifying the active pheromone can be like looking for a needle in a haystack. However, the approach used to screen candidate compounds relies on the crucial involvement of the nose and nerve impulses to the brain. Electrodes are placed near the nose of an anaesthetised fish, and action potentials in the nerve can be detected if an odorant binds to a receptor. Once odorants stimulating a response have been identified, they can be screened for sex pheromonal ability using a bioassay. The bioassay for pheromones released by females involves exposing males to the water-borne compounds and measuring the sex hormones in the blood and the volume of expressible milt. An increase in male sex hormones levels and milt production indicates that it is a sex pheromone.

So what is the likely route of release of a sex pheromone? It was thought probable that females would release a sex pheromone in their urine, as it was known that salmonids in freshwater release a significant quantity (3-5 ml of urine per Kg body weight per hour). In an experiment, male salmon were exposed to female urine and showed a 5-fold increase in sex hormone and expressible milt levels. This demonstrated that female salmon release a sex pheromone in urine to which the males respond, but what could the pheromone be? Many compounds were tested using the bioassay, and the most potent were found to be F-type prostaglandins (PGFs) - hormones involved in ovulation within females. Further experiments showed that the nose of mature males is very sensitive to PGFs, and that this sensitivity is also season dependant, i.e. increases during spermeating. The bioassay showed that PGFs in the water increased expressible milt volumes and the levels of the sex hormones (testosterone and 17,20βP) in the blood. Testosterone is thought to be involved in male reproductive behaviour, and 17,20βP is thought to be involved in milt production and sperm maturation. It was subsequently shown that of the prostaglandins, it is only the F-type prostaglandins (PGF1α and PGF2α) that increase testosterone and expressible milt levels. It was also confirmed that females release PGFs in the urine (18 ng PGFs/ml urine).

Experiments with brown trout have shown they share the same sex pheromone (PGFs) as Atlantic salmon. Similar to salmon, PGFs are released by female brown trout, which the males readily smell and which promote a quick response increasing levels of sex hormones and milt. It has also been shown for brown trout that much higher concentrations of PGFs are released with the discharged ovarian fluid than within the urine (186 v 4 ng/ml). Studies have further shown that males will respond to the urine from females of the other species.

In other, more distantly related salmonids, sex pheromones are present but there are differences in the systems. In Arctic charr, the same pheromone is used, but the effect is on the opposite sex. The males release PGFs that are then smelt by the females who respond by digging a nest and becoming ready for spawning. In rainbow trout, females release a sex pheromones in both the urine and faeces to which the males respond. However, the pheromone is not a PGF - although female rainbow trout do release PGFs in their urine, males cannot smell them.

In summary, all four salmonid species use sex pheromones that stimulate reproductive biology in the individuals that smell them. In three species, PGFs have been identified as the sex pheromone, whereas rainbow trout appear to differ in the sex pheromone(s) used. This research also has applied relevance to fish farming. Firstly, if farmers experience problems with milt production then exposing the males to water from sexually mature females may help. There is evidence from experiments with goldfish indicating that males exposed to female pheromones also produce better quality sperm. Secondly, it is theoretically possible that pheromones released from salmonid farms will affect wild fish. Wild salmonids may, theoretically, be attracted to fish farms, disrupting migration to spawning grounds. Testosterone is released in the urine and is known to be a potent attractant to male salmon. Also, some of the hormones released in the urine of both male and female salmonids are known to be important sex pheromones in coarse fish (e.g. 17,20βP), and so may affect their reproductive biology.

Courtney Hough, General Secretary of the Federation of European Aquaculture Producers (FEAP) then spoke on '*Representing European & National Aquaculture*'. He started the presentation with a quote emphasising that while things are going well industry payments of subscriptions to trade associations is not a problem, but when prices are low or the industry is under pressure, such payments are not forthcoming, at exactly the time when a strong trade association is most needed.

FEAP represents national aquaculture associations on European fish farming issues. In 1993 its old equivalent FES had 14 members and a budget of £20,000. There has since been a period of rapid growth and today FEAP represents 29 associations spread across 21 nations stretching from Iceland to Cyprus, and has an operating budget exceeding £450,000. Mr Hough explained that while some countries have a single national aquaculture association (e.g. Italy), others have associations split by species (e.g. U.K & Spain), or geographically (e.g. North and South Portugal).

The objectives of FEAP are to provide a forum that helps to develop common opinions on issues of importance and then to communicate these opinions to the relevant authorities. FEAP is a member of the EU Commission's Advisory Committee on Fisheries and Aquaculture (1999) (ACFA). ACFA is a statutory body that gives the only official link to European Commission processes. This link provides a line into areas of legislation that are likely to affect the industry. It also provides a mechanism to call up people to discuss contentious issues. Another key representational role of FEAP is liaison with the Food & Agriculture Organisation (FAO) of the United Nations and linking with various FAO committees, which are important for Global and regional policy developments. FEAP is also a member of the Confederation of European Agriculture and therefore an observer to the Council of Europe. FEAP has therefore been involved in the draft convention on fish welfare, which is now in its sixth year of discussion. FEAP also has good informal links with the Fisheries Committee of the European Parliament that is responsible for aquaculture.

The operating structure of FEAP is comprised of three tiers, with the president in the top tier. The second tier is comprised of a management committee (vice-presidents and the secretary), a Secretariat, and the Assembly (of members of the Associations). Representatives from the Assembly then provide input into the third tier - Commissions and Working Groups focussed on specific issues, initiatives or species. FEAP representatives must be professional and expert, whilst still being knowledgeable of, and active in, the sector under discussion. One of the roles of FEAP is to monitor and produce production and pricing information that can be used to help develop proposals for a long-term strategy that dovetails policies for economically, socially and ecologically sustainable development.

Mr Hough then gave his personal point of view on National Associations. He stated that the financially strongest associations tend to be those that have an assured income by collecting subscription fees through the feed companies (e.g. Italy). The politically strongest associations tend to be those from countries that have coherent national policies at political and association levels, with assured representation and policy support (e.g. Spain). The weakest associations tend to be those with modest budgets and part time staff, with the consequence of poor representation and foresight. Most countries that have had several species based associations have now consolidated or created a national Federation of smaller associations (e.g. Denmark, France). Mr Hough again stressed that one national association provides advantages in terms of budgetary consolidation and cost efficiency, as well as providing a single contact point and harmonized opinions.

Mr Hough concluded by stating that a national association was essential, acting as a ‘knowledge centre’ to serve the national industry, providing service and initiatives that individual companies cannot. National associations provide a focal point for representation and development actions, as well as being able to develop quality schemes and marketing actions. Finally he looked to the future position of aquaculture. Although fisheries yield is decreasing, there is a moderate sustained increase in fish farming, which now delivers 12% of the market product but 23% in terms of value. A future challenge will be to compete with the growth in cheap imports. Associations should be looking to increase product value in the future, rather than trying to produce their way out of problems because this is a likely route to disaster.

The talks presented on the second day of the conference will be reported in the next (July) issue of *Trout News*, together with the programme for the 2005 conference. The steering committee is keen to hear from farmers to ensure that the Sparsholt Conference meets their goals. Please feel free to contact any member of the steering committee with feedback or ideas.

STOCKING AND THE STRATEGY

Guy Mawle, Fisheries Strategy Manager, Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol, BS32 4UD

After extensive consultation, the Environment Agency’s National Trout and Grayling Fisheries Strategy for England and Wales was finalised last year. The aim of the Strategy is to conserve and improve wild fish stocks and their environment, whilst enhancing the social and economic benefits from all the fisheries for these species, whether wild or stocked. There are 32 policies of which 8 relate to stocking.

Stocked fisheries are important. In a survey of trout anglers in 2000[(1)], while 68% said that they prefer to catch wild trout, 74% said that they caught stocked trout most often. This is not surprising since for most people stocked still waters offer the nearest available trout fishing. Stocking with farm strain trout can pose a range of potential risks to wild trout if there is a population present, and in some circumstances to other species. These risks include: competition, predation, attracting predators, stimulating fishing, disease, and genetic impacts if there is interbreeding. The Strategy’s policies on stocking aim to minimise these risks and many do not involve a significant change from previous policy. Consent to stock trout into fisheries is required from the Environment Agency. This article outlines some of the key policies for stocking and progress in delivering them.

When considering whether or not to grant consent, **Policy 15** identifies the overall principles, i.e.:

- Stocking should not jeopardise naturally established ecosystems; and
- There should be no detriment to the fisheries of the receiving (or donor) water.

Policy 16 states that: “*we will work with others to identify the limits to the number or size of fish stocked … to avoid undue risk of damage to wild stocks*”. We are taking a close interest in the current three-year study by the Game Conservancy on the impact of stocked trout in upland and lowland streams. We may even contribute to the funding of the third year’s work if it can be adapted to include a comparison between diploid and triploid female trout.

Stocking trout also presents a potential risk to juvenile salmon. This is particularly important in rivers designated as candidate-Special Areas of Conservation for salmon under the EU Habitats Directive. To get a better understanding of the risks involved, we have, with English Nature, co-funded a desk study which is due to report next spring.

Policy 17 is concerned with genetic risks. Stocking with fertile, farm strain brown trout could, through inter-breeding, reduce the viability of wild populations or change distinct or evolutionarily important stocks of *Salmo trutta* (sea trout or brown trout). We are concerned where considering requests for consent to stock that there should, at least, be no additional risk of such genetic damage from stocking. This is being achieved through Policies 27, 28 and 29.

Policy 27 says that, subject to the overall principles in Policy 15, consent to stock a Native Trout Water with brown trout will be granted, provided:

- Stocking is consistent with practice over the past five years; or
- The trout are female, triploids which are sterile; or
- Stock fish are derived from local, naturally produced broodstock and reared under a suitable rearing regime.

Figure 1. An indicative, national map of native trout waters in England and Wales

The first task has been to identify the Native Trout Waters. These are waters which have significant natural production of *Salmo trutta* or from which there is ready access to other waters with such production. Our local fisheries staff have identified such waters based mainly on fish surveys. An indicative, national map of native trout waters has been produced (Figure 1) and can be viewed in more detail on the Fisheries Management pages on our web site, www.environment-agency.gov.uk/fish. If needed, a more detailed local map can be obtained from fisheries staff in the relevant Area office. The map is being used in assessing stocking applications. Should consent to stock be refused because the fishery is a designated 'native trout water' and the applicant considers this inappropriate, a review of the designation by national staff may be requested.

Policy 28 indicates that this policy will be reviewed in 2006 with any possible revisions subject to consultation with fisheries interests. The review will be informed by research into the production, performance and impact of triploid trout relative to diploid, farm-strain trout. The first phase completed by CEFAS was reported in *Trout News 38*. Other research is in hand. One conclusion of the CEFAS report was that technical knowledge on the production of all-female, triploid brown trout was not freely available. To address this, the British Trout Association and the Environment Agency are jointly funding the production of a protocol, to be available next spring.

Policy 29 allows for the creation of Wild Fisheries Protection Zones in native trout waters where no stocking would be allowed. These zones will only be created after consultation with local fisheries and conservation interests for one of three reasons:

- Fisheries owners want their fisheries to contain only wild fish to be more attractive to the rods fishing it.
- The wild trout present are considered to be genetically distinct or evolutionarily important.
- To avoid an unacceptable risk from predation or competition to important salmonid nursery areas.

In November, the first pilot consultation started in the Hampshire and Isle of Wight Area. Its purpose is two-fold:

- to check whether the designation of local 'native trout waters' is correct and if not, why not; and
- ask whether there should be any Wild Fisheries Protection Zones in the Area and if so where, and why.

The outcome of the consultation will be reported in April. Similar consultations will take place in other areas and the whole country should be covered within the next three years.

A copy of the Strategy can be obtained by ringing the EA Customer Contact Centre, 08708-506506, or can be downloaded from the website (www.environment-agency.gov.uk/fish). We hope to report further progress with the Strategy through Trout News.

Reference

1. Simpson, D. and Mawle, G.W. (2002). Survey of rod licence holders 2001. Environment Agency R&D Technical Report W2-057. 104pp.

PAIN PERCEPTION IN FISH

Lynne U. Sneddon, University of Liverpool, School of Biological Sciences, Liverpool L69 7ZB

This article is based upon a talk given at the 2004 Sparsholt BTF Conference

Introduction

Freedom from pain is essential for the welfare of any animal. However, assessing whether an animal group, such as fish, can experience pain is difficult. Many scientists have discussed how to differentiate the ability to perceive pain from simple nociception. Nociception refers to the detection of potentially injurious stimuli. All animal groups possess nociceptors, special sensory cells that preferentially detect potentially damaging stimuli, enabling a reflex withdrawal response. Pain, however, is a much more complicated phenomenon in which the sensory (nociception) component is coupled with a psychological experience. A psychological component is necessary for an animal to be considered as suffering, with suffering being the core of welfare assessment. However, it is very difficult to get into an animal's mind to prove a psychological experience. A series of principles, based on Bateson's criteria[1], have therefore been drawn up to guide decisions as to whether an animal might be capable of experiencing pain. These criteria are based on the presence of appropriate neural hardware, physiology and behaviour, i.e.

I. nociceptors
II. brain structures
III. Pathways to higher brain structures
IV. Opioid receptors and substances
V. Analgesics reduce nociceptive response
VI. Avoidance learning
VII. Suspension of normal behaviour

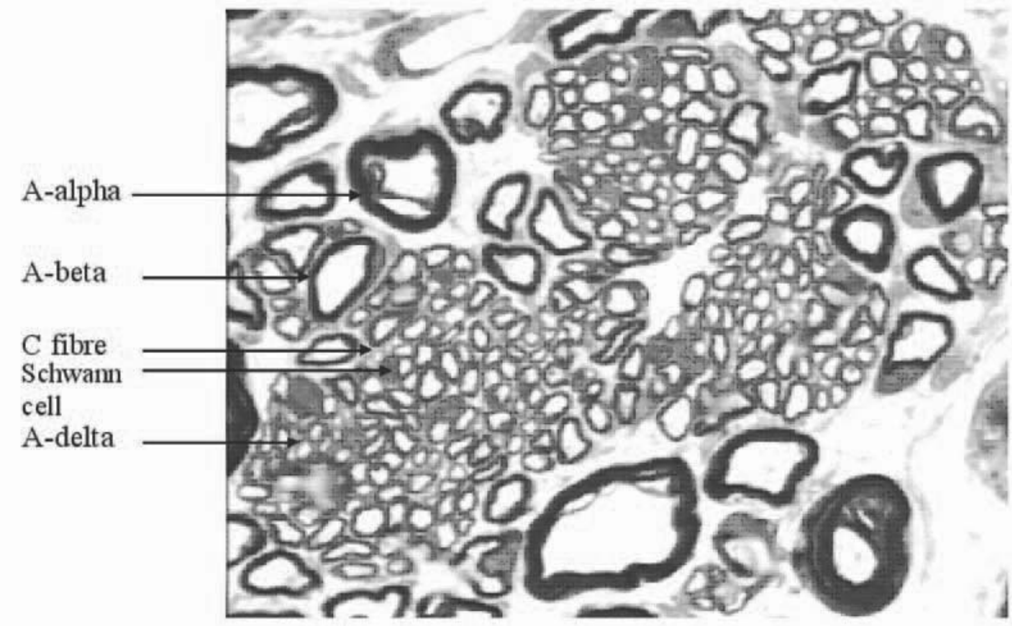

Figure 1. Section through the maxillary branch of the trigeminal nerve in rainbow trout showing the presence of A-delta and C fibres[6]

Each criterion shall be taken in turn to assess whether teleost fish do have the potential to perceive pain.

I. Nociceptors

Nociceptors are associated with free nerve endings and are usually of two nerve types - small myelinated A-delta fibres and smaller unmyelinated C fibres. Although the teleost fish body is covered in free nerve endings of unknown function, few studies have looked for the presence of these fibre types. One recent study on rainbow trout examined the trigeminal nerve – the nerve that conveys pain information from oral and facial areas in humans. A-delta or C fibres were found in all of the three main branches of the trigeminal nerve[2], and these fibres matched the size range found in higher vertebrates (Figure 1).

Receptors on the head of rainbow trout were identified by applying various localised stimuli and assessing innervation of the trigeminal nerve. The majority of receptors identified were slowly adapting mechanoreceptors. From a total of 58 receptors, 22 were also responsive to noxious (>40°C) heat. Of these, 18 also responded to application of acetic acid, a potentially painful chemical, and could be classified as polymodal nociceptors (Figure 2; [3, 4]). The remaining four, which did not respond to acid, were classified as mechanothermal nociceptors. These receptors responded in a similar way to those found in mammals and humans in that they preferentially detected noxious stimuli and were unresponsive to neutral stimuli. This research proves that the rainbow trout is capable of nociception.

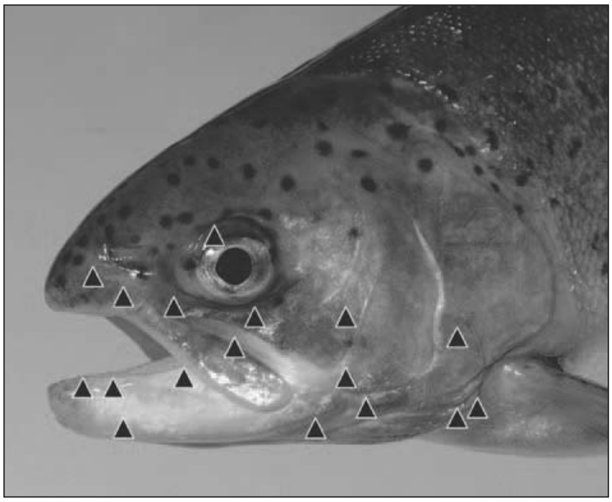

Figure 2. The position of nociceptors on the head of the rainbow trout. These areas or receptive fields detected noxious, potentially painful stimuli (picture taken by R. Field, Roslin Institute[9])

II. Brain Structures

Fishes do have the necessary brain areas for processing nociceptive information (e.g. pons, medulla, thalamus). However, one area of debate is the cortex. The most highly evolved vertebrates, humans and primates, have the most developed cortex with the evolution of the neocortex. Further down the evolutionary tree of vertebrates the cortex becomes less differentiated, but fishes do possess a rudimentary cortex. This telencephalic (forebrain) area is characterised by large well-defined cell groups with a well-developed thalamic input that is necessary for pain processing to occur in other animals. This rudimentary cortex is better developed in teleosts than other fishes, with the hemispheric zones possessing complex projections to the midbrain. Dunlop and Laming[5] have shown that there is neural activity in the brain during potentially painful stimulation in trout and goldfish, demonstrating that the brain is involved and these are not merely reflexes that occur at the spinal level. Ongoing work in our laboratory is examining global gene expression in the brain of common carp whilst enduring a potentially painful event. The majority of gene expression changes have been found to occur in the forebrain where the cortex is situated[6].

III. Pathways to the brain

The major tracts involved in nociceptive processing and relaying information to the brain are the trigeminal tract (conveying information from the head) and the spinothalamic tract (conveying information from the rest of the body). Both tracts have been extensively studied in fish. Research in a variety of species has demonstrated that the trigeminal clearly projects to the midbrain, the thalamus, as it does in higher vertebrates. This pathway is therefore present in fish (Review in [7]). The spinal cord has also been examined in a number of fish and found to be strikingly similar to that of higher vertebrates, showing that fish possess the same basic components of ascending spinal projections as mammals.

IV. Opioids and endogenous opioids

The possession of opioid receptors and endogenous opioids and enkephalins is thought to be a crucial factor in determining whether pain perception can occur. In mammals, opiate receptors and substances are associated with regions involved in the processing of nociceptive and pain information. Opiate receptors and enkephalin like substances have been found in various brain areas of goldfish, catfish, African lungfish and rainbow trout (Review in [7]). Within the fish brain, enkephalins show a similar distribution pattern to that seen in higher vertebrates. Therefore, the distribution of opiate receptors and substances in both elasmobranch and teleost fish groups is comparable to that in higher animals.

V. Analgesics reduce nociceptive responses

Very little is known about analgesia in fish since it has only recently been demonstrated that they possess nociceptors. However, our studies have examined the effects of morphine on the *in vivo* responses to subcutaneous acetic acid injection in the rainbow trout[4, 8]. Acid-injected fish displayed the adverse behavioural response of rubbing the affected area, a behaviour not observed in handled controls or saline injected fish. When morphine was administered to acid-injected fish, there was a dramatic reduction in this rubbing behaviour (Figure 3a). As well as affecting behaviour, the enhanced opercular ventilation rate seen

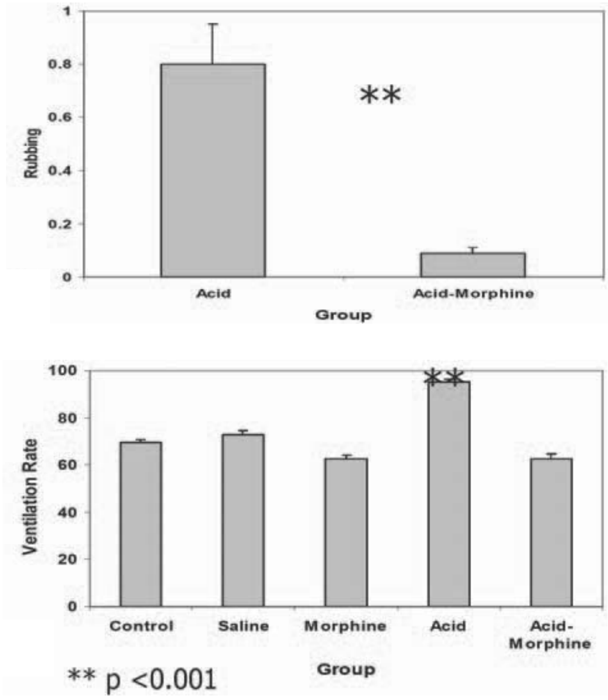

Figure 3. (a)The mean frequency of rubbing performed by rainbow trout injected subcutaneously with 0.1% acetic acid (Acid) and fish also injected with the acid but administered with morphine (Acid-morphine). (b) The mean opercular ventilation rate of handled (Control), saline injected fish (Saline), control fish administered with morphine (Morphine), acid injected fish (Acid) as well as acid injected fish that were treated with morphine (Acid-Morphine)[8]

in acid injected fish was also ameliorated by morphine (Figure 3b). Morphine therefore does appear to reduce nociceptive responses in teleost fish.

VI. Avoidance learning

Ehrensing *et al.*[9] demonstrated that goldfish can learn to avoid an electric shock. They further demonstrated that when morphine was administered, the fish failed to learn and a high voltage of electric shock was needed to elicit a response. When the antagonists that block the action of morphine, MIF-1 and naloxone, were used a response was elicited at a much lower voltage (Figure 4). A few studies have shown that teleost fish are capable of associating a stimulus with a noxious experience and learning to avoid it subsequently[10, 11].

VII. Suspension of normal behaviour

The final criterion to try to gauge whether an animal is perceiving pain rather than displaying a simple nociceptive reflex is the interference of normal behaviour. If normal behaviour is adversely affected and the experience is painful to humans, then it is likely to be painful to the animal. Although this is an indirect and subjective method of assessing how

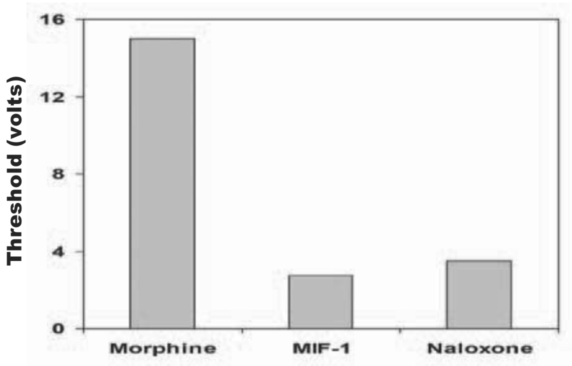

Figure 4. The voltage of electric shock needed to elicit an avoidance response in goldfish administered with morphine or the opioid antagonists MIF-1 and naloxone (5)

the animal responds to the experience, it is currently the primary method available for assessing animal pain[1]. When rainbow trout were injected with acetic acid and bee venom (potentially painful) they did not feed for 3 hours, during which time they showed an enhanced opercular ventilation rate as well as performing anomalous behaviours[4]. In contrast, handled controls and saline injected fish began feeding around 1⅓ hours after treatment, and did not perform anomalous behaviours or show such a great increase in ventilation rate. The noxiously stimulated fish only resumed feeding once the behavioural and physiological affects of the bee venom and acetic acid had subsided (3 hours). Further testing showed that noxiously stimulated trout did not show an appropriate fear response to a fear causing stimulus and it was suggested that the noxious experience dominated attention and the fish could not divert attention to the fear stimulus[12]. Many clinical studies have shown that humans do not perform tasks as well when in pain. These studies on rainbow trout therefore demonstrate that a noxious experience adversely affects normal behaviour, thus suggesting higher processing is involved and hence the potential for pain perception.

Conclusions

In the case of the rainbow trout, all the criteria for nociception and pain to occur have been fulfilled. Therefore, any damaging procedures we submit this species to may be painful and negatively affect their welfare. Studies are now addressing the equipment and techniques used to try and improve conditions for fish and to minimise any damage. Fish are an important food and we have to catch and farm them to provide a constant supply of fresh fish. However, as they have the potential to experience pain, it is important that we do this as humanely as possible.

Acknowledgements

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RAINBOW TROUT ON THE LOOSE IN SCOTLAND

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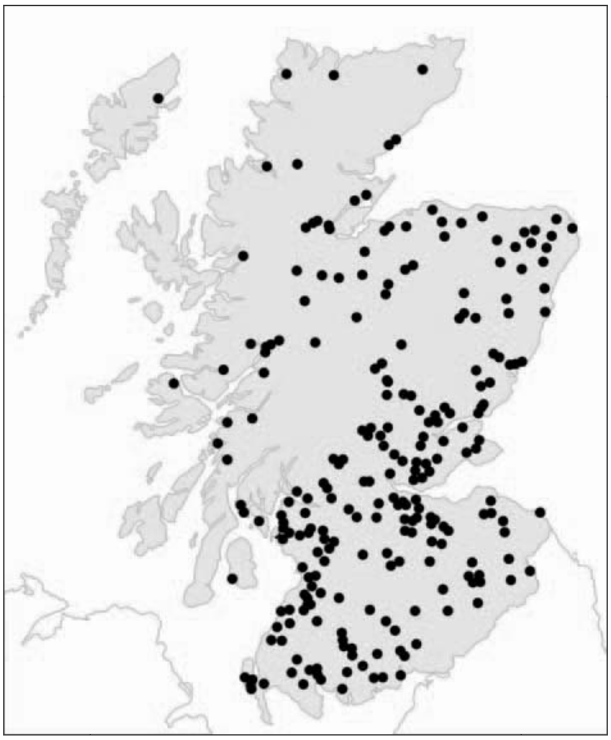
Recent rainbow trout surveys in Scotland

During 2002, FRS Freshwater Laboratory at Pitlochry carried out a questionnaire survey of the national status of rainbow trout stocked in inland Scottish waters. One thousand reply-paid forms were sent to a wide variety of public and private groups with fish and fishery interests and more than 350 replies were received.

The survey found that the use of rainbow trout had grown substantially since the last national survey was conducted in 1974. In line with the increased use of rainbow trout for put-and-take angling across the UK, there had been substantial increases in annual stocking densities per hectare and average size of stocked fish. A total of 305 Scottish stillwaters were identified as currently stocked with rainbow trout. However, this figure almost certainly underestimates the true extent of stocking with this species because many small private fisheries are likely to have been missed. In an FRS report on the results of the questionnaire survey (Walker, 2003), it was estimated that about 1000 tonnes of rainbow trout were stocked in Scotland per annum. Throughout much of the country, but less so in the Highlands and Islands, intensively stocked rainbow trout fisheries are now an important economic and recreational resource. *[A later investigation of the economic impact of game and coarse angling in Scotland, commissioned by the Scottish Executive (Radford et al, 2004), reported that rainbow trout angling was worth £19.4 m. to the Scottish economy, compared with £73.5 m. derived from salmon and sea trout, £14.7 m. from brown trout and £4.9 from coarse angling.]*

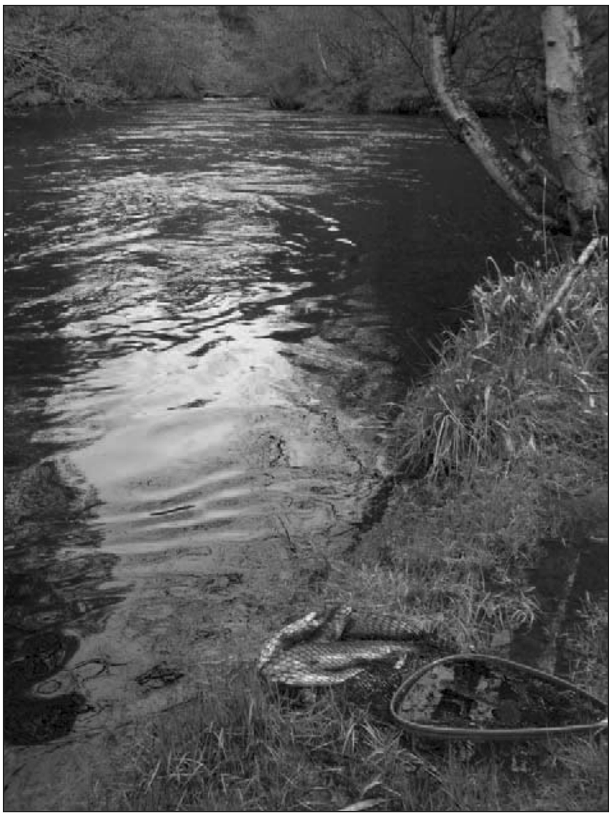


The location of stocked waters in Scotland holding rainbow trout in 2002

Anglers fishing around the cages in Loch Earn, Perthshire

On the negative side, some respondents to the questionnaire on rainbow trout were worried about possible ecological impacts of perceived high levels of escapes into other waters. They were reported from 54 rivers or streams, seven freshwater lochs and three sea lochs, or estuaries, where they were not stocked. These observations were not all recent, but the inference was that escapes from fish farms or fisheries were widespread. Some spawning had been observed, but the overwhelming majority of respondents were unaware of successful reproduction of rainbow trout in the wild in Scotland. Even so, the managers or owners of 14 stocked waters believed that some successful spawning had taken place. This was likely because FRS Freshwater Laboratory staff knew of another 12 waters where such spawning had occurred, although no self-sustaining populations resulted. There was a long-standing (several decades) population in a small hill loch near Invergarry, Inverness-shire, which now appears to be extinct.

Due to the concerns from various parts of the country about the potential for ecological impacts of escapes, a case study was undertaken during 2002/03 in the upper River Earn and Loch Earn, in Perthshire (Walker, 2004). The study confirmed that rainbow trout were indeed common there. During sampling carried out throughout the year, 215 specimens were collected by angling, gill-netting and electro-fishing, 180 from the river and 35 from the loch. They appeared mainly to have come from local rainbow trout farms. The sampled fish covered a wide length range (122 - 456 mm), suggesting multiple escape incidents or sources. Among 204 fish that were sexed, females were much more common than males (188:16). However, nine females and two males had developing gonads and, during the spring sampling period, three females were part-spent, or spent and one male also appeared to have been spawning. Yet, no rainbow trout fry were found during the survey and only two trout were aged more than 2+ years, indicating short-term survival of the escaped fish in the wild. The absence of fry, the highly skewed sex ratio and the fact that all of the fish had fin damage consistent with intensive culture, showed that the escaped rainbow trout were not managing to reproduce effectively.



Angling catch of escaped rainbow trout in the upper River Earn, Perthshire

Even so, rainbow trout ova incubated in mesh boxes buried under gravel in three streams near Pitlochry, as part of an MSc studentship (McMullan, 2003), resulted in 75% of the ova developing normally to the point of fry emergence. After this, 10,000 unfed fry were liberated in one of the streams, in this case one running into a loch where rainbow trout were already stocked. Some were still present two months later, but the very dry summer that year caused the channel of the burn to dry completely. Clearly, natural reproduction of rainbow trout in the wild in Perthshire is feasible although apparently rare. One reason for its rarity is scarcity of mature male fish due to the increased use of all-female stocks for fish farming for the table and for restocking. Another likely reason is the general behavioural incompetence in the wild of rainbow trout that have experienced long-term genetic selection in aquaculture.

Planting stacked experimental boxes of rainbow trout ova to test incubation success levels

The stomach contents of the escaped rainbow trout that were sampled in Loch Earn and the River Earn included a wide range of invertebrate species, including terrestrial insects blown onto the surface of the water. However, there was also a lot of indigestible material, such as bits of stick, stones, and weeds.

Recent escapees, like recent stockees in a put-and-take fishery, were well-charged with intestinal fat, but many of the fish found in the River Earn were losing weight. In spite of vociferous claims to the contrary from some anglers, the survey found no evidence of predation on salmonid fry or parr, although one rainbow trout contained a large minnow. Also, salmon and trout continued to spawn successfully in close proximity to the rainbow trout farms and juvenile densities were good. However, larger brown trout and grayling were scarce. This may have been due to competitive pressure from escaped rainbow trout, but increased angling effort in the area, including bait-fishing, is likely to have depleted wild fish stocks as well as rainbow trout. Escaped rainbow trout are also attractive locally to otters, mink, herons and ospreys and when abundant may increase the general level of predation. *[Following the issue of the report, Jon Gibb, Fishery Manager of the River Lochy Association, Inverness-shire, provided photographic evidence of a partly digested salmon smolt in the stomach of a large escaped rainbow trout and stated that such predation was believed to be common in the River Lochy. We reiterated that greater efforts should be made to contain rainbow trout and suggested that the Lochy Association and Lochaber District Salmon Fishery Board might wish to organise a fuller investigation of the diet of escaped fish in their area, perhaps through the local Fisheries Trust.]*

Conclusions from the studies

- There has been a large increase in the useage of rainbow trout for stocking angling fisheries in Scotland during the last thirty years.
- These fisheries are an important economic and recreational resource and are very popular with anglers.
- Viewed in the context of conserving native stocks of fish, the growing number of stocked rainbow trout fisheries is a concern where natural water bodies are used for this purpose.
- More needs to be done to contain rainbow trout in fish farms and stocked fisheries and prevent them appearing in natural waters where they are generally unwelcome, although their ecological impact remains unclear.
- However, colonisation of Scottish waters by rainbow trout through natural spawning is not an issue although, with gradually changing climatic conditions, it is conceivable that the species could become naturalised here eventually.

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FISH MEDICINES AND FEED ADDITIVES: A GUIDE TO THE REGULATORY IMPLICATIONS OF THEIR USE IN UK AQUACULTURE

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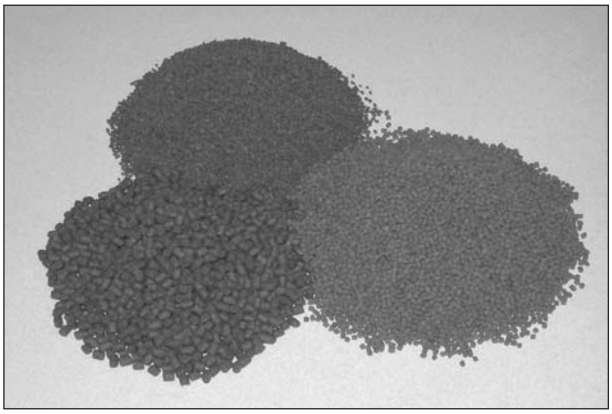
Introduction

It has long been recognised that veterinary medicines, including vaccines, used in food fish production should be demonstrably effective and safe to the target animal, as is the case for other farmed animals. Safety to the eventual consumer and the environment should also be proved. Legislation prohibits the marketing or administration of a veterinary medicinal product unless it is authorised. A marketing authorisation may only be granted where scientific assessment of data supplied by the applicant against statutory criteria of safety, quality and efficacy demonstrates that the



product has a positive risk/benefit ratio when used in accordance with the manufacturer's instructions. In the UK the Veterinary Medicines Directorate (VMD) has responsibility for the regulation of veterinary medicines.

Additives to fish feeds are also regulated and only authorised substances can be used. However, a number of 'non-traditional' products, such as stress relievers and immunostimulants, are now being used in aquaculture that are not authorised as either medicines or feed additives - often because the manufactures and farmers do not view them as being in either category. The purpose of this article is to review the regulatory status of fish medicines, commodity chemicals, feed additives, immunostimulants, stress relievers, probiotics and prebiotics, and clarify some of the confusion in this general area.

Fish medicines

Any product administered to animals that makes a claim for a medicinal effect, or that possesses an ingredient to treat or prevent an adverse condition, is considered to be a veterinary medicine.

> ***Definition of a "medicinal product" (Article 1 of Directive 2001/82/EC)***
> "Any substance or combination of substances presented as having properties for treating or preventing disease; or any substance or combination of substances which may be used in, or administered to, animals with a view either to restoring, correcting or modifying physiological functions by exerting a pharmacological, immunological or metabolic action, or to making a medicinal diagnosis."

Off-label and illegal use of medicinal products in fish

A significant number of products are available in pet shops or through the Internet for the prevention or treatment of a range of fish diseases. However, most of these products do not appear to be authorised as fish medicines. The wide availability of these non-authorised products has been causing some confusion amongst fish health professionals and farmers, with many questioning the relevance of the medicine legislation. Legislation on veterinary medicines applies to all products that fall within the definition of a veterinary medicinal product whether marketed for farmed or pet fish. Such products that are not authorised as medicines are illegal. The use of such products is also illegal and manufacturers, sellers and users can be prosecuted.

In the absence of an authorised product for a specific condition in the animal species being treated, the cascade system can be used by the prescribing veterinary surgeon. Principles of the cascade system are described in detail in the AMELIA guidelines (AMELIA 8) published by the VMD and available

on the publications section of their website. Specific points covered by AMELIA 8 are summarised below:

- The prescribing cascade options are only available to veterinary surgeons who have responsibility for the care of the animals concerned. Where no medicine is authorised for a particular condition in a species, a veterinary surgeon may exceptionally prescribe or administer in accordance with the following cascade provisions:

    1. A medicine authorised for use in another species or for a different use in the same species ("offlabel use"); or, if there is none
    2. A medicine authorised in the UK for human use; or, if there is none
    3. A medicine to be made up at the time on a one-off basis by a veterinary surgeon or a properly authorised person to the veterinary surgeon's specifications.

- When prescribing under the cascade for food-producing animals the medicines used may only contain substances found in a medicine authorised for a food-producing species.

- Where a medicine that is not authorised for the condition and species is used a withdrawal period of at least 500 degree days must be applied.

The veterinarian is required to keep specified records. It should be emphasised that cost is not a justification for using a non-authorised medicine under the cascade.

Import of medicines from outside the UK

Where no suitable medicine is available, even under the cascade and treatment is considered necessary on animal health and welfare grounds, the VMD may exceptionally consider an application for a special treatment authorisation (STA). An STA may authorise the import and use of a limited quantity of medicine from outside the UK on a specified animal or animals. Further information on STAs is available in AMELIA 10 on the VMD website.

Commodity chemicals

The use of commodity chemicals, such as formalin and dyes (e.g. malachite green, methylene blue) is an issue. These products are widely available and have been used on farms for a number of reasons, including 'medicinal' purposes (such as an ectoparasite bath treatment). As the products are not marketed as medicines, they do not fall within the medicine regulations. However, their unregulated medicinal use raises a number of concerns with regards to safety to the user, the animal, the environment and the consumer. Indeed, as all farmers know, the use of malachite green in farmed fish has now been banned and illegal use is subject to prosecution. Likewise, the unauthorised use of other commodity chemicals for a medicinal purpose is illegal and if discovered will be investigated by the relevant regulatory authorities.

Feed additives

Feed additives include substances such as colorants, binders, trace elements and preservatives.

Definition of a 'feed additive' (EC1831/2003)

Feed additives are substances, microorganisms or preparations, other than feed material and premixtures, that are intentionally added to feed or water in order to perform one or more of the following functions:

a. favourably affect the characteristics of feed
b. favourably affect the characteristics of animal products
c. favourably affect the colour of ornamental fish and birds
d. satisfy the nutritional needs of animals
e. favourably affect the environmental consequences of animal production
f. favourably affect animal production, performance or welfare, particularly by affecting the gastrointestinal flora or digestibility of feedingstuffs
g. have a coccidiostatic or histomonostatic effect.

Although not all farmers and manufacturers may be aware of this, there are long established rules that only additives on an EU authorised list can be used in animal feeds (including fish feeds). These rules are intended to safeguard both consumers and animals. New additives can only be included in the list after an assessment of safety, quality and efficacy. A new Regulation (EC1831/2003, which applied from October 2004) rationalises and clarifies a number of requirements and defines the role of the new European Food Safety Authority (EFSA) in assessing and authorising new additives.

The EFSA

The EU established the EFSA in 2002 after the series of food scares in the late 1980s and early 1990s. It was charged with providing independent and objective advice on safety issues associated with the food chain. Authorisations for new additives or new conditions of use can only be obtained after a full review of a dossier submitted to the Commission and EFSA describing the additive, its intended use and its quality, safety and efficacy. Guidelines for drawing up dossiers are set out in Directive 87/153/EC. This was most recently amended by 2001/79/EC that included the requirements for enzyme and microorganism products.

Additives already authorised for use in aquaculture feeds

Most additives that can be used in aquaculture feeds are generic substances, authorised for use in all farmed species, including fish. Examples include a range of antioxidants, emulsifying agents, binders, anti-caking agents and coagulants, preservatives, trace elements, vitamins and provitamins. The only substances that are specifically authorised for use in certain species of food fish (salmon and trout) are the colorants canthaxanthin, astaxanthin and astaxanthin-rich *Phaffia rhodozyma* (ATCC 74219). Authorised additives are sometimes subject to conditions of use, such as maximum food inclusion rates. The maximum levels permitted for canthaxanthin for salmonids has recently been revised downwards from 80 to 25 mg/kg (Directive EC/2003/7).

Recent changes in feed additive regulations

There are some important regulatory changes that fish farmers and aquaculture feed companies should be aware of. Many additives were authorised a number of years ago before the latest guidelines were drawn up. The new regulation requires these substances to be re-evaluated against updated criteria. However, as a first step, all such additives must have been notified to the Commission and EFSA by 7 November 2004. Any additives not so notified cannot be marketed or used in feeds after that date. This re-evaluation process may cause some problems such as the unavailability of products that have not been notified to the Commission/EFSA. Such problems were encountered when comparable legislation was introduced for veterinary medicines. Thus, listing the different classes of additives to be re-evaluated in order of priority will most likely be needed. Organisations representing feed additive manufacturers and compound feed manufacturers were made aware of this requirement and it is understood that they took steps to ensure that important additives were notified. Authorisations will be renewable for 10-year periods for all additives.

The difference between a feed additive and a medicine

With the exception of prebiotics and probiotics, that are specifically dealt with later, the only categories of authorised feed additives that could potentially be regarded as medicines are antibiotics (used as growth promoters), coccidiostatic or histomonostatic additives. As none of the products falling in these categories of authorised feed additives are used in aquaculture, there should be little confusion for fish farmers and feed manufacturers. The use of certain words, such as 'treats', 'prevents', 'cures', 'relieves' 'remedy' - in reference to immunostimulants, stress relievers, prebiotics and probiotics - denotes a medicinal claim, and such products should therefore be considered veterinary medicines.

Immunostimulants and stress relievers

There has been a great deal of interest in using immunostimulants in aquaculture. Perceived benefits of such substances are that they promote the non-specific defence mechanisms in the fish they are administered to, promoting their resistance to disease. Drs Tim Bowden and Ian Bricknell from the FRS Marine Laboratory, Aberdeen have recently reviewed the use of immunostimulants (*Fish Farmer,* Vol. 26 (1), pp. 10-11 Jan-Feb 2003). If these products are sold with health promoting claims they should be authorised as medicines. Under the medicine regulations, such products are required to hold current Marketing Authorisations (MA) before they may be sold or administered legally. As mentioned earlier, the Veterinary Medicines Directorate (VMD) in the UK issues MA. The VMD have noted that some of the marketing claims attached to immunostimulant and stress relief products presently marketed in the UK are indeed medicinal.

Prebiotics and probiotics

There is also a growing interest in the use of prebiotics and probiotics in aquaculture, particularly as potential replacements for antimicrobials.

Definition of prebiotics and probiotics

Prebiotics can be defined as nutrients added to feed to selectively stimulate populations of bacteria in the gut which are already present and established.

Probiotics (as used in aquaculture) are live microbial cultures added to the rearing systems through feed or water, which improve the performance of the cultured animals.

Again the regulatory status of a prebiotic or probiotic product would depend on what claim was attached. If the claim was as a 'digestion improver' that would not constitute a medicinal claim and they should be authorised under the feed additives regulations. If the claim is for 'protection against infection' then it seems reasonable to treat them as medicines. As the regulatory requirements are similar for both feed additives and medicines, there is little advantage to be gained by a manufacturer seeking to authorise their product as an additive versus a medicine.

The feed additives legislation only applies to live microbial cultures added directly to the feed; the regulatory status of live microorganisms that are added directly to the culture system (e.g. biofilter start up cultures) is uncertain.

Conclusions

It needs to be emphasised how seriously the UK regulatory authorities view the use of non-authorised medicinal products and feed additives in animals (including fish) destined for human consumption.

The production of UK aquaculture products that are demonstrably safe to the consumer is of paramount importance. The production of healthy, high quality fish is the goal of all fish farmers and the use of appropriate diets and health management tools are helping them achieve this goal. Many new compounds are now available for farmers. However, this review has shown that these new products can generally be classed as either feed additives or veterinary medicines, and are therefore subject to regulations governing their use in aquaculture, as for all other food animal production systems. The regulatory systems for both feed additives and veterinary medicines are essentially designed to ensure that only products that are safe and efficient can be authorised and used. There are at present a number of products available in the UK that are not authorised, either as feed additives or veterinary medicines. It is reiterated that companies wishing to market a new product for use in fish can get guidance at any time from the FSA and the VMD.

Guidance can also be sought from the FSA for products that may be considered as feed additives, or from other agencies responsible for the licensing of other products (such as the HSE for biocides). The regulatory issues surrounding the use of disinfectants in aquaculture will be dealt with in another article to be published in the next issue of *Trout News*.

Acknowledgements

This article was compiled with assistance from the Food Standards Agency.

THE EXAMINATION OF FARMED SALMONIDS FOR CATEGORY 2 PARASITES

Kevin Denham, Senior Fish Health Inspector, CEFAS, Barrack Road, The Nothe, Weymouth Dorset DT4 8UB

The July 2004 issue of *Trout News* contained a letter from Adrian Taylor, the Fisheries Policy Manager at the Environment Agency, introducing new health check procedures for stocking farmed salmon and trout into the wild.

From 01 April 2005 all salmon and trout supplied for restocking rivers and open waters will require a mandatory health check which will include screening for Category 2 parasites and novel parasites. These parasites are considered by the Environment Agency to pose a serious threat to wild fish stocks and fisheries. The extension of the policy on health checking brings salmonid farms into line with the requirements that have applied for many years to coarse fish farms. Fish farms supplying only to the table market or to other registered fish farms will not be affected by the new health check requirements.

The Environment Agency has contracted the CEFAS Fish Health Inspectorate to undertake the Category 2 health checks on salmonid farms. As all salmonid farmers will be aware the Fish Health Inspectorate is responsible for monitoring for notifiable diseases, such as viral haemorrhagic septicaemia and infectious haematopoietic necrosis, on fish farms. As a part of the EU monitoring programme for notifiable diseases each registered salmonid farm is visited at a minimum annually, and a sample of 30 fish taken for diagnostic testing every second year.

Where possible Fish Health Inspectors will seek to combine Category 2 health checks with their notifiable disease monitoring programme. This will have the advantage of minimising the number of visits required to a farm, and thus disturbance to the fish farmer. It will also result in the sacrifice of less fish, as in many cases, the same fish will be examined for category 2 parasites, and for notifiable diseases. However as the Category 2 examinations require the screening of all species that are restocked, for some farms the sample size will be greater than the 30 fish required for the EU monitoring programme. The Fish Health Inspectors are equipped to undertake the screening of fish on the farm. However in some cases where suitable facilities are not available, the sample will be returned to the CEFAS Weymouth Laboratory for examination.

The first of the Category 2 examinations started in September 2004 when the Fish Health Inspectors commenced their autumn monitoring programme for notifiable diseases. The Fish Health Inspectorate will offer all salmonid farms that produce restocking fish a free Category 2 health check before 1 April 2004 and the health check will be valid for 12 months. However farms remain free to employ the services of a commercial fish health consultant to complete the health checks if they wish.

A report on the results of the Category 2 testing conducted on salmonid farms will be included in the next issue of *Trout News*.

To arrange Category 2 health checks or for any general fish health enquiries please contact the Fish Health Inspectorate on 01305 – 206673/74.

For EA policy matters on Category 2 parasites please contact Andy Martin, Environment Agency on 08708 – 506506.

For information on Section 30 requirements and Category 2 parasites please contact the Environment Agency's National Fisheries Laboratory on 08708 – 506506.

FISH WELFARE – A REPORT ON THE FISH VETERINARY SOCIETY MEETING, 23-24 NOVEMBER 2004

Edward Branson (Red House Farm, Llanvihangel, Monmouth, Gwent, NP25 5HL), Leo Foyle and Scott Peddie

Edinburgh was the venue for the UK's Fish Veterinary Society (FVS) Autumn Scientific meeting, entitled 'Fish Welfare'. The FVS is a specialist division of the British Veterinary Association that aims to bring together fish veterinarians and other fish health professionals to advance the veterinary care and welfare of fish. This meeting brought together a range of experts to review the current state of knowledge of fish welfare, and was very well attended, with international representatives of a wide range of interest groups present, including not only veterinary surgeons and fish health specialists, but also fish farmers, members of fish farming support companies, representatives of government and several non-governmental special interest groups.

During a brief introduction Edward Branson, who organised and chaired the meeting, posed the question which he hoped would be answered: 'Is there enough evidence to convince us that we should treat fish with the same care and consideration, and give them the same level of protection, as mammals and birds?' Over the course of the meeting convincing evidence was presented to demonstrate that fish have all the necessary mechanisms in place to enable them to suffer pain and distress, as do mammals and, as a consequence, the answer seemed to be 'Yes'. It was therefore clear that purely physical indicators of fish welfare are no longer sufficient, and that their psychological well-being also needs to be considered.

The 1st session of the meeting, entitled 'General Fish Welfare', began with a presentation by Professor Alister Lawrence (Scottish Agricultural College & University of Edinburgh) addressing the question: What is welfare? Professor Lawrence outlined the history of animal welfare research in broad terms, reminding delegates that welfare has many difficult aspects, and that the three requirements of: the ability to lead a natural life, to feel well and to function well, can be difficult to measure. Also that fish are not yet legally seen in the same category as other vertebrates under the 1997 Treaty of Amsterdam that covers 'sentient beings'. He also briefly discussed an area of concern to most food producers, namely that there is often a divergence between what consumers want in a welfare context, and what they're actually willing to pay for.

The often-quoted nine-second memory of the goldfish was called into question by Dr. Victoria Braithwaite (University of Edinburgh) in her paper 'Can fish suffer?' Dr Braithwaite compared the neural development of fish with that of mammals and birds, and gave an overview of the research being carried out demonstrating the behavioural and learning abilities of some fish species. For example, it has been reported that guppies can recognise other individuals in a school, and can remember them for at least twelve days. Dr. Braithwaite concluded by emphasising that current evidence indicates that fish have impressive cognitive abilities.

Dr. Tom Pottinger (NERC Centre for Ecology & Hydrology, Lancaster Environment Centre) reviewed current knowledge on 'Stress responses and measurement in fish'. He explained that the physiological manifestation of stress response in fish, namely cortisol production, varied tremendously both within and between species. For example, a rainbow trout has a resting blood cortisol level of 5 ng/ml which rises to approximately 80ng/ml as a result of a primary stress response. However the resting level for a chubb is 125 ng/ml, and can rise to 500ng/l after exposure to a stressor, a level which is likely to be lethal in a trout. The within-species differences are heritable, so making it possible to manipulate the stress response through selective breeding. Nevertheless, the point was made that 'stress' in itself is not necessarily detrimental to fish welfare, particularly if it is a short-lived event. Of more concern is chronic stress, which is known to lead to growth suppression and impairment of the immune response under certain conditions.

Dr Lynne Sneddon (University of Liverpool) spoke on 'Pain and fear in fish'. After first distinguishing between nociception (the simple detection and reflex response to painful stimuli) and pain (the sensory and psychological experience of painful stimuli), Dr Sneddon summarised the evidence available in the scientific literature to indicate that fish are certainly capable of nociception. She then went on to detail experiments which had been carried out to demonstrate neurological activity in the cerebral hemispheres associated with nociception, areas of the brain which are not necessary for nociception. Finally she reviewed behavioural research demonstrating avoidance of painful stimuli and fear responses. In summary, she concluded that fish are indeed able to feel pain and experience fear.

Professor Felicity Huntingford (University of Glasgow) considered 'Welfare related to fish'. Although fish are similar to mammals in some respects, there are important differences, for example, fish are poikilothermic (the same temperature as the surrounding water), and therefore more dependant on their immediate environment. An example of where this becomes important for welfare is that of starvation: an S2 smolt in a river may well be naturally anorexic during the winter, and so starvation at this stage would not be a welfare issue, whereas it would raise serious questions in a mammal. This highlighted how inappropriate it is to draw absolute comparisons between mammals and fish. In summary, it is difficult to define accurately conditions that guarantee good welfare, there being so many interactions: figures on stocking density in farmed fish for example, being dependant on age, species and water quality amongst other factors. But there are basic indices, such as colouration and fin condition, that can practically be employed as 'litmus tests for welfare' that are species and life-stage specific.

Mr Andrew Voas (State Veterinary Service) gave a 'Summary of the current and impending welfare legislation related to fish' in Scotland, UK and Europe. Although some protection for fish exists, it is by no means as extensive as that covering mammals. Draft proposed legislation should bring fish into a similar category as far as protection goes, and will be more concerned with promoting welfare rather than preventing cruelty, as at present.

The 2nd session of the meeting focused on aquaculture. The first speaker of this section was Mr. Philip Lymbery of WSPA (World Society for the Protection of Animals), who spoke on the 'Perceived problems in fish farming'. Mr Lymbery was the author of the Compassion in World Farming Trust's (CIWF) report, 'In Too Deep' published in 2001, and he presented this critique of fish farming from a welfare perspective. Issues such as stocking density, transport, slaughter techniques and disease and its treatment, particularly of sea lice, were cited by Mr Lymbery as cause for concern. This stimulated a lively debate in the discussion session, and a number of delegates questioned the scientific basis of Mr Lymbery's assertions and the accuracy of his information. During the discussion at the end of the meeting, the point was made that the aquaculture industry has made significant strides in production practices since the CIWF report was published, so many of the points contained therein were deemed to be out of date.

Mr Nick Read (Alderley Trout Farm) subsequently presented a 'Fish farm perspective' on fish welfare and emphasised the strict codes of conduct producers adhere to, all of which have a welfare focus. He also discussed the difference between fish welfare perception amongst the general public and the situation in the 'real world'. Mr Read finished his presentation by calling for a more constructive dialogue between special interest groups and fish farmers.

There followed a series of more in-depth discussions on specific welfare aspects of fish farming. Dr. Dave Robb (EWOS Technical Centre) reviewed 'Starvation, pre-slaughter handling and slaughter'. The stress associated with crowding in nets pre-slaughter was a very important welfare concern, with duration of crowding and method of capture playing an important role. For example, blood cortisol levels approaching 700 ng/ml have been measured in fish after 4 hours of crowding where fins are visible and surface thrashing occurred. Dr. Robb reviewed slaughter methods currently in use, concluding that methods achieving immediate insensibility with no recovery of consciousness were necessary to achieve good welfare, such as percussive stunning followed by bleeding out, methods which are now widely used.

Mr. Pete Southgate (Fish Vet Group, Inverness) gave a presentation on 'Fish transport', it's impact on welfare, and strategies to minimise impact. Mr Southgate emphasised the point that there was little research in the area of transport related welfare. Nevertheless, the degree of impact varies according to the species of fish concerned, their life-cycle stage, water quality and duration of transport. He suggested that the main concern was cumulative stress (repeated handling, poor water quality, even osmotic disturbances resulting in the rough equivalent of 'thirst'), not individual acute stressors. He highlighted the need for more definitive guidelines to assist fish farmers in conducting pre-transport checks and monitoring of fish both during and after transport.

Dr Jimmy Turnbull (Institute of Aquaculture, University of Stirling) spoke about 'Stocking density and water quality', and discussed the results of studies investigating the link between stocking density and welfare. He made the general point that extrapolation of data from terrestrial systems is fraught with difficulties, not least because of the three-dimensional aspect of the aquatic environment. For example, through hydroacoustic studies, the available space in a salmon cage was seen to be constantly changing, with the fish not utilising all the volume. With stocking densities between 13-35 kg/m^3 the fish tended to use 45-85% of available space, and actually seemed to shoal more as densities increased. In tank trials with trout fin damage has been seen at high stocking densities, but goods fins have been recorded on farms operating at high stocking densities. In summary, Dr Turnbull said that good and bad welfare can be seen at both high and low stocking densities, so on-farm welfare can neither be accurately predicted, nor controlled by stocking density. Too many other factors, such as water quality, make a simple link impossible to infer, and it is time to move away from stocking density as an accurate predictor of welfare because there are too many complicating factors.

Dr Tim Ellis (CEFAS) followed with a discussion of 'Fin erosion'. This condition occurs in some fish species, including rainbow trout, sea bass and sole (Dover and Senegalese), whereas others, such as Atlantic cod, turbot and eel, appear to be largely unaffected. Fin erosion can be linked to welfare in fish, as it represents injury with the fins capable of nociception, and because damaged tissue can act as a portal of entry for infection. He concurred with Dr. Turnbull that, while evidence suggests stocking density is related to fin erosion, good fins had also been seen at high densities. Evidence was available suggesting various factors are likely to cause and affect fin erosion including: aggression, tank abrasion, disease, high ammonia, alkalinity, temperature, ultra violet light, and uneven size range. He concluded by saying that the matrix of primary and secondary factors that lead to fin erosion is complex, and still poorly understood.

Mr Tom Turnbull (Scottish Seafarms) talked on the subject of 'Deformities' in fish and their potential impact on welfare. He discussed the various deformities seen in aquaculture, and possible causes. Work has shown that egg incubation temperature can be an important factor in some problems, with up to 20% deformities experienced when egg incubation temperatures were around 16-18°C, up to 10% at 10°C and 0% below 8°C, although early stage nutrition can also be important. He reviewed the current research on skeletal deformities, a phenomenon seen in both wild and farmed fish. He concluded that, although some deformity problems still exist, significant improvements have been achieved as a result of research and consequent revised husbandry practices.

Mr Tony Wall (Fish Vet Group, Inverness) discussed the welfare implications of 'Disease control, vaccination and medicine availability'. He made the point that a lack of basic understanding of some disease conditions, allied with an inadequate range of licensed treatments, posed a significant challenge for the aquaculture industry. He reiterated the desperate need for increased availability of licensed medicines stating that, for example, resistance problems and the complete lack of ectoparasite treatments in fresh water have massive implications for the welfare of fish. Encouragingly he said that the use of antibiotics in farmed fish has decreased by over 90% during the last ten years through use of vaccination, increased biosecurity and improved husbandry.

Dr Sunil Kadri (Aquaculture Innovation and the University of Glasgow) briefly outlined the current research on the welfare of 'New species' including Arctic charr, halibut, cod and carp. He spoke of the importance of assessing individual species separately, and that differences within species can be just as large as those between species, for example, different stages of the life cycle of salmon require different conditions. Therefore generalisations between and within species should be avoided in the welfare debate, and it is not acceptable to consider simple parameters as being applicable across the spectrum of fish ages and species.

The formal presentations ended with a brief overview of the role of the new European Food Safety Agency (EFSA) and the implications it might have for fish welfare, given by Professor Ron Roberts, and the status of the fish welfare debate and allied legislation in Norway and Canada by Drs Victoria Braithwaite and Dave Robb, and in Germany by Dr Birgit Oidtmann (CEFAS). Dr Oidtmann outlined a surprising level of protection afforded to fish in Germany. Welfare, including the welfare of fish, is considered to be a 'constitutional goal', and if welfare competes with another issue, as a constitutional goal welfare will have priority. Amongst other things, this has the effect of making put-and-take fisheries, catch and release, live bait, angling competitions and keep nets all illegal, and the ornamental fish trade subject to considerable legislative control.

Delegates were then split into four separate focus groups and asked to consider which key parameters, in their opinion, should be included in any assessment of on-farm welfare. The deliberations of the groups will be summarised and reported as part of a DEFRA/BTA funded project on fish welfare, an objective of which is to produce a standardised protocol for assessing farmed fish welfare.

In a short summary, Edward Branson concluded that the meeting had provided convincing evidence that we should treat fish with the same care and consideration, and give them the same level of protection, as mammals and birds, and that, as a consequence, we need to consider both the physical and psychological well-being of fish in our care. There are many valuable lessons to be learned about the assessment of welfare from mammalian and bird studies, but it is important to remember that the achievement of good welfare for fish cannot necessarily be achieved by a simple extrapolation from terrestrial animals. It must take into account the complexities of fish behaviour and requirements which can, and do, vary both between and within species.
In summary, although research into fish welfare is progressing well, there are still large areas where little is known, and where research is necessary before we can have a full understanding of what actually constitutes good welfare for all species of fish in our care.

This brought to an end what had been a very worthwhile meeting which summarised the current state of knowledge of fish welfare, and raised many issues related to fish culture, some uncomfortable, some encouraging. Open discussions were a part of the proceedings which, because of the diversity of the attendees and the quality of the speakers, raised and aired some very interesting topics. It is the intention of the organisers to publish the proceedings of the meeting in book form, so for those with a stake in the fish welfare debate it should make informative reading.

TECHNOLOGY TRANSFER – FACT OR FICTION?

Mark James FRM Ltd. Coillie Bhrochain, Bonskeid, Pitlochry, Perthshire, PH16 5NP

Technology transfer is a trite alliteration which, in reality, has been something of a holy grail in the world of applied research and development. Long gone are the days when the majority of research scientists could spend their careers meandering through vistas of ‘interesting questions’. It is becoming increasingly tough out there for scientists and the industry that many of them work for – OK, scientists may not be on the farm feeding the fish, but many have devoted their working lives to problem solving for the industry and have a genuine commitment to its success.

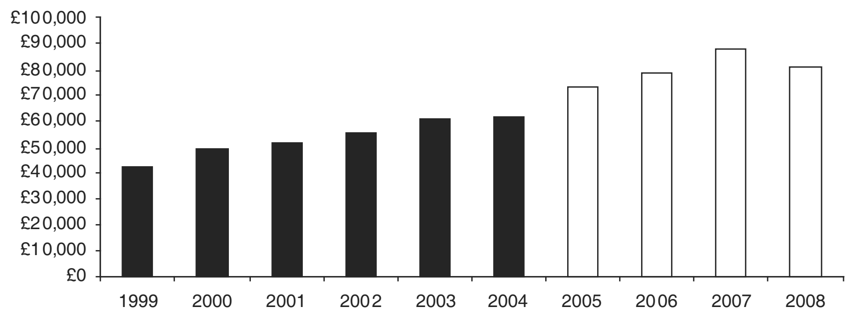
When I became involved in aquaculture related R&D work about ten years ago there seemed to be a distinct lack of focus with little, if any, strategic thinking about the R&D being conducted and how it might contribute to the ‘sustainable’ development of the industry – a now overused phrase that should perhaps be replaced by the term ‘sympathetic exploitation’ as few things we do on this planet are truly “sustainable”.

The same forces that have shaped the industry also drive the research community – regulation, markets and above all, money. Increasing regulation, for better or worse, has sharpened our vision of the need for objective policy making, underpinned by sound scientific evidence – none more so than in the fields of animal welfare and veterinary medicines. Once production led, the industry now ignores the requirements of the customer and the market at its peril – so too the research scientist! Through a range of Government-industry-science initiatives and fora such as LINK, the Committee for Aquaculture Research and Development, the EU CRAFT programme, Knowledge Transfer Partnerships and more recently the Scottish Aquaculture Research Forum (SARF), the scientific community now sees the industry as both customer and partner. Customer, from the point of view of end user demand for the scientific work they conduct; partner, from the perspective that most of industry’s R&D requirements are still financed with public money - a process that often requires industry participation in projects.

The UK Aquaculture R&D database has now been collated for a second year. This online resource is sponsored by Defra and provides the first strategic overview of UK funded research (http://www.defra.gov.uk/science/areas/aquatic/default.asp.htm).

The database contains references to work dating back to 1995 – although some of these ‘early’ references are patchy. Analysis of this archive for projects ending after January 1999 is beginning to reveal an interesting and disturbing pattern. Many of us involved in R&D have long been aware of the increasingly competitive nature of research and the difficulty in securing funding. A view reinforced by evidence of increasing fragmentation in funding sources and a decrease in the capacity of even major sponsors of research in this sector to support substantive projects in some areas.

The total commitment to aquaculture R&D funding between 1999 and 2004, including future project commitments is in the order of £45.1 million. A tidy sum, but underlying this grand total is a picture of significant increase in the average cost of R&D projects which, if the projected figures to 2006 are correct, suggests that the annual cost of R&D will have doubled since 1999. This represents an annual increase in cost of the order of 13%. Whilst this figure is several times the background rate of inflation, it is likely to be a reflection of the pressure applied to both Government agency laboratories and the University sector to fully recover their costs.



Mean annual project cost

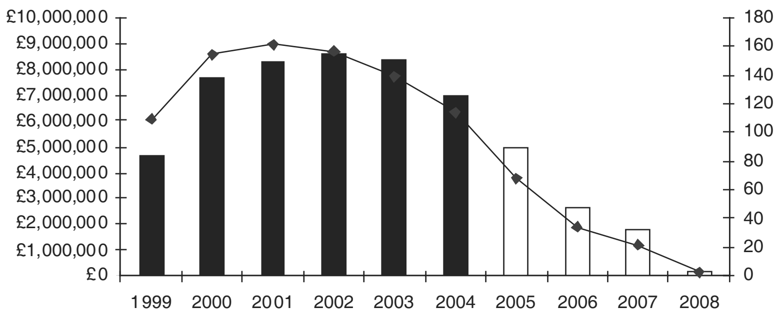
The level of expenditure on R&D in this sector appears to have peaked in 2002 and there are signs of a real decline in funding although it should be noted that the figures for commitments beyond 2004 will increase as more projects are funded. The trend is clearly a downward one which, in terms of the number of projects supported, is exacerbated by their increasing cost. The bottom line is less money and fewer projects. Anecdotal evidence of funding activities in 2004/05 suggest that we may have reached a threshold where many more short term, lower budget projects are being supported which, in the immediate future continues to allow us to show investment in a number of key areas. The question is, does the funding commitment between 1999 and 2002 represent something of a halcyon period in a normally lower funding environment, are we witnessing a levelling off of investment in this sector, or should we anticipate continued decline?

So what are the motivations for R&D investment in the aquaculture sector – and public investment in particular? The most common argument is 'market failure' – a fairly grey economic term which can be loosely translated as 'the industry is not sufficiently profitable to pay for the R&D required to support its continued development'. This argument certainly holds for most, if not all, of the aquaculture sector. Regulation is another inexorable force which drives R&D, although the rationale for supporting this work varies according to ones perspective – for the industry, R&D in support of much regulation is the responsibility of Government – the Government view is that much of this R&D is in support of Trade and, by definition, industry.

Wealth generation and improving quality of life are also offered up as good reasons to support R&D, particularly with respect to the fragile rural and coastal economy. But, in reality, how much R&D is actually delivering on this promise? In theory, a good piece of applied research should provide solutions for an eagerly awaiting industry – an industry with the expertise, resources and sufficient wherewithal to take these costly outputs and turn them into greater efficiencies and profits. The problem with this notion is that little strategic market research is conducted with respect to the R&D being conducted. Few project proposals are heavily scrutinised in terms of their real potential for technology transfer – it is easy to be carried on a wave of intellectual enthusiasm when assessing a genuinely interesting and high calibre piece of research. However, as funding becomes evermore constrained we all have a duty to ask some searching questions about the research required to support the development of the industry. What proportion of this work should be directed towards the general acquisition of potentially useful knowledge and how much should focus on the harsher realities of direct problem solving for the industry?

The trout industry would appear to have been reasonably well served by R&D in recent years. There have been significant advances in the management and treatment of disease, salient questions related to fish welfare have, or are being addressed. More recently a trout selective breeding project has shown encouraging results with respect to the considerable potential that exists to improve valued traits in rainbow trout.

But, what of direct technology transfer in the trout sector? The LINK programme supported the early work on Pyceze. Whilst certainly not a replacement for malachite green, this product has proven to be a useful treatment in some circumstances. Lessons learned from this project are now being applied in a more recently joint funded project between Defra and Scottish Quality Salmon which aims to identify more antifungal treatments for salmonids. The much demonstrated automated humane fish stunner, has now been fully commercialised and units are appearing on farms. Defra and SARF are about to co-fund what may be the final chapter in the battle to find an effective way of managing whitespot. Work on PKD and RTFS is, through a co-funded project between Defra and Schering Plough, focusing on the development of vaccines. The significant



Total annual expenditure and number of active projects. Note that figures for 2005 onwards are a reflection of current commitments and these figures should increase as more projects are funded. The line on the chart shows the trend in the number of projects.

industry cash contribution to these projects perhaps indicating the confidence and commercial promise of an efficacious vaccine. Selectively bred resistance to PKD and a range of other diseases, once a pipedream, now looks like a real possibility as global knowledge of the salmonid genome increases exponentially year on year. A Defra sponsored project on PKD resistance is now progressing.

In the final analysis, to reach the point at which the outputs from R&D can be transferred in some tangible form to industry may take many years, although improved and more rapid scientific techniques together with better management of research is commuting these timescales. However, there is evidence that when the scientific outputs are available in a form which industry could potentially adopt, other factors are confounding uptake. Regulation, lack of investment, lack of critical mass within the industry and short term commercial focus, can all results in wasted scientific effort or potential commercial advantages being lost to competitors elsewhere in the world. With limited resources and increasing commercial pressures, selecting the right R&D and ensuring that we maximise the cost benefits of the outputs will be key to remaining competitive.

ANNOUNCEMENTS

BRITISH TROUT FARMING CONFERENCE 2005

7-9 SEPTEMBER 2005

SPARSHOLT COLLEGE, WINCHESTER, HAMPSHIRE, SO21 2NF

New-look event

- **1½ day conference format (Thursday and Friday am)**
- **+ excellent social events**

Contact: Mark Burdass or Shaun Leonard on 01962 776441 or email: mburdass@sparsholt.ac.uk

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IMPORTANT NOTICE FOR FISH FARMERS IN ENGLAND, SCOTLAND AND WALES INCORPORATING VETERINARY MEDICINES INTO FISH FEED

Introduction of new rules on mixing medicated feedingstuffs

This notice is to alert fish farmers to changes that will be introduced from 1 April 2005 that may affect them. From that date any fish farmers mixing medicated feed, including for use on their own premises, must comply with the full provisions of the Medicated Feedingstuffs Regulations 1998, including the requirement to be registered with, and inspected by, the Animal Medicines Inspectorate (AMI) of the Royal Pharmaceutical Society of Great Britain.

A full public consultation on the proposals for introducing these new arrangements was carried out earlier in 2004. These arrangements take full account of the comments received through that consultation.

What will I need to do?

If you are mixing, or intending to mix, medicated feedingstuffs you will need to submit an application for registration to the Animal Medicines Inspectorate (AMI) of the Royal Pharmaceutical Society of Great Britain by 1 April 2005.

Will my premises need to be inspected?

Yes, following your application, an AMI inspector will carry out an initial inspection of your premises. At this initial inspection the inspector will collect medicated feed samples (if available) and send them for analysis to check that the level of active ingredient is within the permitted tolerance level. If no medicated feed samples are available, i.e. if you are not currently mixing medicated feedingstuffs, then you may be asked to mix a generic product into the feed, from which a sample will be taken.

The AMI inspector will also be able to provide any advice which may be needed to help you to meet the requirements of this legislation.

You may continue mixing until you are inspected, provided you have submitted an application to the AMI.

Will I need to renew my Registration?

Yes. Approval is subject to annual renewal and an application will need to be made each year to re-register the premises. However, inspections will be carried out only every eighteen months.

What will happen at subsequent inspections?

Once your premises have been registered they will be inspected every 18 months by the AMI to ensure that they continue to comply with basic, minimum standards set out in legislation, designed to safeguard operator, animal and consumer health. At such inspections the emphasis will be on checking that those premises continue to be capable of producing medicated feedingstuffs to the required standard. This will normally be done through inspecting mixing equipment, records etc. Feed samples will only be taken on around 10% of farms visited at such inspections.

What guidance will be available?

The VMD is currently working on guidance specifically for fish farmers that will ensure you are aware of the full requirements of the legislation, including what is required to gain an approval and registration for your premises. This guidance will be made available on the VMD's website: www.vmd.gov.uk as soon as it is available.

How do I apply?

Enquiries on how to apply for registration should be addressed to the Animal Medicines Inspectorate; telephone: 02476 849260 or e-mail:ami@rpsgb.org

What will it cost?

The AMI has to achieve full cost recovery for its work from the industry and a registration fee will be charged. A fee is payable for registration and a fee is charged annually on application for re-registration. The fee will be £135 if you mix medicated feed for use on your own premises, but if you wish to sell your product on for use by others then the fee will be £365.

Where can I find out more?

Any enquiries related to how these rules will be applied in GB, or requests for a copy of the consultation package, should be addressed to Mrs Janis McDonald at the Veterinary Medicines Directorate (Tel: 01932 338307, e-mail: j.mcdonald@vmd.defra.gsi.gov.uk).

Any enquiries about how these rules will be applied in Northern Ireland should be addressed to the Department of Agriculture and Rural Development in Northern Ireland, Quality Assurance Branch (Tel: 028 9054 7194).

LANTRA RECEIVES FIVE-YEAR 'LICENCE TO SKILL' UK'S AQUACULTURE INDUSTRY

The UK's aquaculture industry received a boost last June, when Sector Skills Council, Lantra, was awarded a five-year licence from the Secretary of State for Education and Skills, Rt Hon Charles Clarke MP. This significant achievement acknowledges the hard work that employers, trade associations and Lantra staff have put in to developing Lantra as a Sector Skills Council. The licence will enable Lantra to continue leading the drive to increase skills across the aquaculture industry. Aquaculture employer, Doug McLeod, joined other representatives from the 17 environmental and land-based industries that Lantra represents, to celebrate Lantra's achievement at a VIP reception and skills debate at the House of Commons on Tuesday 29 June.

TV presenter Nick Ross hosts skills debate

The award of the licence was marked by a skills debate hosted by TV presenter Nick Ross, which gave employers and industry representatives the opportunity to have their say on the skills issues affecting the sector. An interactive voting system meant some fast answers to inform the debate and to guide the Lantra management on what the sector expects of them. The debate covered many key issues relating to the needs of micro-businesses and sole traders, which predominate in the sector. In particular, the need to upskill employers and improve management skills were discussed.

Employers show support

Doug McLeod of Glenelg Shellfish, Isle of Skye, attended the event. "I found the skills debate both interesting and useful", he said. "The Holy Grail remains that of how to stimulate interest and commitment in training across the aquaculture industry, from multi-nationals to SMEs and micro enterprises". "The five year licence will give Lantra a stability of purpose and allow it to develop and expand its Industry Group based activities, with which I hope to play an active role, promoting the wider interests of training in the aquaculture sector". Lantra's Aquaculture Industry Group, chaired by Doug McLeod, has played a key role in shaping and forming Lantra's strategic direction to meet the needs of the industry and the sector as a whole. The group comprises employers and representatives from across the aquaculture industry.

Ministerial backing for the industry

Rt Hon Charles Clarke MP acknowledged the hard work and commitment from employers, industry representatives and Lantra: "I really congratulate Lantra and all that have worked with you to reach this tremendous moment - the establishment of Lantra

Rt Hon Charles Clarke MP presents Lantra Chairman, Dr Gordon McGlone, with Lantra's five-year licence

as a full Sector Skills Council." Recognising many of the challenges facing businesses in the sector, he continued: "I think the commitment to the skills agenda is tremendously important as a method of controlling the process of change, influencing it and making change happen to benefit communities, rather than simply being victims of it."

Continuing employer commitment

A message emerging from the whole event was the continuing need for employers to voice their skills needs so that Lantra continues to be an effective employer led organisation. Chairman Gordon McGlone said: "We are at the beginning of a new era in which the voices of employers working in the sector are heard louder than ever - and not just heard, but taken notice of."

To find out more about Lantra and its work for the aquaculture industry, visit www.lantra.co.uk/aquaculture.

Doug McLeod of Glenelg Shellfish, Isle of Skye, joins discussions with Lantra Chairman Dr Gordon McGlone and Lantra Industry Partnership Manager Sally Beel

Launch in Wales

Jane Davidson AM, Education and Lifelong Learning Minister, joined employers and industry representatives from Wales' environmental and land-based industries at the Millennium Stadium in September to celebrate the awarding of the new five-year Sector Skills Council licence to Lantra.

Jane Davidson said: "I am delighted that Lantra has received this licence as the Sector Skills Council for the environmental and land-based sector in Wales. This represents another important step towards establishing the Skills for Business network of Sector Skills Councils across the UK and in particular Wales. It is through forming real partnerships and working collaboratively that we will raise our game, and be responsive to the needs of employers. This is the only way we can hope to achieve our goals of a strong, economically and socially secure Wales."

She continued: "Land-based industries such as aquaculture are predicting growth, and these will require new entrants with high quality skills. Existing workers will need to be supported to develop new skills."

Speaking at the event, Lantra Chief Executive, Peter Martin, said: "Lantra is a member of the strategy group for aquaculture and fisheries, which has been facilitated by the WDA. As part of the work of this group, Lantra was invited to review current and future training needs, the results of which are now starting to shape learning provision in Wales."

Raising management skills in Scotland through free ILM course places

As part of efforts to improve business and management skills in Scotland's land-based industries, Lantra is working in partnership with the Institute of Leadership and Management (ILM) to offer free places on the ILM's Introductory Certificate in First Line Management. Funding from the Scottish Executive's Scottish Skills Fund means that 30 places on the course – a short, flexible management qualification ideal for managers with little or no formal training – are available to land-based businesses for free. The offer is open to those working in agriculture, aquaculture, trees and timber and production horticulture businesses based in Scotland. For more information contact Morag Holdsworth on 01738 553311 or email morag.holdsworth@lantra.co.uk.

Further information

To find out how you can get involved with Lantra's Aquaculture Industry Group, contact Tricia Bloomfield, email tricia.bloomfield@lantra.co.uk, or visit www.lantra.co.uk/aquaculture.
For further information on Lantra's work in Wales, visit www.lantra.co.uk/wales or contact the team in Wales on 01982 552646, email wales@lantra.co.uk.

THE VETERINARY RESIDUES COMMITTEE ANNUAL REPORT FOR 2003 HAS BEEN PUBLISHED

The third Veterinary Residues Committee (VRC) annual report on surveillance for residues of veterinary medicines and other substances was published on 7 September 2004. The report sets out the work the Committee have done to assess the health implications from food containing any residues of authorised veterinary medicines or any unauthorised or banned substances. It also summarises the most interesting results from the Veterinary Medicines Directorate's (VMD) surveillance schemes and explains their significance.

The VRC is an independent advisory committee set up in 2001. Its role is to advise the Chief Executives of the VMD and Food Standards Agency on planning surveillance and commenting on the results obtained.

In general very few residues were found in UK produced trout. However, residues of leucomalachite green were found in 3 of 84 trout samples tested for those substances. Restrictions were applied to the three farms where residues were detected. In follow-up investigations on those farms, 44 further samples of trout were collected. Malachite green was found in 1 of the 44 samples and leucomalachite green in 17 of the 44 samples. One sample contained residues of both malachite green and leucomalachite green.

In 2002, Defra made clear that the use of malachite green in farmed fish was not acceptable and must stop. The VRC wishes to see firm evidence that this has happened.

The report is available to download from the VRC website – www.vet-residues-committee.gov.uk and the VMD website – www.vmd.gov.uk.

Hard copies are available on request from Isabel Sharma on 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

INFORMATION FILE

WHERE TO GET HELP AND 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 110, East Block,
10 Whitehall Place, London, SW1A 2HH
(Tel. 020 7270 8826) (Fax. 020 7270 8827)

Grant Aid:-
Fisheries Division 1B, Room 308, East Block,
10 Whitehall Place, London, SW1A 2HH
(Tel. 020 7270 8045) (Fax. 020 7270 8019)

Research and Development Programmes:-
Fisheries Science Unit, Room 614, East Block,
10 Whitehall Place, London, SW1A 2HH
(Tel. 020 7270 8274) (Fax. 020 7270 8302)

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

The Welsh Assembly Government, Agriculture and Rural Affairs Department,
Agricultural Policy Division 5,
New Crown Buildings, Cathays Park, Cardiff CF1 3NQ
(Tel. 02920 823567) (Fax. 02920 823562)
www.wales.gov.uk

Scottish Executive Environment and 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 for Northern Ireland,
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,
The Rural Centre, West Mains, Inglistone
Mid-Lothian, EH28 8NZ
(Tel. 0131 472 4080)
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

Co-ordinator for Defra - CARD R&D
Dr Mark James, Fisheries Resource Management Ltd,
Coillie Bhrochain, Bonskeid, Pitlochry, Perthshire
PH16 5NP (Tel/fax. 01796 474473)
www.frmltd.com

RESEARCH NEWS

1. Breakthrough in captive breeding of eels

Female Japanese eel were administered with weekly injections of salmon pituitary extracts (SPE) at a dose of 20 mg/fish. This induced vitellogenesis and caused oocytes to reach the migratory nucleus stage. A majority of the females that received an injection of SPE at a priming dose, followed 24 h later by 17, 20beta-dihydroxy- 4-pregnen-3-one, ovulated 15 to 18 h after the final injection. In cultivated males, repeated injections of human chorionic gonadotropin at a dose of 1 IU/g b.w./week induced spermatogenesis and spermiation. Potassium ions were found to be essential for maintaining the motility of eel spermatozoa, so artificial seminal plasma containing potassium chloride was designed as a diluent, enabling refrigerated storage of milt for several weeks. As a result, artificial fertilization performed immediately after ovulation with pre-diluted stored milt consistently resulted in the production of high-quality gametes. The captive-bred preleptocephalus stage larvae were initially fed a slurry-type diet made from shark egg yolk until the depletion of their yolk and oil droplet stores. This diet was then supplemented with krill hydrolysate, soybean peptide, vitamins and minerals and larvae fed on this new diet have grown to 50 to 60 mm in length, metamorphosing into glass eels approximately 250 days after hatching.

Tanaka, H. (Natl Res Inst Aquaculture, Nansei, Mie 5160193, Japan), Kagawa, H., Ohta, H., Unuma, T. and Nomura, K. (2003). The first production of glass eel in captivity: fish reproductive physiology facilitates great progress in aquaculture. *Fish Physiology and Biochemistry,* 28: 493-497.

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2. Potential for automated feeding by eavesdropping on feeding sounds

During feeding, fishes produce acoustic signals that depend upon their feeding mode. This study demonstrated that rainbow trout and brown trout, which employ suction feeding in conjunction with forward swimming, produce a maximum acoustic energy in the frequency range 4-6 kHz. In contrast turbot, which feed by exclusive suction, produce a maximum acoustic energy in the frequency range 7-9 kHz. The brevity of the trout feeding sounds (ca. 1 sec) requires adapting the turbot acoustic-detection systems for developing automated feed distribution systems feasible in trout aquaculture.

Lagardere, J.P. (CREMA Houmeau, CNRS IREMER, BP 5, F-17137 Houmeau, France. Email: jplagard@ifremer.fr), Mallekh, R. and Mariani, A. (2004). Acoustic characteristics of two feeding modes used by brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*) and turbot (*Scophthalmus maximus*). *Aquaculture*, 240: 607-616.

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3. Potential for remote monitoring of appetite and stress level via muscle activity

This study involved monitoring the activity levels of adult rainbow trout that were either fasted on a weekly cycle, fed to satiation, or fed to satiation and then acutely stressed by overcrowding twice weekly. Subsamples of fish were implanted with electromyogram (EMG) radio-transmitters that broadcast a signal proportional to muscle activation levels, allowing for the continuous recording of swimming activity by a remote receiver. These EMG transmitters did not affect the swimming performance of fish, but did reveal variation in activity as a result of feeding and stress status. In the future, it may be possible to control feed availability using the behaviour patterns of the fish, with feed being presented upon demand. This type of technology may enhance the automation of intensive fish culture operations while simultaneously minimizing feed wastage as well as overall production costs.

McFarlane, W.J., Cubitt, K.F. (Univ British Columbia, W Vancouver Lab Ctr Aquaculture & Environm, 4160 Marine Dr, W Vancouver, BC V7V 1N6, Canada. Email: kfcubitt@interchange.ubc.ca), Williams, H., Rowsell, D., Moccia, R., Gosine, R. and Mckinley, R.S. (2004). Can feeding status and stress level be assessed by analysing patterns of muscle activity in free swimming rainbow trout (*Oncorhynchus mykiss* Walbaum)? *Aquaculture,* 239: 467-484.

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4. A new partial-reuse system for coldwater aquaculture

This paper describes a model partial-reuse system that provides an alternative to serial-reuse raceway systems for salmonid production and has potential application in other fish-culture situations. The partial-reuse system contained three 10 m^3 circular 'Cornell-type' dual-drain culture tanks. The side-wall discharge from the culture tanks was treated across a microscreen drum filter, then the water was pumped to the head of the system where dissolved carbon dioxide (CO_2) stripping and pure oxygen (O_2) supplementation took place before the water returned to the culture tanks. Dilution with make-up water controlled accumulations of total ammonia nitrogen (TAN). An automatic pH control system that modulated the stripping column fan 'on' and 'off' was used to limit the fractions of CO_2 and un-ionised ammonia. The system was evaluated during the culture of eight separate cohorts of Arctic char, rainbow trout, and an all female brook trout x Arctic char hybrid. The fish performed well, even under intensive conditions, which were indicated by dissolved O_2 consumption across the culture tank that went as high as 13 mg/L and fish-culture densities between 100 and 148 kg/m^3. Feed conversion rates ranged from 1.0 to 1.3, specific growth rates ranged from 1.32 to 2.45% b.w./ day, and thermal growth coefficients ranged from 0.00132 to 0.00218. The partial-reuse system maintained safe water quality in all cases except for the first cohort - when the stripping column fan failed. The 'Cornell-type' dual-drain tank was found to rapidly (within only 1-2 min) and gently concentrate and flush approximately 80% of the total suspended solids (TSS) produced daily within only 12-18% of the tank's total water flow. TSS discharged through the three culture tanks' bottom-centre drains (17.1 mg/L) was 9 times greater than the TSS concentration discharged through the three side-wall drains. Overall, approximately 82% of the TSS produced in the partial-reuse system was captured in an off-line settling tank, which is better TSS removal than others have estimated for serial-reuse systems. For the two cohorts of rainbow trout, the partial-reuse system sustained a production level of 35-15 kg of fish per year for every 1 L/min of make-up water, which is approximately six times greater than the typical 6 kg per year of trout produced for every 1 L/min of water in Idaho serial-reuse raceway systems.

Summerfelt, S.T. (Conservat Fund Freshwater Inst, 1098 Turner Rd, Shepherdstown, WV 25443, USA. Email: s.summerfelt@freshwaterinstitute.org), Davidson, J.W., Waldrop, T.B., Tsukuda, S.M. and Bebak-williams, J. (2004). A partial-reuse system for coldwater aquaculture. *Aquacultural Engineering,* 31: 157-181.

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5. Evidence that low ammonia levels actually increase trout growth

Traditionally, waterborne ammonia is considered a toxicant that decreases productivity in aquaculture. However, several recent studies have suggested, but not proven, that growth of salmonids might actually be stimulated by chronic exposure to very low levels of ammonia. In the present study, two 70 day growth experiments were conducted under rigorously controlled experimental conditions with juvenile rainbow trout at total ammonia concentrations ([T-Amm]) of 0, 70 and 225 µmol/L at pH 7.6. In the first experiment, a small-scale laboratory proof-of-principle study at 15ºC, there was a significant stimulation of weight gain, gross food conversion efficiency, condition factor and protein production per fish at [T-Amm]=70 µmol/L without an increase in voluntary food consumption or change in 'in-tank' oxygen consumption or ammonia excretion rates. These growth stimulatory effects were not seen at [T-Amm]=225 µmol/L, where the fish consumed more food, and excreted more ammonia, yet achieved the same mass and protein content as the controls. In the second experiment, a larger study conducted in an aquaculture facility at 6.5ºC, growth rate, conversion efficiency and protein production per fish were all significantly stimulated at [T-Amm]=225 µmol/L, but not at 70 µmol/L, without any change in voluntary food consumption. These effects occurred despite an early inhibition of growth at both [T-Amm] levels. When ration was restricted, growth was reduced and there were no longer any differential effects attributable to [T-Amm]. While the effective levels of [T-Amm] differed between the two experiments, the un-ionised ammonia level stimulating growth was similar in both. The results are interpreted as reflecting either a stimulation of ammonia incorporation into amino acids and protein synthesis and/or a reduction in metabolic costs. The finding that low levels of exogenous ammonia can serve as a growth stimulant without altering food consumption may be important for aquacultural practice, and challenges traditional dogma that the effects of ammonia are detrimental to growth.

Wood, C.A. (McMaster Univ, Dept Biol, 1280 Main St W, Hamilton, ON L8S 4K1, Canada. Email: woodcm@mcmaster.ca) (2004). Dogmas and controversies in the handling of nitrogenous wastes: Is exogenous ammonia a growth stimulant in fish? *Journal of Experimental Biology,* 207: 2043-2054.

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6. Water hardness affects *Saprolegnia* colonization

In an attempt to explain some of the differences in fungal growth and antifungal chemical effectiveness observed at various fish hatcheries, experiments were conducted to determine the effects of water hardness on colonization by *Saprolegnia diclina*. Fungal growth on nonviable seeds of hemp was observed sooner in water where hardness was elevated by addition of calcium sulphate dihydrate. Seeds in test tubes containing water with a hardness of 300 mg/L exhibited fungal colonization in approximately half the time observed for seeds in water with hardness <150 mg/L. In petri-dishes containing inoculated corn meal plugs, *S. diclina* grew quicker at a hardness of 450 mg/L than at 300 and 150 mg/L. Growth at these hardnesses was, in turn, quicker than growth at the 0 mg/L hardness control water. The relatively minor changes in pH following the addition of water hardness-altering chemicals did not affect the timing of fungal colonization, as a separate experiment indicated no effect of pH (ranging from 3 to 10) on fungal growth.

Barnes, M.E. (S Dakota Dept Game Fish & Pk, McNenny State Fish Hatchery, Spearfish, SD 57783, USA. Email: mike.barnes@state.sd.us), Gabel, A.C., Durben, D.J., Hightower, T.R. and Berger, T.J. (2004). Changes in water hardness influence colonization of *Saprolegnia diclina. North American Journal of Aquaculture,* 66: 222-227.

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7. Origin of VHS

Viral haemorrhagic septicaemia (VHS) caused by the rhabdovirus VHSV is the most economically important viral disease to rainbow trout farming in Europe. Although the virus was originally identified from freshwater salmonids, since 1989 it has also been isolated from an increasing number of wild marine fish species. To study the genetic evolution of VHSV, the entire G gene was analysed for 74 isolates. European freshwater VHSV appeared to share a recent common ancestor with wild marine species caught in the Baltic Sea, Skagerrak, Kattegat, North Sea, and English Channel. Based on the estimated nucleotide substitution rate, the ancestor of the European freshwater isolates was dated some 50 years ago. This finding fits with the initial reports in the 1950s on clinical observations of VHS in Danish freshwater rainbow trout farms. The study also indicates that European marine VHSV and the North American marine line separated approx. 500 years ago. The data support the hypothesis of the marine environment being the original reservoir of VHSV and that the change in host range to include rainbow trout may have occurred several times. Virus from the marine environment will therefore continue to represent a threat to the trout aquaculture industry.

Einer-Jensen, K. (Danish Inst Food & Vet Res, Hangovej 2, DK-8200 Aarhus, Denmark. Email: kej@dfvf.dk), Ahrens, P., Forsberg, R. and Lorenzen, N. (2004). Evolution of the fish rhabdovirus viral haemorrhagic septicaemia virus. *Journal of General Virology*, 85: 1167-1179.

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8. Susceptibility of trout to VHS strains

The susceptibility of rainbow trout to infection with various isolates of viral haemorrhagic septicaemia virus (VHSV) was examined. A total of 8 experiments with rainbow trout ranging from 0.6 to 6.2 g were conducted for 139 isolates originating from wild marine fishes in European waters (115 isolates), farmed turbot from Scotland and Ireland (2 isolates), and farmed rainbow trout (22 isolates). The isolates were tested by immersion and/or intraperitoneal injection either as pooled or single isolates. The isolates from wild marine fishes did not cause mortality by immersion while some of the isolates caused mortality when injected. All VHSV isolates from farmed rainbow trout caused significant mortality by immersion. The two farmed turbot isolates did not cause mortality by immersion, supporting the view that they originated from the marine environment.

Skall, H.F. (Danish Inst Food & Vet Res, Dept Poultry Fish & Fur Anim, Hangovej 2, DK-8200 Aarhus N, Denmark. Email: hfm@dfvf.dk), Slierendrecht, W.J., King, J.A. and Olesen, N.J. (2004). Experimental infection of rainbow trout *Oncorhynchus mykiss* with viral haemorrhagic septicaemia virus isolates from European marine and farmed fishes. *Diseases of Aquatic Organisms,* 58: 99-110.

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9. Iodine supplemented feeds reduces stress response

Various biological, chemical and physical factors can cause chronic stress in farmed fish, potentially leading to a decrease in overall health and growth rate. Dietary iodine has been shown to reduce the stress response in chickens and increase disease resistance in dairy cattle, but has not been extensively examined in fish. This study investigated the effects of iodized feed as a nutritional supplement in relation to stress modulation in trout. The primary, secondary and tertiary stress responses were assessed by measuring the levels of cortisol, glucose and thyroid hormones in the blood as well as red blood cell volume and growth rate. Iodine-supplemented fish had lower levels of plasma cortisol and glucose and lower packed cell volumes than fish fed with regular commercial feed. Iodine-supplemented fish also showed higher levels of thyroid hormones and exhibited better growth over the period of the experiment. The authors concluded that, used with other husbandry practices, iodine-supplemented feed could lead to better host defence, growth and survival in farmed fish.

Gensic, M., Wissing, P.J., Keefe, T.R. and Mustafa, A. (Indiana Univ Purdue Univ, Dept Biol, 2101 E Coliseum Blvd, Ft Wayne, IN 46805, USA. Email: mustafaa@ipfw.edu) (2004). Effects of iodized feed on stress modulation in steelhead trout, *Oncorhynchus mykiss* (Walbaum). *Aquaculture Research*, 35: 1117-1121.

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10. Aeration reduces stress

The stress associated with feeding, counting, grading and harvesting in farmed rainbow trout, and the influence of aeration, was assessed by measuring plasma cortisol concentrations. Feeding, counting, grading and harvesting produced significant elevations in cortisol. Grading was found to be a more stressful practice than feeding or counting. The cortisol response to grading was lower during the winter than during the summer. Winter harvesting was, however, more stressful than summer harvesting, suggesting that lower temperatures may prolong the period for loss of consciousness. The presence of an aerator during these practices significantly reduced the cortisol response, suggesting that stress experienced by trout during fish farming practices can be significantly reduced by oxygenating the water.

Dunlop, R.A. (6 Asbourne, Castledawson, Londonderry, Northern Ireland, BT45 8HP. Email: r.dunlop@uq.edu.au), Laming, P.R. and Smith, T.E. (2004) The stress of four commercial farming practices, feeding, counting, grading and harvesting, in farmed rainbow trout, *Oncorhynchus mykiss. Marine and Freshwater Behaviour and Physiology,* 37: 179-192.

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11. Vertebral abnormalities in farmed trout

Various vertebral abnormalities were recorded in 85 diploid and triploid pan size trout originating from the same fertilization. Vertebral abnormalities did not differ between treatments, although the triploid trout had one more caudal vertebra. Among the 85 specimens showing vertebral abnormalities, 43 had either coalescing vertebrae or a reduction of the length of the vertebral centrum, both phenomena being preferentially localised in three areas: V8-V21, V31-V40, V51-V61. The mineralization rate on the vertebrae of the two first areas did not differ between the diploid and triploid trout, nor between the 'normal' vertebrae and the coalesced ones. The vertebral osseous compacity did not differ between diploid and triploid trout, but was higher in the coalesced caudal vertebrae than in the normal caudal ones. This difference in vertebral osseous compacity may be related to two further observations: 1) the 'normal' vertebrae showed wide erosive lacunae, which could characterize a physiological stress generated by a mineral deficiency. 2) The coalesced vertebrae show abundant bulks of cartilage (cartilaginous basalia, which disappear during normal development) according to the volume of vascular cavities. In the light of these results it is evident that the triploidization process has no major consequence on the histo-morphological characteristics of normal and abnormal vertebrae, other than the induction of one additional caudal vertebra. However, the environmental characteristics (e.g. acid water) and the zootechnical processes of trout farming (e.g. food, growth rate) may impact on the vertebral osseous texture.

Kacem, A. (INRA, SCRIBE, Campus Beaulieu, F-35042 Rennes, France. Email: akacem@beaulieu.rennes.inra.fr), Meunier, F.J., Aubin, J. and Haffray, P. (2004). A histo-morphological characterization of malformations in the vertebral skeleton of rainbow trout (*Oncorhynchus mykiss*) after various triploidization treatments. *Cybium,* 28 Suppl. S: 15-23.

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12. Triploidy affects blood cells of brook trout

This experiment compared the blood cells sampled from batches of diploid (2n) and triploid (3n) brook trout, which originated from the same batch of spawn. The triploids were obtained by applying a hydrostatic pressure shock of 9500 psi (65.5 x 10^3 kPa) for 5 min to eggs 20 min following fertilization at a temperature of 10ºC. The 3n and 2n fish were then reared under the same conditions (environment, feeding) in parallel pools. Blood was sampled for smears, which, in combination with the prepared chromosomes, were used to confirm the fish ploidal level and to examine the blood cells. The percentage of erythrocytes with segmented nuclei in triploid fish was higher (19.1%) than in diploid fish (0.3%). In addition, the number of pathologically cleaved lymphocytes was greater in 3n brook trout (1.5%) than in diploid fish (0.8%). Triploid brook trout blood had a higher percentage of granulocytes with a greater number (≥5) of nuclear segments compared to diploid trout blood. A tendency toward nuclear segmentation in blood cells has been suggested as characteristic for the triploid brook trout.

Wlasow, T. (Univ Olsztyn, Dept Evolut Genet, PL-10718 Olsztyn, Kortowo, Poland. Email: tewlasow@uwm.edu.pl), Kuzminski, H., Woznicki, P. and Ziomek, E. (2004). Blood cell alteration in triploid brook trout *Salvelinus fontinalis* (Mitchill). *Acta Veterinaria Brno,* 73: 115.

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13. UV water treatment increases cataracts in cod

The results of this study indicate that seawater recently disinfected with ultraviolet radiation (254 nm) can increase cataract frequency in juvenile cod. In a 5-month experiment groups of cod were reared in a recirculating system at two stocking densities (54 and 300 fish/m^3), and the frequency of cataracts increased after the fish were exposed to UV-treated water. The tank with the water intake closest to the UV unit (3 m) was affected the most - 39% of the fish developed cataracts compared to 5% in the tank located furthest away (33 m). The frequency of cataracts decreased exponentially with the time it took the seawater to run from the UV light to the rearing tanks, and the calculated half-life of the effect was about 1 min. The effect of the UV light must have been indirect since the UV lamps were placed inside an opaque steel box. It is hypothesized that ozone or other photoproducts formed by UV radiation may cause cataracts in fish. Cataract frequency was double at high density compared to the low density for any given post UV-treatment time, suggesting that density-dependent abrasion of the cornea may enhance the effect of ozone or other photoproduct on the lens. The results imply that UV lights must be used with great caution in fish farming to avoid the development of cataracts.

Bjornsson, B. (Marine Res Inst, Skulagata 4 POB 1390, IS-121 Reykjavik, Iceland. Email: bjornb@hafro.is) (2004). Can UV-treated seawater cause cataract in juvenile cod (*Gadus morhua* L.)? *Aquaculture,* 240: 187-199.

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14. Potential uptake of transgenic fish reviewed

This paper reviews the public and scientific debates over the risks and benefits of aquatic biotechnology worldwide, and in the United States in particular. The basic argument is that business tends to respond to uncertainty with innovation in management and technology. Technological evolution in the fish business is therefore interpreted as a continuous response to new environmental and socio-economic uncertainties and subsequent regulation. The use of aquatic biotechnology in fish breeding is just the latest technological response, but also the most controversial. Growth-enhanced transgenic salmon may become the first bioengineered animal product to be approved for use as food in the United States. The fish may boost future salmon harvests, contribute to productivity increases in aquaculture and lower consumer prices for salmon. However, it also faces public opposition, reluctant investors and scientific scepticism due to mainly environmental concerns. The author argues that, despite the well-elaborated regulatory framework in the United States, it may not be possible to reassure public opposition once transgenic salmon are approved. The consumer market rather than regulation will determine the ultimate fate of transgenic fish, analogous to genetically modified food crops.

Aerni, P. (ETH Zentrum, Ctr Comparat & Int Studies CIS, SEI F6, CH-8092 Zurich, Switzerland. Email: philipp.aerni@iaw.agrl.ethz.ch) (2004). Risk, regulation and innovation: the case of aquaculture and transgenic fish. *Aquatic Sciences,* 66: 327-341.

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15. Study of antibiotic withdrawal time

The international production of farmed fish has been growing continuously over recent years. Until now few veterinary drugs have been approved by the European Union for use in aquaculture, and this has favoured the off-label use of products authorized for use in other food-producing animal species. Adequate field studies are however lacking, especially for those 'minor species' which are consumed extensively only in some European countries. This investigation studied the depletion of the fluoroquinolone antibacterial enrofloxacin over time in farm-reared rainbow trout treated with medicated feed (10 mg/kg b.w./d). Edible tissue samples (muscle plus skin in natural proportions) and fish bone samples were analysed for enrofloxacin and for its major metabolite, ciprofloxacin, at different times after the end of treatment. The results show that at 500 degree-days (the minimum withdrawal period established by European Directive No. 82/2001 for any type of product administered off-label) edible trout tissues might still contain about 170 µg/ kg of enrofloxacin, whereas the maximum residue level for enrofloxacin plus ciprofloxacin is set at 100 µg/kg. No studies of the depletion of enrofloxacin in rainbow trout appear to have been performed. On the basis of the data obtained in the present study, we suggest a more appropriate withdrawal time of 816 degree-days.

Lucchetti, D., Fabrizi, L., Guandalini, E., Podesta, E., Marvasi, L., Zaghini, A. and Coni, E. (Ist Super Sanita, Natl Ctr Food Qual & Risk Assessment, Viale Regina Elena 299, I-00161 Rome, Italy. Email: e.coni@iss.it). (2004). Long depletion time of enrofloxacin in rainbow trout (*Oncorhynchus mykiss*). *Antimicrobial Agents and Chemotherapy,* 48: 3912-3917.

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16. Adipose fin removal can affect swimming performance

The adipose fin is a highly conserved and enigmatic, small, non-rayed fin that persists on some basal teleosts such as salmonids. This experimental study tested the effects of adipose fin removal on swimming performance of juvenile steelhead by measuring the amplitude and frequency of caudal fin movement at multiple flow velocities (10-39 cm/s). In smolts, adipose fin removal increased caudal fin amplitude relative to unclipped fish across all velocities. However, there were no observable effects on smaller (<7 cm) or larger fish (>12 cm). This suggests that the adipose fin may function to control vortices enveloping the caudal fin during swimming or, alternatively, function as a passive precaudal sensor of turbulent flow. Evolutionary persistence of the adipose fin among multiple groups of early bony fishes is probably due to its hydrodynamic attributes rather than developmental constraints. The current widespread practice in fisheries of removing the adipose fin as a marking technique may therefore have significant biological costs.

Reimchen, T.E. (Univ Victoria, Dept Biol, POB 3020, Victoria, BC V8W 3N5, Canada. Email: reimchen@uvic.ca) and Temple, N.F. (2004). Hydrodynamic and phylogenetic aspects of the adipose fin in fishes. *Canadian Journal of Zoology,* 82: 910-916.

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17. Evidence that trout can experience fear

The capacity of rainbow trout to experience fear was assessed using an avoidance-learning task. Each of 13 fish was placed individually into a two-chambered shuttle tank where it could be subjected to the presumed frightening stimulus of a plunging dip net in either chamber. The fish could escape from the stimulus by swimming through a doorway to the other chamber. The fish escaped from the plunging net by swimming through the doorway, some on the first occasion and all after a few exposures. Each fish was then presented with a neutral stimulus of a light that was switched on 10 sec before the net plunged into the water. Over a 5-day period, all fish learned to swim through the doorway when the light was switched on to avoid the plunging net. All fish showed evidence of a longer-term memory by showing the learned avoidance response when they were tested after 7 days of no testing. Whereas the escape responses to the plunging net were immediate and reflexive-like, the avoidance responses to the light going on were delayed a few seconds and more deliberate in nature. This evidence suggests that trout can experience fear and that they can learn to avoid frightening stimuli. It implies that they are sentient animals, more complex than previously thought.

YUE, S. (Univ Guelph, Dept Anim & Poultry Sci, Guelph, ON N1G 2W1, Canada. Email: syue@uoguelph.ca), MOCCIA, R.D. AND DUNCAN, I.J.H. (2004). Investigating fear in domestic rainbow trout, *Oncorhynchus mykiss*, using an avoidance learning task. *Applied Animal Behaviour Science,* 87: 343-354.

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18. Review suggests that fish can suffer

In contrast to other major forms of livestock agriculture, there is a paucity of scientific information on the welfare of fish raised under intensive aquacultural conditions. This reflects an adherence to the belief that these animals have not evolved the salient biological characteristics that are thought to enable sentience. In this review, the scientific evidence for the existence of sentience in fish is discussed and, in particular, their ability to experience pain, fear and psychological stress. Although teleost fish have marked differences in some aspects of brain structure and organization when compared to tetrapods, they do demonstrate functional similarities and a level of cognitive development suggestive of sentience. Anatomical, pharmacological and behavioural data suggest that fish are likely to experience affective states of pain, fear and stress in similar ways to higher vertebrates. This implies that fish do have the capacity to suffer, and that welfare consideration for farmed fish should take these states into account. The authors conclude that the concept of animal welfare can be applied legitimately to fish, and it is therefore appropriate to recognize and study the welfare of farmed fish.

CHANDROO, K.P., DUNCAN, I.J.H. AND MOCCIA, R.D. (Univ Guelph, Dept Anim & Poultry Sci, Guelph, ON N1G 2W1, Canada. Email: rmoccia@uoguelph.ca) (2004). Can fish suffer?: perspectives on sentience, pain, fear and stress. *Applied Animal Behaviour Science,* 86: 225-250.

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19. Use of a Hidrostal pump

The effects of passage through a Hidrostal pump on immediate and delayed (96 h) mortality, descaling, and injury rates were assessed by comparing fish inserted into the entrance (suction side) to control fish inserted at the exit (pressure side). Comparisons were made in 158 trials of striped bass and 86 trials with rainbow trout. The Hidrostal pump had no effect on immediate or delayed (96 h) mortality. Immediate mortality for striped bass and rainbow trout averaged 0.1 and 0%, respectively, and delayed mortality averaged 2.9 and 0.1%, respectively. Mean scale loss after passage for striped bass and rainbow trout was low (0.2 and 1.0%, respectively). Frequency of injury to the head, eyes, skin, and fins of pumped striped bass averaged 1.9, 2.8, 1.9, and 18.7%, respectively, and those of rainbow trout averaged 2.3, 0, 2.4, and 3.1%. No significant relationships were detected between fish mortality and pump speed, injected fish density, and debris load. Results suggest that large Hidrostal pumps have the capacity to transport live striped bass and rainbow trout at high density (1-6 fish/L) with little mortality and body injury.

HELFRICH, L.A. (Virginia Polytech Inst & State Univ, 152 Cheatham Hall, Blacksburg,VA 24061, USA), BARK, R., LISTON, C.R., WEIGMANN, D.L. AND MEFFORD, B. (2004). Live transport of striped bass and rainbow trout using a Hidrostal pump. *Journal of the World Aquaculture Society*, 35: 268-273.

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20. Compensatory growth in trout

The effect of feed cycling on compensatory growth was examined in juvenile rainbow trout, held individually at 15ºC. Fish were fasted for 2, 4, 8, or 14 days and then refed until either their relative feed intake differed by less than 10% of fed controls, or the duration of the refeeding period was four times the fasting period. Feeding regime had no effect on visceral fat or hepatosomatic indices, although variation within treatments was high. Fish subjected to fasting did display compensatory growth, and high growth rate during the recovery phase was achieved by hyperphagia, rather than improved feed conversion. There was a highly significant relationship between feed intake and weight gain, and feed conversion did not differ between fish subjected to the different treatments. The results indicate that rainbow trout can be subjected to short periods of fasting without significant effects on growth, but no improvement in feed utilization was obtained during the refeeding period.

NIKKI, J., PIRHONEN, J. (Univ Jyvaskyla, Dept Biol & Environm Sci, POB 35, FIN-40014, Jyvaskyla, Finland. Email: jpirhon@bytl.jyu.fi), JOBLING, M. AND KARJALAINEN, J. (2004). Compensatory growth in juvenile rainbow trout, *Oncorhynchus mykiss* (Walbaum), held individually. *Aquaculture,* 235: 285-296.

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21. Feed contaminant uptake studied

Atlantic salmon were fed graded levels of dioxins (polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans) and dioxin-like polychlorinated biphenyls (DLPCBs) in their diets for 7 months. The dioxin and DLPCB concentrations in both fillet and whole body of salmon increased with increasing dietary exposure. DLPCBs transferred more efficiently from the feed to edible flesh of salmon than dioxins, and contributed a higher proportion to the total toxic equivalents (TEQ). At the end of the trial, the maximum concentrations of dioxins in fillet and whole fish were 1.9 and 2.3 pg WHO-TEQ / g fresh weight, respectively. Hence with this feeding period even with the most contaminated feed (4.9 pg WHO-TEQ / g dry weight) the dioxin concentrations in salmon did not exceed the maximum level set by the European Commission [4 pg WHO-TEQ /g (EC 2375/2001)]. This study provides valuable information for forthcoming risk assessments and the future establishment of maximum limits for these compounds in feed and fish.

Lundebye, A.K. (Natl Inst Nutr & Seafood Res, POB 176 Sentrum, N-5804 Bergen, Norway. Email: anne-katrine.haldorsen@nifes.no), Berntssen, M.H.G., Lie, O., Ritchie, G., Isosaari, P., Kiviranta, H. and Vartiainen, T. (2004). Dietary uptake of dioxins (PCDD/PCDFs) and dioxin-like PCBs in Atlantic salmon (*Salmo salar*). *Aquaculture Nutrition*, 10, 199-207.

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22. New method for genetic selection shows promise

Growth rate is the main breeding goal of fish breeders, but individual selection has often shown poor responses in fish species. The PROSPER method was developed to overcome possible factors that may contribute to this low success, through 1) using a variable base population and high number of breeders (Ne > 100); 2) selection within groups with low non-genetic effects; and 3) repeated growth challenges. The PROSPER method was evaluated practically by selecting brown trout based on length at the age of one year, and comparing to an unselected control line. After four generations, the mean response per generation in comparison to the control was 6.2% for length at one year, and 21.5% for weight. At the 4th generation, selected fish also appeared to be leaner than control fish when compared at the same size. This high response is promising, however, the key points of the method have to be investigated in more detail.

Chevassus, B., Quillet, E., Krieg, F., Hollebecq, M.G., Mambrini, M., Labbe, A.F.L., Hiseux, J.P. and Vandeputte, M. (INRA, Lab Genet Poissons, F-78352 Jouy En Josas, France. Email: mvande@jouy.inra.fr) (2004). Enhanced individual selection for selecting fast growing fish: the 'PROSPER' method, with application on brown trout (*Salmo trutta fario*). *Genetics Selection Evolution,* 36: 643-661.

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23. Assessing sustainability

Understanding the environmental burdens associated with aquafeeds is a critical component for assessing and improving the environmental performance of aquaculture. The aim of the study was to assess the environmental impacts associated with feeds for rainbow trout production in France, using Life Cycle Assessment (LCA). The stages assessed were: the extraction of the raw materials, the production and transformation of the primary ingredients used, the manufacturing of the feeds, the use of the feeds at the farm, transport at all stages, and the production and use of energy resources. The assessment revealed that the use of fishery resources and nutrient emissions at the farm contribute most to the potential environmental impacts of salmonid aquafeeds. Improvements in feed composition and management practices seem to be the best ways for improving the environmental profile of aquafeeds.

Papatryphon, E. (INRA, Soil Agron & Spatialisat Res Unit ENSAR, 65 Rue St Brieuc, F-35042 Rennes, France. Email: elias.papatryphon@roazhon.inra.fr), Petit, J., Kaushik, S.J. and Van Der Werf, H.M.G. (2004). Environmental impact assessment of salmonid feeds using Life Cycle Assessment (LCA). *Ambio,* 33: 316-323.

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24. Effects of anaesthetics on gamete quality

This study examined the impact of three commonly used anaesthetics - clove oil (86% eugenol), tricaine (tricaine methanesulfonate [MS-222]), and CO_2 - on egg quality and sperm motility for steelhead and white sturgeon. Exposure of unfertilised eggs for 6 or 24 h to 150 mg clove oil/L, 225 mg tricaine/L, or < 100 mm Hg CO_2 resulted in no reduction in egg fertility or embryo survival. However, higher doses (1,500 mg clove oil/L; 2,250 and 22,500 mg tricaine/L; or > 125 mm Hg CO_2) did have a negative impact on egg quality. Similarly, a 3-h exposure to clove oil (150 mg/L) or tricaine (225 mg/L) produced no significant effect on sperm motility in steelhead. Thus, the data suggest that clove oil and tricaine can be used on fish prior to gamete harvesting without significant adverse impacts on gametes. Although CO_2 is unlikely to have deleterious effects on eggs, CO_2-associated declines in ovarian fluid pH may be of concern when ovarian fluid pH is used as an indicator of egg quality.

Holcomb, M., Woolsey, J., Cloud, J.G. and Ingermann, R.L. (Univ Idaho, Dept Biol Sci, Moscow, ID 83844, USA. Email: rolfi@uidaho.edu) (2004). Effects of clove oil, tricaine, and CO_2 on gamete quality in steelhead and white sturgeon. *North American Journal of Aquaculture,* 66: 228-233.

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25. Improving red yeast astaxanthin uptake

Red yeast has been developed as a natural source of astaxanthin in salmonid diets. The aims of this study were to assess the effects of enzymatic cell wall disruption and feed extrusion temperature on utilization of astaxanthin from red yeast in experimental diets for rainbow trout. The red yeast was subjected to three different degrees of enzymatic cell wall disruption, resulting in 45%, 70% and 97% increase in acetone extractability of carotenoids compared to untreated yeast. The three yeast preparations were included in the dry mix of feeds that were extruded at 102 and 137ºC. Each of the six diets was fed to three groups of rainbow trout for 92 days. Extrusion temperature did not affect utilization of dietary astaxanthin or flesh colour significantly. However, increasing the degree of enzymatic cell wall disruption increased flesh astaxanthin concentrations from 2.2 to 6.7 mg/kg, the CIE (1976) a*-value (redness) from 5.5 to 10.7 and b*-value (yellowness) from 11.7 to 16.7, Roche SahnoFan(R) values from 22.6 to 28.6, and astaxanthin retention in the muscle from 3.7% to 17.4%. Cell wall disruption of red yeast cells is therefore crucial to optimise carotenoid utilization.

Storebakken, T. (AKVAFORSK, Inst Aquaculture Res AS APC, POB 5015, N-1432 As, Norway. Email: trond.storebakken@akvaforsk.nih.no), Sorensen, M., Bjerkeng, B. and Hiu, S. (2004). Utilization of astaxanthin from red yeast, *Xanthophyllomyces dendrorhous*, in rainbow trout, *Oncorhynchus mykiss*: effects of enzymatic cell wall disruption and feed extrusion temperature. *Aquaculture,* 236: 391-403.

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26. BKD in Scotland

Bacterial kidney disease (BKD) is a notifiable disease for salmonids under United Kingdom and European Union legislation. Within the UK, legislation and the control of infected fish with BKD has been operating for 25 yr. Infection by the bacterium *Renibacterium salmoninarum* results in a chronic, debilitating infection and mortality. Records of BKD outbreaks and the detection of *R. salmoninarum* were monitored from 1990 through to 2002 for Atlantic salmon and rainbow trout reared in Scottish waters. New outbreaks of BKD in salmon in seawater declined during this period, but with year-to-year variation. Only 1 record of BKD has occurred in freshwater-reared salmon. BKD in rainbow trout farmed in seawater is uncommon and was only identified in 1993 and between 1998 and 2000. The number of active designated area orders (DAOs) for outbreaks in salmon has fallen since 1990, but has remained relatively constant for trout over the period of study.

Bruno, D.W. (FRS Marine Lab, POB 101 375 Victoria Rd, Aberdeen AB11 9DB, Scotland. Email: d.bruno@marlab.ac.uk) (2004). Prevalence and diagnosis of bacterial kidney disease (BKD) in Scotland between 1990 and 2002. *Diseases of Aquatic Organisms,* 59: 125-130.

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27. Review of phosphorus in fish diets

Phosphorus (P) is an essential component of fish diets. Its deficiency affects not only hard tissues leading to skeletal malformation and rickets, but also influences various aspects of intermediary metabolism, and thus growth and feed conversion. Therefore, optimising the dietary inclusion level is critical at all times. As the aquaculture industry has expanded, so the effects of P in farm effluents, derived from excretion and uneaten food sources, have also become recognized. Diets are increasingly formulated on a basis that will not only provide adequate P for fish needs, but also endeavour to ensure minimal acceptable P levels in effluents at the same time. Many variables influence P requirements and P availability in fish diets, so it is inadvisable to feed diets formulated to an assumed minimum dietary requirement level, irrespective of the advantages that such a formulation may provide to environmental impact.

Sugiura, S.H., Hardy, R.W. (Univ Idaho, Hagerman Fish Culture Expt Stn, 3059F Fish Hatchery Rd, Hagerman, ID 83332, USA. Email: rhardy@uidaho.edu) and Roberts, R.J. (2004). The pathology of phosphorus deficiency in fish - a review. *Journal of Fish Diseases,* 27: 255-265.

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